Solar Energy

3.1 Basic

The Sun is the largest energy source of life while at the same time it is the ultimate source of most of our renewable energy supplies. The Sun is a typical star with the following characteristics: mass 2×10^{30} kg, beam length 700.000 km, age 5×10^{9} years and it is calculated that it still has roughly 5 billion more years of life. Its surface temperature is about 5800 K while the internal temperature is approximately 15.000.000 K. This temperature derives from reactions which were based on the transformation of hydrogen in helium. The process of the nuclear fusion, which is characterized from the following reaction

$$4{}_{1}^{1}H \rightarrow {}_{2}^{4}He$$

Energy, is the result of the high temperature of the Sun and the continuous emission of large amounts of energy. It is calculated that for each gram of hydrogen, that is converted to *He*, Sun radiates energy equal with U= 1.67 × 105 kWh. The solar energy is emitted to the universe mainly by electromagnetic radiation.

The Earth spins in an elliptic orbit around the Sun while the distance from the Sun is estimated to be 150.000.000 km. The light in order to cover this distance, having the speed of 300.000 km/sec, requires approximately 8.5 min. The emitted radiation is removed actinic by the aster to the space and the intensity of the radiation *J*, is calculated according to the equation below:

$$J = \frac{P}{4\pi d^2}$$

Where *P* is the power of electromagnetic radiation and d is the distance from the Sun. Approximately one-third of this radiation is reflected back. The rest is absorbed and retransmitted to the space while the Earth reradiates just as energy as it receives and creates a stable energy balance at a temperature suitable for life.

At its core, solar energy is actually nuclear energy. In the inner 25% of the Sun, hydrogen is fusing into helium at a rate of about 7×10^{11} *kg* of hydrogen every second. If this sounds like a lot, it is because it is: this is equivalent to the amount of mass that can be carried by 10 million railroad cars. There is no need to fear, though, that we are going to run out of fuel anytime soon, This energy production, coupled with gravitational compression, keeps the Sun's center near a sweltering 16 million K, which is about 29 million °F. Heat from the core is first primarily radiated, and then primarily converted, to the Sun's surface, where it maintains at a temperature of 5800 K[3]. From the surface of the Sun, the primary method of energy transport is electromagnetic radiation. This form of heat transport depends greatly upon the surface temperature of an object for the amount and type of energy. Stefan-Boltzmann's Law tells us that the amount of energy that is radiated per unit area of surface, depends upon the temperature of the object to the fourth power, i.e. energy/area is proportional to T^4. This means, that the amount of energy that is emitted by the Sun, and therefore, the amount of solar energy that we receive here on Earth, is critically dependent upon this surface temperature. A change of 1% in the temperature of the Sun (58 K) can result in a change of 4% in the amount of energy per unit area that we receive here. While this might not sound like a lot, it is more than enough to plunge us into brutal ice age or hellish global warming.

The type of radiation coming from the Sun also depends on temperature. The Sun is emitting electromagnetic radiation in wide variety of wavelengths. However, most of the radiation is being sent out in the visible spectrum due to its surface temperature. Wien's Law states that the wavelength at which the most energy will be radiated, depends inversely upon the temperature of an object. Thus, as an object gets hotter, the peak radiation will come from shorter wavelengths and vice-versa. Figure 2 shows a theoretical plot of the energy emitted by three perfect blackbody radiators of different temperature. An object that has a temperature of 4000 *K*, has its peak energy being radiated at about 750 nanometers, which is in the near infrared. An object that has a surface temperature of 6000 K, though, has its peak energy being radiated at about 500 nanometers, which is in the green region of the visible spectrum. How these objects will appear to the human eye is determined by just how much energy is in each of the visible wavelengths. The first object will appear a very dim red, while the second (which is close to our Sun's temperature of 5800 K) will appear a bright white that has a hint of yellow.

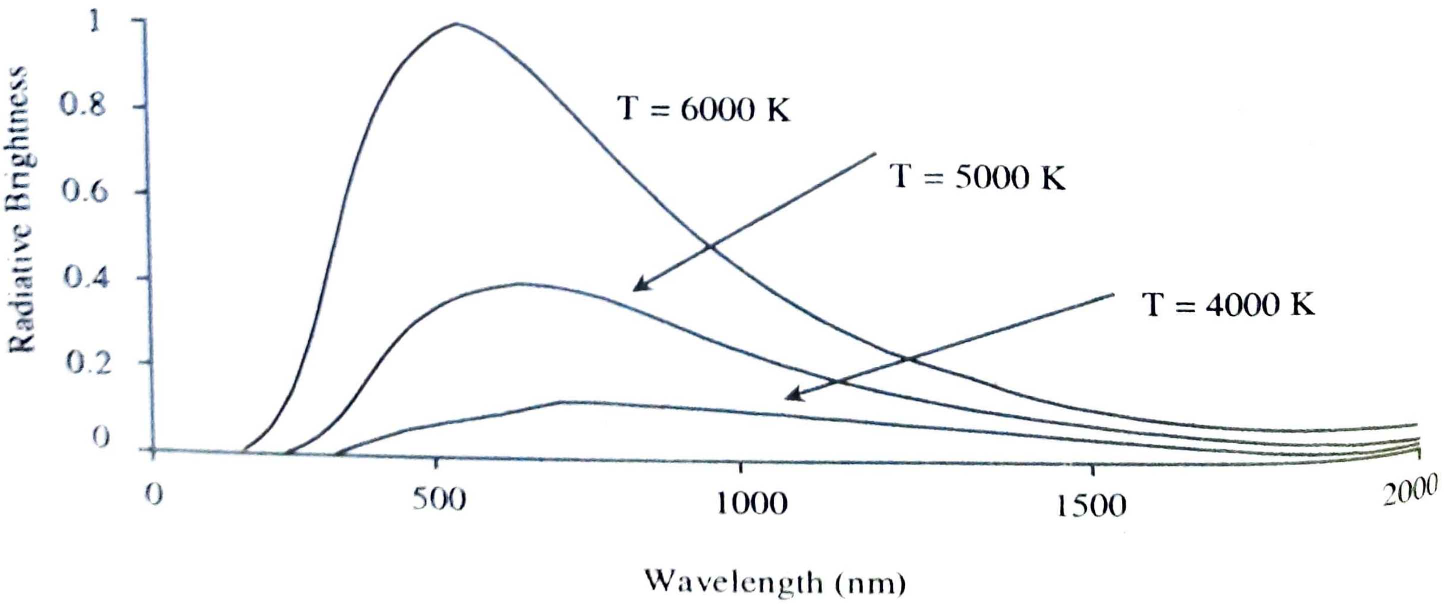

Figure 1 : Brightness vs. wavelength for various temperatures

While our Sun is not a perfect blackbody radiator, its output is fairly close to that described ove. It radiates 1.6 x 10^7 watts of power per square meter from its surface at all wavelengths. wever, by the time that it has reached the Earth's surface, this value is vastly reduced. Between Sun's and the Earth's surfaces, the energy density of the radiation is lessened by spreading and sorption. Light travelling from a spherical object such as the Sun, must spread to fill all ailable space. While the total amount of energy of the radiation will remain the same, the ount of energy crossing any square meter of space will be reduced by the square of the distance tween the object and the area in question. Since the Sun is almost 150 million kilometers from Earth, the energy density per unit time of the Sunlight reaching the upper atmosphere of the rth is only 1340 W/m^2.