Course: Renewable Energy Sources – 18EE653

Module-1: Introduction to Renewable Energy

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Introduction

Energy is the primary and most universal measure of all kinds of work by human beings and nature. Every thing what happens in the world is the expression of flow of energy in one of its forms.

Energy Resources

1. Based on usability of energy.

- Primary Resources: derived directly from natural reserve (solar, wind, nuclear, geothermal, hydropower).
- Secondary Resources (usable form of energy obtained by suitable energy conversion techniques).

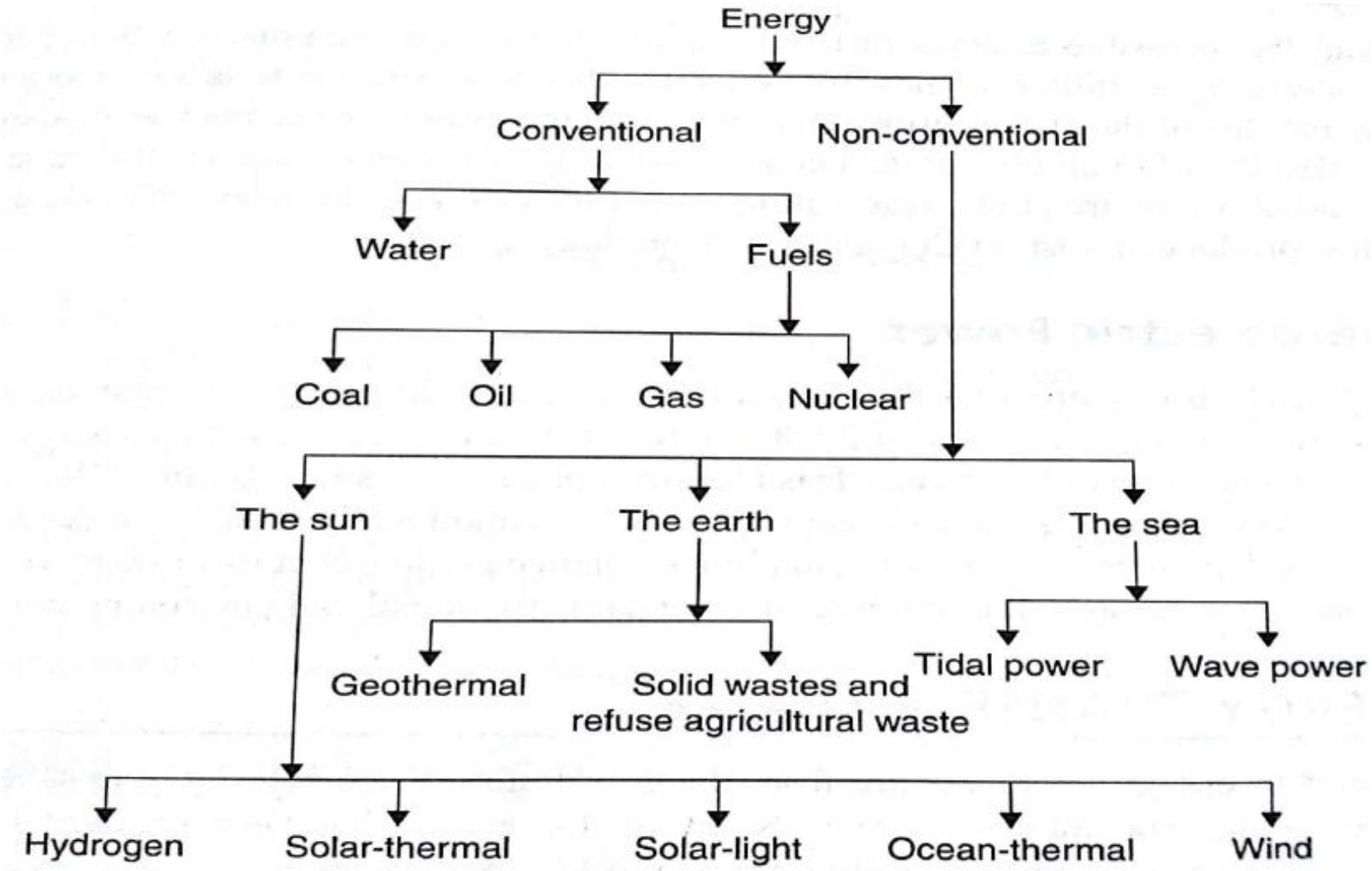
2. Based on Traditional use : Conventional and Non Conventional.

3. Based on Long term Availability: Non Renewable and Renewable.

4. Based on Commercial Application: Commercial and Non Commercial energy Resources.

5. Based on Origin: Fossil fuel, Nuclear, Hydro, Solar, Wind, Biomass, Geo Thermal, Ocean Thermal, Ocean Wave. Tidal.

Classification of Energy Resources



Causes of Energy Scarcity

- The energy crisis is the concern that the world's demands on the limited natural resources that are used to power industrial society are diminishing as the demand rises.
- These natural resources are in limited supply. While they do occur naturally, it can take hundreds of thousands of years to replenish the stores.

Overconsumption

The energy crisis is a result of many different strains on our natural resources, not just one. There is a strain on fossil fuels such as oil, gas, and coal due to overconsumption, which in turn, can put a strain on our water and oxygen resources by causing pollution.

Overpopulation

Another cause of the crisis has been a steady increase in the world's population and its demands for fuel and products.

Poor Infrastructure

Aging infrastructure of power generating equipment is yet another reason for energy shortage. Most of the energy-producing firms keep on using outdated equipment that restricts the production of energy.

Unexplored Renewable Energy Options

Renewable energy still remains unused in most of the countries.

Wastage of Energy

In most parts of the world, people do not realize the importance of conserving energy.

Poor Distribution System

Frequent tripping and breakdown are a result of a poor distribution system.

Uneven Distribution of Energy Resources

Ex: Geographical distribution-Oil reserves in middle east countries, insufficient wind in different continents

Solution for Energy Crisis

1. Control Population Growth
2. Increase Harnessing Efficiency
3. Development of Energy conservation techniques
4. Energy management
5. Provision for pollution free new energy system
6. Buy Energy-Efficient Products
7. Cheap and reliable energy storage systems
8. Move Towards Renewable Resources

Solar energy

- In general, the energy produced and radiated by the sun, more specifically the term refers to the sun's energy that reaches the earth.
- Solar energy, received in the form of radiation, can be converted directly or indirectly into other forms of energy, such as heat and electricity, which can be utilized by man.
- Since the sun is expected to radiate at an essentially constant rate for a few billion years, it may be regarded as an inexhaustible source of useful energy.

The major drawbacks to the extensive application of solar energy are:

1. The intermittent and variable manner in which it arrives at the earth's surface and
2. The large area required to collect the energy at a useful rate.

- Energy is radiated by the sun as electromagnetic waves of which 99 percent have wave lengths in the range of 0.2 to 4.0 micrometers (1 micrometer = 10^-6 meter).
- Solar energy reaching the top of the earth's atmosphere consists of about 8% ultraviolet radiation (short wave length, less than 0.39 micrometer), 46% visible light (0.39 to 0.78 micrometer), and 46% infrared radiation (long wave length more than 0.78 micrometer).

Solar Constant

- The sun is a large sphere of very hot gases, the heat being generated by various kinds of fusion reactions.
- Its diameter is 1.39 x 10^6 km while that of the earth is 1.27 x 10^4 km.
- The mean distance between the two is 1.50 x 10^8 km.
- The rate at which solar energy arrives at the top of the atmosphere is called the solar constant Isc.
- This is the amount of energy received in unit time on a unit area perpendicular to the sun's direction at the mean distance of the earth from the sun.

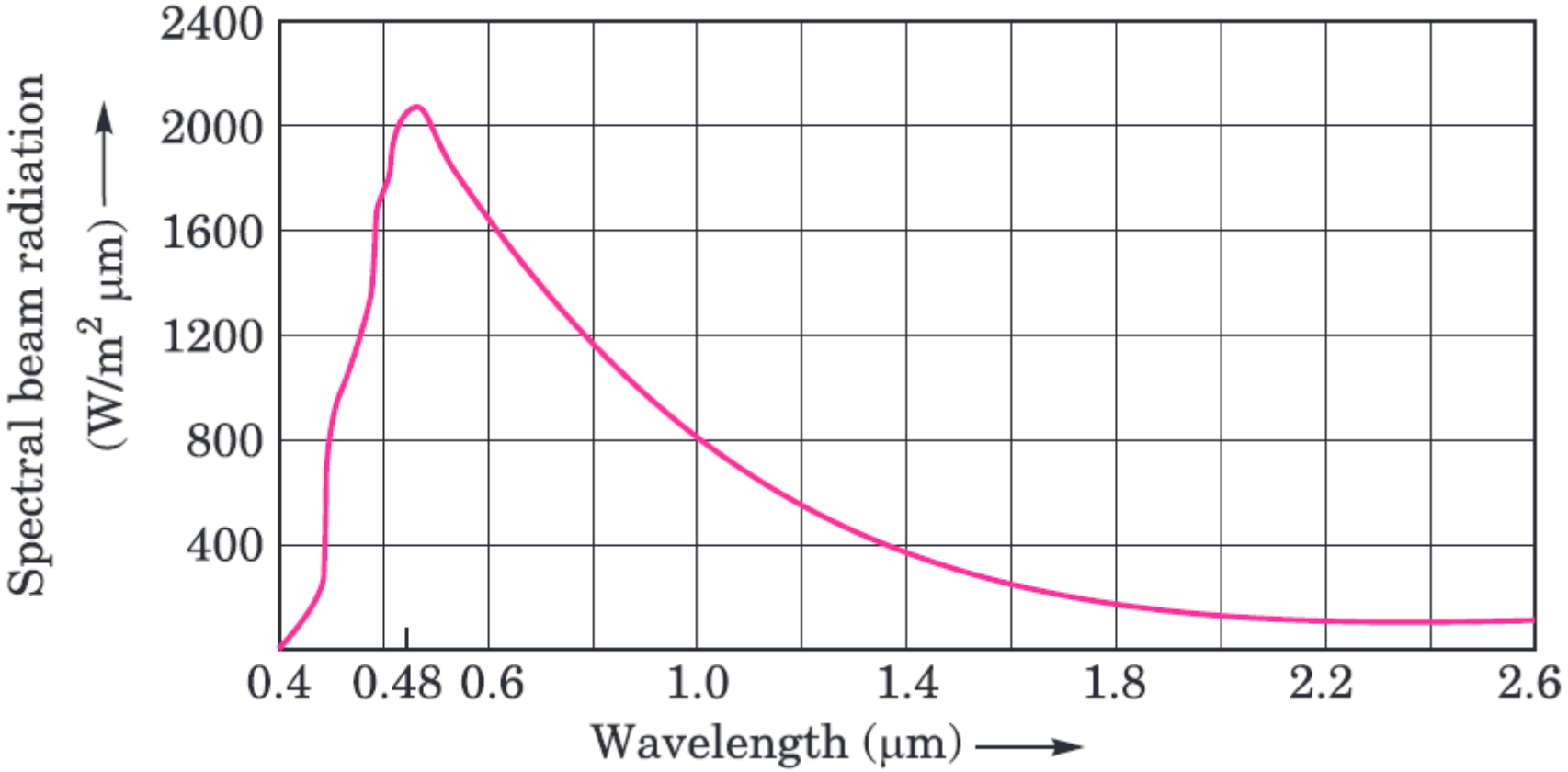
- The distance between the earth and the sun varies a little through the year.
- Because of this variation, the extraterrestrial (out side the earth's atmosphere) flux also varies.
- The earth is closest to the sun in the summer and farthest away in the winter.
- This variation in distance produces a nearly sinusoidal variation in the intensity of solar radiation I that reaches the earth.

This can be approximated by the equation

$$\frac{I}{I_{sc}} = 1 + 0.033 \cos \frac{360(n-2)}{365}$$

$$\simeq 1 + 0.033 \cos \frac{360 \times n}{365}$$

where, n is the day of the year. As the distance between earth and sun varies a little through the year, due to it extraterrestrial radiation also varies.



Spectral distribution of solar radiation intensity.

Solar Radiation at the Earths Surface

- From the point of view of utilization of solar energy we are more interested in the energy received at the earth's surface than in the extraterrestrial energy.
- Solar radiation received at the surface of the earth is entirely different due to the various reasons.

Before studying this it is important to know the following terms:

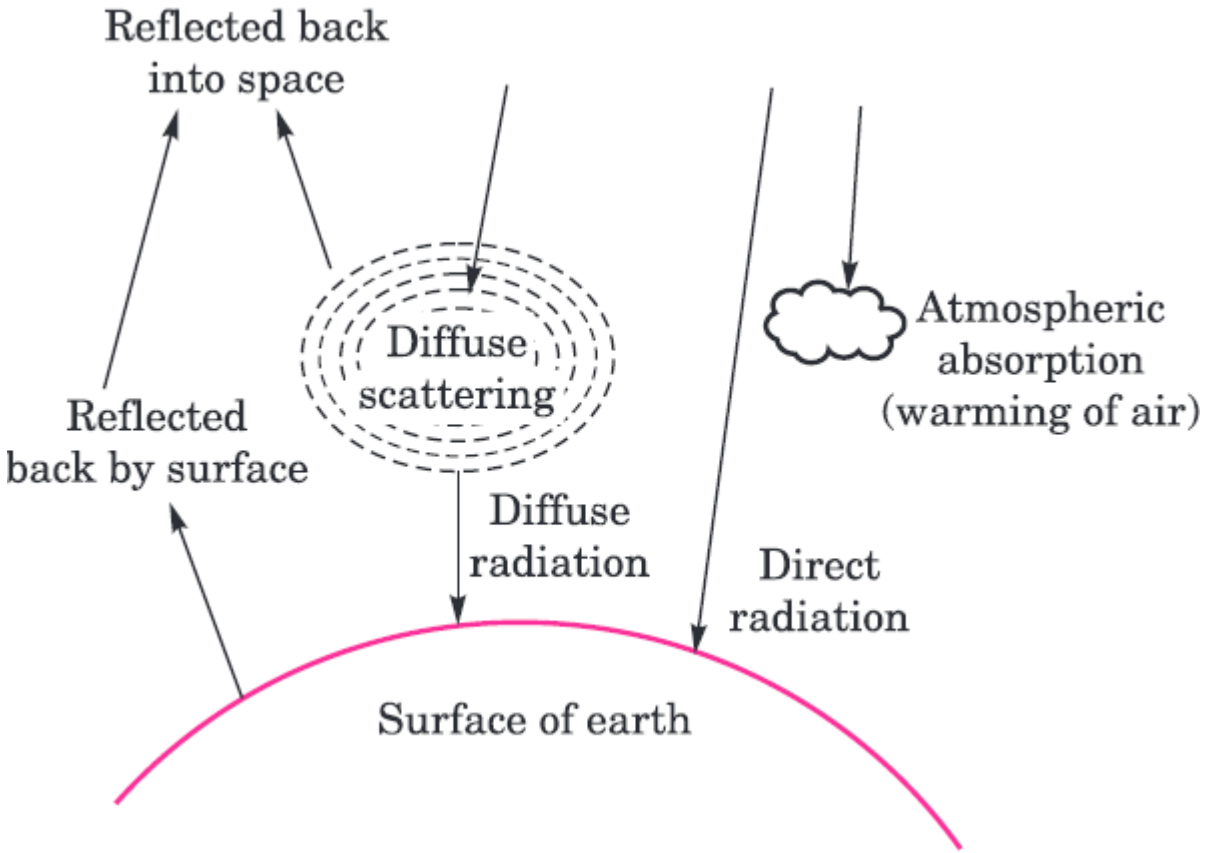
Beam and Diffuse Solar Radiation.

- The solar radiation that penetrates the earth's atmosphere and reaches the surface differs in both amount and character from the radiation at the top of the atmosphere.
- In the first place, part of the radiation is reflected back into the space, especially by clouds.
- Further more, the radiation entering the atmosphere is partly absorbed by molecules in the air.

- Ozone (O_3) formed from oxygen, absorb nearly all the ultraviolet radiation, and water vapour and carbon dioxide absorb some of the energy in the infrared range.
- In addition, part of the solar radiation is scattered (i.e., its direction has been changed) by droplets in clouds by atmospheric molecules, and by dust particles.

- Solar radiation that has not been absorbed or scattered and reaches the ground directly from the sun is called **"direct radiation" or Beam radiation**.
- It is the radiation which produces a shadow when interrupted by an opaque object.
- **Diffuse radiation** is that solar radiation received from the sun after its direction has been changed by reflection and scattering by the atmosphere.
- Because of the solar radiation is scattered in all directions in the atmosphere, diffuse radiation comes to the earth from all parts of the sky.

- Figure shows the **total solar radiation** received at any point on the earth's surface is the sum of the direct and diffuse radiation.
- This is referred to, in a general sense as the **insolation** at that point.
- More specifically, the insolation is defined as the total solar radiation energy received on a horizontal surface of unit area (e.g., 1 sq. m) on the ground in unit time (e.g., 1 day).



Direct, diffuse and total radiation.

Solar Radiation Geometry

In solar radiation analysis, the following angles are useful:

ϕ_l = latitude of location

ω = hour angle

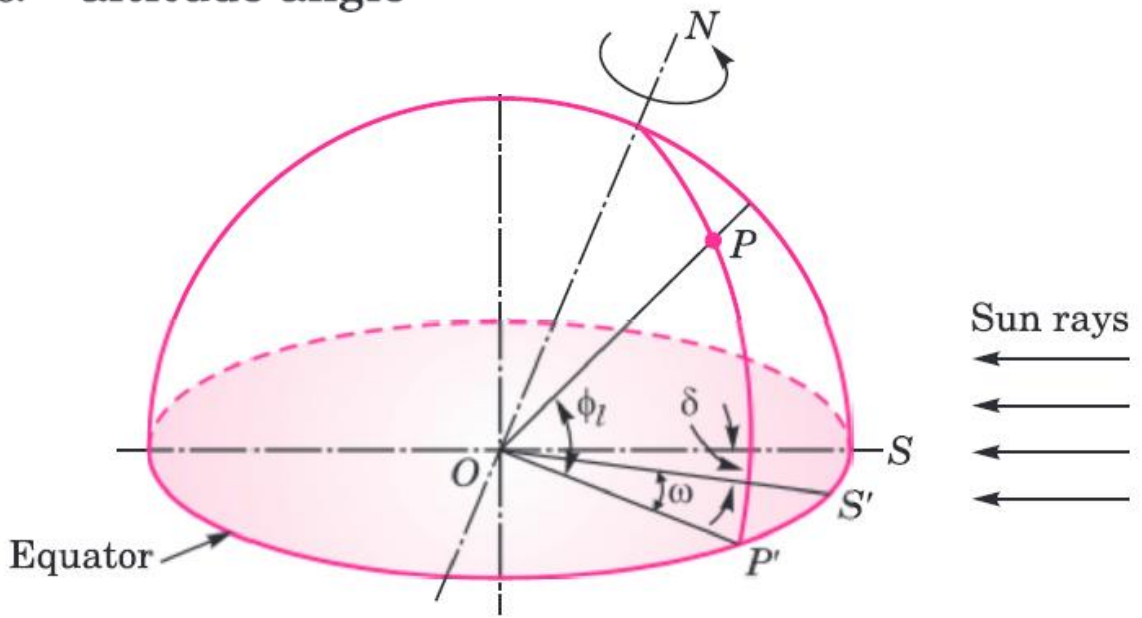
s = slope

θ_z = zenith angle.

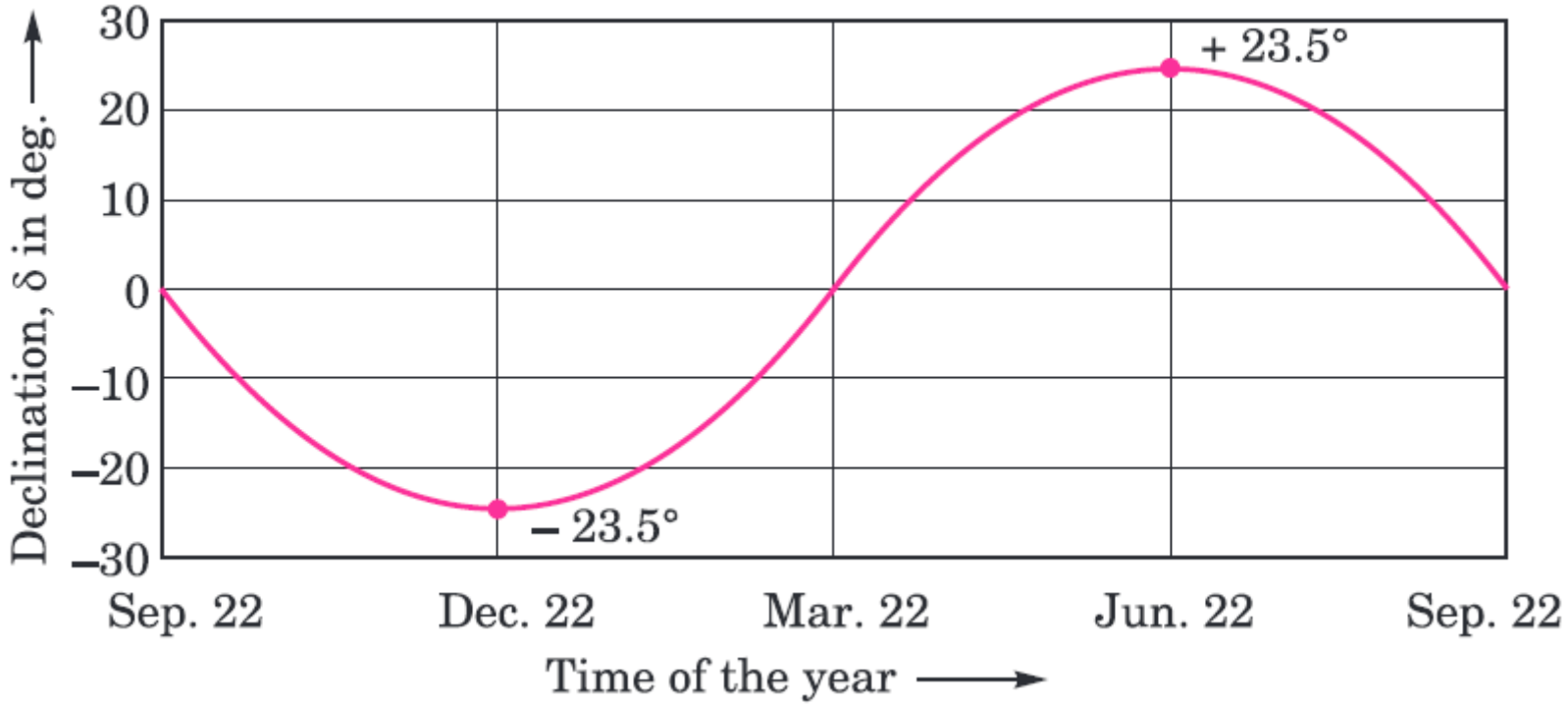
δ = declination

γ_s = solar Azimuth angle

α = altitude angle



Latitude ϕ_l, hour angle ω, and sun's declination δ.



Variation of sun's declination

Example 2.2. *Calculate the angle made by beam radiation with the normal to a flat collector on December 1, at 9.00 A.M., solar time for a location at 28° 35′ N. The collector is tilted at an angle of latitude plus 10°, with the horizontal and is pointing due south.*

Solution. $\gamma = 0$ since collector is pointing due south. For this case we have the equation

$$\cos \theta_T = \cos (\phi - s) \cos \delta \cos \omega + \sin (\phi - s) \sin \delta$$

Declination δ can be obtained with the help of Cooper equation on December 1, $n = 335$.

$$\delta = 23.45 \sin \left[\frac{360}{365} (284 + n) \right]$$

$$= 23.45 \sin \left[\frac{360 \times (284 + 335)}{365} \right] = -22.11°.$$

Hour angle ω corresponding to 9.00 hour $= 45°$

Hence, $\cos \theta_T = \cos (28.58° - 38.58°) \cos (-22.11°)$

$\cos 45° + \sin (-22.11°) \sin (28.58° - 38.58°)$

$= \cos 10° \cos 22.11° \cos 45° + \sin 22.11° \sin 10°$

$= 0.6451 + 0.0653 = 0.7104$

$\theta_T = 44.72°$. **Ans.**

Solar Energy

- Solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be one of the most important supplies of energy specially when other sources in the country have depleted.
- Energy comes to the earth from the sun. This energy keeps the temperature of the earth above that in colder space, causes current, in the atmosphere and in ocean, causes the water cycle and generate photosynthesis in plants.
- The solar power where sun hits atmosphere is 10^17 watts, whereas the solar power on earth's surface is 10^16 watts.

- The total world-wide power demand of all needs of civilization is 10^13 watts.
- Therefore, the sun gives us 1000 times more power than we need.
- If we can use 5% of this energy, it will be 50 times what the world will require.
- The energy radiated by the sun on a bright sunny day is approximately 1 kW/m², attempts have been made to make use of this energy in raising steam which may be used in driving the prime movers for the purpose of generation of electrical energy.
- Utilization of solar energy is of great importance to India since it lies in a temperature climate of the region of the world where sun light is abundant for a major part of the year.

The applications of solar energy which are enjoying most success today are:

(1) Heating and cooling of residential building.

(2) Solar water heating.

(3) Solar drying of agricultural and animal products.

(4) Solar distillation on a small community scale.

(5) Salt production by evaporation of seawater or inland brines.

(6) Solar cookers.

(7) Solar engines for water pumping.

(8) Food refrigeration.

https://www.coolingindia.in/solar-powered-cold-storagefood-preservation-horticulture/

(9) Bio conversion and wind energy, which are indirect source of solar energy.

(10) Solar furnaces.

(11) Solar electric power generation by,

(i) Solar ponds.

(ii) Steam generators heated by rotating reflectors (heliostat mirrors), or by tower concept.

(iii) Reflectors with lenses and pipes for fluid circulation (cylindrical parabolic reflectors).

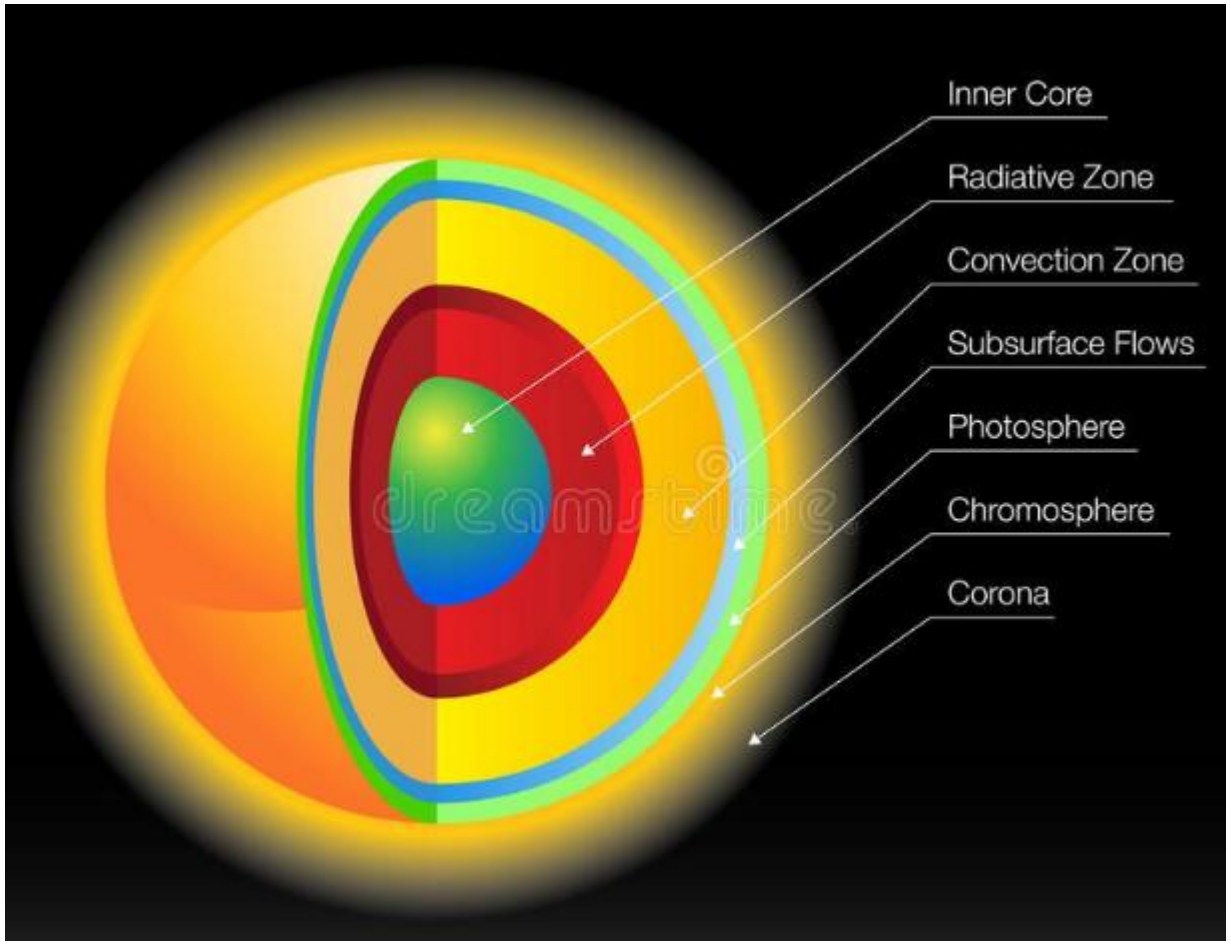
(12) Solar photovoltaic cells, which can be used for conversion of solar energy directly into electricity or for water pumping in rural agricultural purposes.

- The heat from solar collectors is directly used for warming the living spaces of a building in conventional ways e.g., through radiators and hot air registers.
- When the building does not require heat, the warmed air or liquid from the collector can be moved to a heat storage container.

Layers of the Sun

The Sun, as shown by the illustration to the left, can be divided into six layers. From the center out, the layers of the Sun are as follows:

1. The solar interior composed of the **core** (which occupies the innermost quarter or so of the Sun's radius).
2. The **radiative zone.**
3. And the **convective zone**.
4. Then there is the visible surface known as the **photosphere**.
5. The **chromosphere**.
6. And finally the outermost layer, the **corona**.



The energy produced through fusion in the Sun's core powers the Sun and produces all of the heat and light that we receive here on Earth

Thank You