Solutions

2.1

- $\eta_C = 1 - 320/900 = \mathbf{0.644}$.
- $0.67 > 0.644$ exceeds the Carnot bound, so the claim is impossible - no prototype needed.

2.2

- $Q_L = Q_H\, T_L/T_H = 2000 \times 320/900 = \mathbf{711.1}$ kJ.
- $W = 2000 - 711.1 = \mathbf{1288.9}$ kJ.
- $\Delta S_{hot} = -2000/900 = \mathbf{-2.222}$, $\Delta S_{cold} = +711.1/320 = \mathbf{+2.222}$ kJ/K ✓ - the universe is unchanged: reversible.

2.3

- $\sigma = Q(1/300 - 1/600) = 1500 \times 0.003333 - 1500 \times 0.001667 = \mathbf{2.50}$ kJ/K.
- Lost work $= T_0\sigma = 300 \times 2.50 = \mathbf{750}$ kJ.

2.4

- The definition evaluates $\int \delta q/T$ along a path where the system is in internal equilibrium; on an irreversible path the same integral underestimates the change - use the entropy balance with σ instead.
- Throttling keeps h while dropping p irreversibly, so $s_2 > s_1$ with $q = 0$: $\sigma = s_2 - s_1 > 0$.

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