

18ME651

Non-conventional Energy Sources

IAT 1

Answer all questions.

- 1) Explain the following: [20 marks]
 - (a) Solar constant
 - (b) Extra-terrestrial radiation
 - (c) Global radiation
 - (d) Sunshine recorder
- 2) Explain the advantages and limitations of use of non-conventional energy sources. [10 marks]
- 3) What is Pyrheliometer? With a neat sketch, explain its working principle. [10 marks]
- 4) With a neat sketch, explain the working principle of an instrument used to measure Global radiation.

1) Explain the following:

(a) Solar constant: constant. The solar constant (I_{sc}) 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. The value of the solar is 1367W/m^2 .

The solar constant is useful in determining the intensity of extra-terrestrial radiation (I_{ext}). The value on any day can be calculated from the equation

$$I_{ext} = I_{sc} \left(1 + 0.033 \cos \frac{360n}{365} \right)$$

where n is the day of the year.

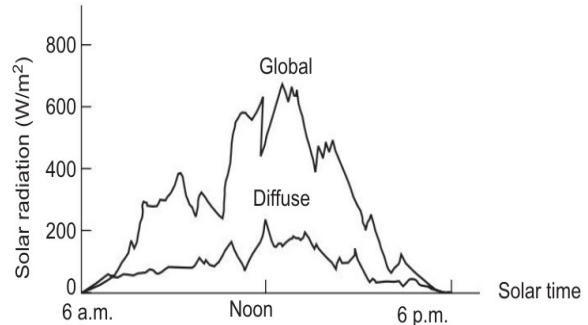
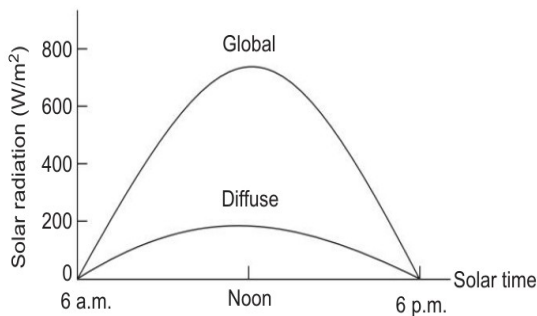
(b) Extra-terrestrial radiation: It is the solar radiation received at the outer reaches of the earth's atmosphere.

About 99 per cent of the extraterrestrial radiation has wavelengths (λ) in the range from 0.2 to $4 \mu\text{m}$ with maximum spectral intensity at $0.48 \mu\text{m}$ (green portion of visible range). About 6.4 per cent of extraterrestrial radiation energy is contained in ultraviolet region ($\lambda < 0.38 \mu\text{m}$); another 48 per cent is contained in the visible region ($0.38 \mu\text{m} < \lambda < 0.78 \mu\text{m}$) and the remaining 45.6 per cent is contained in the infrared region ($\lambda > 0.78 \mu\text{m}$).

(c) Global radiation: The sum of beam and diffuse radiation is referred to as total or global radiation.

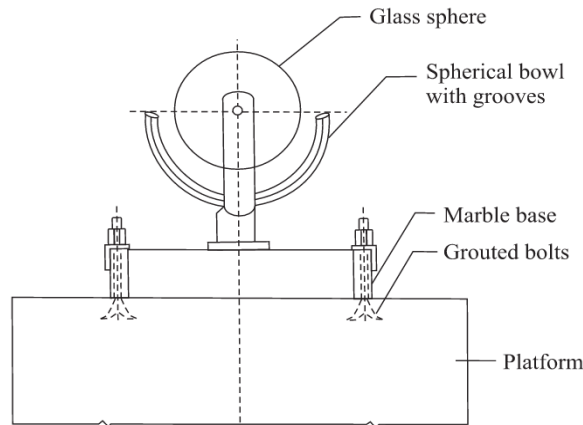
Beam Radiation: Solar radiation propagating in a straight line and received at the earth surface without change of direction, i.e., in line with sun is called beam or direct radiation.

Diffuse radiation: Solar radiation scattered by aerosols, dust and molecules is known as diffuse radiation. It does not have a unique direction.



Global radiation on a clear day (left) and cloudy day(right)

(d) Sunshine recorder: A sunshine recorder is a device that records the duration of bright sunshine at a given location in a day. The sun's rays are focused by a glass sphere to a point on a card strip held in a groove in a spherical bowl mounted concentrically with the sphere. Whenever there is bright sunshine, the image formed is intense enough to burn a spot on the card strip. Through the day as the sun moves across the sky, the image moves along the strip. Thus, a burnt trace whose length is proportional to the duration of sunshine is obtained on the strip.



2) Explain the advantages and limitations of use of non-conventional energy sources.

Non conventional energy sources are those energy sources which are exposed to use from modern technologies advancements; rather than the normal use of conventional fuels as energy sources like gas or oil. Solar Energy, Geo-thermal Energy, Tidal Energy, Bio-Energy are a few of non-conventional resources.

There are a lot of advantages of non-conventional energy resources. A few of them are:

- No Fuel Cost: Renewable energy resources provide energy continuously at negligible fuel cost and hence these are cheap source of energy which makes them favorable over other sources of energy.
- Pollution Free and Eco-Friendly: These Non Conventional Energy Resources are pollution free and hence are Eco-friendly. This is one of the best thing to be considered in this age of global warming.
- Simple Design: Renewable energy sources have simple plant design and hence easy to operate and no specialized workforce is requires in these plants.
- Lower maintenance cost : Being simple in design the maintenance cost of these plants is very less and these plants can thus produce electricity at much lower cost than other plants.
- Available at load center : These plants can be installed remotely and at locations completely off grid. Hence better choice for single plant use.

Limitations of them are:

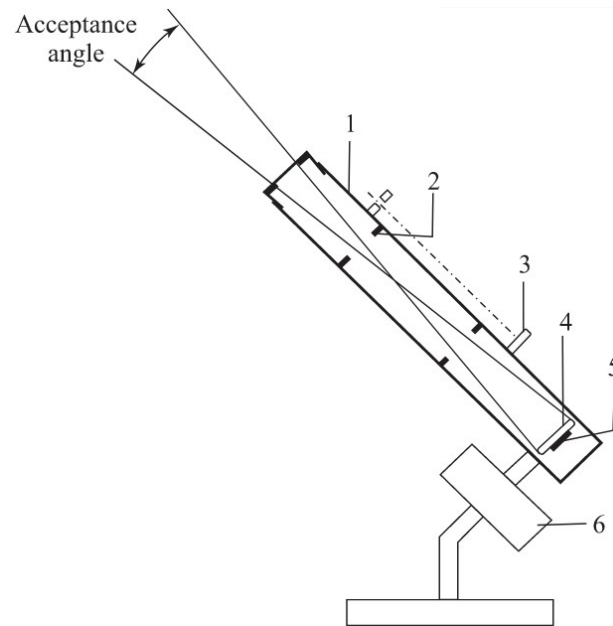
- High Initial cost: Although running cost and maintenance cost of these plants is very low but installation cost for these plants is very high which is major disadvantage to these plants.
- Low energy density: Low energy density is another problem these plants have. Energy per unit area is small in these plants which makes them big in size and hence large area is requires to install them.
- Seasonal: These sources are seasonal in nature like Solar energy is not available in rainy and winter days. Hydro energy is not available in dry days.

3) What is Pyrheliometer? With a neat sketch, explain its working principle.

The normal incidence pyrheliometer uses a long collimator tube to collect beam radiation whose field of view is limited to a solid angle of 5.5° (generally) by appropriate diaphragms inside the tube. The inside of the tube is blackened to absorb any radiation incident at angles outside the collection solid angle. At the base of the tube a wire wound thermopile is provided. The tube is

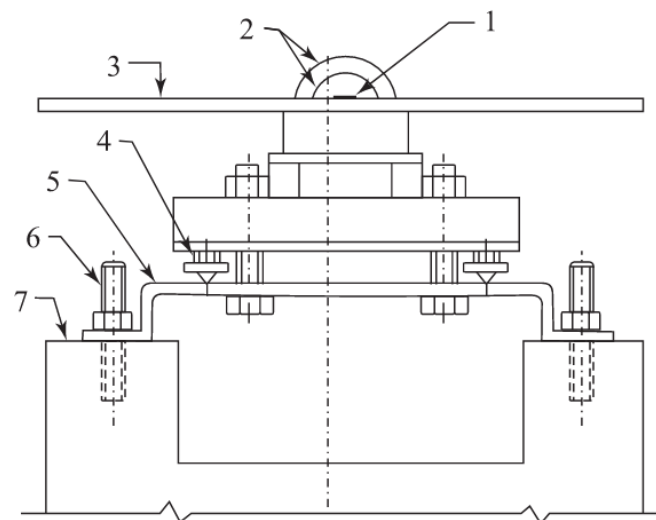
sealed with dry air to eliminate absorption of beam radiation within the tube by water vapor. A tracker is needed if continuous readings are desired.

The pyrliometer consists of a 'black' surface which 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 re-radiation. The hot junctions of a thermopile 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 (usually in the range of 0 to 10 mV) which can be read, recorded or integrated over a period of time and is a measure of the beam radiation.



Pyrheliometer for measuring beam radiation (1. Tube blackened on inside surface, 2. baffle, 3. alignment indicator, 4. black absorber plate, 5. thermopile junctions, 6. two-axis tracking mechanism)

4) With a neat sketch, explain the working principle of an instrument used to measure Global radiation.



Pyranometer for measuring global radiation (1. Black surface, 2. glass domes, 3. guard plate, 4. leveling screws, 5. mounting plate, 6. grouted bolts, 7. platform)

A precision pyranometer is designed to respond to radiation of all wavelengths and hence measures accurately the total power in the incident spectrum. It contains a thermopile whose sensitive surface consists of circular, blackened, hot junctions, exposed to the sun and cold junctions are completely shaded. The temperature difference between the hot and cold junctions is the function of radiation falling on the sensitive surface. The sensing element is covered by two concentric hemispherical glass domes to shield it from wind and rain. This also reduces the convection currents. A radiation shield surrounding the outer dome and coplanar with the sensing element, prevents direct solar radiation from heating the base of the instrument.

It has its hot junctions arranged in the form of a horizontal circular disc of diameter 25 mm and coated with a special black lacquer having a very high absorptivity in the solar wavelength region. The disc is placed on a large diameter guard plate which may be horizontal or sloping. Two concentric hemispheres, 30 and 50 mm in diameter respectively, made of optical glass having excellent transmission characteristics, are used to protect the disc surface from weather conditions. An accuracy of about +2 per cent can be obtained with the instrument.