

Alternative Energy

Chapter 2: Solar Energy Resource

by

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Chapter Description

- **Expected Outcomes**
 - Understand solar energy resources
 - To do site analysis
- **References**
 - Grid-connected Solar Electric Systems: The Earthscan Expert Handbook by Geoff Stapleton and Susan Neill, 2010.
 - Stand-alone Solar Electric Systems: The Earthscan Expert Handbook for Planning, Design and Installation by Mark Hankins, Earthscan, 2010.

Solar radiation

- **Irradiance (G)** - The *rate of solar radiation falling on a given area at a moment in time* (eg: daily, monthly or annually). Measured in W/m^2 or kW/m^2
- **Irradiation/Insolation (H)**- The amount of solar energy received on a specified area over a specified period of time. Measured in kWh/m^2 .

Solar Radiation

1. Direct Radiation, G_b :

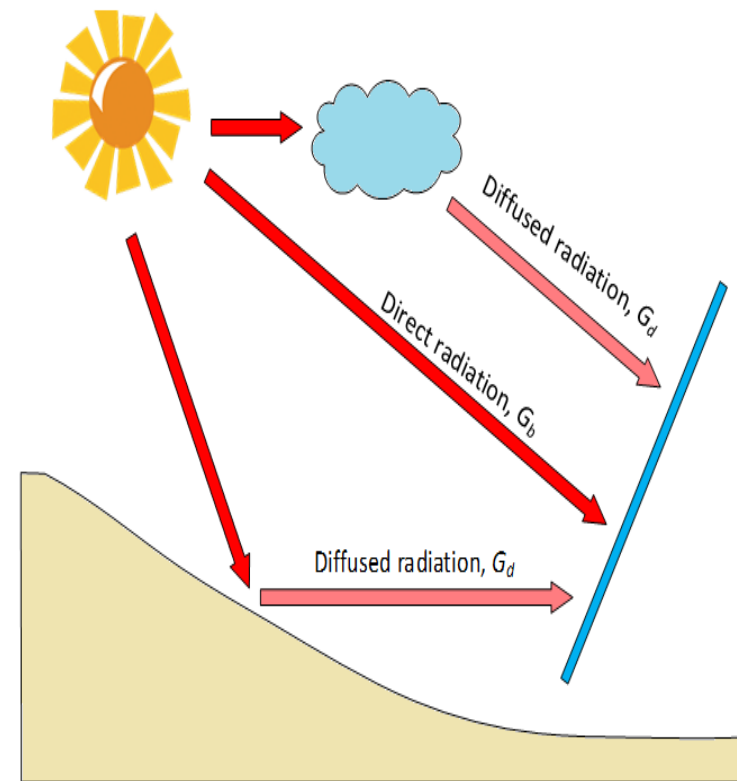
radiation from the sun that reaches the earth without scattering

2. Diffuse Radiation, G_d :

radiation that is scattered by the atmosphere and clouds

3. Global Radiation, G_{global}

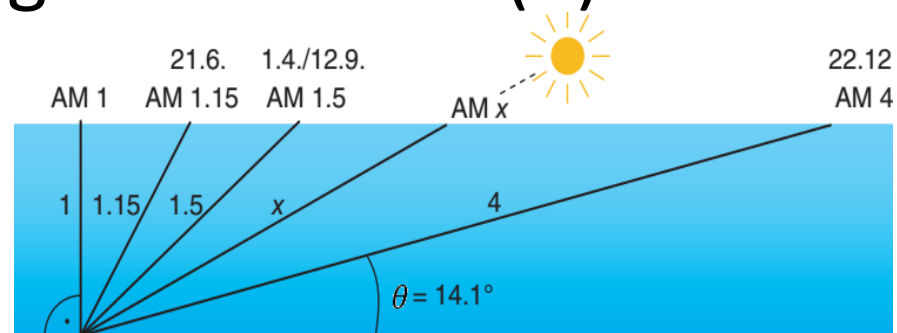
$$G_{global} = G_b + G_d$$



Air Mass (AM)

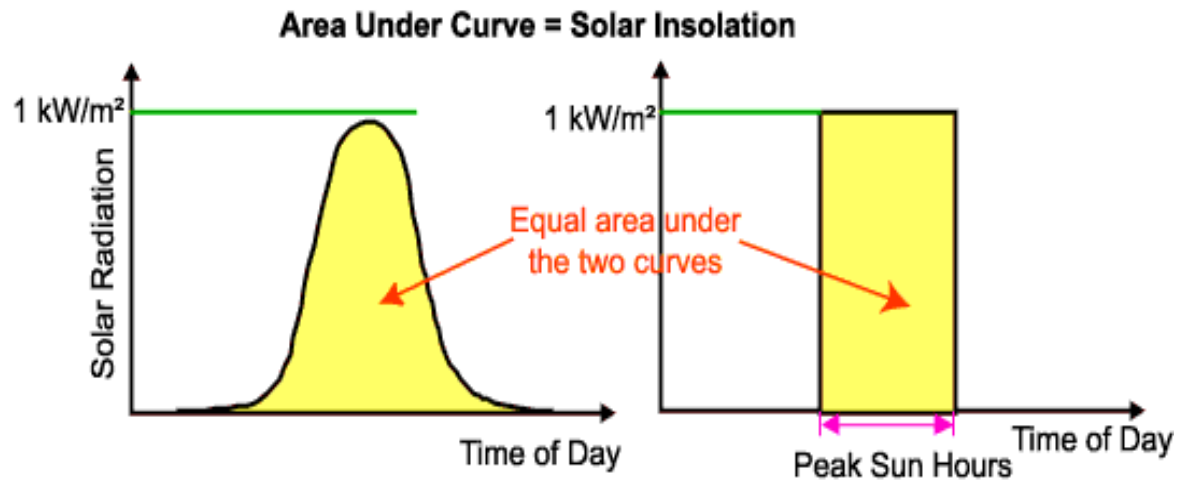
- The sunlight spectrum changes when passing through the atmosphere. The effect is greater, the longer the path of the light.
- The term AM 1.5 means that the light has travelled 1.5 times the distance in comparison to the vertical path through the atmosphere.
- At a known Sun height angle of the Sun (θ) the AM value :

$$AM = \frac{1}{\sin \theta}$$



Peak Sun Hour (PSH)

- Daily irradiation is commonly referred as PSH
- PSH for the day is the number of hours for which energy at the rate of 1 kWm^{-2} would give an equivalent amount of energy to the total for that day.



Peak Sun Hour (PSH)

- To get maximum solar radiation, PV module must be directly faced to the sun
- Therefore, we need some knowledge about the earth-sun geometry in order to find the best PV module orientation and location
- Study about the best tilt angle of the module and the effect of shading around the location

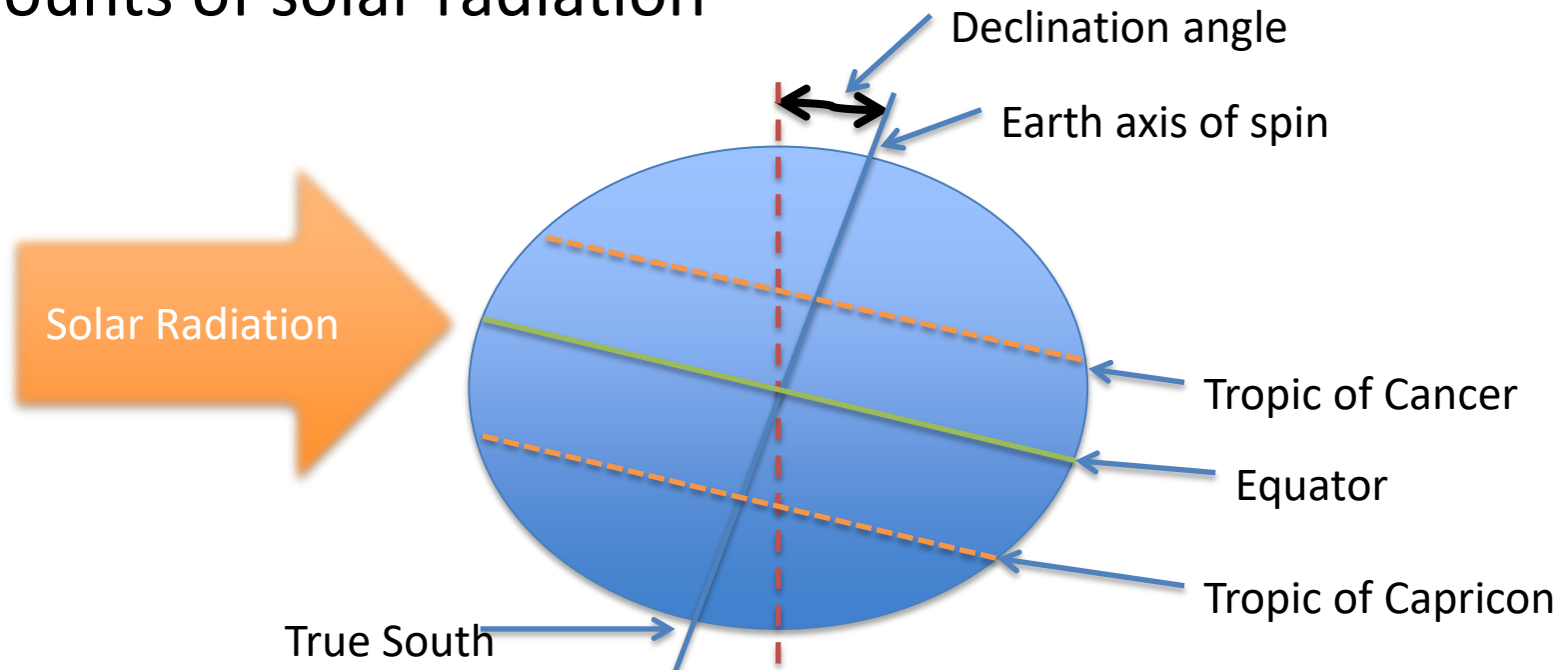
Sun Geometry and Sun Path

The coordinate of any location on the surface of the Earth can be described using latitude and longitude angles measured in degrees described as follows

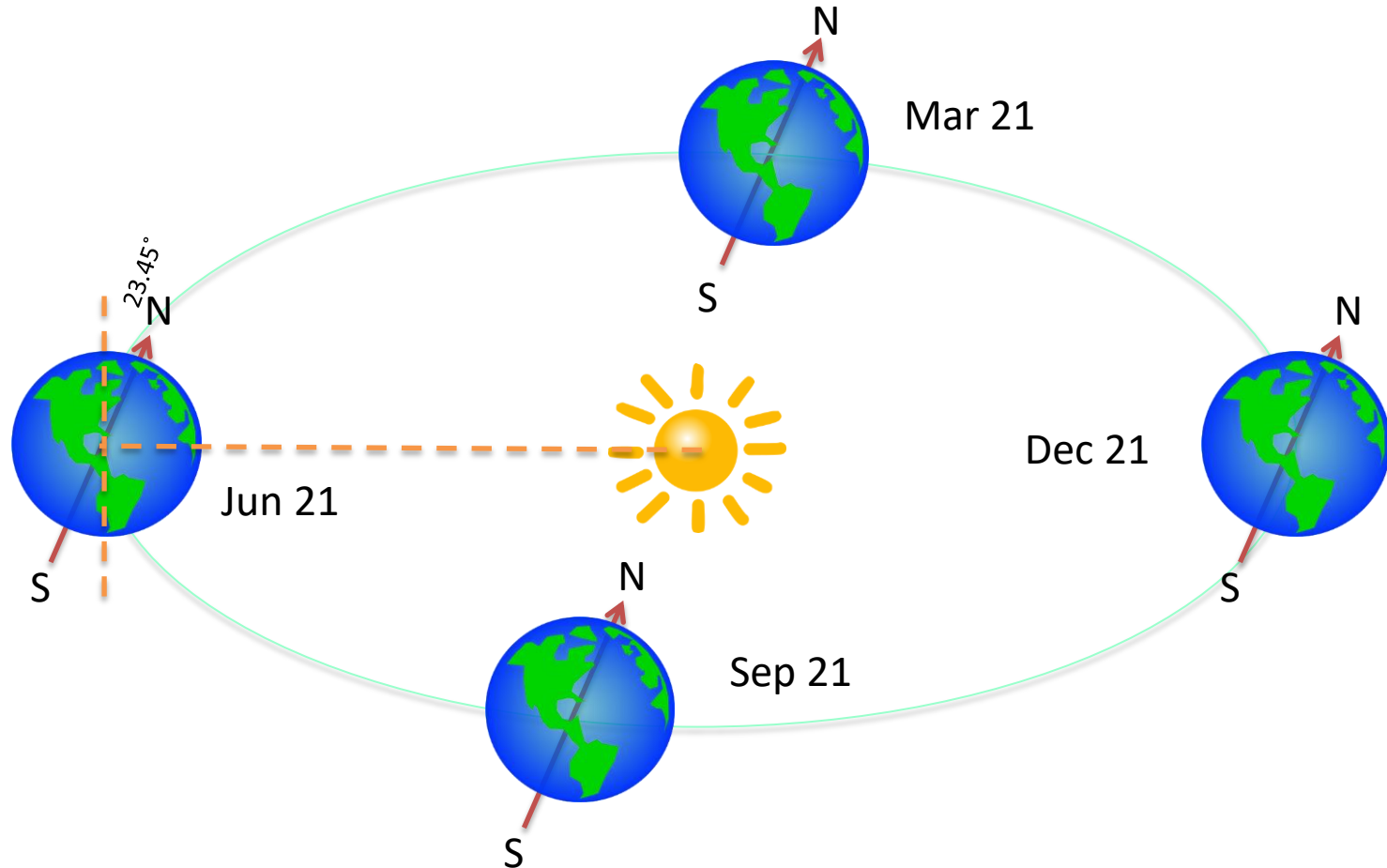
- Latitude: The location of a site either in the geographical Northern ($^{\circ}\text{N}$) or Southern ($^{\circ}\text{S}$) Hemispheres that is divided by the Equator.
- Longitude: The location of a site either in geographical East or West of an accepted reference, i.e. the prime meridian at Greenwich Meridian (GM) defined as 0° . This gives rise to the clock time of the site, being either ahead (negative) or behind (positive) that of Greenwich Meridian Time (GMT).

Sun Geometry and Sun Path

- The earth's axis of spin declined at 23.45°
- Due to the declination during spin and revolution around the sun, the earth surface receives different amounts of solar radiation



Sun Geometry and Sun Path

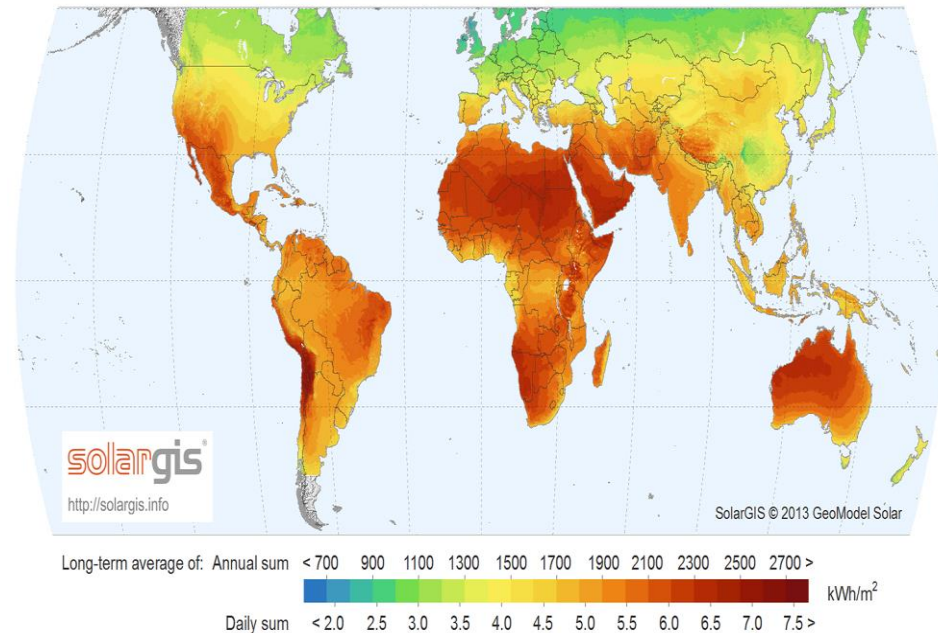


Sun Geometry and Sun Path

Parameter	Latitude (degree)	Specific meaning and implication
Arctic Circle	+66.57	Line that marks the southern extremity of the polar day and polar night.
Tropic of Cancer	+23.45	Line that indicates the highest latitude the Sun's line of sight ever reaches in the Northern Hemisphere
Equator	0.00	Line that divides the Northern and Southern Hemispheres equally
Tropic of Capricorn	-23.45	Line that indicates the highest latitude the Sun's line of sight ever reaches in the Southern Hemisphere
Antarctic Circle	-66.56	Line that marks the northern extremity of the polar day and polar night.

Global Solar Radiation Map

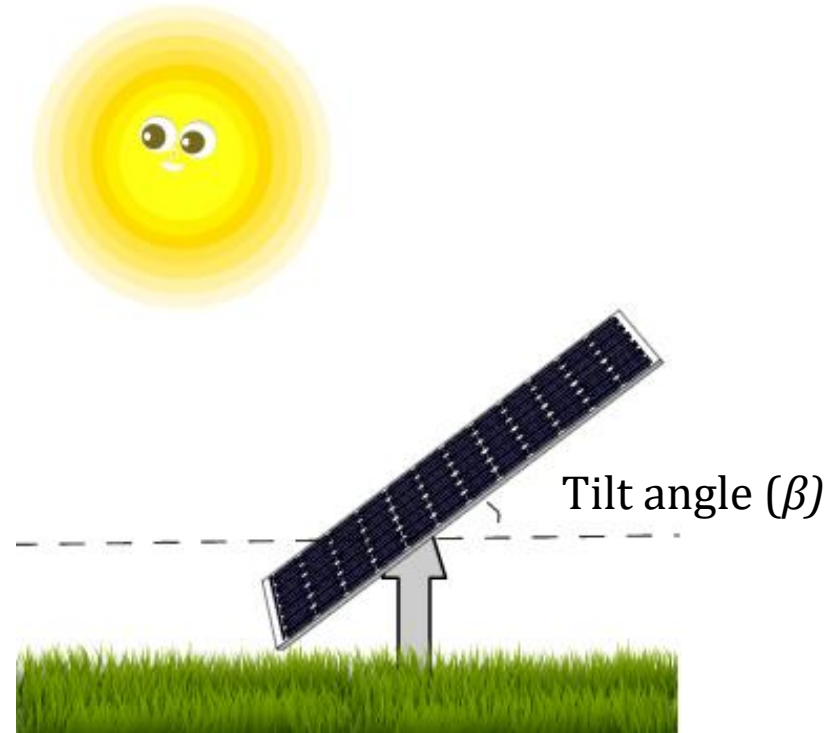
- To estimate the available solar energy, it is necessary to obtain the global radiation data of the site.
- The most important characteristic for this is the year's total H of the global radiation on a horizontal level.
- Nowadays global radiation maps are available that show this characteristic
- The basis of these is many years of measurements by a dense network of measuring stations, satellite pictures and simulation tools.



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Site Analysis

- ❑ Max performance is achieved when modules are perpendicular to the sun's rays
 - ✓ PV module Direction and Orientation
 - ✓ Tilt Angle
- ❑ PV modules are normally installed on pitched roofs so that the module is at an angle β to the horizontal.
- ❑ In case of flat roofs or open air plants it is usual to tilt the modules in order to achieve a higher annual yield



Measuring Tools/Equipment



A **sunshine recorder** is a device that records the amount of sunshine at a given location

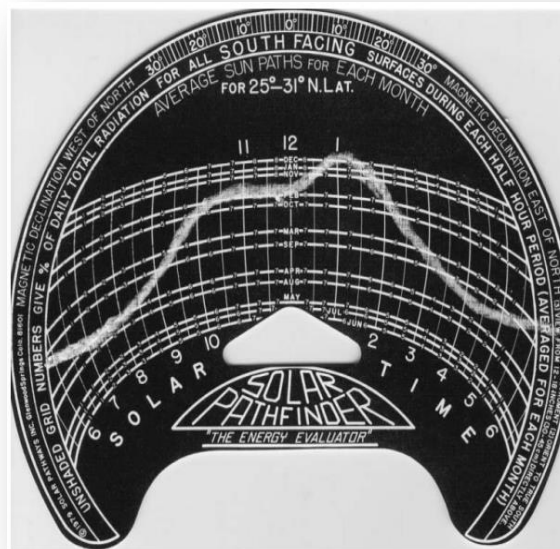
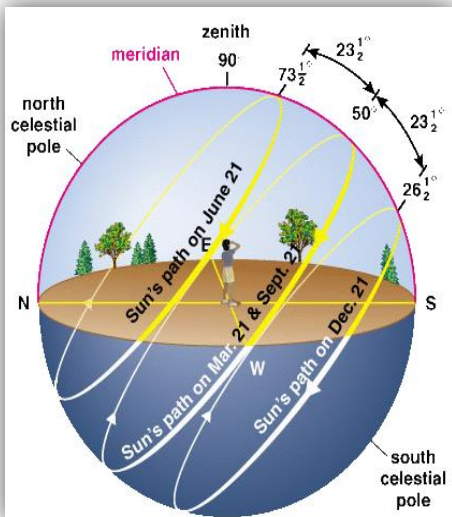


Pyrheliometer for measuring direct radiation: The instrument must continuously track the Sun



Measuring Tools/Equipment

- **Solar Pathfinder** provides fast, accurate solar site analysis.
- In just minutes, the Solar Pathfinder determines and records year-round, site-specific solar data, with precision and ease
- Very useful for studying the shading effect at a particular site



Measuring Tools/Equipment

Pyranometer



Solarimeter



Weather station



- A **pyranometer/solarimeter** used to measure broadband [solar irradiance](#) on a planar surface
- A **Weather station** can also be used to collect the same data

Other Useful Tools/Equipment



● Thermometer/
Infrared Thermometer



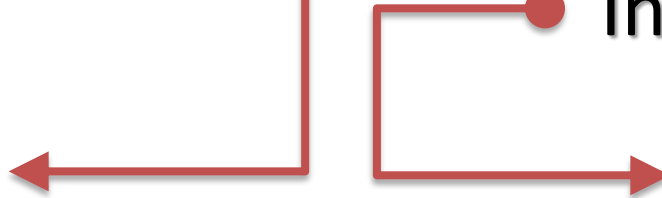
● Sun eye



● Magnetic compass



● Inclinator



THANK
YOU

The text 'THANK YOU' is rendered in a bold, rounded, green font with a dark brown outline. The word 'THANK' is on the top line and 'YOU' is on the bottom line. The text is centered on a teal background with a geometric, low-poly pattern. On either side of the text, there are decorative elements: a stylized pink and red floral swirl on the left and right, and a green leafy branch on the left and right.