Sun as a source of energy

- We call energy from the sun “renewable”, not because it can be refreshed or restored once out, but because its supply is nearly endless.
- It has given us light on earth for more than 4,000 million years and will continue to brighten the lives of countless generations to come
- Though it is terribly far away, it is also incredibly powerful and is the basis of all forms of life or energy on earth.

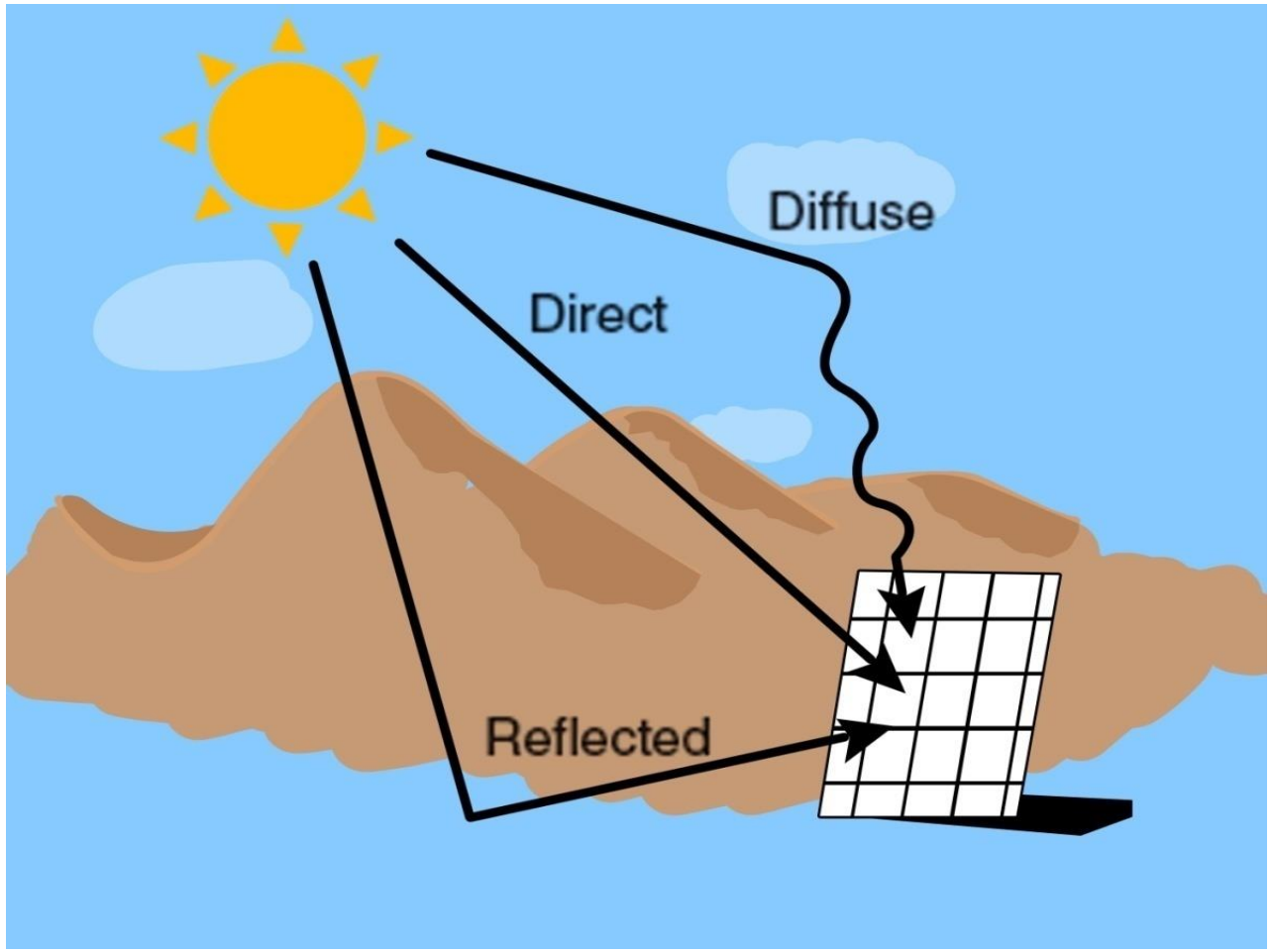
Solar Radiation

- The term solar radiation, often called solar resources refers to energy emitted by the sun. It consists mostly of radioactive energy and light.
- Solar radiation is power and the unit for measuring power is the watt (abbreviated “W”).
- Radiation that is not reflected or scattered but reaches the earth’s surface directly is called **direct radiation (GB).**
- Scattered radiation that reaches the earth’s surface is called **diffuse radiation (GD).**
- **Reflected radiation (GR)** is the radiation reflected back into orbit on reaching the earth.

Solar Radiation

- Total global radiation (**G**) is the sum of : direct radiation (GB), diffuse radiation (GD) and Reflected radiation (GR)

G = GB + GD + GR



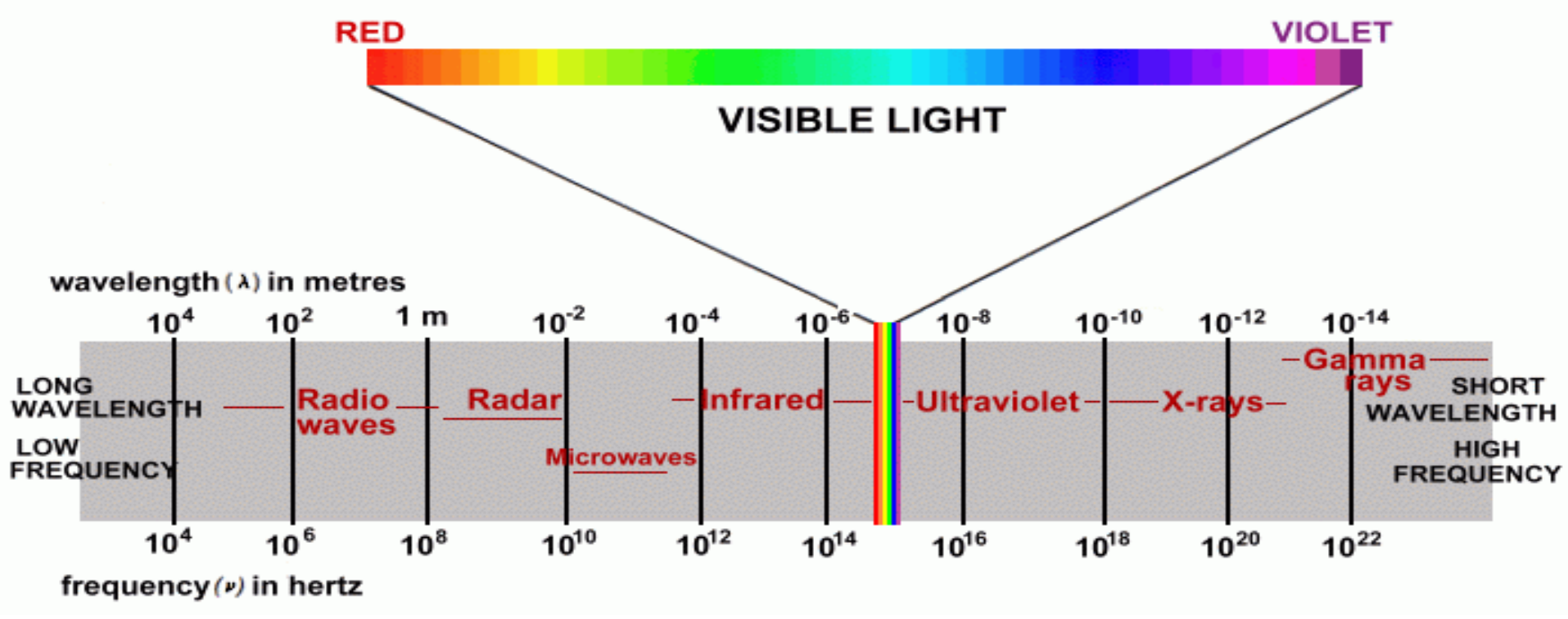
Sunshine =

wide spectrum of electromagnetic waves from the sun, reaching the surface of the earth with

Power

Solar Radiation

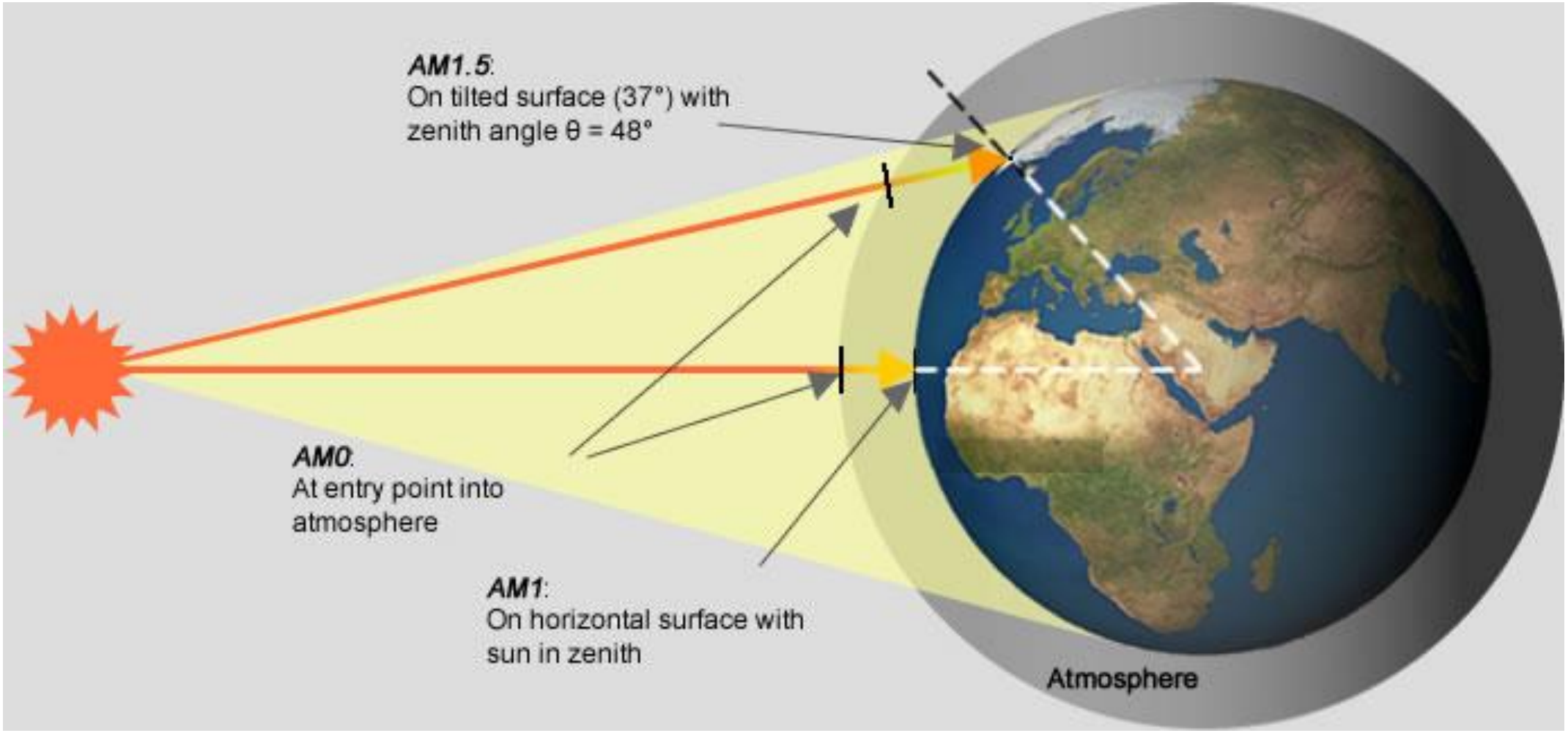
- Solar radiation has a wide spectrum. Based on this spectrum.
- The region of solar radiation wavelength that the solar panels can use for generating electricity is located within the visible light region.



Air Mass

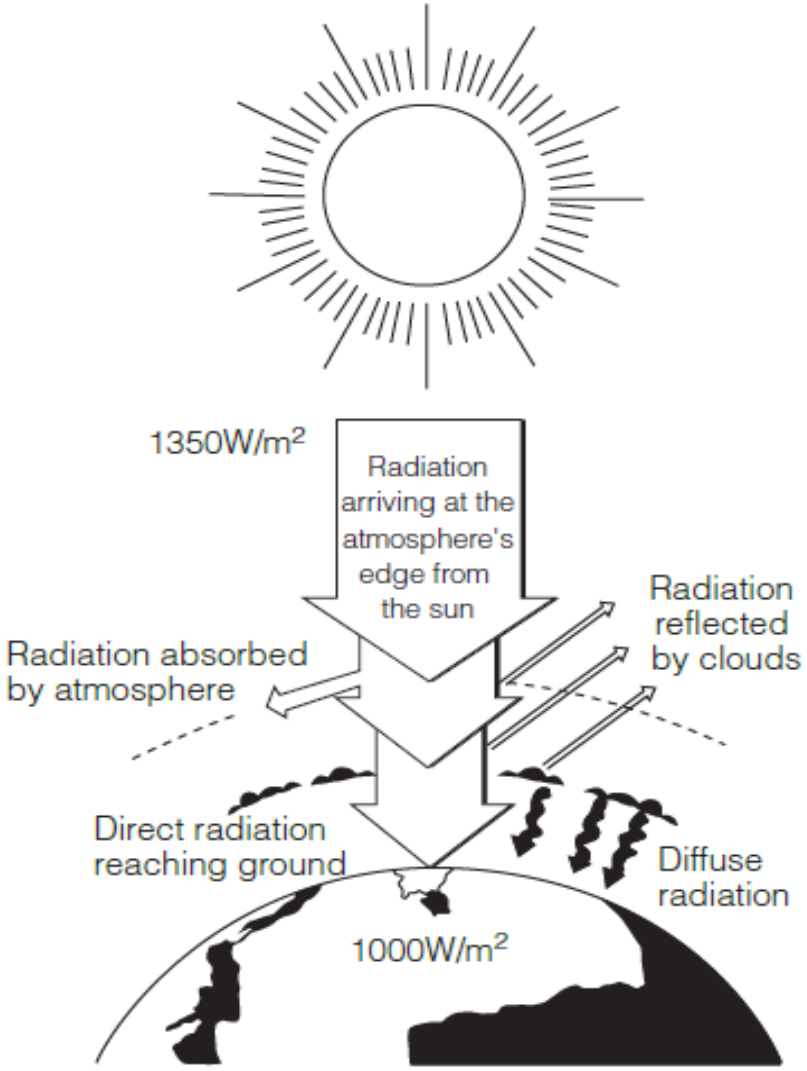
- This is the path length through which solar radiation must pass to reach the Earth's surface.
- This entry point into the atmosphere is called “Air Mass 0” or “AM 0”, where “0” indicates that there is no air mass.
- AM 1.5 is used to calibrate and gauge the efficiency of solar cells.
- Actual air mass values vary widely depending on one’s location on the globe, the time of the year and the time of the day.
- AM1.5 (equivalent to a sun angle of 48.2º from overhead or 41.8º from horizontal plane) has become the standard for photovoltaic standards

Air Mass


AM1.5:
On tilted surface (37°) with
zenith angle θ = 48°
AM0:
At entry point into
atmosphere
AM1:
On horizontal surface with
sun in zenith
Atmosphere

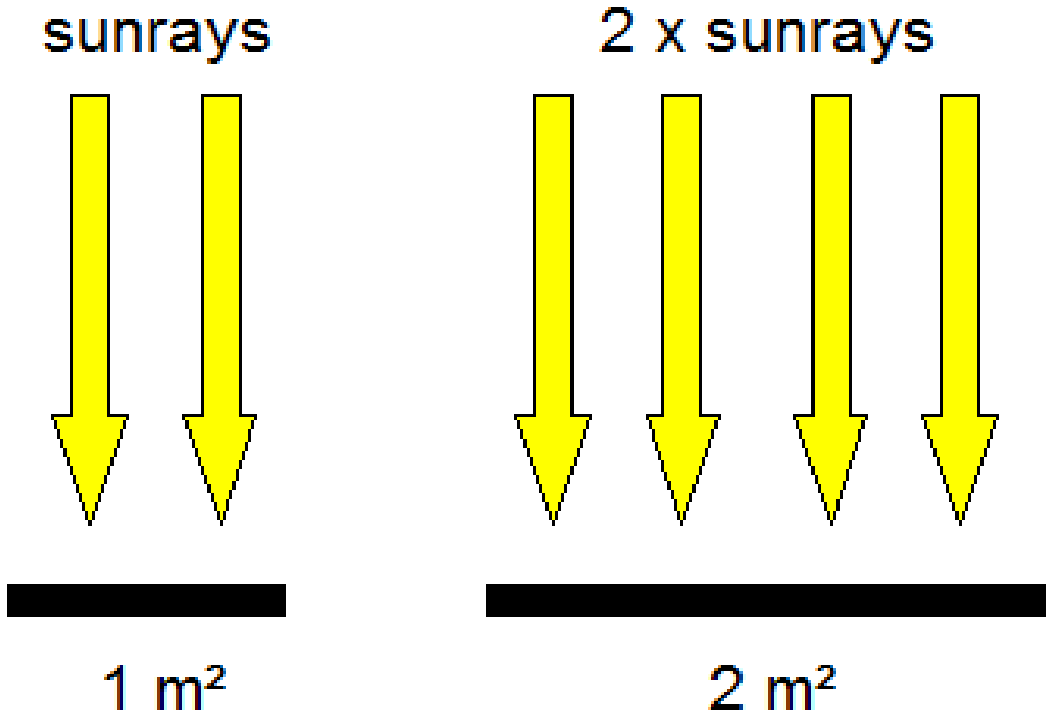
Solar Irradiance

- The term for the intensity of solar radiation striking the earth is irradiance. It is the measurement of power over an area.
- The symbol for irradiance is “E”. However, as the irradiance depends on the surface of impact it has to be defined in W/m^2 or kW/m^2.
- In Nigeria at noon the irradiance on $1m^2$ can be as strong as 1000W. Therefore, we say it is $1000W/m^2$. As 1000W is equal to 1KW, we can also say the irradiance is $1KW/m^2$



Solar Irradiance

- The amount of power depends on the strength of the radiation (how strong the sun shines) and on the size of the surface it shines on. A larger surface receives more power.



Solar irradiation
(insolation)

Solar Irradiation

- Irradiation refers to the cumulative solar energy striking a given surface within a given time. It is represented by the symbol “H” and measured in watt-hours per square metre (Wh/m^2).
- When designing a solar system, it is important to know how much energy can be harvested in a day, a month or a year.
- Therefore, solar energy is measured in kilowatt hours per square metre per day ($kWh/m^2/day$) or per month or per year.

Solar Irradiation

- Irradiation is a measure of solar energy.
- Energy is the impact of power for a period of time. Energy = power × time.
- Energy is measured in Wh or kWh. (watt hour or kilowatt hour).
- Solar energy is the product of solar power (irradiance) and time. Therefore, we measure it in Wh/m^2 or in kWh/m^2.
- Solar technicians need to know how much solar energy can be used during a day. Therefore, we measure the solar energy in $Wh/m^2/day$ or $kWh/m^2/day$.

Irradiance = W/m^2

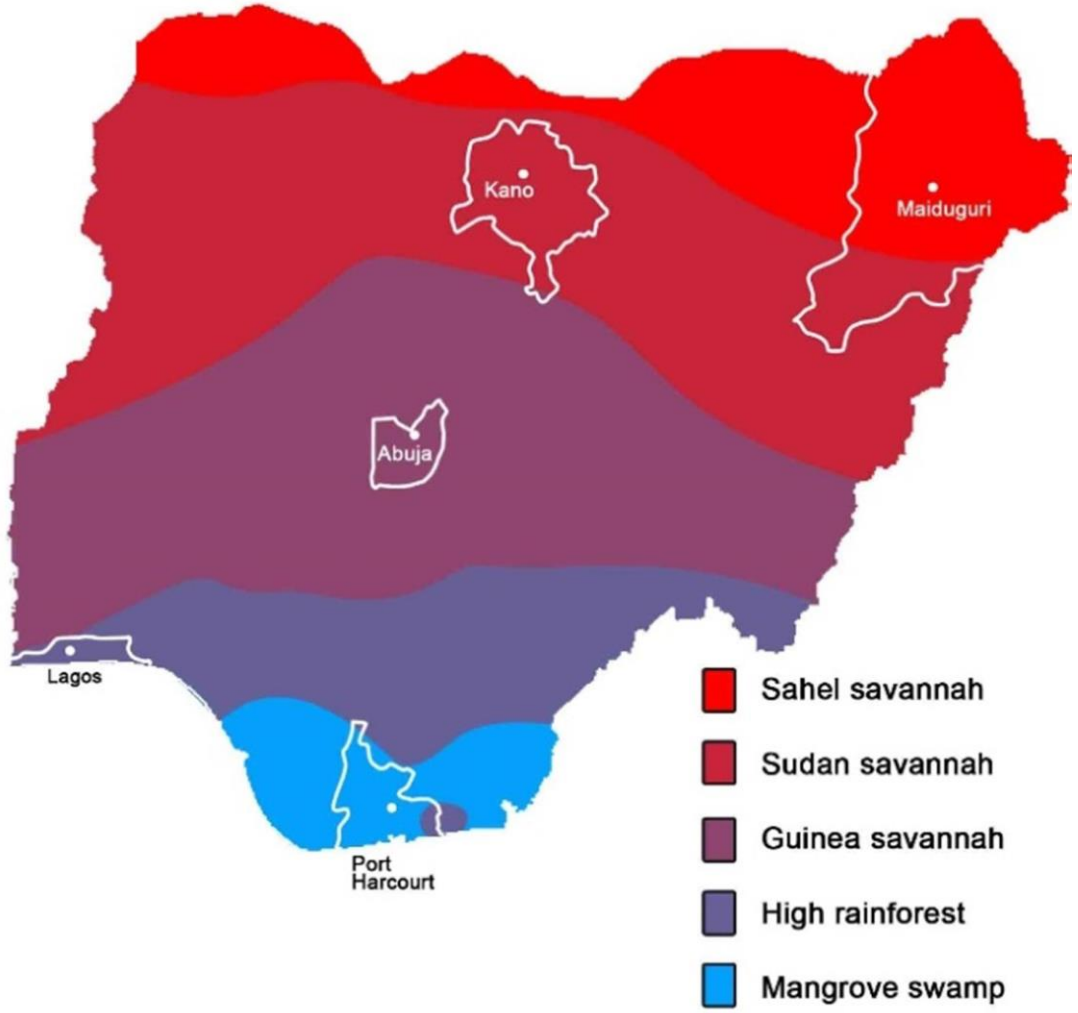
Irradiation = Wh/m^2

Daily Irradiation = $Wh/m^2/day$

Monthly Irradiation = $Wh/m^2/month$

Distribution of solar resources in Nigeria

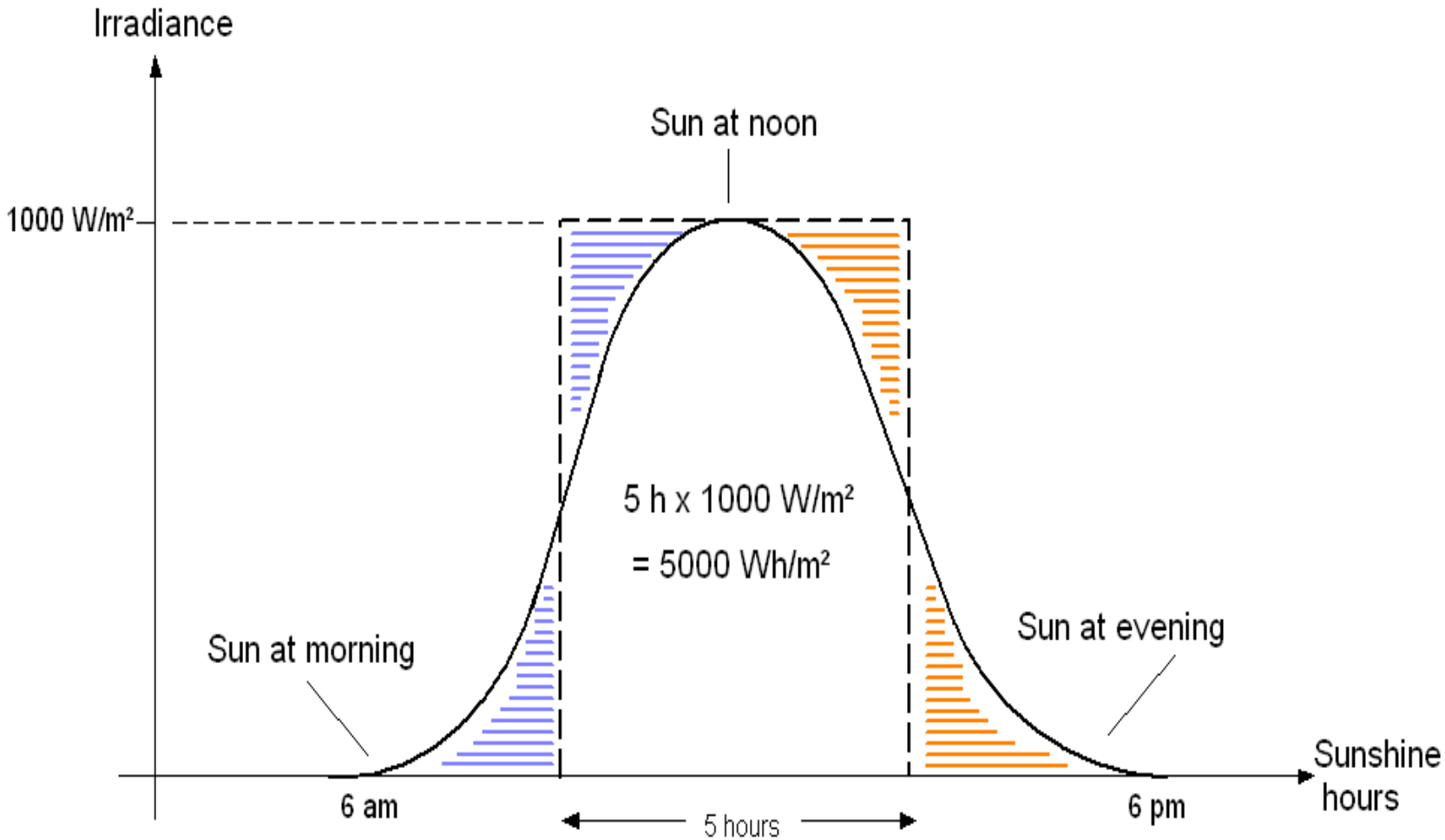
- Nigeria can be divided into five climatic regions:
  - Sahel savannah
  - Sudan savannah
  - Guinea savannah
  - High rainforest
  - Mangrove swamp



Concept of peak sun hours (PSH)

- The peak sun hours for a particular location identify the total amount of solar resource available at a particular location .
- In Nigeria, the PSH can easily be classified based on the different climatic regions.Peak sun hours is a location-specific concept.
- The peak solar radiation is 1 kW/m^2. On a given day, the morning sun does not have its full power of 1 kW/m^2 and the same is true in the evening. This variance continues throughout the day often reaching its zenith at noon. Over the course of the day, the hours of solar radiation across the day, however, sums up to a certain amount of energy.
- In central Nigeria on a sunny day, we have about five hours with a solar radiation of 1kW/m^2, meaning we have five peak sun hours, which is the same as 5 $kWh/m^2/day$

PSH as irradiance over time



PSH of selected areas

Climate	PSH	Example of location
Mangrove swamp	4	Yenegoa, Port Harcourt, Warri
High rainforest	4.5	Abeokuta, Ibadan, Benin city
Guinea savannah	5	Markurdi, Kaduna, Lokoja
Sudan savannah	5.5	Kano, Katsina
Sahel savannah	6	Maiduguri, Bauchi

Total solar irradiation

Solar Irradiance)x no hours of sun shine = daily watt-hours

- For example, if the solar irradiance (power) averages 400 W/m^2 over a 12 hour period, the total solar irradiation (energy) received is

  400 $W/m^2 \times 12$ hr = 4800 Wh/m^2 = 4.8 kWh/m^2.

- Conversely, if the total solar energy received over an 8 hour period is 4 kWh/m^2 , the average solar power would be 4 kWh ÷ 8 hr = 0.5 kW/m^2 = 500 W/m^2.