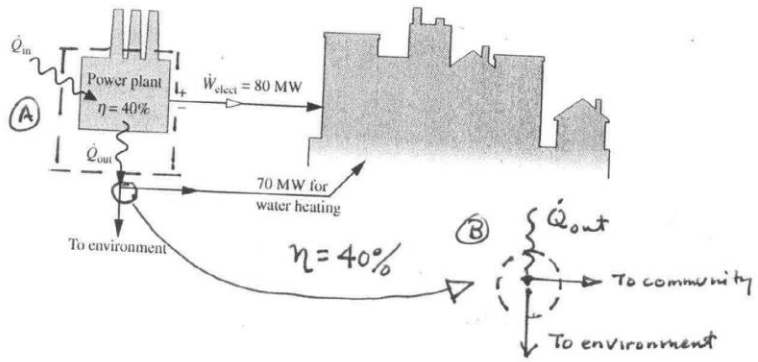
PROBLEM 2.87

KNOWN: Operating data are provided for a cogeneration power plant operating in a thermodynamic cycle at steady state.

FIND: Determine the rates at which energy is added by heat transfer and discarded to the environment. Also determine the value of the electricity generated.

SCHEMATIC & GIVEN DATA:



ENR. MODEL

1. As shown in the schematic, two systems — A and B — are considered.
2. Each system is at steady state. System A operates on a thermodynamic cycle.
3. Electricity is valued at \$0.08 per kW·h

ANALYSIS:

(a) $\eta = \dfrac{\dot{W}_{elect}}{\dot{Q}_{in}} \Rightarrow \dot{Q}_{in} = \dfrac{\dot{W}_{elect}}{\eta} = \dfrac{80\,MW}{0.40} = 200\,MW$ ← $\dot{Q}_{in}$

For the power plant, $\dot{W}_{cycle} = \dot{Q}_{cycle}$. That is

$$\dot{W}_{elect} = \dot{Q}_{in} - \dot{Q}_{out} \Rightarrow \dot{Q}_{out} = \dot{Q}_{in} - \dot{W}_{elect}$$
$$= (200 - 80)\,MW = 120\,MW$$

(b) Considering system B,

$$\dot{Q}_{out} = \dot{Q}_{to\,environment} + \dot{Q}_{community}$$ (All terms are positive in the directions of the arrows.)

$$\Rightarrow \dot{Q}_{to\,environment} = \dot{Q}_{out} - \dot{Q}_{community}$$
$$= 120\,MW - 70\,MW = 50\,MW$$ ← To environment

(c) $$\left[\begin{matrix}\text{Annual Value} \\ \text{of Electricity}\end{matrix}\right] = (80\,MW)\left|\frac{10^3\,kW}{1\,MW}\right|\left(365 \times 24\,\frac{h}{year}\right)\left(\frac{\$0.08}{kW\cdot h}\right)$$

$$= \$\,56.1\,M/year$$ ← Annual value