**Solar Energy availability:**

Detailed information about solar radiation availability at any location is essential for the design and economic evaluation of a solar energy system. Various models based on available climatic data can be used to estimate the solar energy availability. The solar energy is in the form of electromagnetic radiation with the wavelengths ranging from about 0.3 μm to over 3 μm, which correspond to ultraviolet (less than 0.4 μm), visible (0.4 and 0.7 μm), and infrared (over 0.7 μm). Most of this energy is concentrated in the visible and the near-infrared wavelength range.7

**Sun light passing through the atmosphere:**

The total irradiance on a horizontal surface on Earth is also called global irradiance EG,hor. It is the sum of the direct irradiance Edir,hor and the diffuse irradiance Ediff,hor on the horizontal surface: EG,hor = Edir,hor + Ediff,hor

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**The air Mass ratio (AM)**

Air Mass is the ratio of the path length of the sun's rays through the atmosphere when the sun is at a given angle (θ) to the zenith, to the path length when the sun is at its zenith. this leads to the definition:

AM =L/d = 1/sinαs = 1/cos θ, αs: sun height (solar altitude or elevation)

AM is equal to 1, if the light is passing vertically through the atmosphere. The AM value outside the atmosphere is zero.



**Earth Sun Relationships:**

The extraterrestrial solar radiation varies throughout the year because of the variation in the Earth–sun distance (D) as:







N=Day number (starting from January 1 as 1).

**Solar Radiation on A surface**

As solar radiation passes through the atmosphere, some of it is absorbed by air and water vapor, while some gets scattered by molecules of air, water vapor, and dust particles. The part of solar radiation that reaches the surface of the Earth with essentially no change in direction is called direct or beam normal radiation, IbN. The scattered radiation reaching the surface from the atmosphere is called diffuse radiation, Id. IbN can be calculated from the extraterrestrial solar irradiance, I, and the atmospheric optical depth d as:



where θ (z) is the solar zenith angle (angle between the sun rays and the vertical).



To account for the differences in local conditions from the average sea level conditions IbN Equation is modified by a parameter called Clearness Number, Cn, as:



values of Cn vary between 0.85 and 1.15. Total incident solar radiation on a horizontal surface is given by:



where θ (z) is the solar zenith angle and C is called the sky diffuse factor

**Solar Radiation on tilted angle:**

For a tilted surface with angle of incidence θ, the total incident solar radiation is given by:



α ***: Solar altitude angle***

***β: Panel tilt angle (S)***

**θ**: ***Incident angle (i)***

where ρ is the reflectivity of the surroundings. For ordinary ground or grass, ρ is approximately 0.2 while for ground covered with snow it is approximately 0.8.

**Direct Irradiation on tilted surfaces:**

The horizontal surface in Figure below with the area Ahor receives the same radiant power Φ as a smaller area As which is normal to the incoming sunlight.



It becomes apparent that the direct normal or beam irradiance Idir,s on a surface perpendicular to the path of the light is higher than the direct irradiance Idir,hor on a horizontal surface; this fact is taken into account when planning solar energy systems. Inclining the surface of the system increases the energy yield, especially at high latitudes with low solar height angles.

**Solar Radiation Measurements:**

Two basic types of instruments are used in measurements of solar radiation:

1. Pyranometer: An instrument used to measure global (direct and diffuse) solar radiation on a surface. This instrument can also be used to measure the diffuse radiation by blocking out the direct radiation with a shadow band.

2. Pyrheliometer: This instrument is used to measure only the direct solar radiation on a surface normal to the incident beam. It is generally used with a tracking mount to keep it aligned with the sun.

**Defining terms:**

**Diffuse radiation**: Scattered solar radiation coming from the sky.

**Direct or beam normal radiation**: Part of solar radiation coming from the direction of the sun on a surface normal to the sun’s rays.

**Extraterrestrial solar radiation**: Solar radiation outside Earth’s Atmosphere

**Insolation**: Incident solar radiation measured as W/m2

**Solar constant**: Extraterrestrial solar radiation at the mean Earth– sun distance.