ENERGY EFFICIENCY

MRN023

η = 1st law efficiency = $\dfrac{\text{energy out}}{\text{energy in}}$

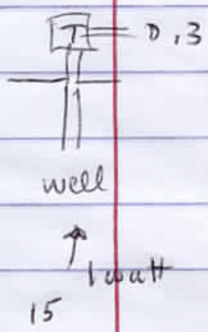
e_c = Carnot effic.

ε = 2nd law efficiency = $\dfrac{\text{energy needed in the ideal machine}}{\text{energy actually used}}$

Geothermal power plant

source: Heat Q_1 from hot reservoir at T_1

use: work W_{out} — ambient temp. T_0



$$\eta = \frac{W_{out}}{Q_1}$$

$$e_c = \frac{T_1 - T_0}{T_1} = 1 - \frac{T_0}{T_1} \qquad e_c < 1$$

$$\varepsilon = \frac{\eta}{e} = \frac{\eta}{1 - T_0/T_1}$$

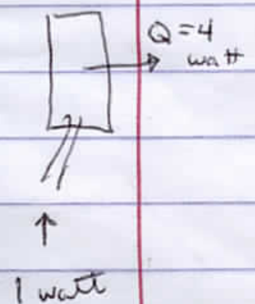
example $\eta = 0.3$ $T_1 = 500\,K$ $T_0 = 300\,K$

$e_c = 0.4$ $\varepsilon = \dfrac{0.3}{0.4} = 0.75$

Electric Refrigerator

source: work W_{in}

end use: heat Q_3 extracted from cool reservoir at T_3 (ambient temp T_0)



$$\eta = \frac{Q_3}{W_{in}}$$

$$e_c = \frac{T_3}{T_0 - T_3} = \frac{1}{\frac{T_0}{T_3} - 1} \qquad e_c > 1$$

$$\varepsilon = \eta\left(\frac{T_0}{T_3} - 1\right)$$

example $\eta = 4$ $T_0 = 300\,K$ $T_3 = 250\,K$ $\dfrac{T_0}{T_3} = \dfrac{6}{5}$

$e_c = 5$ $\varepsilon = \dfrac{4}{5} = 0.8$