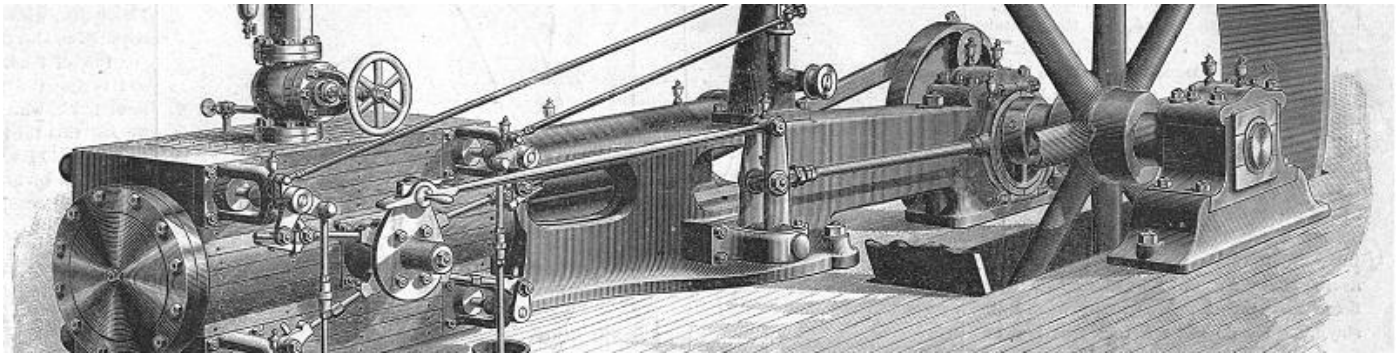
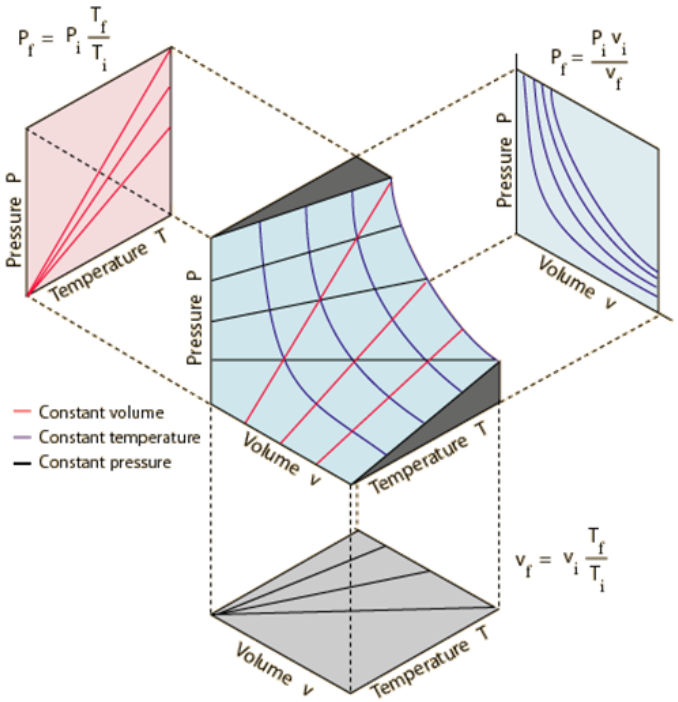
Thermodynamics



The first law: a heat engine balances internal energy, heat and work

$$\Delta U = Q - W$$

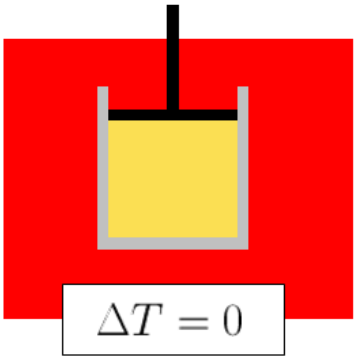
The ideal gas provides the simplest system to consider in thermodynamics



$$PV = nRT$$

$$U = \frac{3}{2}nRT$$

Work done by an ideal gas within isothermal and adiabatic process can be calculated



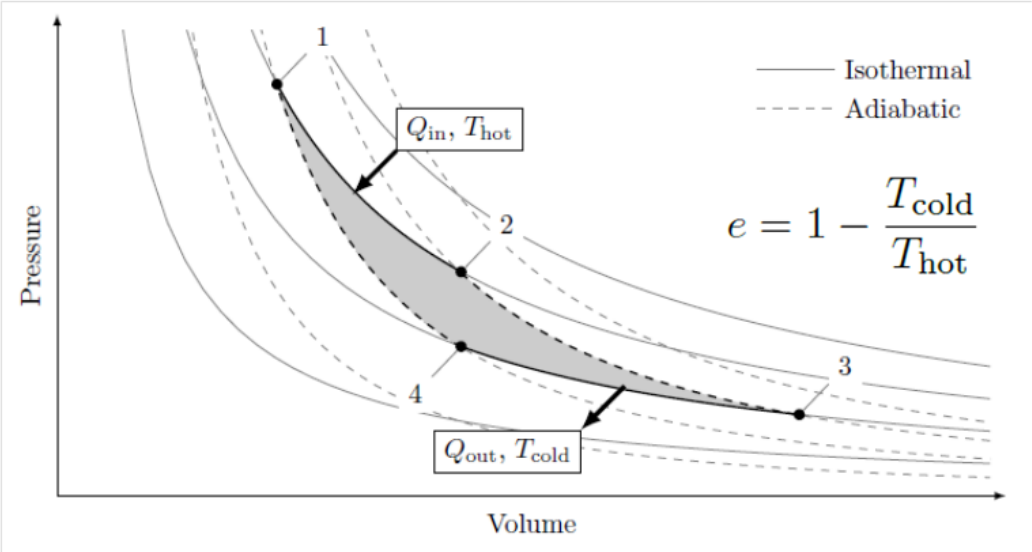
$$W_{\text{isoth}} = nRT \ln(V/V_0)$$

$$PV = \text{const.}$$

$$W_{\text{adiab}} = -\tfrac{3}{2} nR\Delta T$$

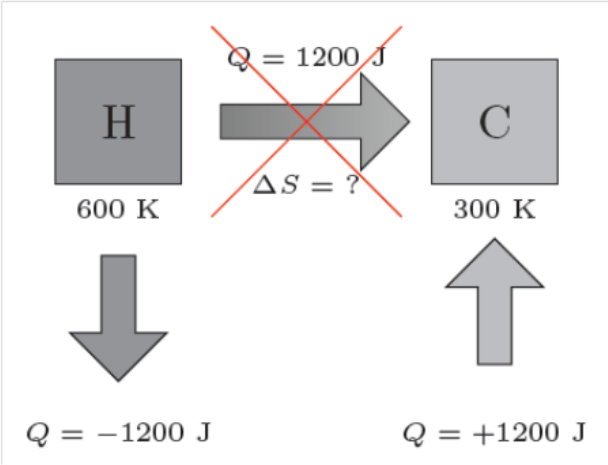
$$PV^{\gamma} = \text{const.}$$
$$\gamma = 5/3$$

The Carnot heat engine is reversible and is therefore the upper bound on efficiency



Another perspective on entropy: energy irreversibly lost to mechanical work

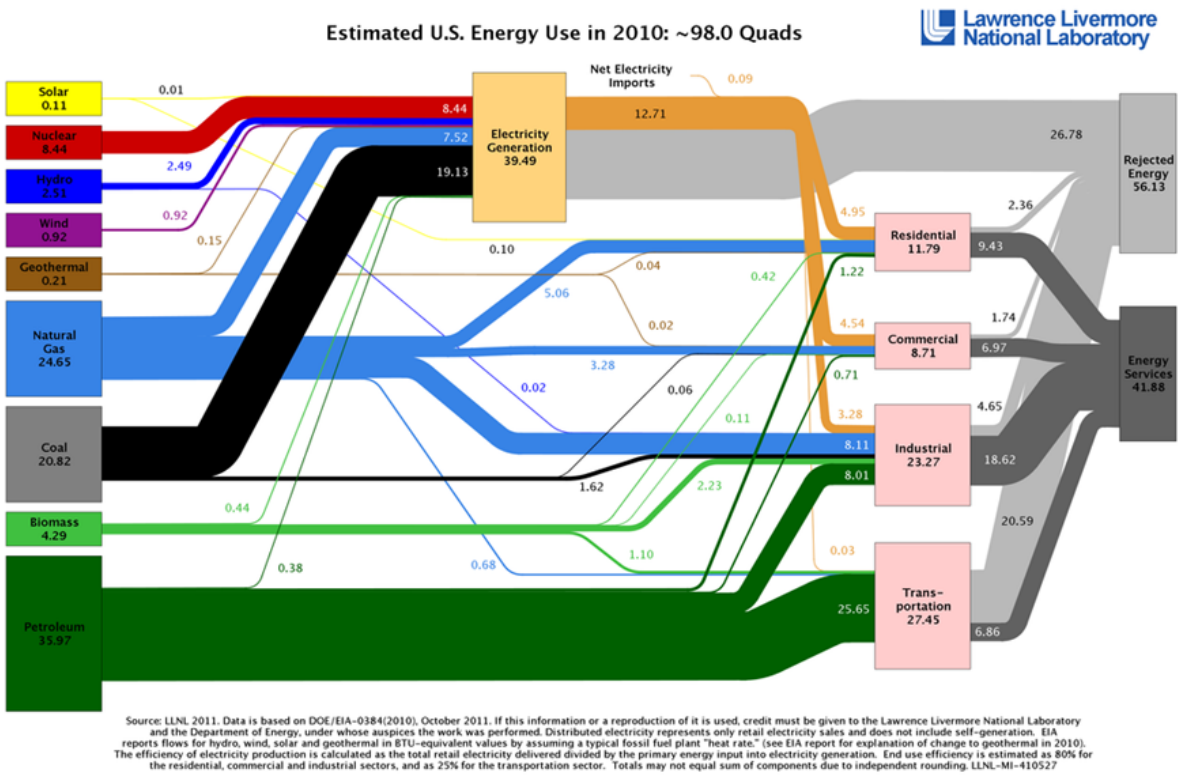
Any decrease in system entropy must come from a larger increase somewhere else



$$\Delta S = Q/T$$

$$\boxed{\Delta S \geq 0}$$

Practical questions about the most efficient use of global energy is challenging



Nearly all electricity generated in the US comes ultimately from steam engines