

The Sun As A Source Of Energy

1. Sun and its solar astronomy

Introduction

- Virtually all of the energy consumed by humans has come from the sun.
- It is an inexhaustible source of energy with minimum of adverse environmental consequences.
- It does not necessarily rely on a high level of technology.
- Fossil fuels have a finite life time.

Introduction

- Earth reception of solar radiation from the sun = 1.7×10^{17} w.
- A world population of 10 billion with a total power need per person of 10 kW would require about 10^{11} kW of energy.
- It is observed that only 1% of irradiation conversion with 10% efficiency could provide the need of all people energy.

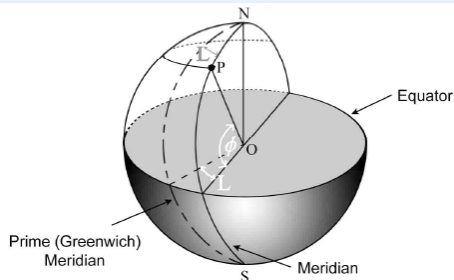
The sun

- A sphere of intensely hot gaseous matter with a diameter of 1.39×10^9 meters and average distance from the earth of 1.5×10^{11} meters.
- Effective blackbody temperature of 5777 K.
- It is estimated that 90% of energy is generated in the region of 0 to 0.23R where R is radius of sun.

Solar Astronomy

1.1. The Earth And It's Orbit Around The Sun

- Earth is considered as a simple sphere with a diameter of approximately 12 800 km.
- The **latitude of a point P**, (φ) is the angle between a radius drawn from the point to the centre of the Earth and a radius drawn from the centre of the Earth to the equator.



values range from 0° to 90° North and 0° to 90° South

1.1. The Earth And It's Orbit Around The Sun

- The Earth rotates around it's axis every 24 hours and orbits the Sun every 365.25 days. (See figure) →
- The Earth's orbit follows an elliptical path.
- The Sun is at one of the foci :
 - * The minimum distance between the Sun and the Earth is 146.10×10^6 km (*on about the 2nd January*)
 - * The maximum distance between is 152.10×10^6 km (*on about 3rd July*). (See figure) →

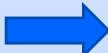
1.1. The Earth And It's Orbit Around The Sun

- The difference between the maximum and minimum distance is only 3.3% with a **mean distance of 149.5985×10^6 km** is normally used.
- The axis of rotation is tilted at an angle of 23.45° with respect to the plane of the orbit around the Sun.
- The axis is orientated so that it always points towards the Pole Star and this accounts for the seasons and changes in the length of day throughout the year.

1.1. The Earth And It's Orbit Around The Sun

- * The angle between the equatorial plane and a line joining the centres of the Sun and the Earth is called the *declination angle δ* .
- * The declination angle changes as the Earth orbits the Sun.

1.1. The Earth And It's Orbit Around The Sun

- * On the *summer solstice (21st June)*
 - * *the Earth's axis is orientated directly towards the Sun, therefore the declination angle is 23.45° (figure 1.3).*
 - * All points below 66.55° south have 24 hours of darkness
 - * All point above 66.55° north have 24 hours of daylight.
 - * The sun is directly over head at solar noon at all points on the *Tropic of Cancer*. 

1.1. The Earth And It's Orbit Around The Sun

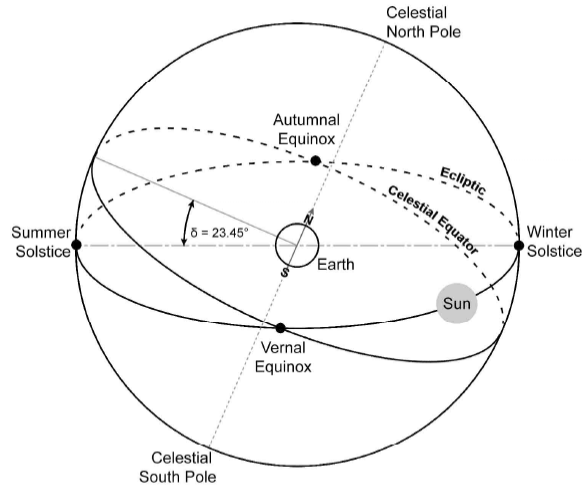


Figure 1.5: The celestial sphere. δ is the declination angle, which is at a maximum at the solstices and zero at the equinoxes.

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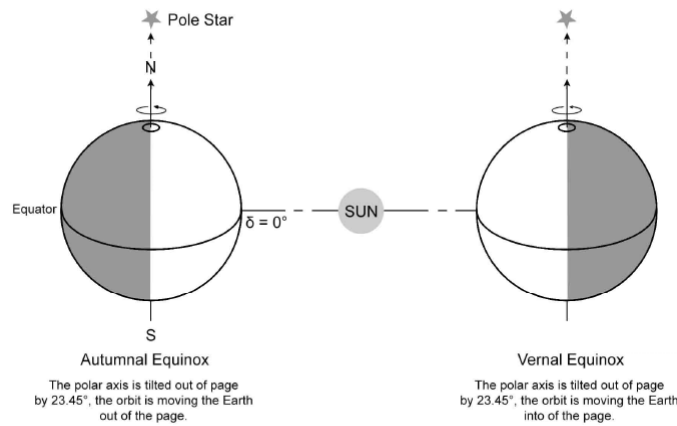


Figure 1.4: The autumnal and vernal winter solstices

1.2 Plotting The Sun Around Across The Sky

- * The position of the Sun in the sky as viewed from any point on the Earth's surface can be defined using a variety of angles:
 - * The *declination angle*, δ
 - * *Hour angle*, ω
- * The hour angle at a point P on the Earth's surface is the angle between the meridian containing point P and the meridian that is parallel to the Sun's rays.

Plotting The Sun Around Across The Sky

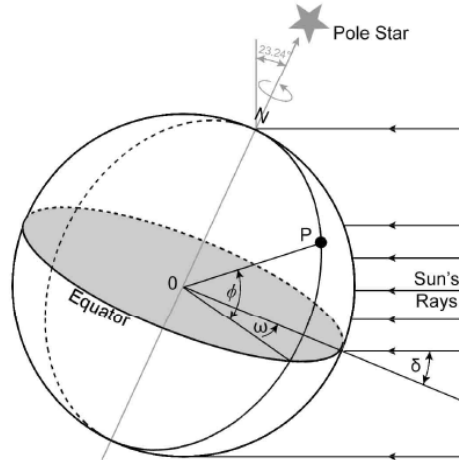



Figure 1.6: The declination angle (δ), latitude (ϕ) and hour angle (ω) for point P.

1.2 Plotting The Sun Around Across The Sky

- The hour angle is negative during the morning, reduces to zero at solar noon (when point P faces the Sun) and becomes increasingly positive as the afternoon progresses.
- Hour angle at any particular time is the same for all points on any particular meridian
- Since the Earth completes one revolution every 24 hours, the hour angle changes by $(360/24)$ 15° every hour.

1.2 Plotting The Sun Around Across The Sky

- The path of the sun across the sky can be determined by two angles:
 1. **Solar zenith angle, θ_z** , (or solar altitude angle, α) (see figure) 
 2. **Solar azimuth angle, A_z**
- The height of the Sun in the sky at any time can be described by θ_z and A_z .

1.2 Plotting The Sun Around Across The Sky

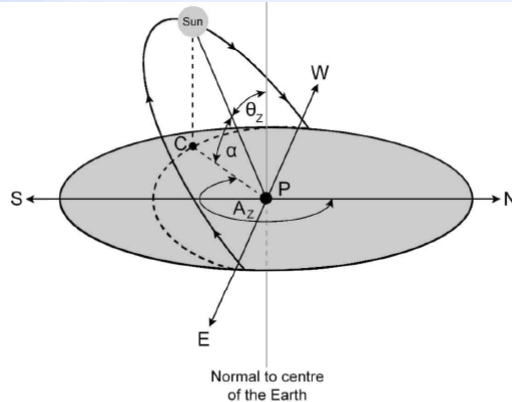
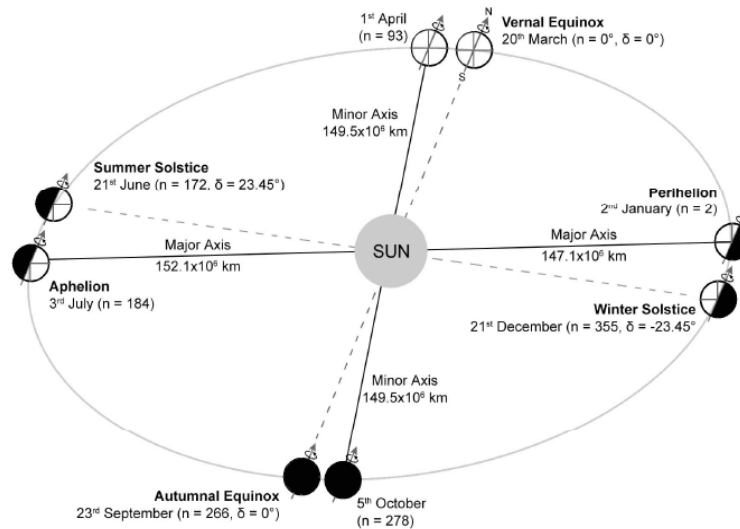


Figure 1.7: The zenith angle (θ_z), the altitude angle (α) and the azimuth angle (A_z) of the Sun when view from point P on the Earth's surface.



The orbit of the Earth around the sun