Carnot Principle and Carnot Cycle

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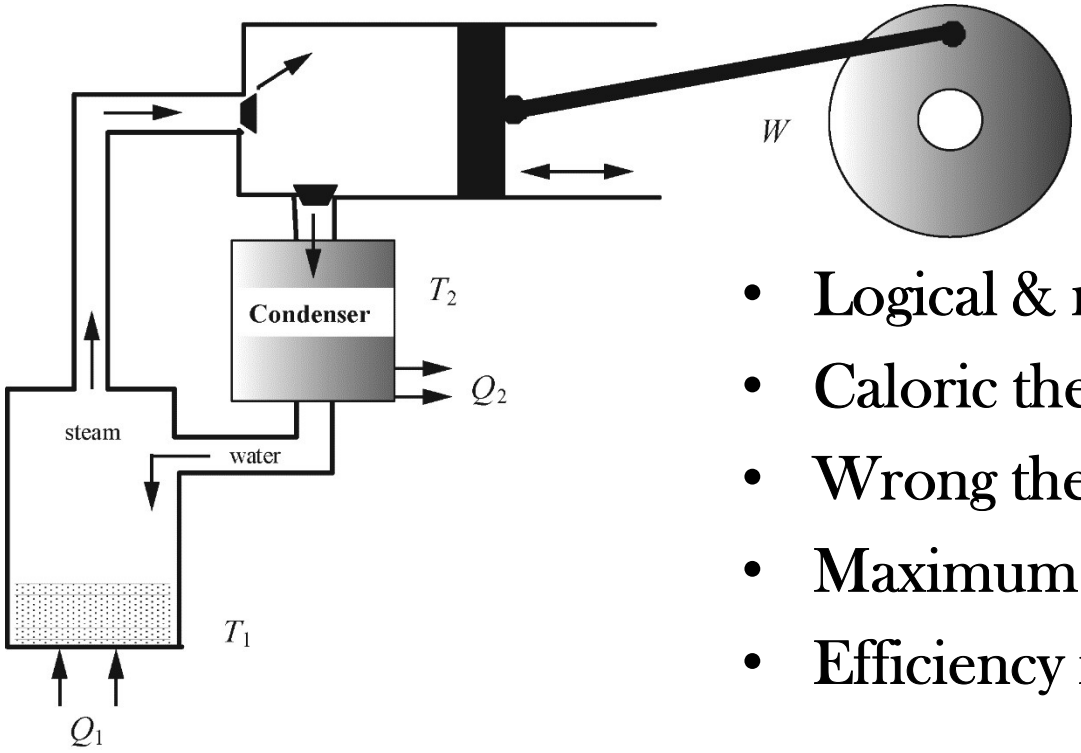
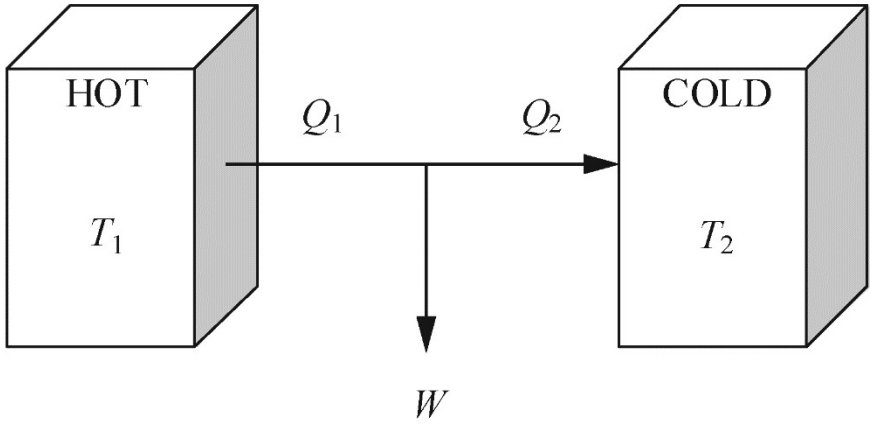
Previous Lecture: Reversible and Irreversible Processes

- All real processes are irreversible!
- Some characteristic features of irreversible processes were elaborated
- Reversible processes are asymptotes to reality and provide bounds (in COP, **η)** for real processes

Motivation for Sadi Carnot: Steam and heat engines



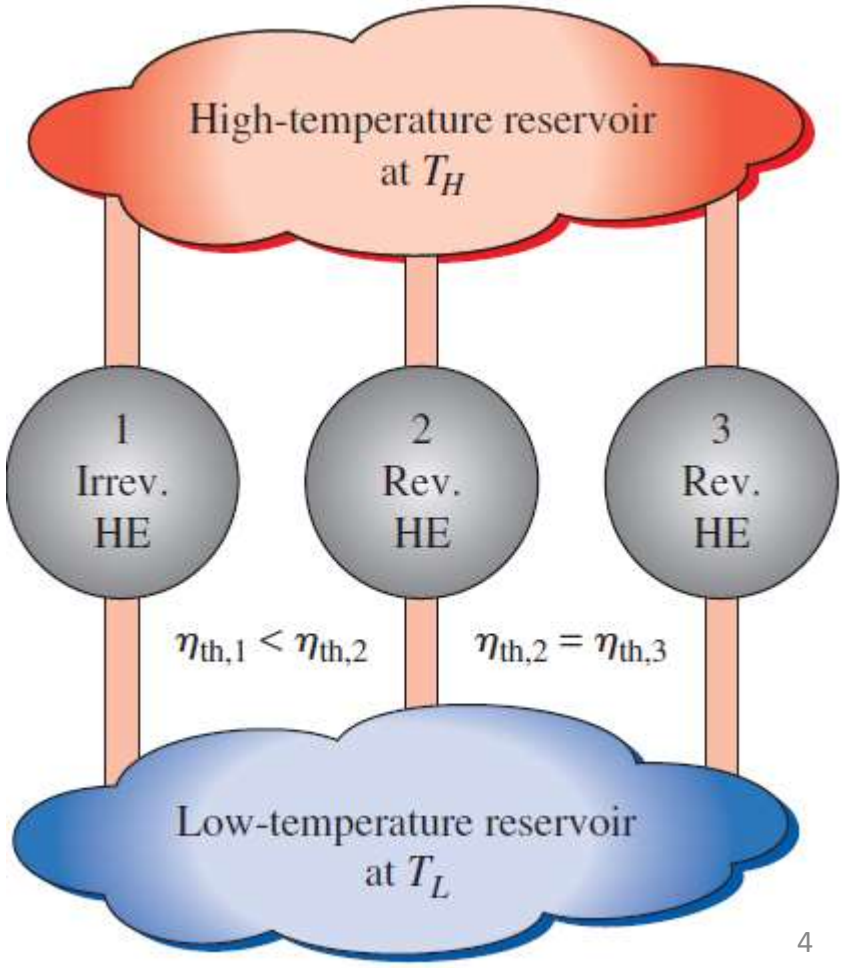
- Logical & non-mathematical arguments
- Caloric theory of heat as basis
- Wrong theory to get right results!
- Maximum effeiciency by a reversible cycle
- Efficiency independent of engine fluid



Figs: TD-Kondepudi & Prigogine

Carnot principles

1. The efficiency of an irreversible heat engine is always less than the efficiency of a reversible one operating between the same two reservoirs.
2. The efficiencies of all reversible heat engines operating between the same two reservoirs are the same.

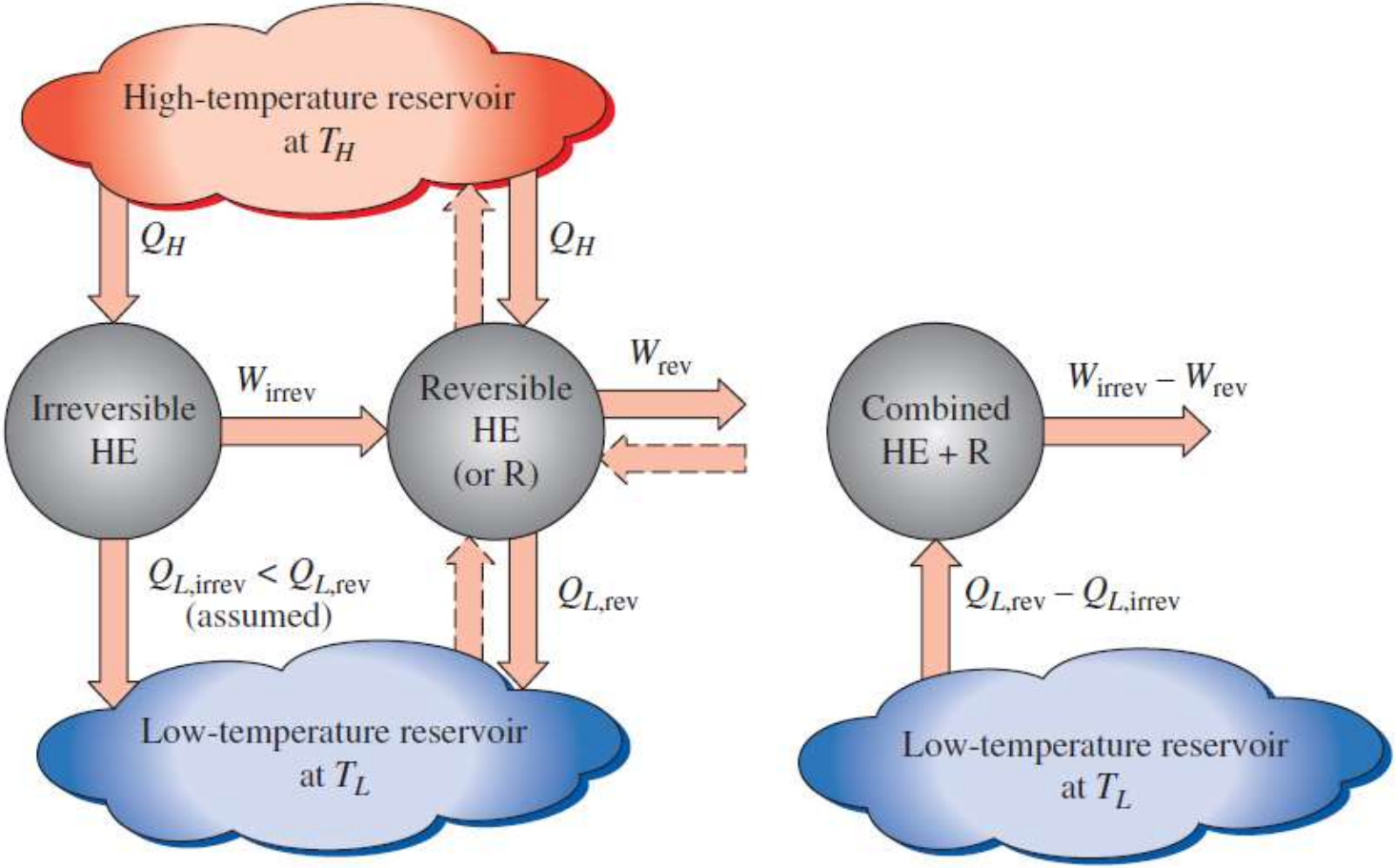


Figs: TD-Cengel & Boles

Logical Argument of Carnot-Principle 1

To be proved: The efficiency of an irreversible heat engine is always less than the efficiency of a reversible one operating between the same two reservoirs.

"Thought experimental device": Violates Kelvin-Planck 2nd TD law Statement



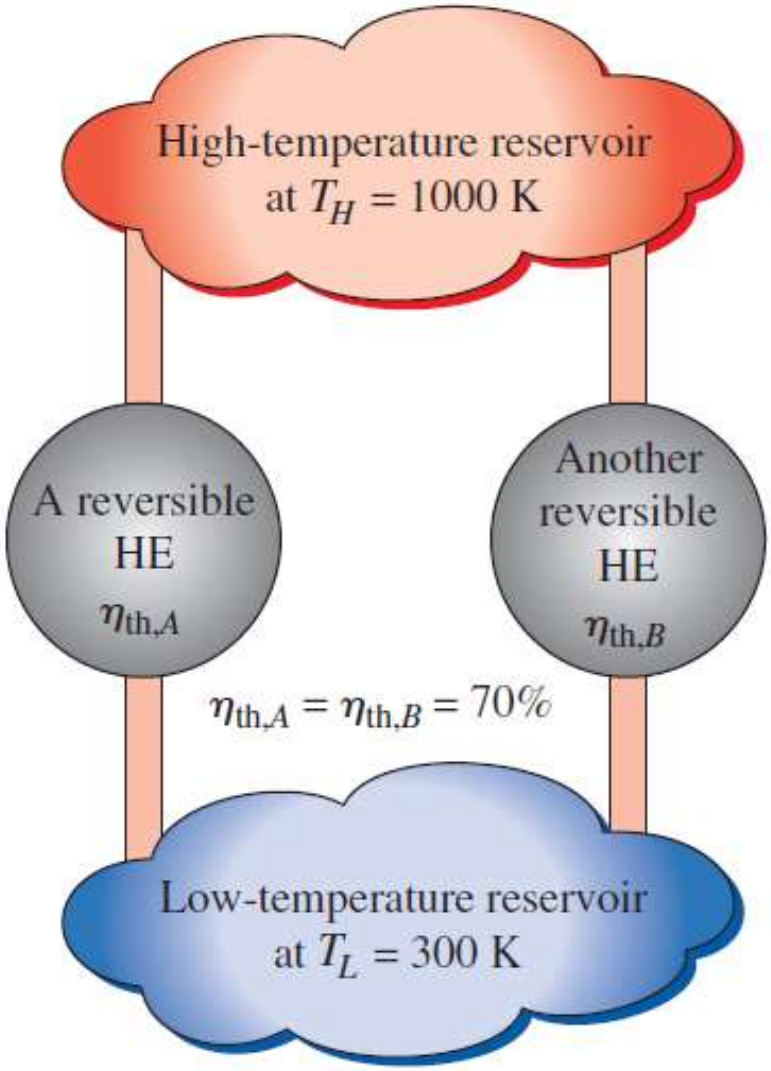
(*a*) A reversible and an irreversible heat engine operating between the same two reservoirs (the reversible heat engine is then reversed to run as a refrigerator)

(*b*) The equivalent combined system

Figs: TD-Cengel & Boles

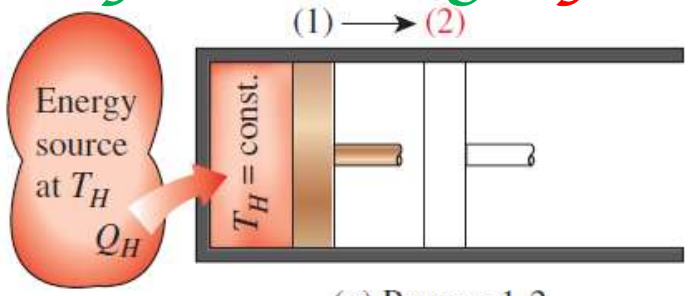
Logical Argument of Carnot-Principle 2

To be proved: The efficiencies of all reversible heat engines operating between the same two reservoirs are the same.

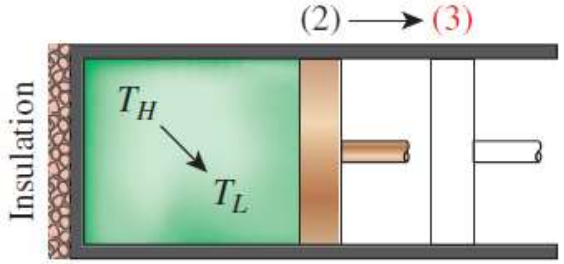


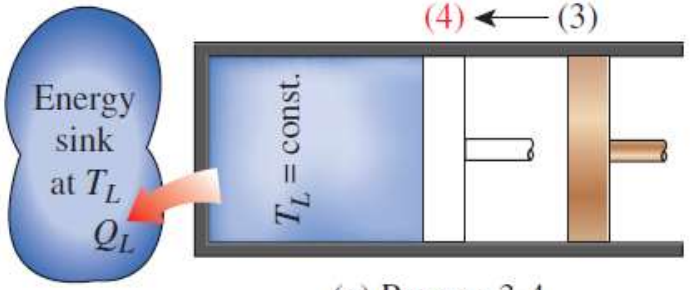
Figs: TD-Cengel & Boles

Representing cyclical TD processes: Carnot Cycle

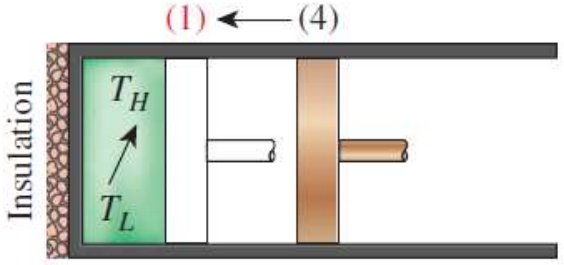


(a) Process 1-2

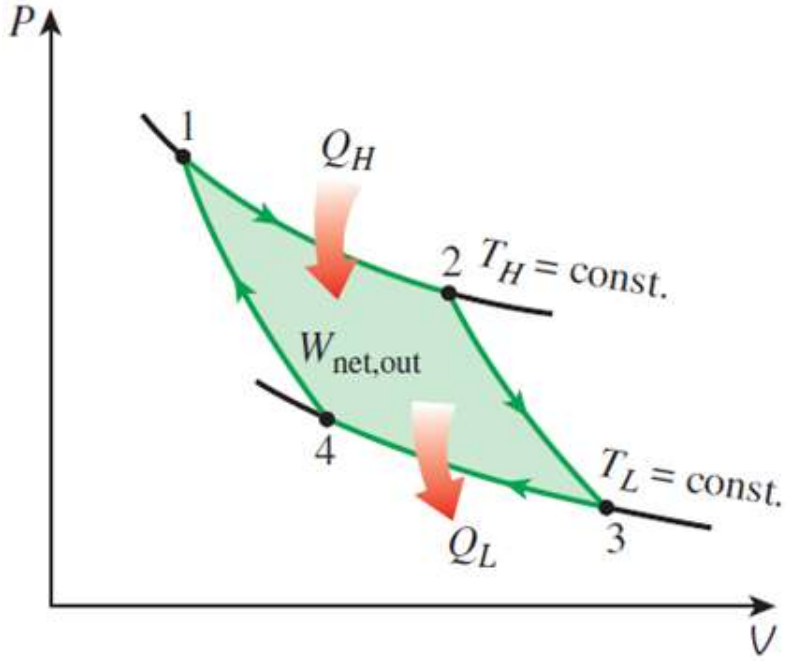


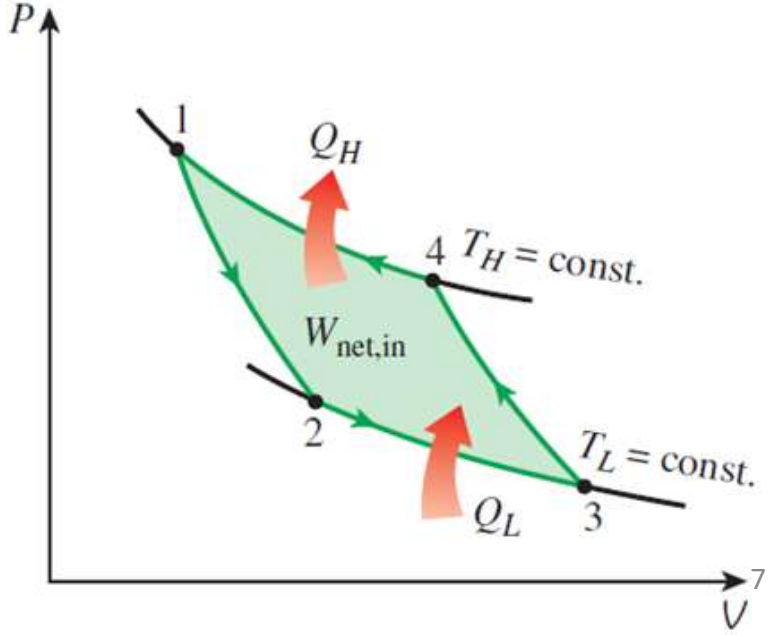


(c) Process 3-4

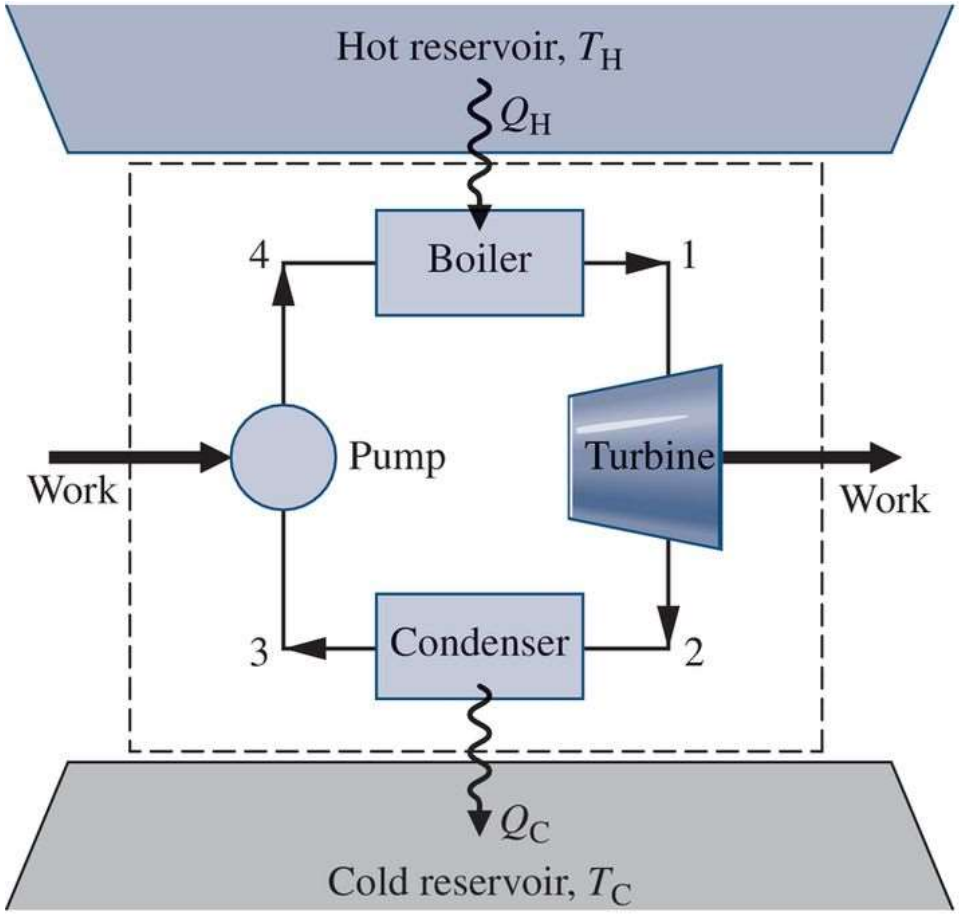


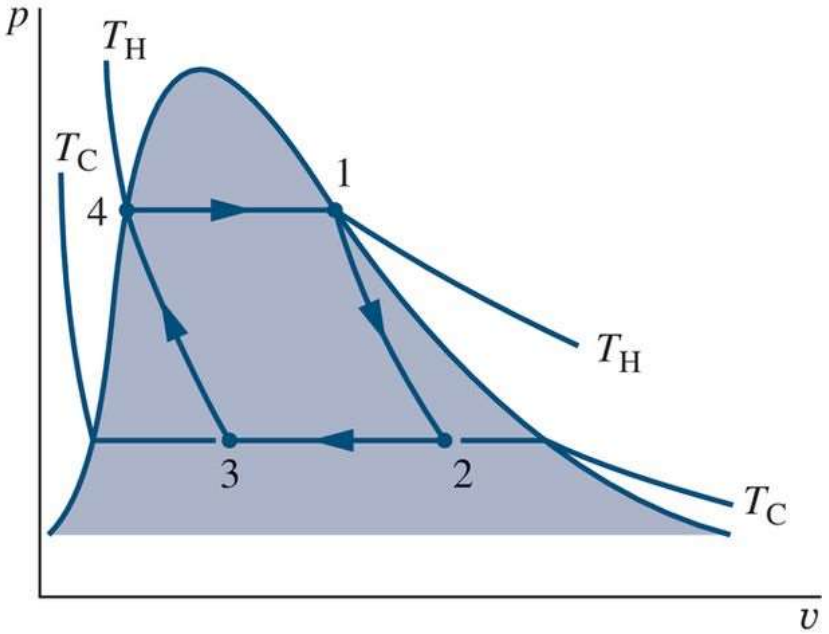
(d) Process 4-1





Beyond piston-cylinder: Carnot vapor power cycle





Figs:TD-Moran, Shapiro, Boettner, Bailey

What's next?

- Thermodynamic temperature scale