

Renewable Energy Sources

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INTRODUCTION TO RENEWABLE ENERGY

Environmental Consequence Of Fossil Fuel Used :-

- Fossil fuel which includes coal, natural gas, petroleum and bitumin are the main source of heat and electrical energy. All these fuel contain beside the major constituent (C, O_2, H_2)
- Air pollution cause by particulate matter and other pollutants not only act directly on the environment but by contamination of water and soil leads to their degradation.

Importance Of Renewable Energy Sources :-

- Concern for the environment due to ever increasing use of fossil fuel and rapid depletion of natural resources have lead to development of alternative source of energy which are renewable and environmental friendly.

→ The following points may be mentioned in this connection.

- * The demand of energy is increasing due to rapid industries and population growth and hence the conventional source of energy will not be sufficient to make the growing demand.

- * Conventional sources are non-renewable and are bound to finish up to one day.

- * Conventional sources fossil fuel, nuclear also cause pollution thereby their use degrades the environment.

- * Large hydro resources effect wild life, cause deforestation and various social problems.

Sustainable Design And Development :-

→ Global environmental degradation is one of the most serious threats facing mankind as a result of the expansion of its activity around the globe.

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→ One of the international responses to global environment problems the framework convention on climate change was ratified and came into effect in March 1994.

Types Of Renewable Energy Sources :-

There are different types of energy that are considered renewable energy namely.

- 1) Solar Energy
- 2) Biomass Energy
- 3) Wind Energy
- 4) Hydro Electric Energy
- 5) Tidal Energy
- 6) Geothermal Energy

1) Solar Energy :-

→ Solar energy is one of the most popular and also the fastest growing renewable energy source.

→ As a free renewable energy source, technology has created a technique for collecting the energy of the sun through solar panels.

→ Solar panels are classified into 2 types

• a) Solar PV cell

b) Solar Thermal Panel.

2) Biomass Energy :-

→ Biomass energy is most widely used renewable energy.

→ It uses organic material like animal, plants and convert them into another form of energy that can be used.

→ The common type used for generating biomass energy is crops, woods and compost.

3) Wind Energy :-

→ Wind energy has been using for several years for power wind mills.

→ When we construct to other type of renewable energy, wind energy is considered as well as very reliable.

→ It convert wind energy to electrical energy.

4) Hydro Electric Energy :-

→ The hydro electric energy uses the flow of water to rotate turbine for generating electricity.

→ There are some issues while using hydro electric energy, this energy can be generated from dam river other wise it can have major effect on the soil as well as wild life and also effect on ~~fish~~ communities.

5) Tidal Energy :-

→ Tidal energy is the same as wind energy but these are predictable as well as steady. This is the main reason that tidal mills have been use for many years.

→ Usually tidal energy has faced from relatively high cost as well as incomplete accessibility of sites through suitably high tidal range.

6) Geo-thermal Energy :-

→ The term geothermal taken from the greek word 'Geo' (Earth) and it receive the heat from the earth and convert heat into energy for instance hot water or steam energy which are generated from the earth can be utilized for generating energy, it is called to the renewable supply of energy because the water is filled by the normal ~~rain~~ fall and the heat used is generated through other planet.

Advantages Of Renewable Energy Source :-

- Renewable energy technology require less overall than traditional generators that use traditional ~~fuel~~ source.
- Renewable energy makes real economical since because it is cheaper alternative to most traditional source of energy since the instfection of renewable energy new and stable jobs have been added to the most world economic.

- Empowering of people on country side.
- Renewable energy generation mainly takes place in remote setting, this means that local focus would get a fair share of power generated of powers generated.

Limitation Of Renewable Energy Source :-

- The electricity generation capacity is still not large enough.
- Renewable energy can be of low efficiency
- It require a huge capital outlet.
- It takes a lot of space.

Present India And International Energy Scenario :-

World Energy States :-

- At present the annual primary energy consumption of the world is 500 Hexajule.
- Fossil fuel roughly provide about 90% of this energy will continue to provide more than 80% of the total energy demand well into the future.

A' Energy Scenario In India :-

- India is both measure energy producer and consumer.
- India currently ranked as the world 11th greatest energy producer accounting for about 2.4% of the world total energy production.
- Thus India is a net energy importer mostly due to the large imbalance between oil production and consumption.

Sector wise energy consumption :-

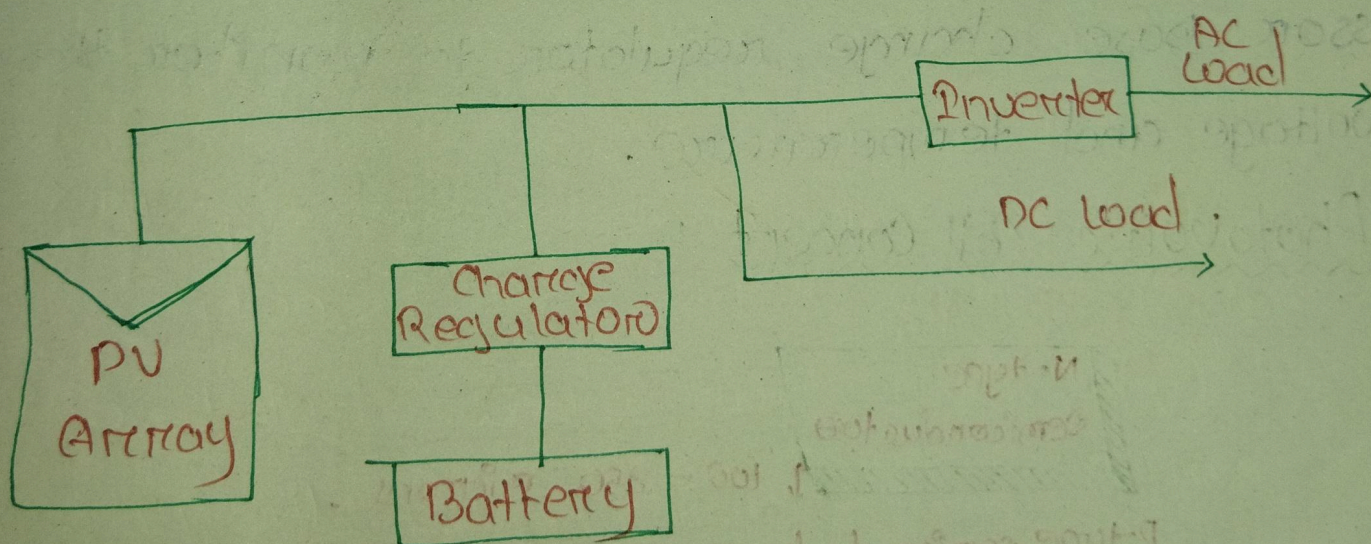
Industry	49%
Transport	22%
Residential	10%
Agriculture	5%
Others	14%

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SOLAR ENERGY

Solar Photovoltaic Operating System :-

- A photovoltaic module produces DC power to operate electrical appliances used in house holds, inverter and are used to convert DC power into 220 V, 50 Hz AC power.
- Components other than PV module are collectively known as balance of system (BOS) which includes storage batteries and electric charge collector and an inverter.



(Block diagram of solar photovoltaic operating system)

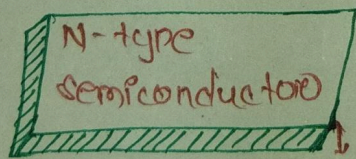
→ The capacity of the battery is expressed in ampere hour and is cell of the load acid tide battery is 2V.

→ An inverter is provided for converting DC power from battery or PV array to AC power. It needs to have automatic switch off in case of the output voltage from the array is too low or too high.

→ The inverter is also protected against overloading & short circuit.

→ Batteries are installed with a microprocessor base charge regulator to monitor the voltage and temperature.

Photovoltaic Cell Concept :-



P-type semiconductor

→ The basic cell structure of a typical n or p type semiconductor a bulk silicon cell is used the bulk material is P-type silicon.

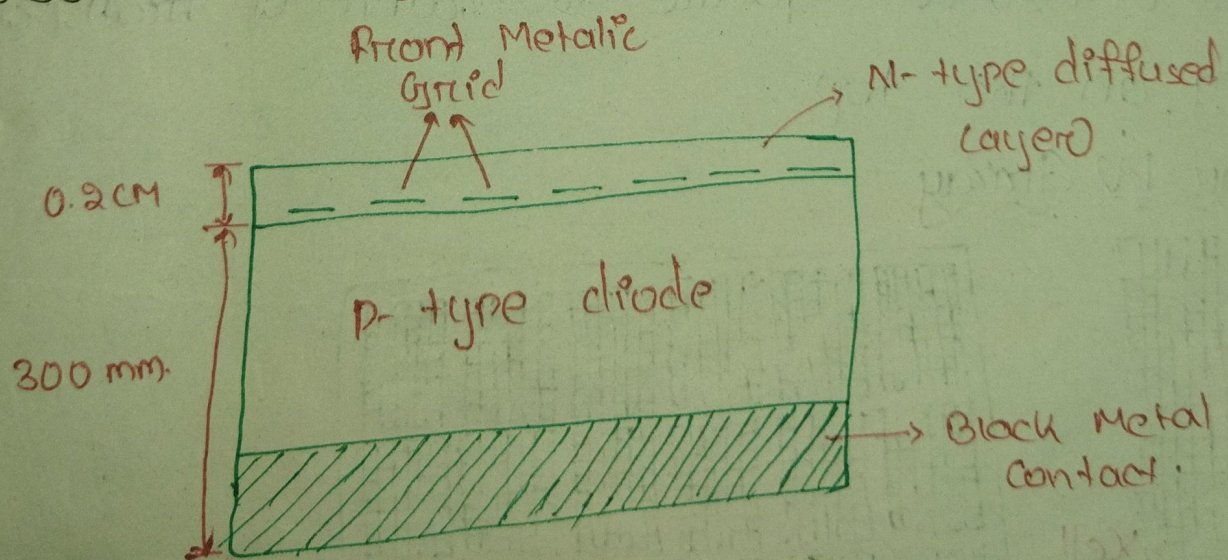
with a thickness of 100-350 microns. Depending on the technology used.

→ A thin layer of N-type silicon is formed at the top surface by diffusing an impurity from the Vth group to get a P-N junction.

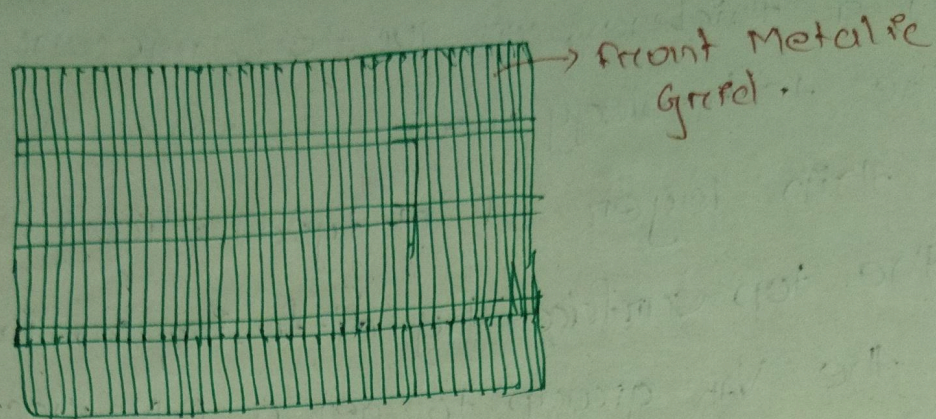
→ These two metallic contacts on p and n layers respectively form the positive and negative terminal of the solar cell.

→ In addition to basic element several enhancement features are also included in the construction. For example - Providing entire reflecting coating, to capture maximum photons.

Solar PV Modules



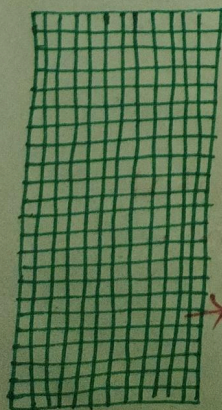
(Cross-section View)



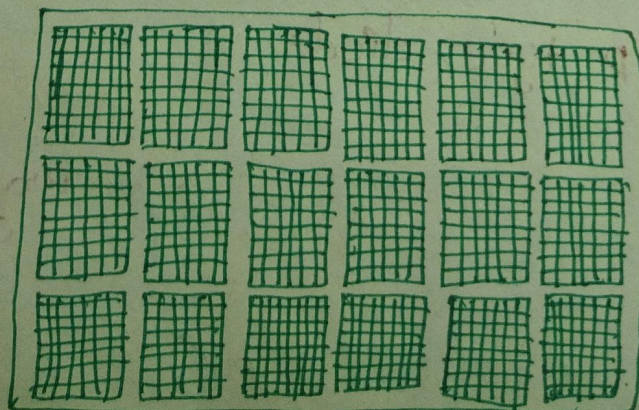
→ A bare single cell can't be used for outdoor energy generation by itself it is because the output of a single cell is very small and it requires protection against dust, moisture, mechanical shocks.

→ Workable voltage and reasonable power is obtained by interconnecting an appropriate no. of cell the unit is fix on a durable back cover of several square feet with a transparent cover on the top.

Solar PV Array :-



Module



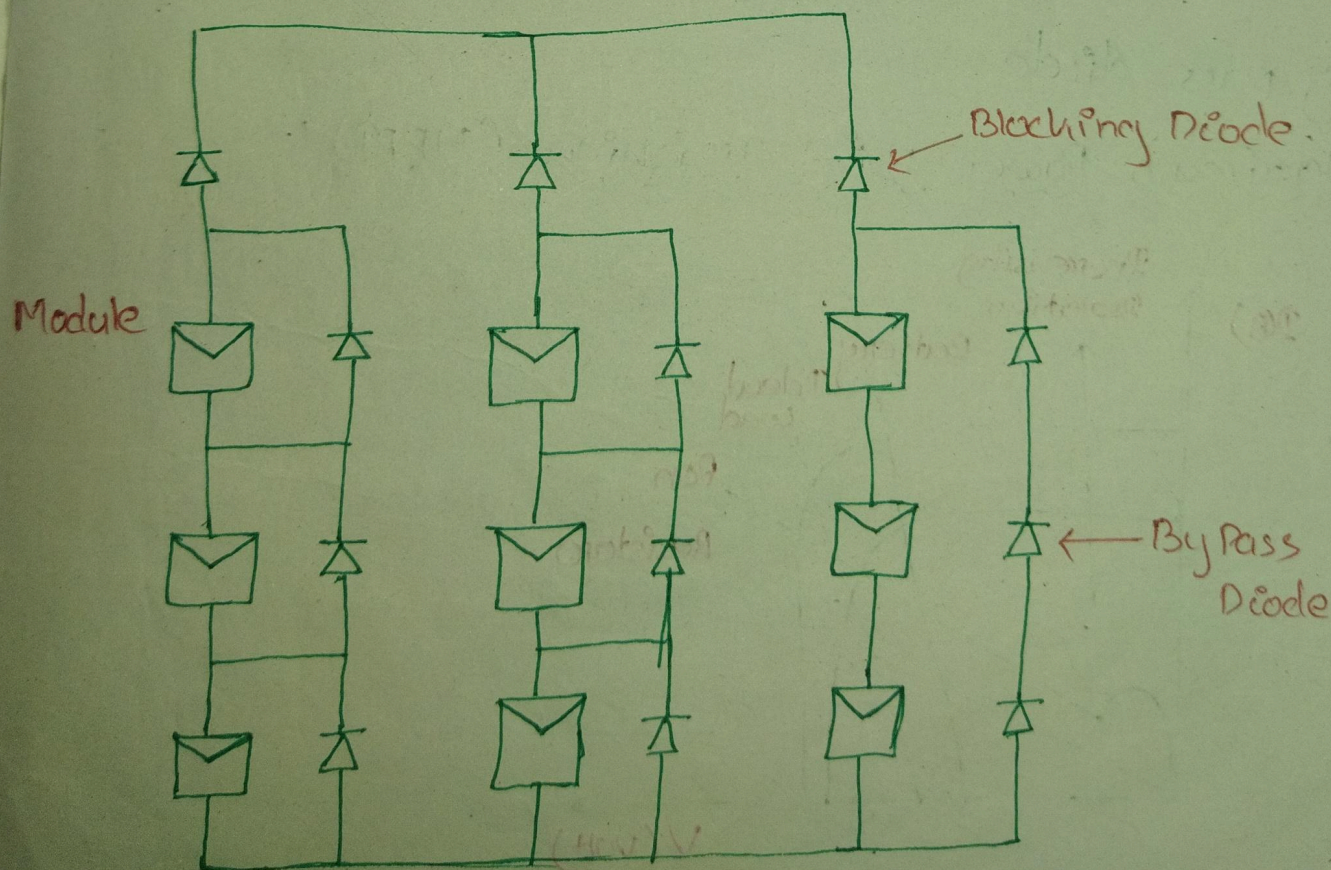
Panel

→ In general a large number of interconnected solar panel known as solar PV array are installed in an array field.

→ Those panel may be installed as stationary or with sun tracking mechanism.

→ The lay out and mechanical design of the array such as tilt angles of the panels, height of the panels etc. are carried out taking into consideration the local climatic condition, each of maintenance etc.

Parallel And Series Connection :-

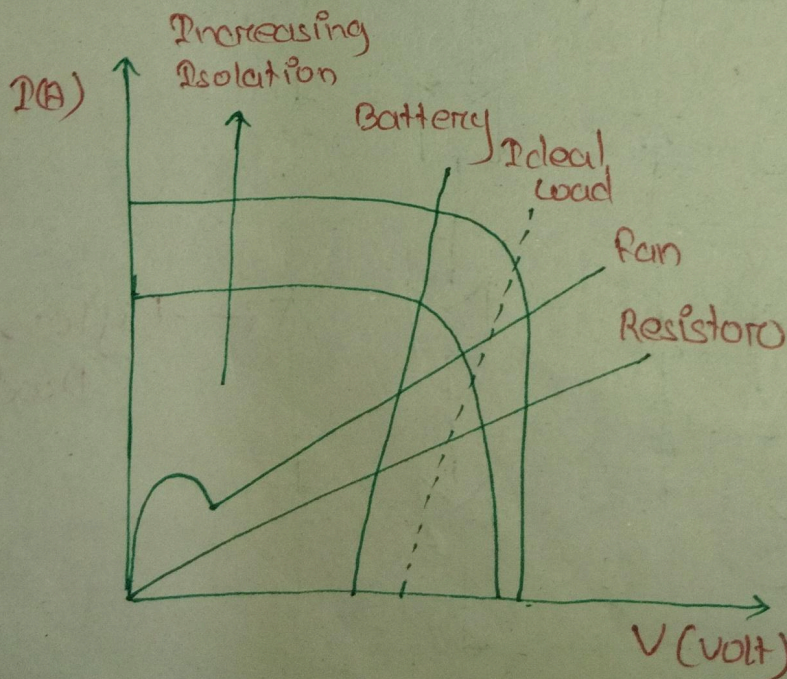


→ Above figure shows the series parallel connection of module in a panel.

→ In a parallel connection blocking diode are connected in series with each series string of module so that if any string should fail the power output of the remaining series string will not be absorb by the fail string.

→ A by pass diode are installed across each module so that if one module should fail the output of the remaining module in a string will by pass the fail module, some modern PV module come with such internally embedded by pass diode.

Maximum Power Point Tracking (MPPT) :-



(Characteristics of PV and some load)

→ when a solar PV system is deployed for practical application the $V-I$ characteristics keeps on changing with insolation and temperature.

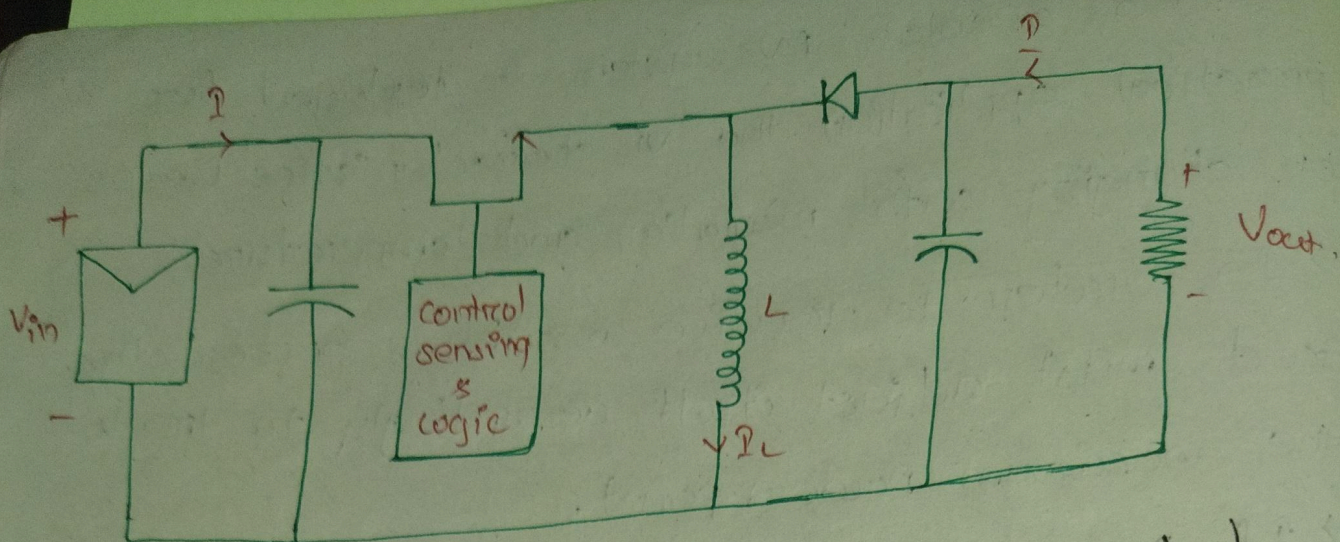
→ In order to receive maximum power the load must adjust itself accordingly to track the maximum power point.

→ If the operating point departs significantly from the maximum power point it may be desirable to interpose an electronic maximum power point tracker (MPPT) between the PV system and the load.

→ The ~~big~~ buck-boost scheme is commonly used with voltage and current sensor tied into a feedback loop using a controller to vary a switching time.

$$V_{out} = \frac{D}{1-D} V_{in}$$

where, D is duty cycle of the MOSFET expressed as fraction ($0 < D < 1$)



(Maximum Point Tracker Using Buck-boost converter)

→ The power output of PV system is given by

$$P = VI$$

→ with incremental change in current and voltage the modified power is given by.

$$P + \Delta P = (V + \Delta V)(I + \Delta I)$$

→ There are three possible strategy for equation of an MPPT:

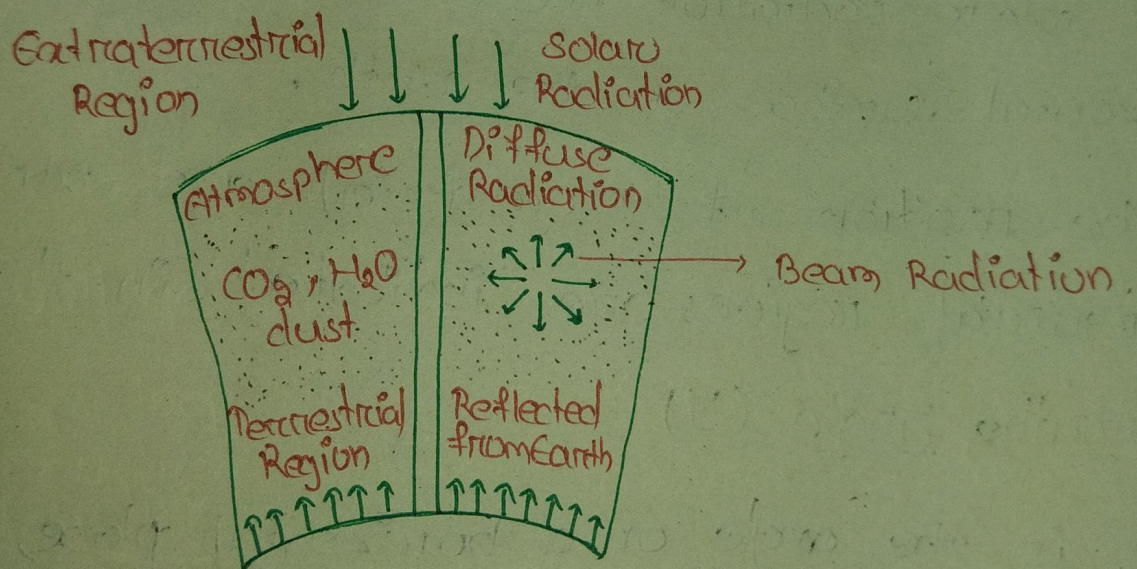
- * By monitoring dynamic and static impedance.
- * By monitoring power output.
- * By fixing the output voltage as a fraction of V_{oc} .

Character

Classification of Energy source :-

- ① Central Power Station
- ② Distributed System
 - * Stand Alone System
 - * Grid Interactive System
 - * Small system for Consumer Application

Extraterrestrial and Terrestrial Radiations :-



(Propagation of solar radiation)
through atmosphere

→ The extraterrestrial radiation, being outside the atmosphere, is not affected by changes in atmosphere conditions.

→ While passing through the atmosphere, it is subjected to mechanisms of atmospheric absorption and scattering depending on atmospheric conditions, depleting its intensity.

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

→ The term solar insolation is defined as the solar radiation received on a flat horizontal surface on the earth.

→ The position of terrestrial and extra-terrestrial regions are indicated in figure.

Azimuth Angle (ψ) :-

→ It is the angle on a horizontal plane, between the line due south and projection of the sun's ray on the horizontal plane.

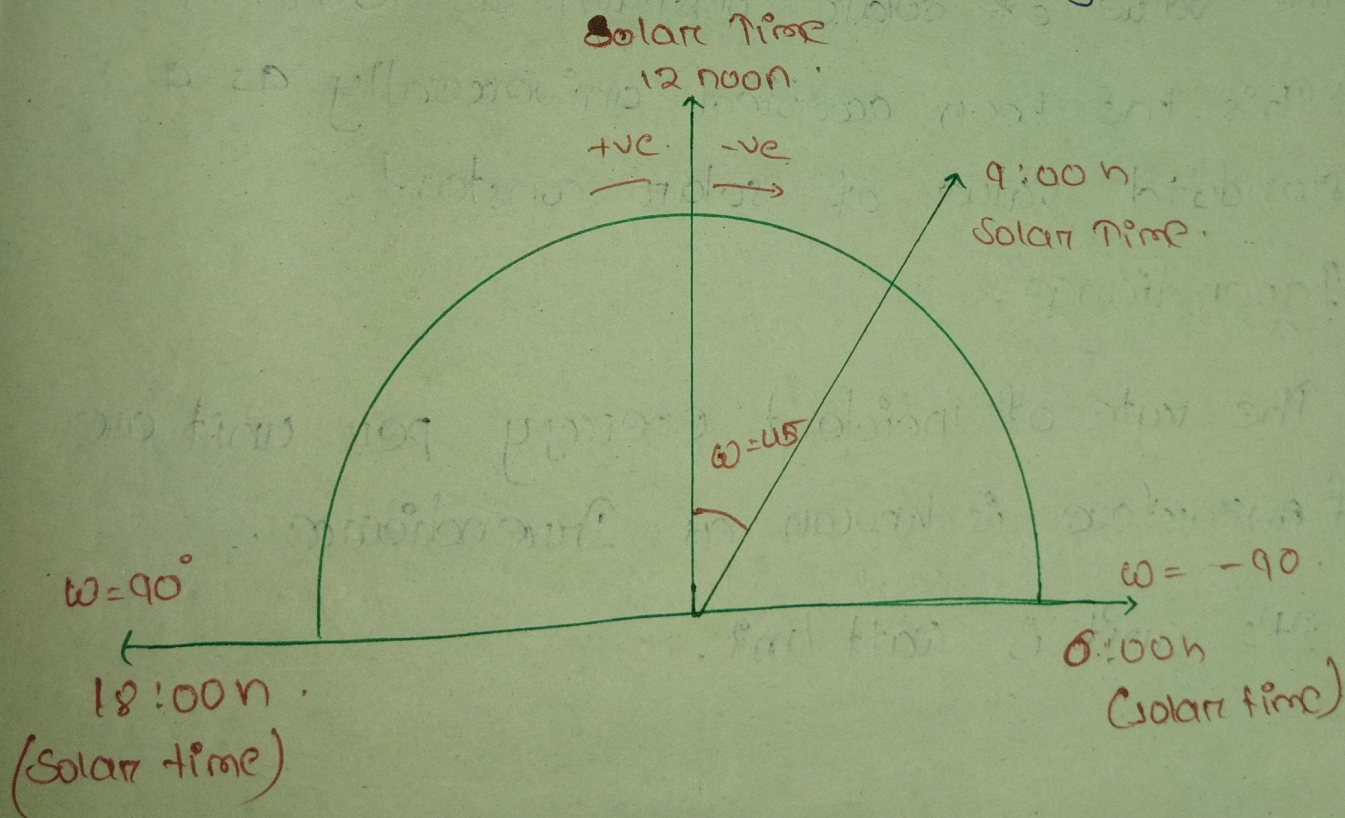
→ It is taken as positive when measured from south towards west.

Zenith Angle (θ) :-

→ It is the angle between the sun's ray and the perpendicular (normal) to the horizontal plane.

Hour Angle (ω) :-

The hour angle any moment is the angle through which the earth must turn to bring the meridian of the observer directly in the line with the sun's rays.



Solar Constant :-

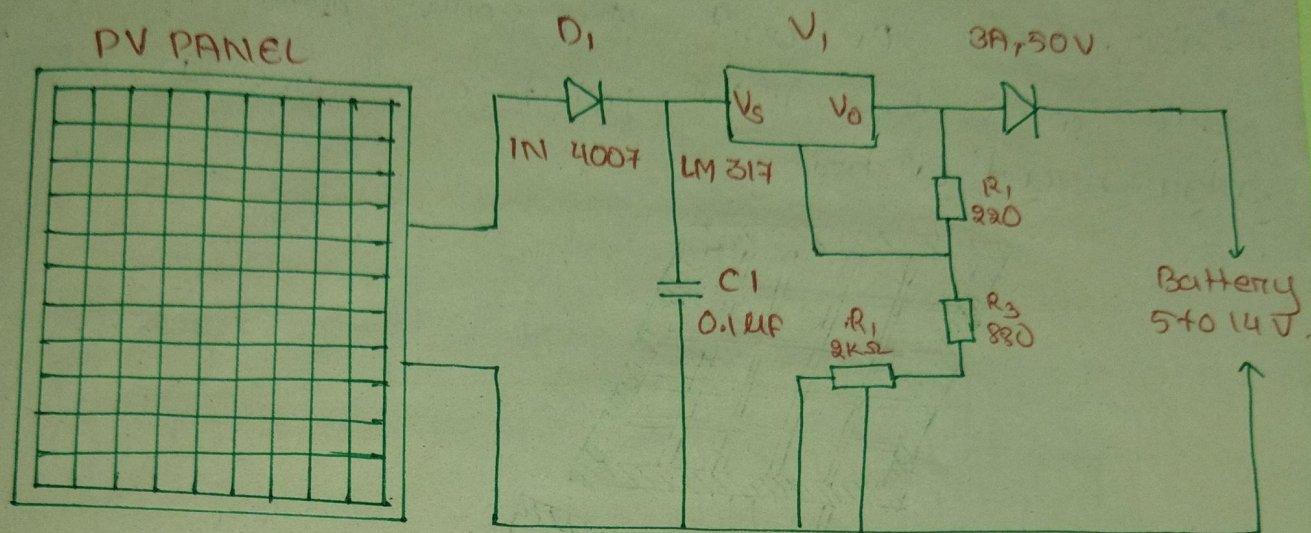
- The solar constant I_{se} is defined as the energy received from the sun per unit time on a unit area of surface perpendicular to the direction of propagation of radiation at the top of the atmosphere and the earth's mean distance from sun.
- The world radiation center (WRC) adopted the value of solar constant as 1367 W/m^2 .
- This has been accepted universally as a standard value of solar constant.

Irradiance :-

- The rate of incident energy per unit area of ~~an~~ surface is known as Irradiance.
- It's unit is Watt/m^2 .

Application :-

Photo Voltaic Battery Charger :-



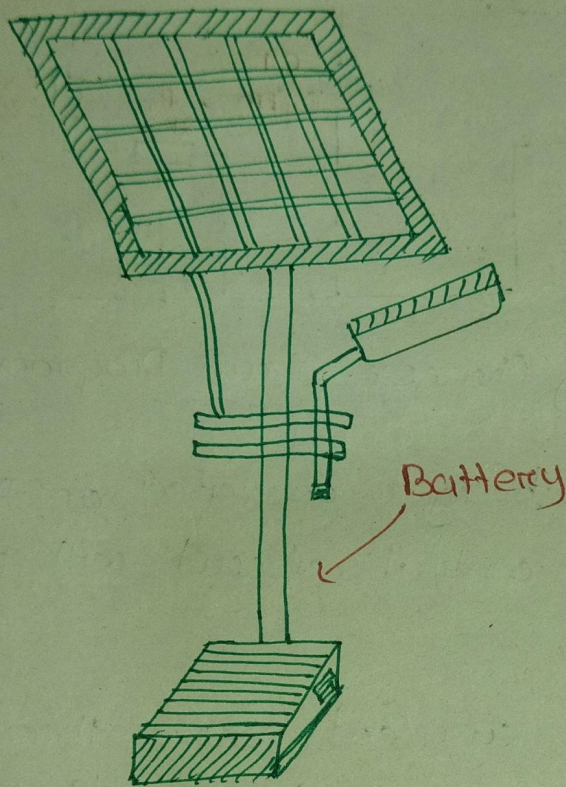
(Solar Battery Charger Circuit Diagram)

- Solar battery charger operated on the principle that the charge control circuit will produce the constant voltage.
- The charging current passes through LM 317 voltage regulator through the diode D_1 .
- The output voltage and current are regulated by adjusting the adjust pin of LM 317 voltage regulator battery is charged using some current.

Domestic Lightning :-

→ Home lightning system are the most popular solar PV unit, typically desired to work with two light point and one PV point.

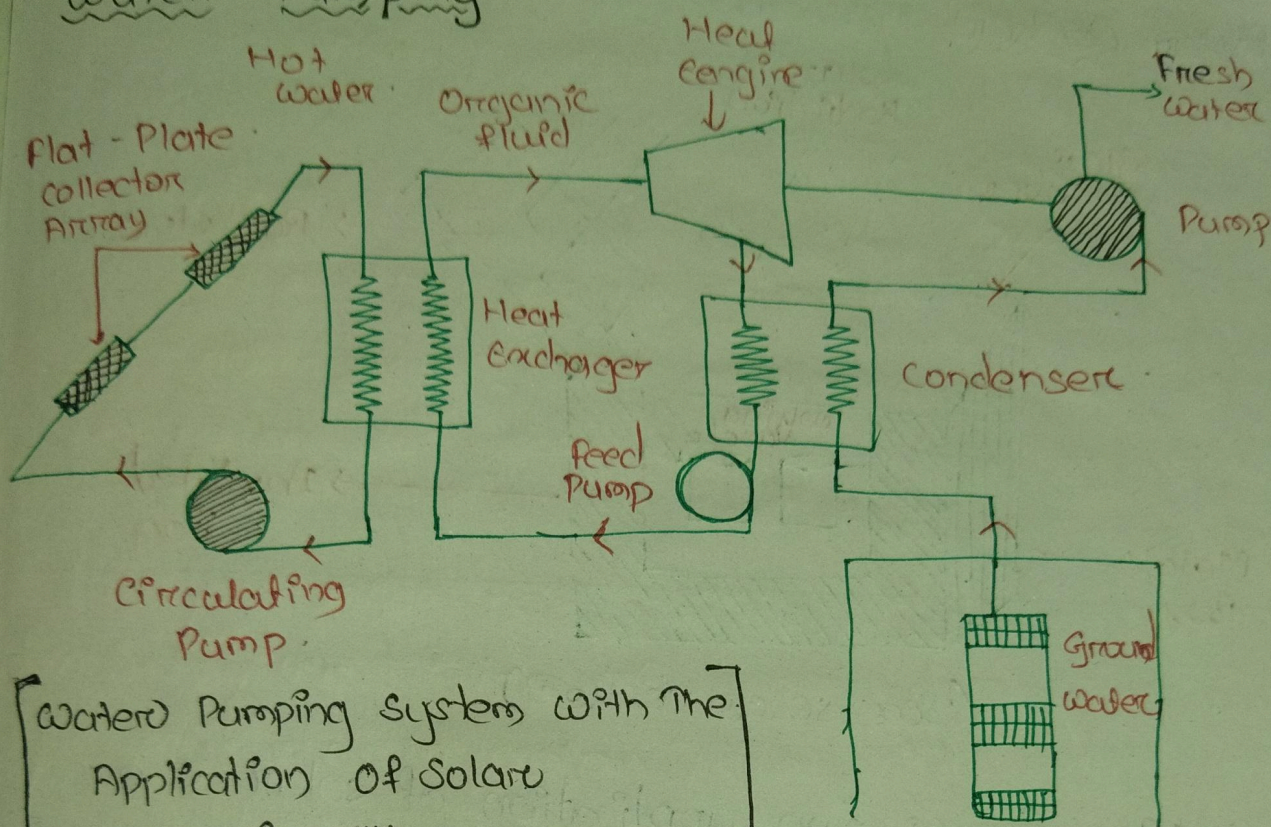
Solar Street Lighting :-



(Solar Street Light Installation)

- solar street lighting system is shown in figure describe a standalone PV power generating device.
- It comprises a compact fluorescent lamp, ~~to~~ 30 watt solar module and 80 Ah tubular cell battery.

Water Pumping :-



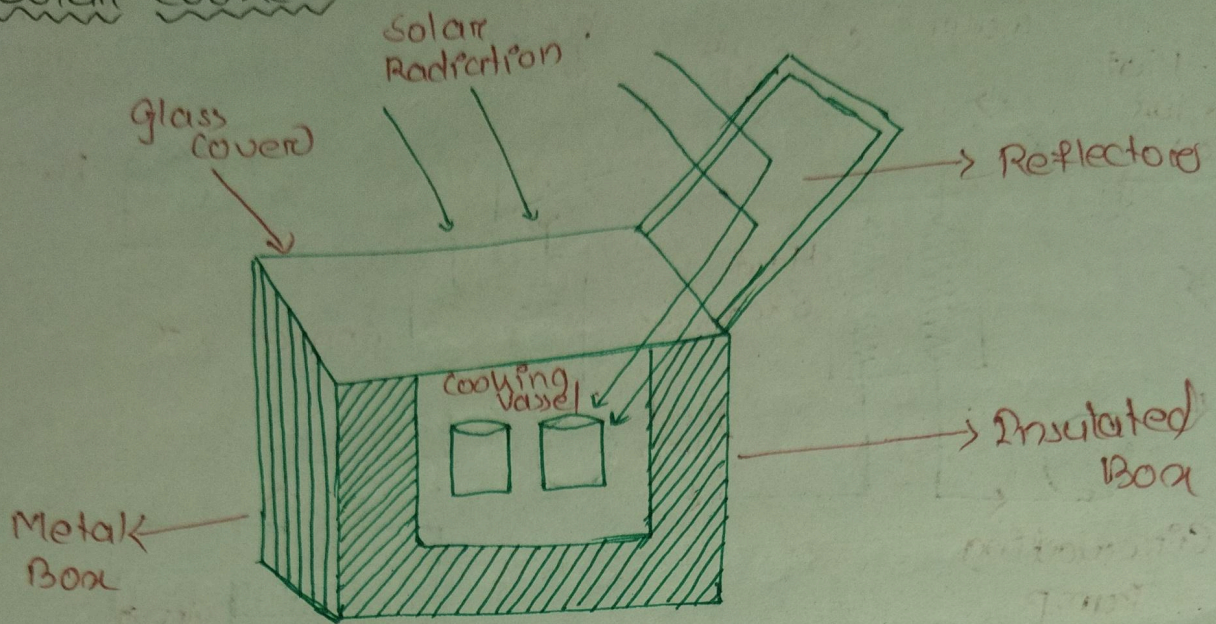
[Water Pumping system with the Application of Solar Energy]

→ Water pump can be driven directly by solar heated water or fluid which operates either heat engine or turbine.

→ For ~~low~~ head, the pump driven by vapour of a low boiling point liquid heated by a flat plate collector is used.

→ For larger head, a parabolic trough concentrator or a parabolic bowl concentrator is installed to drive a steam turbine.

Solar Cooker :-



(Box solar cooker)

→ Cooking is common application of solar energy in India. Several varieties of solar cookers are available to suit different requirements.

Box Solar Cooker :-

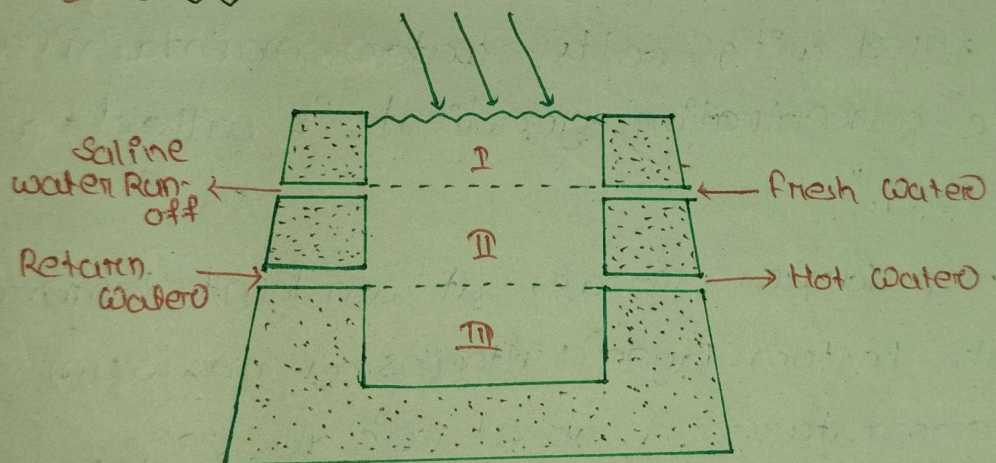
→ It consists of an outer box made of either fibre glass or aluminium sheet, a blackened aluminium tray, a double glass lid, a reflector, insulation and cooking pots as detailed in figure.

→ Blackened aluminium tray is fitted inside the box and sides are covered with an insulating material to prevent heat loss. A

reflecting mirrors provided on the box cover to increase the solar energy input.

→ Metallic cooking pots are painted black on the outer side food to be cooked is placed in cooking pot and the cooker is kept facing the sun to cook the food. An electric heater may also be installed to serve as a backup during non-sunshine hours.

Solar Pond :-



(Schematic Diagram of)
Solar Pond

I = Structure Convective Zone (SCZ)

II = Concentration Gradient Zone (CGZ)

III = Lower Convective Zone (LCZ)

→ The concept of solar pond was derived from the natural lakes, where the temperature rises of the order 45°C towards the bottom.

→ It happens due to natural salt gradient in this lakes where water at the bottom is denser.

→ In salt concentration lakes, convection does not occur and heat loss from hot water takes place only by conduction.

→ This technique is utilized for collecting and storing solar energy. An artificially designed pond filled with salty water maintaining a definite concentration gradient is called a "Solar Pond."

→ The top layers remain at constant temperature while the bottom layer attains a maximum steady state temperature of about 60°C to 85°C .

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WIND ENERGY

Introduction To Wind Energy :-

→ Wind energy is the kinetic energy associated with movement of large masses of air. These motions result from uneven heating of the

atmosphere by the sun creating temperature density and pressure differences.

Wind Energy Conversion :-

→ wind turbines extract energy from wind energy by converting the kinetic energy of wind to rotational motion required to operate an electric generator.

→ By virtue of the kinetic energy, the velocity of the following wind decreases.

→ It is assumed that the mass of air which passes through rotor is only affected and remains separate from the air which does not pass through the rotor.

Types of Wind Turbine :-

→ wind turbines are classified as horizontal-axis turbines or vertical-axis turbines depending upon the orientation of axis of rotation of their rotors. A wind turbine operates by slowing down the wind and extracting a part of its energy in the process.

→ For a horizontal-axis turbine, the rotor axis is kept horizontal and aligned parallel in the direction of the wind stream. In a vertical axis turbine; the rotor axis is vertical and fixed and remains perpendicular to the wind stream.

→ In general, wind turbines have blades, sails or buckets fixed to a central shaft. The extracted energy causes the shaft to rotate. This rotating shaft is used to drive a pump, to grind seeds or to generate electric power, wind turbines are further classified into 'lift' and 'drag' type.

Types of Rotors

Different type of rotors used in wind turbine are.

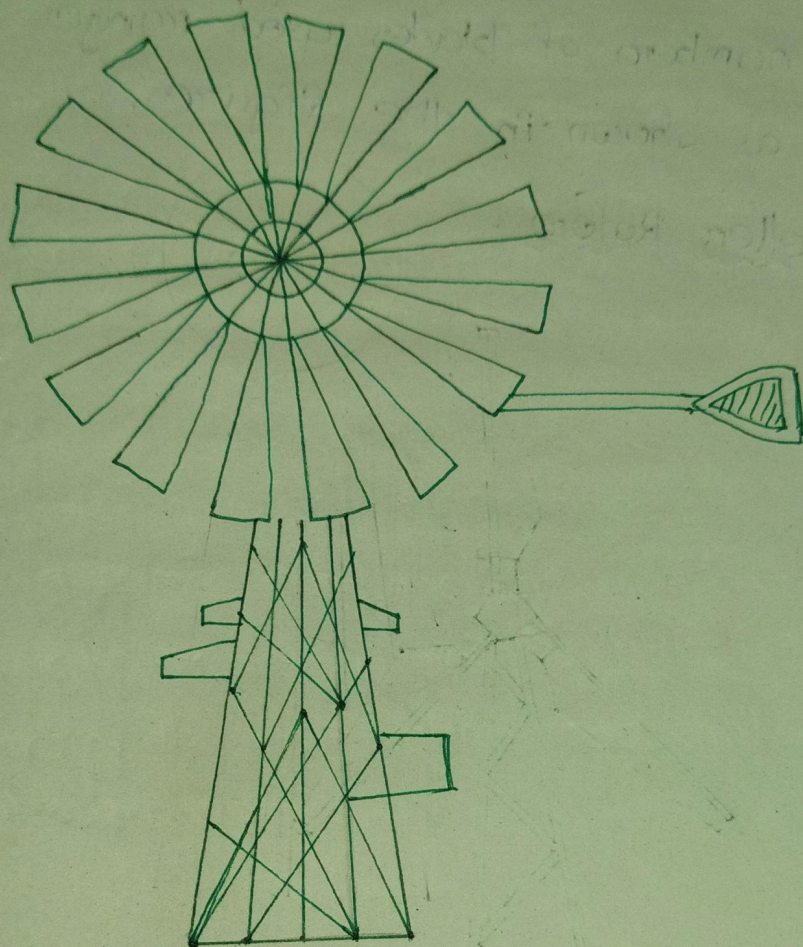
a) Multiblade Type

b) Propeller Type

c) Savonius Type

d) Darrieus Type

a) Multiblade Type



(Multiblade Rotor Installed In a tower)

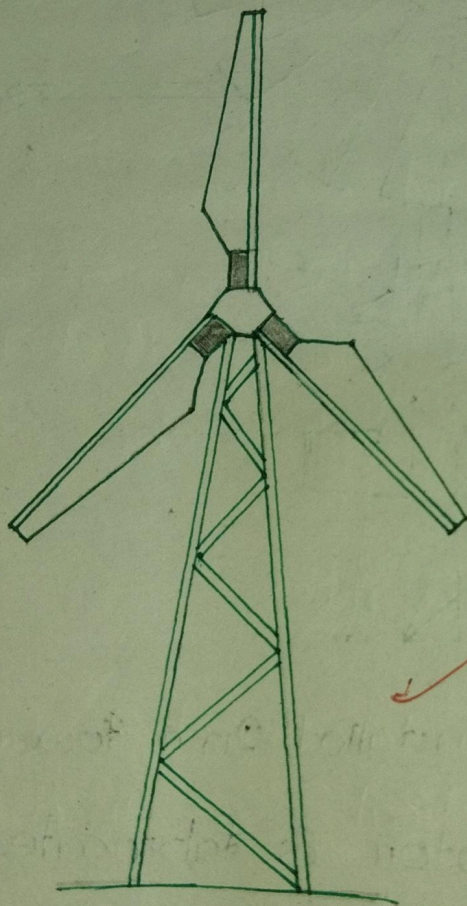
→ The multiblade rotor is fabricated from curved steel metal blades. The width of blade increases outwards from the centre.

→ Blades are fixed at their inner ends on a circular rim. They are also welded near their

outer edge to another rim to provide a stable support.

→ The number of blades used ranges from 12 to 18 as shown in the figure.

b) Propeller Rotor :-

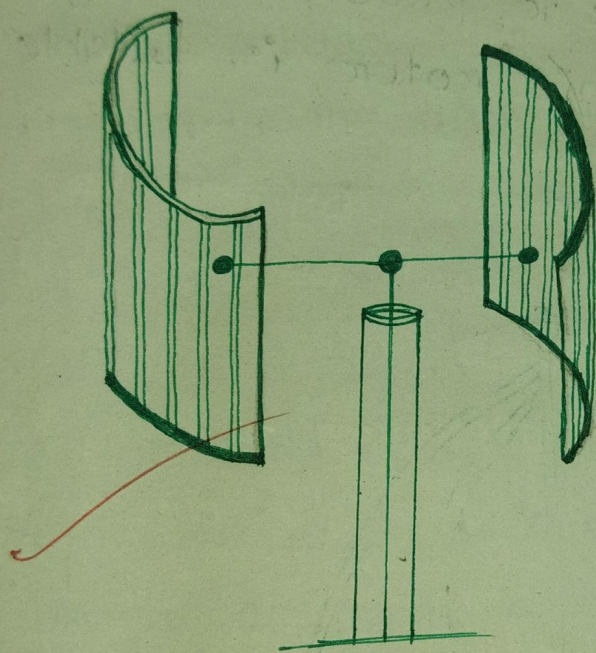


(Propeller Rotor Installed On A Tower)

→ The propeller rotor comprises two or three aerodynamic blades made from strong but light weight material such as fibre glass reinforced plastic.

→ The diameter of the rotor ranges from 2m to 25m as detailed in figure. The blade slope is designed by using the same aerodynamic theory as for aircraft.

c) Savonius Rotor :-



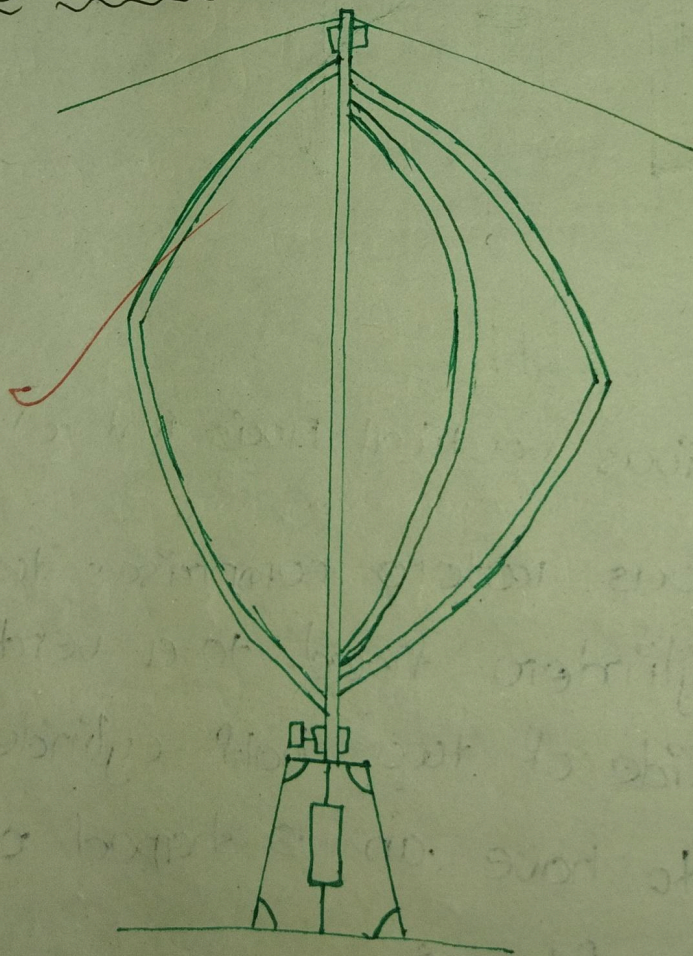
(Savonius Vertical Axis Rotor)

→ The savonius rotor comprises two identical hollow semicylinders fixed to a vertical axis. The inner side of two half-cylinders face each other to have an S shaped crosssection, as detailed in figure.

→ Irrespective of wind direction, the rotor rotates due to pressure difference between the two sides. This vertical axis rotor was developed by an engineer savonius of Finland in the year 1920.

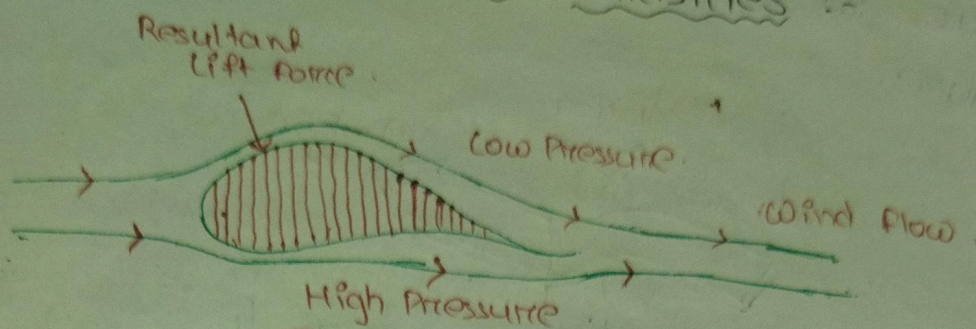
→ It is self starting and the driving force is mainly of drag type. The rotor ~~possesses~~ possesses high solidity so as to produce a high starting torque and hence this rotor is suitable for water pumping.

d) Darrieus Rotor :-



(Darrieus Rotor)

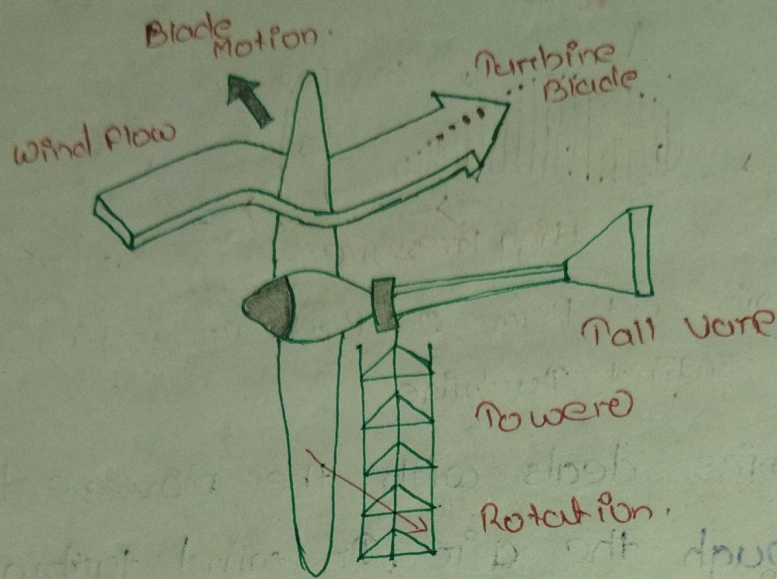
Aerodynamics Of Wind Turbines



(Aerodynamic Lift Force On Blade Crosssection of)
Wind Turbine

- Aerodynamics deals with the movement of solid bodies through the air. In wind turbines aerodynamics provides a method to explain the relative motion between airfoil and air. Air foil is the cross-section of wind turbine blades.
- When the wind passes through the surface of the rotor blade, it automatically passes over the longer on upper sides of blade, creating a low pressure area above the air foil as shown in figure.
- The difference between the top and bottom surfaces results in a force called the aerodynamic lift that causes the air foil to rise.
- As the blades can only move in a plane with the hub as their centre, the lift force is same

cause rotation about the hub as shown in figure:



→ The turbine thus extract energy from the wind stream by converting the wind's linear kinetic energy into rotational energy/motion.

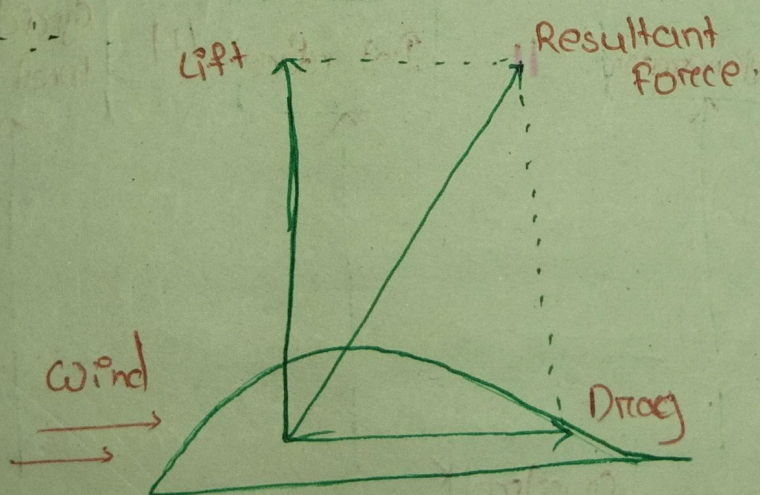
→ The addition to the lift force, a drag force perpendicular to the lift force, also acts on the blade which impedes rotor rotation.

→ The prime objective in wind turbine design is the desired lift to drag ratio of the blade (airfoil structure). The basic principles of lift and drag forces are dealt with in the next section.

Drag :-

- It is the resistance which a body experience when a fluid moves over it. Flood water washes away animals, vehicles and buildings, wind storm ~~and~~ damage the transmission towers, trees, sweeps, and ships.
- There are few undesirable examples of drag forces. The force that a flowing fluid exerts on a body in the direction of flow is called drag force.
- Drag may bring an undesirable effect of friction, such as burning of space vehicles on entering into the earth's atmosphere.
- Reduction of drag is the basic engineering approach, associated with the reduction in fuel consumption in automobiles, aircraft and submarines.

Lift :-

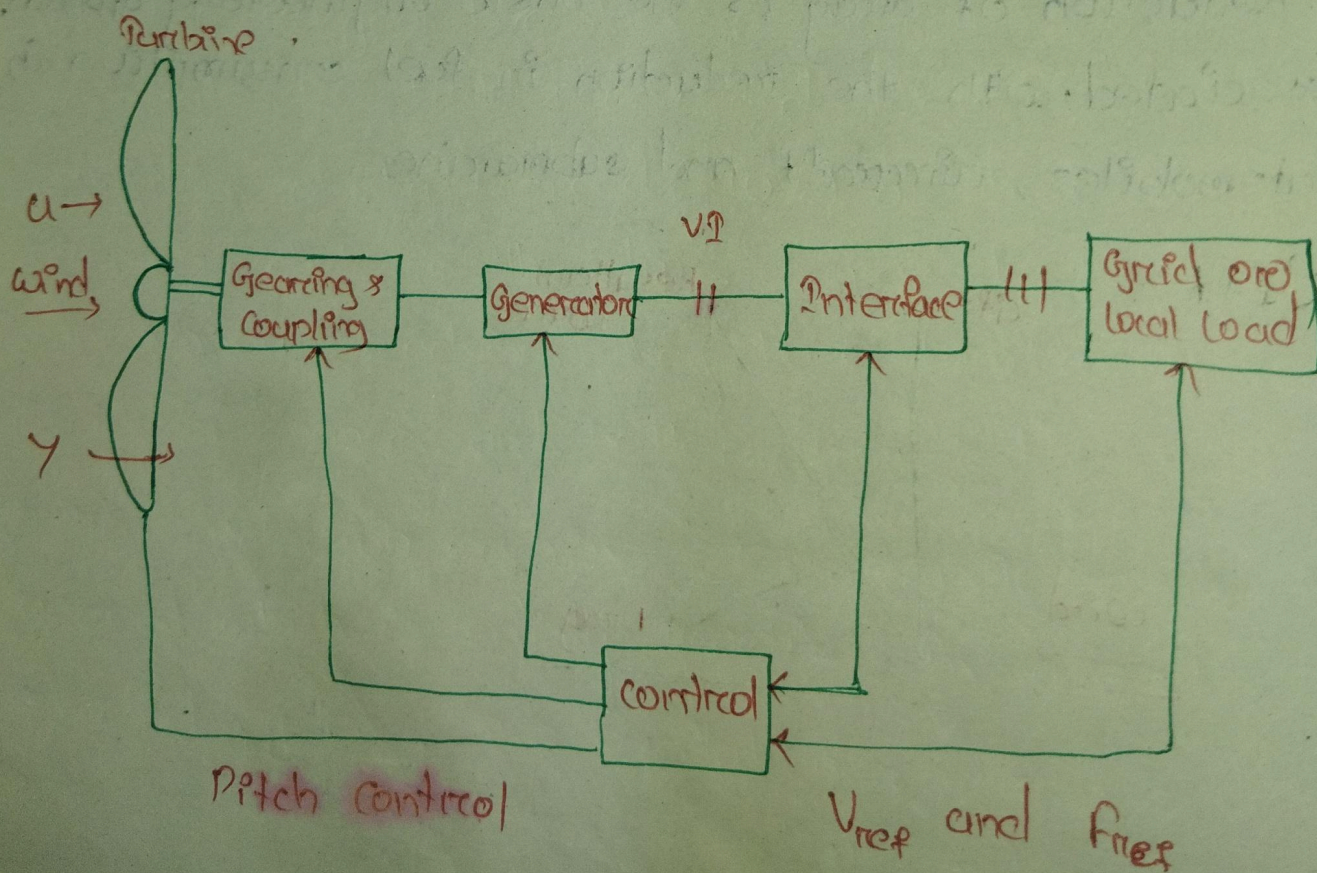


→ when a body is immersed in a standstill fluid, only the normal pressure force is exerted on it. A flowing fluid in addition exerts tangential shear force on the surface.

→ Both these forces have two components one is drag in the flow direction, the other is perpendicular to the fluid flow called "lift."

→ It causes the body to move in the upward direction. The relative magnitude of drag and lift forces depend completely on the shape of the object.

Wind Turbine Control System: Conversion of Electrical Power :-



→ A wind energy conversion system converts wind energy into some form of electrical energy. In particular medium and large scale wecs are designed to operate in parallel with a public or local ac grid. This is known as a grid connected system.

→ A small system isolated from the grid, feeding only to a local load known as autonomous, remote, stand-alone or isolated power system.

→ A general block diagram of a grid-connected wecs is shown in figure.

→ Ratio to suit the electrical generator and fine-tuning of speed is incorporated by pitch control. This block act as a drive for the generator.

→ Use of variable gear ratio has been considered in the past and was found to add more problem than benefits.

→ Hence DC synchronous or induction generators are used for mechanical to electrical power conversion depending on design of the system. The interface conditions the generated power to grid-quality power.

→ It may consist of a power electronic converter, transformer and filters etc. The control unit monitors and controls the interaction among various blocks.

→ It derives the reference voltage and frequency signals from the grid and receives wind speed, wind direction, wind turbine speed signals etc. It processes them accordingly and controls various blocks for optimal energy balance.

Induction Generator :-

→ The primary advantages of an induction machine are the rugged brushless construction, no need of separate DC field power and tolerance of slight variation of shaft speed ($\pm 10\%$) as these variations are absorbed in the slip. Compared to DC and synchronous machines, they have low capital cost, low maintenance and better transient performance.

→ The induction machine requires AC excitation current which is mainly reactive. In case of a grid-connected system, the excitation current is drawn from the grid and therefore the network must be capable of supplying the reactive power.

Synchronous Generators :

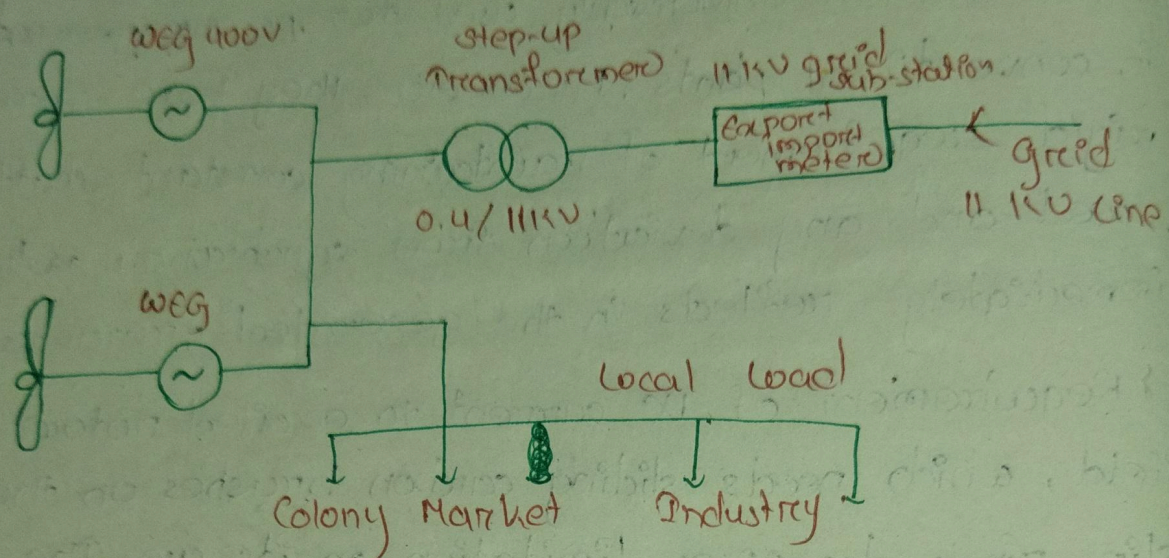
→ Synchronous generators produce high quality output and are universally used for power generation in conventional plants. However, they have very rigid requirement of maintaining constant shaft speed and any deviation from synchronous value immediately reflects in the generated frequency.

→ Requirement of DC current to excited rotor field, which needs sliding carbon brushes on the slip rings also poses limitation on its use. The need of a DC field current and brushes can be eliminated by using reluctance rotor. The reliability is greatly improved while reducing the cost.

→ The machine rating, however, is limited to tens of kW. Synchronization of a wind-driven generator with the power grid also poses problems. ~~Especially~~

→ The main advantage is that it generating both active as well as reactive powers.

Grid Connected And Self Excited Induction Generator Operation:



(Grid Connected Wind Turbine Generator)

→ WEGs generate electric power at 400V. It is then stepped up to make this voltage compatible to the grid (11 kV). In India, grid-connected WEGs constitute wind farms where the generated power is distributed among the nearby consumers and the excess power is exported to the grid. Electrical energy is purchased from the grid during periods of no wind.

Constant Voltage And Constant Frequency Generation with Power Electronic Control:

- Modern variable speed drive schemes make use of power electronics converters for power conditioning.
- The harmonics are filtered out to get quality output or to get grid quality output before connecting to the grid.
- The rectifier, inverter, filter and transformer are constitute the main parts of the interface.

Single Output System:

- For a power system with substantial power generation from wind farms, controllability of the wind farm power output is critical to power system reliability and economy.

a) Maximum

- It has a operating mode

a) Maximum Power Tracking (MPPT)

b) Power Regulation (PR)

a) Maximum Power Tracking (MPPT) :- MPPT is traditional operating mode, aimed on enabling wind turbines in wind farms to convert as much of the electrical energy as possible under normal operation conditions.

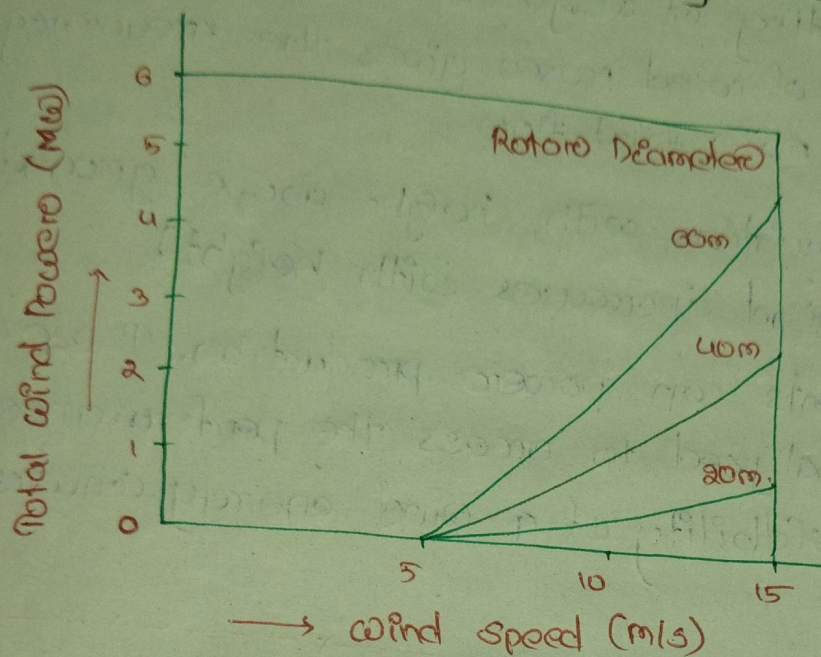
b) Power Regulation (PR) :- PR is concerned with adjusting the wind turbine power output as needed by power system reliability or economic condition.

Double Output System :-

→ The double rotor speed regulating wind power generation system has the ability of speed regulation and power generation at the same time. in a certain period of time and reduces the capacity of the generator and converter.

→ Moreover, the system can realize the capacity of active power overload and reactive power support of the grid. Since the synchronous generator is directly connected with the power grid at the end of the driving chain.

Characteristics Of wind Energy Power Plant :-



- Power in the wind is proportional to cube of wind speed and is highly site specific. It is necessary to carry out wind measurement if the performance of the wind turbine is to be estimated accurately.
 - The highest wind speed sites are exposed hills tops, off shore on the coastal sites. For developing wind energy at any site the different parameters required are :-
 - * Mean wind speed.
 - * Daily, seasonal and annual variations in wind speed.
- Wind speed frequency distribution generally described by weibull probability distribution.

* Direction of wind by studying the 'wind rose' data for micro siting of wecs (wind energy generator system). The map of wind roses gives the frequency distribution of main wind flow.

* Wind speed variation with height above ground. (Power in the wind increases with height)

→ These instruments can powered production. These readings are analyzed to assess the performance and economic viability of a wind energy conversion system (wecs).

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OTHER SOURCES OF ENERGY

Tidal Energy :-

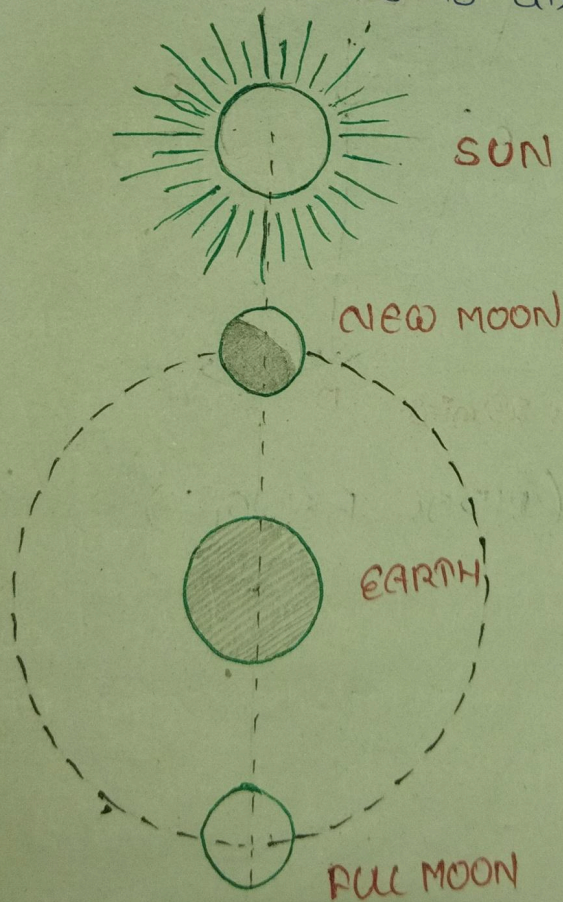
→ The tide are caused by the combine attraction of the sun and moon on the water of the revolving globe. *

→ The effect of the moon is about 2.6 times more than that of sun, influencing the tides of ocean.

→ Thus, tide is a periodic rise and fall of water level of the ocean twice during a lunar day (i.e within 24 hours 50 mins) the water in

the oceans and seas rises and falls. The excess of 50 min over the solar day results in the maximum water level, occurring at different times on different days.

- The amplitude of water level variation at different points on the earth depends on the latitude and the nature of the shore. The rotation of earth causes two high tides and two low tides to occur daily at any place.
- The revolution of the moon around the earth increases the time interval between two successive high tides from 12 hours to about 12 hours and 25 minutes.

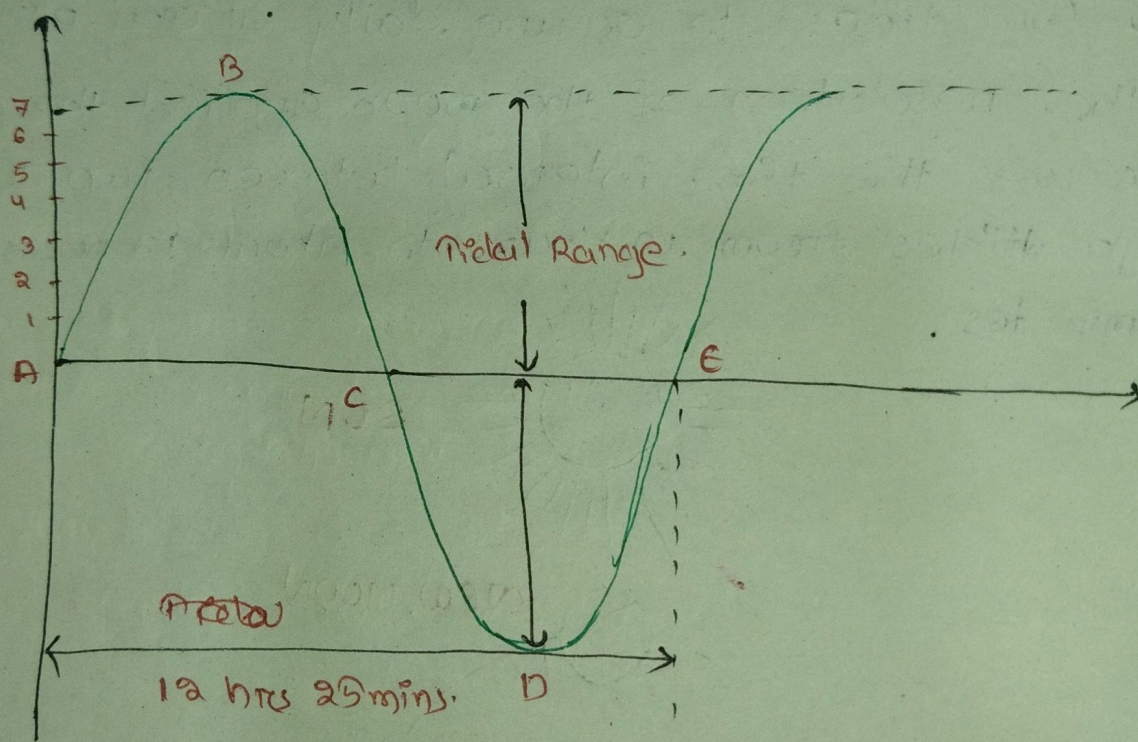


(The sun and moon acting in combination to create)
Spring tides

→ The solar pull comes in line with the lunar pull at "new moon" and "full moon". causing greater flow and known as spring tides.

→ The spring tides is particularly greater when the moon is new and full at which time it is at closest point of its orbit to the earth.

Tidal Range:-



(TIDAL RANGE)

- The tidal range is expressed as the difference in water level between two consecutive high tides.
- Consecutive high tides and low tide. The rise and fall of water level in the sea during tides can be represented by sine waves.
- One tidal day is of 24 hrs 50 mins and there are two tide cycle in one tidal day.
- The normal tide is a semi tide with a period of 12 hrs 25 mins.