Given: $kJ := 1000J$

A heat pump is used to meet the heating requirements of a house and maintain it at 20°C. On a day when the outdoor air temperature drops to -2°C, the house is estimated to lose heat at a rate of 80,000 kJ/hr.

Required:

If the heat pump under these conditions has a COP of 2.5, determine the power consumed by the heat pump and the rate at which heat is absorbed from the cold outdoor air.

Solution:

Assuming the heat needed to maintain the desired temperature in the house is the same as the heat that is being lost by the house, the heat rejected by heat pump may then be defined as

$$Q'_H := 80000 \frac{kJ}{hr} = 22.222 \cdot kW$$

The COP of the heat pump is defined as

$$COP_{HP} := 2.5$$

Using the definition of COP, the net work supplied to the heat pump may be found. This is shown below.

$$COP_{HP} = \frac{Q'_H}{W'_{net,in}} \qquad \text{or} \qquad \boxed{W'_{net,in} := \frac{Q'_H}{COP_{HP}} = 8.889 \cdot kW}$$

The heat supplied to the heat pump may then be found by

$$\boxed{Q'_L := Q'_H - W'_{net,in} = 13.33 \cdot kW}$$

This illustrates the cost savings of a heat pump in comparison with a simple resistance heater. When using a heat pump, the required electricity is $W'_{net,in} = 8.889\,kW$. However, when using a simple resistance heater, the required electricity is $Q'_H = 22.22\,kW$ (it actually may be more when considering efficiency of the heater).