Course: Sustainable Energy Technology 1

12150310

Title: Solar Energy-L1

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Solar Energy

The Sun:

The Sun is the star at the center (heart) of the Solar System.

It is a nearly perfect sphere of hot plasma. All of the bodies in the solar system revolve around it.

- Sun Radius: 695,700 km.
- Sun Surface temperature: 5,778 K
- Sun Mass: 1.989 × 10^30 kg
- Average distance between the sun and the earth is nearly 149.6 million km

Earth makes a complete revolution around the sun every 365.25 days (one year). However, Earth's orbit is not a perfect circle; it is shaped more like an oval, or an ellipse. Over the course of a year, Earth moves sometimes closer to the sun and sometimes farther away from the sun. Earth's closest approach to the sun, called **perihelion**, comes in early January and is about 146 million km. The farthest from the sun Earth gets is called **aphelion**. It comes in early July and is about 152 million km.

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The Sun:

- The composition of the Sun: 71% Hydrogen, 27% Helium and 2% the other 90 elements.
- About 3.8×10^{26} joules of energy being produced in the core of the Sun every second.
- Total World Wide energy consumption for the year of 2005 was 5 x 10^20 Joules. That is one millionth of the energy that leaves the Sun every second

The nuclear reactions are the reactions that are producing this energy

Four hydrogen atoms are changed into Helium atoms and energy is released.

$4H \longrightarrow$ He + energy (Nuclear reaction)

The Sun converts 564 million tons of hydrogen into 560 million tons of helium every second. That means that every second 4 million tons of hydrogen is turned into energy.

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The Sun:

Ps is the emitted power from the sun surface.

$Ps = \sigma * (Ts)^4 * As = \sigma * (Ts)^4 * \Pi * (Ds)^2$

σ is the Stefan Boltzman Constant = $5.67 * 10^{-8}$ $W/(m^2K^4)$

$Ds = 1.4 * 10^6$ km

$Ps = 3.8 * 10^{23}$ kW.

$Gn = Ps / (4 * \Pi * (r_{SE})^2) = 1324$ W/m^2 ----- Solar Constant (calculated Value)

Gn measured 1353 W/m^2

$D_{SE} = 1.5 * 10^{11}(1 + 0.017 \sin (360 (N-93)/365))$ m

$Gn = 1353 (1 + 0.34 \cos ((360*N)/365))$ W/m^2

Extraterrestrial solar radiation (Outside atmosphere)

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The Sun Radiation

Solar radiation is usually measured on horizontal surfaces that are free from obstacles. Global, beam (direct) and diffuse are solar quantities that may be measured on horizontal surfaces, but the solar quantity that is mostly measured is the global radiation.

The global radiation measured on horizontal surface (G_H) comprises of two components: beam (direct) component (G_b) and the diffused component (G_d)

$$G_H = G_{bn} + G_d$$

where G_{bn} is the normal component of the beam radiation part, and is calculated using the following formula

$$G_{bn} = G_b * sin\,\alpha$$

where α is the solar altitude angle that describes the angle between the horizon and the line to the sun (it is the complement of the zenith angle which is the angle between the vertical and the line to the sun).

This angle, alongside other angles that describe the position of the sun relative to a certain plane and orientation are shown in the figure below:

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The Sun Radiation angles: