NCES IMP QUE WITH SOL

Credits:- Apne kaam se kaam rakh na yaar

1 Explain the types energy sources with examples.

3 Classification of energy resources:

1. Based on the usability of energy:
    a. Primary resources: Resources available in nature in raw form is called primary energy resources. Ex: Fossil fuels (coal, oil & gas), uranium, hydro energy. These are also known as raw energy resources.
    b. Intermediate resources: This is obtained from primary energy resources by one or more steps of transformation & is used as a vehicle of energy.
    c. Secondary resources: The form of energy, which is finally supplied to consume for utilization. Ex: electrical energy, thermal energy (in the form of steam or hot water), chemical energy (in the form of hydrogen or fossil fuels). Some form of energy may be classified as both intermediate as well as secondary sources. Ex: electricity, hydrogen.
2. Based on traditional use:
    a. Conventional: energy resources that have been traditionally used for many decades. Ex: fossil fuels, nuclear & hydro resources
    b. Non-conventional: energy resources which are considered for large scale & renewable. Ex: solar, wind & bio-mass
3. Based on term availability:
    a. Non-renewable resources: resources that are finite, & do not get replenished after their consumption. Ex: fossil fuels, uranium
    b. Renewable resources: resources which are renewed by nature again & again & their supply are not affected by the rate of their consumption. Ex: solar, wind, bio-mass, ocean (thermal, tidal & wave), geothermal, hydro
4. Based on commercial application:
    a. Commercial energy resources: the secondary useable energy forms such as electricity, petrol, and diesel are essential for commercial activities. The economy of a country depends on its ability to convert natural raw energy into commercial energy. Ex: coal, oil, gas, uranium, & hydro
    b. Non-commercial energy resources: the energy derived from nature & used – directly without passing through the commercial outlet. Ex: wood, animal dung cake, crop residue.

cake, crop residue.

5. Based on origin :

a. Fossil fuels energy	f) bio-mass energy
b. Nuclear energy	g) geothermal energy
c. Hydro energy	h) tidal energy
d. Solar energy	i) ocean thermal energy
e. Wind energy	j) ocean wave energy

2 Explain the need for energy alternatives.

1.1 The need for alternatives:

1. The average rate of increase of oil production in the world is declining & a peak in production may be reached around 2015. There after the production will decline gradually & most of the oil reserves of the world are likely to be consumed by the end of the present century. The serious nature of this observation is apparent when one notes that oil provides about 30% of the world's need for energy from commercial sources & that oil is the fuel used in most of the world's transportation systems.
2. The production of natural gas is continuing to increase at a rate of about 4% every year. Unlike oil, there has been no significant slowdown in the rate of increase of production. Present indications are that a peak in gas production will come around 2025, about 10 years after the peak in oil production.
3. As oil & natural gas becomes scarcer, a great burden will fall on coal. It is likely that the production of coal will touch a maximum somewhere around 2050.
4. Finally, it should be noted that in addition to supplying energy, fossil fuels are used extensively as feedstock material for the manufacture of organic chemicals. As resources deplete, the need for using fossil fuels exclusively for such purposes may become greater.

3 Explain briefly India's production and reserves of commercial energy sources.

2 India's production & reserves of commercial sources:

2.1 Coal:

Coal is the end product of a natural process of decomposition of vegetable matter buried in swamps & out of contact with oxygen for thousands of years. The word 'coal' denotes a wide variety of solid fuels. The varieties in approximate order of their formation are peat, lignite, bituminous and anthracite coal. The rate of production of coal in India over the last 50 years is shown in fig (a). It can be seen that there has been an eleven-fold increase in production from 1951 to 2004 & that the average annual growth rate has been about 4.5%. In 2000, India's production was 300mt, which was about 6.7% of the world's production. India has fairly large reserves of coal.

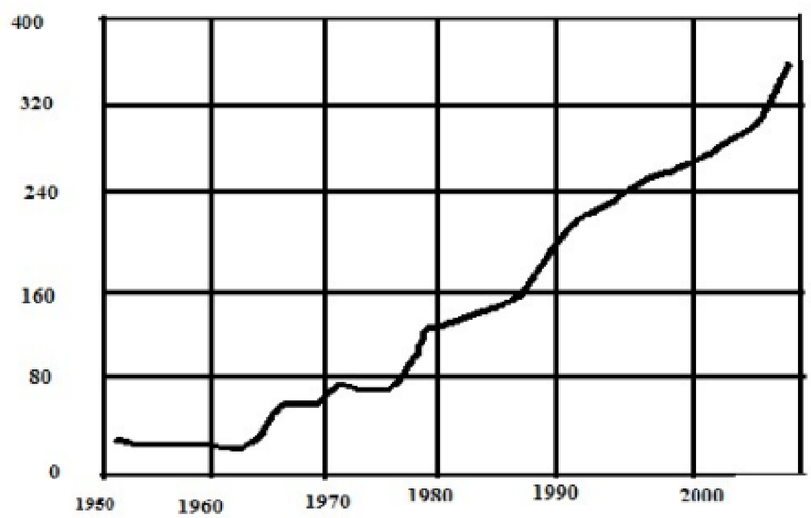


Figure 1: Annual production of coal in India [production rate [Production Rate (Mt/Year) v/s Year]

Table 1: Coal reserves in India (in Mt)

Year	Proved reserves	Indicated & inferred reserves	Total reserves (Resources)
1972	21360	59590	80950
1981	27912	87490	115402
1985	35030	120870	155900
1992	64800	129000	193800
2006	95866	157435	253301

2.2 Oil:

Below fig.2. Represents presents data on the annual consumption of petroleum products in India (curve 3) from 1951 onwards. It also shows the variation in the domestic production of crude oil (curve 1) & the import of crude (curve 2) over the years.

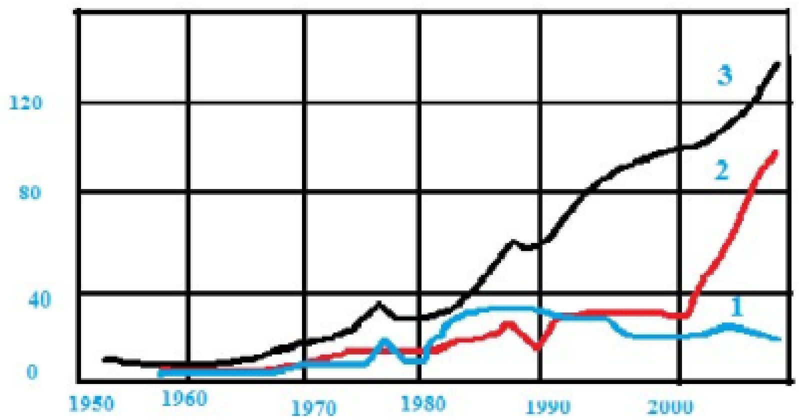


Figure 2: Annual production, import & consumption of oil in India [Production Rate (Mt/Year) v/s Year]

Curve 1. Domestic production of crude, Curve 2. Import of crude, Curve 3. Consumption of products

2.3 Natural gas:

presents data on the annual useful production of natural gas in India from 1969 onwards. In 1969, the production was only 0.516 billion m^3. It did not change much till 1973. However,

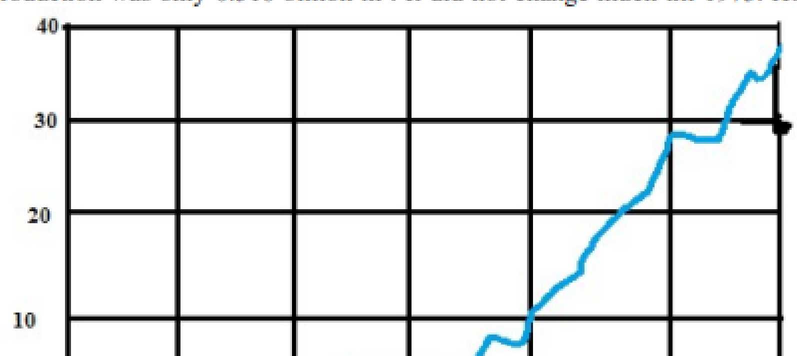


Figure 3: Annual production of natural gas in India [Production rate (10^9 m^3/year v/s year

subsequently, the production increased rapidly. It was 8.913 billion m^3 in 1989, 13.5% from 1989 to 1997 & 3.1% from 1997 to 2005.

2.4 Water –power:

It is one of the indirect ways in which solar energy is being used. Water- power is developed by allowing water to fall under the force of gravity. It is used almost exclusively for electric power generation. Data on the installed capacity of hydropower in India & the electricity produced from it from 1947 onwards is presented in below fig. 4.

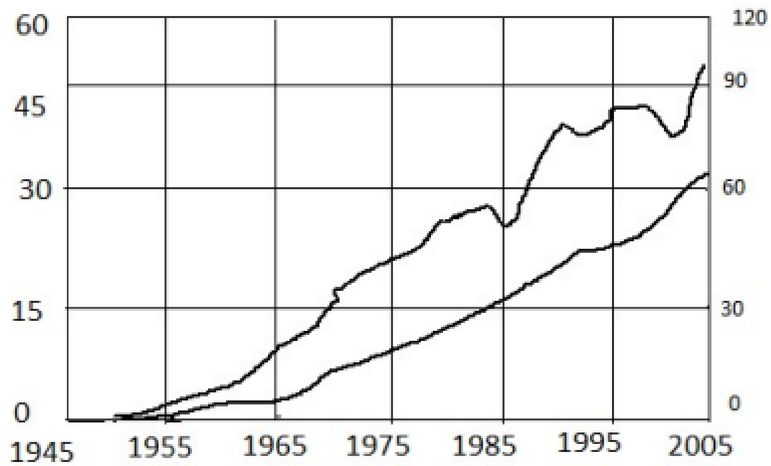


Figure 4: installed capacity & electricity generation from water-power in India 10^3 GW

2.5 Nuclear power:

Data on the electricity production from nuclear power is plotted below fig .5. It is seen that the electricity produced has been generally increasing over the years, as more units are getting commissioned. The higher amount, viz 19242 GWh was produced in 2002. The fall in certain years is because of some units being down for maintenance.

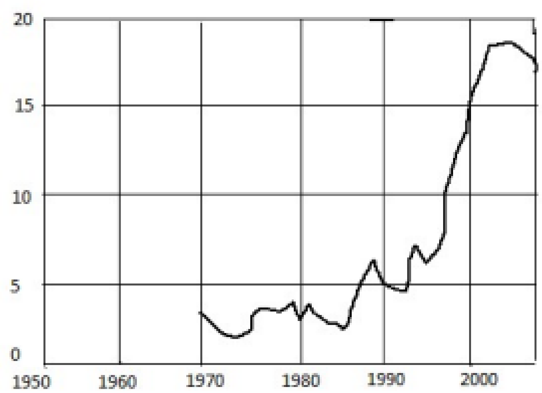


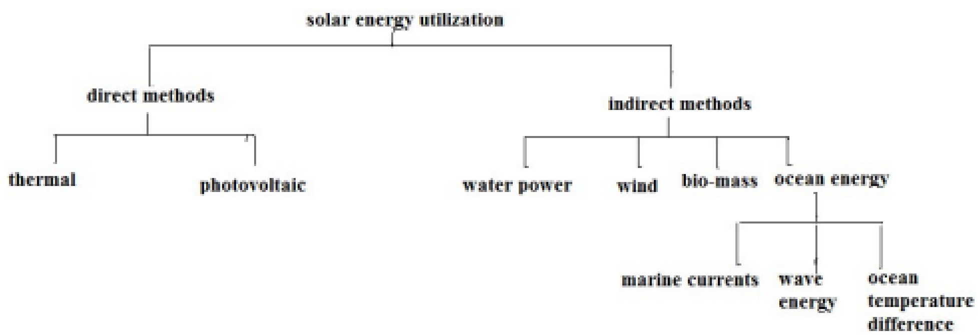
Figure 5: Electricity produced from nuclear power in India in GW

4 Explain solar energy. What are the advantages and disadvantages?

6 Solar energy:

Solar energy is a very large, inexhaustible source of energy. The power from the Sun intercepted by the earth is approximately 1.8×10^{11} MW which is many thousands of time larger than the present consumption rate on the earth of all commercial energy sources. Thus, in principle solar energy could supply all the present & future energy needs of the world on a continuing basis. This makes it one of the most promising of the unconventional energy sources. Solar energy is received in the form of radiation, can be converted directly or indirectly into other forms of energy, such as heat & electricity. This energy is radiated by the Sun as electromagnetic waves of which 99% have wave lengths in the range of 0.2 to 4 micro meters. Solar energy reaching the top of the Earth's atmosphere consists about 8% U.V radiation, 46% of visible light, 46% Infrared radiation.

6.1 Classification of methods for solar energy utilisation:



Merits of solar energy:

1. It is an environmental clean source of energy
2. It is free & available in adequate quantities in all most all parts of world where people live.

Demerits of solar energy:

1. It is a dilute source of energy because even in hottest region the radiation flux is available only 1 KW/m² & total radiation over a day is 7 KW/m². These are low values from the point of view of technological utilization.
2. It is required large collecting areas are required in many applications & these results increase of cost.

3. Solar energy availability varies widely with time, it occurs because of the day-night cycle & also seasonally because of the Earth's orbit around the Sun [even local weather condition].

Solar applications:

- ✓ Solar heating
- ✓ Solar cooling
- ✓ Solar pumping
- ✓ Solar furnace
- ✓ Solar production of hydrogen
- ✓ Solar green houses
- ✓ Solar distillation
- ✓ Solar energy
- ✓ Solar cooking

5 Explain briefly thermal energy.

6.2 Thermal Energy:

Thermal energy refers to the internal energy present in a system in a state of thermodynamic equilibrium by virtue of its temperature. The average transitional kinetic energy possessed by free particles in a system of free particles in thermodynamic equilibrium. This energy comes from the temperature of matter.

Thermal energy is the total energy of all the molecules in an object. The thermal energy of an object depends on the 3 things:

1. The number of the molecules in the object

2. The temperature of the object (average molecular motion)

3. The arrangement of the object molecules (states of matter)

There are 3 modes of thermal energy

1. Conduction, 2. convection, 3. radiation

1. **Conduction**: Heat is transferred from one molecule to another without the movement of matter.

2. **Convection**: Fluids (liquids & gases) transfer heat by convection, a process that causes mixing of the warmer regions with the cooler regions of liquid or gas.

The main difference between convection & conduction is that convection involves the movement of matter & conduction does not.

3. **Radiation**: it is the transfer of energy by electromagnetic waves.

ADVANTAGES:

1. It is eco friendly
2. Renewable sources
3. No/less pollution
4. By using this produce electricity
5. Its help full for oil refining in Industry & home heating

DISADVANTAGES:

1. Producing greenhouse gas
2. Collecting of energy is a big problem, it requires sophisticated technology hence cost is more.

Applications:

1. Steam engine
2. Gasoline engine

6 Explain tar sand and oil shale.

6.10 Tar sands:

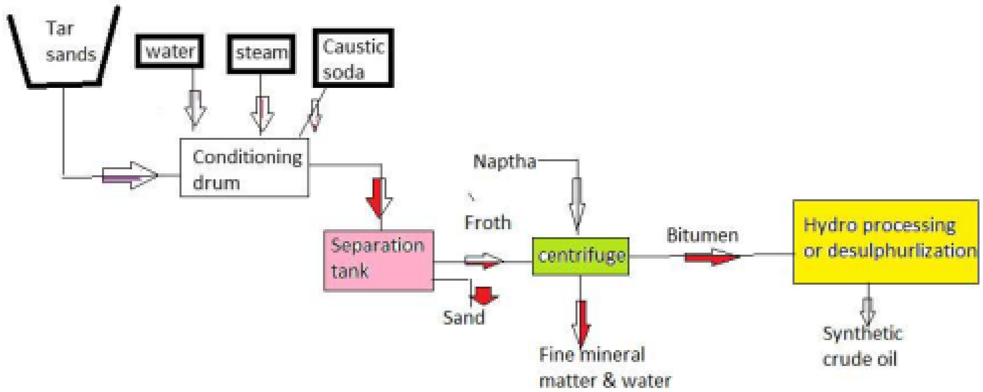


Figure 8: production of synthetic crude oil from tar sands

Tar sand or oil sands is an expression used to describe porous sandstone deposits impregnated with heavy viscous oils called bitumen or simply deposits of heavy oils. The above schematic diagram indicating the processes involved in producing synthetic crude oil from tar sands made up of sand stone deposits containing bitumen. The sands obtained from surface mining are first passed through a conditioning drum where water, steam & caustic soda are added & slurry is formed. The slurry passes into a separation tank where the coarse sand settles at the bottom & a froth of bitumen, water & fine mineral matter forms on the top. The froth is diluted with naptha & subjected to centrifugal action. As a result, fine mineral matter & water is removed. After this, the naptha is recovered & recycled, & the bitumen obtained is subjected to hydro processing & desulphurization to produce synthetic crude oil.

6.11 Oil shale:

Oil shale [a sedimentary rock] refers to a finely textured rock mixed with a solid organic material called kerogen. When crushed, it can be burnt directly [like coal] & has a heating value ranging from 2000 to 17,000 KJ/Kg. It is used in this manner for generating electricity & supplying heat.

Alternatively, the oil shale can be converted to oil. This is done by heating crushed oil shale to about 500 ˚c in the absence of air. Under the conditions, pyrolysis occurs & the kerogen is converted to oil.

Demerits:

1] The use of oil shale is the environmental degradation associated with surface mining & with the disposal of large amounts of sand & spent shale rock which remains after the crude oil is obtained.

2] A large amount of energy is consumed in producing oil from these sources.

7 What are the advantages and disadvantages of non-conventional energy sources?

5.1 Salient features of non-conventional energy resources

Merits:

1. NCES are available in nature, free of cost.

2. They cause no or very little pollution. Thus, by and large, they are environmental friendly.

3. They are inexhaustible.

4. They have low gestation period.

Demerits:

1) Though available freely in nature, the cost of harnessing energy from NCES is high, as in general, these are available in dilute forms of energy.

2) Uncertainty of availability: the energy flow depends on various natural phenomena beyond human control.

3) Difficulty in transporting this form of energy.

8 Explain solar constant.

7.5 Solar Constant (I_{SC}):

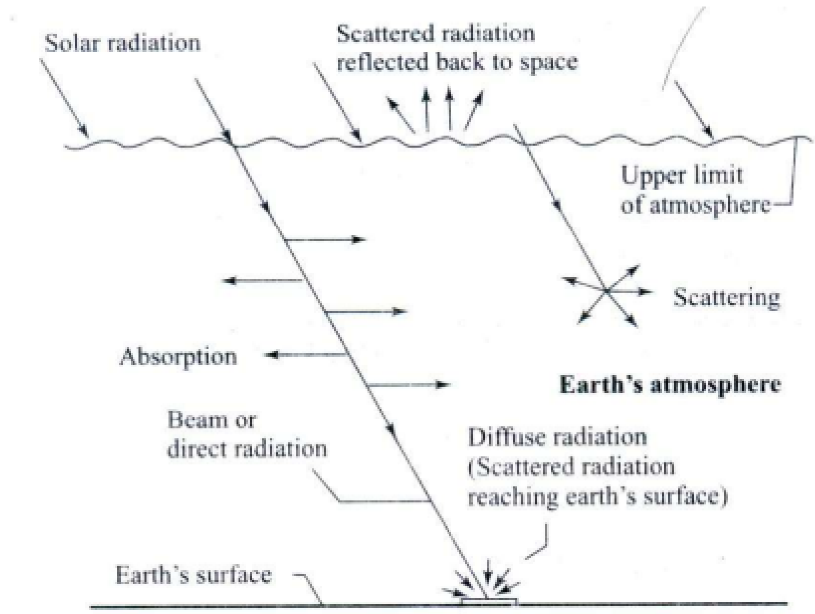
It is the rate at which energy is received from the sun on a unit area perpendicular to the rays of the sun, at the mean distance of the earth from the sun. Based on the measurements made up to 1970 a standard value of 1353W/m^2 was adopted in 1971. However, based on subsequent measurements, a revised value of 1367 W/m$_2$ has been recommended. The earth revolves around the sun in an elliptical orbit having a very small eccentricity and the sun at the foci. Consequently, the distance between earth and sun varies a little through the year. Because of this variation, the extra-terrestrial flux also varies. The value on any day can be calculated from the equation.

$$I = I'_{sc}\left\{I + 0.033\cos\frac{360n}{365}\right\}$$

9 Explain with the help of sketch solar radiation at the earth surface.

7.6 Solar Radiation Received at the Earth's surface:

Solar radiation received at the earth's surface is in the attenuated form because it is subjected to the mechanisms of absorption and scattering as it passes through the earth's atmosphere (Figure below).



Absorption occurs primarily because of the presence of ozone and water vapor in the atmosphere and lesser extent due to other gases (like CO_2, NO_2, CO, O_2, and CH_4) and particulate matter. It results in an increase in the internal energy of the atmosphere. On the other hand, scattering occurs due to all gaseous molecules as well as particulate matter in the atmosphere. The scattered radiation is redistributed in all directions, some going back to space and some reaching the earth's surface. Solar radiation received at the earth's surface without change of direction i.e., in line with the sun is called ***direct radiation or beam radiation***. The radiation received at the earth's surface from all parts of sky's hemisphere (after being subjected to scattering in the atmosphere) is called ***diffuse radiation***. The sum of beam radiation and diffuse radiation is called as ***total or global radiation.***

Diffused radiation:

The scattered reflected and refracted radiation that is sent to the earth's surface from the sun in all directions (reflected from particles, molecules, clouds, etc) is indirect radiation is called diffuse radiation. The intensity of the diffused radiation is represented by Id.

Beam radiation:

The radiation that comes directly from the sun is direct radiation and is called beam radiation. The intensity of the beam radiation is represented by Ib.

Irradiance:

The irradiance is the flux of radiant energy per unit area which is measured in W/m^2. The irradiance will be normal to the direction of the flow of radiant energy through a medium.

Insolation:

Insolation can be measured in J/m2which is the amount of solar radiation reaching a given area.

Terrestrial and extraterrestrial radiation:

Terrestrial radiation:

Terrestrial radiations are those radiations that flow throughout the year.

Extra-terrestrial solar radiation:

The extra-terrestrial radiation is the radiation which is incident outside the earth atmosphere. The extra-terrestrial radiation is 1367 $watts/m^2$.

10 Explain with neat sketch pyrometer.

7.7.1 Pyranometer:

A pyranometer is an instrument that measures either global or diffuse radiation falling on a horizontal surface over a hemispherical field of view. A sketch of one type of pyranometer as installed for measuring global radiation is shown in the following figure.

1.Black surface, 2. Glass domes ,

3. Guard plate 4. Leveling screws,

5.mounting plate, 6. Grouted bolts,

7.platform.

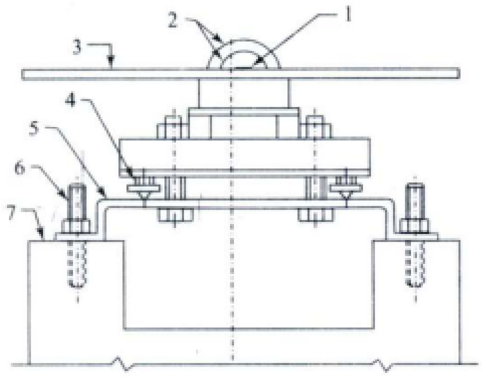


Figure 11: Pyranometer

Pyranometer consists of a black surface that heats up when exposed to solar radiation. Its temperature increases until the rate of heat gain by solar radiation equals the rate of heat loss by convection, conduction, and radiation. The hot junctions of thermopiles are attached to the black surface, while the cold junctions are located under a guard plate so that they do not receive the radiation directly. As a result, an emf is generated. This emf which is usually in the range of 0 to 10mv can be read, recorded, or integrated over a period of time and is a measure of global radiation. The pyranometer can also be used for the measurement of diffuse radiation. This is done by mounting it at the center of a semi-circular shading ring. The shading ring is fixed in such a way that its plane is parallel to the plane of the path the of sun's daily movement across the sky and it shades the thermopile element and two glass domes of pyranometer at all the times from direct sun shine. Consequently, the pyranometer measures only the diffuse radiation received from the sky.

11 Define the following.

A)Solar altitude angle :- It is the angle of the sun relative to the Earth's horizon, and is measured in degrees. The altitude is 0 at sunrise and sunset, and can reach maximum of 90 degrees

B) solar azimuth angle

1.6 Solar Azimuth Angle (γ_s)

It is the angle on a horizontal plane, between the line due south and the projection of sun's ray on the horizontal plane. It is taken as +ve when measured from south towards west.

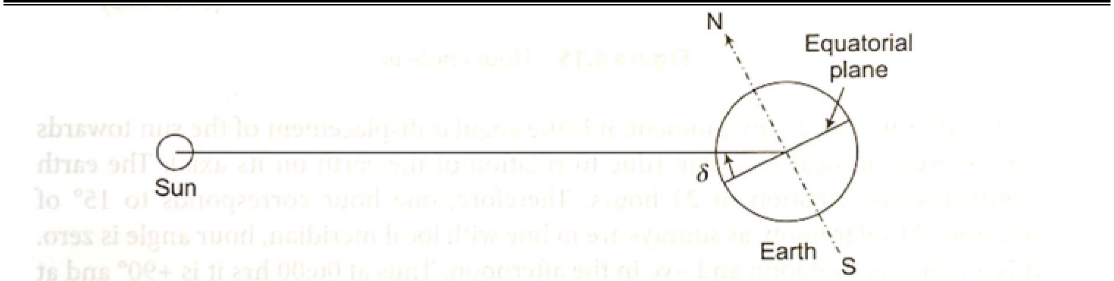
C) Declination

1.2 Declination, (δ)

It is defined as the angular displacement of the sun from the plane of earth's equator as shown in Fig. It is positive when measured above equatorial plane in the northern hemisphere. The declination δ can be approximately determined from the equation:

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

where n is day of the year counted from 1st January.



(b) Declination angle δ

Figure Latitude and declination angle

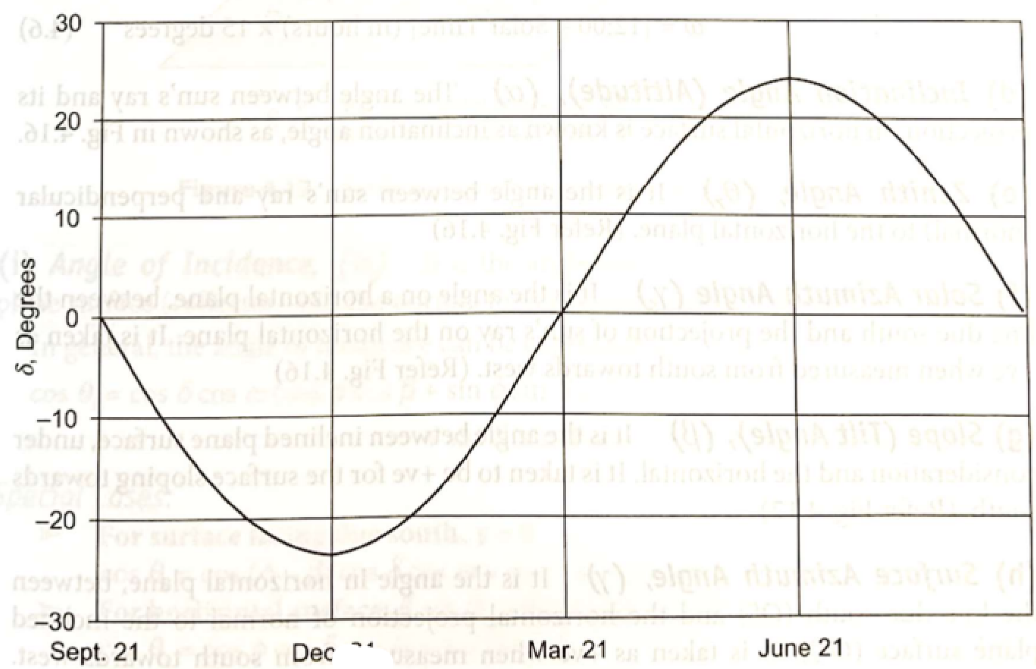


Figure 4.14 Variations in sun's declination

13 Explain beam and diffuse radiation.

2.1 Beam radiation (r_b):

It is defined as the ratio of flux of beam radiation incident on an inclined surface (I_b') to that on a horizontal surface (I_b)

$$I_b' = I_{bn}\ Cos\Theta_i$$

$$I_b = I_{bn}\ Cos\Theta_z$$

where, I_{bn} is the beam radiation on a surface normal to the direction of sunrays

$$r_b = \frac{I_b'}{I_b} = \frac{Cos\Theta_i}{Cos\Theta_z}$$

For a tilted surface facing south. γ = 0°, the expression for r, may be written as:

$$r_b = \frac{(\sin\delta\ \sin(\phi - \beta)) + (\cos\delta\cos\omega\cos(\phi - \beta))}{\sin\delta\sin\phi + \cos\delta\cos\omega\cos\phi}$$

2.2 Diffuse radiation (r_d):

It is defined as the ratio of flux of diffuse radiation falling on inclined surface to that on the horizontal surface. The value of this tilt factor depends upon the distribution of diffuse radiation over the sky and on the portion of the sky dome seen by the tilted surface. Assume that the sky is an isotropic source of diffuse radiation; we have for a tilted surface with slope β

$$r_d = \frac{1 + \cos\beta}{2}$$

14 Explain with neat sketch liquid flat plat collector.

3.1.1 Liquid flat-plate

A sketch of a liquid flat-plate collector is shown in Fig. below. As stated earlier, it consists of an absorber plate on which the solar radiation falls after coming through a transparent cover (usually made of glass). The absorbed radiation is partly transferred to a liquid flowing through tubes that are fixed to the absorber plate or are integral with it. This energy transfer is a useful gain. The remaining part of the radiation absorbed in the absorber plate is lost by convection and re-radiation to the surroundings from the top surface, and by conduction through the back and the edges. The transparent cover helps in reducing the losses by convection and re-radiation, while thermal insulation on the back and the edges helps in reducing the conduction heat loss. The liquid most commonly used is water. A liquid flat-plate collector is usually held tilted in a fixed position on a supporting structure, facing south is located in the northern hemisphere.

To reduce the heat lost by re-radiation from the top of the absorber plate of a flat-plate collector, it is usual to put a selective coating on the plate. The selective coating exhibits the characteristic of a high value of absorptivity for incoming solar radiation and a low value of emissivity for out-going re-radiation. As a result, the collection efficiency of the flat-plate collector is improved. Further improvement in the collection efficiency (or in the operating temperature) is obtained by evacuating the space above the absorber plate and leads to the design of an evacuated tube collector.

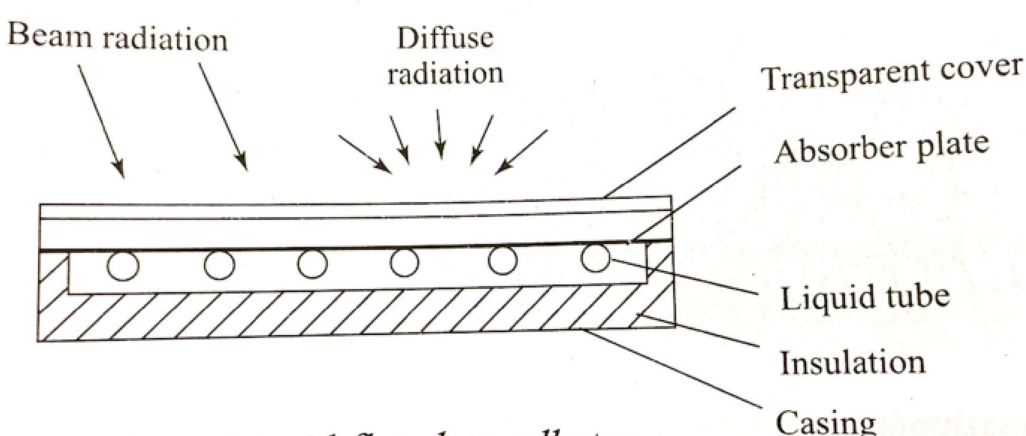


Fig. *Liquid flat-plate collector*

15 Explain with sketch cylindrical parabolic concentrator.

3.1.4 Line-focusing concentrating and Paraboloid concentrating collector

When higher temperatures are required, it becomes necessary to concentrate the radiation. This is achieved using focusing or concentrating collectors. A schematic diagram of a typical line-focusing concentrating collector is shown in Fig. The collector consists of a concentrator and a receiver. The concentrator shown is a mirror reflector having the shape of a cylindrical parabola. It focuses the sunlight on to its axis, where it is absorbed on the surface of the absorber tube and transferred to the fluid flowing through it. A concentric glass cover around the absorber tube helps in reducing the convective and radiative losses to the surroundings. In order that the sun's rays should always be focused on to the absorber tube, the concentrator has to be rotated. This movement is called tracking. In the case of cylindrical parabolic concentrators, rotation about a single axis is generally required. Fluid temperatures up to 400°C can be achieved in cylindrical parabolic focusing collector systems. The generation of still higher working temperatures is possible by using paraboloid reflectors that have a point focus. These require two-axis tracking so that the sun is in line with the focus and the vertex of the paraboloid

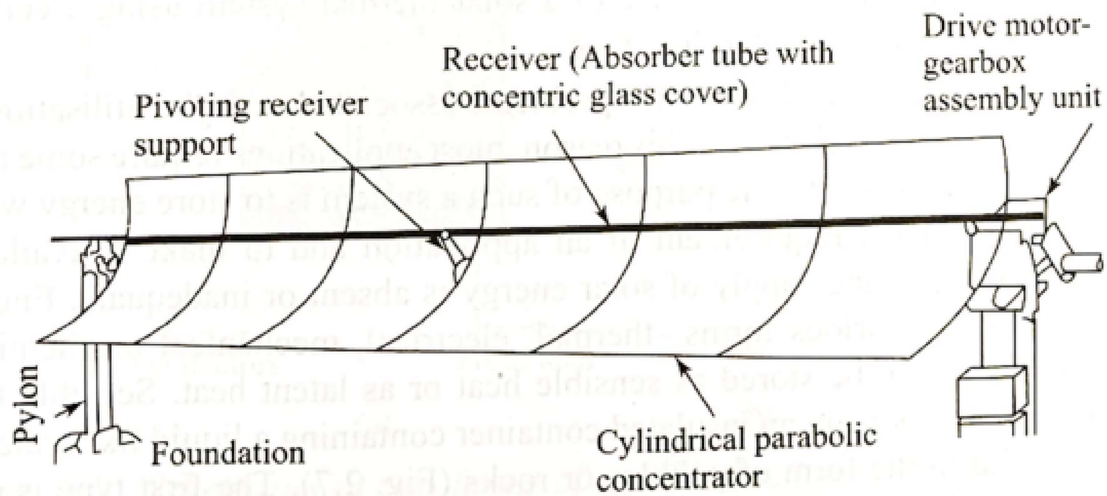


Fig. *Cylindrical parabolic concentrating collector*

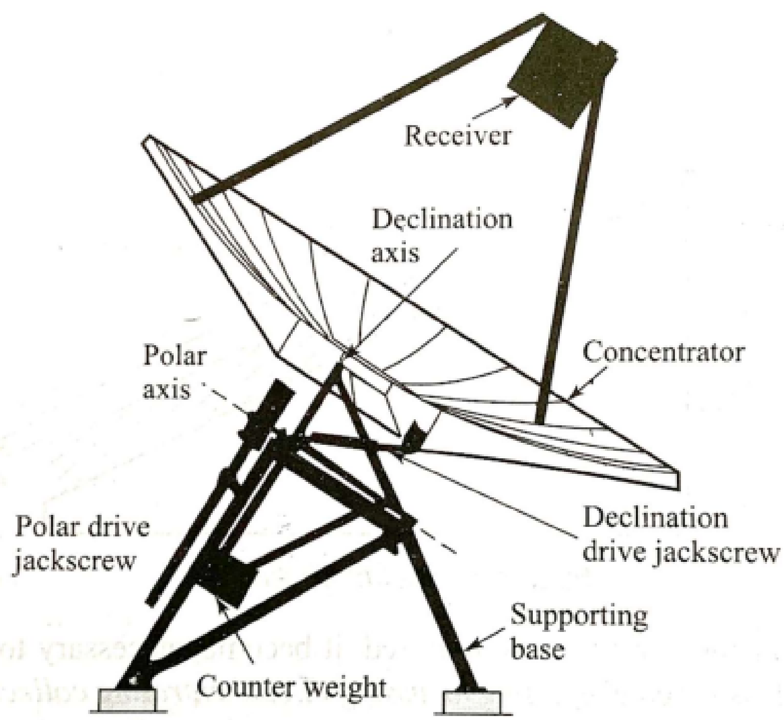
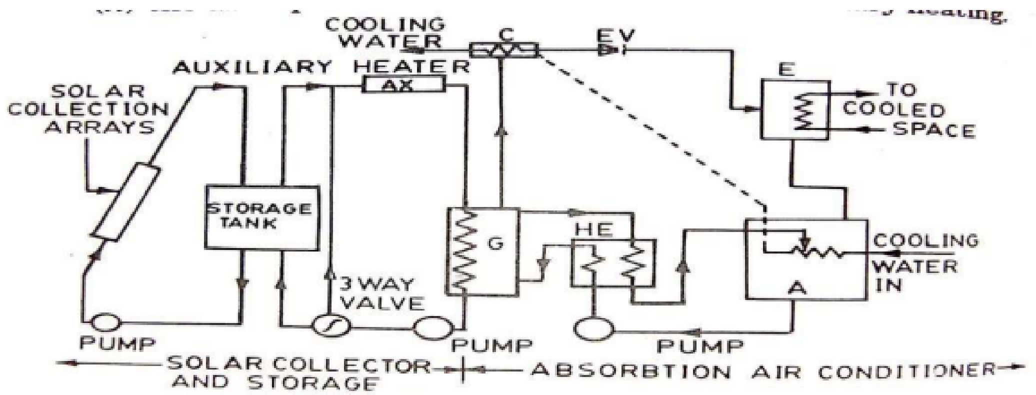


Fig. *Paraboloid concentrating collector*

16 Explain with neat sketch solar energy water heating.

17 Explain with neat sketch space cooling for building.

3.2.4 Solar space cooling of buildings: vapour absorption air cooling (LiBr-H2O system 85 to 95°C with FPC /NH3-H2O cooler 120 to 130°C with concentrating collectors) (Solar refrigeration)



G—GENERATOR
C—CONDENSER
E—EVAPORATOR
A—ABSORBER
HE—HEAT EXCHANGER

Fig. Schamatic of Solar Operated Absorption Air Conditioner.

The absorption air conditioning system is shown schematically in Fig.

The system consists of two parts

1. The solar collector and storage, and
2. The absorption air conditioner and the auxiliary heating.

The essential components of the cooler are (i) generator (G), (ii) condenser (C), (iii) evaporator (E), (iv) absorber (A), (v) heat-exchanger (HE).

The operation of air conditioners with energy from flat-plate collectors and storage systems is the most common approach to solar cooling today. In essence, cooling is accomplished as the generator of the absorption cooler is supplied with heat by a fluid pumped from the collector storage system or from an auxiliary. Heat is supplied to a solution of refrigerant in absorbent in the generator, where the refrigerant is distilled out of the absorbent fluid. The refrigerant is condensed and goes through a pressure-reducing valve to the evaporator where it operates and cools air or water for the cooling space. The refrigerant vapor goes to the absorber where it comes in contact with the solution which is weak in refrigerant and which flows from the generator. The vapor is absorbed in the solution, which is then returned to the generator. A heat exchanger is used for sensible heat recovery and greatly improves cooler C.O.P.

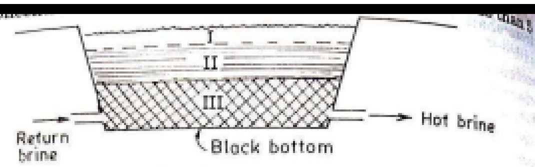
From the point of view of the use of a conventional energy source, there is a single index of performance for rating cooling processes, that is the COP, the ratio of the amount of cooling to the energy required. For solar operation, there are two additional factors, the temperature required in the solar collector to drive the process and the ratio of cooling produced to the solar energy incident on the collector. As solar processes are inevitably transient in their operation, the energy ratios and temperatures will vary with time, and COP based on long-term integrated performance provides an appropriate index of performance. Pumping to the more absorbent solution may be by mechanical means or by vapor-lift pumping in the generator for low-pressure systems like LiBr-H_2O system require water cooling of absorber and condenser. Systems of this type shown in the figure have been the basis of most of the experiences to date with solar air conditioning.

The coolers used in most experiments to date are LiBr-H_2O machine water-cooled absorber and condenser. The pressure in the condenser and generator is fixed largely by temperature drops across heat transfer surfaces in the generator and condenser. The pressure in the evaporator and absorber is fixed by the temperature of the cooling fluid to the absorber and by the temperature drop across the heat transfer surfaces in the evaporator and the absorber. Thus, to keep the generator temperatures within the limits imposed by the characteristics of a flat-plate collector, the critical design factors and operational parameters include the effectiveness of the heat exchangers and coolant temperature. The common practice in solar experiments has been to use water-cooled absorbers and condensers, which in turn requires a cooling tower.

18 Explain with neat sketch solar pond.

3.2.7 Solar pond

A solar pond is a mass of shallow water about 1 or 2 meters deep with a large collection area, which acts as a heat trap. It contains dissolved salts to generate a stable density gradient. Part of the incident solar radiation entering the pond surface is absorbed throughout the depth and the remainder which penetrates the pond is absorbed at the black bottom. If the pond were initially filled with freshwater, the lower layers would heat up, expand and rise to the surface. Because of the convective mixing and heat loss at the surface, only a small temperature rise in the pond could be realized. On the other hand, convection can be eliminated by initially creating a sufficiently strong salt concentration gradient. In this case, thermal expansion in the hotter lower layers is insufficient to destabilize the pond. With convection suppressed, the heat is lost from the lower layers only by conduction. Because of the relatively low conductivity, the water acts as an insulator and permits high temperatures (over 90° C) to develop in the bottom layers. At the bottom of the pond, a thick durable plastic liner is laid. Materials used for the liner include butyl rubber, black polyethylene and Hypalon reinforced with nylon mesh. Salts like magnesium chloride, sodium chloride, or sodium nitrate are dissolved in the water, the concentration varying from 20 to 30 percent at the bottom to almost zero at the top.



(i) Surface convective zone.
(ii) Non-convective zone.
(iii) Storage zone.

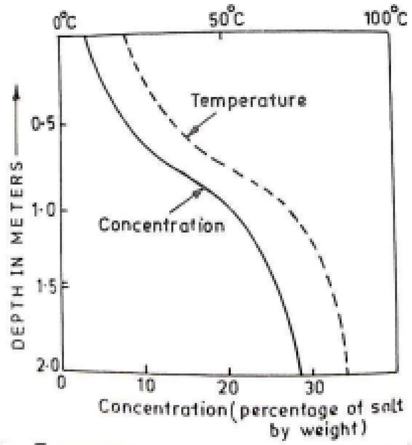


Fig Temperature and concentration profile for a typical pond.

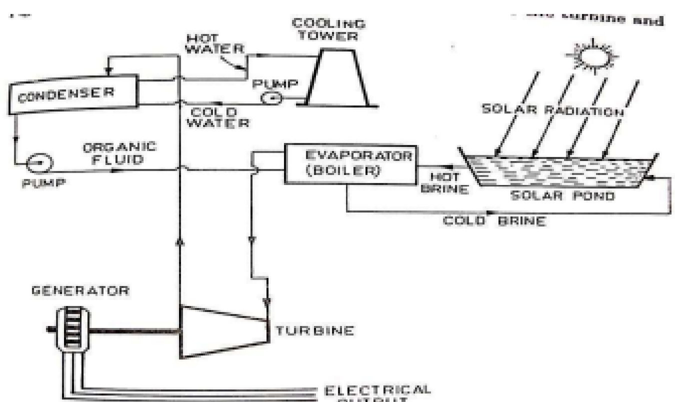


Fig. Solar pond electric power plant with cooling tower.

19 Explain with neat sketch sensible and latent heat storage.

20 Explain with neat sketch solar air heater.

3.1.3 Flat-plate collector for heating air

A schematic cross-section of a conventional flat-plate collector for heating air (commonly referred to as a solar air heater) is shown in Fig. 2.3. The construction of such a collector is essentially similar to that of a liquid flat-plate collector except for the passages through which the air flows. These passages have to be made larger in order to keep the pressure drop across the collector within manageable limits. In the diagram shown, the air passage is simply a parallel plate duct.

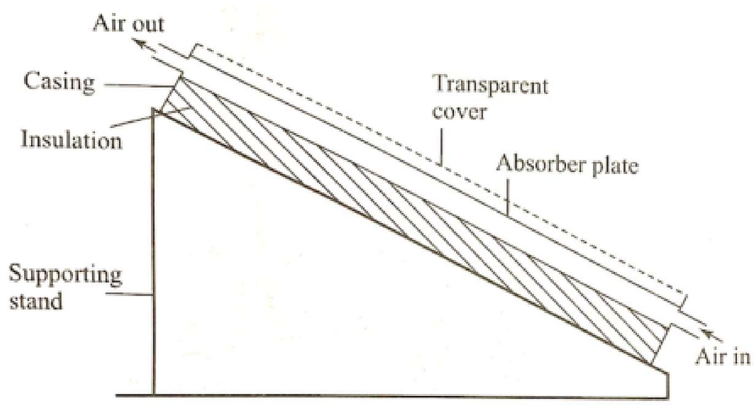


Fig. Solar air heater

21 What is the application of solar energy?

Application of solar energy