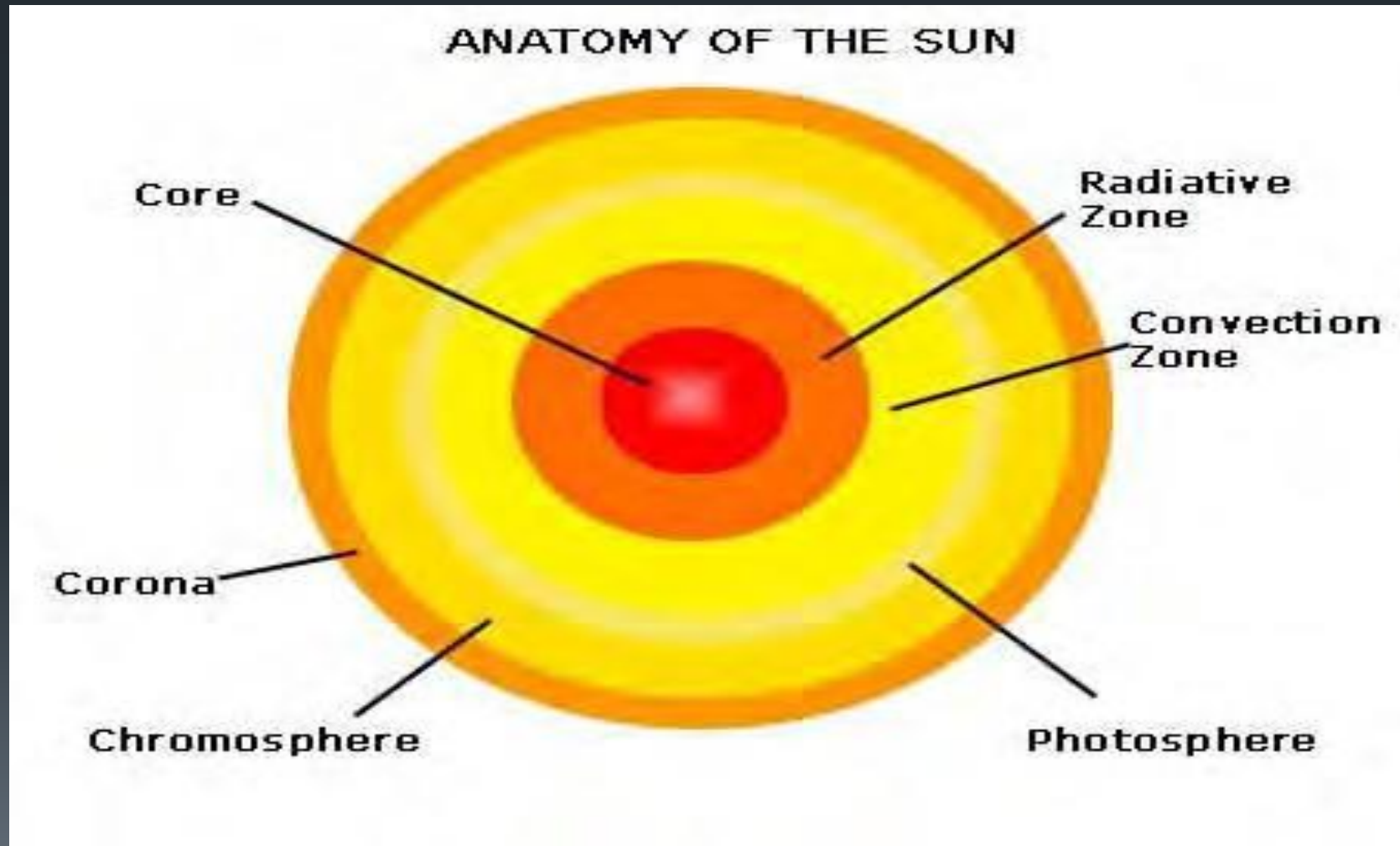


# IAT-1 Solution

1. Write short notes on the layers of the sun.

# Layers of the Sun





## Core

- Innermost layer
- Highly dense  $160\text{g/cm}^3$
- 40% suns mass in 10% volume
- Gaseous state
- 1,50,00000 degree celcius
- Fusion reactions produce gamma rays and neutrinos
- Each high energy gamma ray that leaves the solar envelope will become thousand low energy photons
- Neutrinos are non reactive

# Solar envelope

- Radiative envelope surrounded by convective envelope
- Temp is 4 million Kelvin
- Less dense than core
- 60% mass in 90% volume
- Puts pressure on core and maintains core temperature
- Cooler and More Opaque than core
- Energy movement in huge cells in convection zone only



## Photosphere

- Zone from which sunlight is seen and emitted
- Thin layer of low pressure gases
- 6000 degree celcius

## Chromosphere

- A red circle can sometimes be seen outside the sun during eclipse which is called chromosphere
- Hydrogen abundant so red in colour
- 7000 K, hotter than photosphere



## Corona or Crown

- The outermost layer of the sun
- Thin and faint so difficult to observe from the earth
- Visible during total solar eclipse
- Outer layer is very dim
- It is the hottest  $10^6\text{K}$  layer though Spreads over several million kilometers into space, lots of room for molecules to move
- Causes Solar winds

2. Discuss about the causes of energy scarcity.





# Causes of Energy Scarcity

[Renewable Energy Systems](#)

[Course Objectives](#)

[Energy Scarcity](#)

[Causes](#)

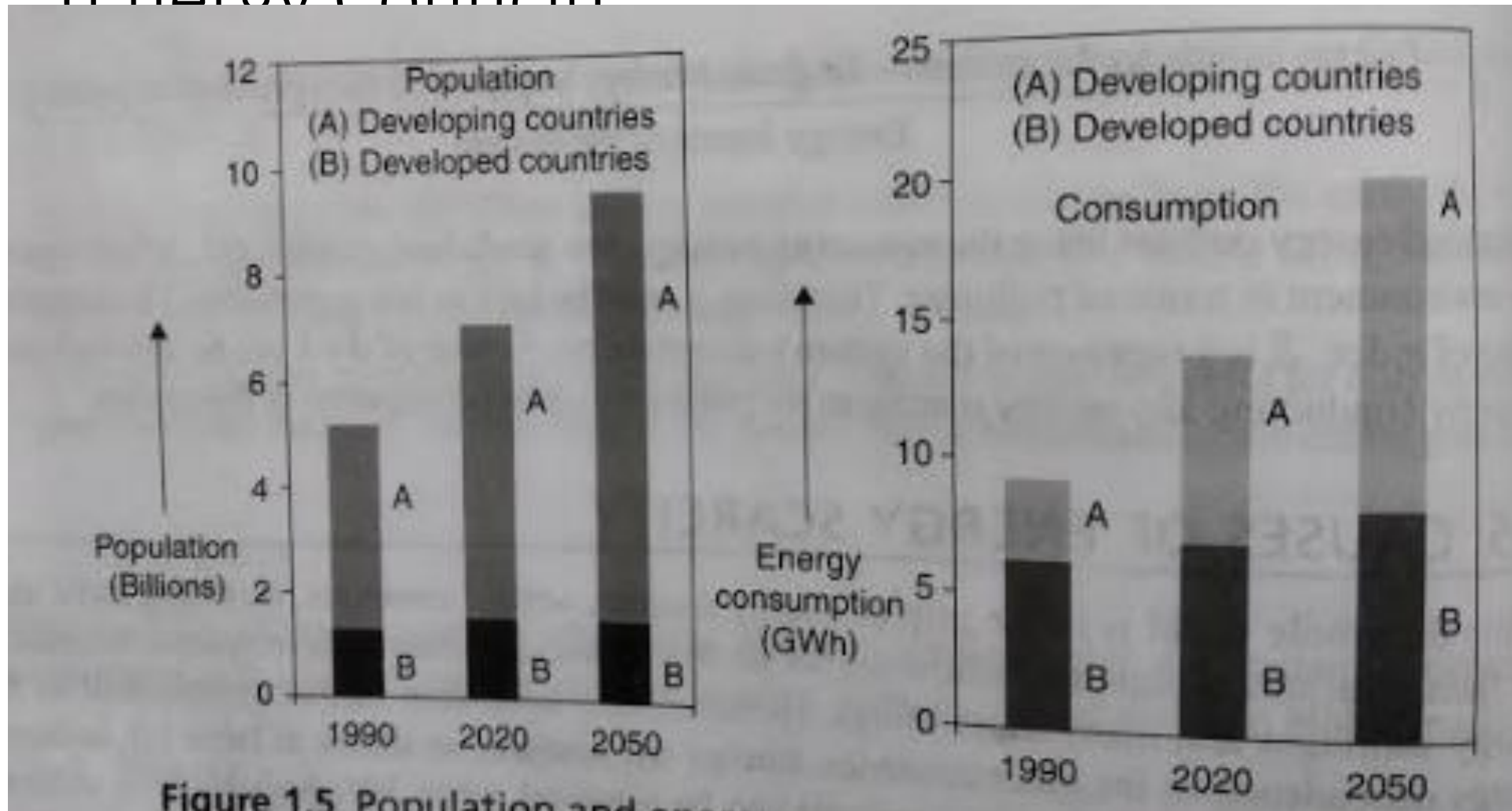
[Solution](#)

[Factors](#)

[Classification](#)

- 1 Increasing Population
- 2 Increase Energy Usage or Consumption
- 3 Uneven Distribution of Energy Resources
- 4 Lacks of Technical Knowhow
- 5 Poor Infrastructure at power generating stations
- 6 Unexplored Renewable Energy Options
- 7 Delay in Commissioning of Power Plants
- 8 Wastage of Energy
- 9 Poor Distribution System
- 10 Major Accidents and Natural Calamities
- 11 Wars and Attacks
- 12 Miscellaneous Factors-strikes, military coup, political events, severe hot summers or cold winters.

# Population and Energy Consumption (Energy Council)

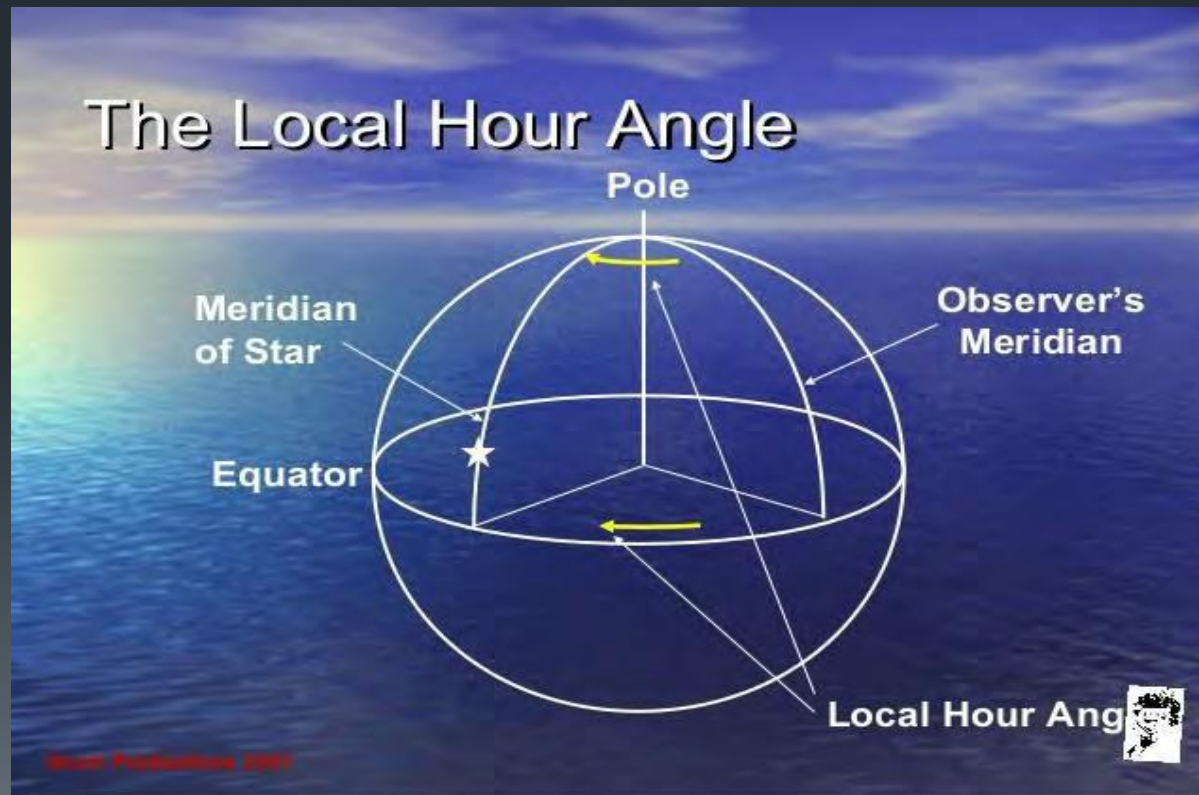


3.a. Define (i) Hour angle (ii) latitude angle (iii) Zenith angle

# Earth-Sun Angles

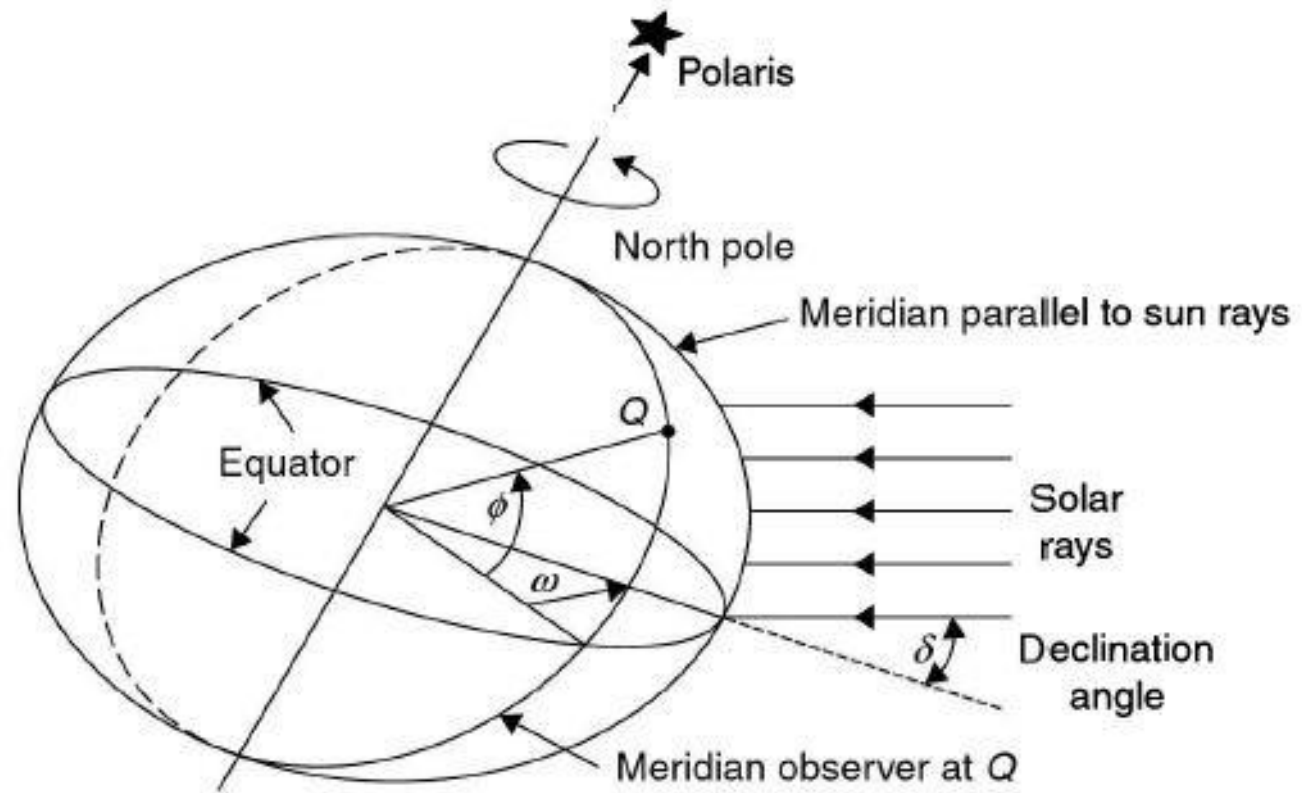
## 1.Hour Angle ( $\omega$ )

- Hour angle is the angular distance between the meridian of the observer and the meridian whose plane contains sun
- Hour angle is zero at solar noon
- Increases by 15 degrees every hour



### 3. Latitude Angle ( $\phi$ )

- Angle between line drawn on a point from earth's surface to the center of earth and the earth's equatorial plane
- Intersection of earth's equatorial plane with the surface of earth forms the equator and it is at 0 degree latitude
- +90 degree— North Pole
- -90 degree –South Pole
- +23.45 degree-Tropic of Cancer
- -23.45 degree –Tropic of Capricorn
- 66.55 degree- Artic Circle
- -66.55 degree -Antarctic Circle



- **Solar Altitude Angle( $\alpha$ )**

- Angle between the central ray of the sun and a horizontal plane containing the observer

- **Zenith Angle( $\theta_z$ )**

- Complement of solar altitude angle

- $\theta_z = 90 - \alpha$

- **Solar Azimuth Angle**

- Angle between the horizontal projection of sun's ray on the horizontal surface and the south coordinate

3.b. What are the advantages and limitations of renewable energy sources?



- **Advantages of non conventional energy sources**

- Available abundantly in nature
- They cause no pollution and hence environment friendly
- They are inexhaustible
- Low gestation period

- **Disadvantages of non conventional energy sources**

- Though freely available cost of harnessing them is
- generally very high
- Availability is uncertain, since it is dependent on natural phenomenon
- Difficult in transporting such forms of energy

4. a.

- Calculate zenith angle, of the sun at Lucknow ( $26.75^\circ$  N) at 9:30 am on February 16, 2012

- $\delta = 23.45 \sin [360 (284+n)/365]$

$$n = 31 + 16 = 47$$

$$\delta = -12.95^\circ = -13^\circ$$

- Hour angle  $\omega$

$$\omega = (1/4) t_m$$

$$t_m = 12.00 - 9.30 = (12 \cdot 60) - (9 \cdot 60) + 30 = 720 - 570 = 150 \text{ min}$$

$$\omega = \frac{150}{4} = -37.5$$

- $\phi = 26.75$

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

- $\theta_z = 53.914$

- 4.b. Find the solar altitude angle at 2 hour after local solar noon on 1<sup>st</sup> June 2012 for a city, which is located at 26.75°N latitude.

- Declination angle  $\delta = 23.45 \sin [360 (284+n) / 365]$

$$n = 31+29+31+30+31+1 = 153$$

$$\delta = 22.17^\circ$$

- The hour angle  $\omega = (1/4) t_m = (1/4) 120 = 30^\circ$

- Solar Altitude Angle  $\alpha$

$$\text{Zenith angle } \Theta_z = 90^\circ - \alpha$$

$$\cos \Theta_z = \cos (90^\circ - \alpha) = \sin \alpha$$

$$\sin \alpha = \cos \phi \cos \delta \cos \omega + \sin \phi \sin \delta$$

$$= \cos 26.75^\circ \cos 22.17^\circ \cos 30^\circ + \sin 26.75^\circ \sin 22.17^\circ$$

$$\sin \alpha = 0.88265$$

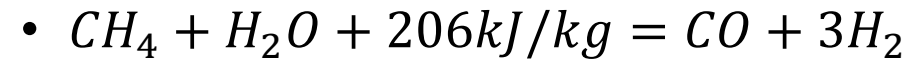
$$\alpha = 62.4^\circ \text{ (approx)}$$

5. Explain the Thermochemical production techniques used to produce Hydrogen energy.

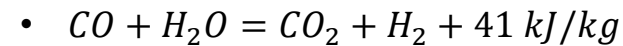
# 1. Thermochemical production technologies

## 1. Steam reforming

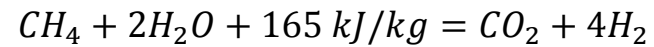
- Methane or methanol reacts with steam over nickel alumina



- Carbon monoxide reacts with water



Total reaction



Natural gas 48%

Oil 30%

Coal 18%

Electrolysis 4%

# 1. Thermochemical production technologies

## 2. Partial oxidation or ceramic membrane reactor

- Natural gas and oxygen at high pressure
- Carbon and oxygen ratio has to be maintained to avoid soot formation
- The carbon dioxide formed can be removed by providing oxygen and also purifies hydrogen
- Catalytic partial oxidation reaction
  - $CH_4 + \frac{1}{2}O_2 = CO + 2H_2$
  - This is exothermic reaction
  - Reduced size and capital cost
  - Less efficient than steam reforming

# 1. **Thermochemical** production technologies

## 3. **Biomass gasification or pyrolysis**

plant material or fossil fuels

- Organic material at high temperatures
- Burning of wood
- Liquid product bio oil is produced

6. Discuss about the factors or guidelines for wind turbine site selection. Also explain the worldwide wind energy scenario.



# Considerations & guidelines

## Factors to be considered

- 1. Hill effect** – wind pressure increases as it reaches the hill top and increases speed
- 2. Roughness or amount of friction that earth's surface exerts on wind** – Oceans have very little roughness, but city or forest has a great deal of roughness, which slows the wind.
- 3. Tunnel effect** – high wind pressure and speed
- 4. Turbulence** – It causes fluctuations in the wind speed and wear and tear on the turbine
- 5. Variations in wind speed**- During day sun heats the air so the wind blow faster compared to night. Wind speed varies on Season as well.
- 6. Wake:** the air coming out of the blade sweep has less energy because it has been slowed. The abrupt change in the speed makes the wind turbulent, a phenomenon called wake. Wind turbines in the wind farms are placed 3 rotor diameter away
- 7. Wind obstacles** – Trees, Buildings and rock formation
- 8. Wind shear:** It is the difference in wind speeds at different heights of turbine blades. Top pointing blade can experience wind speed of 14km per hour but bottom blade experiences 11km per hour. This causes stress on the blades results in wind shear and causes the turbine to fail.

## Guidelines

1. Turbines work good on high and exposed sites. costal sites are good.
2. ✘ Town and highly populated area
3. ✘ roof mounted turbines
4. ✘ Distance of caballing, more power loss in cables
5. Turbine height is twice obstacle distance
6. Speed of wind must be 4.5 m/s to produce electricity
7. Remote location sites are expensive as it is required to connect it with grid

# World energy scenario

**Normal annual wind Speed 3m/s not suitable for wind generation, if it is 4.5m/s then power generation is economical**

- 1. Worldwide capacity reached 196630MW**
- 2. Growth rate 23.6% is reducing**
- 3. China is 1<sup>st</sup> in total installed capacity and the centre for international wind Industry, 50% of world's market of new turbines installation.**
- 4. USA and North America lost its 1<sup>st</sup> position due to reduction in number of new installations**
- 5. Western European countries stagnation, while strong growth in Eastern European countries**

Year	Generation in Gigawatts
2010	196
2015	433
2016	433+60
2021	800
2030	2110(20% Global electricity)

# World energy scenario

6. In Europe Germany is 1<sup>st</sup> with 27 GW Spain is 2<sup>nd</sup> with 20 GW

7. Highest share of world wind energy is from European countries : Denmark(21%)

Portugal(18%), Spain(16%)

8. Highest share of installation is from Asia(54.6%), Europe(27%) , North America(16.7%)

9. Lowest in installations Latin America(1.2%), Africa(.4%)

10. Japan has known importance of Wind power b/c of Nuclear disaster

11. World Wind Energy Association(WWEA) predicts the global capacity of 600,000MW production by 2015 and 1,500,000MW by 2020.