http://en.wikipedia.org/wiki/Nicolas_L%C3%A9onard_Sadi_Carnot

Nicolas Léonard Sadi Carnot (1796-1832) in the dress uniform of a student of the École Polytechnique.

Born	1 June 1796(1796-06-01) Palais du Petit-Luxembourg, Paris, France
Died	24 August 1832 (aged 36) Paris, France
Residence	France
Nationality	French
Fields	Physicist and engineer
Institutions	French army
Alma mater	École Polytechnique École Royale du Génie Sorbonne Collège de France
Academic advisors	Siméon Denis Poisson André Marie Ampère Dominique François Jean Arago
Known for	Carnot cycle Carnot efficiency Carnot theorem Carnot heat engine
Influenced	Benoît Paul Émile Clapeyron Rudolf Julius Emmanuel Clausius

Nicholas Leonard Sadi Carnot (1796-1832)

Notes

He was the brother of Hippolyte Carnot, his father was the mathematician Lazare Carnot, and his nephews were Marie François Sadi Carnot and Marie Adolphe Carnot.

Excerpts from "*The Second Law*" by P. W. Atkins

"War and the steam engine joined forces and forged what was to become one of the most delicate of concepts [the Second Law]"

Sadie Carnot was an engineer, and the son of a famous mathematician who was also a minister of war under Napoleon. Carnot fought against England in 1814.
After France lost that war, Carnot perceived that if France could develop a more efficient steam engine, it would rule the world.

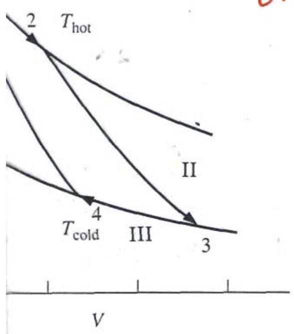
From Wikipedia:
"Carnot sought to answer two questions about the operation of heat engines: "Is the work available from a heat source potentially unbounded?" and "Can heat engines in principle be improved by replacing the steam with some other working fluid or gas?" He attempted to answer these in a memoir, published as a popular work in 1824 when he was only 28 years old. It was entitled *Réflexions sur la puissance motrice du feu* ("Reflections on the Motive Power of Fire"). "

Published in 1824, this work was largely overlooked until Clausius recognized it as containing the key message of the 2nd Law in 1850.

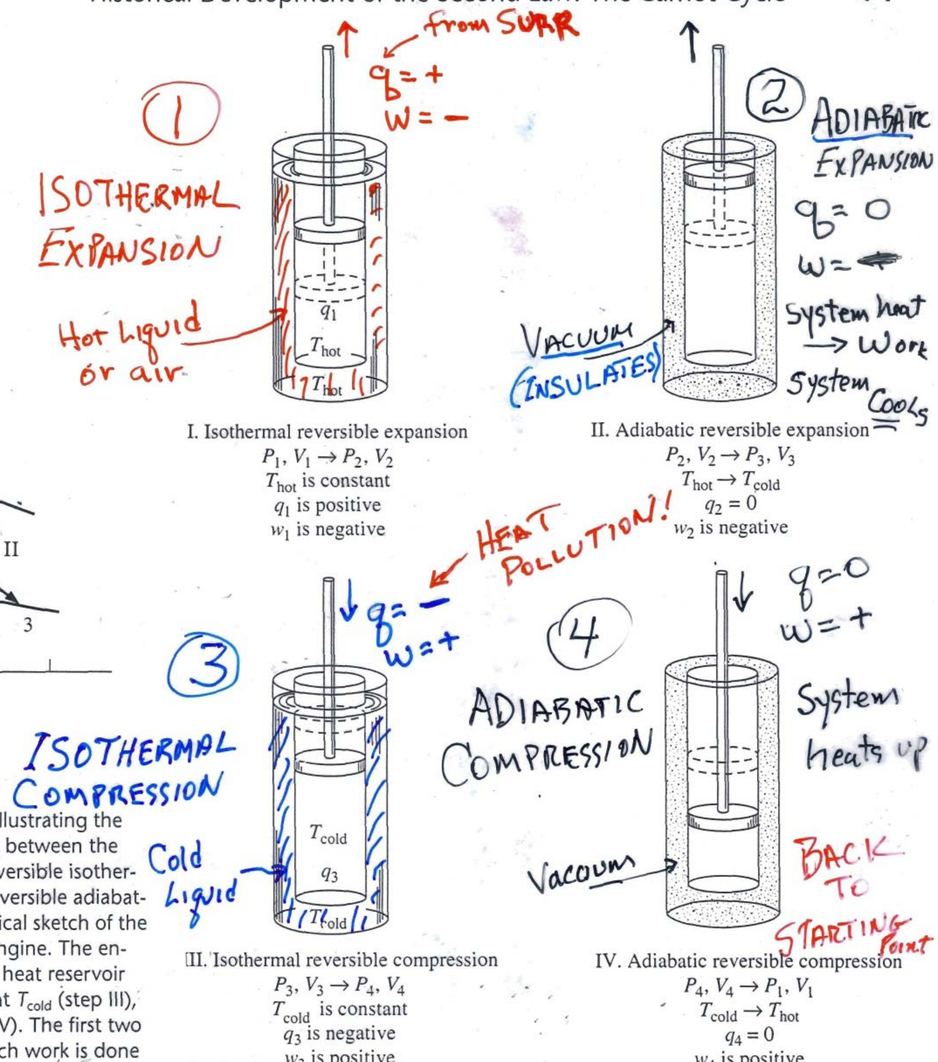
The entire concept evolved from a simple hypothetical heat engine now known as the Carnot Cycle. From its simple reversible isothermal and adiabatic expansions and compressions of an ideal gas, Carnot elegantly proved that the theoretical maximum efficiency of any heat engine is given only by the fractional difference of the temperatures involved in the heat flow:

$$\frac{\text{Net work out}}{\text{Heat from hot reservoir}} = \frac{T_{ho} - T_{col}}{T_{hot}}$$

Fig. 3.2



(a)



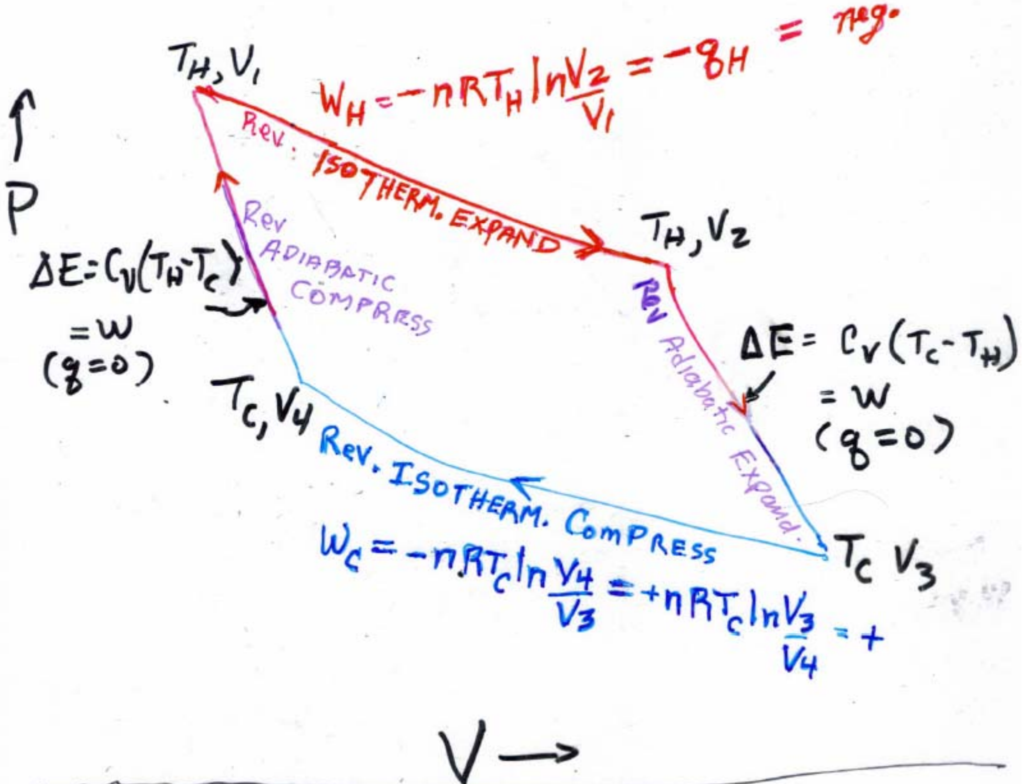
(b)

or a Carnot cycle, illustrating the
ps taken in moving between the
. There are two reversible isother-
and III) and two reversible adiabat-
nd IV). (b) A graphical sketch of the
arnot-cycle heat engine. The en-
contact with a hot heat reservoir
old heat reservoir at T_{cold} (step III),
ated (steps II and IV). The first two
expansions in which work is done
next two steps (III and IV) are
hich work is done on the engine.

a relation between the temperature and volume changes for versible expansion (or compression) of an ideal gas. The third ps are similar to the first and second, respectively:

$\ldots \ln \frac{V_4}{\ldots}$ (isothermal)

CARNOT CYCLE



① THE TWO ADIABATIC PARTS CANCEL

② net $w = w_H + w_C$ = neg. because $T_C < T_H$

③ $\sum_{\text{cycle}} \frac{q_i}{T_i}\text{rev} = 0$ IF $\frac{V_3}{V_4} = \frac{V_2}{V_1}$

MAX EFFICIENCY OF REVERSIBLE HEAT ENGINE

$$\text{Eff.} = \frac{\text{NET WORK BY SYSTEM}}{\text{Heat absorbed from HOT Reservoir}} = \frac{-(W_H + W_C)}{q_H}$$

$$= \frac{nRT_H \ln\frac{V_2}{V_1} - nRT_C \ln\frac{V_3}{V_4}}{nRT_H \ln\frac{V_2}{V_1}}$$

$$\text{EFFICIENCY} = \frac{T_H - T_C}{T_H}$$

TRUE for ALL Heat engines regardless of design & materials

REASON: A MORE EFFICIENT ENGINE COULD DRIVE THE REVERSIBLE ONE IN REVERSE, i.e., HEAT WOULD SPONTANEOUSLY FLOW FROM

COLD ⟶ HOT !

THIS HAS NEVER BEEN SEEN TO HAPPEN

ENTROPY ≡ S = State variable

$$dS = \frac{dq_{rev}}{T}$$ $\frac{J}{K}$ units or $\frac{cal}{K}$ "entropy unit"

$$\Delta S = \int \frac{dq_{rev}}{T}$$

$$\rightarrow \frac{q_{rev}}{T}$$ if T constant

$$\text{Efficiency of Heat Engine} = \frac{w_{HOT} + w_{COLD}}{q_{HOT}}$$

$$= \frac{T_{HOT} - T_{COLD}}{T_{HOT}}$$

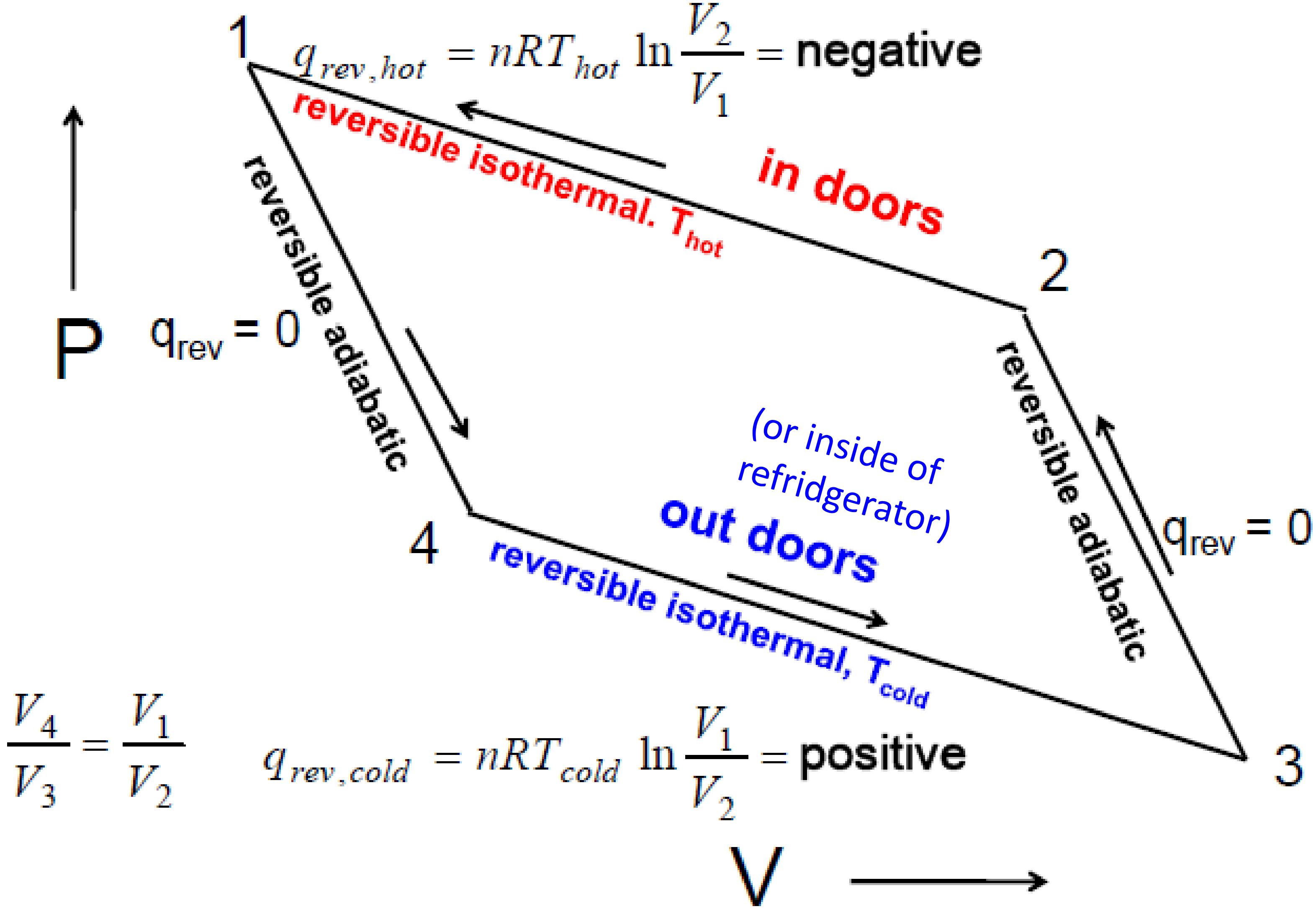
Our Best Steam Turbines

$T_{HOT} = 1000\,K$, $T_{COLD} = 400\,K$

$$\text{Eff.} = \frac{1000 - 400}{1000} = 60\%$$

WHAT ABOUT USING SUN & SPACE ?

Reversed Carnot's Cycle is a HEAT PUMP



As for the heat engine, for the *heat pump* what is valuable is q_{hot} , but now it is positive. Heat and work trade places. The efficiency is simply turned upside down.

$$\frac{\text{Heat } \textit{into} \text{ warm house}}{\text{Net work from NW Energy}} = \frac{nRT_{hot}\ln\frac{V_1}{V_2}}{nRT_{hot}\ln\frac{V_2}{V_1} - nRT_{cold}\ln\frac{V_3}{V_4}}$$

$$= \frac{T_{hot}}{T_{hot} - T_{cold}} = \frac{300}{300 - 270} = \frac{10 \text{ J of heat}}{1 \text{ J of electricity}}$$