Conventional energy sources	Non-conventional energy sources
1. Conventional energy sources are also known as non-renewable energy sources which includes coal, Petroleum, natural gas, etc.	1. Non-conventional energy sources are also known as renewable energy sources. that includes solar energy wind energy, tidal energy etc.
2. depletion rate is high	2. There is no depletion of resources
3. They cause Pollution.	3. They do not cause Pollution.
4. these sources are costly & involve more expenditure.	4. These sources are comparatively cheaper
5. They are difficult to handle	5. They are easy to handle.

Solar energy:-

The heat energy received by the earth in the form of radiation is known as solar energy. The solar energy cheap & Pollution free. It can be collected by using solar devices such as solar collectors, which transfers the energy to a fluid passing in contact with it for water heating & home heating. The solar energy is used to Generate the electricity with the help of solar Panels or solar modules & is also used for generation of thermal energy.

Applications of solar energy:-

1. it can be employed for distillation of saline water.
2. it is used in air conditioning & refrigeration.
3. it is used in solar cookers, solar heaters, solar water heaters, solar water pumping systems.
4. it is used in the Generation of electrical power.

Environmental Impacts of solar energy:-

1. harnessing of solar energy requires large land area, which leads to loss of land.
2. Chemical Pollution may occur during the production of some solar devices, such as photovoltaic cells, which involves the utilisation of sulfuric acid, cynaid etc.

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3. The use of reflectors may be harmful to eye sight.
4. It causes water pollution, due to the discharge of waste thermal energy into the water sources.
5. Global warming emmissions are produced.

Solar time:-

It is defind as the time used to determine the hour angle. It can be measured from the standard time of the clock by incorporating some of corrections, which occur due to the dif in longitude of location & that of meridian and due to small deviations in the earth's orbit and rotational rate. It is given by.

local solar time = standard time ± (standard time longitud longitude of location) + equation of time correction.

Angle of incidence:-

It is defind as the angle between the solar radiation incident on the surface and normal drawn to that surface. It varies with the position of sun & is denoted by 'θ'.

Zenith angle:-

It is defind as the angle b/w the solar radiation and the perpendicular drawn to the horizontal plane.

It is given by

$$\theta_z = \frac{\pi}{2} - \alpha$$

Significance of solar constant in power generation:-

Solar constant is used to compute the amount of energy produced by the sun. The total radiation energy received from the sun per unit area per unit time on a surface perpendicular to the sun's rays and at earth's mean distance from the sun. The value of solar constant is approximately 1.37 kW/m². With this value it is possible to obtain area required to receive radiation and it varies with time of day and year as well as with the lattitude & weather conditions. experimental value of 2 calories/cm²-min with a probable error of 2%. is used to estimate solar energy availability in design of power generation calculations.

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(2) Terrestrial Radiation:

(2)

The solar energy in the form of radiations incident on the earth's surface is called terrestrial radiation. These radiation may not be straight & parallel as in the case of extraterrestrial radiation. Some of the terrestrial radiations are direct or beam type while some of them are scattered due to clouds, dust particles and other gases present in atmosphere.

The terrestrial radiations are not constant and its intensity depends upon the following factors.

i) due to the rotation of the earth about its own axis.
ii) seasonal changes because of the sun's declination angle.
iii) change in distance b/w the sun and the earth due to revolution of earth in elliptical orbit. In summer, the earth comes closer to the sun, whereas in winter it moves away from the sun.

Solar Photovoltaic systems:

This system are used for converting solar energy directly into electrical energy. This is done by a means of a solar cell or a photovoltaic cell.

Solar cell is a device which directly converts solar energy into electrical energy. It uses semiconductor material which works on the principle of photovoltaic effect under solid state physics. Solar cell is made from a monocrystalline silicon wafer. When photons in sun light strikes the solar panel they are absorbed by semiconductor material then electrons are knocked and thereby seperated from atoms and flow through the materials to produce electricity. The electrons are allowed to move in a single direction. Solar cell converts solar energy into direct current electricity.

Advantages of Solar PV Systems:

1. Intermediate conversion like thermal energy to mechanical energy is not required, as it allows direct conversion of solar energy into electrical energy.

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2, Absence of moving parts.
3, they are highly reliable and durable.
4, These systems do not require any maintenance.
5, High compatibility with all environment conditions.
6, These systems can be installed near to utilisation area, which eliminates the need of auxiliary distribution systems.

Limitations of Solar Photovoltaic systems:-

1, Photovoltaic energy conversion is expensive.
2, due to non-availability solar radiation at night, the energy received during day has to be stored in suitable storage devices. Reliable batteries for energy storage are not available.
3, For setting up a solar power plant, a very large land has to be acquired.
4, cost of electrical power generated is relatively high.
5, Fabrications of silicon crystals consume more work force & energy
6, The initial capital required for setting up a solar plant is very high.

Collector:-

A collector is a metalic plate usually made of copper, steel or Al. The collector absorbs the solar energy from the sun and transfers the energy to the working fluid. There are usually two types of collector, they are

i, Flate plate collector
ii, Concentrating collector

Working of collector:-

The collector is also termed as absorber, as it has high absorptive property. As the collector absorbs the solar energy from sun, it gets heated. The heat from the collector is transferred to the working fluid across the collector. The working fluid heat is protected by insulation. The heat absorbed by working fluid can be utilized for different purpose by storing it in storage devices.

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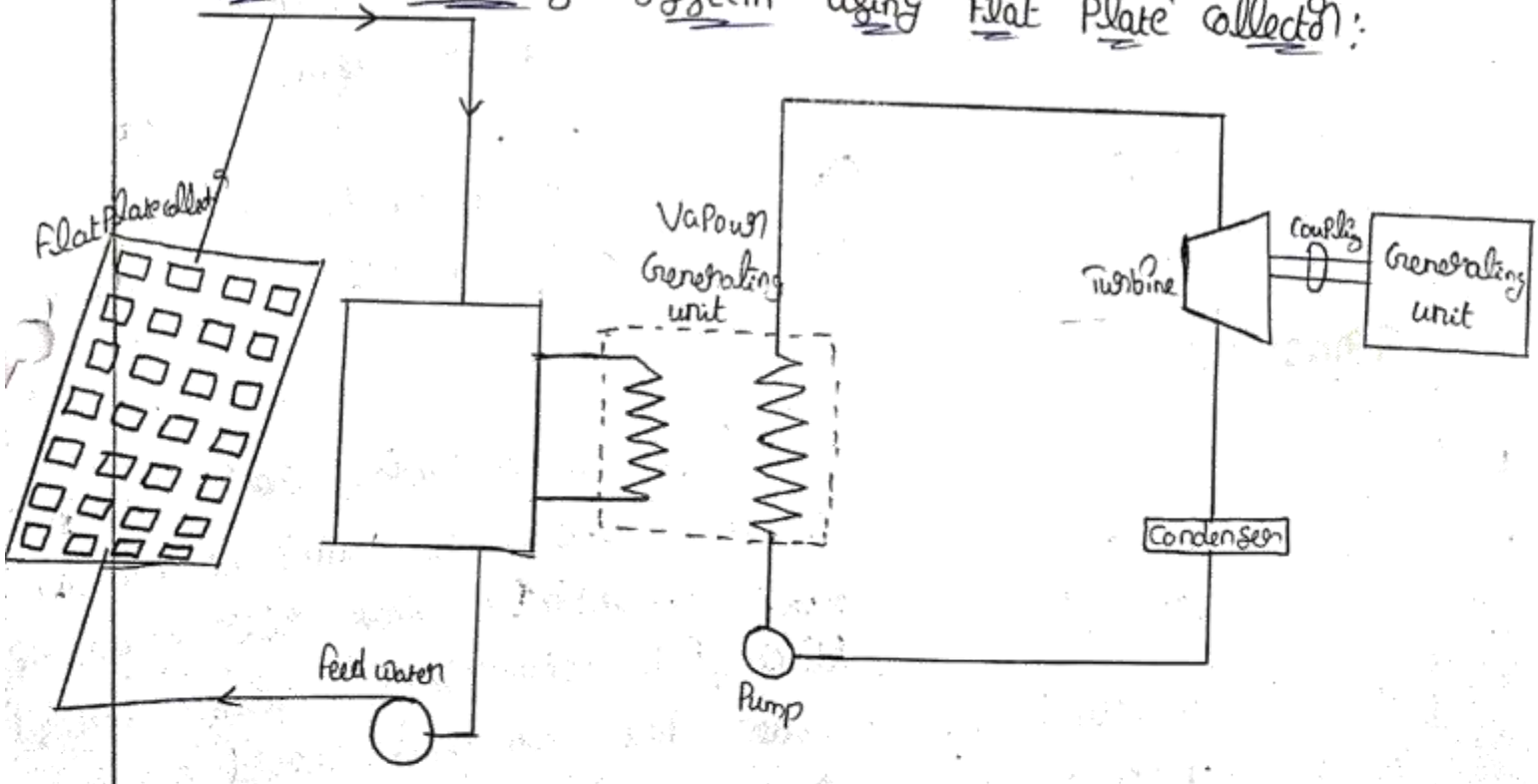
Concentrating collectors:-

Concentrating collectors are also known as focussing collectors. It's consist of concentrating device like mirror attached to a flat plate. The mirrors are set at an angle so that they reflect solar radiation onto the absorber plate. Thus, the flat plate absorbs reflected radiation in addition to that normally falling on it. Some part of the radiation falls directly onto the absorber plate and the part that reaches on the mirror is reflected to the absorber plate. Thus the concentration effects arises mainly from the increase in direct radiation reaching the absorber plate. Due to the apparent motion of the sun, the concentrating surface is unable to redirect the sunrays on the absorber throughout the day. If both the concentrating surface and the absorber surfaces are stationary so, the angles of the mirror has to be changed, according to the change in altitude of sun.

Power Generating System using Flat Plate collector:



low temperature collectors:

The flat plate collectors are one of the types of solar collectors, in these collectors, the operating temperature of the fluid does not exceed 100°C. As such, they are used for space heating & water heating purposes. However in a concentrating type of solar collector the working fluids can reach temp as high as 500°C. hence, flat solar collectors are classified as low temperature collectors

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The heat losses in solar flat plate collector reduces due to selective coating on absorber. The main functions responsible to reduce losses are as follows

1. High absorbance ability for short wave radiation (i.e <2.5 μm).
2. Low emittance property for long wave radiation (i.e >2.5 μm)
3. It reflects thermal radiation.
4. It can withstand temp. & humidity variations.
5. It is more adhesive and can resist atmospheric oxidation, corrosion etc,...

Optical efficiency:-

The combined effect of losses due to radiation or absorption and losses due to geometrical in the optical system can be analysed by an efficiency parameter, which is called as optical efficiency.

Therefore, it can be given as

$$\text{optical efficiency } \eta_{opt} = \rho \cdot \gamma (\tau \cdot \alpha)$$

where $(\tau \cdot \alpha)$ - Product of transmittance and absorptance

ρ - Specular reflectance of reflector surface.

γ - Intercept factor.

The optical losses in collectors are minimised by concentrating the flux that is incident on the surface of absorber on a smaller area.

Tracking:-

In a concentrating collector, a concentrator or mirror reflector having the shape of a cylindrical parabola, focusses the sunlight onto the surface of the absorber tube. A concentric glass cover around the absorber tube helps in reducing the convective & radiative losses to the surroundings. In order that sun rays should always be focussed onto the absorber tube, the concentrator has to be rotated in relation to the position of sun. This movement of continous regulation of concentrator with sun is called tracking.

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(4) Collector efficiency:- (4)

It is defined as the ratio of the useful solar heat gain over a specific time period to the amount of solar energy incident on the surface over that time

$$\eta_c = \frac{\int Q_u \, d\tau}{\int H_R \, d\tau}$$

The collector efficiency depends on the heat transfer coefficient of absorber plate, thermal conductivity of absorber material etc,..

Cosine losses:-

cosine loss is defined as the difference b/w the amount of solar energy falling on a surface which is pointing at the sun & the solar energy falling on a surface which is //el to the surface of earth.

cosine loss is also called cosine effect. It occurs as a result of cross sectional area reduction as mirrors tilt to redirect sunlight to a target

Heat Removal Factor:-

The heat removal factor of a solar collector is defined as the ratio of actual useful solar energy gain of a collector to the useful energy gain, when the collector surface is kept at a temperature equal to the fluid inlet temperature. It is denoted by F_R.

The value of heat removal factor (F_R) ranges b/w 0 & 1

$$F_R = \frac{m C_p}{U_L A_b}\left[1 - \exp\left(\frac{-\eta \times U_L \times A_b}{m C_p}\right)\right]$$

where m = mass flow rate through collector

C_p = specific heat

U_L = collector overall heat loss coefficient

η = collector efficiency

A_b = Area of the absorber

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Calculate the angle of incidence on a horizontal plane surface of a location whose longitude & latitude are $88^\circ 20'$ E & $22^\circ 32'$ N respectively at 11:00 hrs (IST) on June 1 the standard IST longitude is $81^\circ 44'$ E.

Given that

latitude $\phi = 22^\circ 32'$ $\gamma = 0, \beta = 0$

day of the year of June 1, $n = 31+28+31+30+31+1 = 152$

Declination $\delta = 23.45 \sin\left[\frac{360}{365}(284+n)\right]$

$= 23.45 \sin\left[\frac{360}{365}(284+152)\right]$

$\delta = 22.03^\circ, \quad \omega = -15$

$\cos\theta_z = \cos\phi \cos\delta \cos\omega + \sin\delta \sin\phi$

$= \cos(22.32) \cos(22.03) \cos(-15) + \sin(22.03) \sin(22.32)$

$\cos\theta_z = 0.9707$

$\theta_z = \cos^{-1}(0.9707)$

$\therefore$ angle of incidence $\theta_z = 13.9^\circ$

Determine the sunset hour angle and day length for allahabad.

Given that January - 1 $n = 1$

latitude $\phi = 24^\circ 25' N$

longitude $= 81^\circ 58' E$

$\delta = 23.45 \sin\left(\frac{360}{365}(284+n)\right)$

$= 23.45 \sin\left(\frac{360}{365}(284+n)\right)$

$\delta = -23.01$

$\phi = 24^\circ 25'$

$= 24.4167^\circ$

i) Solar sunset angle is negative of solar sunrise angle

$\omega_s = \cos^{-1}[-\tan\phi \tan\delta] \Rightarrow \cos^{-1}[-\tan(24.4167) \tan(23.01)]$

$\omega_s = 78.88^\circ$

$\therefore$ Solar sunset angle $= -78.88^\circ$

ii) Day length $t_d = \frac{2 \times \omega_s}{15} \Rightarrow \frac{2 \times 78.88}{15}$ $\therefore t_d = 10.51$ hrs.

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(5) Determine the local solar time corresponding to 10.00 am IST on February 8 for a location at 87.5° east longitude.

(5)

Given that

Time = 10:00 am

longitude of location = 87.5°

Standard longitude of India = 81°54'

Error = 4 min.

Local solar time = Standard time ± 4[L_{st} - L_{loc}] + E

= 10:0 hr ± 4 [81.9° - 87.5°] + 4'

= 10:00 hr - 4 (-5.6°] + 4'

= 10:00 hr + 4[-5.6]' + 4'

LST = 10:00 hr 26.4 min.

Classification of energy sources:

The various energy sources are classified as

(a) Renewable or nonconventional energy sources.

(b) non Renewable or conventional energy sources.

Renewable & non Renewable energy sources.

* Non-Renewable energy is generally derived from fossil fuel (coal, wood soil)
* The fossil fuel deposits can be regraded to be available in fixed quantity.
* The time taken for the development of energy which is obtained by combustion of fossil fuel, is approximately 600 million year.
* at the present consumption rate it is probable to consume earth's entire supply of fossil fuel in less than hundred years
* Renewable energy can be derived from dif sources such as sun's heat earth's heat, energy in waves and wind.
* The problems associated with renewable energy sources is that, the energy will not be available at all times and in sufficient quantity.
* The sun does not shine always, hence, it is not possible to obtain energy during winter & rain days.
* The speed of waves required to [illegible] conversation machines not costly.

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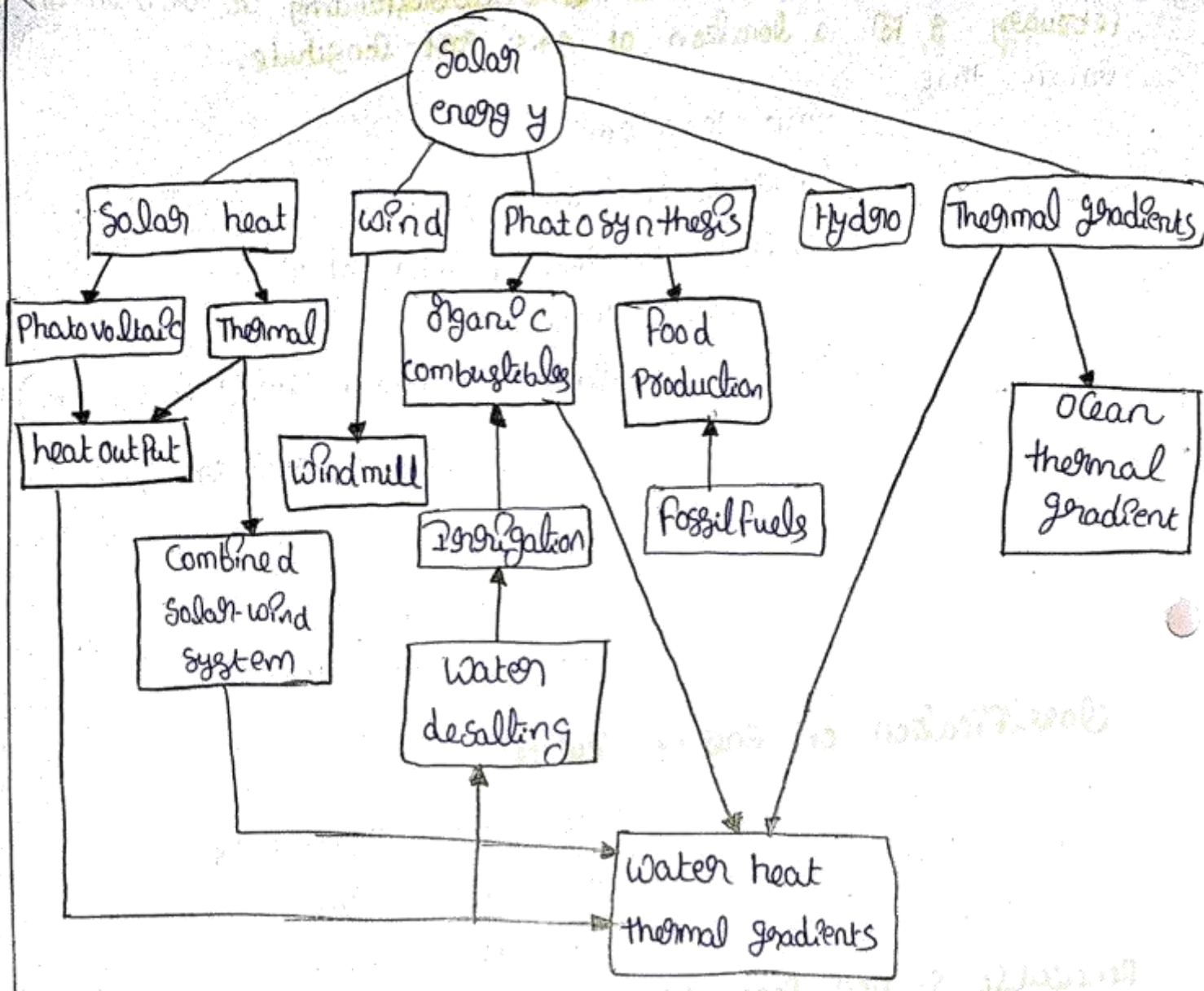

Renewable energy sources:-

The energy sources which are inexhaustible and can replenish once used called renewable energy sources The various renewable energy sources are.

1. Solar energy
2. Wind energy
3. Ocean energy
4. Tidal energy
5. Geothermal energy
6. Biofuel energy

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Indian scenario of Renewable energy sources:

(6) (6)

Wind energy:

* In India, greater wind speeds are obtained in coastal areas of Saurashtra, some parts of central & western Rajasthan. In these areas, there would be a possibility of using medium & large size wind mills for the generation of electricity.
* many projects on the wind mill systems for water pumping & for production of electrical power were taken up by ~~also~~ many organizers in our country.

Some of the developments are stated below

1. WP-2 water pumping wind mill by NAL Bangalore.
2. CAZRI wind mill at Jodhpur (Rajasthan).
3. 12 PU 500 wind mill at NAL Bangalore.
4. MP-1 soil wind mill at NAL Bangalore.
5. madural wind mill at madural (Tamil nadu)

Geothermal energy:

* Remarkable developments in the use of geothermal energy are expected in several countries including India in the up coming years. This will also help in pollution control & conservation of fossil fuels.
* In India, Himachal pradesh is reported to have geothermal energy in considerable amount.
* under the sponsorship of DNES, a 7.5 tonne capacity cold storage point plant based on geothermal energy is installed at manikaran, Himachal pradesh.

Ocean thermal energy conversion:

* In India the department of Non-conventional energy sources also known as DNES has proposed to install a 1 MW OTEC plant in Lakshadweep Island at minicoy and kavaratti.
* preliminary oceanographic studies on the eastern side of lakshadweep Island indicates the possibility of the establishment of shore based OTEC plant at the Island.

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* The OTEC plant will bring up the water from 1000 m depth which has large nutrient value.

Advantages of Renewable energy sources:

1, Renewable energy is an inexhaustible resource available in considerable quantities to all developing nations. It enables economic improvement and develops a scop for local employment.

2, Application of renewable energy rural areas, is more economic and efficient as cost of transmitting electrical power or transporting conventional fuel is reduced to a great extent.

3, There is a provision for development of conversion technology

4, It has wide range of applications.

Limitations of Renewable energy sources:

1, In appropriate documentation and evaluation of past experiance may lead to difficult in project.

2, Renewable energy system may become unsuccessfully if financed by improper sources or weak institutions.

3, lack of energy planning may lead to undesired energy consumption

4, Technical or economic problems caused in energy systems, increase the cost of conversion.

5, The information available to co-ordinate energy system activities from past projects is very less.

The availability and merits of different non-conventional energy sources are explained as follows.

1, Solar energy

availability:

i, Solar energy is cheap, clean and abundantly available renewable energy

ii, it gives 10000 times more power than required.

iii, The availabl power is 178 billion MW

iv, In India 48% of power is generated from solar ray.

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2. Wind energy:

(7)

Availability:

i. it is available in some part of Central India & western Rajasthan.

ii. The wind pumps employed for generating and energy around the world is about 0.7 million.

iii. Its potential ranges from 20000MW to 2500 MW.

Merits:

i. It is clean, abundant and cheap & exist as long as sun exists.

ii. It is permanent and inexhaustible source of fuel.

iii. It does not produce toxic wastes or green house gases, which contribute to global warming.

iv) It is pollutions free energy.

3. Biomass Energy:-

i) It is derived from wood, animal and agricultural residues, etc

ii) Biogas plants are mostly found in China

iii) the power available is up to 1 MW

iv) It is mostly used in villages.

merits:-

i) the wastes may be utilized to produce energy.

ii) the fuel used is less expansive.

iii) this energy saves firewood, leading to conservation of forest.

4. Geothermal Energy:-

Availability:-

i) It is obtained from thermal energy, which is stored ~~bene~~ beneath the surface of earth.

ii) It is available in the form of hot water or steam.

iii) merits:-

i) It does not contribute to pollution and greenhouse effect

ii) ~~the~~ no fuel is needed to generate electricity

iii) the power stations do not occupy much space, hence, no impact on environment.

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5. Ocean Tidal energy:

Availability:

i. it is available in India, China, Europe, Argentina, USA etc,..

ii. the power available in canada, Scotland is 20 MW and Russia, Cuba is 400 kW.

Merits:

i. it is pollution free, as no greenhouse gases are produced.

ii. it does not need fuel.

iii. the long stretch of coastlines can be protected from high storm tides.

6. Ocean wave energy:

Availability:

i. it is available in portugal, Scotland, england Japan etc.

ii. No fuel the wave paper power generation is approximately 50000 MW.

Merits:

i. low operation and maintenance cost

ii. no fuel is needed as the energy of waves occur naturally.

Indirect forms of solar energy:

The indirect forms of solar energy are,

a) energy derived from local

b) energy derived from natural gas

c) energy derived from oil

d) wind energy

e) Tidal energy

f) energy derive from water

g) Biofuels

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Harnessing of solar energy:

(8)

Harnessing of solar energy refers to the collection of solar energy which can be utilized for various applications. The problems of harnessing solar energy has been solved after a long period of research. The early harnessing of solar energy began with the elementary draping of clothes to the solar power plants in the recent times.

The main aim of increasing the utilisation of solar energy is due to the excessive rate of exhaustion of non renewable energy sources together with the unavoidable pollution they cause. The research and development of cost effectives solar harnessing devices is still undergoing and is excepted to beome a reality to have a cheap & clean source of energy in every house.

Solar energy:

Solar energy is a important form of non-conventional sources of energy. The scope for technological advancement has led to the developmet of Photovoltaic cells which are efficient & economic.

The high rate of consumption of fossil fuels like coal, natural gas, oil etc,. necessitates the use of non conventional source of energy. The non-conventional sources of energy such as solar energy must be used as a alternative source.

The earth receives abudant solar radiation particularly during summer period, hence, it can be tapped, stored & utilized for various applications.

As pollution increases, the demand for energy increases. In present time, it is noted that, a big difference occures b/w the supply of power and demand. hence non-conventional sources of energy must be given much significance, which can fullfill the future power demand.

The Photovoltaic cells or solar cells convert solar power directly into electrical power. This power can be stored and utilized for multiple purpose.

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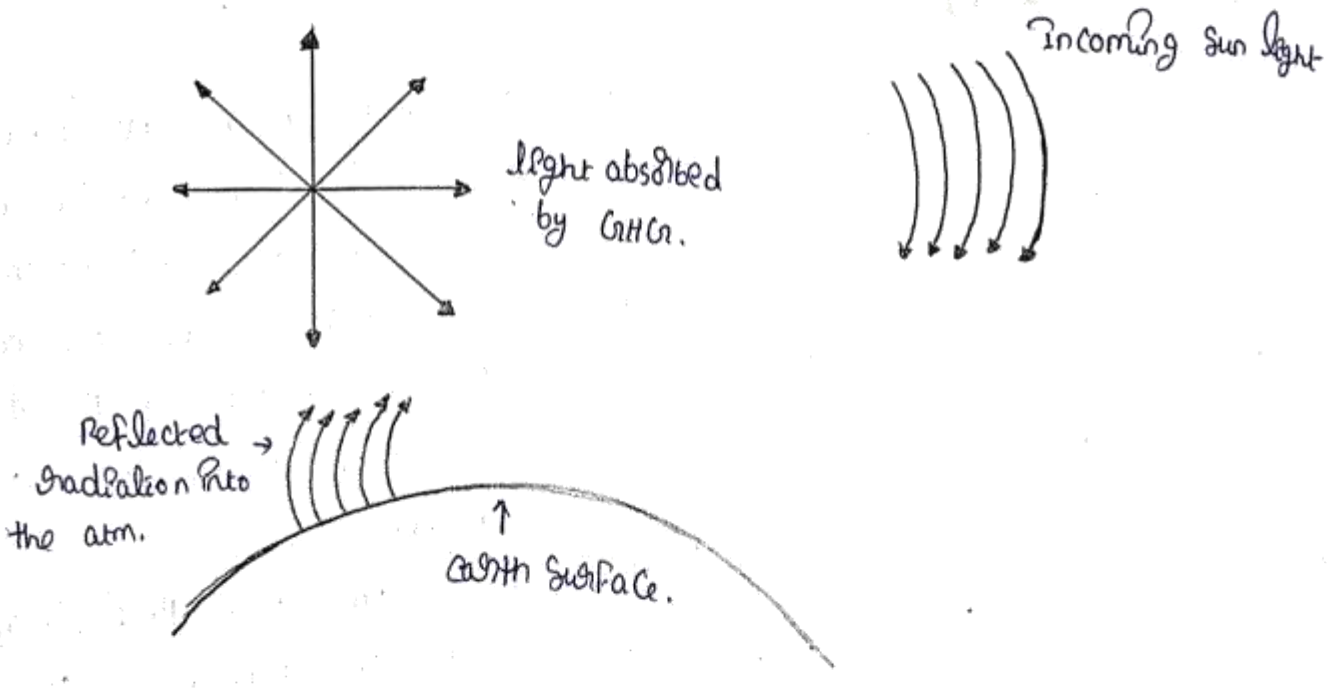
Conversion Solar radiation into heat:

The principle involved in the conversion solar radiation into heat is "Green house effect".

The gases in the atmosphere that absorb the solar radiation are referred as green house gases (GHG). These include carbondioxid (CO_2) water vapour (H_2O), nitrous oxide (N_2O), methane (CH_4) and chlorofluro carbons (CFCs)

When the solar radiation strikes the surface of the earth in the form of visible light, ultraviolet light, infrared and other types of radiation. The gases trap the suns heat & help to sustain life on earth. Solar energy requires minimum temperature as 30°c - 40°c.



Structure of Sun:

The sun is a hydrodynamic large sphere of intensely hot ionised gaseous matter. It continuously generates heat energy by the process of thermonuclear fusion reactions. Most of the heat energy is produced only due to the fusion of hydrogen to helium particles in the core of the sun. This heat is produced is subsequently transferred to it's outer surface before radiating into the space.

The dia. of the sun is approximated to 1.39×10^6 km, The dia. of earth is 1.27×10^4 km & distance b/w the sun & earth is 1.5×10^8 km.

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(9) Solar Radiation Geometry:

The earth's axis is tilted to 23.5° with respect to its orbit about the sun. In its orbited movement, the earth keep it's axis oriented in the same direction. The tilted position of the earth along with earth's daily rotation & yearly revolution accounts for the varying distribution of solar radiation over the earth's surface. The changing length of hours of day night and darkness and seasons changing are also caused due to tilting of earth's surface. In solar radiation geometry, the following angles are used.

δ = Angle of declination

ω = hour angle

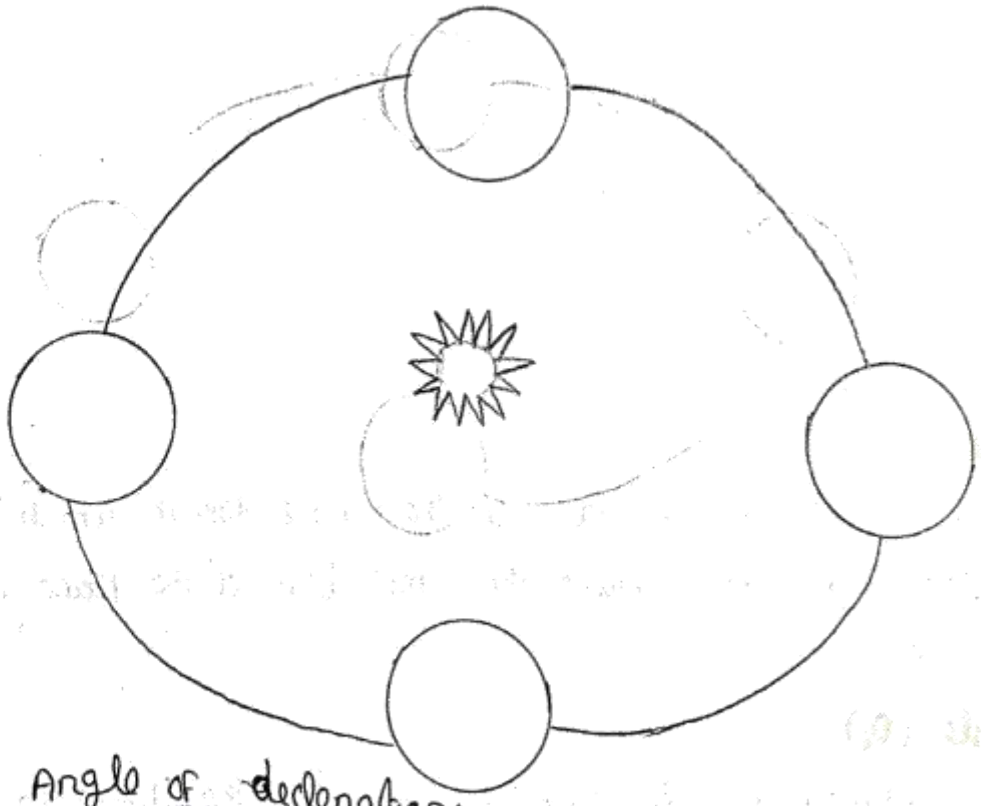
γ_0 - Solar azimuth angle

ϕ_L - latitude of location

S - slope

α - altitude angle

θ_z - zenith angle.



Angle of declination:

The vertical angle subtended by the line joining the of the sun & the earth with its projection on the earth plane is called angle declination.

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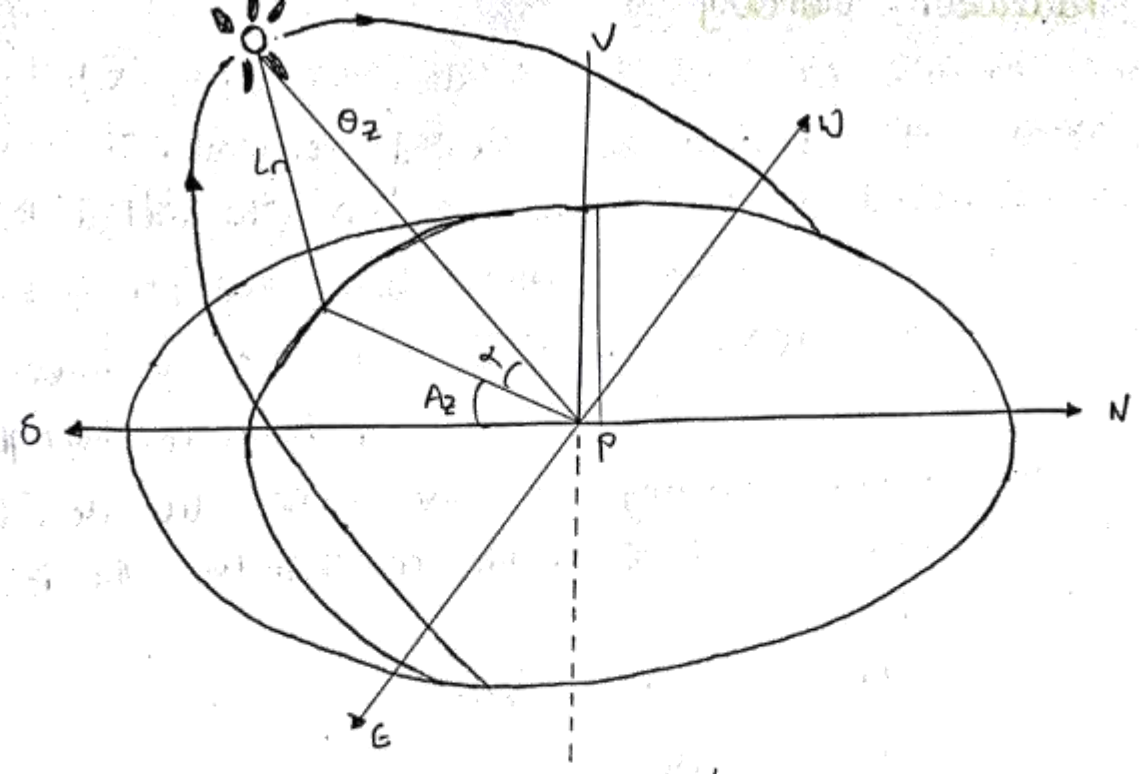

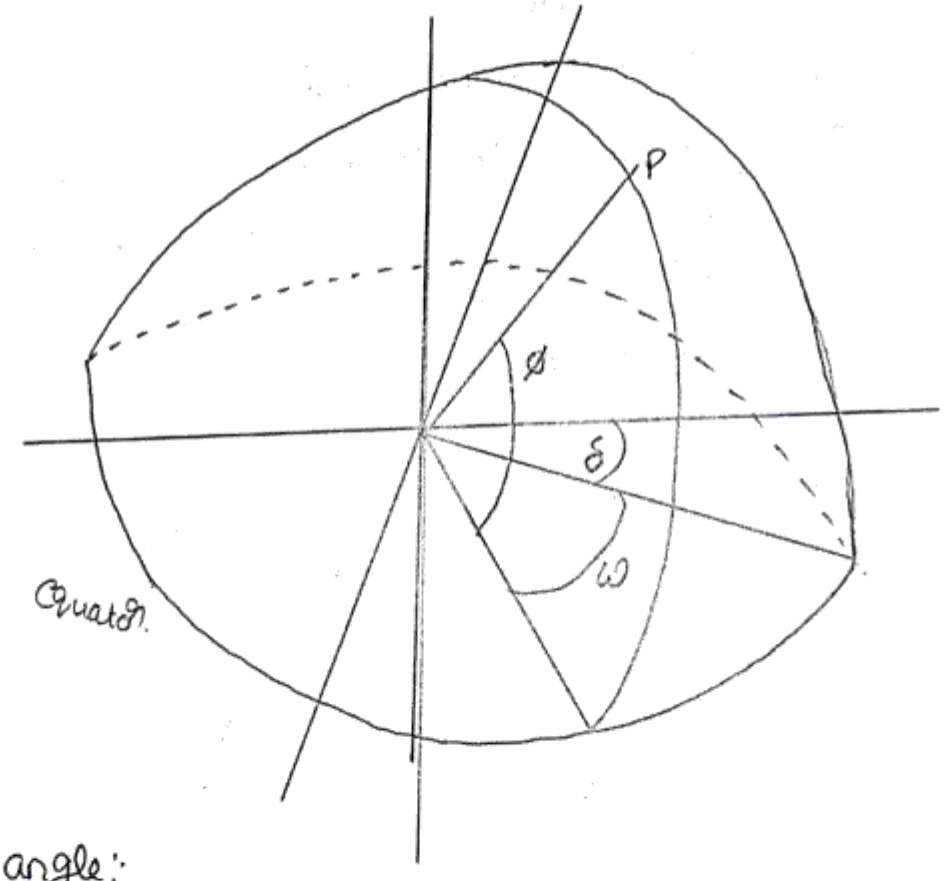

Hour angle:

The hour angle is defined as the angle through which the earth is to be rotated to adjust the meridian of the place direct under the sun.

Latitude angle (θ_L):

The angle formed b/w the radial joining the place to the centre of earth, θ such that the projection of line lies on the equatorial plane is called latitude angle.

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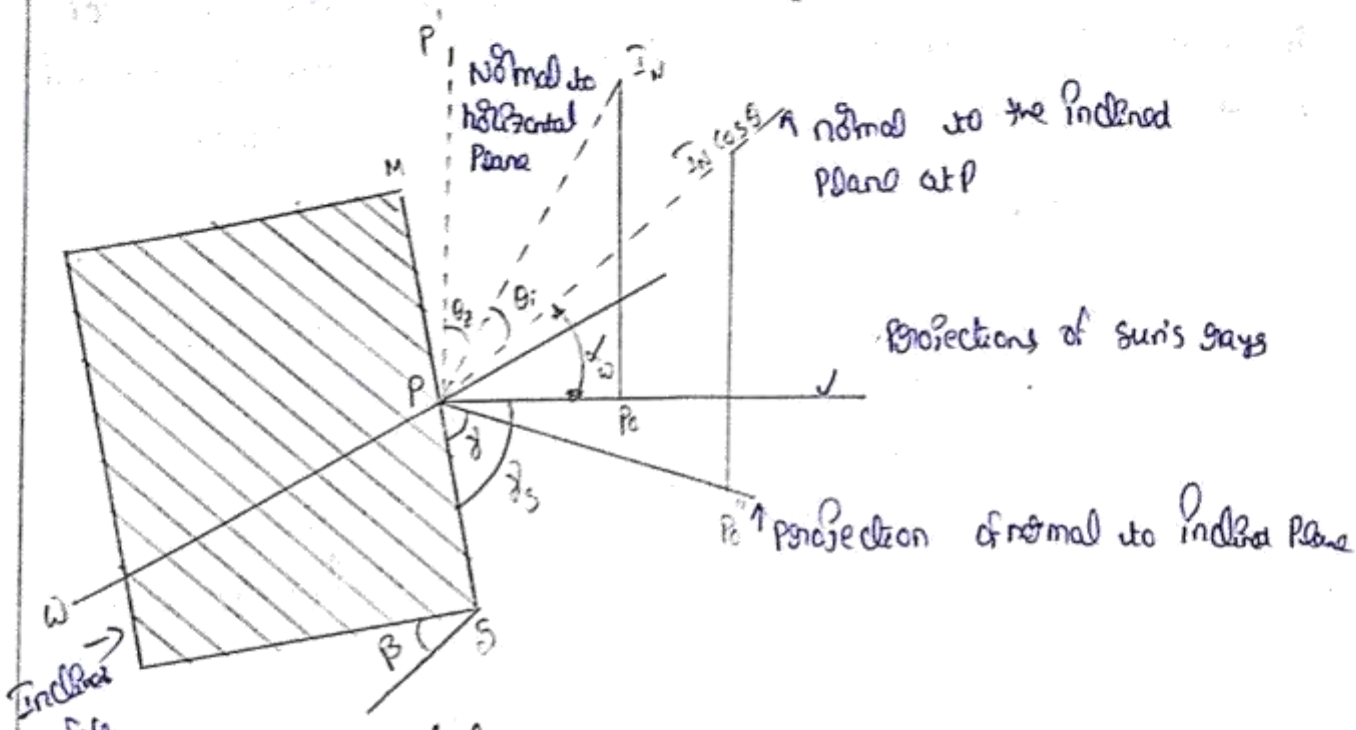
The total solar radiation incident on a surface comprises of the following. (10)

1. Beam solar radiation
2. Diffuse solar radiation
3. Reflected solar radiation.

To determine the total radiation incident on an tilted surface, it is required the sum of beam radiation diffuse radiation & reflected radiation.



Beam Solar Radiation :-

The ratio of beam radiation flux incident on a inclined surface to that on a horizontal surface is called beam solar radiation it is denoted by 'R_b'

Flux falling on a horizontal surface $I_b = I_N \cos\phi_z$

Flux falling inclined surface $I_b' = I_N \cos\phi_i$

The beam solar radiation is expressed as

$$R_b = \frac{I_b'}{I_b}$$

$$\therefore R_b = \frac{\cos\phi_i}{\cos\phi_z}$$

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Solar radiation:

The ratio formed by the diffused radiation flux incident on an inclined surface to that on a horizontal surface. It is denoted by R_d.

$$R_d = \left(\frac{1+\cos\beta}{2}\right)$$

3. Reflected solar radiation:

It is defined as the radiations obtained from the ground & surrounding objects. It becomes the reverse of diffused radiation if the considered reflections are diffuse & isotropic.

$$R_g = \left(\frac{1+\cos\beta}{2}\right) \times \rho$$

where ρ = Reflection co-efficient of the ground

= 0.2 for ordinary ground

= 0.7 for snow covered ground.

The total radiation incident on a tilted surface at any instant given by Li and Jordan as

$$I_T = I_b R_b + I_d R_d + (I_b + I_d) R_g$$

Substituting (1), (2) (3) & (4) equ^n

$$I_T = I_b\left[\frac{\cos\phi_i}{\cos\phi_z}\right] + I_d\left[\frac{1+\cos\beta}{2}\right] + (I_b + I_d)\left[\frac{1-\cos\beta}{2}\right]\rho$$

total radiation on horizontal surface.

$$I_g = I_b R_b + I_d R_d.$$

From equation (4) & (5) it is observed that 'R_g' for horizontal surface is zero. hence the horizontal surface receives no ground reflected radiations.

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Solar measuring equipments:

(11)

The different solar energy measuring equipments are

(1) Pyrheliometer type
- The Angstrom Pyrheliometer
- The Abbot Silver disc Pyrheliometer
- Eppley Pyrheliometer

(2) Pyranometer type
- Eppley Pyranometer
- Yellot solarimeter
- Moll - Gorczy heski solarimeter
- Bimetallic Actinograph of Rabitzch type
- Velochme Pyranometer
- Thermo electric Pyranometer

Pyranometer:-

It is used to measure the total radiation beam rate & diffuse radiation on a surface. It consist of a black surface, glass dome, thermopile, supporting stand and a levelling screw.

during it's working the solar radiation is absorbed by the black surface, when it is kept under the sun. due to this the temp. of these surface increases, which is sensed by the thermopile, leading to the generation of thermo emf. then the emf is calibrated to give the measure of absorbed radiation. The generated emf is proportional to the amount of radiation absorbed thus the total or global solar radiations are measured.

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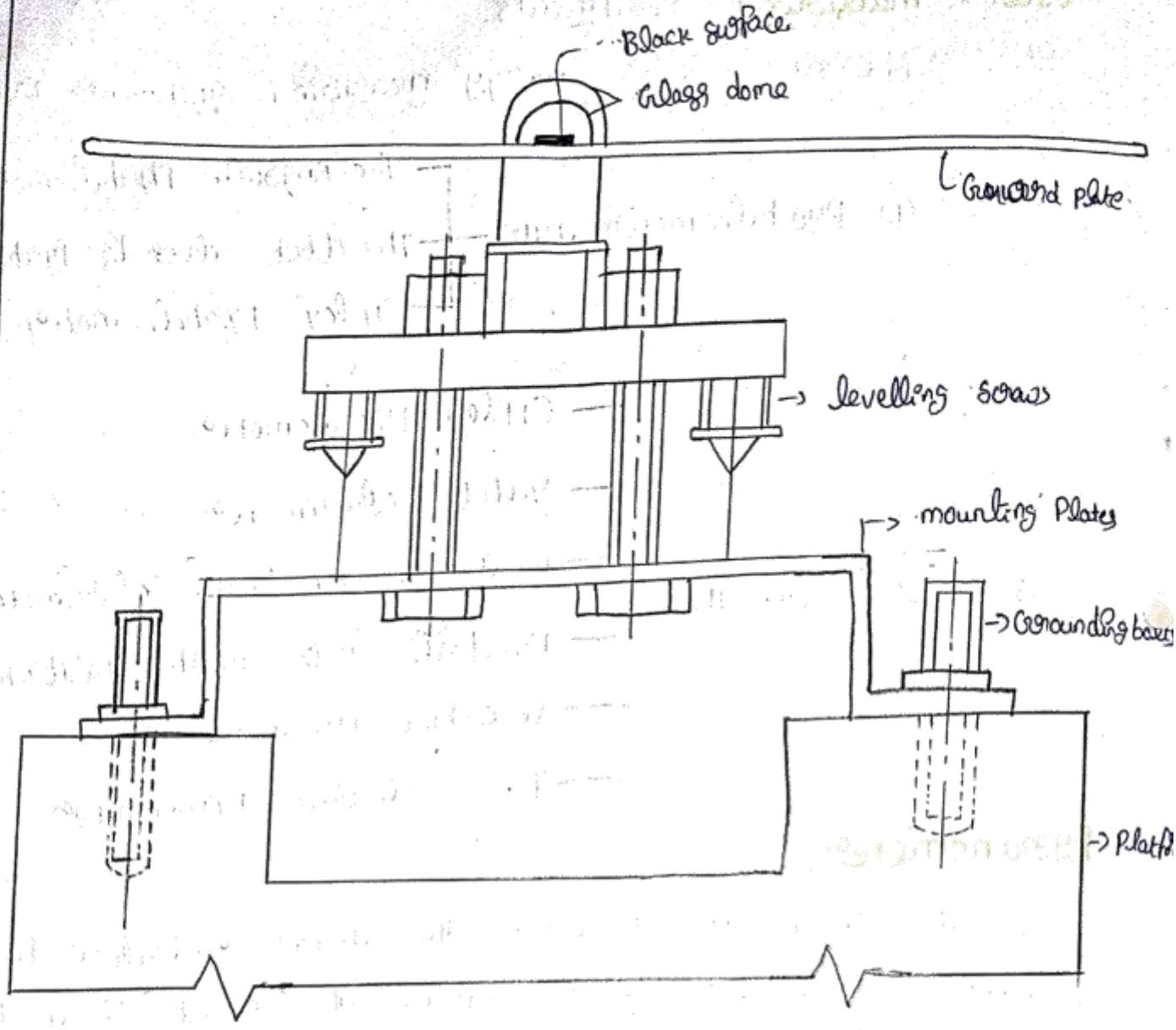

Pyrheliometer:

it is a instrument for measuring the intensity of direct or beam solar radiations. A collimated detector is employed for measuring the solar radiations from the sun & small portion of it's surroundings at normal incidence angle. It is a small telescope like device mounted on a drive mechanism which follows the sun throughout the day.

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calculate the angle of incidence of beam radiation on a surface located at madison. WI at 10.30 on February 13. If the surface is tilted 45° from the horizontal & pointed 15° west of south

(12)

Given that:

slope $\beta = 45^\circ$

latitude $\phi = 43^\circ$

surface azimuth angle $\gamma = 15^\circ$

for February

Day of the year $= 31 + i$

$= 31 + 13$

$= 44$

hour angle $\omega = 15^\circ h$

$= 15^\circ \times (-1.5)$

$= -22.5^\circ$

Delination $\delta = 23.45 \sin\left[\frac{360}{365}(284+n)\right]$

$= 23.45 \times \sin\left[\frac{360}{365}(284+44)\right]$

$= -13.946 \simeq -14^\circ$

The angle of incidence of beam radiation can be calculated by

$\cos\theta = \sin\delta \cdot \sin\phi \cdot \cos\beta - \sin\delta \cdot \cos\phi \sin\beta \cos\gamma + \cos\delta \cos\phi \cos\beta \cos\omega + \cos\delta \cdot \sin\phi \sin\beta \cos\gamma \cos\omega + \cos\delta \sin\beta \sin\gamma \sin\omega$

$\Rightarrow \sin(-14^\circ) \cdot \sin(43^\circ) \cos(45^\circ) - \sin(-14^\circ) \cdot \cos 43^\circ) \sin(45^\circ) \cos(15^\circ) + (\cos(-14^\circ) \cos 43^\circ)$

$\cos(45^\circ) \cos(-22.5) + \cos(-14^\circ) \cdot \sin(43^\circ) \cdot \sin(45^\circ) \cos 15^\circ \cos(-22.5^\circ)$

$+ \cos(-14^\circ) \sin(45^\circ) \sin(15^\circ) \cdot \sin(-22.5^\circ)$

$\Rightarrow 0.117 - (-0.121) + 0.464 + 0.458 + (-0.068)$

$\cos\theta = 0.818$

$= \cos^{-1}(0.818)$

$\therefore \theta = 35.115^\circ$

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Determine for the following atmospheric conditions, the atmospheric total transmitted for scattering only, when the sun is at zenith.

Wave length = 0.5 M

Total pressure = 750 mm of Hg

Dust particle concentration at the ground particles = 800/cm³

Dust of precipitable water = 20 mm

Assume monochromatic atmospheric transmittance

Answer:-

Given that

Wavelength $\lambda = 0.5\ \mu m$

Pressure $p = 750$ mm of Hg

Dust particles concentration, $d = 800\ cm^3$

Depth of precipitable water, $w = 20$ mm

When sun is at zenith $m = 1$

Atmospheric transmittance for scattering is

$$T_\lambda = \left[(T_{a\lambda})^{p/760} \times (T_{a\lambda})^{d/800} \times (T_{a\lambda})^{w/20}\right]^m$$

$$T_{a\lambda} = 10^{-0.0038\lambda - 1}$$

$$= 10^{-0.00389 \times (0.5)^{-4}} = 0.866$$

$$T_{a\lambda} = 10^{-0.00353 \times (0.5)^{0.75}} = 0.986$$

$$T_{a\lambda} = 10^{-0.0075\lambda^{-2}} = 10^{-0.0075 \times (0.5)^{-2}} = 0.933$$

$$= \left[(0.866)^{\frac{750}{760}} \times (0.986)^{\frac{800}{800}} \times (0.933)^{\frac{20}{20}}\right]$$

$$T_{\lambda(0)} = 0.798$$

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