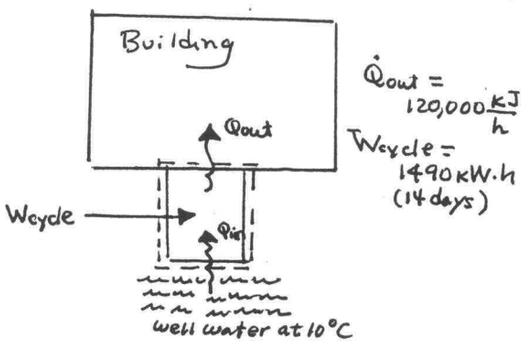
PROBLEM 2.90

KNOWN: Operating data are provided for a heat pump cycle operating at steady state while receiving energy by heat transfer from well water.

FIND: Determine the amount of energy received from well water and the heat pump's coefficient of performance.

SCHEMATIC & GIVEN DATA:



ENGR. MODEL:

1. The heat pump is the system.
2. The building and well water play the roles of hot and cold bodies, respectively.
3. The heat pump operates at steady state.
4. All energy transfers are positive in the directions of the arrows.

ANALYSIS:

(a) Applying an energy balance using assumption 4 (Eq. 2.44),

$$W_{cycle} = Q_{out} - Q_{in} \Rightarrow Q_{in} = Q_{out} - W_{cycle}$$

($\dot{Q}_{out}$ 4t)

$$Q_{out} = (120{,}000 \tfrac{kJ}{h}) \left| \tfrac{24\,h}{day} \right| (14\ days)$$

$$= 40.32 \times 10^6\ kJ$$

$$W_{cycle} = (1490\ kW \cdot h) \left| \tfrac{1\ kJ/s}{1\ kW} \right| \left| \tfrac{3600\,s}{1\,h} \right| = 5.364 \times 10^6\ kJ$$

Thus

$$Q_{in} = (40.36 - 5.364) \times 10^6\ kJ = 34.956 \times 10^6\ kJ \quad \leftarrow Q_{in}$$

(b) Apply Eq. 2.47

$$\gamma = \frac{Q_{out}}{W_{cycle}} = \frac{40.36 \times 10^6\ kJ}{5.364 \times 10^6\ kJ} = 7.52 \quad \leftarrow \gamma$$