

POTENTIAL FOR SOLAR ENERGY USE

1. How far from a 100-W light bulb is the radiation intensity the same as sunlight on Earth (assume that no energy is lost in the atmosphere)? (Hint: Intensity is power per unit area (W/m^2); set intensity from light bulb equal to that from the Sun on Earth.) For the calculation, assume that all the power used by the light bulb is converted into radiation.

2. The electricity consumption in the United States in the year 2001 was about 3600 billion kWh ("kilo-watt-hour"), and in the whole world, 13,900 billion kWh (data from "International Energy Annual"; <http://www.eia.doe.gov/emeu/iea/table62.html>). A kWh is a measurement of the amount of energy supplied by 1 kW in one hour. For example, if a 100-W light bulb is on for 10 hours, the energy used is 1 kWh of energy.

a) How does 1 kWh relate to Joules?

[Hint: kWh and J are both units of energy.

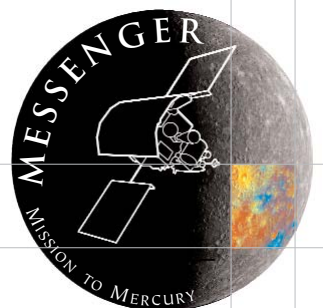
1 kWh = 1 kilowatt \times 1 hour

How many seconds are there in an hour?

How does Watt relate to Joule?

What is the final conversion factor from kWh to Joules?]

b) What is the electricity consumption of the United States and the world in Joules?



c) If we were able to capture all solar radiation arriving on Earth (at the top of the atmosphere) and convert it to electricity with 100% efficiency, how long would we need to capture this energy to satisfy the electricity consumption for the whole year for the United States? The world? (Hint: calculate the cross-sectional area of Earth.)

d) Is it actually possible to capture the Sun's energy with 100% efficiency over the whole Earth (on top of the atmosphere)? Why or why not?

Useful Formulae and Constants

Surface Area of Sphere = $4\pi r^2$ (where r is the radius of the sphere)

Cross-sectional Area of Sphere = πr^2 (where r is the radius of the sphere)

Astronomical Unit (1 AU = average Earth-Sun distance) = 1.50×10^{11} m

Solar Constant = 1370 W/m^2 (Remember: $1 \text{ W} = 1 \text{ J/s}$)

Radius of the Earth = 6.37×10^6 m

Power of the Sun = 3.83×10^{26} W.

