1 Heat pump

(a) Show that for a reversible heat pump the energy required per unit of heat delivered inside the building is given by the Carnot efficiency:

$$\frac{W}{Q_H} = \eta_C = \frac{T_H - T_C}{T_H} \tag{1}$$

What happens if the heat pump is not reversible?

(b) Assume that the electricity consumed by a reversible heat pump must itself be generated by a Carnot engine operating between the even hotter temperature T_{HH} and the cold (outdoors) temperature T_C. What is the ratio $\frac{Q_{HH}}{Q_H}$ of the heat consumed at T_{HH} (i.e. fuel burned) to the heat delivered at T_H (in the house we want to heat)? Give numerical values for $T_{HH} = 600\text{K}$; $T_H = 300\text{K}$; $T_C = 270\text{K}$.

(c) Draw an energy-entropy flow diagram for the combination heat engine-heat pump, similar to Figures 8.1, 8.2 and 8.4 in the text (or the equivalent but sloppier) figures in the course notes. However, in this case we will involve no external work at all, only energy and entropy flows at three temperatures, since the work done is all generated from heat.