LECTURE NOTES ON

RENEWABLE ENERGY SOURCES

6TH SEMESTER ETC

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ENERGY SITUATION AND RENEWABLE ENERGY SOURCES

→ There are two major categories of energy:
i) Renewable energy resources
ii) Non-Renewable energy resources

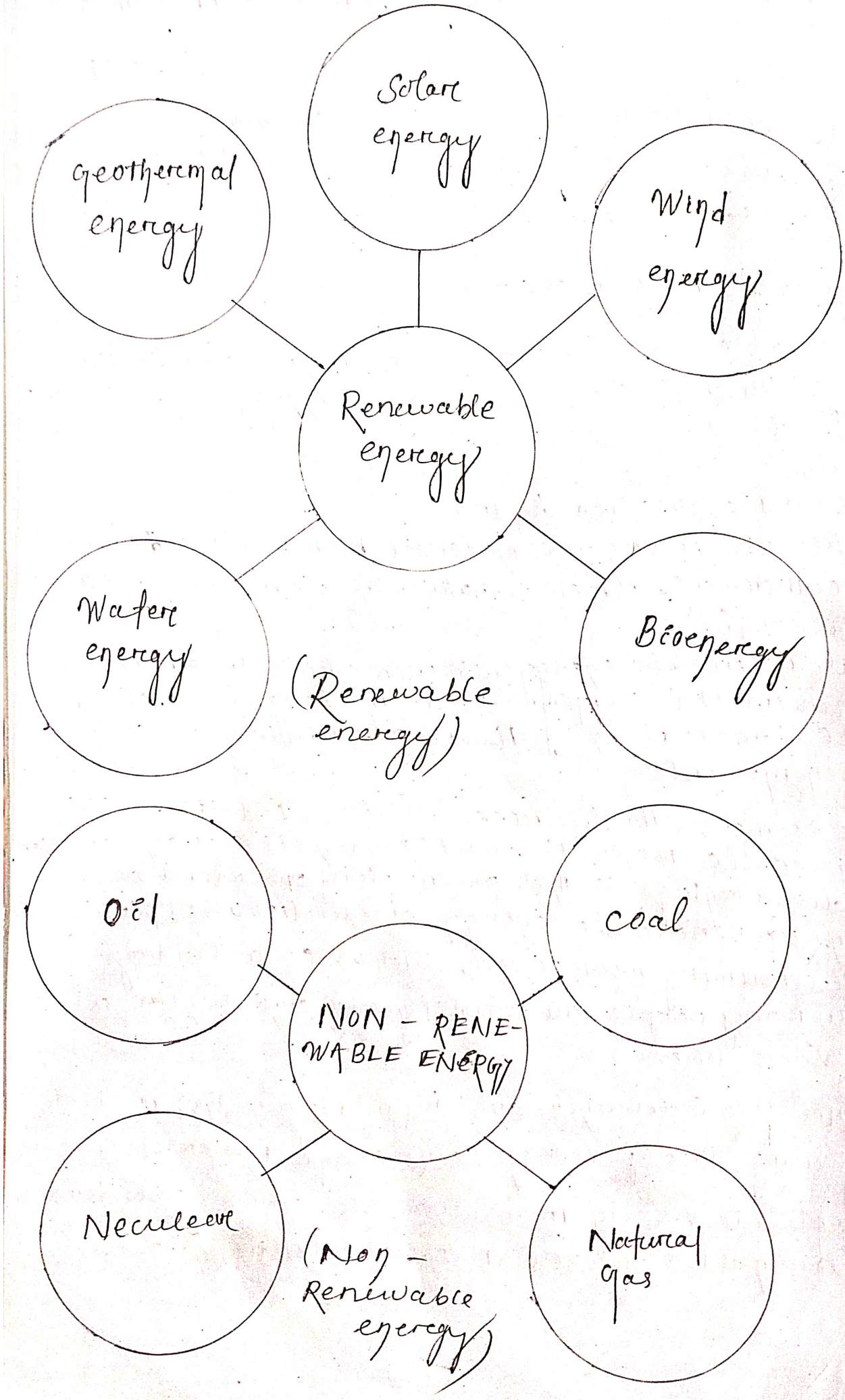
Renewable resources

Renewable resources, on the other hand, replenish themselves. The five major renewable energy resources are:
→ Solar
→ Wind
→ Water, also called hydro
→ Biomass, or organic material from plants and animals
→ Geothermal, which is naturally occurring heat from the earth.

While renewable energy resources have the advantage of unlimited supply over the long haul, they are limited in their availability at any given moment.

For example, the sun rises each day, but its ability to generate power is limited when it's cloudy. Another disadvantage is that power plant operators can't crank up renewable energy production when people are consuming more power, such as on a hot day when many people are running air conditioners at the same time.

States like California are trying to solve this problem by using energy storage, like large batteries, to collect electricity from renewable source when demand is low in order to use it later when demand goes up.


Solar energy
Geothermal energy
Wind energy
Renewable energy
Water energy
Bioenergy
(Renewable energy)
Oil
coal
NON - RENEWABLE ENERGY
Nuclear
Natural gas
(Non - Renewable energy)

Non-renewable Energy and Climate change

Non-renewable energy resources are available in limited supplies, usually because they take a long time to replenish. The advantages of these non-renewable resources is that power plants that use them are able to produce more power on demand. The non-renewable energy resource are:

- Coal
- Nuclear
- Oil
- Natural

When coal, natural gas and oil are burned to produce energy. They emit heat-trapping gases such as carbon dioxide. This process of trapping heat is what drives climate change, and the failure to address this problem is what's catalyzing the current climate crisis.

Fossil fuels are hydrocarbon-containing materials like coal or gas that are found in the earth's crust and formed in the geological past from the remains of living organisms. These energy sources account for the majority of the world's greenhouse gas emission.

Scientists say this increase in the temperature would threaten life on the planet in a myriad of ways, including severe water shortages; more air pollution; rising sea levels; habitat loss; heat waves; melting ice sheets in west Antarctica and Greenland; and destruction of the world's coral reefs.

Energy and Environment

Energy exists in various forms including mechanical, thermal, chemical, electrical, gravitational, and nuclear, which are all interconvertible. Mechanical energy results from movement and is the combination of kinetic and potential energy. Thermal energy is the outcome of temperature differences between two systems. Electromagnetic energy (also called radiant energy) is the outcome of electromagnetic waves, such as light emitted by the sun. Gravitational energy is the foundation of mechanical energy derived from the attraction of two masses, the earth being the most significant.

Forms of energy comes from sources qualified as renewable and non-renewable, which include chemical reactions (mainly combustion), nuclear reactions (fission or fusion), the effect of gravity (mainly tidal), and direct (photovoltaic) and indirect (photosynthesis, wind, and hydraulic) solar energy conversion.

ENVIRONMENT → The term environment has been derived from a French word "Environ" means to surround. It refers to both Abiotic (physical or non-living) and Biotic (living) environment. The word environment means surroundings. In which organisms live. Environment and the organisms are two organised and complex component of nature. Environment controls the life of the organisms including human

beings. Human beings beings interact with the environment more rigorously than other living beings. Ordinarily environment refers to the materials and forces that surround the living organism.

Environment can be defined as the surrounding or conditions in which a person, animal, or plant lives or operates. The term "environment" refers to all elements of the physical and biological world, as well as the interactions between them, Environment plays preeminent role in the life cycle of human being as human life is highly dependent on environment. Environment has productive value. Aesthetic / Recreational value :- which has been explained latter on under the paragraph of "What Environment does for us".

Origin of renewable energy source

The contribution of renewable energy demand was 19% in 2013. Today, renewable energy sources account for 23% of the global electricity generation [2].

See the gap. Fossil fules still provide 77% of the global electricity demand.

Think of how far away we are from our dream of 100% renewable energy.

Is it possible to replace fossil fuels with renewables 100%?

Prior to answer this question, let's take a look at some real global energy facts.

→ Global energy demand was around 17.5TW in 2010,
→ its milestone of 63 TW by next century (2100) according to the recent estimations.
→ It seems to be a bullish jump by more than 45TW.

Global energy demand is not something at rest but a rapidly increasing demand.

It is crystal clear that a single source of renewable energy cannot replace the demand for fossil fuels. Nothing to worry! There are plenty of renewable energy source around us. They can provide more than enough energy we need. Now let's talk about different forms of renewable energy and how much of energy they can provide us.

The Potential of Renewable Energy Source

India become the world's third largest producer of electricity in the year 2013 and accounts for 4.8% of global share in electricity generation. But its per capita electricity consumption. But its per capita electricity consumption is only

746 KWh, which is lower compared to many countries through electricity ~~tariff~~ tariff is cheaper in India.
-Lekha Chandran

November 5, 2015 → India became the world's third largest producer of electricity in the year 2015 and accounts generation. But its per capita electricity consumption is only 746 KWh, which is lower compared to many countries, through electricity tariff is cheaper in India. energy is the basic input in all cheaper in India.

Energy is the basic input in all sectors of the nation's economy, and the standard of living is directly related to per capita energy consumption. As the country is heavily polluted, provision of adequate quantities and kinds of energy is a challenge to the government, and the institutions in the country engaged in tasks relating to energy supply and transport. The commercial energy inputs to the Indian economy are from conventional sources like coal, hydroelectricity and nuclear energy. The country currently has total installed capacity of thermal 70%, hydroelectric 16%, nuclear 2% and renewable 12% for long term sustainability minimum utilisation of fossil fuel for energy and maximum utilisation of renewable energy are to be considered. At the same time, minimum losses during generation transport and utilisation sector is also important.

Direct - use Technology

The natural energy flows through the earth's ecosystem, and the geographical and technical potential of what they can produce for human needs, exceeds current energy use by many times (approximately 425 EJ in 2002). But in order to place renewable energy resources in perspective it is important to examine the long-term energy resource availability from the viewpoint of theoretical maximums, or ultimately recoverable resources. This is known as the theoretical potential. Admittedly, it can be argued that an analysis based on recoverable resources is irrelevant because hydrocarbon occurrences or natural flows become resources only if there is demand for them and appropriate technology has been developed for their conversion and use. The appraisal of technical potential therefore takes into account engineering and technological criteria. In any case, the picture is clear, renewable energy resources are immense and will not act as a constraint on their development.

Introduction

→ The degree of development and civilisation of country is measured by the utilization of energy by human beings for their needs.

→ The rate of energy consumption is increasing rapidly and supply is depleting rapidly, which results in inflation and shortage of energy. This is called energy crisis.

Classification of energy resources

→ Energy classification maybe based on its nature availability and storing capacity.

Comercial and Non comercial resources

→ These are also called as primary energy resources.
→ These are available in nature in a raw form Ex: Coal, natural gas, petroleum, wind and water etc.
→ The other resources which is fully available to us like solar energy, agricultural waste etc are known as non-comercial energy resources.
→ Hydro electric power and nuclear power also comes under comercial resources.

Renewable and Non-renewable Energy

→ Renewable resources are those which can be used to produced energy again and again.
Ex: Solar, geothermal, tidal energy etc.
→ Non-renewable resources can not be replaced once they used. ex: coal, petroleum, natural gas etc.
→ These energy resources are limited and could be exhausted within prescribed period of time.

Conventional and Non-conventional energy resources

→ Coal, oil, and gas are commonly known as conventional energy resources.

→ The conventional energy resources are limited due to their insufficient availability.

→ The scope of meeting the huge energy demand, non conventional energy are required. such as: agricultural waste, solar, wind, tide etc.

→ The non-conventional energy resources can not be easily stored.

→ But conventional energy resources can be stored.

Solare Radiation & Collectors

Solare Radiation through Atmosphere

→ The Sun is a hot sphere of gas heated by nuclear fusion reaction at it centere.

→ Everey second the Sun emits a total energy flow of about 4×10^{23} kW out of which only a verey small fraction reaches the earth.

→ Solare radiation is the electromagnetic radiation emitted by the Sun.

→ This radeation can be converted into useful forem of energy, such as hit and electricity, by the different type of technology.

→ The electromagnetic radeation emitted by the Sun is devided into 2 catagories.

→ Ionizing radeation (x-rays and Gamma rays)

→ Non ionizing radeation (UVR, visible and infrared radeation)

→ The highly insereation ionizing radeation doesn't the earth's atmosphere.

→ As sunlight passes through a atmosphere some part of it is absorved, scattered and reflected by aire molecule, watere vapours, clouds, dust and pollutencie, this is called diffuse Solare radeation.

→ The diffuse solare radeation doesnot have can unique path.

→ The solare radeation that reaches the surface of the earth without being diffuse is called direct beam Solare radeation.

→ The Sum of the diffuse and direct Solare radeation is called total radeation global Solare radeation.

→ For any spot earth is surface, the amount of energy it receives will vary on an hourly, daily, and seronal bases.

→ θ_1 is the angle of sun position in the sky relative to a point earth surface that determine that intencity of sunlight reaches that spot.

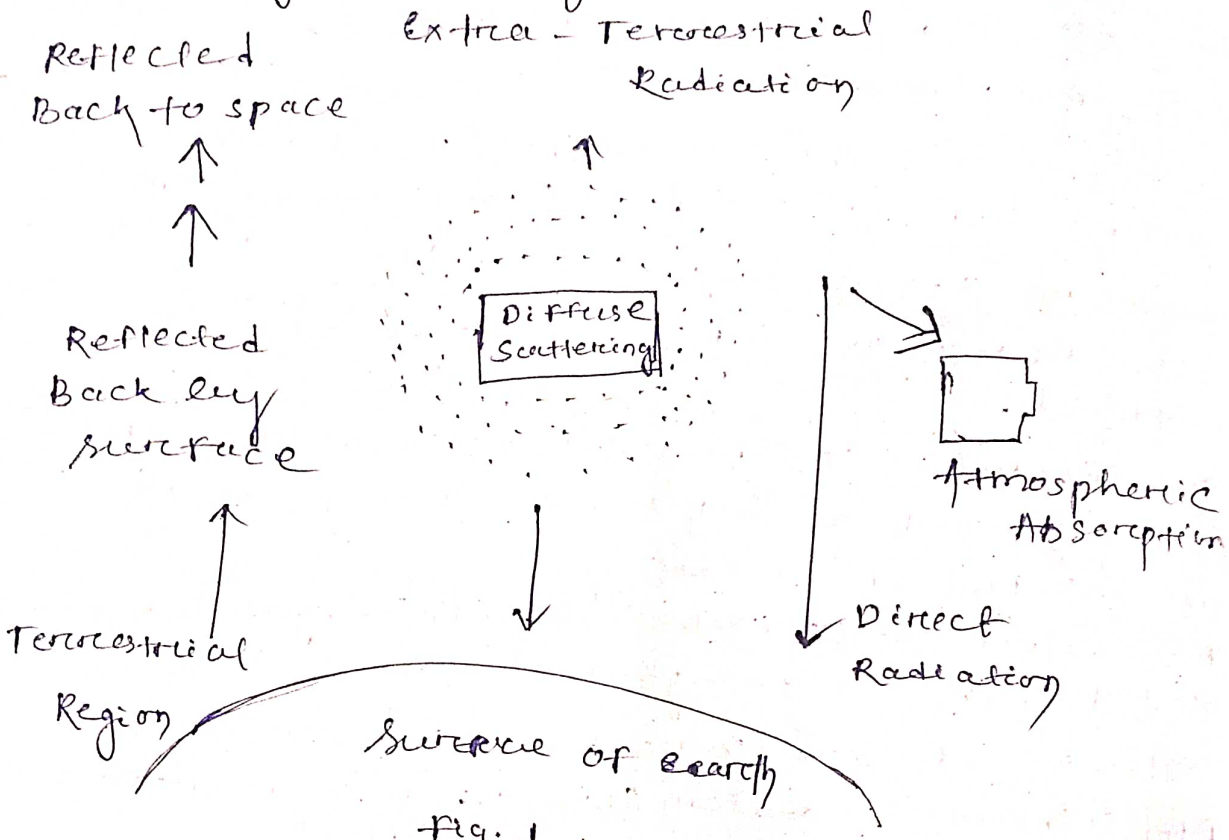


fig. 1

(Direct, Diffuse and Total Solar radiation)

Terrestrial Solare Radiation

→ The solare radiation that reaches earth surface after passing through the earth atmosphere is known as terrestrial radiation.

→ Solare radiation passes through the earth's atmosphere ultra violet rays (short waves) are absorved by the ozone in the atmosphere and infrared waves (long waves) are absorved by the carbon dioxide and moisture in the atmosphere.

→ The radiation which is reaches on the earth consist of purely beam radiation

(direct radiation) and partly diffuse radiation is called terrestrial solar radiation.

Extra terrestrial radiation

⇒ The solar radiation incident on the outer atmosphere of the earth is known as extra-terrestrial radiation.

→ The extra terrestrial solar radiation is entirely direct beam radiation.

Measurement of Solar radiation

→ Measurement indicate that the energy flux receive from the sun outside the earth atmosphere is essentially constant.

→ The solar constant Isc is the rate at which energy is received from the sun on an centerica perpendicular to the rays of the sun at the my-distance of the earth from the sun.

→ The value of solar constant has been recomanded as 1367 W/m²

→ The ~~value of solar~~ cons earth revolves around the sun in an eliptical orbit having a very small eccentricity with the sun earth one of its foce.

→ The distance between the earth and sun varries at little through the yeare.

→ because of this variation, the extra terrestrial flux also varries.

→ The value of any day can be calculated from the equation

$$I'sc = Isc \left(1 + 0.033 \cos \frac{360n}{365}\right)$$

where n is the day of the year. From Eq 7 we see that since the cosine function varies from +1 to -1 the extraterrestrial radiation flux varies by ±3.3 percent over a year.

-: Introduction of Renewable Energy:-

Renewable Energy:-

↳ It is an useful energy that is collected from renewable resources which are naturally replenished on a human time scale.

↳ It include carbon neutral sources like sunlight, wind, rain, tides, waves and geothermal heat.

Fossil fuel:-

→ Fossil fuels are energy sources that form naturally via the long-term decomposition of plants and animals. Fossil fuels like petroleum, coal and natural gas have satisfied human energy demands since the Industrial revolution.

↳ The major types of Fossil fuels used are

1. Coal
2. Natural Gas
3. Oil.

1. Coal:-

↳ Coal is a solid fuel that is composed primarily of carbon.

↳ Depending on its carbon composition coal can be classified into -

(i) Lignite
(ii) Sub-bituminous
(iii) Bituminous
(iv) Anthracite.

↳ The vast majority of coal burned in the united states is bituminous or sub-bituminous.

↳ coal can be extracted via underground mining or strip mining from the surface (some time called mountain top removal)

② Natural gas:-

↳ Natural gas is gaseous fuel. Natural gas extraction can occur during coal mining or oil drilling. Natural gas can also be extracted from oil shales via hydraulic fracturing or fracking.

↳ It is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but higher alkanes and some small percentage of carbon dioxide, nitrogen, hydrogen sulfide or helium.

③ Oil:-

Crude oil is a liquid fuel that can be refined to create gasoline, kerosene, propane, jet fuel, paint and plastics. It can be found in pure liquid from in oil deposits or mixed with viscous sand and rock in tar sands.

Uses of fossil fuels:-

↳ Fossil fuels have powered countless sectors of human activity for decades. uses for fossil fuel.

↳ It includes.

- Electricity generation.
- Home heating.
- Transportation fuel
- Plastics.

- Electricity generation:-

Coal and natural gas power the majority of power plants around the world. They compete with nuclear power, water power, solar power and wind power. All of the which produce fewer carbon emission than fossil fuel use - but remain the dominant fuel sources around the world.

- Home heating:-

↳ Natural gas (a by product of coal mining) powers many home heating system, hot water heaters, and gas stoves. In recent years, concern about in home burning of nitrogen oxides (found in natural gases) has led some consumers advocaly groups to purpose shifting from gas appliances to electric.

- Transportation fuel:-

Gasoline and diesel, both petroleum products currently Power most products, consumers, vehicles, aircraft are Powered by jet fuel which is similar in composition to kerosene.

- Plastic:-

Plastics are created from oil. Plastics manufacturing was initially a by product of oil refined for electricity and transist, but now 300 million tons of plastics are Produced every year. According to the united states environmental protection Agency (EPA), the burning of fossil fuels causes community health risks, pollution and global warming. The environmental impacts of fossil fuels includes:-

(1) Aire pollution.
(2) water pollution.
(3) Global warming.

(1) Aire Pollution:-

The burning of fossil fuels perticularly coal, can release harmful chemicals like sulfure dioxide and carbo monoxide in to the aire. The health effect of aire pollution include severe asthama, which has been observed in regions downward of coal power plants.

(2) Water Pollution:-

The sulfer dioxide released from untreated coal smoke can mix with other elements and produce acid rain, and oil spills poison marine ecosystem. While water pollution is not unique to fossil fuels (even so-called clean energy sources like nuclear can pollute water), unregulated fuel spillage pollutes water and endangers plants, animals and human health.

(3) Global warming:-

Methane and carbon dioxide emissions stemming from electricity plants, gasoline-burning vehicles, cement manufacturing and other industrial processes trap heat in Earth's atmosphere, leading to a surge in global temperatures in recent decades.

Importants of Renewable sources of energy:-

↳ The importance of renewable source of energy are they differ from fossil fuels principally in their diversity, abudance and potential for use any where on the planet, but above all in that they produce neither green house gasses which cause climate change - non polluting emission.

↳ Renewable energy sources also produce clean energy.

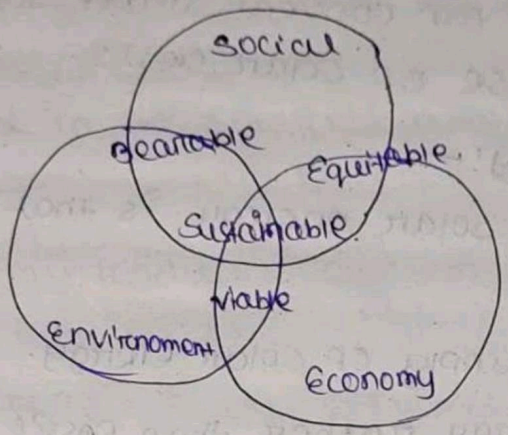
↳ Hydropower is the most widely used renewable power source, with the global hydroelectric for more than 18% of the worlds total installed power generation capacity and more than 54% of the global renewable power generation capacity.

↳ Biomass provides most of the renewable heat in industrial process renewable electricity also can provide heat reducing energy element in industrial process is key to substituting fossil fuels with renewables, as in building

↳ As the renewable sources are fast growing, the cheapest and do much less damage to nature and world life surrounding their ~~source~~ sources as opposed to fossil fuels.

↳ Some important benefits are job creation, no climate change, clear air etc.

Sustainable design and development:-



↳ Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This is generally considered to be a balance between economics, environmental and social factors.

↳ If development can produce good economic and social benefits and not damage the environment or even enhance the environment then it could be called sustainable development.

↳ There are three key principles for sustainable development are -
(i) Economic
(ii) Environmental
(iii) Social.

Types of renewable energy sources:-

There are some types of renewable energy.
(i) Solar energy.
(ii) Wind energy.
(iii) Hydroelectric.

(iv) Ocean energy.
(v) Geothermal energy.
(vi) Biomass energy
(vii) Hydrogen.

(1) Solar energy:—

↳ Solar energy is energy from sunlight and converting it into heat, electricity or hot water.
↳ Photovoltaic (PV) system can convert direct sunlight into electricity through the use of solar cells.

Benefits of solar energy:—

↳ one of the benefits of solar energy is that sunlight is endless.
↳ There is a limitless supply of solar energy.
↳ Relying on solar energy rather than fossil fuels also helps us improve public health and environmental condition.
↳ Solar energy could eliminate energy costs, and reduce our energy bills.

Advantages:—

↳ It is a renewable energy source.
↳ It has low maintenance costs.

Disadvantages:—

↳ Cost is very high.
↳ It uses a lot of space.
↳ Solar energy storage is expensive.

(ii) Wind energy:—

↳ Wind farms capture the energy of wind flow by using turbines and converting it into electricity.
↳ There are many systems to convert wind energy.
↳ commercial grade wind-powered generating systems can power many different organizations.
↳ single wind turbines are used to help supplement pre-existing energy organisations.

Benefits of wind energy:-

↳ wind energy is a clean energy source which means that it doesn't pollute the air like other forms of energy.

↳ wind energy doesn't produce carbon dioxide or release any harmful products that can cause environmental degradation or negatively effect humanhealth like smogs, acid rain etc.

↳ Investment in wind energy technology can also open up new avenues for jobs and training, as the turbines on farms need to be serviced and maintained to keep running

Advantages:-

↳ wind energy reduces carbon emmissions when used instead of fossil fuels.

↳ wind energy is cost effective.

Disadvantages:-

↳ wind turbines can damage the habits of birds and marine life.

↳ wind farms can be expensive to construct.

(iii) Hydroelectric energy:-

→ Dams are what people most associate with when it comes to hydroelectric power.

↳ water flows through the dams turbine to produce electricity known as pumped-storage hydropower.

↳ Run of river hydropower uses a channel to funnel water through rather than powering it through a dam.

Benefits of Hydroelectric energy:-

↳ Hydroelectric power is very versatile and can be generated using both large-scale projects and small scale projects like underwater turbines and lower dams on small rivers and streams.

↳ It does not generate pollution, and therefore is a much more environmentally friendly energy option for our environment.

(IV) Geothermal Energy:-

↳ Geothermal heat is heat that is trapped beneath the earth's crust from the formation of the earth 4.5 billion years ago and radio active decay.

↳ Sometime large amounts of this heat escape naturally, but all at once, resulting in familiar occurrences such as vulcanic eruptions and geysers.

↳ This heat can be captured and used to produce geothermal energy by using steam that comes from the heated water pumping below the surface.

Benefits of geothermal energy:-

↳ It is not as common as other types of renewable sources, but it has a significant potential for energy supply.

(V) Biomass Energy:- (Benefits):-

↳ The use of biomass in energy production creats carbon dioxide that is put into the air, but the regeneration of plants consumes the same amount of carbon dioxide, which is said to creat a balanced atmosphere.

↳ Biomass can be used in many different ways in our daily lives.

↳ These days people can improve the environment with greener energy solution (Renewable energy)

Biomass energy:-

↳ It is a renewable energy derived from biomass.

↳ Biomass is organic matter that comes from recently living plants and organism.

↳ This can be done by burning biomass or harnessing methane gas which is produced by the natural decomposition of organic materials in ponds or even landfills.

(VI) Hydrogen Energy:-

↳ It needs to be combined with other elements, such as oxygen to make water as it does not occur naturally as a gas on its own.

↳ When hydrogen is separated from another element it can be used for both fuel and electricity.

Benefits of hydrogen energy:-

↳ It can be used as clean burning fuel which leads to less pollution and cleaner environment.

↳ It can also be used for fuel cell which is similar to batteries and can be used for powering an electric motor.

Limitation to renewable energy:-

↳ There's only enough renewable energy on earth for a billion years.

↳ The electricity generation capacity is still not large length.

↳ Low efficiency level.

↳ Take a lot of space to install.

↳ Require a high upfront capital quality.

↳ Expensive storage costs.

↳ Expensive set up and output could be affected by drought.

↳ In hydro generators need enough rain to fill dams for their supply of flowing.
↳ In wind energy the turbines need wind to turn their blades.
↳ In solar energy solar pannels need clear skies and sunshine to get the heat needed to generate electricity.

Renewable energy sources - policies of India!-

As its name we can known about its working it means that varity types of policies. To produce the energy by using renewable energy sources like, Sun, solar, wind, tidal, geothermal etc.

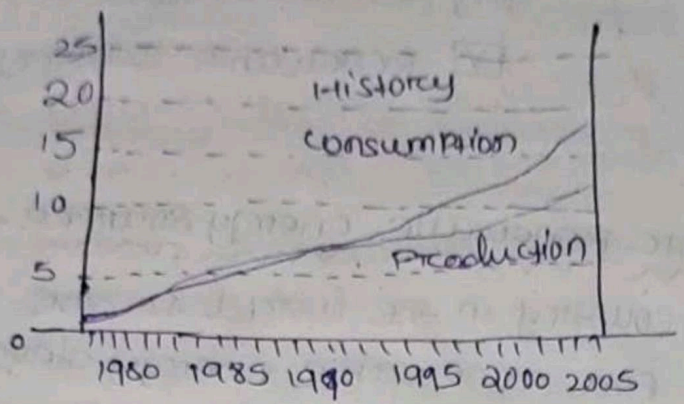
Some following points i.e;

Current energy scenario in India!-

↳ India ranks sixth in the world in total energy consumption
↳ India has increased installed power capacity from 1362 MW. To over 1,62,160 MW since independence.
↳ India has electrified more than 50,000 village.
↳ India is a development largest economy in the world, in terms of purchasing power.
↳ The demand for energy how grown at an average of 3.6% per annum over the past few years.
↳ The rapid increase in use of energy has created problems of demand and supply.
↳ More than 80,000 villages are yet to be electric field.

↳ Around 44%. of household 2005, the central government, ... preparing the ... to the electricity.

It indicates that India has had a -ve ... among others, ...ilization balance for decades'—



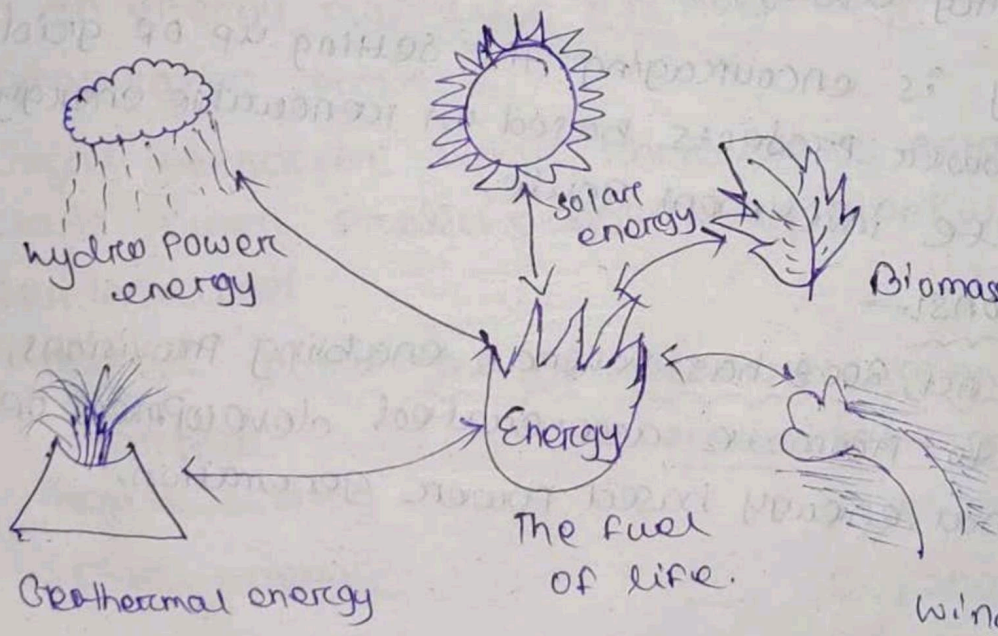
[India's energy Balance]

Power for All by 2012

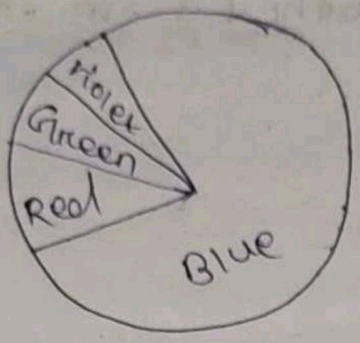
↳ The Government of India has an ambitions missions of power for all by 2012.

↳ This mission would require that the installed generation capacity should more than 2,00,000 mw by 2012 from the present level of 1,02,366mw.

How India can meet energy needs of all?



Power in India:-



[B] Thermal power (63%)
[R] Hydro power (21%)
[G] Nuclear power (8%)
[V] Renewable sources (8%)

Policies of India for Renewable energy sources:-

↳ India is the only country in the world to have an exclusive ministry for renewable energy development, The ministry of non-conventional energy sources (MNES).

↳ India has pioneered in the world in any administrative actions of RE promotion such as? -

1) Electricity Regularity commission - 1991
2) Mandatory environmental audits for power Projects - 1992.
3) Energy conservation bill - 2000.
4) The ministry energy promotion bill - 2005.

⇒ The ministry is encouraging the setting up of grid interactive power projects based on renewable energy through private investment Route.

Legal Provisions:-

→ Electricity Act, 2003 has several enabling provisions, with a view to promote accelerated development of non-conventional energy based power generation.

↳ Under the electricity act 2003, the central government, from time to time, is responsible for preparing the national electricity policy, in consultation, among others, with the state. Governments for the optimal utilization of all resources, including renewable sources of energy.

Renewable energy sources - potential of India:-

↳ India utilizes twelve primary hydro electric power plants : Bihar, Punjab, ~~Uttarpradesh~~ Uttaranchal, Karnataka, Uttarpradesh, Sikkim, Jammu and Kashmir, Gujarat and Andhrapradesh.

↳ India has the 5th largest wind power installed capacity in the world.

↳ The ten machines near Okha in the Provinence of Gujarat were some of the first wind turbines installed in India.

↳ 140mw solar thermal hybrid power plant will be consontrated in Rajasthan raising India into the second position in the werce in utilization of solar thermal.

↳ A 500Kw grid interactive biomass gassifier linked to an energy plantation has been commissional under a demostration projects.

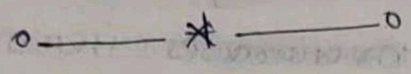
↳ Grid interactive solar photovolatic solar photo volatic power projects aggregating 2400Kw have so far been installed.

Estimated potential of renewable energy sources:-

Source	Approximate potential in MWs
Biomass energy	19,500
Solar energy	20,000

Wind energy	45,000
Small hydropower	15,000
Other RE sources	50,000

Total estimated potential is around 1,49,500 mw.



Chapter-2 -: Solar energy :-

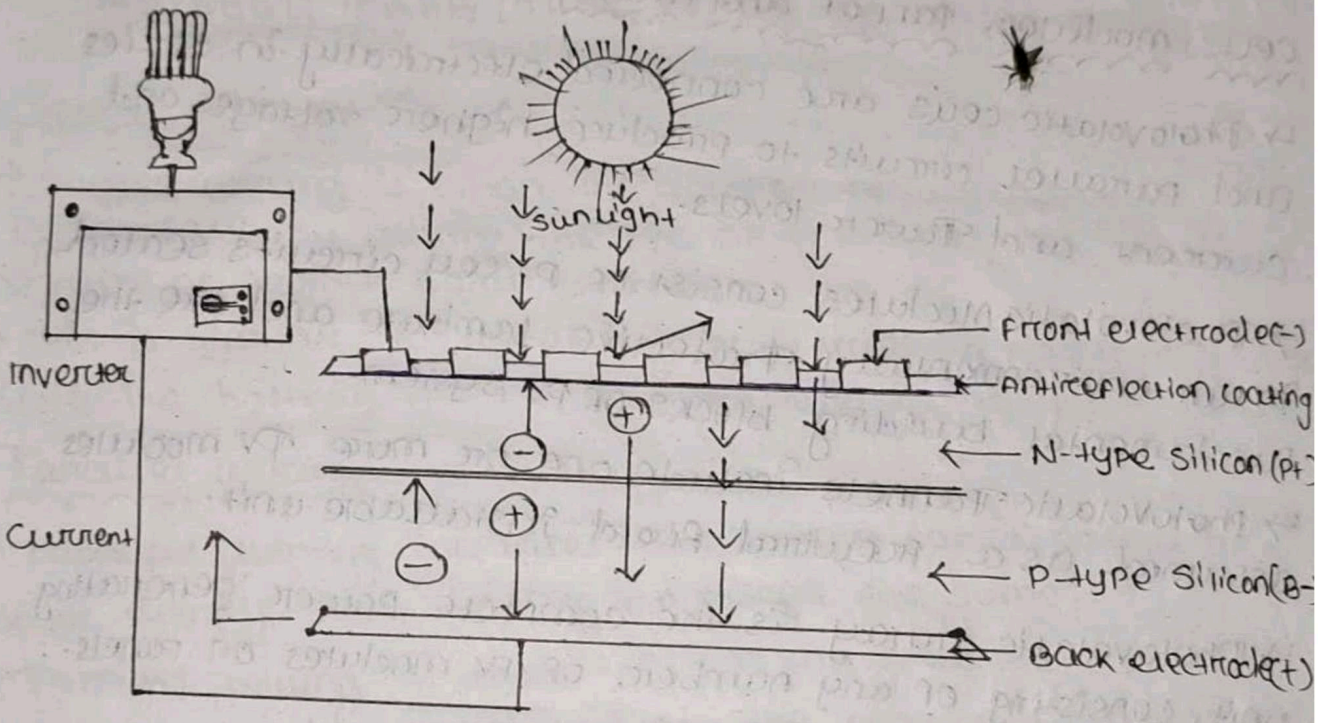
Working Principle of Solar Photo-volatic System:-

↳ Solar Photovolatic system use cells to convert sunlight into electricity.

↳ The PV cell consists of one or two layers of a semi conducting material, usually silicon.

↳ When light shines on the cell it creats an electric field across the layer causing electricity to flow.

↳ The greater the intensity of the light, the greater the flow of electricity.



→ PV cells are reforred to in terms of the amount of energy they generate in full sunlight; known as Killowatt Peak (KWP).

↳ The Solar cell is the basic building block of Solar PV technology. Most people are familiar with PV Solar cells that power calculators.

→ These cells are wired together to form a module (PV Solar Panel)

→ The PV modules gather Solar energy in the form of Sunlight and convert it into DC electricity.

↳ An inverter can convert this DC power into AC power. PV modules are joined together to form a PV Solar Panel system.

↳ Large PV system can be integrated into buildings to generate electricity.

Photovoltaic cell concept:-

↳ A photovoltaic cell also known as a solar cell is an electronic components that generates electricity when exposed to photons, or particles of light.

↳ A photovoltaic cell is a specialized semiconductor diode that converts visible ligh into direct current.

cells, modules, pannel and array:-

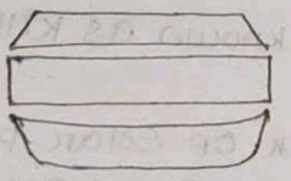
↳ Photovoltaic cells are connected electrically in series and parallel circuits to produce higher voltages and current and power levels.

↳ Photovoltaic modules consist of PV cell circuits sealed in an environmentally protective laminate and are the fundamental building blocks of PV system.

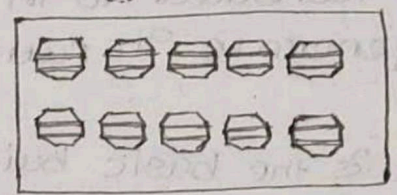
↳ Photovoltaic Pannels include one or more PV modules assumed as a prewired field installable unit.

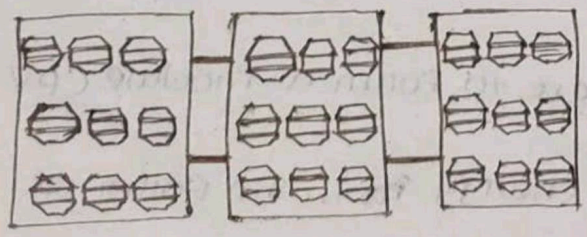
↳ Photovoltaic array is the complete power generating unit, consisting of any number of PV modules or panels.

Photo volatic cell

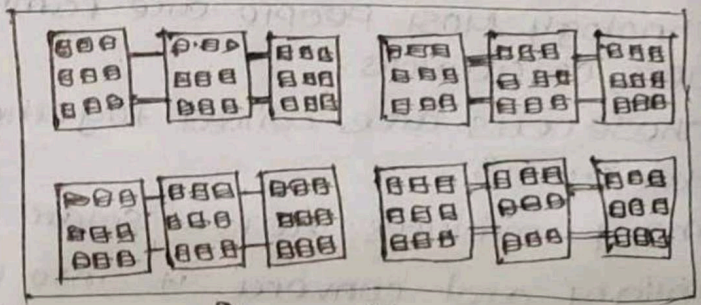


Module





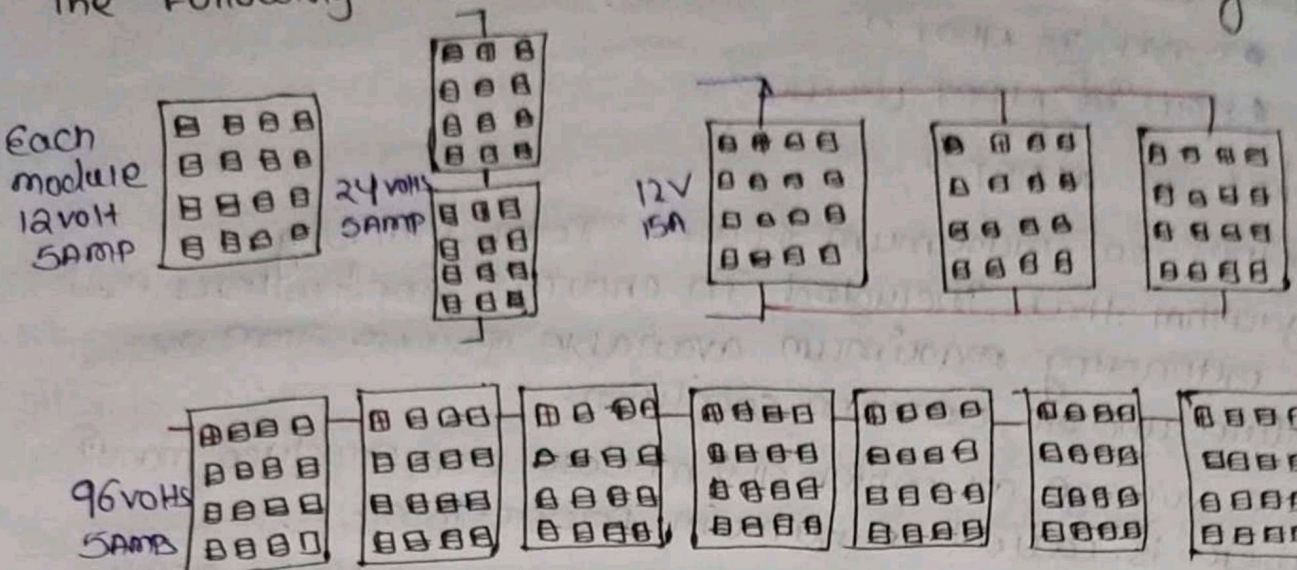
(Panel)



(Array)

Series and Parallel wiring:-

The following the series and parallel wiring.



Series wiring:-

→ Series wiring is when the voltage of a solar ~~array~~ array is increase by wiring the +ve of one solar module to the negative of another solar module.

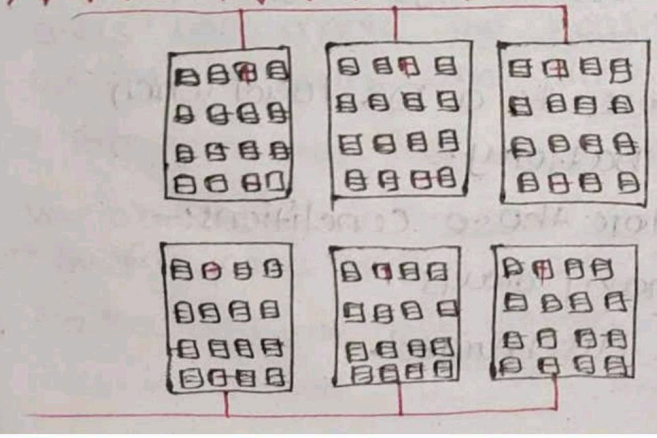
→ This is similar to installing batteries in flashlight. As you slide the battery into the flashlight tube the voltage increases.

Parallel wiring:-

→ Parallel wiring increases the current (amps) output of a solar array while keeping the voltage the same.

↳ Parallel wiring is when the +ve of multiple modules are connected together and all the negative for the same modules are connected together.

Series Parallel combination:-



Maximum Power Point tracking (MPPT):-

Basics of MPPT solar charge controller:-

- what is MPPT?
- How it is MPPT works?

- what is MPPT?

↳ MPPT or maximum power Point tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain condition.

↳ the voltage at which PV module can produce maxm power is called maximum power Point.

↳ Maximum Power varies with solar radiation, ambient temperature and solar cell temperature.

↳ Typical PV module Produces Power with maximum Power voltage of around 17V measured at a cell temperature of 25°C it can drop to around 15V on a very hot day and it can also raise to 18V on a very cold day.

- How it is works?

↳ The major principle of MPPT is to extract the maxm available Power from PV module by making them operate at the most efficient voltage.

↳ That is to say: MPPT checks output of PV modules, comprises it to battery voltage then fixes what is the best power that PV module can Produce to charge the battery and converts it to the best voltage to get maxm current into battery.

↳ It can also supply Power to a DC load which is connected directly to the battery.

MPPT is most effective under these conditions:-

* cold weather, cloudy or hazy days.
* when battery is deeply discharged.

There are two main types of solar energy technology
(i) photovoltaic cell.
(ii) concentrating solar energy (CSP)

Again it depends what type of panels you use
→ This is because as panels get large (in watts) they are also become a little bit more efficient.
→ A 1 KW system using 250W panels will require about 1.7 square meters of roof to be installed.

Hot body:—

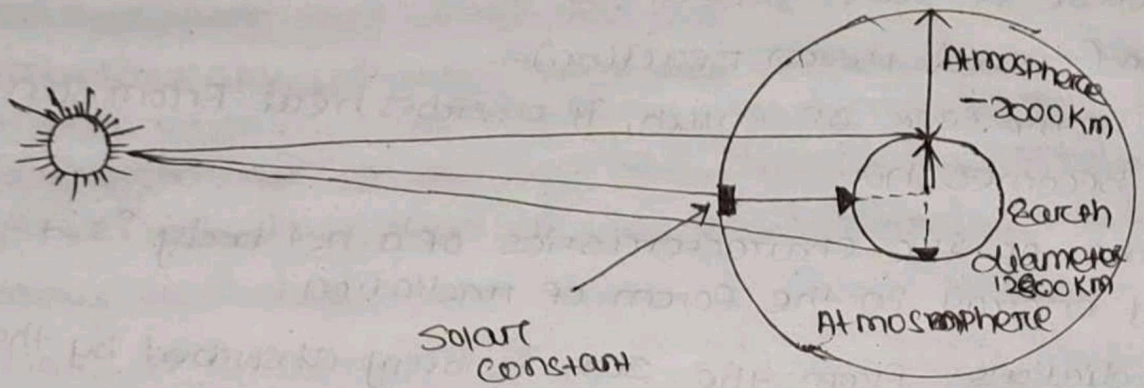
Hot body means any object which get heated up by either internal or external mechanism. ~~(Caused reaction)~~

Ex:- In case of sun, the sun is hot due to the internal mechanism (called fusion reaction).
While in the case of earth, it absorbes heat from sun ray and becomes hot.
→ Now one of the characteristics of a hot body is it emits heat energy in the form of radiation.
→ The radiations from the sun is being absorbed by the earth (called insolation) and it re-radiates back when the earth is termed as terrestrial radiation or earths radiation.
→ Earth's surface is not homogeneous and it varies from one area to another.
→ Due to earth's rotation and revolution with a tilted axis also made the heating effect of sun rays variable with both space and time.
→ The total heating up of the earth surface is variable.
→ Every part of the earths from morning to night radiates heat back depending upon the intensity of heat it receives from the sun. And this re-radiation of heat

is called terrestrial radiation or earth's radiation.
→ So terrestrial radiation is happening all the time and it varies from space to space and time to time leads to the formation of energy deficit zones and energy surplus zones.
→ Energy deficit zones is having -ve value of terrestrial radiation. This is a continuous process and will stop when sun stops its radiation.

Extraterrestrial irradiation:— The solar constant:—

The intensity of solar irradiation directly outside the earth's atmosphere on a horizontal surface is almost constant at around 1,360 W/m2. So called "solar constant"



entry point into atmosphere:
intensity ~ 1360 W/m2

Irradiation: —[W/m2]

The intensity of solar radiation hitting a surface which is the sum of the contributions of all wave lengths within the spectrum, expressed in units of watts per m2 of a surface.

Solar collector:—

→ A solar thermal collector heat by absorbing sunlight. A collector is a device for capturing solar radiation.
→ Solar radiation is energy in the form of electromagnetic radiation from the infrared (long) to the electroviolet (short) wavelength.

→ There are two types
(1) PV (photovoltaic)
(2) ST (solar thermal)

PV (photovoltaic) :-

Photovoltaic solar panel

→ PV converts sunlight into electricity using a semiconductor material (normal silicon).
→ when light strikes the cell a portion is absorbed within the semiconductor material knocking electrical load and allowing them to flow.
→ The results in an electric current and thus electricity production.
→ PV panels primarily absorbs the visible portion of the light spectrum.
→ PV panels are normally connected to an inverters to convert from DC to AC and subsequently the electricity is fed into the power grid.

ST (solar thermal) :-

Aprices evacuated tube collector solar water heater.
→ Solar thermal panels are referred to by a number of different names such as solar water heater, Solar hot water panel, Solar hot water collector, Solar thermal panel or solar thermal collector. These terms all described the same generic device.
→ Solar water heaters works by absorbing sunlight and converting it into usable heat.
→ A simply analogy is to thing about a black coloured object sitting in the summer sun.
→ over time it can become very hot from absorbing

-the sunlight. Solar water heaters work in the same way by using material that are specially designed to maximise the efficiency of that absorption.
→ High quality absorber coating, as used by aprdius product, are able to absorb up-to 95-% of the energy in sunlight throughout the spectral range.
→ Below is an example of quality absorber from coating manufacture Fimon that absorbs 95% of available sunlight and only radiates (emits) about 4% of the absorbed energy as heat.
→ The key areas to look at are the yellow which represents solar radiation and the light blue which is how much of that sunlight is absorbed by the coating.

Solar thermal and photovoltaic working together:-

→ Solar thermal and PV should not be seen as competing technologies or products as they perform different functions and as shown below can be installed together to provide a well balanced solar energy harnessing system.
→ electricity can be used for almost any application, and so is a universal energy sour
→ Heat is required for hot water and space heating which represent a large percentage of a house hold's total energy requirements.

Application:-

① Battery chargers:-

→ A solar charger that employees solar energy to supply electricity devices or batteries they are generally portable.

→ Solar charges can charge lead acid or Nicd battery bank upto 48V and hundreds of ampere hours capacity.
→ Such type of solar charger setups generally use an intelligent charge controller.

② Domestic lights:-

The building regulators compliances guide currently stipulates that 75% of fixed light internal fittings in new domestic construction should use low energy lamps.

Lamps:-

→ Tungsten incandescent lamps, as mentioned above have now largely been phased out from general domestic use.
→ Usually with an output of 60w or 100w and giving a warm yellowish light.
→ Tungsten halogen lights also produce a bright warm light and are often used in recessed fittings.

Fittings:-

→ Lighting design needs to be considered both in terms of the general level of illuminance required and in term of the relevant working plane.
→ For example compare an office where there is a uniform general level of illuminance to a museum. where everything is in darkness except the brilliant it display objects.

③ Street light:-

→ A street light or street lamp is a raised source of light often mounted on a lamp column or pole either on the side of the road or within the median, or suspended on a wire above the road to provide illumination.
→ Street lighting can provide safety benefits at mid block and intersection locations and can also improve safety for pedestrians, particularly at crossing points.

Midblock:-

→ The provision of midblock street lighting increases safety by making road features such as, road alignment kerbs, footpaths, street furnitures, surface condition and other road users.

→ The object that may be on the road visible to both vehicular and pedestrian traffic.

Intersection:-

Providing street light at intersection locations can reduce night time crashes by making the intersection features visible to both vehicular and pedestrian traffic.

④ Water Pumping:-

→ The Pumping of water is a basic and practical technique, far more practical than scooping it up with one's hands or fitting it in a hand held bucket.

→ This is true whether the water is drawn from a fresh source, moved to a needed location, purified or used for irrigation, washing etc.

→ Stream, river, pond or lake is often pumped to higher ground for irrigation, livestock, cooking, cleaning or other uses by humans, who quite naturally need fresh water.

⑤ Solar Cooker:-

→ A solar cooker is a device which uses the energy of direct sunlight to heat, cook and other food material.

→ Many sololar cookers currently in use are relatively inspensive low tech devices, and advanced, large scale solar cookers can cook for hundreds of people.

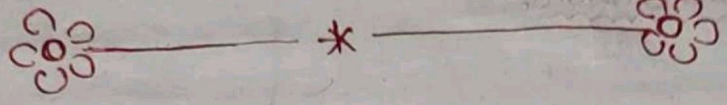
→ Because they use on fuel and cost nothing to operate, many nonprofit organisations are promoting their use worldwide in order to help reduce fuel costs and air pollution.

⑥ Solar Pond:-

→ A solar pond is a pool of saltwater which collects and stores solar thermal energy.

→ The saltwater naturally from a vertical salinity gradient also known as a 'halocline' in which low salinity water floats on top of high salinity water.

→ The largers of salt solutions in concentration with depth below a certain depth, the solution.



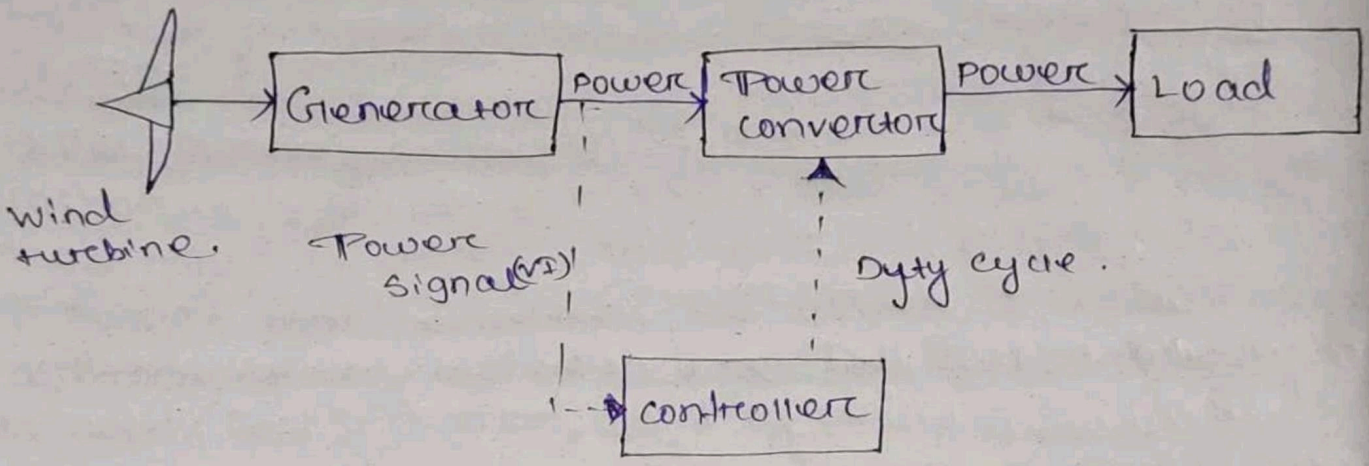
Chapter-3 :- WIND Energy :-

Introduction:-

→ wind energy is one of the energy sources in the world, several countries in the world using the wind as one of its energy sources.

→ It can be used for generating electricity for special uses, the wind it has kinetic energy can be converted to mechanical energy to drive a turbine which converts the mechanical energy to electricity.

Wind energy conversion:-



→ wind energy (or wind power) describes the process by which wind is used in generate electricity.

→ wind turbines convert the kinetic energy in the wind into mechanical power.

→ This mechanical power converted to the electrical power by the help of a generator.

Types of wind turbines:-

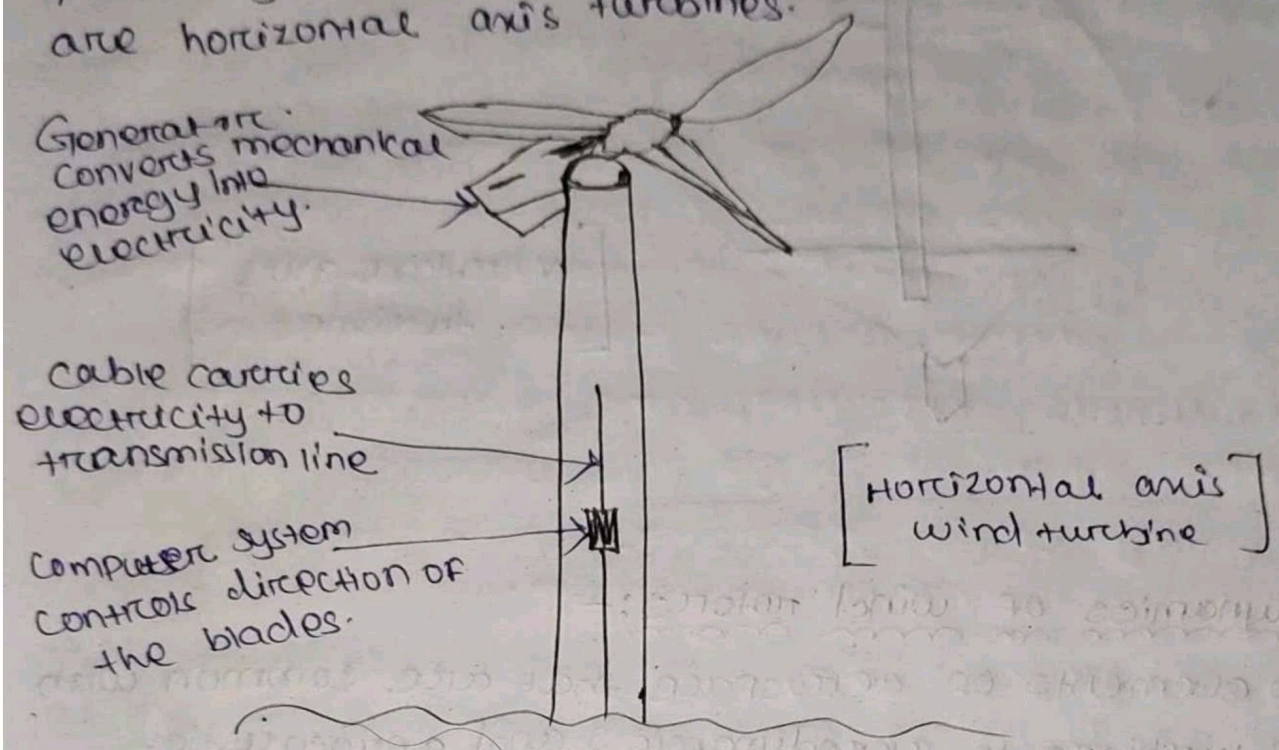
There are two basic types of wind turbines:-

1) Horizontal axis turbines.
2) Vertical axis turbines.

1) Horizontal axis turbines:-

→ Horizontal axis turbines have blades likes aeroplane propellers, and they commonly have three blades.

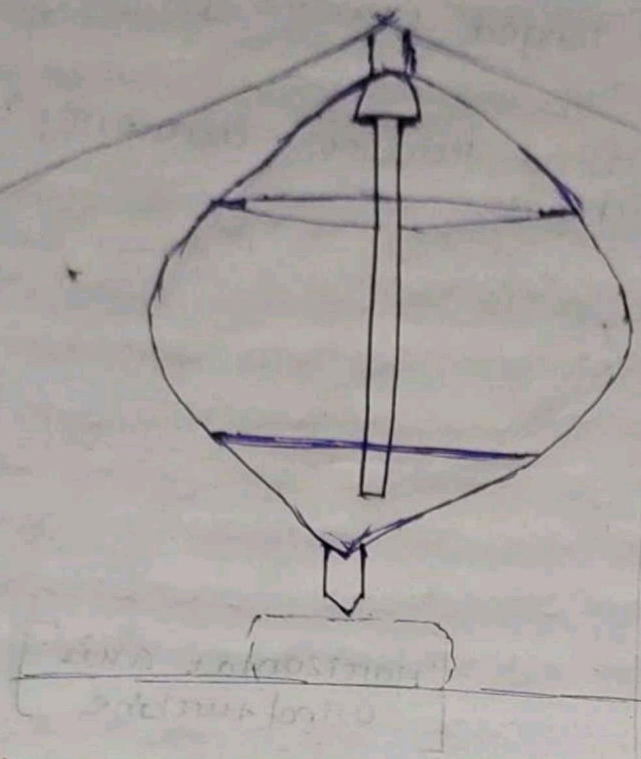
→ The largest horizontal axis turbines are as tall as 20 storey buildings and have blades more than 100 feet long.
→ Taller turbines with longer blades generate more electricity.
→ Nearly all of the wind turbines currently in use are horizontal axis turbines.



[Horizontal axis wind turbine]

② Vertical axis turbines:-

→ Vertical axis turbine look like egg beaters.
→ That blades that are attached to the top and the bottom of a vertical rotor.
→ The most common type of vertical axis turbine the Darrieus wind turbine named after the georgeus Darrieus who patented the design in 1931 looks like a giant two bladed egg beater.
→ Some versions of the vertical axis turbine are 100 feet tall and 50 feet wide.
→ Very few vertical axis wind turbines are in use today because they do not perform as well as horizontal axis turbines.



[vertical axis turbines]

Aerodynamics of wind rotors:-

→ Two elements of aerospace that are common with wind turbines is aerodynamics and aeroacoustic.

Aerodynamics:-

→ It is the science used to design turbine blade profiles and structures.

→ The principles of loads, lift, friction, (drag) and vibration are nearly the same wheather designing turbine blades or wings for aircraft.

Aerodynamics breaking:-

→ Bleads when $\perp^{r}$ to the wind flow direction, blade takes K.E from wind and convert it into mechanical energy by rotation of blade rotor.

→ When blade make different angles with the wind direction (less than 90°) some wind just by passes the blade profile and when angle becomes 0° nearly all wind by passed from ideal blead profile.

→ This zero degree position of rotor blade is Aerodynamics breaking position.

Wind turbine control system:-

→ wind energy simply means K.E of air in motion.
→ we know that the earth surface is containing very different types of land and lots of water.
→ It sucks up the sun's energy at unusual rates means the sun heat is not uniformly distributed over the earth's surface.
→ wind or flow of air on earth is caused by massive convection currents in the atmosphere.
→ As long as the sun heats up the earth there will be wind energy available on the earth.

* How wind energy convert to electrical Power ?

→ As we know that wind does not present everywhere at the same speed. so that we set up a wind farm where, the speed of wind is sufficient to move the blade of turbine.
→ Blades rotate when a wind strikes over them and blades are coupled with a rotor.
→ So when blade move, rotor is also moved.
→ Rotor is connected to low speed shaft is connected to gear and it boosts up or raise the rotational speed of generator shaft 30 to 60 rpm to 1000 to 1800 rpm.
→ This is the speed of common generator.
→ This high speed generator produces electricity.
→ Apart from this wind turbine also consist of controller which determines when start or stop the m/c.
→ Generally wind speed of about 8-16 miles per hour for starting the m/c and the m/c automatically stopped at about 65 miles per hour.

Synchronous Generator :-

→ That is an alternator with the same rotor speed as the rotating magnetic field of stator.

→ AC to the structure, it can be divided, into two types:-

(a) Rotating armature.

(b) Rotating magnetic field.

→ It is the one of the most commonly used alternator

→ In the modern power industry, It is widely used used in hydro power, thermal power nuclear power generation, diesel power generation.

→ Synchronous generators are generally adopts DC excitation. when the single m/c operates independently

→ The voltage of the generator can be conviently adjusted by adjusting the excitation current.

→ If it is integrated into the goal operation, the voltage is determined by the grid and cannot be changed.

→ At this time, the result of adjusting the excitation current is to adjust the power factor and reactive power of the motor.

*Induction generator:-

→ It is a motor that uses electromagnetic induction between the rotors to induce current in the rotor to achive electromechanical energy conversion.

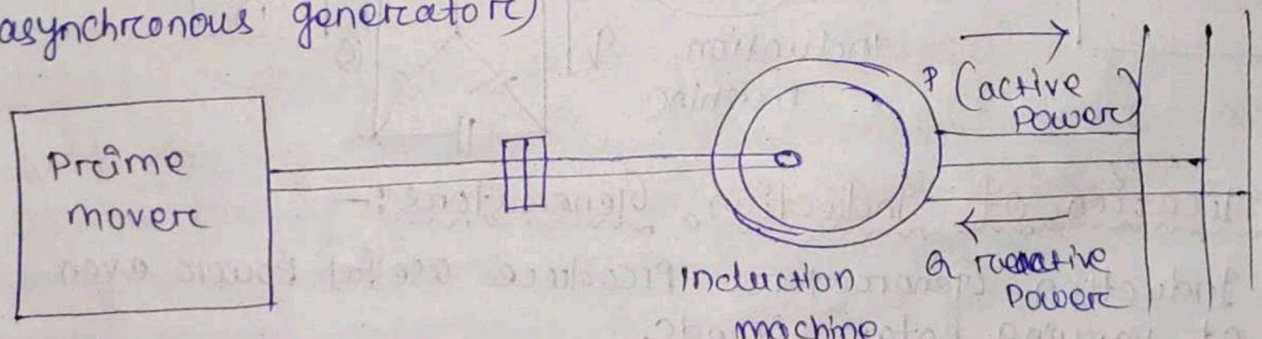
→ Induction generator has the advantages of simple structure, Firmness, small size, light weight, less auxiliary equipment, convenient operation and maintenance etc.

→ Especially the independent operation of induction generator makes it very practical for remote mountainous areas or power shortage that can't

be covered by power grid.
→ Towns and villages are as an efficiency back up power sources.
→ The steering of the rotor is the same as the steering of the rotating magnetic field, but the rotational speed is slightly higher than the synchronous rotational speed of the rotating magnetic field.

* How Induction Generators work :-

→ Consider an AC supply is connected to the stator terminals of an Induction machine Rotating magnetic field produced in the stator pulls the rotor to rotate behind it.
→ If the rotor is accelerated to the synchronous speed by means of a prime over the slip will be zero & hence the net torque will be zero.
→ If the rotor is made to rotate at a speed more than the synchronous speed the slip becomes negative.
→ A rotor current is generated in the opposite direction due to the rotor conductors cutting Stator magnetic field.
→ This generated rotor current produces a direction due to the Rotor conductors cutting stator magnetic field.
→ This generated rotor current produces a Roting magnetic field in the Rotor which pushes (force of opposite way) onto the stator field.
→ The machine is now working as an inductor generator (asynchronous generator)



→ Induction generator is not a self excited machine.

→ When Running as a generator the machine takes Reactive Power form the AC power line & supplies active power back into the Line.

→ The Relative power is needed for producing Rotating magnetic field.

→ The active power supplied back in the Line is proportional to slip above the synchronous speed.

Self-excited Induction Generator :-

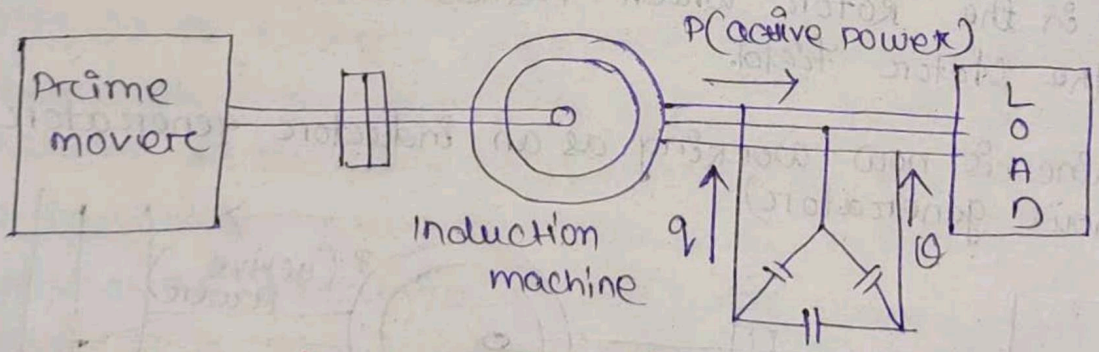
→ An induction machine needs reactive power for excitation regardless whether it is operating as a generator or motor.

→ when an induction generator is connected to a grid it takes Reactive Power from the grid.

→ A capacitor bank can be connected across the Stator terminals to supply Reactive Power to the machine as well as to the Load.

→ when the Rotor is Rated at an enough Speed a small voltages is generated across the Sector terminals due to Residual magnetism.

→ Due to this small generated voltage capacitor Current is produced which provided further Reactive Power for magnetization.



Application of Induction Generators :-

→ Induction Generators produce useful power even at varying Rotor Speeds.

→ They are suitable in wind turbines.

Advantages :-

→ Induction or asynchronous generators are more rugged & require no commutator & brush arrangements. (as it needed in case of synchronous generators)

Disadvantages :-

→ It is that they take quite large amount of reactive power.

Constant voltage & const-frequency control by electric system :-

→ This paper proposed a single phase three level Inverter that has constant voltage constant frequency (CVCF).

→ It has been shown that the proposed technique has less harmonic distarction & better performance than the conventional inventor for the some Load & Switching frequency.

→ The constant voltage & frequency used feed-back PI control blocks.

→ The proposed control schema is varified by MATLAB/ Simlink Results & the Result prove that the proposed method is able to achieve not only low harmonic distortion but constant voltage & constant frequency for various operating conditions.

(1) Double output Induction generator (DOIG) :-

→ With growing concerns about environmental pollution & a possible energy shortage, great efforts have been taken by the governments around the world to implement renewable energy programs, based mainly on wind power, solar energy, small hydro-electric power, etc.

→ with improving techniques, reducing cost & low environmental impact, wind energy seems certain to play a major part in the world's energy future.

→ Due to its many advantages such as the improved power quality, high energy efficiency & controllability etc. the variable speed wind turbine using a DOIG, is becoming a popular concept & thus the modeling of the DOIG based wind turbine becomes an interesting research topic.

→ As the wind power penetration continually increases, power utilities concerns are shifting focus from the power quality issue to the stability problem caused by the wind power connection.

→ In such cases, it becomes important to consider the wind power impact properly in the power system planning & operation.

→ Unfortunately, few people power system analysis tools have included wind turbine models such as have been developed for traditional power generators.

→ The paper develops analytical steady state & dynamic models to provide this insight & correcting the operating performance of DOIG of wind energy conversion system using MATLAB simulink environment.

→ This power considers a grid-connected system; a further paper will describe a stand alone system.

* Advantages of wind power :-

→ wind power can be started when batteries exhausted, & not all winds can use to the suit the timing of demands for energy.

→ wind power has many benefits, which is why it is the most rapidly growing form of energy in the world. (1)

1. Clean Energy :-

→ This is a clean & safe source of fuel. The wind energy never pollutes the environment unlike other coal & natural gas power plants.

→ Also, wind turbines will not produce atmospheric emissions, which in-turn cause acid rain or greenhouse effect on planets.

2. Need less Space :-

→ The space required for the wind turbines is much smaller & the land surrounding, it can continue to use for other uses such as agriculture.

3. Domestic Sources :-

→ It is a domestic energy source & needs a limitless local resources. The supply is masive & inexhaustite. Even more, grant turbines used to contribute to meet domestics power supply.

4. Renewable Energy :-

→ Energy from wind is economical. It is one of the most sustainable alternatives available. today at a rate at 4-6 events per Kilowat-hour, depending on the wind power & Project financing.

5. Produce Energy in Remote Sections :-

→ on large forms or ranches, wind turbines may be installed This is of significant benefit to the rural economy, while offers most of the best wind forms:

→ As wind turbines need a small fraction of the land, farmers & ranches can continue to work on the earth.

6. Cut Greenhouse Gas Emmissions :-

→ Wind turbines can cut generated or waste contaminating pollutants & do not need cutting word.

→ The amount of energy product from fossils, fuels, leads to lower total air pollution & carbon emmissions can also be decreased by wind turbines.

7. Reduce Power Sector water consuption :-

→ Practically no water used in wind energy wind energy has the lowest water consumption foot paints.

→ So replacing wind power in thermal & unclear power stations is a significant step towards swing & maintaining the excellent assets of water in the world from possible defects of electricity generated by energy.

* Grand Challenges of wind Power :-

→ There are various grand challanges in wind energy which require advanced progress from the scientific industry. Let's have a glance of challanges here:

1. High Initial cost :-

→ It is highly costly to build turbines wind farms offshore wind power provides more electricity than onshore wind power, but it costs for more.

→ construction & maintences are the primary costs of wind turbines.

2. Technology Immunity :-

→ Today's wind turbines have seen rapid technological advances to rise sustainbility.

→ Future technology helps these wind power generation models & expertise needed to meet the power generation potential.

3. Unexpected wind patterns :-

→ For adequate generation power, the wind needs to blow continuously are a long period. As the wind conditions can't be forecast, enough, in central n areas. It is challenging to obtain sufficient power.

Chapter-4 :- Biomass energy :-

What is biomass energy?

Biomass is fuel that is developed from organic materials, a renewable & sustainable source of energy used to create electricity or other forms of power.

Some examples of materials that make up biomass fuels are:

- Scrap Lumber
- Forest Debris
- Certain Crops
- Manure
- Some types of waste Residue

With a constant supply of waste - from construction & demolition activities, to wood not used in papermaking, to municipal solid waste - green energy production can continue indefinitely.

Biomass is a renewable source of fuel to produce energy because:

- waste residues will always exist - in terms of scarp wood, mill residuals & forest resources; and
- properly managed forests will always have more trees, so we will always have crops & the residual biological matter from those crops.

Biomass power is carbon neutal electricity generated from renewable organic waste that would otherwise be dumped in landfills, openly burned, or left as fodder for forest fires.

When burned, the energy in biomass is released as heat. If you have a fireplace, you already are participating in the use of biomass as the wood you burn in it is a biomass fuel.

In biomass power plants, wood waste or other waste is burned to produce steam that runs a turbine to make electricity, or that provides heat to industries & homes.

* Biomass is available in all three basic forms of matter: Solid, Liquid, and gas, which themselves can be sub-divided into primary (produced by direct use of solar energy through photosynthesis) & secondary (generated by the decomposition or conversion of organic substances) products. The biofuels derived from these three states are defined as:

■ Solid Biomass - also known as "feedstock", which are solid or compressed pieces of organic matter in the form of pellets that release their stored energy through combustion & burning. solid biomass or feed stock materials include:

* wood & wood residues such as trees, shurbs, sawdust, pelltes, chips & waste wood.
* Agricultural residues like straw, grasses, seeds, roots, dried plants, nut shells & husks.

* Energy crops from Charcoal, Peat leaf litter & more.
* Processed waste such as Bagasse plant waste.
* Animal waste such as dried slurry & manure.
* Municipal solid waste from household rubbish & garbage.

■ Liquid Biomass - also known as 'biofuel' is any kind of fluid or liquid produced from solid matter that is still growing or has been alive at some point which can be processed to produce a type of fuel. Liquid biomass or biofuel fluids include:

* Pure vegetable oils from sunflower & rapeseed, or recycled waste vegetable oils.
* methanol, Ethanol & alcohol based fuels fermented from corn, grain & other plant matter.
* Biodiesel distilled from vegetable oils & animal fats.
* P-Series fuels, which blend various solid & liquid matters together to produce a fuel.

■ Gas Biomass - also known as "biogas" is any kind of natural forming gas given off by decaying plants, rotting rubbish, decomposing animals, slurry & manure that can be used as a type of fuel. Liquid biomass or biogas include:

* Methane from decomposing plants, animals & manure.
* Biogases generated from rotting rubbish in landfills.
* Hydrogen for batteries & fuel cells.
* Synthesis Gas blended from Carbon monoxide and Hydrogen.
* Natural gas from fossil fuels.

●●● Types of Biogas Digesters & Plants:-

- 2.1 fixed Dome Biogas Plants.
- 2.2 Floating Drum Plants.
- 2.3 Low-cost polyethylene Tube Digester.

- 2.4 Ballon Plants.
- 2.5 Horizontal Plants.
- 2.6 Earth-pit Plants.
- 2.7 Ferro-cement Plants.

Gasification of wood :-

Gasification is a process that converts organic or fossil based carbonaceous materials into carbon monoxide, hydrogen & carbon dioxide. This is achieved by reacting the material at high temperatures (> 700°C), without combustion, with a controlled amount of oxygen &/or steam. The resulting gas mixture is called syngas which is itself a fuel. The power derived from gasification & combustion of the resultant gas is considered to be a source of renewable energy if the gasified compounds were obtained from biomass.

In a gasifier, the carbonaceous material undergoes several different processes : The dehydration or drying process occurs at round 100°C. The pyrolysis (or de-volatization) process occurs at arround 200-300°C. Volaties are relased & Char is produced, resulting in up to 70% weight loss for coal. The combustion occurs as the volatile products & some of the char reacts with oxygen to primarily from carbon dioxide & small amounts of carbon monoxide, which provides heat for the subsequent gasification reactions. The gastication process occurs carbon monoxide & hydrogen. In addition, the reversible gas phase water gas at the temperatures in a gasifier. This balances the concentrations of carbon monoxide, steam, carbon dioxide & hydrogen.

pyrolysis ... such as biomass, in the absence of oxygen. Because no oxygen is present the material does not combust but the chemical compounds (i.e. cellulose, hemicellulose & ligin) that make up that material thermally decompose into combustible gases & charcoal.

Application:-

Biogas:-

→ Biogas as a cooking fuel and some common Indian burner designs.
→ Burners designs commonly used in china.
→ use of Biogas as a lighting fuel.
→ Utilisation of biogas for Pumping water and miscellaneous other applications.
→ Biogas as a fuel for running IC engines.
→ Biogas as a vehicle fuel.

Biodiesel:-

→ Railway usage.
→ Aircraft use.
→ As a heating oil.
→ Cleaning oil spills.
→ Biodiesel in generators.
→ Vehicles.

Biomass combustion:-

→ Biomass combustion simply means burning organic material for millenia, humans have used this basic technology to creat heat and later, to generate Power through steam.

→ while wood is the most commonly used feedstock, a wide range of materials can be burned effectively.

Fermentation:—

→ the methods include: burning/ incineration, Pyrolysis biochar and gasification. the least two create hydrocarbon fuels can be stored and converted to almost any hydrocarbon.

→ Fermentation is also possible but uses a lot more land and takes longer.

→ there are two types of fermentation i.e;

→ Fermentation of forest and industrial residues.

→ Fermentation of agriculture wastes.

Anaerobic digestion:—

Anaerobic digestion (AD) is a natural process where plant and animal materials (biomass) are broken down by micro organisms in the absence of air.

→ the anaerobic digestion process begins when biomass is put inside a sealed tank or digester.

→ Naturally occurring micro-organisms digest the biomass which releases a methane-rich gas that can be used to generate renewable heat and power; this helps cut fossil fuel use and reduce green house gas emmissions.

→ the remaining material is rich in nutrients so it can be used as a fertiliser.

Chapter-5 :- Other energy sources :-

Tidal energy :-

→ Tidal energy is a form of hydro power which converts the energy obtained from tides into other useful energies. The tidal energy is the result of the sun and moon's influence over the ocean. The high difference between low and high tides gives raise to tidal currents is coastal areas which drives the turbines.

→ Tidal energy is also called tidal power. Tidal Power utilizes the energy contained in tides to produce electricity.

Barrage and Non Barrage tidal Power system :-

→ The barrage is a type of low-head, diversion dam which consists of a large gates that can be opened or closed to control the amount of water passing through :-

→ This allows the structure to regulate and stabilize river water elevation up stream for use in irrigation and other system.

→ The functional point view in a barrage these are classified into three types ; upstream, sheet piles, intermediate sheet piles. Down stream sheet piles.

→ Tidal turbines are 80% efficient which is higher than solar and wind energy generators barrage reduce the damage of high tidal surges on the land.

→ A hybrid energy system, or hybrid power typically uses two or more renewable energy sources, which provide greater balance in the energy supply as well as

increasing the efficiency of the system.

→ A renewable energy is the energy that is collected from renewable sources which are naturally replenished at a human time frame such as sunlight, wind, rain, tide waves and geothermal heat.

→ Renewable energy often provides energy in four important areas. electricity generation air and water heating, cooling transport and rural off-grid energy services.

Need for hybrid system:-

→ The WRF 3D-VAR system uses only climatological background error covariances.

→ Flow dependant covariance through ensemble is needed.

→ Hybrid combiness climatological and flow-dependant background error covariances.

→ IF can be adopted to an existing 3D-VAR system.

→ Hybrid can be robust formal size ensembles.