

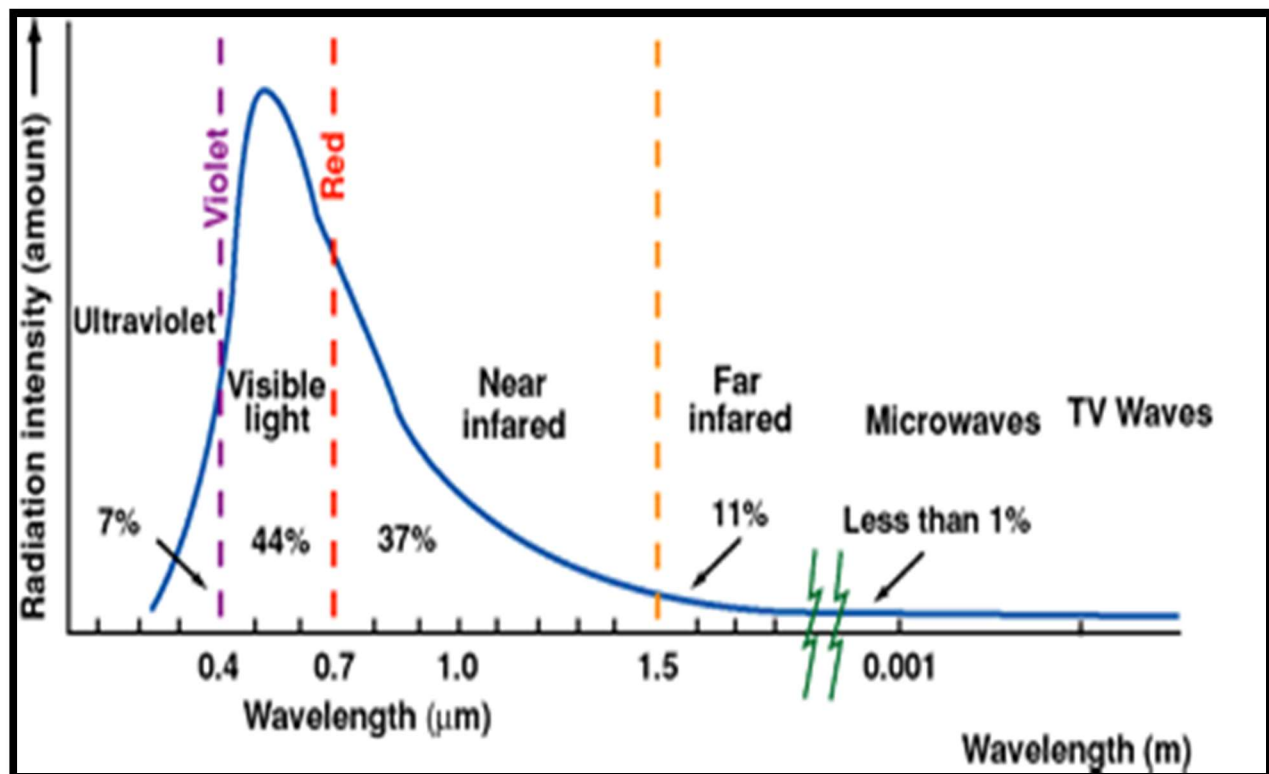
T. Y. B.Sc. (Physics)
Semester : III
Elective-I : Renewable Energy Sources

MODULE 1
AN INTRODUCTION TO ENERGY SOURCES

Solar Energy (or) Solar radiation outside the earth's atmospheres

(Extra-Terrestrial Radiation) :

The graph shows spectral distribution of solar intensity at the outer limit of the atmosphere .The area under the entire curve is the solar radiation .The intensity is maximum in the green portion of the visible spectrum that is at $0.48 \mu\text{m}$.The sun emission spectra indicate that the sun is a black body radiator at a temp of 5762K .



The curve shows the spectral distribution of the extra terrestrial radiation available at the mean earth-sun distance and 1353 W/m^2 as the solar constant . However , due to the fact that the earth revolves around the sun not in circular orbit but follows an elliptic path with sun is one of the focii , there is a variation in the extra terrestrial radiation.

The table shows solar radiation in various portions of the solar radiation spectrum. From this table , we see that the visible part of the solar energy spectrum carries about half of its total energy .

Parameters	UV rays	Visible light rays	IR rays
Wavelength range (μm)	0-0.38	0.38-0.78	0.78-4.0
Approximate energy (W/m^3)	95	640	618
Approximate percentage of total energy	7%	47.3%	45.7%

Solar radiation at the earth's surface (Terrestrial Radiation) :

The solar radiation received at the earth's surface in an attenuated form because it is subjected to the mechanism of absorption and scattering as it passes through the earth's atmosphere .

1. Absorption :

It occurs because of presence of ozone and water vapors in the atmosphere, due to gases (CO , NO_2 , CO_2 , O_2 and CH_4) and particulate matter. As solar radiation passes through the earth's atmosphere the UV rays are absorbed by the ozone in the atmosphere and IR waves are absorbed by carbon dioxide and moisture in the atmosphere. It results an increase in internal energy of the atmosphere.

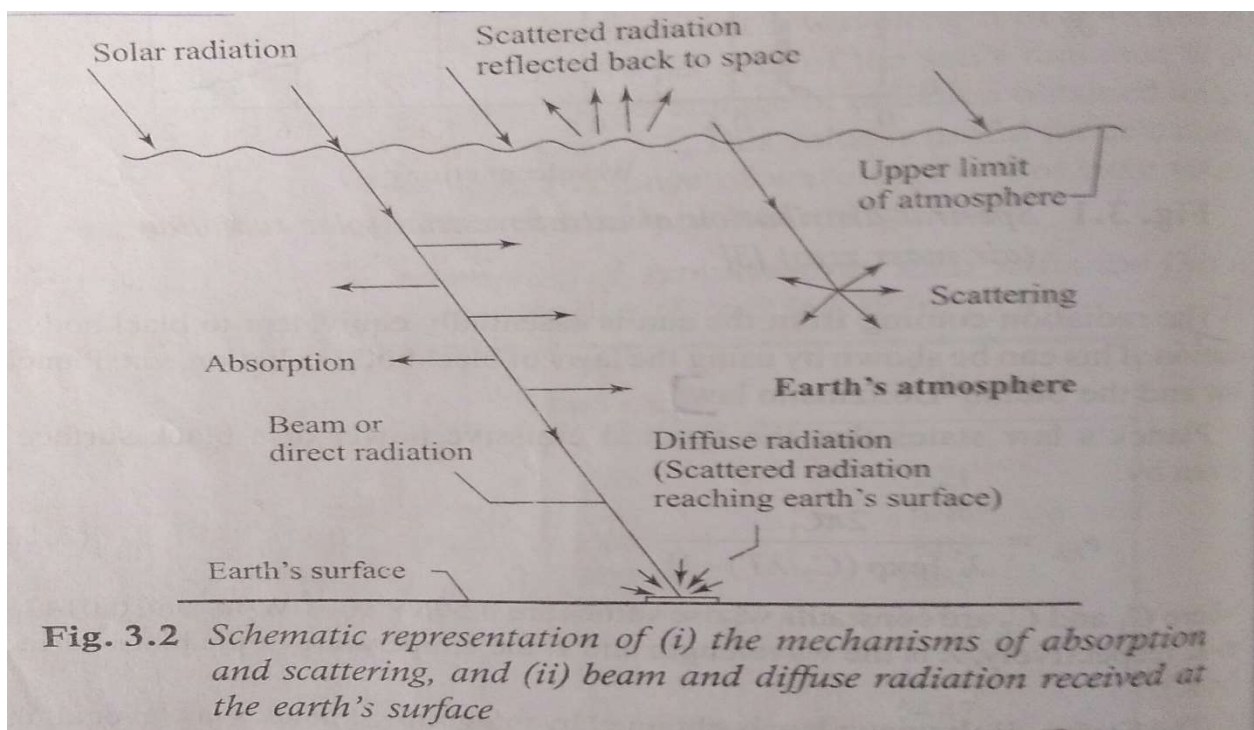
2. Scattering :

The scattering occurs due to all gaseous molecules and the particulate matter in the atmosphere. A portion of this scattered radiation always reaches the earth's surface as diffuse radiation. It must be realised that scattering attenuates the radiation. The scattered radiation is redistributed in all directions , some going into space and some reaching the earth's surface.

The atmosphere at any location on the earth's surface is often classified into two broad types such as :

a) An atmosphere without clouds : If the atmosphere is without clouds , it is obvious that less attenuation takes place, consequently maximum radiation is received on the earth's surface .

b) An atmosphere with clouds : If the atmosphere is cloudy , more attenuation takes place. Consequently minimum radiation is received on the earth's surface which is in the form of diffuse or scattered radiation.



There are three types of the radiation which reaching the earth surface which as follows:

1. Beam radiation (Direct radiation):

The solar radiation which comes directly from the apparent disc , without reflection from the other objects , is called as the beam or direct radiation. The

solar radiation received at the earth's surface without change of direction that is in line with the sun . The solar radiation outside the the earth's atmospheres is entirely direct radiation.

2. Diffuse radiation:

The solar radiation received from the sun after its direction has been changed by reflection and scattering by the atmosphere. It is defined as the solar radiation scattered by aerosols and dust molecules. It does not have any direction. Diffuse solar radiation is the total solar radiation minus the direct radiation or beam radiation.

3. Global radiation (Total radiation):

Total or global radiation is all solar radiation , incident on surface , including scattered , reflected and direct . It does not include radiation that has been absorbed by matter and then re-emitted , because most of this radiation is at longer wavelenths $3\text{ }\mu\text{m}$.

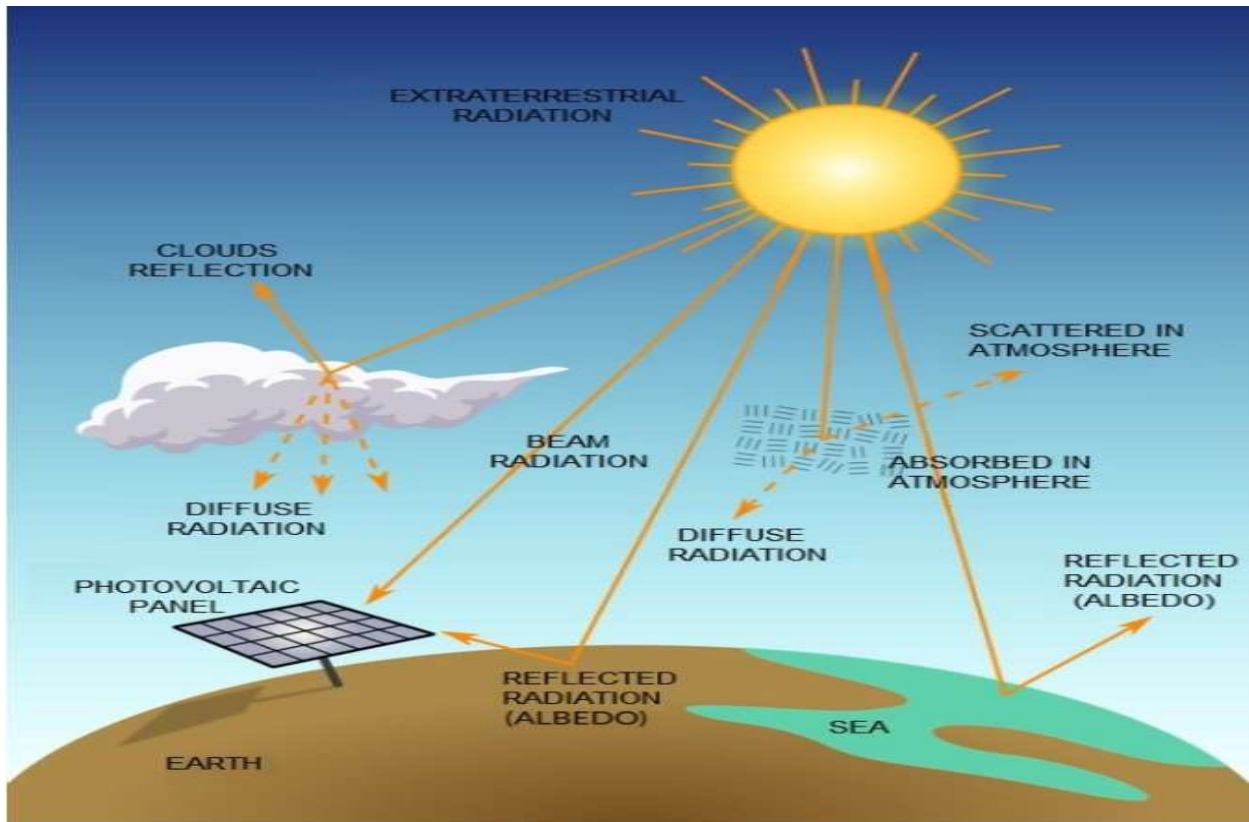


Figure 1 Direct , diffuse and total solar radiation

Radiation Intensity received at the Earth's surface also depends on other factors like:

Zenith angle :

The solar radiations which makes an angle with the normal horizontal surface of the earth that angle is known as zenith angle.

- **Sun at zenith :** If the position of the sun is directly over head then it is called as sun at zenith.

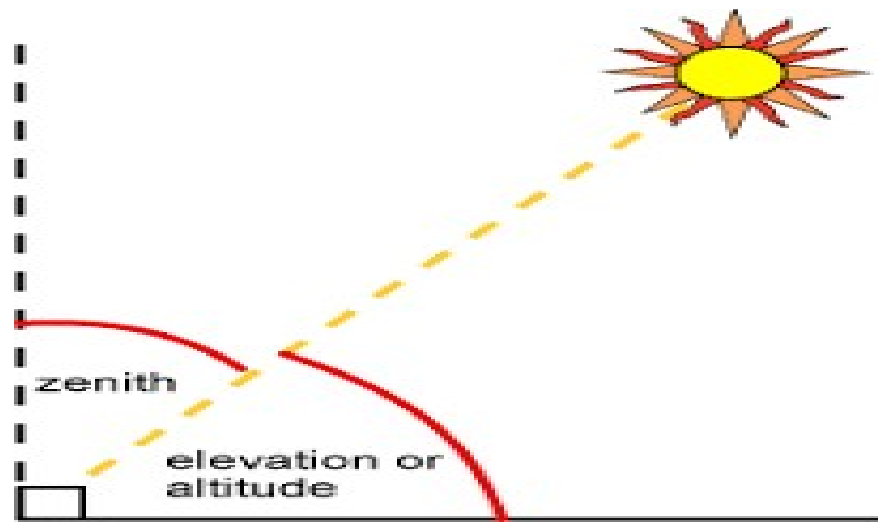


Figure 2 Angle of Sun's elevation and Zenith angle

Air Mass :

It is defined as the ratio of the mass of the atmosphere through which the beam radiation passes to the mass it would pass through if the sun is directly overhead that is at its zenith.

The air mass zero corresponds to extra terrestrial radiations , air mass one corresponds to the case of the sun at its zenith and the air mass two corresponds the case of a zenith angle of 60° . The relationship between air mass and zenith angle is given by

$$AM = \sec(\theta_z)$$