Clausius Statement, its equivalence to Kelvin-Planck Statement and the impossibility of perpetual motion machine

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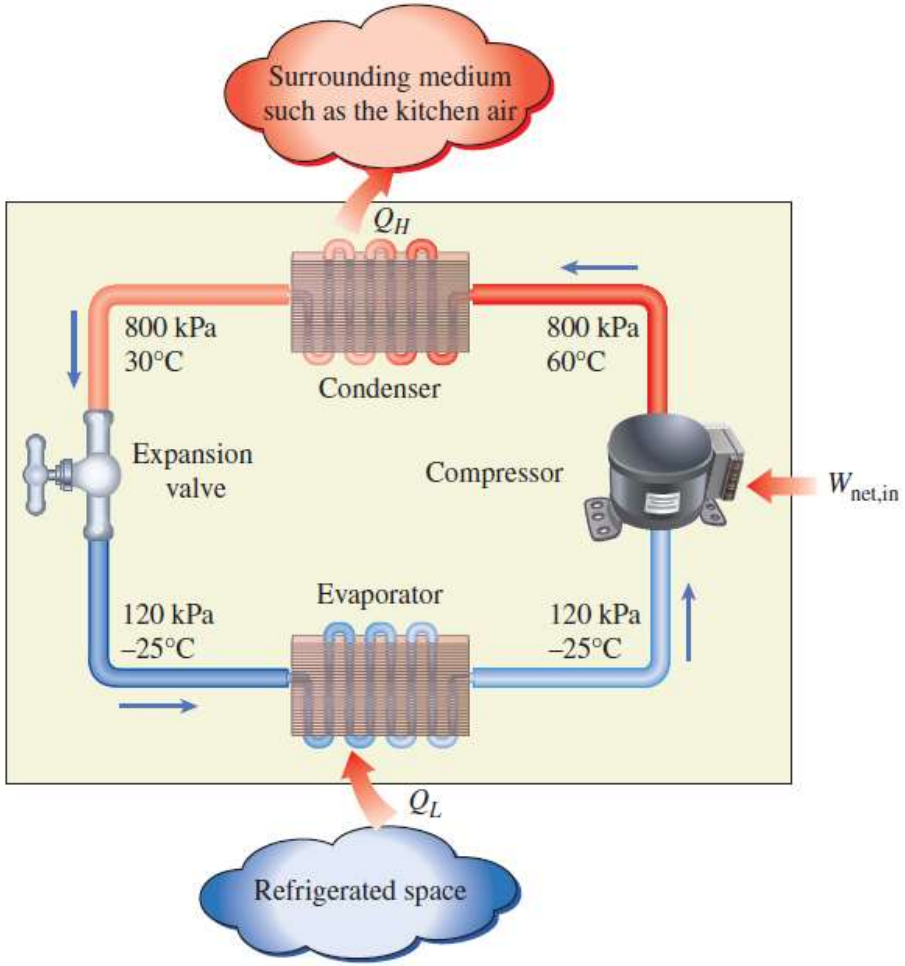
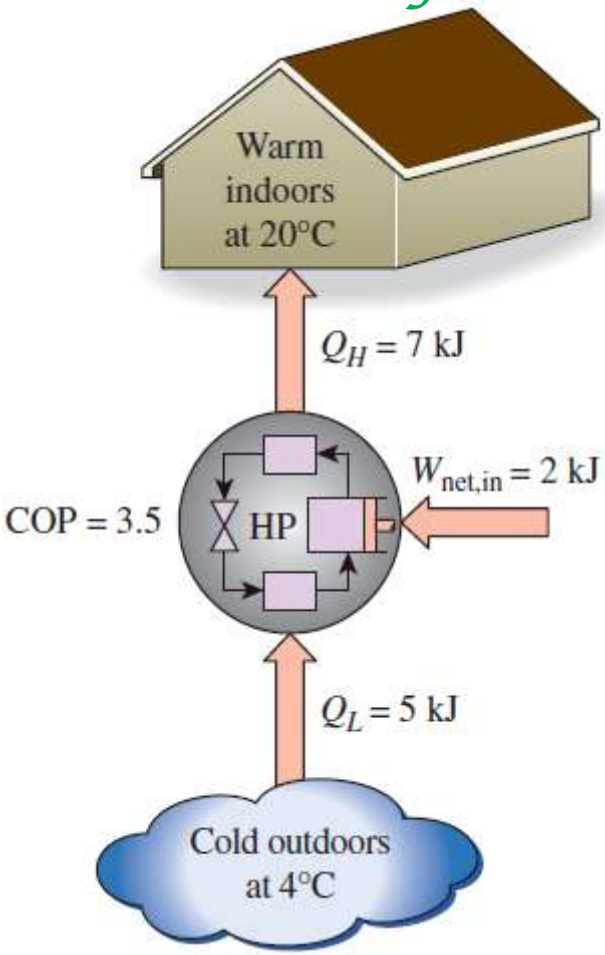
Previous Lecture: Refrigeration & Heat Pumps





$$\text{COP}_R = \frac{\text{Desired output}}{\text{Required input}} = \frac{Q_L}{W_{net,in}}$$

$$\text{COP}_R = \frac{Q_L}{Q_H - Q_L} = \frac{1}{Q_H/Q_L - 1}$$

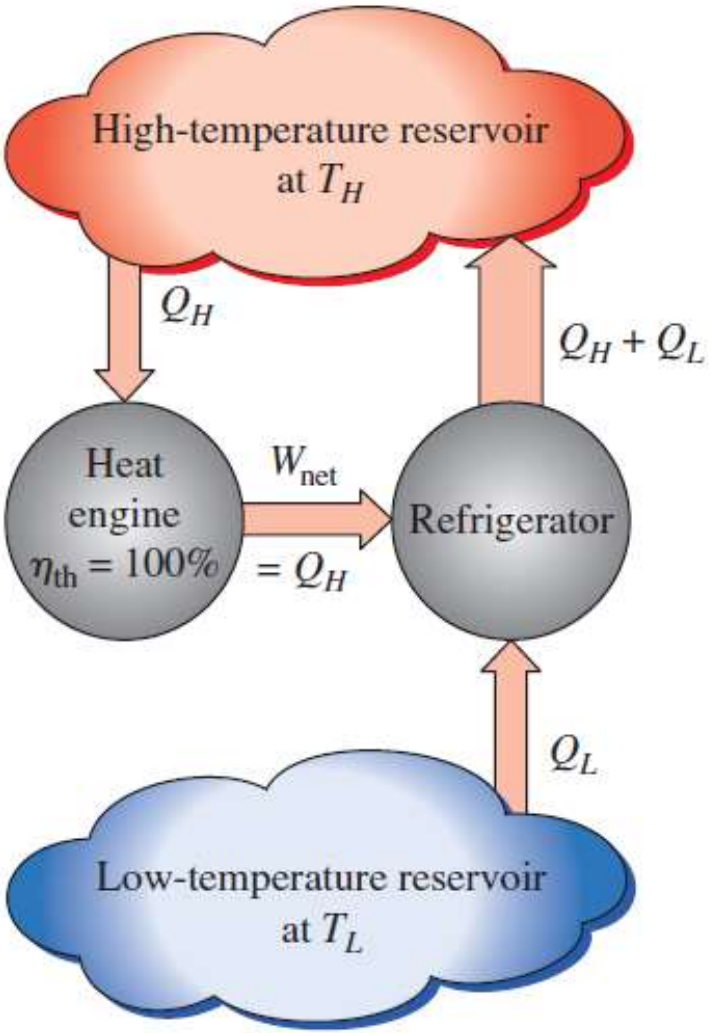
$$\text{COP}_{HP} = \frac{\text{Desired output}}{\text{Required input}} = \frac{Q_H}{W_{net,in}}$$

Figs: Cengel & Boles: TD

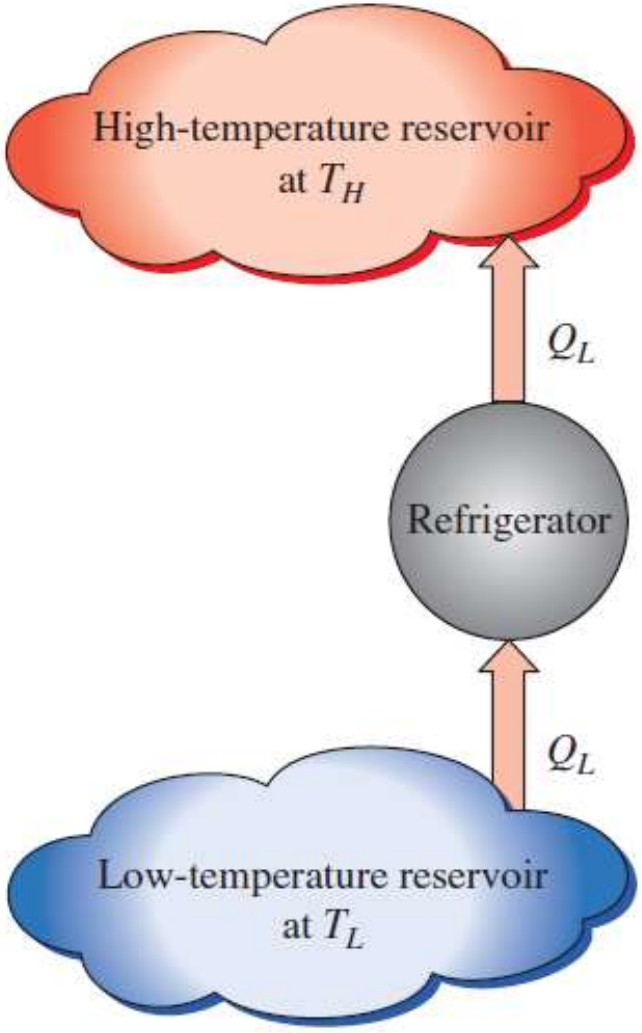
Clausius Statement of 2nd Law of TD

"It is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower-temperature body to a higher-temperature body."

Violation of K-P's statement implies violation of Clausius



(*a*) A refrigerator that is powered by a 100 percent efficient heat engine



(*b*) The equivalent refrigerator

Figs: Cengel & Boles: TD

Violation of Clausius' statement implies violation of K-P…

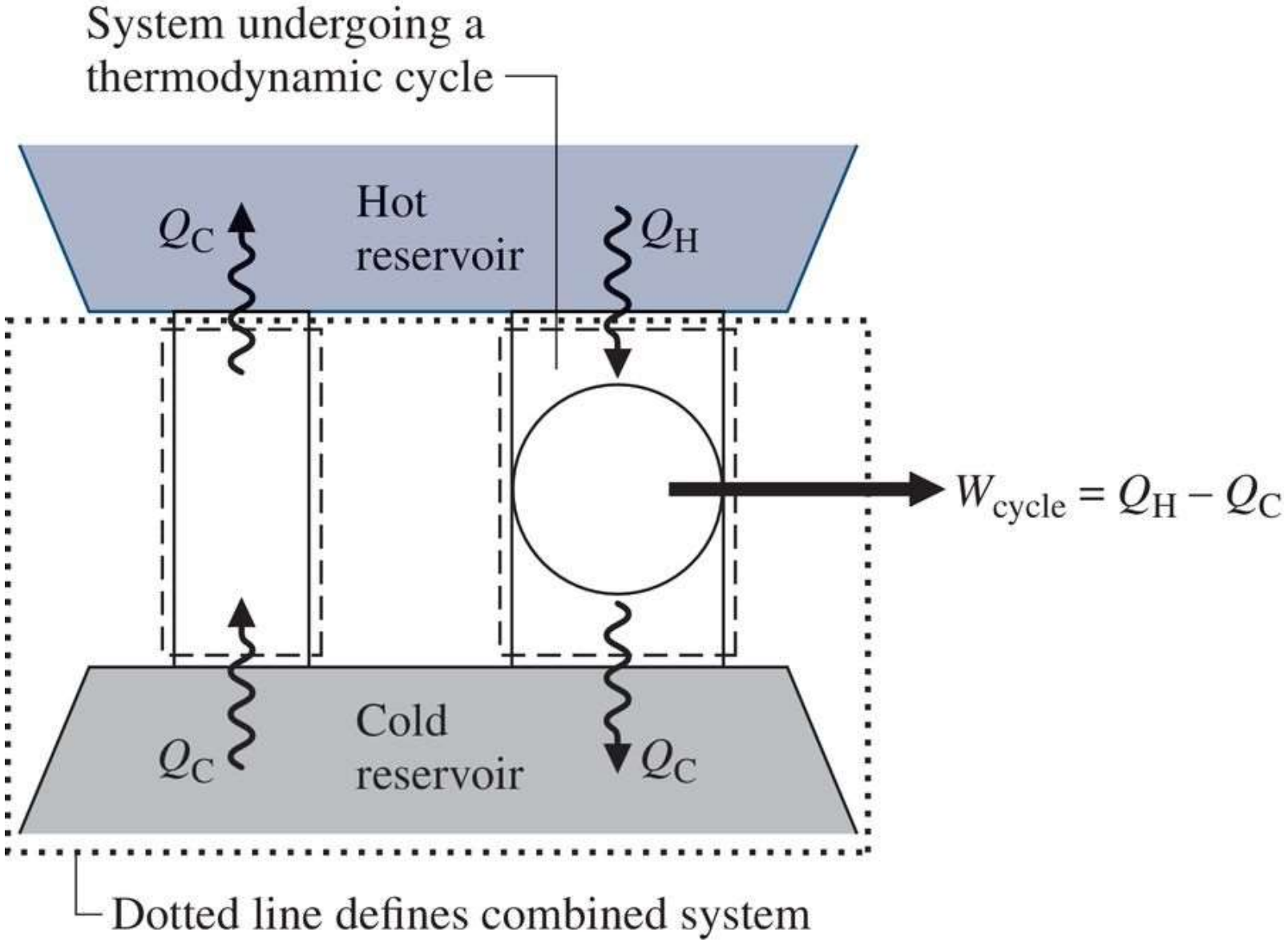
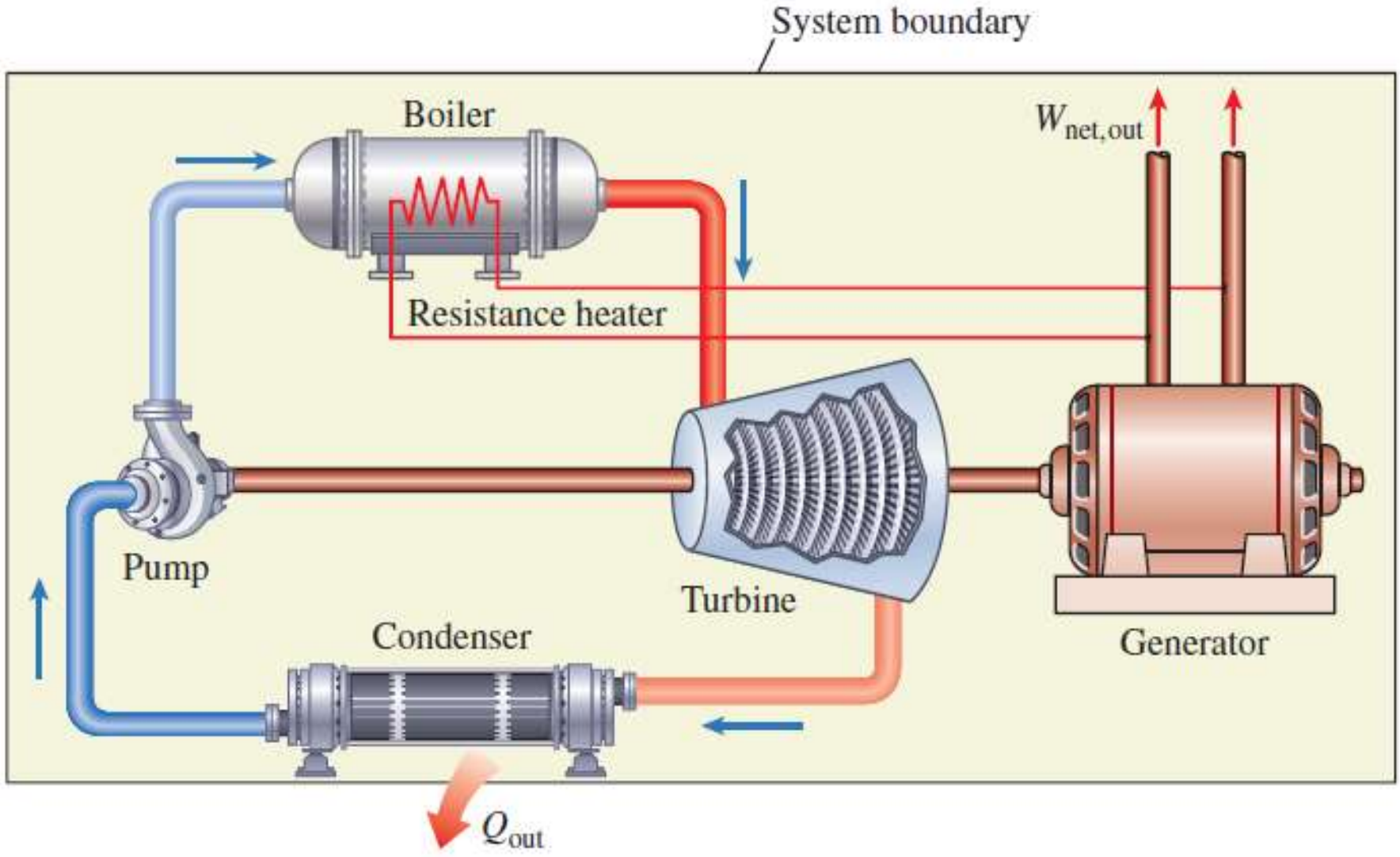


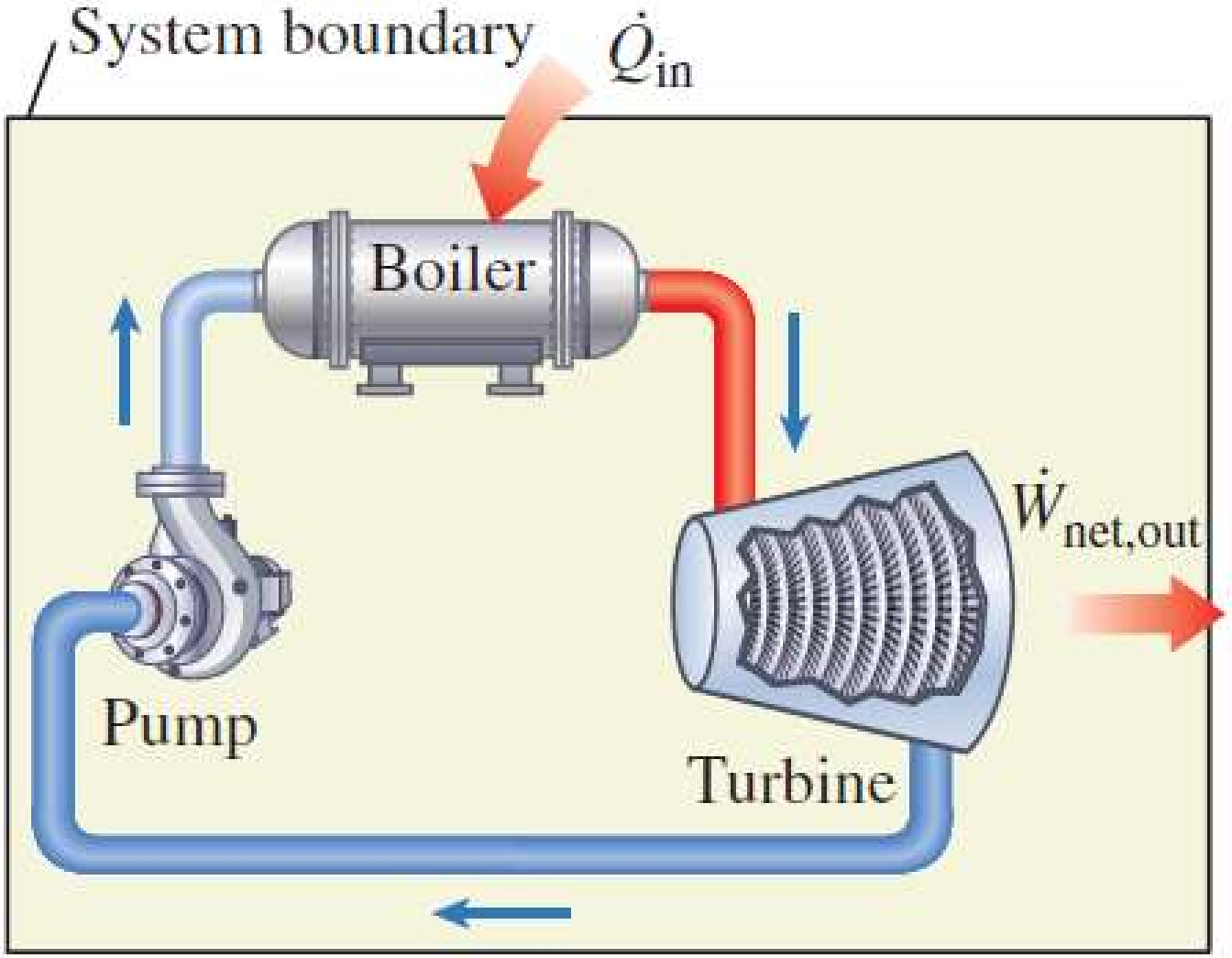
Fig: Cengel & Boles: Moran, Shapiro, Boettner, Bailey

Perpetual motion machine violating 1st TD law



Figs: Cengel & Boles: TD

Perpetual motion machine violating 2nd TD law



Figs: Cengel & Boles: TD

What's next?

- Reversible & irreversible processes