KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University)
(Established Under Section 3 of UGC Act 1956)
Coimbatore – 641021.
(For the candidates admitted from 2017 onwards)
DEPARTMENT OF PHYSICS

SUBJECT : RENEWABLE ENERGY AND ENERGY HARVESTING

SEMESTER : III

SUBJECT CODE: 18PHU303A **CLASS: II B. Sc. PHYSICS**

LECTURE PLAN
DEPARTMENT OF PHYSICS

S. No.	Lecture Duration Hour	Topics to be Covered	Support Material/Page Nos
		UNIT - I	
1	1	Introduction about Renewable Energy	R1, R2
2	1	Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy	W1, W2
3	1	Non-conventional energy sources, An overview of developments in Offshore Wind Energy	W1, W2
4	1	An overview of developments in Tidal Energy, wave energy systems, solar energy	T1. Pg: 580, 17-38
5	1	An overview of developments in biomass, biochemical conversion, biogas generation	T1. Pg. 595-606
6	1	Recapitulation and Discussion of Important Questions	
	Total No of Hours Planned for Unit I = 06		
		UNIT - II	

1	1	Solar energy: Solar energy, its importance, storage of solar energy, Solar pond, non convective solar pond, applications of solar pond and solar energy	T1. Pg: 1-16, 306-309
2	1	Solar water heater, flat plate collector, Solar distillation, solar cooker, Solar green houses, Solar cell	T1. Pg: 313, 500, 522, 362, 459
3	1	Absorption air conditioning	T1. Pg. 459
4	1	Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.	T1. Pg. 9
5	1	Recapitulation and Discussion of Important Questions	
	Total No of Hours Planned for Unit II = 05		
		UNIT – III	
1	1	**Wind Energy Harvesting:** Fundamentals of Wind energy	T1. Pg: 580-593
2	1	Wind Turbines and different electrical machines in wind turbines	T2. Pg: 100-112
3	1	Power electronic interfaces, and grid interconnection topologies	W4
4	1	Ocean Energy: Ocean Energy Potential against Wind	W5
5	1	Solar Wave Characteristics and Statistics	W5
6	1	Wave Energy Devices	W5
7	1	Tide characteristics and Statistics, Tide Energy Technologies	W5
8	1	Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass	W5
9	1	Recapitulation and Discussion of Important Questions	
	Total No of Hours Planned for Unit III = 09		

		UNIT - IV	
1	1	**Hydro Energy:** Hydropower resources, hydropower technologies, environmental impact of hydro power sources	W6
2	1	Piezoelectric Energy harvesting: Introduction	W7
3	1	Physics and characteristics of piezoelectric effect	W7
4	1	Materials and mathematical description of piezoelectricity	W7
5	1	Piezoelectric parameters and modeling, piezoelectric generators	W8
6	1	Piezoelectric energy harvesting applications, Human power	W8
7	1	Recapitulation and Discussion of Important Questions	
	Total No of Hours Planned for Unit IV = 07		
		UNIT - V	
1	1	**Electromagnetic Energy Harvesting:** Linear generators	W9
2	1	Physics mathematical models, recent applications	W9
3	1	Geothermal Energy: Introduction	W10
4	1	Geothermal Resources, Geothermal Technologies, Carbon captured technologies	W10
5	1	Cell, batteries, power consumption, Environmental issues and Renewable sources of energy, sustainability	W10, R3
6	1	Recapitulation and Discussion of Important Questions	

7	1	Discussion of Previous ESE Question Papers.	
8	1	Discussion of Previous ESE Question Papers.	
9	1	Discussion of Previous ESE Question Papers.	
	Total No of Hours Planned for Unit V = 9		
Total Planned Hours		**36**	

SUGGESTED READINGS:

1. G.D.Roy. (2004) Solar energy utilization, Khanna Publishers.
2. Cheten Singh Solanki. (2009) Renewable energy technologies. New Delhi: PHI
3. B. H. Khan. (2006) Non-Conventional Energy Resources. New Delhi: Tata McGraw Hill
4. Godfrey Boyle. (2012) Renewable Energy, Power for a sustainable future. (3rd Ed.).Oxford University Press.
5. P. Jayakumar. (2009) Solar energy Resources assessment Hand Book. Asian and Pacific Centre for Transfer of Technology (APCTT)

WEBSITES:

W1- www.ecology.com

W2-https://www.nrel.gov

W3-https://en.wokipedia.org/wiki/renewable-energy

W4-www.electrical4u.com

W5-www.ifcc.ch/pdf/special-reports/srren/drafts

W6-www.nationalgeoghraphic.org

W7-www.renewableenrgyworld.com/hydropower/tech

W8-citeseerx.ist.psu.edu>viewdoc>

W9-www.ipe.nchu.edu.tw>286_emrotex

W10 – www.nationalgeoghraphic.com/envoronment/global-warming/geothermal-energy/

UNIT-I

SYLLABUS

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, solar energy, biomass, biochemical conversion, biogas generation.

Fossil fuels:

Fossil fuels are fuels that come from very old life forms that decomposed over a long period of time. The three most important fossil fuels are coal, petroleum, and natural gas. Oil and gas are hydrocarbons (molecules that have only hydrogen and carbon in them). Coal is mostly carbon. These fuels are called fossil fuels because they are dug up from underground. In the oil sands in Alberta, about 1 billion cubic feet of natural gas was used per day in 2007 to heat the soil so the oil would come out of the earth.

Uses:

1. Most of the fuels people burn are fossil fuels. A big use is to make electricity. In power plants fossil fuels, usually coal, are burned to heat water into steam, which pushes a fan-like object called a turbine. When the turbine spins around, magnets inside the turbine make electricity.
2. Crude oil can be separated to make various fuels such as LPG, gasoline, kerosene, jet fuel, and diesel fuel. These substances are made by fractional distillation in an oil refinery. They are the main fuels in transportation. That means that they are burned in order to move cars, trucks, ships, airplanes, trains and even spacecraft. Without them, there wouldn't be much transport.
3. People also burn fossil fuels to heat their homes. They use coal less for this than they did long ago, because it makes things dirty. In many homes, people burn natural gas in a stove for cooking.
4. Fossil fuels are widely used in construction.

Problems:

1. Fossil fuels produce a lot of air pollution when burned. This can be reduced by making the combustion process more efficient, and by using various techniques to reduce the escape of harmful gases. This pollution is responsible for causing the earth to get warmer, called global warming. They are also non-renewable resources, there is only a limited amount of coal, gas, and oil, and it is not possible to make more. Eventually all the fossil fuels will be used. Some scientists think that coal will have run out by 2200 and oil by 2040.
2. Renewable energy sources like biomass energy such as firewood are being used. Countries are also increasing the use of wind power, tidal energy, and solar energy to generate electricity. Some governments are helping automobile makers to develop electric cars and hybrid cars that will use less oil.

Advantage of fossils fuels:

1. A major advantage of fossil fuels is their capacity to generate huge amounts of electricity in just a single location.
2. Fossil fuels are very easy to find.
3. When coal is used in power plants, they are very cost effective. Coal is also in abundant supply.
4. Transporting oil and gas to the power stations can be made through the use of pipes making it an easy task.
5. Power plants that utilize gas are very efficient.
6. Power stations that make use of fossil fuel can be constructed in almost any location. This is possible as long as large quantities of fuel can be easily brought to the power plants.

Disadvantages of Fossil Fuels:

1. Pollution is a major disadvantage of fossil fuels. This is because they give off carbon dioxide when burned thereby causing a greenhouse effect. This is also the main contributory factor to the global warming experienced by the earth today.
2. Coal also produces carbon dioxide when burned compared to burning oil or gas. Additionally, it gives off sulphur dioxide, a kind of gas that creates acid rain.
3. Environmentally, the mining of coal results in the destruction of wide areas of land. Mining this fossil fuel is also difficult and may endanger the lives of miners. Coal mining is considered one of the most dangerous jobs in the world.

4. Power stations that utilize coal need large amounts of fuel. In other words, they not only need truckloads but trainloads of coal on a regular basis to continue operating and generating electricity. This only means that coal-fired power plants should have reserves of coal in a large area near the plant's location.
5. Use of natural gas can cause unpleasant odors and some problems especially with transportation.
6. Use of crude oil causes pollution and poses environmental hazards such as oil spills when oil tankers, for instance, experience leaks or drown deep under the sea. Crude oil contains toxic chemicals which cause air pollutants when combusted.

Alternative Energy Sources:

Human civilization has started realizing how much harm they have already caused to the environment; and when it comes to take a stand against these environmental problems, the focus shifts to the use of alternative energy sources. Have you ever wondered what Alternative Energy Sources are and why are they supposed to help us sustain? Alternative sources of energy are the ones which do not cause any undesirable consequences to the environment, are renewable and are free!

Alternative energy sources can be implemented for houses, for cars, factories and any other facility you can imagine. Scientists around the world are researching on developing and discovering new Alternative Energy Sources so that the growing energy needs of human population can be met more easily, safely and efficiently. Here is a list of Alternative Energy Sources which will help us maintain the balance of nature without causing it much harm as compared to the conventional energy sources.

1. Hydroelectric Energy

The potential energy stored in the water held in dams by is made to drive a water turbine and generator which in turn produces electric power. This form of energy generation is called hydroelectric power. Out of all the alternative energy sources, this one has been most commonly adopted in the current time.

Advantages of hydroelectric power generation

– The source of hydroelectric power generation i.e., water is free of cost.

– Dams can provide virtually continuous electricity generation.

– The water used for power generation can be put to use again.

– There is no chemical process involved in the power production process, therefore, the power generated is clean and does not harm the environment.

2. Solar Energy

This is the energy which the earth receives from the Sun. This is one of the most promising alternative energy sources, which will be available to the mankind for centuries to come. The only challenge remains to tap the solar energy in the most efficient way. The solar power generation is done by using a series of photovoltaic cells where the solar rays are converted into electricity. Apart from electricity production solar energy is also being used for heating water, cooking food etc.

Advantages of solar energy

– The source of energy is absolutely 'free'.

– Solar power which is generated in the day time can be stored to be made available in the night time as well.

– Solar power generators can be used to generate power in rural and remote areas where there is no reach of the conventional form of energy.

– Solar power generation is quite and absolutely clean.

– Solar energy is a renewable form of energy will not deplete until thousands of years.

3. Wind Energy

The power of the wind is harnessed to propel the blades of wind turbine attached to an electric generator to generate wind energy. Wind energy is an effective alternative source of energy in areas where the velocity of wind flow is high.

Advantages of wind energy

– Wind energy is a clean form of energy.

– The source of power generation i.e., wind is free of cost.

– Wind energy is a renewable source of energy.

4. Biomass Energy

This is the energy developed from the wastes of various human and animal activities like the by-products and wastes from timber industry, agricultural yields, municipal solid waste etc. Out of the many alternative sources of energy this is the one which takes into account the utilization of waste material to develop energy thereby disposing them off in a profitable and effective way.

Advantages of biomass energy

– It is an environmental friendly way of energy production in which biological mass is recycled and re-used.

– The biomass will keep generating and decomposing as part of the natural biological cycle. Therefore, biomass energy is considered as a renewable source of energy.

New alternative energy sources:

To answer the question of which Alternative Energy Source have been brought to picture newly, you should understand that as you are reading this, there are developments being carried on to find more and more alternative energy sources. Apart from the commonly known alternative energy sources there have been recent advancements in terms of discovering new alternative energy sources to add to the list of alternative energy sources.

1. Geothermal Energy

This is the energy tapped from the heat inside the earth. Hot rocks residing in the core of earth heat water which emits the surface of the earth with pressure and as steam. This pressurized steam can be used to run steam turbines to generate electricity.

Advantages of geothermal energy

– Similar to other alternative energy sources, geothermal energy source is free of cost.

– With a proper power generation system in place, no harmful by-products are produced.

2. Tidal Power

The surface of earth is 71.11% covered by water bodies especially oceans. The tides in water rise and fall due to the gravity of sun and moon. Since we know about how the position of moon changes we can predict the rise and fall of tides. This rise and fall of tides can be utilized by setting up small dams and passing water through the turbines to generate power.

Advantages of tidal energy

– The source of power generation is free and renewable.

– The power generated is clean and does not cause any pollution.

Why use alternative energy sources?

Alternative energy sources are available free of cost and do not tax the environment for their usage. Power generation through alternative sources of energy is clean and 'green'. If we shift to use power generated from these sources, then carbon dioxide emission from the conventional energy sources will be greatly reduced, and the problem of global warming will be solved in a few years. Also the fast depleting traditional energy sources can be preserved. Along with air pollution, the use of traditional energy resources also cause soil pollution and water pollution by releasing various toxins to the land and water. This can also be controlled reasonably.

The damage that we have caused to earth after the industrial revolution is huge and we will have to take action immediately if we want to keep the planet sustainable for our future generations. The biggest leap that mankind can take to prevent further damage is to start using alternative energy sources.

Nuclear energy and their limitations:

Nuclear energy is the energy in the nucleus of an atom. Atoms are the smallest particles that can break a material. At the core of each atom there are two types of particles (neutrons and protons) that are held together. Nuclear energy is the energy that holds neutrons and protons.

Nuclear energy can be used to produce electricity. This energy can be obtained in two ways: nuclear fusion and nuclear fission. In nuclear fusion, energy is released when atoms are combined or fused together to form a larger atom. The sun produces energy like this. In nuclear fission, atoms are split into smaller atoms, releasing energy. Actually, nuclear power plants can only use nuclear fission to produce electricity.

When one of these two physical reactions (nuclear fission or nuclear fusion) success, atoms experiment a slight loss of mass. This mass lost generates a big amount of heat energy, explained by Albert Einstein with his famous equation $E = mc^2$.Although the production of electricity is the most common utility there are many other uses of nuclear energy in other sectors, such as medical, environmental or wartime (atomic bomb).

Nuclear's limitations:

1) Nuclear plants are uninsurable

2) Accidents happen

3) Decommissioning& waste disposal costs are huge.

4) Plants in the UK inevitably serve a military dual use (we see this in DU munitions, Trident etc)
5) Nuclear's main output (electricity) will not fuel the cars, planes, trucks, trains and household boilers we have today.
6) Nuclear output represented a modest 9% of the domestic energy the UK produced in 2003 (this 9% nuclear was used to provide for 22% of electricity demand according to EU statistics).
7) Renewable energy and efficiency savings could doubtless substitute the heat and light energy currently supplied by nuclear power. The problem with renewable is not intermittent waves, wind, sun, rivers etc. The problem is renewable do not as yet allow a country to project and maintain power internationally.

Non-conventional energy:

Energy generated by using wind, tides, solar, geothermal heat, and biomass including farm and animal waste as well as human excreta is known as non-conventional energy. All these sources are renewable or inexhaustible and do not cause environmental pollution. More over they do not require heavy expenditure.

1. Wind Energy:

Wind power is harnessed by setting up a windmill which is used for pumping water, grinding grain and generating electricity. The gross wind power potential of India is estimated to be about 20,000 MW, wind power projects of 970 MW capacities were installed till March. 1998. Areas with constantly high speed preferably above 20 km per hour are well-suited for harnessing wind energy.

2. Tidal Energy:

Sea water keeps on rising and falling alternatively twice a day under the influence of gravitational pull of moon and sun. This phenomenon is known as tides. It is estimated that India possesses 8000-9000 MW of tidal energy potential. The Gulf of Kutch is best suited for tidal energy.

3. Solar Energy:

Sun is the source of all energy on the earth. It is most abundant, inexhaustible and universal source of energy. AH other sources of energy draw their strength from the sun. India is blessed with plenty of solar energy because most parts of the country receive bright sunshine throughout the year except a brief monsoon period. India has developed technology to use solar energy for cooking, water heating, water dissimilation, space heating, crop drying etc.

4. Geo-Thermal Energy:

Geo-thermal energy is the heat of the earth's interior. This energy is manifested in the hot springs. India is not very rich in this source,

5. Energy from Biomass:

Biomass refers to all plant material and animal excreta when considered as an energy source. Some important kinds of biomass are inferior wood, urban waste, Bagasse, farm animal and human waste.

Importance of non-conventional sources of energy:

1. The non-conventional sources of energy are abundant in nature. According to energy experts the non-conventional energy potential of India is estimated at about 95,000 MW.
2. These are renewable resources. The non-conventional sources of energy can be renewed with minimum effort and money.
3. Non-conventional sources of energy are pollution-free and eco-friendly

Wave Energy Systems:

While there is a wide range of wave energy designs being tested, the method for connecting these facilities to the electrical grid is largely the same.

Wave Energy System Types

Ocean wave energy technologies are still in the early development and demonstration phase. There are four predominant wave energy technologies: point absorbers, attenuators, terminators, and overtopping devices. These four technologies are classified according to their size and orientation. Point absorbers have a small horizontal dimension compared with the vertical dimension. Attenuators are elongated floating structures whose length, which is about one wavelength or longer, is aligned in the direction of the wave propagation. Terminator devices are aligned perpendicular to the direction of wave propagation. Overtopping devices are reservoirs that are filled by incoming waves to levels above the average surrounding ocean.

Point Absorbers

A point absorber device consists of a buoy that is connected to components that move relative to each other due to the rising and falling of waves. This mechanical energy drives an electrical generator. The electrical energy is fed down a single umbilical cable to a junction on the seabed. Several devices can be connected together and linked to shore through a single underwater cable. The device can either float or be anchored to the sea floor. An individual point absorber device may produce up to 11 MW of electricity, although most current designs would produce much less.

Attenuators

Attenuators are long, multi-segment floating structures anchored so they are aligned perpendicular to the direction of wave travel. The segments flex at hinged joints as a wave passes along the device. The mechanical motion of the flexing is converted to electrical energy using hydraulic motors and generators. The electrical energy is fed down a single umbilical cable to a junction on the seabed. Several devices can be connected together and linked to shore through a single underwater transmission cable. The energy generating capacity of a single attenuator device can be up to 1 MW.

Terminators

Terminators are oriented perpendicular to the direction of wave travel and are often located onshore or near shore. One example, shown to the right, is the oscillating water column. This system consists of a chamber, which is a fixed structure with its bottom open to the sea. The wave motion inside the chamber alternately compresses and decompresses the air that exists above the water level inside the chamber. As a result, an alternating stream of high-velocity air is generated. This airflow is driven through a duct to a turbine generator that is used to generate electricity.

For an offshore device, the electrical energy is fed down a single umbilical cable to a junction on the seabed. Several devices can be connected together and linked to shore through a single underwater cable. The energy generating capacity of a single terminator device can be up to 1.5 MW.

Overtopping Devices

Overtopping devices generally are anchored in open water and consist of reservoirs that are filled by wave action to levels above the surrounding sea level. The collected water is released from the reservoir to drive a turbine and generator to produce electrical energy in the same way a hydroelectric plant does. Overtopping devices have been designed and tested for both onshore and floating offshore. The Wave Dragon (shown on the right) is an example of an offshore overtopping device.

The electrical energy is fed down a single umbilical cable to a junction on the seabed and is then linked to shore through a single underwater transmission cable. The energy generating capacity of a single overtopping device can be up to 11 MW.

Wave Energy Facility Size

An individual wave energy device is capable of producing up to 11 MW, depending upon the design of the device. A utility-scale installation of most types of devices would include many wave energy devices, depending upon the intended use. Utility-scale wave energy facilities would generate a large amount of electricity that would be transmitted from a near-shore wave energy farm to many users through a transmission system, similar to that of any other commercial power plant.

A wave farm at Agucadoura, Portugal, consists of three attenuators manufactured by Pelamis Wave Power. It produces 2.25 MW, enough to power 2,000 homes. The wave farm will ultimately contain 30 such devices, which will occupy approximately 250 acres.

An individual overtopping device could occupy from 0.4 to 9 acres. Because there are no large systems in place, the ultimate size of these facilities is unknown. Estimates used in the OCS Alternative Energy and Alternate Use PEIS indicate that commercial-scale wave energy facilities likely would occupy less than 2 km2 (1.9 mi2).

Primary Wave Energy Facility Components

Wave Energy Devices

The major component of a wave farm is the device that captures the mechanical energy of the ocean waves. Each device is attached to the sea floor via various anchoring systems. Turbines or hydraulic motors and generators produce the electricity. Power cables from each device are connected to a seabed cable. Grid synchronization occurs via a variable speed drive and step-up transformer to a suitable voltage level.

Power Cables

Generated electricity is brought to shore via a standard submarine electrical cable, which is usually installed in a trench in the seafloor and under the beach at the shore. The cable runs to an interconnection substation that might be as small as 225 ft2 (25 m2). From that point, the electricity is transferred to consumers through the land-based transmission grid.

Onshore Facility

The submarine electrical cable would be connected to a local power distribution grid or a long-distance power transmission grid. The control and monitoring of devices and transformers would be carried out remotely using fiber-optic cables or other communication devices.

Tidal energy:

Tidal energy, sometimes called tidal power, is capturing the energy contained in moving water in tides and open ocean currents.

Tidal energy systems can extract either kinetic energy from the moving water of rivers, tides and open ocean currents; or potential energy from the difference in height (or head) between high and low tides. The first method - generating energy from tidal currents - is becoming more popular because people believe that it does not harm the environment as much as barrages or dams. Many coastal sites worldwide are being examined for their suitability to produce tidal (current) energy.

Like other hydroelectricity, tidal power produces no pollution and is a renewable energy source, because tides are caused by events that happen in the solar system and so will not run out. The root source of the energy is the rotation of the Earth. Tidal power has great potential for future power and electricity generation because of the essentially inexhaustible amount of energy contained in these rotational systems. Tidal power is reliably predictable (unlike wind power and solar power). In Europe, tide mills have been used for nearly 1,000 years, mainly for grinding grains. Modern tide mills provide tidal stream power.

Uses of Tidal Energy:

Tidal Electricity – Like other forms of Energy, the main usage of Tidal Energy is in the generation of Electricity. Tidal Energy is being used in France to generate 240 MW of Tidal Electricity at very low costs. There are other smaller plants in operation in Canada, China and Korea as well. DOE has located 40 places in the world where the differences between the low and high tides are big enough to generate commercial levels of Tidal Electricity. Note the Power generated from Tidal Energy is reliable as Tides are uniform and predictable in nature.

Grain Mills – Tidal Energy has been used for hundreds of years. Just like Wind Mills, Tidal Energy was used for the mechanical crushing of grains in Grain Mills. The movement of Turbines due to Tidal Energy was used in the crush Grains. However with the advents of Fossil Fuels, this usage of Tidal Energy has become quite low.

Energy Storage – Tidal Energy can also be used as a store of Energy. Like many of the hydroelectric dams which can be used a large Energy Storage, so Tidal Barrages with their reservoirs can be modified to store energy. Though this has not been tried out, with suitable modifications Tidal Energy can be stored as well though costs may prove to be high.

Provide Protection to Coast in High Storms – Tidal Barrages can prevent Damage to the Coast during High Storms and also provide an easy transport method between the 2 arms of a Bay or an Estuary on which it is built.

Advantages of Tidal Energy

1) It is an inexhaustible source of energy.
2) Tidal energy is environment friendly energy and doesn't produce greenhouse gases.
3) As 71% of Earth’s surface is covered by water, there is scope to generate this energy on large scale.
4) We can predict the rise and fall of tides as they follow cyclic fashion.
5) Efficiency of tidal power is far greater as compared to coal, solar or wind energy. Its efficiency is around 80%.
6) Although cost of construction of tidal power is high but maintenance costs are relatively low.
7) Tidal Energy doesn’t require any kind of fuel to run.
8) The life of tidal energy power plant is very long.
9) The energy density of tidal energy is relatively higher than other renewable energy sources.

Disadvantages of Tidal Energy

1) Cost of construction of tidal power plant is high.
2) There are very few ideal locations for construction of plant and they too are localized to coastal regions only.
3) Intensity of sea waves is unpredictable and there can be damage to power generation units.

4) Influences aquatic life adversely and can disrupt migration of fish.

5) The actual generation is for a short period of time. The tides only happen twice a day so electricity can be produced only for that time.

6) Frozen sea, low or weak tides, straight shorelines, low tidal rise or fall are some of the obstructions.

7) This technology is still not cost effective and more technological advancements are required to make it commercially viable.

8) Usually the places where tidal energy is produced are far away from the places where it is consumed. This transmission is expensive and difficult.

Solar energy:

Solar energy is the energy that is in sunlight. It has been used for thousands of years in many different ways by people all over the world. As well as its traditional human uses in heating, cooking, and drying, it is used today to make electricity where other power supplies are absent, such as in remote places and in space. It is becoming cheaper to make electricity from solar energy and in many situations it is now competitive with energy from coal or oil. A solar cooker can be used for cooking food. Solar energy is also called "Heat Trapper" as it is the automatic, non-mechanical, sun ray trapper. This Sun trapper like devices was used by soldiers during WWII for heat requirements in the army and enemy directions.

Energy use

Solar energy is used today in a number of ways:

As heat for making hot water, heating buildings, and cooking

To generate electricity with solar cells or heat engines

To take the salt away from sea water.

To use sun rays for drying clothes and towels.

Energy from the Sun

After passing through the Earth's atmosphere, most of the Sun's energy is in the form of visible light and infrared light radiation. Plants convert the energy in sunlight into chemical energy (sugars and starches) through the process of photosynthesis. Humans regularly use this store of energy in various ways, as when they burn wood or fossil fuels, or when simply eating plants, fish and animals.

Solar radiation reaches the Earth's upper Earth's atmosphere with the power of 1366 watts per square meter (W/m2). Since the Earth is round, the surface nearer its poles is angled away from the Sun and receives much less solar energy than the surface nearer the equator.

At present, solar cell panels convert, at best, about 15% of sunlight hitting them into electricity. The dark disks in the third diagram on the right are imaginary examples of the amount of land that, if covered with 8% efficient solar panels, would produce slightly more energy in the form of electricity than the world needed in 2003.

Advantages:

- Solar power is pollution free and causes no greenhouse gases to be emitted after installation
- Reduced dependence on foreign oil and fossil fuels
- Renewable clean power that is available every day of the year, even cloudy days produce some power
- Return on investment unlike paying for utility bills
- Virtually no maintenance as solar panels last over 30 years
- Creates jobs by employing solar panel manufacturers, solar installers, etc. and in turn helps the economy
- Excess power can be sold back to the power company if grid interconnected.
- Ability to live grid free if all power generated provides enough for the home / building
- Can be installed virtually anywhere; in a field to on a building
- Use batteries to store extra power for use at night

Disadvantages:

- High initial costs for material and installation and long ROI
- Needs lots of space as efficiency is not 100% yet
- No solar power at night so there is a need for a large battery bank
- Some people think they are ugly (I am definitely not one of those!)
- Devices that run on DC power directly are more expensive
- Depending on geographical location the size of the solar panels vary for the same power generation

- Cloudy days do not produce much energy
- Solar panels are not being massed produced due to lack of material and technology to lower the cost enough to be more affordable
- Solar powered cars do not have the same speeds and power as typical gas powered cars
- Lower production in the winter months

Need of renewable energy:

Renewable energy is reliable and plentiful and will potentially be very cheap once technology and infrastructure improve. It includes solar, wind, geothermal, hydropower and tidal energy, plus biofuels that are grown and harvested without fossil fuels. Non-renewable energy, such as coal and petroleum, require costly explorations and potentially dangerous mining and drilling, and they will become more expensive as supplies dwindle and demand increases. Renewable energy produces only minute levels of carbon emissions and therefore helps combat climate change caused by fossil fuel usage.

Renewable How?

Renewable energy sources are so named because, aside from geothermal and tidal energies, they are replenished constantly by sunlight. Uneven solar heating of the Earth's surface causes wind. Sunlight also fuels the water cycle, which is harnessed through hydropower, including hydroelectric dams and less invasive systems that harness streams or ocean currents. Biofuels are grown using sunlight. Geothermal energy is considered renewable because radioactive decay in the Earth's core, which isn't expected to cool down any time soon, produces it. The gravitational pull of the sun and moon causes the tides.

1. Accessibility:

Coal, natural gas and oil reserves are finite and hidden. An unknown and limited amount of each resource is buried deep underground or under the ocean. As more is harvested, finding new sources becomes more difficult and more expensive, and exploiting them becomes more challenging and sometimes dangerous as well. Marginal reserves, such as oil sands, require the burning of huge amounts of natural gas to refine them into usable oil. Drilling under the ocean floor can lead to catastrophic accidents, such as the British Petroleum oil spill of 2010. Renewable energy, by contrast, is as easy to find as wind or sunlight.

2. Reliability, Stability and Safety:

The daily price of oil depends on many factors, including political stability in historically volatile regions. Political strife has caused energy crises, including those that occurred in 1973 and 1979. Renewable energy can be locally produced and therefore is not vulnerable to distant political upheavals. Many of the safety concerns surrounding fossil fuels, such as explosions on oil platforms and collapsing coal mines do not exist with renewable energy.

3. Pollution:

Renewable energy is far cleaner than fossil fuels. Coal mining and petroleum exploration and refinement produce solid toxic wastes, such as mercury and other heavy metals. The burning of coal to produce electricity uses large quantities of water often discharges arsenic and lead into surface waters and releases carbon dioxide, sulfur dioxide, nitrogen oxides and mercury into the air. Gasoline and other petroleum products cause similar pollution. These pollutants cause respiratory illnesses and death in humans, produce acid rain that damages buildings and destroys fragile ecosystems, and deplete the ozone layer.

4. Climate Change:

Strong consensus in the scientific community states that climate change and global warming are occurring and are caused by human production of carbon dioxide and other greenhouse gases. Climate change may also damage agriculture, because widespread extinctions imperil clean water supplies and aid the spread of tropical diseases.

Importance of renewable energy:

- ❖ No need to burn fossil fuels. As a result of minimal environmental pollution, there will be fewer health complications.
- ❖ It’s greener. Very minimal or no pollution to the environment.
- ❖ Responsible. It preserves the world for future generations.
- ❖ It is reliable for the future. Since the energy resources are renewable, there is energy security.
- ❖ Renewable energy sources are inexhaustible and hence a sustainable source of energy.
- ❖ It tends to be efficient.
- ❖ It can be very cost effective. It may entail a higher initial cost; the running cost is generally cheaper.

- ❖ It reduces climate change. renewable energy emits little to no greenhouse gases.
- ❖ Renewable energy is available all over the world hence fewer energy-related conflicts.
- ❖ Availability of reliable sources of energy spurs economic growth.

Offshore wind energy:

Offshore wind power refers to the construction of wind farms in bodies of water to generate electricity from wind. Unlike the typical usage of the term "offshore" in the marine industry, offshore wind power includes inshore water areas such as lakes, fjords and sheltered coastal areas, utilizing traditional fixed-bottom wind turbine technologies, as well as deeper-water areas utilizing floating wind turbines.

The U.S. National Renewable Energy Laboratory has further defined offshore wind power based on its sitting in terms water depth to include shallow water, transitional water, and deep water offshore wind power.

Common environmental concerns associated with offshore wind developments include:

1. The risk of seabirds being struck by wind turbine blades or being displaced from critical habitats;
2. The underwater noise associated with the installation process of driving monopile turbines into the seabed;
3. The physical presence of offshore wind farms altering the behaviour of marine mammals, fish, and seabirds with attraction or avoidance;
4. The potential disruption of the near field and far field marine environment from large offshore wind projects.

Advantages:

- ❖ Offshore wind speeds tend to be faster than on land. Small increases in wind speed yield large increases in energy production: a turbine in a 15-mph wind can generate twice as much energy as a turbine in a 12-mph wind. Faster wind speeds offshore mean much more energy can be generated.
- ❖ Offshore wind speeds tend to be steadier than on land. A steadier supply of wind means a more reliable source of energy.

❖ Many coastal areas have very high energy needs. 53% of the United States' population lives in coastal areas, with concentrations in major coastal cities. Building offshore wind farms in these areas can help to meet those energy needs from nearby sources.

❖ Offshore wind farms have many of the same advantages as land-based wind farms – they provide renewable energy; they do not consume water; they provide a domestic energy source; they create jobs; and they do not emit environmental pollutants or greenhouse gases.

Disadvantages:

❖ Offshore wind farms can be expensive and difficult to build and maintain. In particular:

❖ It is very hard to build robust and secure wind farms in water deeper than around 200 feet (~60 m), or over half a football field's length. Although coastal waters off the east coast of the U.S. are relatively shallow, almost all of the potential wind energy resources off the west coast are in waters exceeding this depth.

❖ Wave action, and even very high winds, particularly during heavy storms or hurricanes, can damage wind turbines.

❖ The production and installation of power cables under the seafloor to transmit electricity back to land can be very expensive.

❖ Effects of offshore wind farms on marine animals and birds are not fully understood.

Offshore wind farms built within view of the coastline (up to 26 miles offshore, depending on viewing conditions) may be unpopular among local residents, and may affect tourism and property values.

Biomass:

Biomass is organic material that comes from plants and animals, and it is a renewable source of energy.

Biomass contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis. When biomass is burned, the chemical energy in biomass is released as heat. Biomass can be burned directly or converted to liquid biofuels or biogas that can be burned as fuels.

Uses:

❖ wood and wood processing wastes—burned to heat buildings, to produce process heat in industry, and to generate electricity

- agricultural crops and waste materials—burned as a fuel or converted to liquid biofuels
- food, yard, and wood waste in garbage—burned to generate electricity in power plants or converted to biogas in landfills
- animal manure and human sewage—converted to biogas, which can be burned as a fuel

Converting biomass to other forms of energy:

Burning is only one way to release the energy in biomass. Biomass can be converted to other useable forms of energy such as methane gas or transportation fuels such as ethanol and biodiesel.

Methane gas is a component of landfill gas or biogas that forms when garbage, agricultural waste, and human waste decompose in landfills or in special containers called digesters.

Crops such as corn and sugar cane are fermented to produce fuel ethanol for use in vehicles. Biodiesel, another transportation fuel, is produced from vegetable oils and animal fats.

How much biomass is used for fuel?

Biomass fuels provided about 5% of the primary energy used in the United States in 2016. Of that 5%, about 48% was from biofuels (mainly ethanol), 41% was from wood and wood-derived biomass, and about 11% was from the biomass in municipal waste. Researchers are trying to develop ways to use more biomass for fuel.

ADVANTAGES:

1) Biomass used as a fuel reduces need for fossil fuels for the production of heat, steam, and electricity for
residential, industrial and agricultural use.
2) Biomass is always available and can be produced as a renewable resource.
3) Biomass fuel from agriculture wastes maybe a secondary product that adds value to agricultural crop.
4) Growing Biomass crops produce oxygen and use up carbon dioxide.
5) The use of waste materials reduce landfill disposal and makes more space for everything else.
6) Carbon Dioxide which is released when Biomass fuel is burned is taken in by plants.
7) Less money spent on foreign oil.

DISADVANTAGES:

1) Agricultural wastes will not be available if the basic crop is no longer grown.

2) Additional work is needed in areas such as harvesting methods.

3) Land used for energy crops maybe in demand for other purposes, such as faming, conservation, housing, resort or agricultural use.

4) Some Biomass conversion projects are from animal wastes and are relatively small and therefore are limited.

5) Research is needed to reduce the costs of production of Biomass based fuels.

6) Is in some cases is a major cause of pollution.

POSSIBLE QUESTIONS

UNIT-I

PART - A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

PART - B (2 MARKS)

1. Write a note on solar energy?
2. Give some examples for renewable energy?
3. Give the advantage of solar energy?
4. Give the disadvantage of solar energy?
5. Give an importance of Photovoltaics.

PART - C (6 MARKS)

1. Explain that why the solar energy is important for this generation?
2. Write a short note on any four types of solar energy?
3. Explain about solar cells and working of solar cells?
4. Draw the model of photovoltaic system and its equivalent circuits.
5. Describe about solar cooker and solar green house?
6. Describe the characteristics of photovoltaic (PV) system?
7. Explain about photovoltaic effect and working principle?
8. Give an importance of solar energy and Photovoltaic.

KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF PHYSICS
II B.Sc., PHYSICS (2018-2021)
:NEWABLE ENERGY AND ENERGY HARVESTING (16PHU304A)
UNIT - I

QUESTIONS	CHOICE 1	CHOICE 2	CHOICE 3	CHOICE 4
The __________ is the angular distance of the sun's rays north ((	sun's declii	slope	azimuth	altitude
____________ is the angular distance of the location measured ε	latitude	slope	azimuth	longitude
_____________ is the angle through which the earh must turn to	slope	azimuth	hour angle	altitude
The ________ of a point on the surface of the earth is its angular	longitude	latitude	slope	azimuth
________ is an instrument for measuring the intensity of direct sc	pyrheliome	pyranomet	pygeomete	none
______________ is an instrument for measurement of the solar r	pyrheliome	pyranomet	pygeomete	anemomete
In sunshine recorder with an sun radiation intensity is more than _	400	1000	200	100
The sun's declination varies from ________° to ________°	23.5 to -25	23.5 to -23	25 to -25	50 to -50
__________ is a vertical angle between the projection of sun's ra	azimuth	zenith	altitude	slope
________ is complimentary angle of sun's altitude angle	zenith	slope	latitude	longitude
____________ is the solar angle in degrees along the horizon ea	solar altituc	solar zenith	solar azimu	latitude
__________ is the angle being measured between the beam of ra	slope	latitude	azimuth	incident an
__________ is the angle between the horizontal and the plane	surface azi	solar azimu	slope	none
__________ is a function of latitude and solar declination	length of a	altitude	slope	azimuth
At solar noon hour angle is ___________°	180	90	0	360
Each hour equates _______° of longitude with morning positive	30	15	45	60
________ is the angle of deviation of the normal to the surface fr	solar azimu	altitude	zenith	surface azi
The sun's declination is ___________° at equinoxes	23.5	-23.5	0	15
Equinox means __________	equal days	equal night	equal days	unequal da
One hour is equivalent to _________	0.262 rad	0.75 rad	0.65 rad	0.50 rad
___________ is an imaginary great circle normal to the earth's ax	angular dis	earth's equ	northern he	southern he
_____________ are the ends of the axis of rotation of the earth w	equator	continuty	poles of the	Artic region
The difference between local solar time and local civil time is ___	,eridian tim	Greenwich	equation of	Local solar
The value of solar constant is _________W/m2	1300	1600	1360	1353
The mean distance between the sun and the earth is _________	2 x 10^8 Kı	1.5 x 10^8	1.6 x 10^8	1.8 x 10^10
_________ expresses the time of a day wih respect to solar noon	hour angle	slope angle	azimuth	zenith
__________ is taken as reference for the time	Greenwich	prime meri	Scotland ol	Secondary
The solar radiation intensity varies ____ as the square of the dista	inversely	directly	proportiona	neither inve
The portion of incident solar radiation which comes directly from t	diffused rac	scattered ra	total global	direct radia
The scattered radiation which reaches the observer from various	diffused rac	global radia	direct radia	scattered ra
The position of the sun directly over head is called_____	slope	zenith	azimuth	hour angle
As the solar radiation passes through the earth's atmosphere, the	IR rays	X-rays	Gamma ray	UV rays
The sky which is conviniently assumed as a large sphere is called	visible sphe	celestial sp	extra-terres	terrestrial s
The _________ divides the earth into two hemisphere	latitude	longitude	sun's declii	equator
Greenwich meridian has ________° longitude	0	90	180	45
Time measured by the apparent diurnal motion of the sun is calle	local time	astronomic	solar time	local civil tir
At a given locality watch time may differ from ________	solar time	local time	civil time	Greenwich
LST = LCT + ______________________________	equation of	astronomic	watch time	Greenwich
At the time of sunrise (or sunset) zenith angle = ___________°	180	270	90	0
________ can be used as a source of average radiation if data ar	maps	atlas	tables	none

	ANSWER
	sun's declination
	longitude
	hour angle
	azimuth
	pyrheliometer
er	pyranometer
	200
	23.5 to -23.5
	altitude
	zenith
	solar azimuth angle
gle	incident angle
	slope
	length of a day
	0
	15
muth	surface azimuth
	0
ys and nights	equal nights
	0.262 rad
emispher	earth's equator
	poles of the earth
time	equation of time
	1353
) kn	1.5 x 10^8 km
	hour angle
meridian	Greenwich meridian
esely nor directly	inversely
tion	direct radiation
adiation	diffused radiation
	zenith
	UV rays
phere	celestial sphere
	equator
	0
me	solar time
meridian time	civil time
time	equation of time
	90
	maps

UNIT- II

SYLLABUS

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

Sun Tracking Solar Panel Principle:

The Sun tracking solar panel consists of two LDRs, solar panel and stepper motor and ATMEGA8 Micro controller.

Two light dependent resistors are arranged on the edges of the solar panel. Light dependent resistors produce low resistance when light falls on them. The stepper motor connected to the panel rotates the panel in the direction of Sun. Panel is arranged in such a way that light on two LDRs is compared and panel is rotated towards LDR which have high intensity i.e. low resistance compared to other. Stepper motor rotates the panel at certain angle.

How Sun Tracking Solar Panel Works?

- Initially power the circuit.
- Place the set up in dark
- When the two LDRs are in dark, there is no movement in the panel.
- Now place a torch in front of the left LDR. Panels slowly move towards its left.
- Now move light from left to right. You can observe the panel moving slowly with the torch towards right.
- In the middle, when intensity on both LDRs is equal, panel will not move until there is difference between the light intensity falling on the LDRs.

Advantages of Sun Tracking Solar Panel:

- The solar energy can be reused as it is non renewable resource.
- This also saves money as there is no need to pay for energy used.
- Sun Tracking Solar Panel Applications:

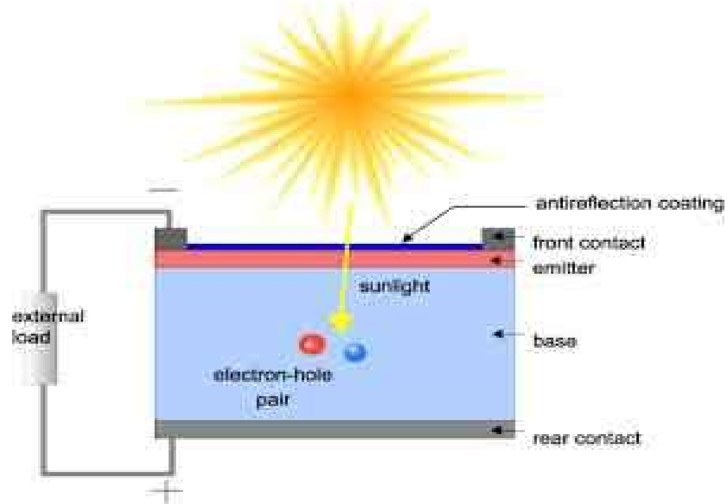
- These panels can be used to power the traffic lights and streetlights
- These can be used in home to power the appliances using solar power.
- These can be used in industries as more energy can be saved by rotating the panel.
- Limitations of Sun Tracking Solar Panel Circuit:
- Though solar energy can be utilized to maximum extent this may create problems in rainy season.
- Although solar energy can be saved to batteries, they are heavy and occupy more space and required to change time to time.
- They are expensive.

Solar cell :

A solar cell or photovoltaic cell is a device that converts light energy into electrical energy. Sometimes the term solar cell is reserved for devices intended specifically to capture energy from sunlight, while the term photovoltaic cell is used when the light source is unspecified. The device needs to fulfill only two functions: photogeneration of charge carriers (electrons and electron holes) in a light-absorbing material, and separation of the charge carriers to conductive contact that will transmit the electricity. This conversion is called the photovoltaic effect, and the field related to solar cells is known as photovoltaics.

Solar Cell Structure :

A solar cell is an electronic device which directly converts sunlight into electricity. Light shining on the solar cell produces both a current and a voltage to generate electric power. This process requires firstly, a material in which the absorption of light raises an electron to a higher energy state, and secondly, the movement of this higher energy electron from the solar cell into an external circuit. The electron then dissipates its energy in the external circuit and returns to the solar cell. A variety of materials and processes can potentially satisfy the requirements for photovoltaic energy conversion, but in practice nearly all photovoltaic energy conversion uses semiconductor materials in the form of a p-n junction.



The basic steps in the operation of a solar cell are:

- The generation of light-generated carriers;
- The collection of the light-generated carries to generate a current;
- The generation of a large voltage across the solar cell; and
- The dissipation of power in the load and in parasitic resistances.

Advantages of Using Solar Cells :

- It is present in abundance
- They have no moving parts and hence require little maintenance and work quite satisfactorily without any focusing device
- It does not cause any environmental pollution like the fossil fuels and nuclear power
- Solar cells last a longer time and have low running costs

Disadvantages :

- The entire process of manufacture is still very expensive as silver is used for interconnection of these cells in the panel, which is a very expensive metal.
- Silver is the best conductor of electricity having very low resistance and it increases its efficiency.
- A practical problem linked with the use of solar cell panels is regarding the storage of electricity general by them. The electricity generated by the solar cell panel is stored during the day with the help of storage batteries which give us only direct current. But to operate our

devices we need alternating current. Therefore we need to convert DC to AC before using any appliance and thus it increases the cost of such solar panels as the sources of electricity.

Uses of Solar Cells :

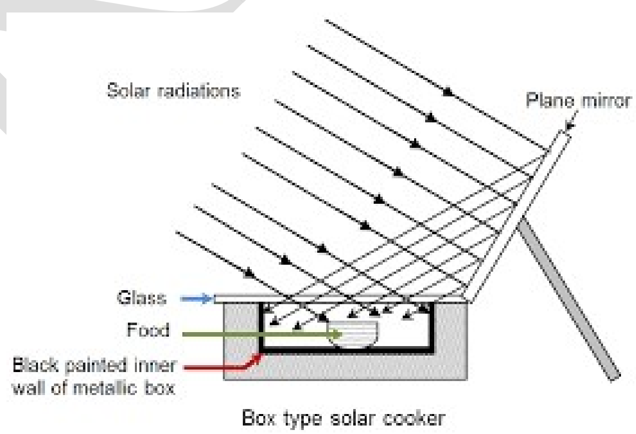
- Artificial satellites and in space probes like Mars orbiters
- Wireless transmission systems or TV relay stations in remote locations
- Traffic signals, calculators and in toys

solar cooker :

A solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurize drink. Many solar cookers currently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves, and advanced, large-scale solar cookers can cook for hundreds of people. Because they use no fuel and cost nothing to operate, many nonprofit organizations are promoting their use worldwide in order to help reduce fuel costs (especially where monetary reciprocity is low) and air pollution, and to slow down the deforestation and desertification caused by gathering firewood for cooking. Solar cooking is a form of outdoor cooking and is often used in situations where minimal fuel consumption is important, or the danger of accidental fires is high, and the health and environmental consequences of alternatives are severe.

Many types of solar cookers exist, including curved concentrator solar cookers, solar ovens, and panel cookers, among others.

Principles :



1) Concentrating sunlight: A mirrored surface with high specular reflectivity is used to concentrate light from the sun on to a small cooking area. Depending on the geometry of the surface, sunlight can be concentrated by several orders of magnitude producing temperatures high enough to melt salt and smelt metal. For most household solar cooking applications, such high temperatures are not really required. Solar cooking products, thus, are typically designed to achieve temperatures of 150 °F (65 °C) (baking temperatures) to 750 °F (400 °C) (grilling/searing temperatures) on a sunny day.
2) Converting light energy to heat energy: Solar cookers concentrate sunlight onto a receiver such as a cooking pan. The interaction between the light energy and the receiver material converts light to heat. This conversion is maximized by using materials that conduct and retain heat. Pots and pans used on solar cookers should be matte black in color to maximize the absorption.
3) Trapping heat energy: It is important to reduce convection by isolating the air inside the cooker from the air outside the cooker. Simply using a glass lid on your pot enhances light absorption from the top of the pan and provides a greenhouse effect that improves heat retention and minimizes convection loss. This "glazing" transmits incoming visible sunlight but is opaque to escaping infrared thermal radiation. In resource constrained settings, a high-temperature plastic bag can serve a similar function, trapping air inside and making it possible to reach temperatures on cold and windy days similar to those possible on hot days.
4) Black Colour absorb more heat
5) Glass sheet trap heat inside the cooker because glass sheet doesn't allow heat to go back.

Advantages :

- High-performance parabolic solar cookers can attain temperatures above 290 °C (550 °F). They can be used to grill meats, stir-fry vegetables, make soup, bake bread, and boil water in minutes.
- Conventional solar box cookers attain temperatures up to 165 °C (325 °F). They can sterilize water or prepare most foods that can be made in a conventional oven or stove, including bread, vegetables and meat over a period of hours.

- Solar cookers use no fuel. This saves cost as well as reducing environmental damage caused by fuel use. Since 2.5 billion people cook on open fires using biomass fuels, solar cookers could have large economic and environmental benefits by reducing deforestation.
- When solar cookers are used outside, they do not contribute inside heat, potentially saving fuel costs for cooling as well. Any type of cooking may evaporate grease, oil, and other material into the air; hence there may be less cleanup.

Disadvantages :

- Solar cookers are less useful in cloudy weather and near the poles (where the sun is low in the sky or below the horizon), so an alternative cooking source is still required in these conditions. Solar cooking advocates suggest three devices for an integrated cooking solution: a) a solar cooker; b) a fuel-efficient cook stove; c) an insulated storage container such as a basket filled with straw to store heated food. Very hot food may continue to cook for hours in a well-insulated container. With this three-part solution, fuel use is minimized while still providing hot meals at any hour, reliably.
- Some solar cookers, especially solar ovens, take longer to cook food than a conventional stove or oven. Using solar cookers may require food preparation start hours before the meal. However, it requires less hands-on time during the cooking, so this is often considered a reasonable trade-off.
- Cooks may need to learn special cooking techniques to fry common foods, such as fried eggs or flatbreads like chapattis and tortillas. It may not be possible to safely or completely cook some thick foods, such as large roasts, loaves of bread, or pots of soup, particularly in small panel cookers; the cook may need to divide these into smaller portions before cooking.
- Some solar cooker designs are affected by strong winds, which can slow the cooking process, cool the food due to convective losses, and disturb the reflector. It may be necessary to anchor the reflector, such as with string and weighted objects like bricks.

Solar water heater:

Solar water heating (SWH) is the conversion of sunlight into heat for water heating using a solar thermal collector. A variety of configurations are available at varying cost to provide solutions in different climates and latitudes. SWHs are widely used for residential and some industrial applications.

A sun-facing collector heats a working fluid that passes into a storage system for later use. SWH are active (pumped) and passive (convection-driven). They use water only, or both water and a working fluid. They are heated directly or via light-concentrating mirrors. They operate independently or as hybrids with electric or gas heaters. In large-scale installations, mirrors may concentrate sunlight onto a smaller collector.

The global solar thermal market is dominated by China, Europe, Japan and India, although Israel was one of the first countries to mandate installation of SWH in 1980, leading to a flourishing industry.

Solar water heaters -- also called solar domestic hot water systems -- can be a cost-effective way to generate hot water for your home. They can be used in any climate, and the fuel they use -- sunshine -- is free.

Working :

Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive, which don't.

Active Solar Water Heating Systems

There are two types of active solar water heating systems:

Direct circulation systems

Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.

Indirect circulation systems

Pumps circulate a non-freezing, heat-transfer fluid through the collectors and a heat exchanger. This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.

Illustration of an active, closed loop solar water heater. A large, flat panel called a flat plate collector is connected to a tank called a solar storage/backup water heater by two pipes. One of these pipes is runs through a cylindrical pump into the bottom of the tank, where it becomes a coil called a double-wall heat exchanger. This coil runs up through the tank and out again to the flat plate collector. Antifreeze fluid runs only through this collector loop. Two pipes run out the top of the water heater tank; one is a cold water supply into the tank, and the other sends hot water to the house.

Passive Solar Water Heating Systems

Passive solar water heating systems are typically less expensive than active systems, but they're usually not as efficient. However, passive systems can be more reliable and may last longer. There are two basic types of passive systems

Integral collector-storage passive systems

These work best in areas where temperatures rarely fall below freezing. They also work well in households with significant daytime and evening hot-water needs.

Thermo siphon systems

Water flows through the system when warm water rises as cooler water sinks. The collector must be installed below the storage tank so that warm water will rise into the tank. These systems are reliable, but contractors must pay careful attention to the roof design because of the heavy storage tank. They are usually more expensive than integral collector-storage passive systems.

Illustration of a passive, batch solar water heater. Cold water enters a pipe and can either enter a solar storage/backup water heater tank or the batch collector, depending on which bypass valve is opened. If the valve to the batch collector is open, a vertical pipe (which also has a spigot drain valve for cold climates) carries the water up into the batch collector. The batch collector is a large box holding a tank and covered with a glaze that faces the sun. Water is heated in this tank, and another pipe takes the heated water from the batch collector into the solar storage/backup water heater, where it is then carried to the house.

Storage Tanks and Solar Collectors

Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

Three types of solar collectors are used for residential applications:

Flat-plate collector

Glazed flat-plate collectors are insulated, weatherproofed boxes that contain a dark absorber plate under one or more glass or plastic (polymer) covers. Unglazed flat-plate collectors -- typically used for solar pool heating -- have a dark absorber plate, made of metal or polymer, without a cover or enclosure.

Integral collector-storage systems

Also known as ICS or batch systems, they feature one or more black tanks or tubes in an insulated, glazed box. Cold water first passes through the solar collector, which preheats the water. The water then continues on to the conventional backup water heater, providing a reliable source of hot water. They should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather.

Evacuated-tube solar collectors

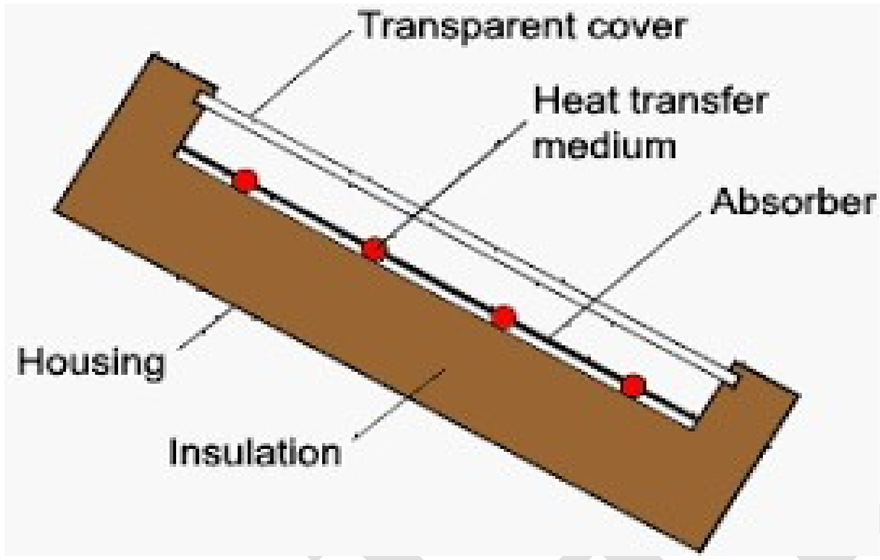
They feature parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but inhibits radiative heat loss. These collectors are used more frequently for U.S. commercial applications.

Solar water heating systems almost always require a backup system for cloudy days and times of increased demand. Conventional storage water heaters usually provide backup and may already be part of the solar system package. A backup system may also be part of the solar collector, such as rooftop tanks with thermosyphon systems. Since an integral-collector storage system already stores hot water in addition to collecting solar heat, it may be packaged with a tankless or demand-type water heater for backup.

Flat plate collector :

A typical flat-plate collector is a metal box with a glass or plastic cover (called glazing) on top and a dark-colored absorber plate on the bottom. The sides and bottom of the collector are usually insulated to minimize heat loss.

Sunlight passes through the glazing and strikes the absorber plate, which heats up, changing solar energy into heat energy. The heat is transferred to liquid passing through pipes attached to the absorber plate. Absorber plates are commonly painted with "selective coatings," which absorb and retain heat better than ordinary black paint. Absorber plates are usually made of metal—typically copper or aluminum—because the metal is a good heat conductor. Copper is more expensive, but is a better conductor and less prone to corrosion than aluminum. In locations with average available solar energy, flat plate collectors are sized approximately one-half- to one-square foot per gallon of one-day's hot water use.



Principle of Flat Plate Collector :

The principal behind a flat collector is simple. If a metal sheet is exposed to solar radiation, the temperature will rise until the rate at which energy is received is equal to the rate at which heat is lost from the plate; this temperature is termed as the 'equilibrium' temperature. If the back of the plate is protected by a heat insulting material, and the exposed surface of the plate is painted black and is coved by one or two glass sheets, then the equilibrium temperature will be much higher than that for the simple exposed sheet. This plate may be covered into a heat collector by adding a water circulating system, either by making it hollow or by soldering metal pipes to the surface, and transferring the heated liquid to a tank for storage. For heat with withdrawal from the system the equilibrium temperature must decrease, since no useful heat can be extracted at he maximum equilibrium temperature at which the collection efficiency is zero. The other extreme condition is when the flow of liquid is so flat that the temperature rise is very small; in such a case although the losses are small and the efficiency of the heat collection approaches 100 percent, yet no useful heat can be extracted. The optimum is approximately midway between the equilibrium temperature, whereby an output of hot liquid at a useful temperature is obtained.

Applications: The main use of this technology is in residential buildings where the demand for hot water has a large impact on energy bills. This generally means a situation with a large family, or a situation in which the hot water demand is excessive due to frequent laundry washing.

Commercial applications include laundromats, car washes, military laundry facilities and eating establishments. The technology can also be used for space heating if the building is located off-grid or if utility power is subject to frequent outages. Solar water heating systems are most likely to be cost effective for facilities with water heating systems that are expensive to operate, or with operations such as laundries or kitchens that require large quantities of hot water.

Unglazed liquid collectors are commonly used to heat water for swimming pools. Because these collectors need not withstand high temperatures, they can use less expensive materials such as plastic or rubber. They also do not require freeze-proofing because swimming pools are generally used only in warm weather or can be drained easily during cold weather.

While solar collectors are most cost-effective in sunny, temperate areas, they can be cost effective virtually anywhere in the country so should be considered.

Some advantages of the flat-plate collectors is that they are:

- Easy to manufacture
- Low cost
- Collect both beam and diffuse radiation
- Permanently fixed (no sophisticated positioning or tracking equipment is required)
- Little maintenance.

Applications of solar energy :

1. Concentrating Solar Power (CSP): Concentrating solar power (CSP) plants are utility-scale generators that produce electricity using mirrors or lenses to efficiently concentrate the sun's energy. The four principal CSP technologies are parabolic troughs, dish-Stirling engine systems, central receivers, and concentrating photovoltaic systems (CPV).

2. Solar Thermal Electric Power Plants: Solar thermal energy involves harnessing solar power for practical applications from solar heating to electrical power generation. Solar thermal collectors, such as solar hot water panels, are commonly used to generate solar hot water for

domestic and light industrial applications. This energy system is also used in architecture and building design to control heating and ventilation in both active solar and passive solar designs.

3. Photovoltaics: Photovoltaic or PV technology employs solar cells or solar photovoltaic arrays to convert energy from the sun into electricity. Solar cells produce direct current electricity from the sun's rays, which can be used to power equipment or to recharge batteries. Many pocket calculators incorporate a single solar cell, but for larger applications, cells are generally grouped together to form PV modules that are in turn arranged in solar arrays. Solar arrays can be used to power orbiting satellites and other spacecraft and in remote areas as a source of power for roadside emergency telephones, remote sensing, and cathodic protection of pipelines.

4. Solar Heating Systems: Solar hot water systems use sunlight to heat water. The systems are composed of solar thermal collectors and a storage tank, and they may be active, passive or batch systems.

5. Passive Solar Energy: It concerns building design to maintain its environment at a comfortable temperature through the sun's daily and annual cycles. It can be done by (1) Direct gain or the positioning of windows, skylights, and shutters to control the amount of direct solar radiation reaching the interior and warming the air and surfaces within a building; (2) Indirect gain in which solar radiation is captured by a part of the building envelope and then transmitted indirectly to the building through conduction and convection; and (3) Isolated gain which involves passively capturing solar heat and then moving it passively into or out of the building via a liquid or air directly or using a thermal store. Sunspaces, greenhouses, and solar closets are alternative ways of capturing isolated heat gain from which warmed air can be taken.

6. Solar Lighting: Also known as day lighting, this is the use of natural light to provide illumination to offset energy use in electric lighting systems and reduce the cooling load on HVAC systems. Day lighting features include building orientation, window orientation, exterior shading, saw tooth roofs, clerestory windows, light shelves, skylights, and light tubes. Architectural trends increasingly recognize day lighting as a cornerstone of sustainable design.

7. Solar Cars: A solar car is an electric vehicle powered by energy obtained from solar panels on the surface of the car which convert the sun's energy directly into electrical energy. Solar cars are not currently a practical form of transportation. Although they can operate for limited

distances without sun, the solar cells are generally very fragile. Development teams have focused their efforts on optimizing the efficiency of the vehicle, but many have only enough room for one or two people.

8. Solar Power Satellite: A solar power satellite (SPS) is a proposed satellite built in high Earth orbit that uses microwave power transmission to beam solar power to a very large antenna on Earth where it can be used in place of conventional power sources. The advantage of placing the solar collectors in space is the unobstructed view of the sun, unaffected by the day/night cycle, weather, or seasons. However, the costs of construction are very high, and SPSs will not be able to compete with conventional sources unless low launch costs can be achieved or unless a space-based manufacturing industry develops and they can be built in orbit from off-earth materials.

9. Solar Updraft Tower: A solar updraft tower is a proposed type of renewable-energy power plant. Air is heated in a very large circular greenhouse-like structure, and the resulting convection causes the air to rise and escape through a tall tower. The moving air drives turbines, which produce electricity. There are no solar updraft towers in operation at present. A research prototype operated in Spain in the 1980s, and EnviroMission is proposing to construct a full-scale power station using this technology in Australia.

10. Renewable Solar Power Systems with Regenerative Fuel Cell Systems: NASA has long recognized the unique advantages of regenerative fuel cell (RFC) systems to provide energy storage for solar power systems in space. RFC systems are uniquely qualified to provide the necessary energy storage for solar surface power systems on the moon or Mars during long periods of darkness, i.e. during the 14-day lunar night or the12-hour Martian night. The nature of the RFC and its inherent design flexibility enables it to effectively meet the requirements of space missions. And in the course of implementing the NASA RFC Program, researchers recognized that there are numerous applications in government, industry, transportation, and the military for RFC systems as well.

Storage of solar energy :

One of the drawbacks of solar energy systems is that the Sun doesn't provide a constant stream of energy.

On cloudy days or at night, the amount of energy your system receives is reduced or eliminated altogether. This in turn impacts the amount of electricity or heat that your system produces during those times.

To overcome this drawback, homeowners can take advantage of several methods available to them for storing solar energy. The methods available differ depending on whether you are using solar electricity applications or solar heating applications.

Solar Electricity Storage

Homeowners are able to generate solar electricity by using a photovoltaic solar power system. There are two primary methods of Energy Storage with a PV solar power system.

1. Battery Banks
2. Grid Inter-Tie

One way solar power storage can be accomplished is by using a battery bank to store the electricity generated by the PV solar power system. A battery solar power storage system is used in a grid-tied PV system with battery backup and stand-alone PV systems.

The major components of a battery solar power system are

Charge Controller: Prevents the battery bank from overcharging by interrupting the flow of electricity from the PV panels when the battery bank is full

Battery Bank: A group of batteries wired together. The batteries are similar to car batteries, but designed specifically to endure the type of charging and discharging they'll need to handle in a solar power system.

System Meter: Measures and displays your solar PV systems performance and status.

Main DC Disconnect: A DC rated breaker between the batteries and the inverter. Allows the inverter to be quickly disconnected from the battery bank for service.

The third type of PV solar power system is a grid-tied PV system. This system can actually use the grid as its solar energy storage system. This is done using net-metering.

With net-metering, when you produce excess solar electricity, you send it to the grid and your electric meter rolls backwards. Later on, at night for example, when your system is not producing electricity, you can pull electricity from the grid and your electric meter will roll forward. You are essentially using the grid to store your solar electricity.

Solar Thermal Storage :

There are three solar heating applications...

1. Solar Space Heating
2. Solar Water Heating
3. Solar Pool Heating

Each of these solar heating applications uses their own methods for Solar Thermal Energy Storage.

Thermal mass and water tanks are the two primary methods of storing solar energy in solar space heating systems.

Thermal Mass: Used in both passive and active space heating systems. Absorbs heat during the day and slowly releases it at night.

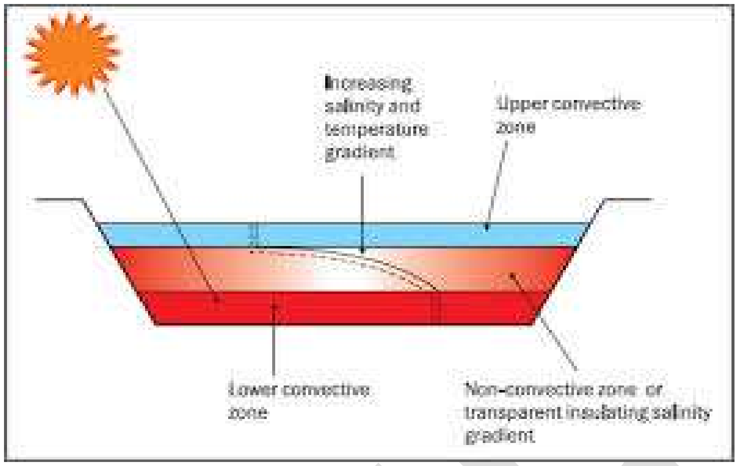
Water Tanks: Used in active liquid systems. A heat-exchanger transfers the heat from the heat-transfer fluid to the water in the tank.

Solar water heating systems use water tanks for the storage of solar energy. Both passive and active solar water heating use water tanks. Active indirect systems use a heat-exchanger to transfer the heat from the heat-transfer fluid. The other solar water heating systems use the actual household water and therefore do not need water tank with a heat-exchanger.

Solar pool heating uses the swimming pool water for solar energy storage. By circulating your swimming pool water through solar pool collectors, you will be able to extend your swimming season.

Solar pond :

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.



Advantages and disadvantages

- The approach is particularly attractive for rural areas in developing countries. Very large area collectors can be set up for just the cost of the clay or plastic pond liner.
- The accumulating salt crystals have to be removed and can be both a valuable by-product and a maintenance expense.
- No need for a separate collector for this thermal storage system.
- The extremely large thermal mass means power is generated night and day.
- Relatively low-temperature operation means solar energy conversion is typically less than 2%.
- Due to evaporation non-saline water is constantly required to maintain salinity gradients.

Applications of solar ponds :

1. Heating and Cooling of Buildings:

Because of the large heat storage capability in the lower convection zone of the solar pond, it has ideal use for heating even at high latitude stations and for several cloudy days. Many scientists have attempted and sized the solar pond for a particular required heating load for house heating. Calculations have shown that a solar pond with a 100m diameter and 1m deep lower convection zone is sufficient to drive either an absorption system or chillier capable of meeting 100 percent of typical cooling load of a 50 house community in Forthworth (USA).

2. Production of Power:

A solar pond can be used to generate electricity by driving a thermo-electric device or an organic Rankine cycle engine - a turbine powered by evaporating an organic fluid with great promise in those areas where there is sufficient insolation and terrain, and soil conditions allow for construction and operation of large area solar ponds necessary to generate meaningful quantities of electrical energy. Even low temperatures heat that is obtained from solar pond can be converted into electric power. The conversion efficiency is limited due to its low operating temperatures (70-100ºC). Because of low temperature, the Solar pond power plant (SPPP) requires organic fluid which have low boiling points such as halo-carbons (like Freons) or hydrocarbons (such as propane).

3. Industrial Process Heat:

Industrial process heat is the thermal energy used directly in the preparation and of treatment of materials and goods manufactured by industry. Several scientists have determined the economics of solar pond for supply of process heat in industries. According to them the solar pond can play a significant role supplying the process heat to industries thereby saving oil, natural gas, electricity, and coal. From the calculations it was concluded that for crop drying and for a paper industry, for which economics have been determined, the heat from solar pond is highly competitive with oils and natural gas.

4. Desalination:

The low cost thermal energy can used to desalt or otherwise purify water for drinking or irrigation.

Multi-flash desalination units along with a solar pond is an attractive proposition for getting distilled water because the multi-flash desalination plant below 100ºC which can well be achieved by a solar pond. This system will be suitable at places where portable water is in short supply and brackish water is available. It has been estimated that about 4700 m^3/day distilled water can be obtained from a pond of 0.31km^2 area with a multi-effort distillation unit. The cost of distilled water appears to be high for industrialized countries but can be used in developing countries where there is a shortage of potable water. Moreover this type of desalination plant produces five times more distilled water than the conventional basin type solar still.

5. Heating animal housing and drying crops on farms:

Low grade heat can be used in many ways on farms, which have enough land for solar ponds. Several small demonstration ponds in Ohio, Iowa and Illinois have been used to heat green houses and hog barns.

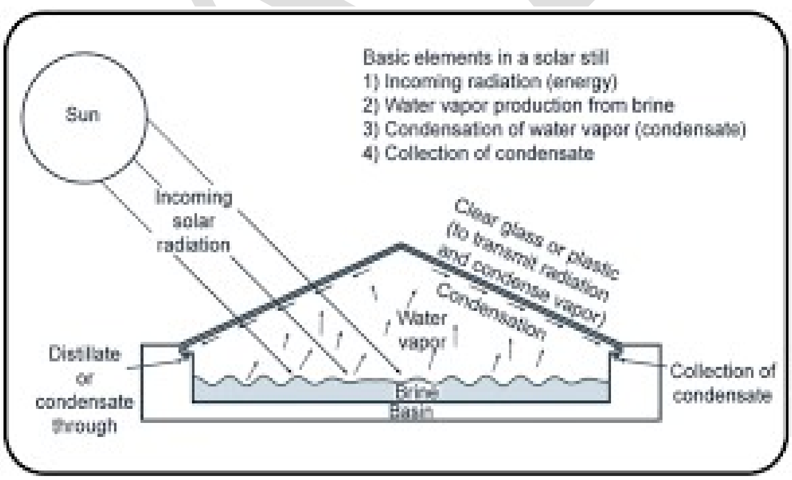
6. Heat for biomass conversion:

Site built solar could provide heat to convert biomass to alcohol or methane. While no solar ponds have been used for this purpose, it is an ideal coupling of two renewable-energy technologies.

Solar desalination :

Solar desalination is a technique to desalinate water using solar energy. There are two basic methods of achieving desalination using this technique; direct and indirect.

There are two primary means of achieving desalination using solar energy, through a phase change by thermal input, or in a single phase through mechanical separation. Phase change (or multi-phase) can be accomplished by either direct or indirect solar distillation. Single phase is predominantly accomplished by the use of photovoltaic cells to produce electricity to drive pumps although there are experimental methods being researched using solar thermal collection to provide this mechanical energy.



How Solar Water Distillation Works

Distillation of water with solar energy is quite simple. Think about how nature creates rain: The Sun heats and evaporates water, which at the same time is separated from salt, dirt or anything else for that matter. When the temperature and pressure is right, the water molecules reforms and returns to liquid. Regardless of where in the World you are located, if you catch rain before it hits the ground, it is considered safe to drink.

Devices that are built around the concept of solar distillation all mimic the natural process of rain formation and can be described in two simple steps:

1. Evaporation to remove impurities.
2. Condensation to collect the water.

Different Still Designs

1. Single-Basin Solar Stills

A basin is covered by sloped glass or plastic where the evaporated water is condensed and lead into a rainwater channel. The darker the color of the basin, the more sunlight is turned into heat.

The clean water output is higher in the evening due to greater temperature differences between warm water on the inside of the device and the outside ambient air.

A stationary installation should be made out a glass basin to ensure longevity, but plastic would be better for a portable solar still.

2. Emergency Stills

An emergency solar distillation is essentially the same thing as the single-basin still described above except it is simpler.

A mixing bowl can be used as the basin and plastic foil is put on top. A rubber holds the two together. Then a small stone is placed in the middle on top of the plastic foil and a cone shape forms. A cup and saltwater can be placed in the mixing bowl you have an emergency still. In case you don’t have a mixing bowl you can dig a pit to use as your basin.

Multi-Stage Flash Distillation (MSF)

This is where it gets a little bit more advanced. Multi-stage flash distillation (as well as multiple-effect distillation below) is used in larger scales where distillation plants are made to supply clean water for hundreds if not thousands of people.

Multi-stage flash distillation is used to distill seawater by flashing water (lowering pressure to induce vaporization) in several stages. Distillation plants using multi-stage flash supplies 85% of all desalinated water worldwide.

Multiple-Effect Distillation (MED)

Another big one, as with multi-stage flash distillation above, multiple-effect distillation also consists of several stages (effects). Seawater is heated by steam in tubes, leading to partial evaporation and more steam in the next stage. The process is repeated several times. Every stage reuses some of the energy from the previous stages.

Important of photovoltaic :

PV-generated power offers advantages over diesel generators, primary (one-time use) batteries, and even conventional utility power. These benefits make PV the power of choice in more and more cases every day:

1. High Reliability
2. Low Operating Costs
3. Environmental Benefits
4. Modularity
5. Low Construction Costs

1. High Reliability

PV cells were originally developed for use in space, where repair is extremely expensive, if not impossible. PV still powers nearly every satellite circling the earth because it operates reliably for long periods of time with virtually no maintenance.

2. Low Operating Costs

PV cells use the energy from sunlight to produce electricity-the fuel is free. With no moving parts, the cells require little upkeep. This low-maintenance, cost-effective PV systems are ideal for supplying power to communications stations on mountain tops, navigational buoys at sea, or homes far from utility power lines.

3. Environmental Benefits

Because they burn no fuel and have no moving parts, PV systems are clean and silent. This is especially important where the main alternatives for obtaining power and light are from diesel generators and kerosene lanterns. As we become more aware of "greenhouse gases" and their detrimental effects on our planet, clean energy alternatives like PV become more important than ever.

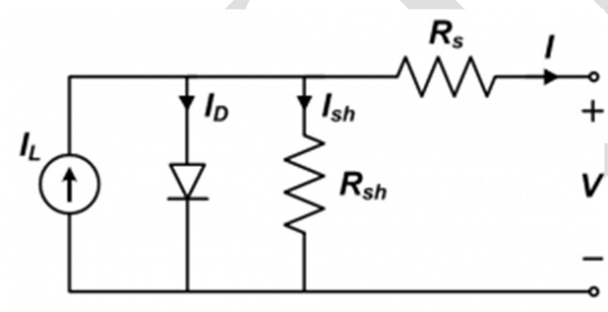
4. Modularity

A PV system can be constructed to any size based on energy requirements. Furthermore, the owner of a PV system can enlarge or move it if his or her energy needs change. For instance, homeowners can add modules every few years as their energy usage and financial resources grow. Ranchers can use mobile trailer-mounted pumping systems to water cattle as the cattle are rotated to different fields.

5. Low Construction Costs

PV systems are usually placed close to where the electricity is used, requiring much shorter power lines than if power is brought in from the utility grid. In addition, using PV eliminates the need for a step-down transformer from the utility line. Less wiring means lower costs, shorter construction time, and reduced permitting paperwork, particularly in urban areas.

Equivalent circuit of photovoltaic :



Equivalent circuit models define the entire I-V curve of a cell, module, or array as a continuous function for a given set of operating conditions. One basic equivalent circuit model in common use is the single diode model, which is derived from physical principles (e.g., Gray, 2011) and represented by the following circuit for a single solar cell:

The governing equation for this equivalent circuit is formulated using Kirchhoff's current law for current I:

$$I = I_L - I_D - I_{sh}$$

Here I_L presents the light-generated current in the cell I_D V represents the voltage-dependent current lost to recombination, and I_{sh} represents the current lost due to shunt resistances. In this single diode model, I_D is modeled using the Shockley equation for an ideal diode:

$$I_D = I_0 \left[\exp\left(\frac{V + IR_s}{nV_T} \right) - 1 \right]$$

where n is the diode ideality factor (unitless, usually between 1 and 2 for a single junction cell), I is the I_O saturation current, and V_T is the thermal voltage given by:

$$V_T = K\,T_C \,/\, q$$

where k is Boltzmann's constant (1.381×10^{-23} J/K) and q is the elementary charge (1.602×10^{-19} C).

Writing the shunt current as $I_{sh} = (V + I R_S) / R_{sh}$ and combining this and the above equations results in the complete governing equation for the single diode model:

$$I_M = I_L - I_0 \left[\exp\left(\frac{V_M + I_M N_s R_s}{n N_s V_T}\right)\right.$$

The five parameters in this equation are primary to all single diode equivalent circuit models:

I_L : light current (A)

I_O : diode reverse saturation current (A)

R_S : series resistance (Ω)

R_{sh} : shunt resistance (Ω)

n : diode ideality factor (unitless)

For a photovoltaic module or array comprising N_S cells in series, and assuming all cells are identical and under uniform and equal irradiance and temperature (i.e., generate equal current and voltage)

$I_{module} = I_{cell}$ and $V_{module} = N_S \times V_{cell}$

The single diode equation for a module or array becomes :

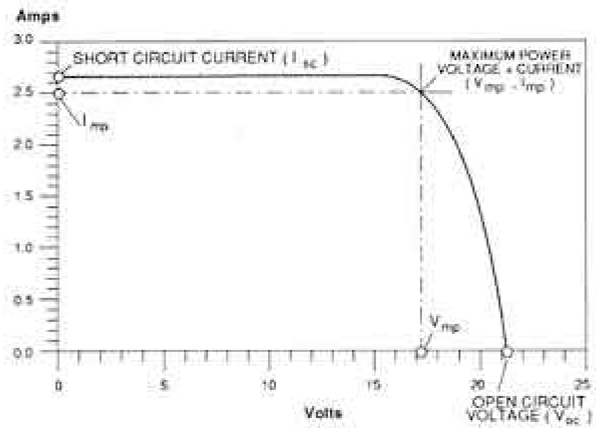
$$I = I_L - I_0 \left[\exp\left(\frac{V + I R_s}{n V_T}\right) - 1\right]$$

Where I_M and are V_M the current and voltage, respectively, of the module or array. Care should be taken when implementing model parameters, as they are either applicable to a cell, module, or array. Parameters for modules or arrays are strictly used with the single diode equation for I , which is the more commonly implemented form.

In some implementations the thermal voltage V_T, diode ideality factor n, and number of cells in series N_S are combined into a single variable a termed the modified ideality factor.

$$a \equiv \frac{N_s n k T_c}{q}$$

Characteristics of photovoltaic :



A current-voltage (I-V) curve shows the possible combinations of current and voltage output of a photovoltaic (PV) device. A PV device, such as a solar module, produces its maximum current when there is no resistance in the circuit, i.e., when there is a short circuit between its positive and negative terminals. This maximum current is known as the short circuit current and is abbreviated Isc. When the module is shorted, the voltage in the circuit is zero.

Conversely, the maximum voltage occurs when there is a break in the circuit. This is called the open circuit voltage (Voc). Under this condition the resistance is infinitely high and there is no current, since the circuit is incomplete.

These two extremes in load resistance, and the whole range of conditions in between them, are depicted on the I-V curve. Current, expressed in amps, is on the (vertical) y-axis. Voltage, in volts, is on the (horizontal) x-axis .

The power available from a photovoltaic device at any point along the curve is just the product of current and voltage at that point and is expressed in watts. At the short circuit current point, the power output is zero, since the voltage is zero. At the open circuit voltage point, the power output is also zero, but this time it is because the current is zero.

There is a point on the knee of the curve where the maximum power output is located. This maximum power point on our example curve is where the voltage is 17 volts, and the current is 2.5 amps. Therefore the maximum power in watts is 17 volts times 2.5 amps, or 42.5 watts.

The I-V of a PV device curve is based on the device being under standard conditions of sunlight and device temperature. It assumes there is no shading on the device. Standard sunlight conditions on a clear day are assumed to be 1,000 watts of solar energy per square meter (1000 W/m2 or 1 kW/m^2). This is sometimes called one sun, or a peak sun. Less than one sun will reduce the current output of the PV device by a proportional amount. For example, if only one-half sun (500 W/m^2) is available, the amount of output current is roughly cut in half.

UNIT - II

PART - A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

PART - B (2 MARKS)

1. Define ocean energy.
2. Write a short note bio-mass.
3. Define Tide energy.
4. Define Ocean energy.
5. Why the wind energy is important?
6. Draw the instrumentation of wind turbine?

PART - C (6 MARKS)

1. Write a note on wind energy? And give working principle of wind turbine?
2. Write a short note on parts of the wind turbine?
3. Give the advantage and disadvantage of wind energy?
4. Explain the working principle of wind turbine?
5. Describe about ocean energy?
6. Describe that why we need ocean energy?
7. Explain about tide energy technology?

KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF PHYSICS
II B.Sc., PHYSICS (2018-2021)
:NEWABLE ENERGY AND ENERGY HARVESTING (16PHU304A)
UNIT - II

QUESTIONS	CHOICE 1	CHOICE 2	CHOICE 3	CHOICE 4
Thermal insulation of ----------------------thickness is effective	5 to 10 cms	5 to 6 cms	to 8 cms	10 to 5 cms
Insulation material is generally -------------------- fibre glass.	mineral wo	glass wool	a heat resis	above all
Glass is generally used for the -----------------	transparen	emittance	absorptanc	transmittan
Radiation losses in the infra-red apectrum reduced by a further --	55%	25%	80%	75%
The primer should be of the --------- type	self -etchir	Aircollector	liquid	masking
The liquid heated is generally -----------	water	olive oil	kerosene	oil
If ambient temperatures below ------------	` 0°c	2°c	273°c	-2°c
The absorbed plate is selectively coated with ---------paint or (dye	red	black	green	blue
The made of metal sheet ------------mm thickness.	2 to 1 mm	3 to 2 mm	1 to2 mm	2 to 4 mm
The distanc between the first and sicond glass cover may be in th	3 to 6 cm	6 to 3 cm	2 to 1 cm	1 to 3 cm
The insulation thickness varies from -----------	5 t0 10 cm	9 ton 5 cm	10 to 5 cm	7 to 5 cm
The collector heat exchange area is equal to the -------------- area	collector ap	collector	change	reflector are
Basically air heaters are classified into ------------catogories.	two	three	four	five
Transmission of the solar radiation through the --------------- cove	transparen	black cover	none of the	collector
Unless selective coatings are used to the ---------------	adiative los	absorbed lo	conductive	convection
The lower matrix layers are hotter than the --------------.	lower one	upper one	radiation	middle laye
The air stream can effectively transfer heat from the -----------	lower matri	upper matr	matrix	above all
The pressure drops reported for porous matrix absorbers are still	non-porous	porous	radiative	selctive co
The flow cross section is much ------------------	lower	larger	medium	above all
Thermal losses could be significantly ------------	increase	reduce	gradually i	infinite
Tb is the ----------------n temperature.	high tempe	low temper	bottom ten	above all
The transparent cover Uo is given by -----------------	1/(1/UL+1/	(1/U +1/h)	(1/Ul + 1/h	1/Ug
F' and F " can be ----------------- by increasing the mass flow rate p	decreasing	gradually d	none of the	increasing
The solar radiation intensity is --------------	HcR	HR	H	Hc
The critical radiation intensity denotes by --------------------	UL (T1 - T	HR	HcR	I
The critical radiation intensity must be -------------	increased	decreased	gradually in	exponentia
The efficiency η is plotted against -------------	(T1 -Ta)/H	HR	HcR	T1-Ta/(HR
UL has a ------------ value	negative	positive	very low	infinite
The convectional air heaters values of -------------- of efficiency	80%	73%	65%	60%
The corresponding values for nmesh type of heater is about ------	50%	25%	100%	82%
The air flow rate was varied from ----------------- gm/m-cm^2	150 to66	77 to n82	66 to 150	80-100
The generator temperature is kept nearly at --------------	85°c	95°c	70°c	35°c
The term "green house effect" usually refers to solar ------------ he	air	water	solar heat	concentrato

	ANSWER
s	5 to 10 cms
	above all
ce-emittance	transparent
	25%
	self -etching type
	water
	`0°c
	black
	1 to2 mm
	3 to 6 cm
	5 t0 10 cm
ea	collector aperture
	two
	transparent cover
losses	radiative losses
rs	upper one
	matrix
ating	non-porous
	larger
	gradually increased
	bottom temperature
	1/(1/UL+1/h)
	increasing
	H
	HcR
lly increases	increased
)	T1-Ta/(HR)
	positive
	60%
	50%
	66 to 150
	95°c
or	air

UNIT- III

SYLLABUS

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.
Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power. Ocean Bio-mass.

Wind Energy:

Source of wind energy

- Atmosphere – a layer of gases that may surround a material body of sufficient mass, and that is held in place by the gravity of the body.
- Wind – the flow of gases on a large scale. Wind is composed of:
- Air – the gas found in the Earth's atmosphere. Air is mainly composed of nitrogen, oxygen, and argon, which together constitute the major gases of the atmosphere.
- Gas – one of the three classical states of matter (the others being liquid and solid).
- Motion – change in position of an object (including particles) with respect to time. Motion is typically described in terms of velocity, acceleration, displacement and time. Flow is a type of motion.

History of wind energy

- History of wind power – has been used as long as humans have put sails into the wind.
- Maritime history – The Ancient Egyptians had knowledge to some extent of sail construction.[1]
- History of sails – The earliest known depictions of sails are from ancient Egypt around 3200 BC, where reed boats sailed upstream against the River Nile's current.
- Age of Sail – the period in which international trade and naval warfare were dominated by sailing ships, lasting from the 16th to the mid 19th century.

Wind power

Wind power – conversion of wind energy into a useful form of energy.

- Variable renewable energy – any source of renewable energy that is not continuously available due to some factor outside direct control. The variable source may be quite predictable, for example, tidal power, but cannot be dispatched to meet the demand of a power system.
- Environmental impact of wind power – relatively minor compared to the environmental impact of traditional energy sources. Wind power consumes no fuel, and emits no air pollution, unlike fossil fuel power sources.
- Wind power forecasting – estimating the expected production of wind farms.
- Wind resource assessment – the process by which wind power developers estimate the future energy production of a wind farm.

Types of wind power

- Wind turbine – a turbine that converts wind energy into mechanical energy.
- Windmill – a machine which converts the energy of wind into rotational energy by means of vanes called sails or blades.
- Wind pump – a windmill used for pumping water, either as a source of fresh water from wells, or for draining low-lying areas of land.
- Sail – any type of surface intended to move a vessel, vehicle or rotor by being placed in a wind – in essence a propulsion wingWind power

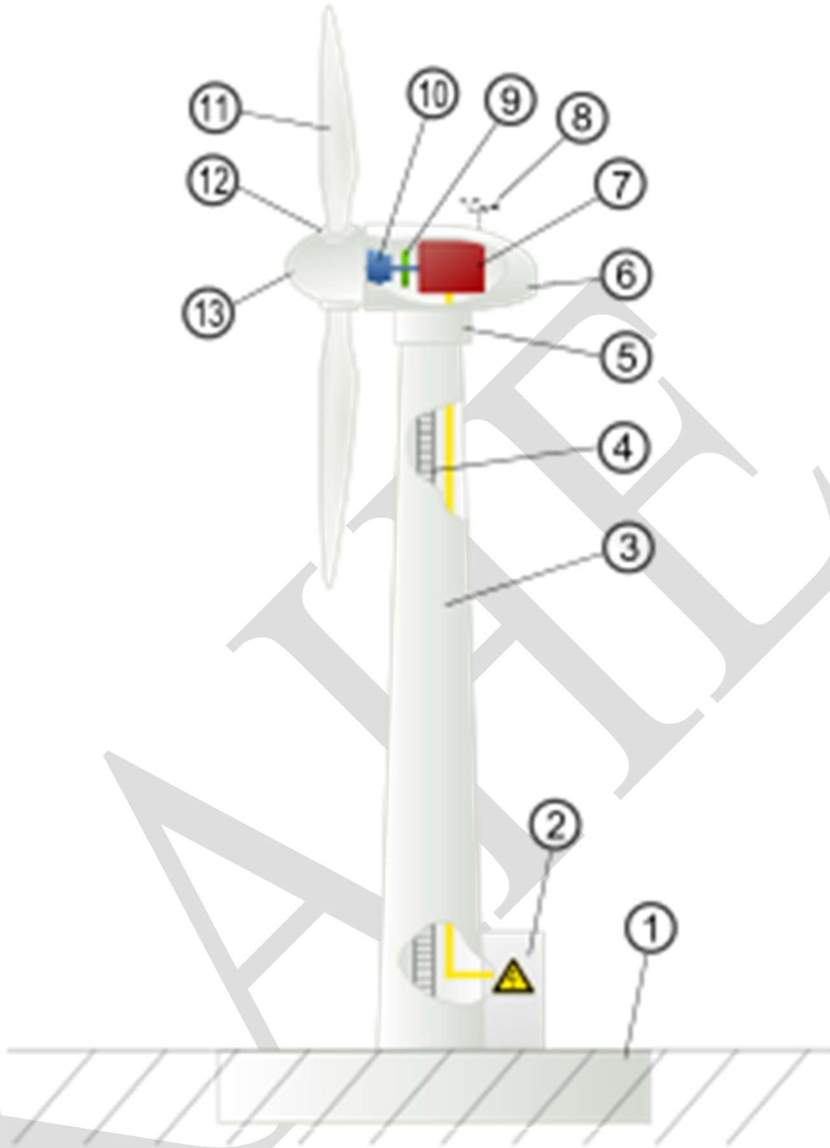
Wind power is the use of air flow through wind turbines to mechanically power generators for electric power. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land. The net effects on the environment are far less problematic than those of nonrenewable power sources.

Wind farms consist of many individual wind turbines which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants. Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.

Wind power gives variable power which is very consistent from year to year but which has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply. As the proportion of wind power in a region increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur. Power management techniques such as having excess capacity, geographically distributed turbines, dispatchable backing sources, sufficient hydroelectric power, exporting and importing power to neighboring areas, or reducing demand when wind production is low, can in many cases overcome these problems. In addition, weather forecasting permits the electric power network to be readied for the predictable variations in production that occur.

As of 2015, Denmark generates 40% of its electric power from wind, and at least 83 other countries around the world are using wind power to supply their electric power grids. In 2014, global wind power capacity expanded 16% to 369,553 MW. Yearly wind energy production is also growing rapidly and has reached around 4% of worldwide electric power usage, 11.4% in the EU.

3)Wind Turbines:



Typical wind turbine components:

1. Foundation
2. Connection to the electric grid
3. Tower
4. Access ladder
5. Wind orientation control (Yaw control)
6. Nacelle
7. Generator

8. Anemometer
9. Electric or Mechanical Brake
10. Gearbox
11. Rotor blade
12. Blade pitch control
13. Rotor hub

4) Marine energy

Marine energy or marine power (also sometimes referred to as ocean energy, ocean power, or marine and hydrokinetic energy) refers to the energy carried by ocean waves, tides, salinity, and ocean temperature differences. The movement of water in the world's oceans creates a vast store of kinetic energy, or energy in motion. This energy can be harnessed to generate electricity to power homes, transport and industries.

The term marine energy encompasses both wave power i.e. power from surface waves, and tidal power i.e. obtained from the kinetic energy of large bodies of moving water. Offshore wind power is not a form of marine energy, as wind power is derived from the wind, even if the wind turbines are placed over water.

The oceans have a tremendous amount of energy and are close to many if not most concentrated populations. Ocean energy has the potential of providing a substantial amount of new renewable energy around the world. Energy from the ocean is also known as hydroelectricity.

Global potential

There is the potential to develop 20,000–80,000 terawatt-hours (TWh) of electricity generated by changes in ocean temperatures, salt content, movements of tides, currents, waves and swells

Global potential	
Form	**Annual generation**
Tidal energy	>300 TWh
Marine current power	>800 TWh
Osmotic power Salinity gradient	2,000 TWh
Ocean thermal energy Thermal gradient	10,000 TWh
Wave energy	8,000–80,000 TWh
Source: IEA-OES, Annual Report 2007	

Indonesia as archipelagic country with three quarter of the area is ocean, has 49 GW recognized potential ocean energy and has 727 GW theoretical potential ocean energy.

Forms of ocean energy

Renewable

The oceans represent a vast and largely untapped source of energy in the form of surface waves, fluid flow, salinity gradients, and thermal.

Marine and Hydrokinetic (MHK) or marine energy development in U.S. and international waters includes projects using the following devices:

- Wave power converters in open coastal areas with significant waves;
- Tidal turbines placed in coastal and estuarine areas;
- In-stream turbines in fast-moving rivers;
- Ocean current turbines in areas of strong marine currents;
- Ocean thermal energy converters in deep tropical waters.

Strong ocean currents are generated from a combination of temperature, wind, salinity, bathymetry, and the rotation of the Earth. The Sun acts as the primary driving force, causing winds and temperature differences. Because there are only small fluctuations in current speed and stream location with no changes in direction, ocean currents may be suitable locations for deploying energy extraction devices such as turbines.

Ocean currents are instrumental in determining the climate in many regions around the world. While little is known about the effects of removing ocean current energy, the impacts of removing current energy on the far field environment may be a significant environmental concern. The typical turbine issues with blade strike, entanglement of marine organisms and acoustic effects still exists; however, these may be magnified due to the presence of more diverse populations of marine organisms using ocean currents for migration purposes. Locations can be further offshore and therefore require longer power cables that could affect the marine environment with electromagnetic output.

Water typically varies in temperature from the surface warmed by direct sunlight to greater depths where sunlight cannot penetrate. This differential is greatest in tropical waters, making this technology most applicable in water locations. A fluid is often vaporized to drive a turbine that may generate electricity or produce desalinized water. Systems may be either open-cycle, closed-cycle, or hybrid.

Non-renewable

Petroleum and natural gas beneath the ocean floor are also sometimes considered a form of ocean energy. An ocean engineer directs all phases of discovering, extracting, and delivering offshore petroleum (via oil tankers and pipelines,) a complex and demanding task. Also centrally important is the development of new methods to protect marine wildlife and coastal regions against the undesirable side effects of offshore oil extraction.

Marine energy development

The UK is leading the way in wave and tidal (marine) power generation. The world's first marine energy test facility was established in 2003 to kick start the development of the marine energy industry in the UK. Based in Orkney, Scotland, the European Marine Energy Centre (EMEC) has supported the deployment of more wave and tidal energy devices than at any other single site in the world. The Centre was established with around £36 million of funding from the Scottish Government, Highlands and Islands Enterprise, the Carbon Trust, UK Government, Scottish Enterprise, the European Union and Orkney Islands Council, and is the only accredited wave and tidal test centre for marine renewable energy in the world, suitable for testing a number of full-scale devices simultaneously in some of the harshest weather conditions while producing electricity to the national grid.

Clients that have tested at the centre include Aquamarine Power, AW Energy, Pelamis Wave Power, Seatricity, Scottish Power Renewables and Wello on the wave site, and Alstom (formerly Tidal Generation Ltd), ANDRITZ HYDRO Hammerfest, Kawasaki Heavy Industries, Magallanes, Nautricity, Open Hydro, Scot renewables Tidal Power, and Voith on the tidal site.
Leading the €11m FORESEA (Funding Ocean Renewable Energy through Strategic European Action) project, which provides funding support to ocean energy technology developers to access Europe's world-leading ocean energy test facilities, EMEC will welcome a number of wave and tidal clients to their pipeline for testing on site.
Beyond device testing, EMEC also provides a wide range of consultancy and research services, and is working closely with Marine Scotland to streamline the consenting process for marine energy developers. EMEC is at the forefront in the development of international standards for marine energy, and is forging alliances with other countries, exporting its knowledge around the world to stimulate the development of a global marine renewables industry.

Environmental effects

Common environmental concerns associated with marine energy developments include:

- the risk of marine mammals and fish being struck by tidal turbine blades
- the effects of EMF and underwater noise emitted from operating marine energy devices
- the physical presence of marine energy projects and their potential to alter the behavior of marine mammals, fish, and seabirds with attraction or avoidance
- the potential effect on near field and far field marine environment and processes such as sediment transport and water quality.

5) Tidal power:

Sihwa Lake Tidal Power Station, located in Gyeonggi Province, South Korea, is the world's largest tidal power installation, with a total power output capacity of 254 MW.

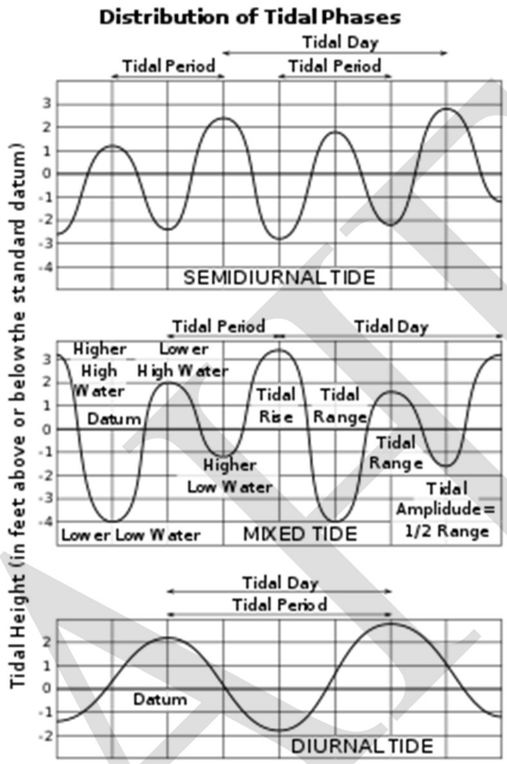
Tidal power or **tidal energy** is a form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity.

Although not yet widely used, tidal energy has potential for future electricity generation. Tides are more predictable than the wind and the sun. Among sources of renewable energy, tidal energy has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability. However, many recent technological developments and improvements, both in design (e.g. dynamic tidal power, tidal lagoons) and turbine technology (e.g. new axial turbines, cross flow turbines), indicate that the total availability of tidal power may be much higher than previously assumed, and that economic and environmental costs may be brought down to competitive levels.

Historically, tide mills have been used both in Europe and on the Atlantic coast of North America. The incoming water was contained in large storage ponds, and as the tide went out, it turned waterwheels that used the mechanical power it produced to mill grain. The earliest occurrences date from the Middle Ages, or even from Roman times. The process of using falling water and spinning turbines to create electricity was introduced in the U.S. and Europe in the 19th century.

The world's first large-scale tidal power plant was the Rance Tidal Power Station in France, which became operational in 1966. It was the largest tidal power station in terms of output until Sihwa Lake Tidal Power Station opened in South Korea in August 2011. The Sihwa station uses sea wall defense barriers complete with 10 turbines generating 254 MW.

Generation of tidal energy



Variation of tides over a day

Tidal power is taken from the Earth's oceanic tides. Tidal forces are periodic variations in gravitational attraction exerted by celestial bodies. These forces create corresponding motions or currents in the world's oceans. Due to the strong attraction to the oceans, a bulge in the water level is created, causing a temporary increase in sea level. When the sea level is raised, water from the middle of the ocean is forced to move toward the shorelines, creating a tide. This occurrence takes place in an unfailing manner, due to the consistent pattern of the moon’s orbit around the earth. The magnitude and character of this motion reflects the changing positions of the Moon and Sun relative to the Earth, the effects of Earth's rotation, and local geography of the sea floor and coastlines.

Tidal power is the only technology that draws on energy inherent in the orbital characteristics of the Earth–Moon system, and to a lesser extent in the Earth–Sun system. Other natural energies exploited by human technology originate directly or indirectly with the Sun, including fossil fuel, conventional hydroelectric, wind, biofuel, wave and solar energy. Nuclear energy makes use of Earth's mineral deposits of fissionable elements, while geothermal power taps the Earth's internal heat, which comes from a combination of residual heat from planetary accretion (about 20%) and heat produced through radioactive decay (80%).

A tidal generator converts the energy of tidal flows into electricity. Greater tidal variation and higher tidal current velocities can dramatically increase the potential of a site for tidal electricity generation. Because the Earth's tides are ultimately due to gravitational interaction with the Moon and Sun and the Earth's rotation, tidal power is practically inexhaustible and classified as a renewable energy resource. Movement of tides causes a loss of mechanical energy in the Earth–Moon system: this is a result of pumping of water through natural restrictions around coastlines and consequent viscous dissipation at the seabed and in turbulence. This loss of energy has caused the rotation of the Earth to slow in the 4.5 billion years since its formation. During the last 620 million years the period of rotation of the earth (length of a day) has increased from 21.9 hours to 24 hours in this period the Earth has lost 17% of is rotational energy. While tidal power will take additional energy from the system, the effect is negligible and would only be noticed over millions of years.

Generating methods

The world's first commercial-scale and grid-connected tidal stream generator – SeaGen – in Strangford Lough. The strong wake shows the power in the tidal current.

Tidal power can be classified into four generating methods:

Tidal stream generator

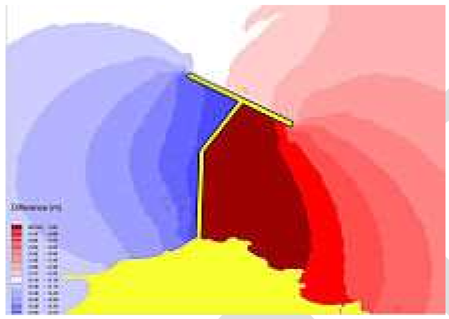
Main article: Tidal stream generator

Tidal stream generators (or TSGs) make use of the kinetic energy of moving water to power turbines, in a similar way to wind turbines that use wind to power turbines. Some tidal generators can be built into the structures of existing bridges or are entirely submersed, thus avoiding concerns over impact on the natural landscape. Land constrictions such as straits or inlets can create high velocities at specific sites, which can be captured with the use of turbines. These turbines can be horizontal, vertical, open, or ducted.

Tidal barrage

Tidal barrages make use of the potential energy in the difference in height (or hydraulic head) between high and low tides. When using tidal barrages to generate power, the potential energy from a tide is seized through strategic placement of specialized dams. When the sea level rises and the tide begins to come in, the temporary increase in tidal power is channeled into a large basin behind the dam, holding a large amount of potential energy. With the receding tide, this energy is then converted into mechanical energy as the water is released through large turbines that create electrical power through the use of generators. Barrages are essentially dams across the full width of a tidal estuary.

Dynamic tidal power



Top-down view of a DTP dam. Blue and dark red colors indicate low and high tides, respectively.

Dynamic tidal power (or DTP) is an untried but promising technology that would exploit an interaction between potential and kinetic energies in tidal flows. It proposes that very long dams (for example: 30–50 km length) be built from coasts straight out into the sea or ocean, without enclosing an area. Tidal phase differences are introduced across the dam, leading to a significant water-level differential in shallow coastal seas – featuring strong coast-parallel oscillating tidal currents such as found in the UK, China, and Korea.

Tidal lagoon

A new tidal energy design option is to construct circular retaining walls embedded with turbines that can capture the potential energy of tides. The created reservoirs are similar to those of tidal barrages, except that the location is artificial and does not contain a preexisting ecosystem. The lagoons can also be in double (or triple) format without pumping or with pumping that will flatten out the power output. The pumping power could be provided by excess to grid demand renewable energy from for example wind turbines or solar photovoltaic arrays. Excess renewable energy rather than being curtailed could be used and stored for a later period of time. Geographically dispersed tidal lagoons with a time delay between peak production would also flatten out peak production providing near base load production though at a higher cost than some other alternatives such as district heating renewable energy storage. The proposed

Tidal Lagoon Swansea Bay in Wales, United Kingdom would be the first tidal power station of this type once built.

6) Osmotic power

Osmotic power, **salinity gradient power** or **blue energy** is the energy available from the difference in the salt concentration between seawater and river water. Two practical methods for this are reverse electro dialysis (RED) and pressure retarded osmosis (PRO). Both processes rely on osmosis with membranes. The key waste product is brackish water. This byproduct is the result of natural forces that are being harnessed: the flow of fresh water into seas that are made up of salt water.

In 1954, Pattle suggested that there was an untapped source of power when a river mixes with the sea, in terms of the lost osmotic pressure, however it was not until the mid '70s where a practical method of exploiting it using selectively permeable membranes by Loeb was outlined.

The method of generating power by pressure retarded osmosis was invented by Prof. Sidney Loeb in 1973 at the Ben-Gurion University of the Negev, Beersheba, Israel. The idea came to Prof. Loeb, in part, as he observed the Jordan River flowing into the Dead Sea. He wanted to harvest the energy of mixing of the two aqueous solutions (the Jordan River being one and the Dead Sea being the other) that was going to waste in this natural mixing process. In 1977 Prof. Loeb invented a method of producing power by a reverse electro dialysis heat engine.

The technologies have been confirmed in laboratory conditions. They are being developed into commercial use in the Netherlands (RED) and Norway (PRO). The cost of the membrane has been an obstacle. A new, lower cost membrane, based on an electrically modified polyethylene plastic, made it fit for potential commercial use.[6] Other methods have been proposed and are currently under development. Among them, a method based on electric double-layer capacitor technology and a method based on vapor pressure difference.

Biomass

Biomass briquettes are an example fuel for production of dendrothermal energy

Biomass is an industry term for getting energy by burning wood, and other organic matter. Burning biomass releases carbon emissions, but has been classed as a renewable energy source in the EU and UN legal frameworks, because plant stocks can be replaced with new growth. Also, since the plants build themselves using carbon dioxide and release oxygen as they grow, the net balance of the carbon dioxide after the matter has burned is zero, meaning no extra carbon dioxide is added to the atmosphere. It has become popular among coal power stations, which switch from coal to biomass in order to convert to renewable energy generation without wasting existing generating plant and infrastructure. Biomass most often refers to plants or plant-based materials that are not used for food or feed, and are specifically called lignocellulosic biomass. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel. Conversion of biomass to biofuel can be achieved by different methods which are broadly classified into: *thermal*, *chemical*, and *biochemical* methods.

7) Electrical grid:

"Power grid" redirects here. For the board game, see Power Grid.

General layout of electricity networks. Voltages and depictions of electrical lines are typical for Germany and other European systems.

An **electrical grid** is an interconnected network for delivering electricity from producers to consumers. It consists of generating stations that produce electrical power, high voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers

Power stations may be located near a fuel source, at a dam site, or to take advantage of renewable energy sources, and are often located away from heavily populated areas. They are usually quite large to take advantage of economies of scale. The electric power which is generated is stepped up to a higher voltage at which it connects to the electric power transmission network.

The bulk power transmission network will move the power long distances, sometimes across international boundaries, until it reaches its wholesale customer (usually the company that owns the local electric power distribution network).

On arrival at a substation, the power will be stepped down from a transmission level voltage to a distribution level voltage. As it exits the substation, it enters the distribution wiring. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage(s).

Electrical grids vary in size from covering a single building through *national grids* which cover whole countries, to *transnational grids* which can cross continents.

In telecommunications, **interconnection** is the physical linking of a carrier's network with equipment or facilities not belonging to that network. The term may refer to a connection between a carrier's facilities and the equipment belonging to its customer, or to a connection between two (or more) carriers.

In United States regulatory law, interconnection is specifically defined (47 C.F.R. 51.5) as "the linking of two or more networks for the mutual exchange of traffic."

One of the primary tools used by regulators to introduce competition in telecommunications markets has been to impose interconnection requirements on dominant carriers.

UNIT - III

PART - A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

PART - B (2 MARKS)

1. What is hydro energy?
2. Write a note on hydropower technology?
3. How the hydrothermal technologies are impact the environment?
4. Write a short note on piezoelectric effect,
5. Explain briefly the piezoelectric generators?
6. Give an importance about hydro energy.

PART - C (6 MARKS)

1. What are the applications of hydropower technology?
2. Write a note on hydropower technology?
3. Explain piezoelectric effect and give some example.
4. Give an importance of piezoelectric effect?

5. What is the role of piezoelectric effect in energy harvesting?
6. Explain the piezoelectric generators?
7. Write a short note on piezoelectric effect, and its applications?

KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF PHYSICS
II B.Sc., PHYSICS (2018-2021)
:NEWABLE ENERGY AND ENERGY HARVESTING (16PHU304A)

QUESTIONS	CHOICE 1	CHOICE 2	CHOICE 3	CHOICE 4
UNIT - III				
________ is a time dependent and intermittent energy resource	electrical e	chemical e	thermal en	solar enegy
If photovoltaic or photochemical processes are used storage is pı	electrical e	chemical e	thermal en	solar enegy
Storage by causing a material to rise in temperature is called ___	thermal sto	pebble bed	sensible he	latent heat
Storge by phase change the transition from solid to liquid or from	latent heat	sensible he	water stora	hydro stora
________ is the least expensive and most readily available salt h	sodium chl	Glauber's s	potassium	ammonium
When the heat added produces only a temperature increase in th	sensible he	latent heat	specific hea	Augmentec
If there is no phase change, the rise in temperature is approximat	heat and vo	volume anc	mass and t	heat and m
Which one of the following is not a characteristics of water storag	high therma	water acts	pumping co	inexpensive
If the tank is pressurized, the temperature limit will be slightly ___	dependent	above	below	equal to
Pressurized tanke are generally not applicable for smaller comme	high pressu	low pressu	low therma	higher cost
________ is a simple device for collecting and storing solar heat	pyrheliome	pyranomete	solar pond	flat-plate cc
In natural ponds heat is lost through _____ and _______	conduction	convection	conductin a	evaporation
Solar pond may be classified as __________-	conducting	convecting	conducting	conducting
_________ solar pond reduces heat loss by being convered by a	convecting	conducting	salt gradien	non-convec
In convecting solar ponds each pond module includes a long narr	5-10cm	10-20cm	20-30cm	30-40cm
In convecting solar pond bottom of the bag is __________ to abs	white	black	transparen	opaque
_________ solar ponds prevent heat losses by inhibiting the conv	conveting	conducting	non-convec	non-conduc
__________ is the most common type of non-convecting solar pc	site-built sc	salt gradien	conducting	salt diminis
Salts has been dissolved in hihg concentration near the bottom w	decreasing	increasing	same	neither incr
Which of the following salt is not used commonly for salt gradient	magnesium	ammonium	sodium chl	cesium chlo
In salt gradient ponds, when convection suppressed the heat in lo	evaporation	radiation	conduction	all the abov
Because of low temperature, the solar pond power plant requires	low boiling	high boiling	low melting	high melting
__________ system will be suitable at places where portable wat	site-built pc	solar pond	multi-flash	salt gradien
___________ insulation of thermal storage tank is not recommen	fibre	cellulose	cardboard	aluminium
The quantitiy which is not dependent upon the size of thermal sto	heating loa	evaporative	collector ef	heating frac
The most comon tank material in thermal storage tank which offe	aluminium	steel	concrete	fibre
_________ tanks are inexpensive and can be constructeed on sil	concrete	fibre	aluminium	steel
___________ type of thermal storage has advantages over water	foam pad	coaltar	rockbed	calcium oxi
In packed bed thermal storage, the conductivity of the bed will be	low boiling	high boiling	medium	absent
Pebble bed storage units for air-based solar heating systems may	horizontal c	vertical only	horizontal a	horizontal c
In height limited places or rural places _____ pebble beds are mc	horizontal c	both vertica	vertical	vertical or h
Lime stone and sand stone should not be used in pebble bed stoı	they are nc	they does r	they may fr	thery impro
Which one of the following type of rock can be used in pebble bed	marble	dolomite	rounded riv	sand stone
The pressure gradient through the rock bed is defined as the ratic	rock depth	mass of roc	density of r	rock area
When the rock diameter increases, the pressure gradient through	increases	decreases	does not de	remains the
A storage system that stores heat by undergoing a change of pha	latent heat	packed bed	sensible he	water stora
_____________ storage system is more effective way of stabilizi	sensibel he	latent heat	electrical st	chemical st
The latent heat storage occurs when the storage temperature ___	increases	has no cha	decreases	moderate
__________ are substances having a waxy consistency at room t	cupric acid	stearic acic	paraffins	palmetic ac
Which one of the following is not eutetic	acetamide	urea	water	Glauber's s
The most efficient and practical fuel in chemical storage is _____	hydrogen	nitrogen	carbon	methane
Algae coule be grown in nutrient-loaded muncipal sewage in chem	methane	hydrogen	oxygen	carbondiox
The transition from ___________ is an excellent example for ene	water to ste	ice to water	water to ice	steam to wa

	ANSWER
/	solar enegy
/	chemical energy
storage	sensible heat storage
ge	latent heat storage
chloride salt	Glauber's salt
l heat	sensible heat
ass	heat and mass
e	water acts as its own heat exchanger
	below
	higher cost
ollector	solar pond
n only	convection and evaporation
and non-conducting	convecting and non-convecting
cting	convecting
	5-10cm
	black
cting	non-convecting
hed	salt gradientpond
easing nor decreasing	decreasing
oride	ammonium chloride
ve	conduction
g point	low boiling point
nt solar ponds	multi-flash distillation
	cellulose
ction	evaporative loss
	steel
	concrete
de	rockbed
	low boiling point
or vertical	horizontal or vertical
horizontal	horizontal only
ve air flow	they may fracture
	rounded river bottom stones
	rock depth
e same	decreases
ge	latent heat storage
torage	latent heat storage
	has no change
cid	paraffins
alt	Glauber's salt
	hydrogen
ide	methane
ater	ice to water

UNIT- IV

SYLLABUS

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power.

Hydro Energy :

Flowing water creates energy that can be captured and turned into electricity. This is called hydroelectric power or hydropower.

The most common type of hydroelectric power plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. But hydroelectric power doesn't necessarily require a large dam. Some hydroelectric power plants just use a small canal to channel the river water through a turbine.

Another type of hydroelectric power plant - called a pumped storage plant - can even store power. The power is sent from a power grid into the electric generators. The generators then spin the turbines backward, which causes the turbines to pump water from a river or lower reservoir to an upper reservoir, where the power is stored. To use the power, the water is released from the upper reservoir back down into the river or lower reservoir. This spins the turbines forward, activating the generators to produce electricity.

A small or micro-hydroelectric power system can produce enough electricity for a home, farm, or ranch.

Hydropower types :

- Hydropower is used primarily to generate electricity. Broad categories include:
- Conventional hydroelectric, referring to hydroelectric dams.

- Run-of-the-river hydroelectricity, which captures the kinetic energy in rivers or streams, without a large reservoir and sometimes without the use of dams.
- Small hydro projects are 10 megawatts or less and often have no artificial reservoirs.
- Micro hydro projects provide a few kilowatts to a few hundred kilowatts to isolated homes, villages, or small industries.
- Conduit hydroelectricity projects utilize water which has already been diverted for use elsewhere; in a municipal water system, for example.
- Pumped-storage hydroelectricity stores water pumped uphill into reservoirs during periods of low demand to be released for generation when demand is high or system generation is low.
- Pressure buffering hydropower use natural sources (waves for example) for water pumping to turbines while exceeding water is pumped uphill into reservoirs and releases when incoming water flow isn't enough.

ADVANTAGES:

1. Once a dam is constructed, electricity can be produced at a constant rate.
2. If electricity is not needed, the sluice gates can be shut, stopping electricity generation. The water can be saved for use another time when electricity demand is high.
3. Dams are designed to last many decades and so can contribute to the generation of electricity for many years / decades.
4. The lake that forms behind the dam can be used for water sports and leisure / pleasure activities. Often large dams become tourist attractions in their own right.
5. The lake's water can be used for irrigation purposes.
6. The buildup of water in the lake means that energy can be stored until needed, when the water is released to produce electricity.
7. When in use, electricity produced by dam systems do not produce green house gases. They do not pollute the atmosphere.

DISADVANATGES:

1. Dams are extremely expensive to build and must be built to a very high standard.

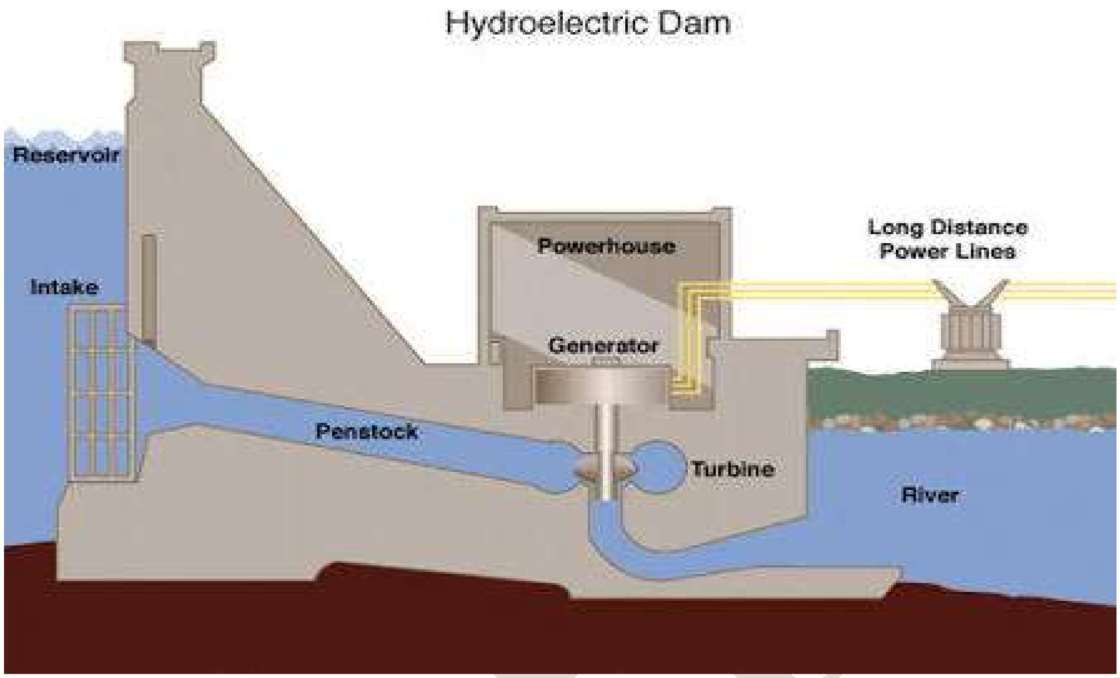
2. The high cost of dam construction means that they must operate for many decades to become profitable.
3. The flooding of large areas of land means that the natural environment is destroyed.
4. People living in villages and towns that are in the valley to be flooded, must move out. This means that they lose their farms and businesses. In some countries, people are forcibly removed so that hydro-power schemes can go ahead.
5. The building of large dams can cause serious geological damage. For example, the building of the Hoover Dam in the USA triggered a number of earth quakes and has depressed the earth's surface at its location.
6. Although modern planning and design of dams is good, in the past old dams have been known to be breached (the dam gives under the weight of water in the lake). This has led to deaths and flooding.
7. Dams built blocking the progress of a river in one country usually means that the water supply from the same river in the following country is out of their control. This can lead to serious problems between neighbouring countries.
8. Building a large dam alters the natural water table level. For example, the building of the Aswan Dam in Egypt has altered the level of the water table. This is slowly leading to damage of many of its ancient monuments as salts and destructive minerals are deposited in the stone work from 'rising damp' caused by the changing water table level.

Hydropower Works :

Hydropower plants capture the energy of falling water to generate electricity. A turbine converts the kinetic energy of falling water into mechanical energy. Then a generator converts the mechanical energy from the turbine into electrical energy.

Hydroplants range in size from "micro-hydros" that power only a few homes to giant dams like Hoover Dam that provide electricity for millions of people.

The photo on the right shows the Alexander Hydroelectric Plant on the Wisconsin River, a medium-sized plant that produces enough electricity to serve about 8,000 people.



Parts of a Hydroelectric Plant :

Most conventional hydroelectric plants include four major components (see graphic below):

Dam: Raises the water level of the river to create falling water. Also controls the flow of water. The reservoir that is formed is, in effect, stored energy.

Turbine: The force of falling water pushing against the turbine's blades causes the turbine to spin. A water turbine is much like a windmill, except the energy is provided by falling water instead of wind. The turbine converts the kinetic energy of falling water into mechanical energy.

Generator: Connected to the turbine by shafts and possibly gears so when the turbine spins it causes the generator to spin also. Converts the mechanical energy from the turbine into electric energy. Generators in hydropower plants work just like the generators in other types of power plants.

Transmission lines: Conduct electricity from the hydropower plant to homes and business.

Environmental impacts of hydro power technology :

Hydropower Is Nonpolluting, but Does Have Environmental Impacts

Hydropower does not pollute the water or the air. However, hydropower facilities can have large environmental impacts by changing the environment and affecting land use, homes, and natural habitats in the dam area.

Fish Ladder at the Bonneville Dam on the Columbia River Separating Washington and Oregon. Most hydroelectric power plants have a dam and a reservoir. These structures may obstruct fish migration and affect their populations. Operating a hydroelectric power plant may also change the water temperature and the river's flow. These changes may harm native plants and animals in the river and on land.

Reservoirs may cover people's homes, important natural areas, agricultural land, and archeological sites. So building dams can require relocating people. Methane, a strong greenhouse gas, may also form in some reservoirs and be emitted to the atmosphere.

Environmental Impacts of Hydropower Plants :

The impact of hydroelectric power plant on the environment is varied and depends upon the size and type of the project. Although hydropower generation does not burn any fuel to produce power and hence does not emit greenhouse gases, there are definite negative effects that arise from the creation of reservoir and alteration of natural water flow. It is a fact that dams, inter-basin transfers and diversion of water for irrigation purposes have resulted in the fragmentation of 60% of the world's rivers.

ENVIRONMENTAL IMPACT

The physical environment is affected rather significantly by the construction of a hydroelectric power station. Both the river and ecosystem of the surrounding land area will be altered as soon as dam construction begins.

1. Impact of Size and Type of Hydropower Plant :

It is difficult to correlate the damage caused by dams to their size or type, as the impacts depend on local conditions. Generally plants with smaller dams are considered less environmentally damaging than those with larger dams. Also, run-of-river (ROR) hydropower plants are generally less damaging than reservoir power plants, because it is not necessary to flood large areas upstream of the project for storage. Yet in some cases run of river impacts can also be severe due to river diversion over long stretches of the river.

2. Impact of River Diversion :

While both ROR and reservoir types of hydropower dams may divert water, this is always the case with ROR plants, since they seek to increase kinetic energy with an increased head. The length of diversion can range from a few meters or less to kilometers (km). For example, the Teesta-V ROR dam in northeastern India diverts water for a 23 km long stretch of the river. Eventually the diverted water is returned to the river.

Often downstream flows are reduced considerably or even completely stopped during certain periods of time with sudden intervals of high flows. Such drastic variability in water flow impacts the structure of aquatic ecosystems often leading to a loss of biodiversity. Also, under normal conditions, increased sediment transport from low to intermediate flows provides a warning to aquatic organisms that high flows may follow. Abrupt changes from low to high flows obliterate this cue, making it difficult for organisms to respond to impending environmental changes. A decrease in fish populations has been observed in dewatered reaches below diversions. After long periods of little to no flow some species may not be able to recover and go extinct.

3. Impact of the Reservoir :

Dams have major impacts on the physical, chemical and geo-morphological properties of a river. Environmental impacts of dams have largely been negative. Worldwide, at least 400,000 square kilometers have been flooded by reservoirs.

Once the barrier is put in place, the free flow of water stops and water will begin to accumulate behind the dam in the new reservoir. This land may have been used for other things such as agriculture, forestry, and even residences, but it is now unusable. The loss of habitat may not seem severe but if this area was home to a threatened or endangered species, the dam construction could further threaten that species risk of extinction.

3.1 Sedimentation :

Large dams with reservoirs significantly alter the timing, amount and pattern of river flow. This changes erosion patterns and the quantity and type of sediments transported by the river. Sedimentation rate is primarily related to the ratio of the size of the river to the flux of sediments. The reservoir that has been rapidly filling up with water immediately begins filling up with sediment as well. The trapping of sediments behind the dam is a major problem. Every year it is estimated that 0.5 to 1% of reservoir storage capacity is lost due to sedimentation. The engineering problem with sedimentation is that less power is generated as the reservoir's capacity shrinks.

3.2 Downstream Erosion:

Trapping of sediments at the dam also has downstream impacts by reducing the flux of sediments downstream which can lead to the gradual loss of soil fertility in floodplain soils. Clean water stripped of its sediment load is now flowing downstream of the dam. This clean water has more force and velocity then water carrying a high sediment load and thus erosion of the riverbed and banks becomes problematic. Since this is unnatural and a form of "forced erosion" it occurs at a much faster rate than natural river process erosion to which the local ecosystem would be able to adapt.

3.3 Impact on Local Climate :

Another often-ignored environmental effect of the reservoir is the impact on the micro-climate level. Studies indicate that man-made lakes in tropical climates tend to reduce convection and thus limit cloud cover. Temperate regions are also impacted with "steam-fog" in the time period before freezing. Since water cools and warms slower then land, coastal regions tend to be much more moderate then land-locked regions in terms of temperature. Therefore, large dams have a slight moderating effect on the local climate.

3.4 Greenhouse Gas Emission from Dams :

Freshwater reservoirs can emit substantial amounts of the greenhouse gases methane and carbon dioxide as organic matter submerged in a reservoir decays under anaerobic and aerobic conditions, respectively. Studies indicate that GHG emissions from hydropower reservoirs in boreal and temperate region are low relative to the emissions from fossil fuel power plants, but higher relative to life cycle emissions from wind and solar power.

Tropical reservoirs with high levels of organic matter and shallow reservoirs have higher emission levels. A recent compilation of greenhouse gas emissions from reservoirs found a correlation between the age of the reservoir and latitude. Younger reservoirs and those in low latitudes are the highest emitters. For example, of four Brazilian dams in the Amazon, showed that the GHG emissions factor of the electricity produced by those hydropower dams exceed those from a coal-fired power plant.

3.5 Dams Inducing Earthquakes :

Finally, a least studied and most disputed physical impact of reservoirs is the possibility of inducing earthquakes. Many scientists believe that seismic activity can be attributed to the creation of dams and their adjacent storage reservoirs. They postulate that the added forces of the dam along inactive faults seem to free much stronger orogenic tensions. Early research indicates that the depth of the water column may be more important to inducing earthquakes rather than total volume of water in the reservoir. While more research is needed on this subject several disasters such as the Koyna Dam in India seem to provide some truth to this theory. While these impacts can be quite severe often they do not receive the attention of the biological impacts that people tend to associate more with animals like fish.

3.6 Impact on Fisheries :

Dams and river diversion can impact freshwater, as well as marine fisheries. Estuarine and marine fisheries are dependent on estuaries and rivers as spawning grounds and the transport of nutrients from the river to the sea. Migratory fish are especially vulnerable to the impacts of dam construction. Dams can prevent migrating fish such as salmon and eel to reach their spawn grounds.

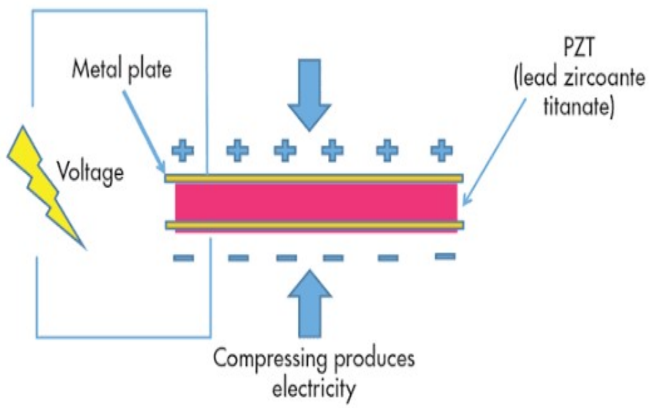
A survey of 125 dams by the World Commission on Dams (WCD) reported that blocking the passage of migratory fish species has been identified as a major reason for freshwater species extinction in North America. Lower catch is a common side effect of dams and has been reported worldwide. There have been cases where fishery production below a dam has increased due to controlled discharge of the sediments.

Piezo electric effect harvesting Principles :

Piezoelectricity is found in crystalline materials that possess non-centrosymmetry. This effect induces an electric polarization proportional to an applied mechanical stress (direct piezoelectric effect) or a mechanical strain proportional to an applied electric field (converse piezoelectric effect). During vibration energy harvesting, piezoelectric materials convert mechanical strain into an electrical charge or voltage via the direct piezoelectric effect. The power output of a particular piezoelectric energy harvester depends upon intrinsic and extrinsic factors. Intrinsic factors include the frequency constant of the piezoelectric element, piezoelectric and mechanical properties of the material, and the temperature and stress dependence of the physical properties. Extrinsic factors comprise of the input vibration frequency, acceleration of the base/host structure, and the amplitude of the excitation. Figure 1 illustrates different configurations of piezoelectric harvesters and their features. The combination of the mechanical architecture and material properties allows for variations in the frequency operating range and the power output.

The efficiency and the power density of a piezoelectric vibration energy harvester are strongly frequency dependent, because, the piezoelectric material generates its maximum power at the electromechanical resonance frequency. The low frequency fundamental mode should be targeted in the design of the energy harvesting device since the potential output power is proportional to 1/f (f = the frequency of the fundamental vibration mode). That said, the lower the frequency of the vibration base, the more complex it becomes to design the energy harvesting structure, as the dimension and weight constraints limit the use of the ceramics to achieve the desired fundamental frequency.

What is the Piezoelectric Effect?



Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. The word Piezoelectric is derived from the Greek piezein, which means to squeeze or press, and piezo, which is Greek for "push".

One of the unique characteristics of the piezoelectric effect is that it is reversible, meaning that materials exhibiting the direct piezoelectric effect (the generation of electricity when stress is applied) also exhibit the converse piezoelectric effect (the generation of stress when an electric field is applied).

When piezoelectric material is placed under mechanical stress, a shifting of the positive and negative charge centers in the material takes place, which then results in an external electrical field. When reversed, an outer electrical field either stretches or compresses the piezoelectric material.

The piezoelectric effect is very useful within many applications that involve the production and detection of sound, generation of high voltages, electronic frequency generation, microbalances, and ultra fine focusing of optical assemblies. It is also the basis of a number of scientific instrumental techniques with atomic resolution, such as scanning probe microscopes (STM, AFM, etc). The piezoelectric effect also has its use in more mundane applications as well, such as acting as the ignition source for cigarette lighters.

The History of the Piezoelectric Effect :

The direct piezoelectric effect was first seen in 1880, and was initiated by the brothers Pierre and Jacques Curie. By combining their knowledge of pyroelectricity with their understanding of crystal structures and behavior, the Curie brothers demonstrated the first piezoelectric effect by using crystals of tourmaline, quartz, topaz, cane sugar, and Rochelle salt.

Their initial demonstration showed that quartz and Rochelle salt exhibited the most piezoelectricity ability at the time.

Over the next few decades, piezoelectricity remained in the laboratory, something to be experimented on as more work was undertaken to explore the great potential of the piezoelectric effect. The breakout of World War I marked the introduction of the first practical application for piezoelectric devices, which was the sonar device. This initial use of piezoelectricity in sonar created intense international developmental interest in piezoelectric devices. Over the next few decades, new piezoelectric materials and new applications for those materials were explored and developed.

During World War II, research groups in the US, Russia and Japan discovered a new class of man-made materials, called ferroelectrics, which exhibited piezoelectric constants many times higher than natural piezoelectric materials. Although quartz crystals were the first commercially exploited piezoelectric material and still used in sonar detection applications, scientists kept searching for higher performance materials. This intense research resulted in the development of barium titanate and lead zirconate titanate, two materials that had very specific properties suitable for particular applications.

Piezoelectric Materials :

There are many materials, both natural and man-made, that exhibit a range of piezoelectric effects. Some naturally piezoelectric occurring materials include Berlinite (structurally identical to quartz), cane sugar, quartz, Rochelle salt, topaz, tourmaline, and bone (dry bone exhibits some piezoelectric properties due to the apatite crystals, and the piezoelectric effect is generally thought to act as a biological force sensor). An example of man-made piezoelectric materials includes barium titanate and lead zirconate titanate.

In recent years, due to the growing environmental concern regarding toxicity in lead-containing devices and the RoHS directive followed within the European Union, there has been a push to develop lead free piezoelectric materials. To date, this initiative to develop new lead-free piezoelectric materials has resulted in a variety of new piezoelectric materials which are more environmentally safe.

Applications Best Suited for the Piezoelectric Effect :

Due to the intrinsic characteristics of piezoelectric materials, there are numerous applications that benefit from their use:

1. High Voltage and Power Sources :

An example of applications in this area is the electric cigarette lighter, where pressing a button causes a spring-loaded hammer to hit a piezoelectric crystal, thereby producing a sufficiently high voltage that electric current flows across a small spark gap, heating and igniting the gas. Most types of gas burners and ranges have a built-in piezo based injection systems.

2.Sensors :

The principle of operation of a piezoelectric sensor is that a physical dimension, transformed into a force, acts on two opposing faces of the sensing element. The detection of pressure variations in the form of sound is the most common sensor application, which is seen in piezoelectric microphones and piezoelectric pickups for electrically amplified guitars. Piezoelectric sensors in particular are used with high frequency sound in ultrasonic transducers for medical imaging and industrial nondestructive testing.

3. Piezoelectric Motors :

Because very high voltages correspond to only tiny changes in the width of the crystal, this crystal width can be manipulated with better-than-micrometer precision, making piezo crystals an important tool for positioning objects with extreme accuracy, making them perfect for use in motors, such as the various motor series offered by Nanomotion. Regarding piezoelectric motors, the piezoelectric element receives an electrical pulse, and then applies directional force to an opposing ceramic plate, causing it to move in the desired direction. Motion is generated when the piezoelectric element moves against a static platform (such as ceramic strips).

The characteristics of piezoelectric materials provided the perfect technology upon which Nanomotion developed our various lines of unique piezoelectric motors. Using patented piezoelectric technology, Nanomotion has designed various series of motors ranging in size from a single element (providing 0.4Kg of force) to an eight element motor (providing 3.2 Kg of force). Nanomotion motors are capable of driving both linear and rotary stages, and have a wide dynamic range of speed, from several microns per second to 250 mm/sec and can easily mount to traditional low friction stages or other devices. The operating characteristics of Nanomotion's motors provide inherent braking and the ability to eliminate servo dither when in a static position.

Human Power :

Human power is an often overlooked form of renewable energy with quite a bit of potential. As energy prices rise with no relief in sight, more companies are developing devices designed to harness human power and make use of our most natural resource: our own bodies. There are a number of ways to generate human power, and in fact most of them are based on principles we use every day that many people don't realize actually produce energy. Perhaps the most common example of human power in modern devices is the Faraday flashlight. Retail department stores and television sales offer these "eternal" flashlights that need no batteries. Rather, they are run by human power-simply shake the flashlight vigorously for about thirty seconds, and the flashlight will produce a strong, steady source of light for several minutes. Faraday flashlights operate using magnets and copper coils.

Human power can also be used for crank generators, which are devices that generate electricity by manually turning a crank. Crank generators often incorporate built-in flashlights, and are available with a range of energy output. Small human power crank generators can produce enough energy from three minutes of cranking to power a dead cell phone for two to eight minutes. Larger capacity crank generators are capable of much more energy output.

The most popular and effective method of human power generation, however, is cycling. There are several devices that can convert human power from cycling to energy. Most are either free-standing equipment with pedals attached to a generator, or a portable device that actually attaches to a bicycle and generates power while you ride. Human power is an exciting form of alternative, renewable energy that offers the added benefit of exercise while you pump out power.

Linear alternator :

A linear alternator is essentially a linear motor used as an electrical generator.

An alternator is a type of alternating current (AC) electrical generator. The devices are often physically equivalent. The principal difference is in how they are used and which direction the energy flows. An alternator converts mechanical energy to electrical energy, whereas a motor converts electrical energy to mechanical energy. Like most electric motors and electric generators, the linear alternator works by the principle of electromagnetic induction. However, most alternators work with rotary motion, whereas "linear" alternators work with "linear" motion (i.e. motion in a straight line).

Theory :

When a magnet moves in relation to an electromagnetic coil, this changes the magnetic flux passing through the coil, and thus induces the flow of an electric current, which can be used to do work. A linear alternator is most commonly used to convert back-and-forth motion directly into electrical energy. This short-cut eliminates the need for a crank or linkage that would otherwise be required to convert a reciprocating motion to a rotary motion in order to be compatible with a rotary generator.

Applications :

The simplest type of linear alternator is the Faraday Flashlight. This is a torch (UK) or flashlight (USA) which contains a coil and a permanent magnet. When the appliance is shaken back and forth, the magnet oscillates through the coil and induces an electric current. This current is used to charge a capacitor, thus storing energy for later use. The appliance can then produce light, usually from a light-emitting diode, until the capacitor is discharged. It can then be re-charged by further shaking.

Other devices which use linear alternators to generate electricity include the free-piston linear generator, an internal combustion engine, and the free-piston Stirling engine, an external combustion engine.

UNIT - IV

PART - A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

PART - B (2 MARKS)

1. Write a note on cell.
2. Write a note on batteries.
3. What are the applications of electromagnetic energy?
4. Give a short note on any two renewable energies.
5. State briefly about geothermal energy.
6. Give a note on electromagnetic energy.

PART - C (6 MARKS)

1. How the energy is harvesting from electromagnetic effect?
2. Describe about geothermal energy?
3. Write a short note on renewable energy sources?
4. Give the importance about renewable sources of energy?
5. Write the different type of renewable energy sources and give the examples.
6. Explain why we need the renewable energy?

KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF PHYSICS
II B.Sc., PHYSICS (2018-2021)
:NEWABLE ENERGY AND ENERGY HARVESTING (16PHU304A)

QUESTIONS	CHOICE 1	CHOICE 2	CHOICE 3	CHOICE 4
UNIT - IV				
The differences in __________ gradients induce circulation of air	pressure	temperatur	height	humidity
The global circulation of the atmosphere occurs in ________ dist	five	three	six	two
It has been estimated that roughly ____________ millions megav	100	150	60	10
A largest wind generator built in recent times was the 800 KW un	china	france	india	america
Wind energy is one of the ______________'s greatest natural so	america	france	india	australia
In ____ the interest in the wind mills was shown in the last fifties a	india	france	italy	japan
Data quoted for india wind speed value lies between _________k	15-20	20-30	10 to 15	1 to 10
Dry cells provide energy at the astronomical cost of about Rs. __	200	100	50	300
____________ wind farm projects of aggregate capacity of 53 MV	9	6	7	10
The power in the wind can be computed by using the concept of _	kinetics	mechanics	photometry	photoelasti
The wind mill works on the principle of converting __________ of	kinetic ene	potential er	thermal en	mechanical
Power is equal to ___________ per unit time	work	energy	speed	acceleratio
The miaximum conversion rate is ______ of the energy of wind	15/27	16/32	16/34	16/27
Fraction of the available energy that is converted is called the __	transmissic	mechanica	power coef	electrical e
Wind power is measured by wind mill type devices or ______	scintillators	anemomet	endiometer	bolometer
Convertible power P is proportional to __________ of the wind sp	cube	square	square roo	cube root
If wind speed decreases by 20% the powere output is reduced by	200	100	50	300
________ wind farm projects of aggregate capacity of 53 MW ha	40%	50%	80%	10%
Wind speed ___________ with height above ground	decreases	increases	does'nt cha	equal
The average value of wind energy on the sea coast is _________	2500	2000	2400	1300
The best sites for wind energy are found off shore and on the ___	sea coast	plains	mountains	desert regi
The second best site for wind energy are ___________	plains	plateau	mountains	humid equi
Among the following the lowest level of the wind energy is found i	plains	mountains	off shore	sea coast
In the humid equitorial region, there is _______ wind energy	very high	very low	no	none
In _________ wind energy may not be usual because of the frequ	Japan	china	Italy	Russia
___________ is a renewable source of energy	fuel	wind energ	coal	LPG
_________________ power systems are non-polluting	electrical	fuel	wind	hydroelectr
______________ energy systems avoid fuel provisions and trans	chemical	wind energ	electrical	mechanical
Horizontal type wind mills are also refered to as ___________	wind axis r	cross wind	darrieus ty	savonius rc
_____________ is vertial axis type wind mill	wind axis r	savoniums	Dutch type	Darrious ty
In horizontal axis type wind mill the rotors are oriented ________	horizontal	in same dir	normal	vertical plai
____________ requires low velocity winds	Savonius	Darrieous	bladed	Vertical axi
Savonius rotor type wind mill was invented by S.J. Savonius in th	1935	1925	1960	1920
___________ produces power effectively in winds as slow as 8 k	Darrieous r	Savonius r	sail type	vertical axis
Rotors with more than ______ blades would have slightly higher p	1	2	10	15
_____________ types have been mainly used in the electric pow	vertical axi	Darrieous	Savonius	horizontal a
Number of blades is _________________ to the Cp maximum	directly pro	equal	inversely p	infinite
At about ___________ m/s the rotor is fused to avoid damage	50	10	20	30
The total systems efficiency of a wind generator amount to _____	3 to 18	1 to 5	3 to 7	2 to 8
_________ have a typical average of wind energy of 750 kWh/m2	plains	mountains	plateau	off shore
Convertible power of energy is _________ to the cube of the winc	proportiona	not proport	equal	moderate

	ANSWER
	temperature
	five
	10
	france
	america
	india
	15-20
	300
	9
city	kinetics
l energy	kinetic energy
n	energy
	16/27
fficiency	power coefficient
	anemometers
	cube
	300
	50%
	increases
	2400
on	sea coast
torial region	mountains
	plains
	no
	Japan
	wind energy
ic	wind
l	wind energy
otor	wind axis rotors
pe	savoniums rotor
ne	normal
s machine	Savonius
	1920
s type	Savonius rotor
	2
axis type	horizontal axis type
	inversely proportional
	30
	3 to 7
	plains
	proportional

UNIT- V

SYLLABUS

Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications, Geothermal Energy: Geothermal Resources, Geothermal Technologies. Carbon captured technologies, cell, batteries, power consumption, Environmental issues and Renewable sources of energy, sustainability.

Energy Harvesting from Electromagnetic Energy

Many schemes have been proposed recently focusing in the development of systems capable of harnessing useful electrical energy from existing environmental sources, especially in the wireless sensor networking community. Photo-Voltaic conversion of visible part of the electromagnetic spectrum to electrical power is well established and Photo-Voltaic cells provide relatively high efficiency over a broad range of wavelengths. These devices are typically low cost and provide voltage and current levels that are close to those required for micro-electronics. Conversion of ambient RF signals to useful electrical energy is far more challenging due to the broadband, low intensity nature of the signals typically present. An example of a system drawing energy from RF signals are crystal radio kits that draw their power directly from AM radio stations, which play audibly through high-impedance headphones without needing a local energy source.

One of the examples of similar harvesting scheme is the aftermarket modules that flash LED's using energy from electromagnetic waves when a cell phone uses its radio. Rather than relying on the limited energy scavenged from ambient radiation, other approaches actively beam power from a transmitter to remote devices. The dream of wirelessly broadcasting power to an urban area dates back to the turn of the 20'th century and Nicola Tesla, who experimented with grandiose concepts of global resonance and gigantic step-up coils that radiated strong, 150 kHz electromagnetic fields able to illuminate gas-filled light bulbs attached to a local antenna and ground at large distances. Recently researchers have experimented with microwave transmission of power in domestic environments. At much lower power levels, short-range wireless power transmission is now commonplace in passive Radio Frequency Identification (RFID) systems, which derive their energy inductively, capacitively or radiatively from the tag reader.

Researchers have explored the possibility of extracting power from the magnetic fields from high-voltage power lines. Many of these techniques use a current transformer to convert the magnetic fields to usable current. A recent work describes energy harvesting from power lines attached to electric motors. Solutions based on current transformers require that the single current carrying wire be passed through it. There are some commercial products which can be snapped on a high-voltage single wire. All similar techniques are quite limited in applications because of their placement constraints. Recently, Anthony Rowe et al. designed an LC tank based receiver circuit tuned to the AC 60Hz and used the received signal for clock synchronization.

In this paper, we investigate the feasibility of harvesting energy from the magnetic fields emanating from the AC power lines in addition to synchronization. Average available power from this harvesting scheme is lower than the requirements of a typical sensor node, so the node should only be turned on when enough energy has been accumulated for the useful work. The mismatch in duty-cycles and wake-up times of different nodes in a network will severely constrain the coordination among nodes. Therefore, by powering a wireless sensor device through the magnetic fields we can also exploit the dual advantage of maintaining the clock synchronization using the same signal. It was established in that nodes may remain synchronized for long periods of time without exchanging messages because of the global clock from the EM fields. However, other energy harvesting schemes with limited available power may not be practical if frequent communication is required just to maintain the clock synchronization.

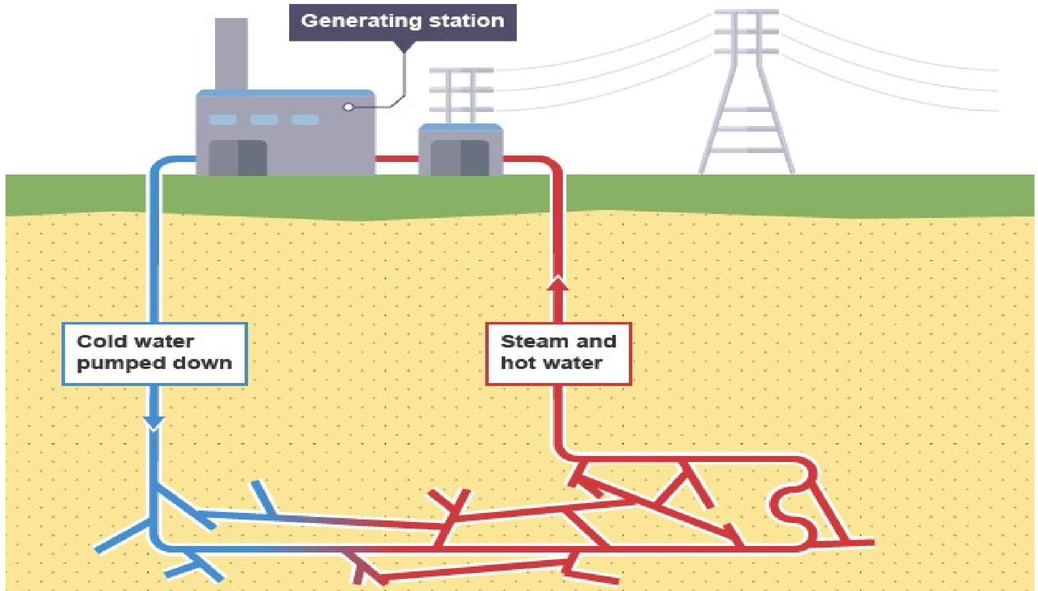
We need to measure the average power that can be extracted from the magnetic fields emanating from AC power lines, in order to understand the feasibility of proposed energy harvesting system. We conducted controlled experiments where we observed the power available from various arrangements of current carrying conductors and configuration of inductors in the magnetic field associated with the conductors.

We laid two parallel conductors on a graduated flat board, and these conductors were used to power a load consisting of ten light bulbs of 100 Watts each in parallel. When the complete load is applied, a current of 8.4 Amps flows through the conductors. We explored many inductors for conducting our experiments. The results presented in the paper are using two inductors with inductance values of L = 15H and L = 4.50H. The experiments for each of the inductors were conducted separately in order to avoid any magnetic coupling effects. We present the results for the following experiments: Measured induced voltage on the inductors for varying distances from a pair of conductors, where the distance between the conductors is very high (> 15 inches). Change the supplied load and measure the induced voltage. Keep the conductors at a distance of one inch apart with the inductors between the conductors and measure the variation of the induced voltage along with the height of the inductors from the plane of the conductors. Measure the voltage induced on the inductor when placed over a bunch of wires passing in a metal conduit typically seen in buildings.

Limitations

Not unlike many other energy harvesting schemes, there are some limitations of using magnetic fields of the AC power lines. Firstly, magnetic field strength from the power lines is significant only in their close proximity, which limits the freedom of placement of harvesting system close to the AC wires. However, we can extract power even if the wires are laid inside the wall and the device is placed on the wall at a distance of few(2-3) inches. If the power cables are deployed in metal conduits then most of the magnetic field is constrained inside it, which nullifies any possibility of harvesting energy. Second limitation of the system is that a highly efficient power transfer circuit is required to store charge in a super-capacitor with minimum losses.

Geo thermal energy :



The Earth's heat-called geothermal energy-escapes as steam at a hot springs in Nevada. Credit: Sierra Pacific

Geothermal energy is the heat from the Earth. 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.

Almost everywhere, the shallow ground or upper 10 feet of the Earth's surface maintains a nearly constant temperature between 50 °F and 60 °F (10 °C and 16 °C). Geothermal heat pumps can tap into this resource to heat and cool buildings. A geothermal heat pump system consists of a heat pump, an air delivery system (ductwork), and a heat exchanger-a system of pipes buried in the shallow ground near the building. In the winter, the heat pump removes heat from the heat exchanger and pumps it into the indoor air delivery system. In the summer, the process is reversed, and the heat pump moves heat from the indoor air into the heat exchanger. The heat removed from the indoor air during the summer can also be used to provide a free source of hot water.

In the United States, most geothermal reservoirs of hot water are located in the western states, Alaska, and Hawaii. Wells can be drilled into underground reservoirs for the generation of electricity. Some geothermal power plants use the steam from a reservoir to power a turbine/generator, while others use the hot water to boil a working fluid that vaporizes and then turns a turbine. Hot water near the surface of Earth can be used directly for heat. Direct-use applications include heating buildings, growing plants in greenhouses, drying crops, heating water at fish farms, and several industrial processes such as pasteurizing milk.

Hot dry rock resources occur at depths of 3 to 5 miles everywhere beneath the Earth's surface and at lesser depths in certain areas. Access to these resources involves injecting cold water down one well, circulating it through hot fractured rock, and drawing off the heated water from another well. Currently, there are no commercial applications of this technology. Existing technology also does not yet allow recovery of heat directly from magma, the very deep and most powerful resource of geothermal energy.

Advantages :

1) It is a renewable source of energy.
2) By far, it is non-polluting and environment friendly.
3) There is no wastage or generation of by-products.
4) Geothermal energy can be used directly. In ancient times, people used this source of energy for heating homes, cooking, etc.
5) Maintenance cost of geothermal power plants is very less.
6) Geothermal power plants don't occupy too much space and thus help in protecting natural environment.
7) Unlike solar energy, it is not dependent on the weather conditions.

Disadvantages :

1) Only few sites have the potential of Geothermal Energy.
2) Most of the sites, where geothermal energy is produced, are far from markets or cities, where it needs to be consumed.
3) Total generation potential of this source is too small.
4) There is always a danger of eruption of volcano.
5) Installation cost of steam power plant is very high.
6) There is no guarantee that the amount of energy which is produced will justify the capital expenditure and operations costs.
7) It may release some harmful, poisonous gases that can escape through the holes drilled during construction.

Carbon capture technology :

CCS, or Carbon Capture and Storage, is a working low carbon technology which captures carbon dioxide (CO2) from the burning of coal and gas for power generation, and from the manufacturing of steel, cement and other industrial facilities, and transports it by either pipeline or ship, for safe and permanent underground storage, preventing it from entering the atmosphere and contributing to anthropogenic climate change.

There are three stages to CCS: capture, transport, and safe underground storage.

Capture – First, the carbon dioxide is removed, or separated, from coal and gas power plants, and from the manufacturing of steel and cement. There are three types of capture; post-combustion, pre-combustion and oxyfuel combustion. This is called carbon dioxide capture and can captures 90% of carbon dioxide emissions.

Transport – The carbon dioxide is then compressed and transported to a suitable storage site. The transport is generally carried out in pipelines. Ship transport is also an option for offshore carbon dioxide transport.

Storage – The carbon dioxide is the injected into a suitable storage site deep below the ground. The storage site must be a geological formation that ensures safe and permanent storage. Storage can either take place in depleted oil & gas fields, or deep saline formations.

Carbon capture is divided into two main areas:

Carbon Capture and Storage (CSS)

Bio Carbon Capture and Storage (Bio CSS)

Carbon Capture and Storage (CSS)

CSS is the process of capturing and storing CO_2 emissions from power plants and industrial manufacturing plants. There are three methods for CSS, which are:

Post-combustion

Precombustion

Oxy-fuel combustion

Post-combustion involves capturing waste gases by adding a filter to the smoke stack of power and manufacturing plants. The captured gases (called flue gases) are processed to extract CO_2, which then gets shipped to a storage area. This process recovers 80 to 90 percent of the waste CO_2. The advantages include being able to retrofit older styled plants with this system. The disadvantages include that the final CO_2 extraction and preparation for storage process is energy intensive.

Pre-combustion, as the name implies, involves capturing CO_2 before a fossil fuel is burned. This process involves extracting CO_2 by partially oxidizing the fuel in a gasifier, which results in the separation of CO_2 from CO (carbon monoxide) and H_2 (Hydrogen). The hydrogen can then be used as fuel. Approximately 80 to 90 percent of CO_2 is captured this way. The advantages include that the process is relatively inexpensive. The disadvantages include that the process cannot be retrofitted to older plants.

Oxy-fuel combustion involves burning fossil fuels in pure oxygen instead of air, which creates CO_2 and water vapor. The water vapor is condensed leaving almost pure CO_2, which can then be transported to a storage area. This process captures about 90 percent of the CO_2. The advantages include an effective method of carbon capture. The disadvantages include the cost of supplying pure oxygen.

Carbon storage

All three of the above carbon capture processes require that the captured CO_2 be stored. Carbon storage is an area that is still under development and full of questions. There are two main areas for CO_2 storage: underground and under water.

Underground storage includes injecting CO_2 into:

- Oil fields
- Gas fields
- Saline formations
- Basalt formations
- Sandstone reservoirs

Although the technology exists to accomplish CO_2 storage in these types of geological formations there remain many unknowns, e.g., the long term effects of stored CO_2 on these areas and the potential for leakage. In most cases storing CO_2 involves unrecoverable costs.

On the other hand, there is plenty of space for storage. It has been estimated that in the U.S. alone there is enough underground CO_2 storage area to last 500 years.

Under water CO_2 storage techniques include:

Dissolution:

Injecting CO_2 to depths greater than 1000 m, where the CO_2 dissolves

Lake:

Injecting CO_2 to depths below 3000 m where a CO_2 "lake" forms due to the CO_2 being heavier than water

Storing CO_2 as clathrate hydrates:

Under high pressure and low temperature, e.g., the deep ocean floor, CO_2 becomes a negatively buoyant icy compound called clathrate hydrate

Techniques for storing CO_2 under water are less well understood than those for underground storage and pose many questions including:

Electrical Cell:

Electrical Cell is a power generating device which converts the stored chemical energy into electrical energy. Is it the combination of electrodes and electrolytes, where a difference of certain electric potential is established between the electrodes as a result of the chemical reaction between the electrodes and electrolytes.

The difference in the electric potential between electrodes in an electrical cell depends upon the types of electrolytes and electrodes used.

1. Primary Cell:

An Electrical cell which is powered by the irreversible chemical reaction is called Primary Cell. Since the primary cell is powered by irreversible chemical reaction , It cannot be recharged after being used so it can be used only once and need to be disposed off after single use. Most of the primary cell contains their electrolytes in solid form absorbed within some absorbent material so these kind of cells are also called Dry Cell.

2. Secondary Cell:

The Electrical Cell which can be electrically recharged after being used is called secondary cell. These kinds of cells are powered by reversible chemical reaction and the state of Electrodes and Electrolyte can be reversed to its original form by applying external power source after being used. Secondary Cells usually have high discharge rate performance compared to Primary cell, and can be used with high loads that requires good discharge rate performance.

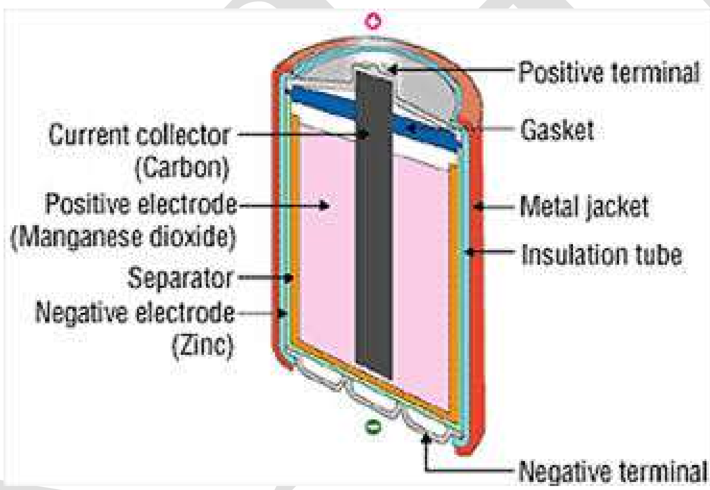
3. Reserve Cell:

The types of cells where one of the key components of the cell is separated from the rest of the components until activated manually or by some automatic means is called reserve cell. These kinds of cell remain deactivated and nonfunctional until it is activated manually or by some means like heat, water or other means. One example is thermal cell where the electrolyte remains inactive in its solid form until the heat applied melts the electrolyte to activate the cell.

4. Fuel Cell:

A Fuel Cell is the kind of cell where the chemical energy from a fuel fed into the cell is converted into electrical energy through a chemical reaction with oxidizing agent. The fuel that is fed into a fuel cell can be Hydrogen , Hydrocarbons, Natural gas etc. A fuel cell can produce electricity as long as the fuel and the oxidizing agent is fed into the fuel cell.

Battery:



A single unit of electro-chemical generator is known as Electrical Cell, while the combination of several such units connected electrically is known as a Battery. Several cells are combined and connected electrically in series or parallel to form a battery which has two main terminal electrodes one Positive and one Negative. The electrical potential difference between the two main electrodes depends upon the numbers of cells , types of cells and the types of combination used to form the battery.

Types of Battery:

Based on the electric properties batteries can be classified into two main groups:

Primary Battery:

Primary battery is the type of battery which is made up of primary cells. The energy is inherently present in the cells of Primary Battery. These kinds of batteries are non-rechargeable and are for single time use. Examples of primary battery are: Leclanche battery, zinc-chlorine battery, alkaline-manganese battery, metal air battery etc.

Secondary Battery:

Secondary battery is the type of battery which is made up of secondary cells. The energy is induced in the chemicals of the cells of the secondary battery by applying external energy or sources prior to using it. Examples of secondary battery are: lead-acid battery , nickel cadmium battery, nickel-iron battery etc.

Secondary cells are used in a variety of places due to it's chemical and physical properties. The secondary batteries can also be classified into following types based on their use:

1. Automotive / SLI / Portable Batteries.

These kinds of batteries are used in automobiles and portable systems. The battery is used for Starting, Lighting & Ignition (SLI) in automobiles. Examples of Automotive or SLI or Portable batteries are: lead-acid batteries, nickel-cadmium batteries etc.

2. Vehicle Traction / Motive Power / Industries Batteries.

These kinds of batteries are used to power battery powered vehicles or to power various high power devices in industries. These kinds of batteries have high energy density in the range of 100-120 Watt Hour / Kilo Gram. Batteries like Lead-acid batteries, nickel-iron batteries silver-zinc batteries etc falls in this kind and also various high-temperature batteries are under development which also falls under this kind of batteries.

3. Stationary Batteries.

These kinds of batteries are used in stationary systems, Such as standby power systems and load-leveling systems. These kinds of batteries are used to store power when load is low or extra power is available and provide extra power to the system when load is very high or no power is available.

Environmental Sustainability :

Environmental sustainability icon to define environmental sustainability we must first define sustainability. Sustainability is the ability to continue a defined behavior indefinitely. To define what environmental sustainability is we turn to the experts.

Herman Daly, one of the early pioneers of ecological sustainability, looked at the problem from maintenance of natural capital viewpoint. In 1990 he proposed that:

1. For renewable resources, the rate of harvest should not exceed the rate of regeneration (sustainable yield);
2. The rates of waste generation from projects should not exceed the assimilative capacity of the environment (sustainable waste disposal); and
3. For nonrenewable resources the depletion of the nonrenewable resources should require comparable development of renewable substitutes for that resource.

This list has been widely accepted. It's an elegant abstraction, one that made me pause and read it three times when I first encountered it.

The list can be shortened into a tight definition. Environmental sustainability is the rates of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely. If they cannot be continued indefinitely then they are not sustainable.

UNIT - V

PART - A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

PART - B (2 MARKS)

1. Write a note on batteries and applications.
2. Give a short note on any two renewable energies.
3. State electromagnetic effect.
4. Write the needs of the renewable energy?
5. Write the examples of different type of renewable energy sources.
6. Give the applications of renewable energy.

PART - C (6 MARKS)

1. What are the applications of electromagnetic energy?
2. Give the importance about renewable sources of energy?
3. Describe about renewable energy?
4. Write a short note on renewable energy sources?
5. Give the examples of renewable and non renewable sources.
6. Explain the energy is harvesting from electromagnetic effect?

KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF PHYSICS
II B.Sc., PHYSICS (2018-2021)
:NEWABLE ENERGY AND ENERGY HARVESTING (16PHU304A)

QUESTIONS	CHOICE 1	CHOICE 2	CHOICE 3	CHOICE 4
UNIT - V				
Focussing collector is a device to collect solar energy with _____	low intensit	high intens	medium int	moderate ir
The main advantages of concentrated systems over flat plate coll	structural s	smaller abs	higher attai	all the abov
Concentrator is a component used to increase the intensity of __	concentrati	intensity of	incident rac	high intensi
All optical systems form an image of the sun on the receiver beca	very small a	large angle	no angle is	moderate a
In plane reflector and plane receiver type	Both reflec	reflector is	reflectors a	concentrati
Parabolic system have receiver	beyond the	at the focal	nearer to th	behind the
Parabolic systems are used where_________	low temper	high tempe	optimum te	in all cases
In parabolic systems concentration ratio is _________	very low	medium	very high	moderate
The concentration ratio in Fresnel lenses is about __________	1	100	5	10
Fresnel reflector consists of an ___________	Both reflec	parabolic s	reflector is	reflector is
Concical reflector and cylindrical receiver type _______________	both reflect	parabolic s	reflector is	cylindrical
In a cylindrical system, the concentration is _________ than para	lower	higher	medium	moderate
Focussing collectors permit _________ temperature energy colle	lower	medium	proportiona	higher
The most critical properties for a concentrating collector are ____	reflectance	transmittan	absorptivity	all the abov
In focussing collector systems, the thermal losses are ________	higher	lower	medium	moderate
Concentration ratio is the ratio of the _________ of the concentra	volume	mass	area	height
Fresnel reflector consists of a parabolic shape reflector made up	small	large	medium	moderate
In a central receiver the fill factor is about _______%	50	60	40	80
The compound parabolic concentrator consists of ____________	three	four	two	six
Compound parabolic concentrator reflectors can be designed for	flat one-sid	flat two-sid	wedge like	all the abov
The heat flux in a focussing system is __________	low	high	medium	infinte
___________ was developed by Winston	Compound	line focussi	fresnel lens	point focus
With concentric turbulence absorber with an evacuated jacket, te	150	500	200	350
The efficiency for accepting diffuse radiation in compound parabo	medium	larger	smaller	above 50%
In solar heating and cooling applications the _______ temperatur	lower	medium	higher	moderate
The total useful operating time per year can be ________ for a co	proportiona	small	medium	large
The word ______________ will be applied to the total system inc	absorber	covers	collector	porous abs
The linear focus collector in the forms of ________ through or the	spherical	conical	parabolic	fresnel lens
Winston collector is also known as __________	flat plate co	compound	Fresnel len	line focussi
The reflectors can be designed for the following absorber type	flat one-sid	flat two-sid	wedge like	all the abov
Focussing collector differ in their thermal behaviour from the flat-p	the temper	the edge ef	radiation flu	all the abov
For choice of materials, the most critical properties for a concentr	the reflecta	the transmi	absorptivity	all the abov
In non-evacuated collector when emissivity is reduced below 0.2	conduction	conductors	radition dor	convection
Higher efficiency in terms of utilisation area is for ___________	fresnel lens	line focussi	paraboliods	point focus
Radiation losses are small because of ____________	large area	high therma	small area	at the focal
The parabolic system double reflection system is used ________	to shift the	increase th	decrease th	behind the
Maximum concentration for paraboloidal systems are of the order	10	100	1000	10000
In CPC reflectors for economic as well as for thermal reasons the	flat one sid	tubular type	wedge like	flat two side
Winston collector are capable of competetive performance at higl	300	500	800	100

	ANSWER
ntensity	high intensity
'e	all the above
ity	intensity of energy flux
ngle	very small angle subtended by the sun at any point on the earth
on ratio may be of the (	Both reflector and receiver are plane
reflector	at the focal point
	high temperature are required
	very high
	10
cylindrical	parabolic shape reflector made up of small segments
	reflector is conical and receiver is cylindrical
	lower
	higher
'e	all the above
	lower
	area
	small
	40
	two
'e	all the above
	high
sing	Compound parabolic concentrator
	200
	larger
	higher
	large
orbers	collector
;	parabolic
ng collector	compound parabolic concentrator
'e	all the above
'e	all the above
'e	all the above
dominate conduction l(	conduction and convection will begin to dominate radiative losses
sing type	paraboliods
point	small area of absorber at the focus
focal point	to shift the focus to a convinient point
	10000
ed absorbers	flat one sided absorber are preferable
	300