.

Physics of Human Energy Use
Assignment 9

Due November 19, 2010

1) If you run a heat pump with a SEER of 15 and power it with electricity generated in a coal-burning plant with thermal efficiency 40%, what is the ratio between the energy input into this system and the heat brought into the house?

2) A typical American house has about 250 m^2 of floor space spread over two floors. Suppose that its footprint is square, each story requires 3m of height, and (for simplicity) that its roof is flat. Windows generally occupy about 4% of the wall area. For the following questions, assume that the inside-outside temperature difference is 20 C. You can also use these facts and relations:

The minimum ventilation requirement is 15 (A/100m^2)l/s + 3.5 l/(s-person), where the relevant area for the first term is the total floor area. The specific heat of air is 1×10^3J/(m^3-C) and its thermal conductivity is 0.024 J/(m-s-C).

a) If there are four people inside, what is the minimum heating power associated with ventilation?

b) If you insulate all the walls and roof with a material having a thermal conductivity of 0.02 J/(m-s-C) (e.g., sprayed insulation), how thick must it be in order to reduce the heat lost through the walls and roof to less than the minimum heat required to warm the ventilating air?

c) Similarly, if the windows are double-paned glass, how thick must their trapped air space be in order to keep the heat lost through the windows less than the minimum ventilation heating power?

d) If the mean daytime angle of incidence between sunlight and a south-facing window is 45° and half the sunlight arriving at the top of the atmosphere reaches ground level, how large must that window be so that during 10 hours of daylight the solar energy entering the house is equal to the ventilation heating energy for a full 24 hr day?