Exercise 1.87

The total rate at which power is used by humans worldwide is approximately 15 TW (terawatts). The solar flux averaged over the sunlit half of Earth is 680 W/m^2 (assuming no clouds). The area of Earth's disc as seen from the sun is 1.28×10^{14} m^2. The surface area of Earth is approximately 197,000,000 square miles. How much of Earth's surface would we need to cover with solar energy collectors to power the planet for use by all humans? Assume that the solar energy collectors can convert only 10% of the available sunlight into useful power.

Solution

The amount of useful power generated per square meter is 10% of the solar flux.

$$680 \ \frac{\text{W}}{\text{m}^2} \times 10\% = 68 \ \frac{\text{W}}{\text{m}^2}$$

Given that the total energy consumption is 15 TW, the amount of surface area on Earth that needs to be covered in solar panels is

$$15 \ \cancel{\text{TW}} \times \frac{10^{12} \ \cancel{\text{W}}}{1 \ \cancel{\text{TW}}} \times \frac{1 \ \text{m}^2}{68 \ \cancel{\text{W}}} \approx 2.2 \times 10^{11} \ \text{m}^2.$$