

Unit 2:- Solar Energy



Syllabus...Unit 2

- Solar radiation, Flat plate collectors, solar concentration, thermal applications of solar energy, photovoltaic technology and applications, energy storage.

Books ...

- Gilbert M. Masters, *Renewable and Efficient Electrical Power Systems*, Wiley - IEEE Press, August 2004.
- Godfrey Boyle, *Renewable Energy*, Third edition, Oxford University Press, 2012.
- Chetan Singh Solanki, *Solar Photovoltaics-Fundamentals, Technologies and Applications*, PHI Third Edition, 2015.

Supplementary Reading:

- D.P.Kothari, K.C.Singal, Rakesh Rajan, *Renewable Energy Sources and Emerging Technologies*, PHI Second Edition, 2011.

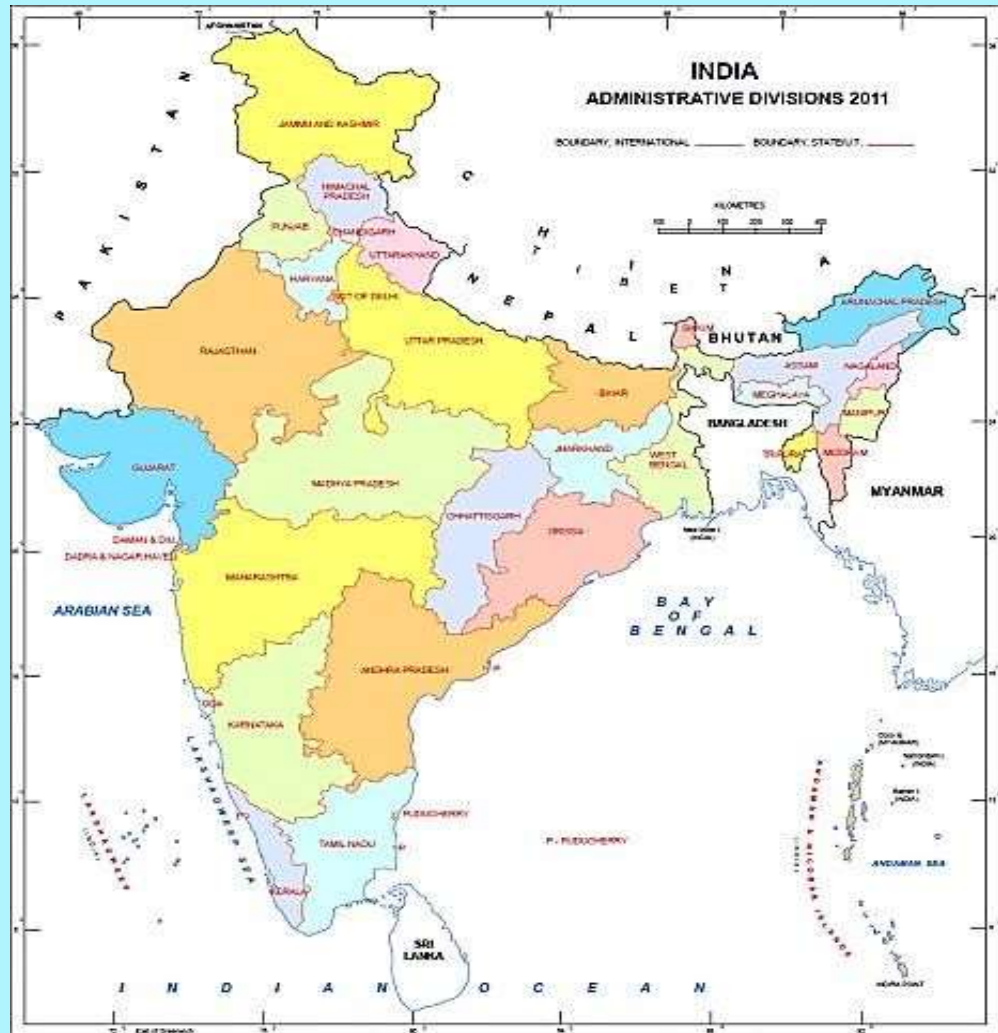
Lecture 1

- Coordinates and elevation
- Direction and orientation
- Earth and its rotation
- Sunlight density and spherical shape
- Sun position
- Declination angle
- Power out put and angle
- Optimum tilt angle
- Solar power utilization
- Different solar systems

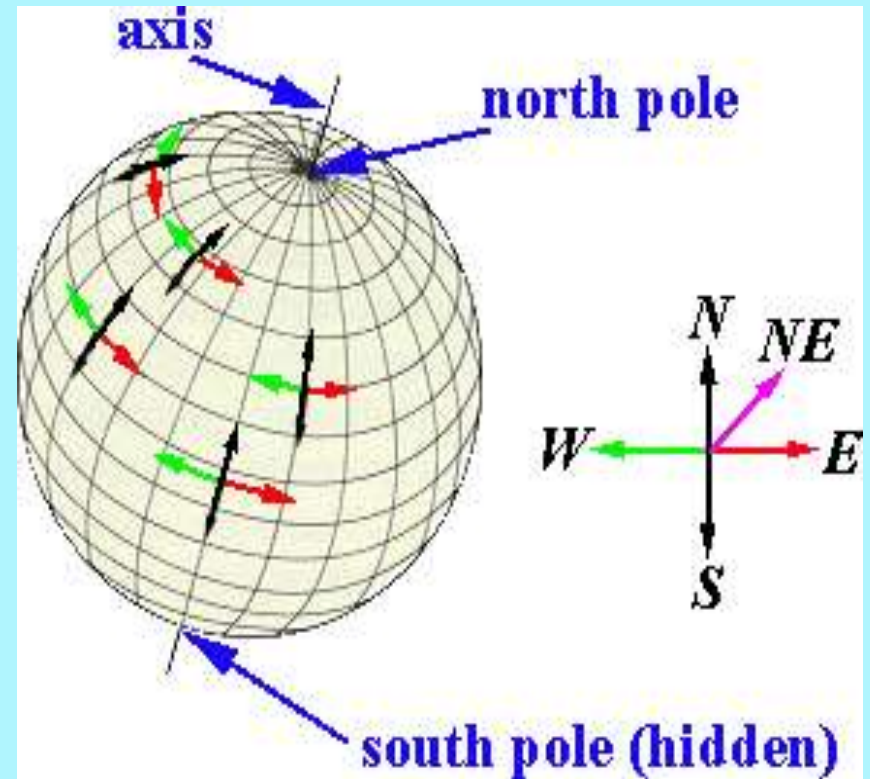
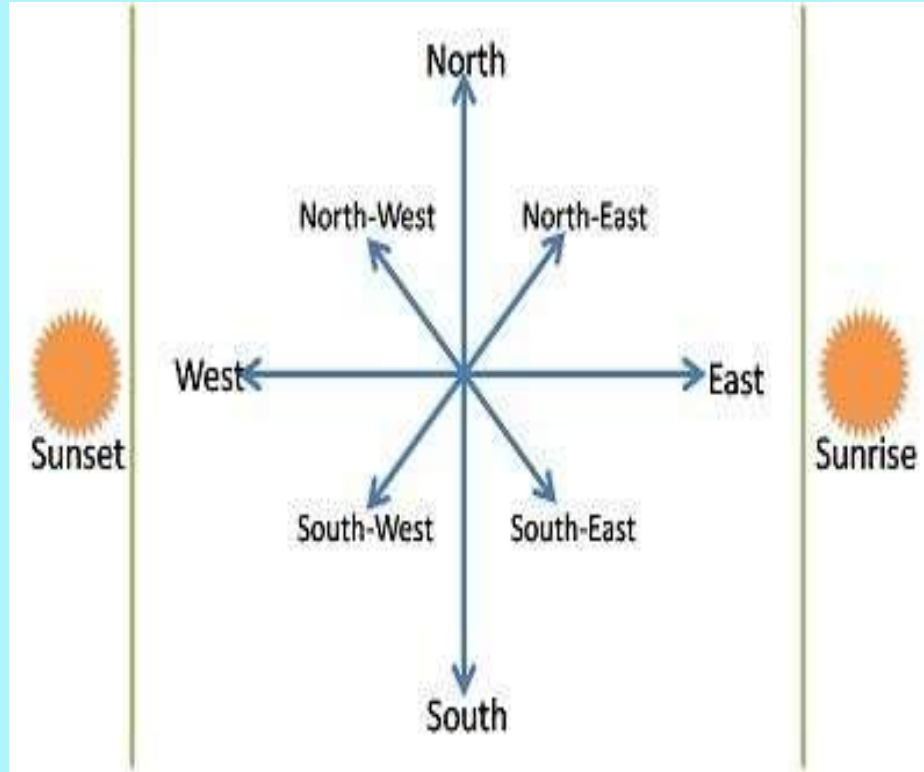
Coordinates and elevation

India is in between
latitude of
8 to 36 degrees N

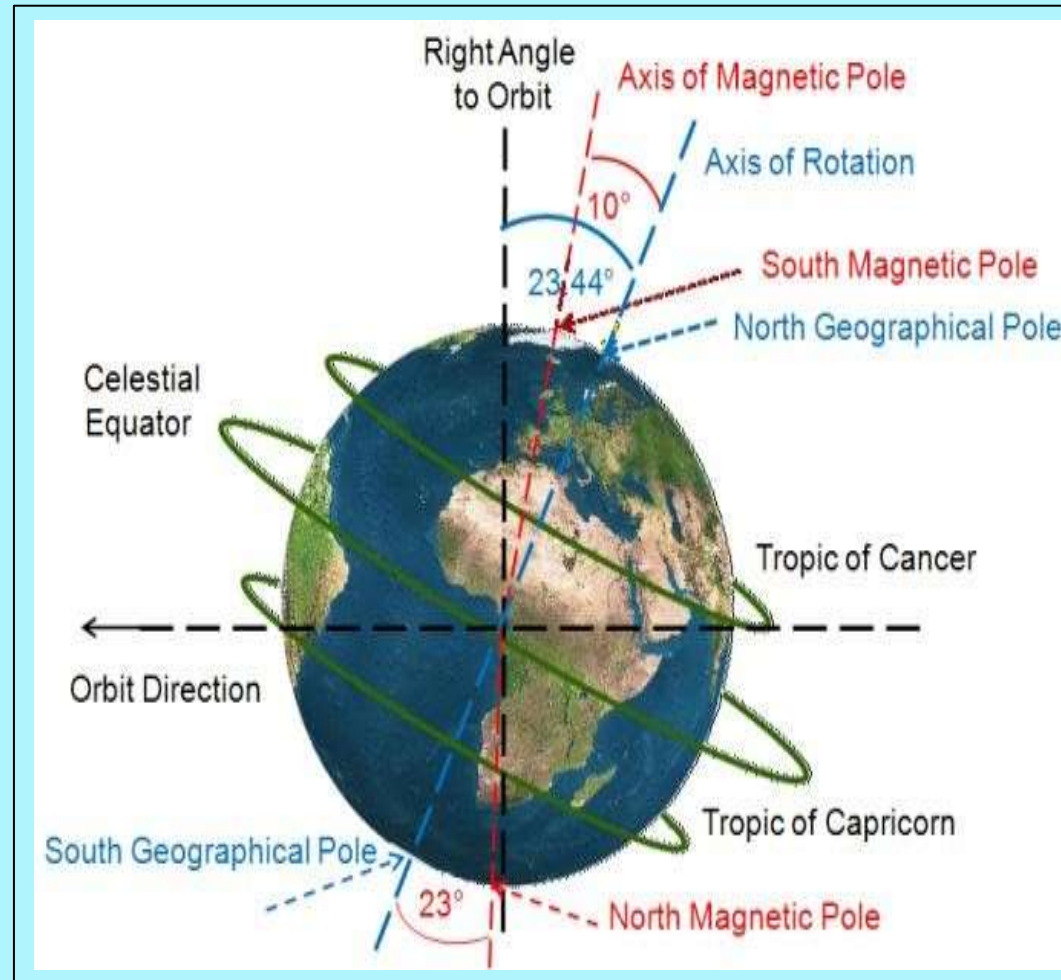
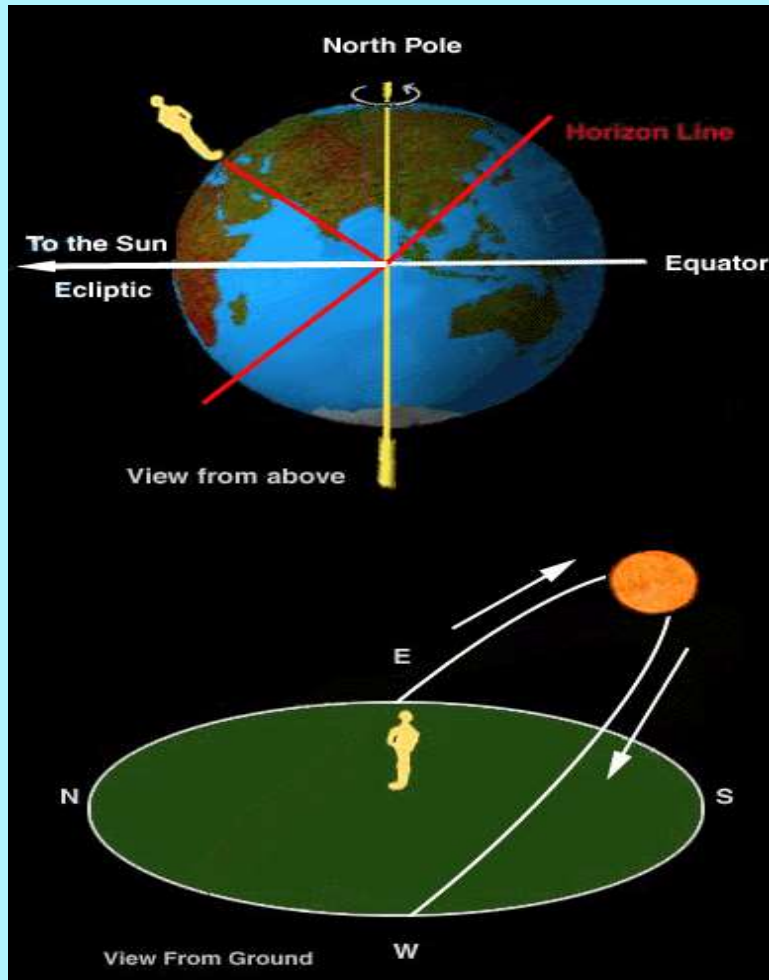
Pune
18.5204 Deg. N
73.8567 Deg. E
560m Elevation



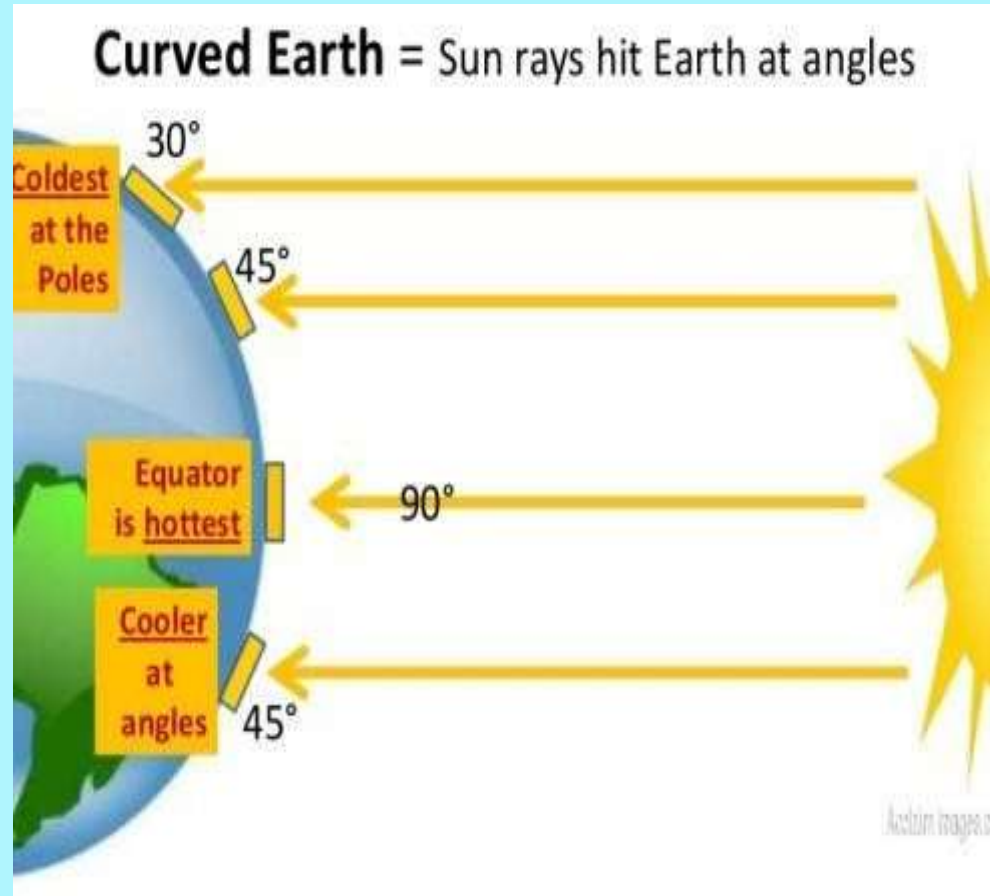
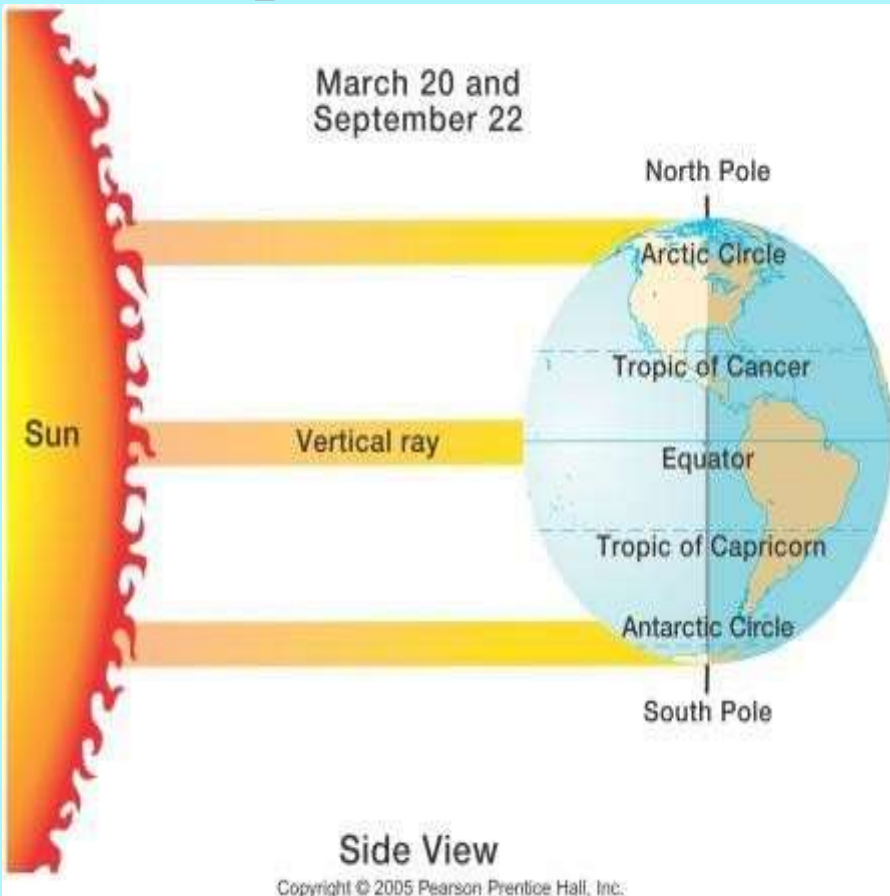
Direction and Orientation...



Earth & its Rotation...

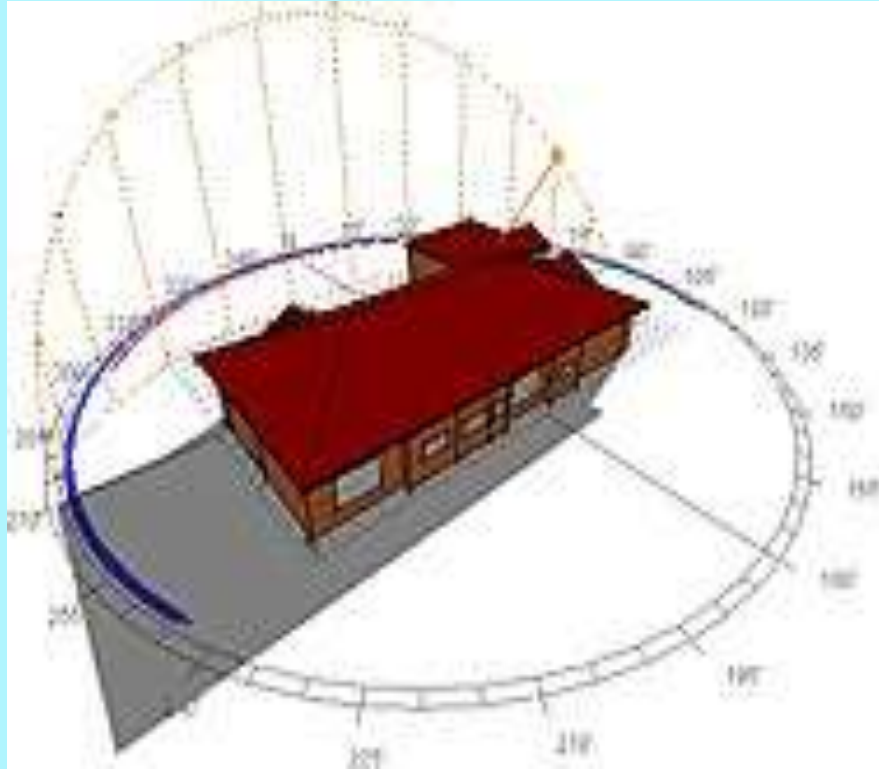


Change In Sunlight Density As Spherical Shape...

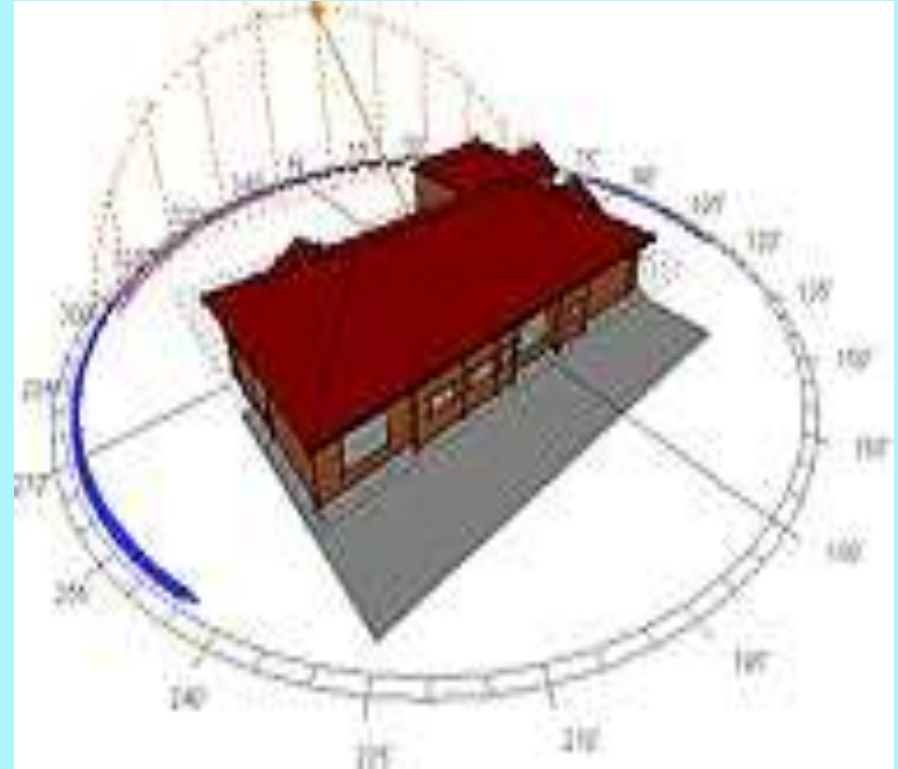


Due to the earth shape on a given day different places are receiving different intensity

Change In Sun Position

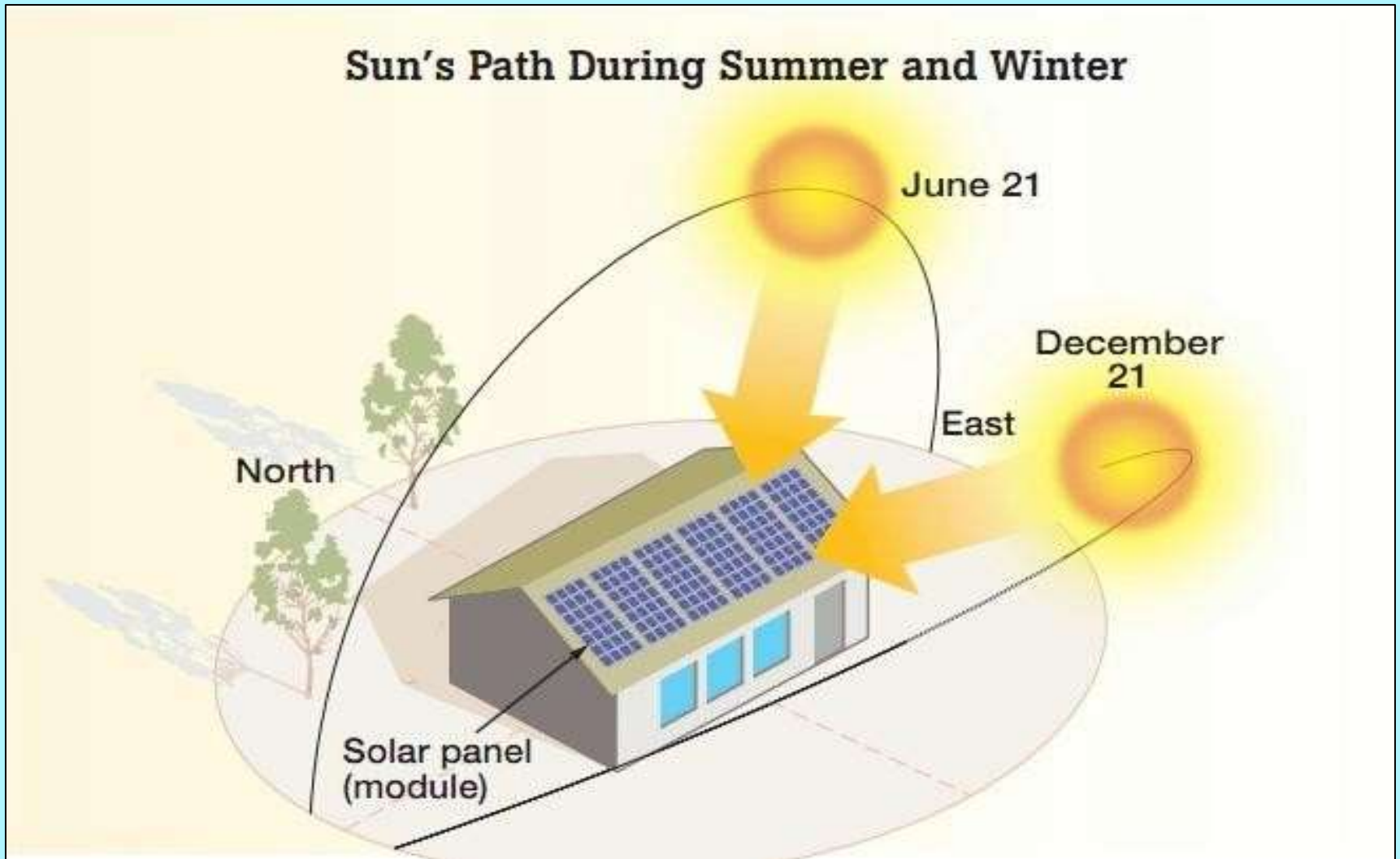


Over a Day

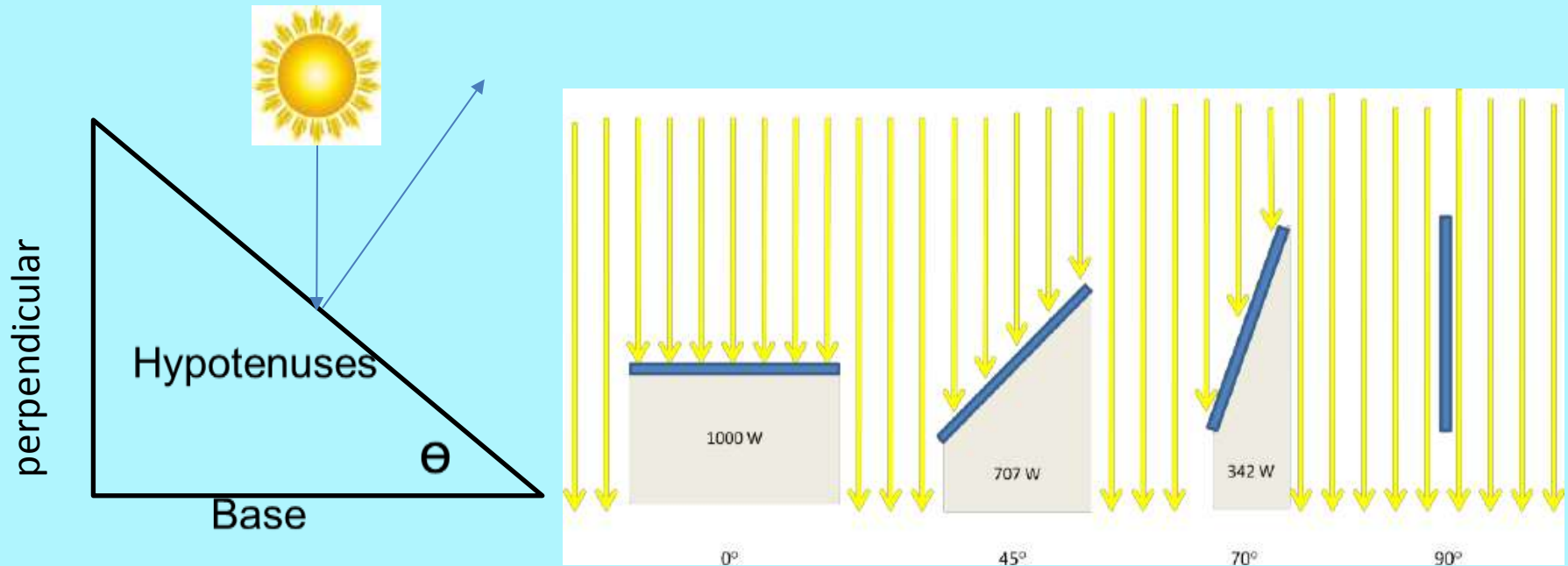


Over a Year

Declination Angle...

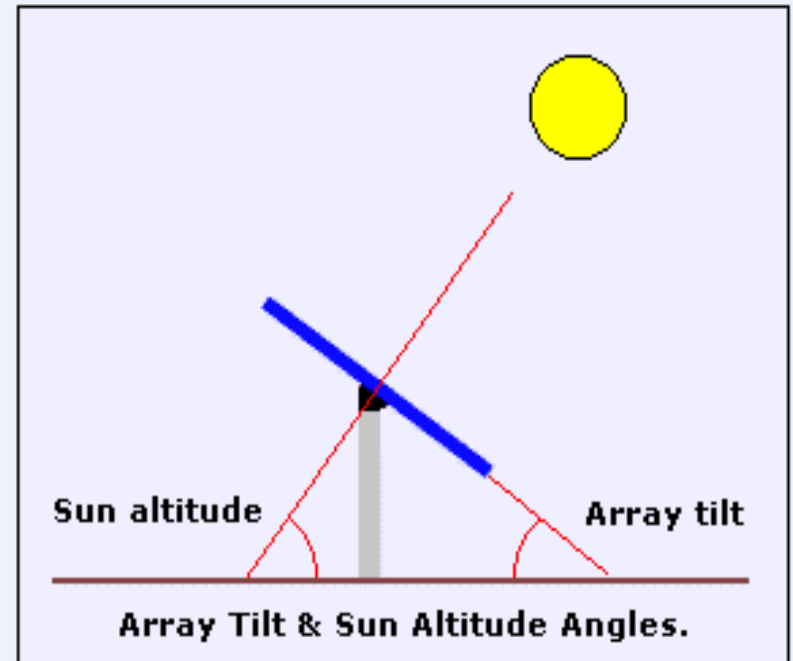
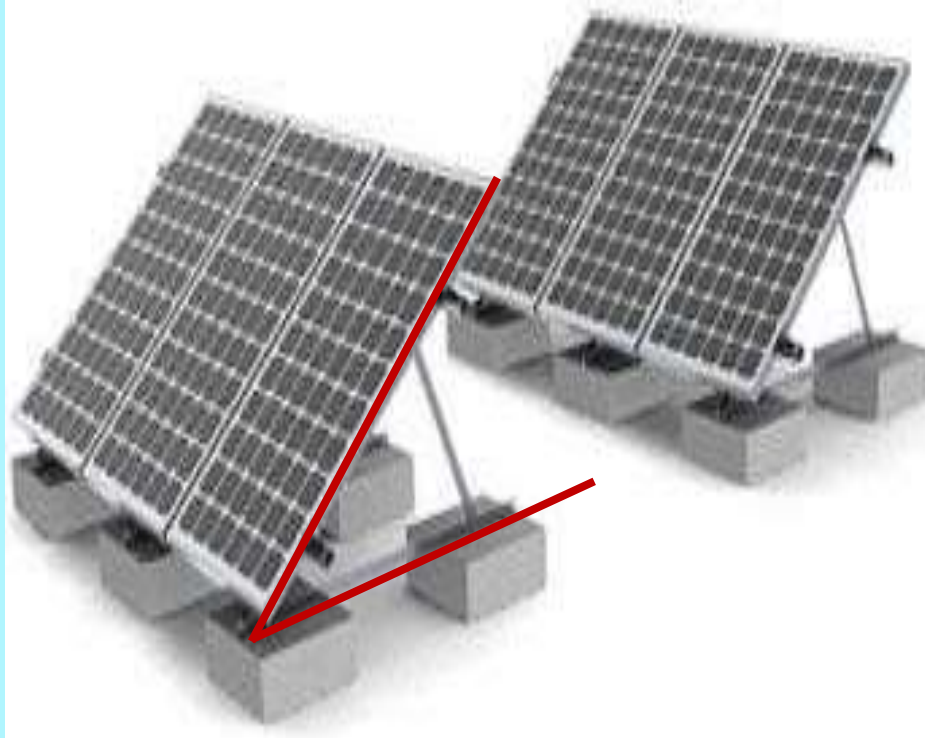


Sun Intensity Vs Power Output



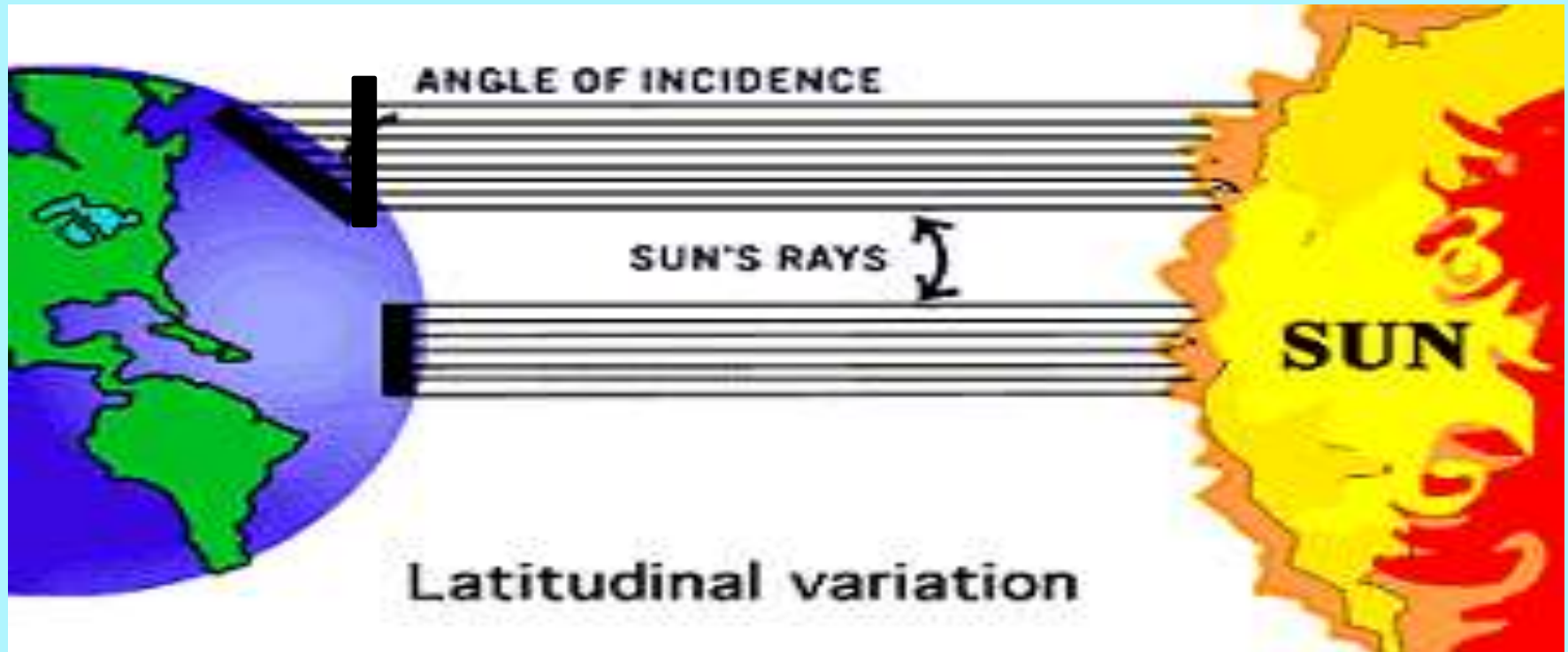
- Sun collector Angle and sun rays that varies the output of the solar panels,
- Reduction of radiation by the cosine of the angle between the solar radiation and a surface normal is called the **cosine effect**.

Optimum Tilt Angle



Tilt Angle, It is the optimum angle, between Solar array and horizontal surface, which gives maximum solar irradiation throughout the year

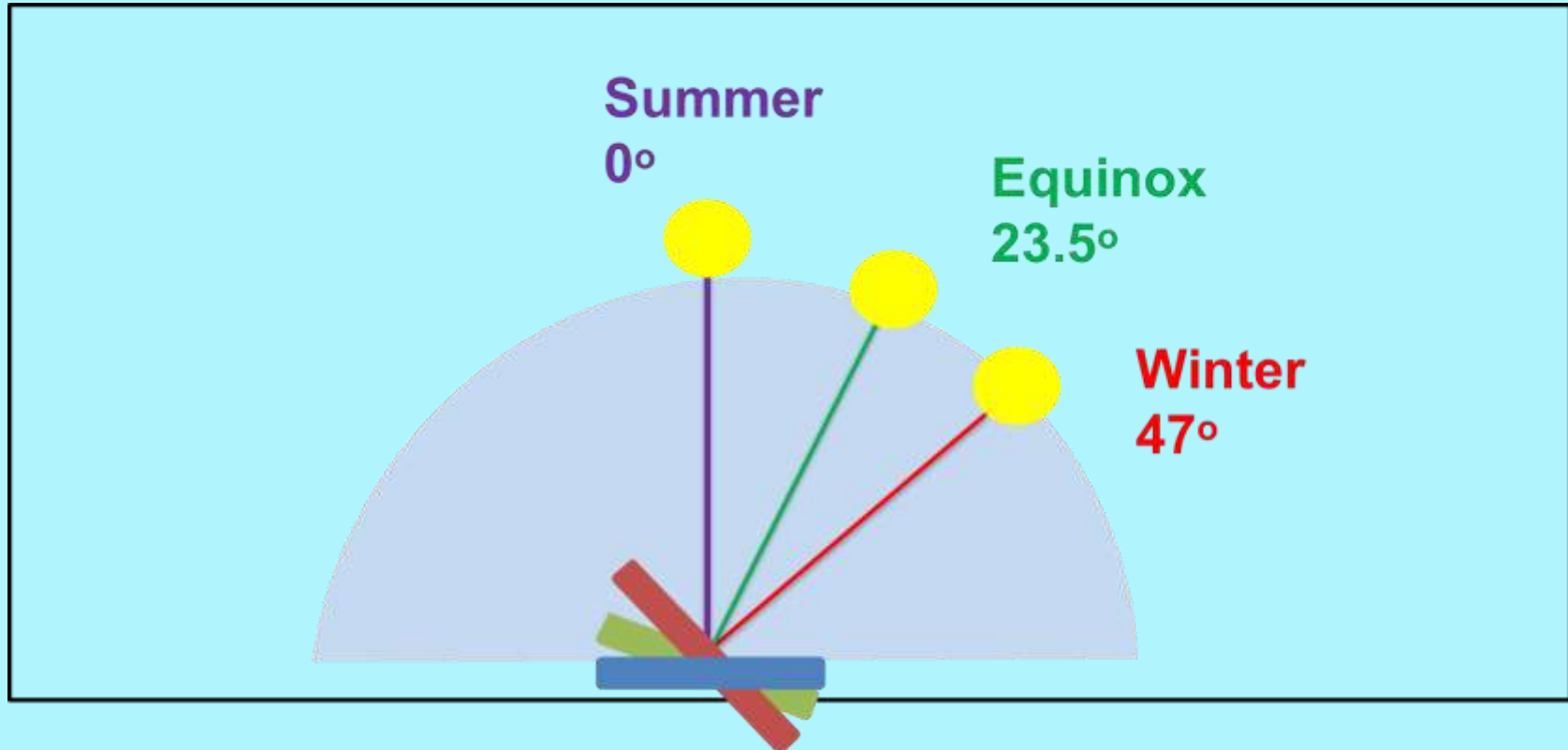
Optimum Tilt Angle



Tilt Angle, It is the optimum angle, between Solar array and horizontal surface, which gives maximum solar irradiation throughout the year

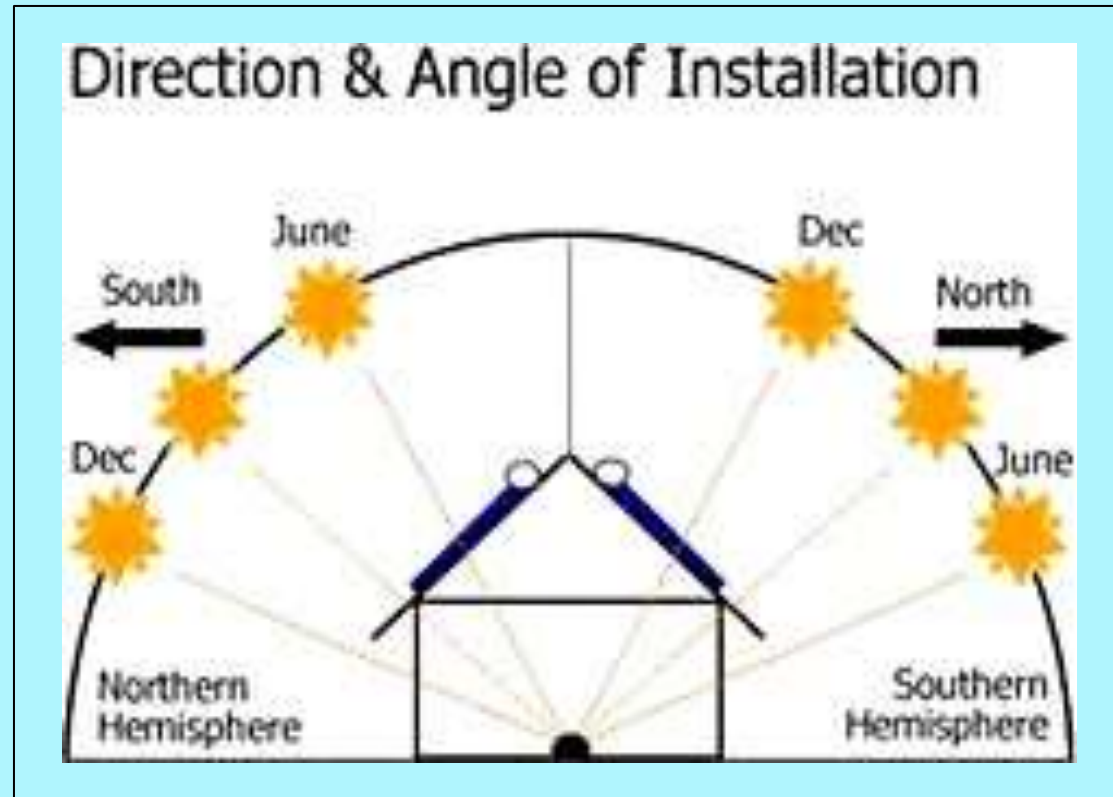
Sun Declines in a Year

Eg. Jabalpur



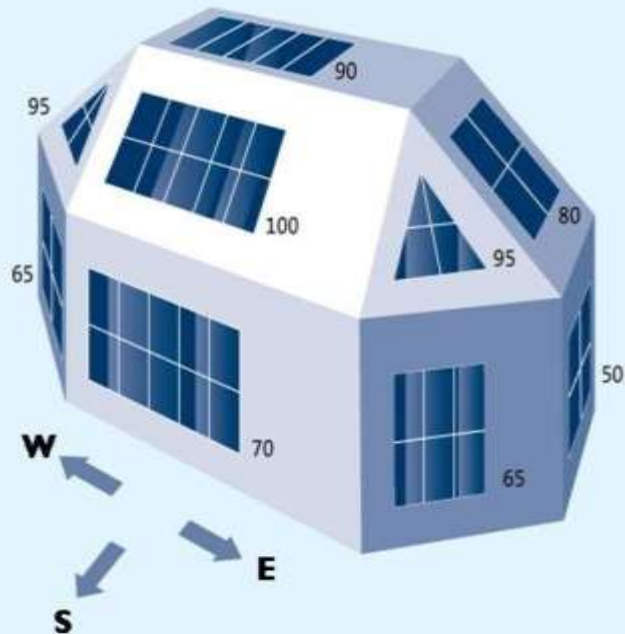
- ☀ Solar radiation available at a particular location keeps changing during the day and also during the year
- ☀ The amount of solar radiation received by a solar array is not same during all the time of the day and it is also not the same in different months of a year

Sun Declines in a Year



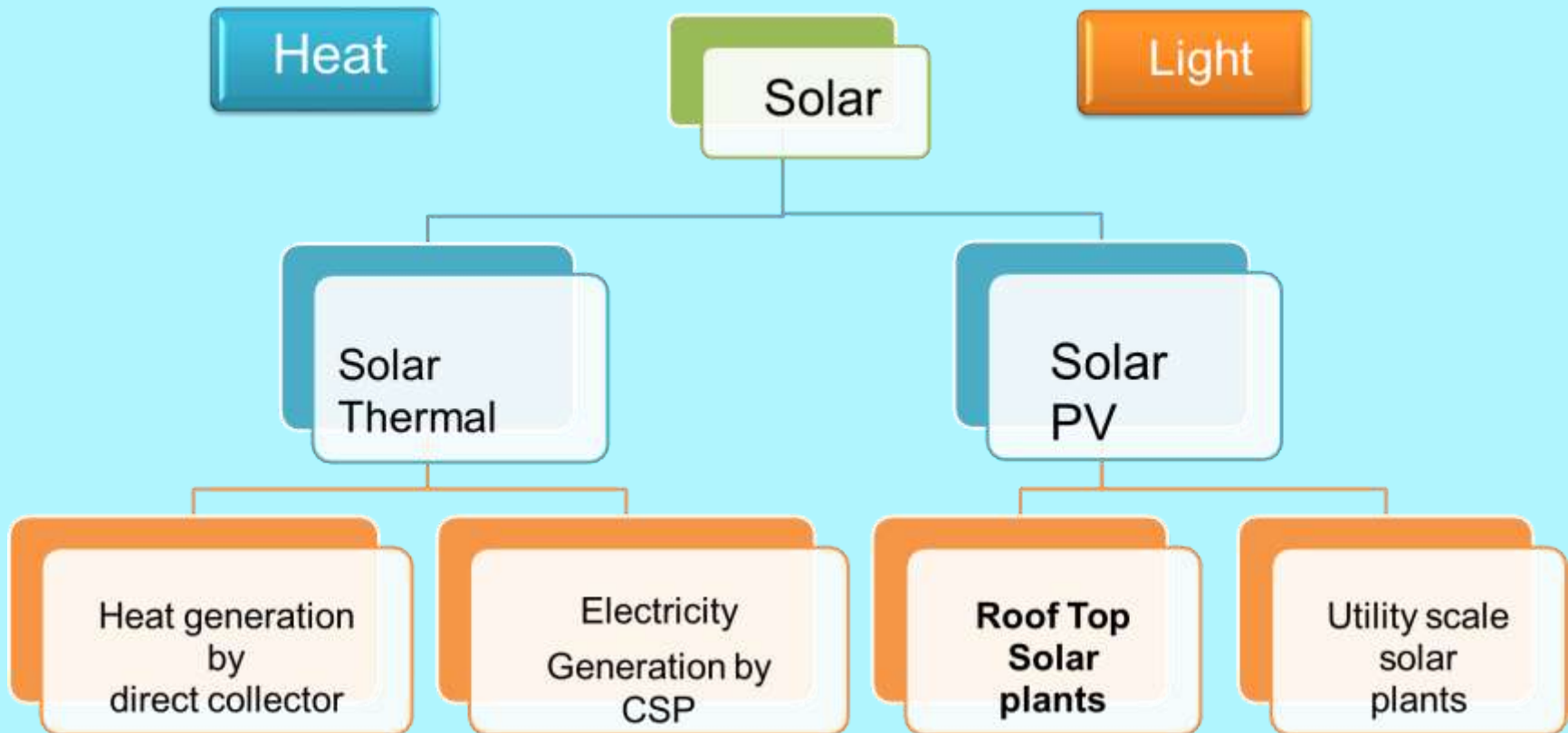
Solar panels should always face true south if you are in the northern hemisphere, or true north if you are in the southern hemisphere a photovoltaic system. SPV array need geographical south not the magnetic

Effect of Orientation Angle

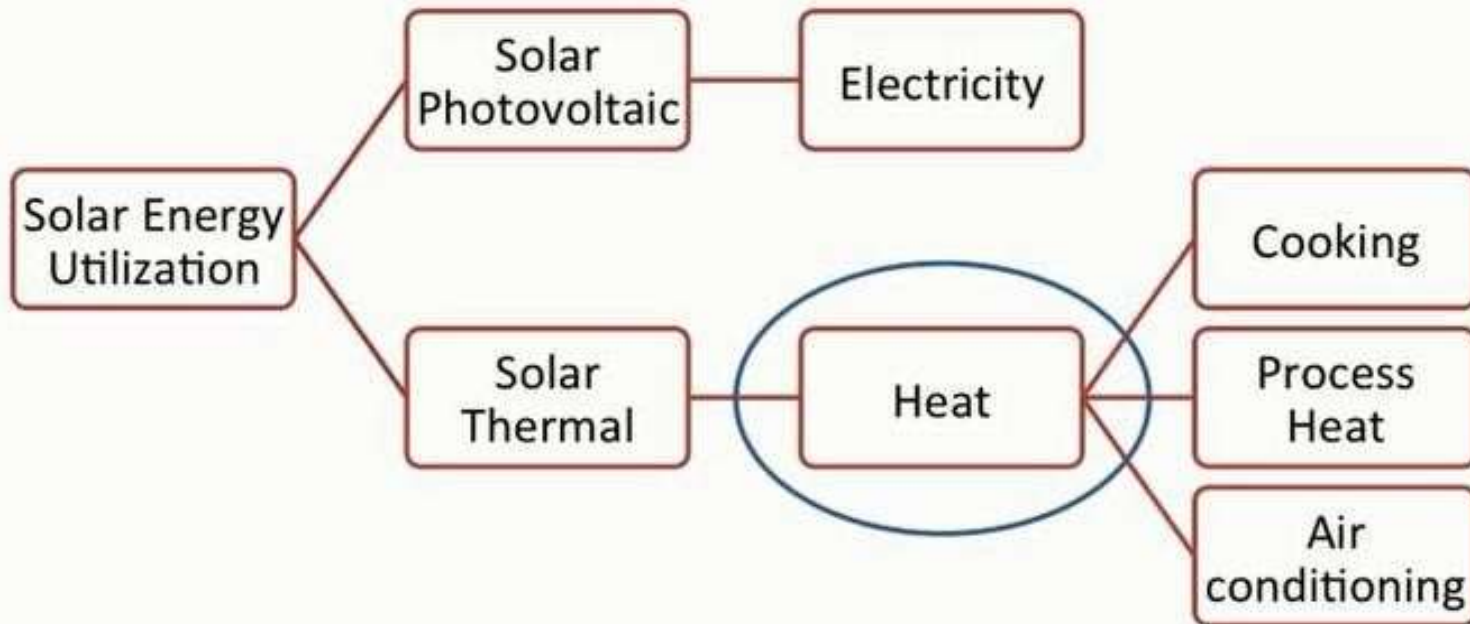


	West			SW			South			SE			East
Horiz	270°	255°	240°	225°	210°	195°	180°	165°	150°	135°	120°	105°	90°
0°	90	90	90	90	90	90	90	90	90	90	90	90	90
10°	89	91	92	94	95	95	95	95	95	94	93	91	90
20°	87	90	93	96	97	98	98	98	97	96	94	91	88
30°	86	89	93	96	98	99	100	100	98	96	94	90	86
40°	82	86	90	95	97	99	100	99	98	96	92	88	84
50°	78	84	88	92	95	96	97	97	96	93	89	85	80
60°	74	79	84	87	90	91	93	93	92	89	86	81	76
70°	69	74	78	82	85	86	87	87	86	84	80	76	70
80°	63	68	72	75	77	79	80	80	79	77	74	69	65
90°	56	60	64	67	69	71	71	71	71	69	65	62	58
Vertical													

Solar Power Utilization



Solar Power Utilization

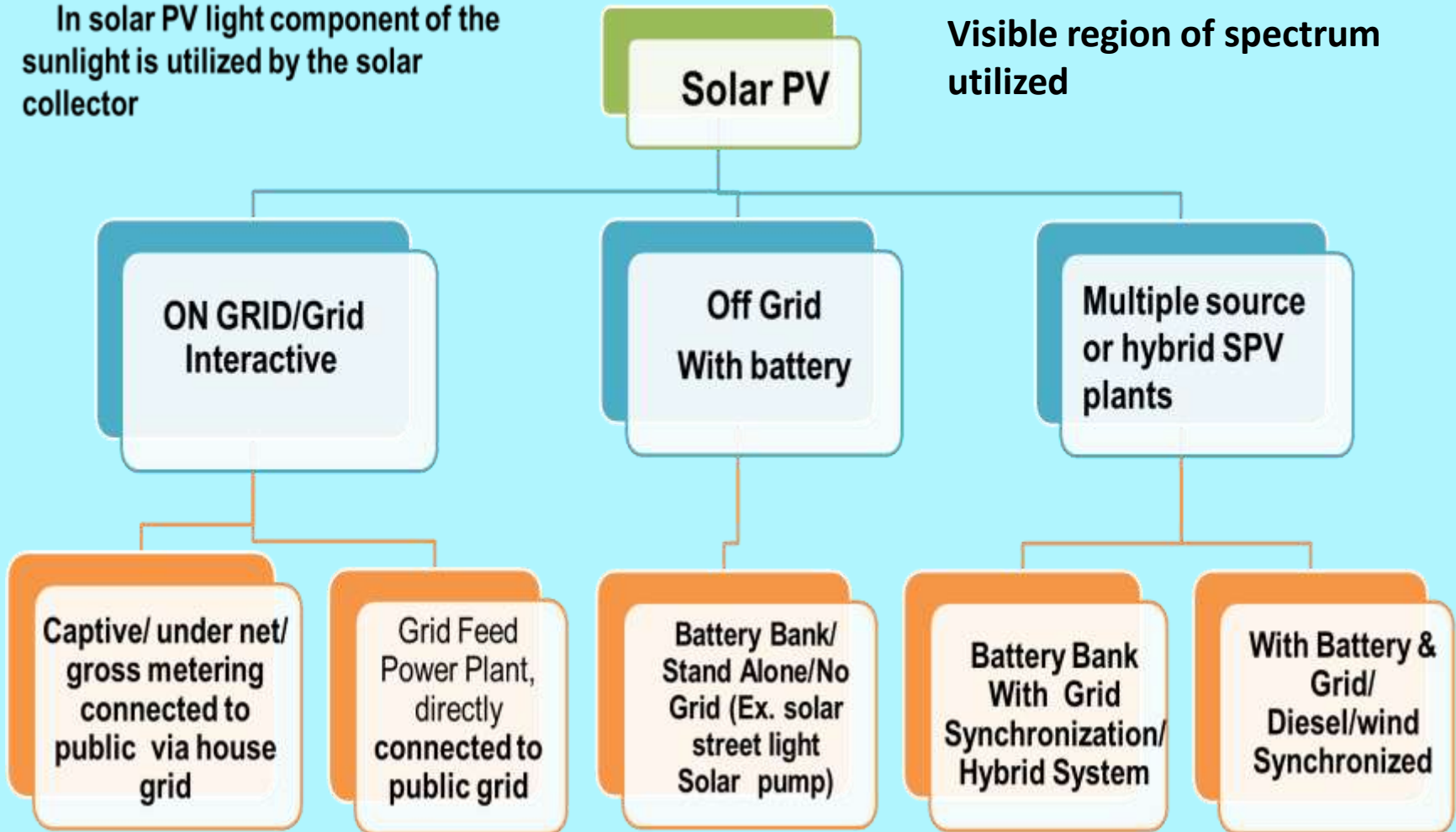


- In solar thermal heat component of the sunlight is utilized by the solar collector i.e. Infrared region of spectrum

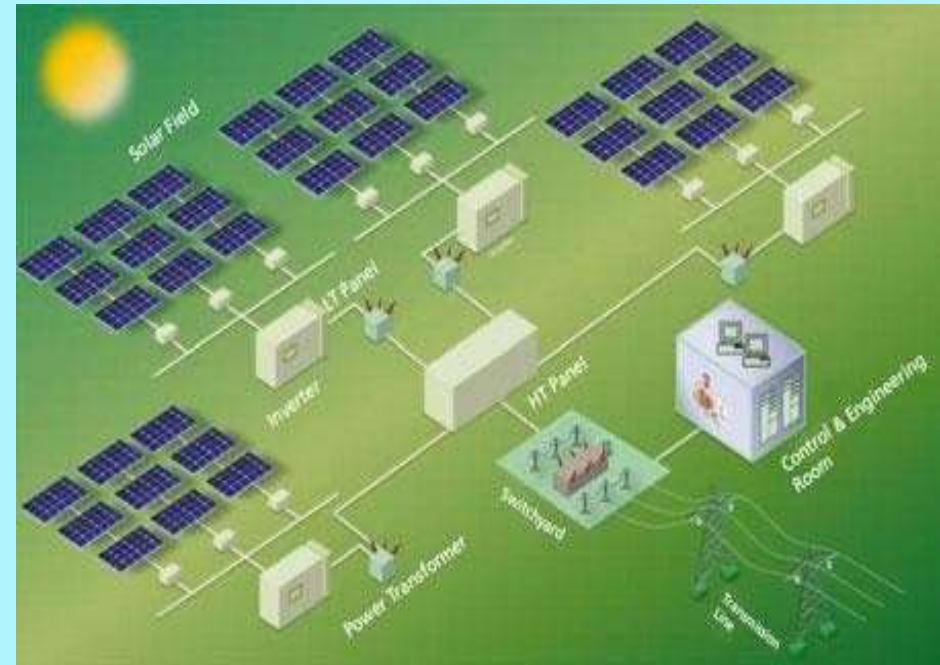
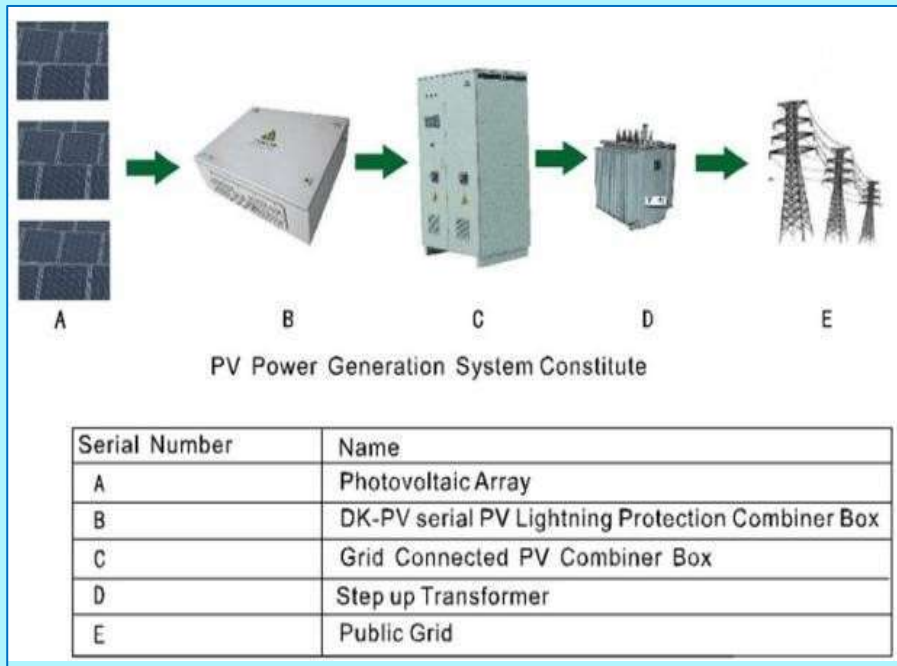
Solar Power Utilization

In solar PV light component of the sunlight is utilized by the solar collector

Visible region of spectrum utilized



Grid-connected photovoltaic power systems



Grid-connected photovoltaic power systems are energized by photovoltaic solar panels, which are connected directly to the utility grid.

Solar Power Utilization



12MWp Solar Plant at Cochin International Airport[720P].MP4