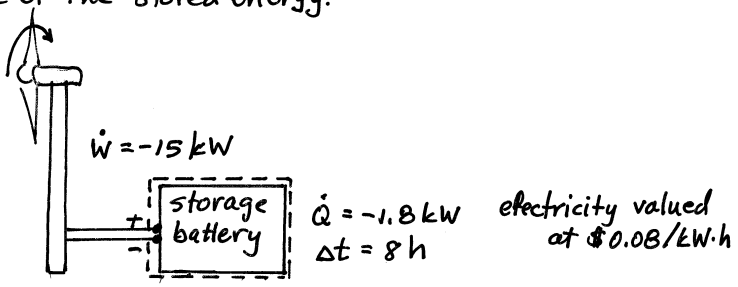
PROBLEM 2.59

KNOWN: A storage battery is charged by the electric power output from a windmill. The work and heat transfer rates are known.

FIND: Determine for 8 h of operation (a) the total amount of energy stored and (b) the value of the stored energy.

SHEMATIC & GIVEN DATA:



ASSUMPTIONS: (1) The battery is a closed system. (2) The work and heat transfer rates are constant.

ANALYSIS: (a) The amount of energy stored is found from an energy balance

$$\Delta E = Q - W \qquad (*)$$

To evaluate Q and W, respectively

$$Q = \int_{t_1}^{t_2} \dot{Q}\,dt = \dot{Q}\,\Delta t = (-1.8\ \text{kW})(8\ \text{h}) = -14.4\ \text{kW·h}$$

$$= (-14.4\ \text{kW·h})\left|\frac{1\ \text{kJ/s}}{1\ \text{kW}}\right|\left|\frac{3600\ \text{s}}{1\ \text{h}}\right|$$

$$= -51{,}840\ \text{kJ}$$

$$W = \int_{t_1}^{t_2} \dot{W}\,dt = \dot{W}\,\Delta t = (-15\ \text{kW})(8\ \text{h}) = -120\ \text{kW·h}$$

$$= (-120)\left|\frac{1}{1}\right|\left|\frac{3600}{1}\right| = -4.32\times10^{5}\ \text{kJ}$$

Inserting these results in (*)

$$\Delta E = (-51{,}840) - (-4.32\times10^{5}) = 3.8\times10^{5}\ \text{kJ} \longleftarrow \Delta E$$

(b) If electricity is valued at $0.08/kW·h

$$\text{value of stored energy} = (3.8\times10^{5}\ \text{kJ})\left|\frac{1\ \text{kW}}{1\ \text{kJ/s}}\right|\left|\frac{1\ \text{h}}{3600\ \text{s}}\right|(\$0.08/\text{kW·h})$$

$$= \$\,8.45 \longleftarrow \text{value}$$