



Introduction to Critical issues of energy and resources

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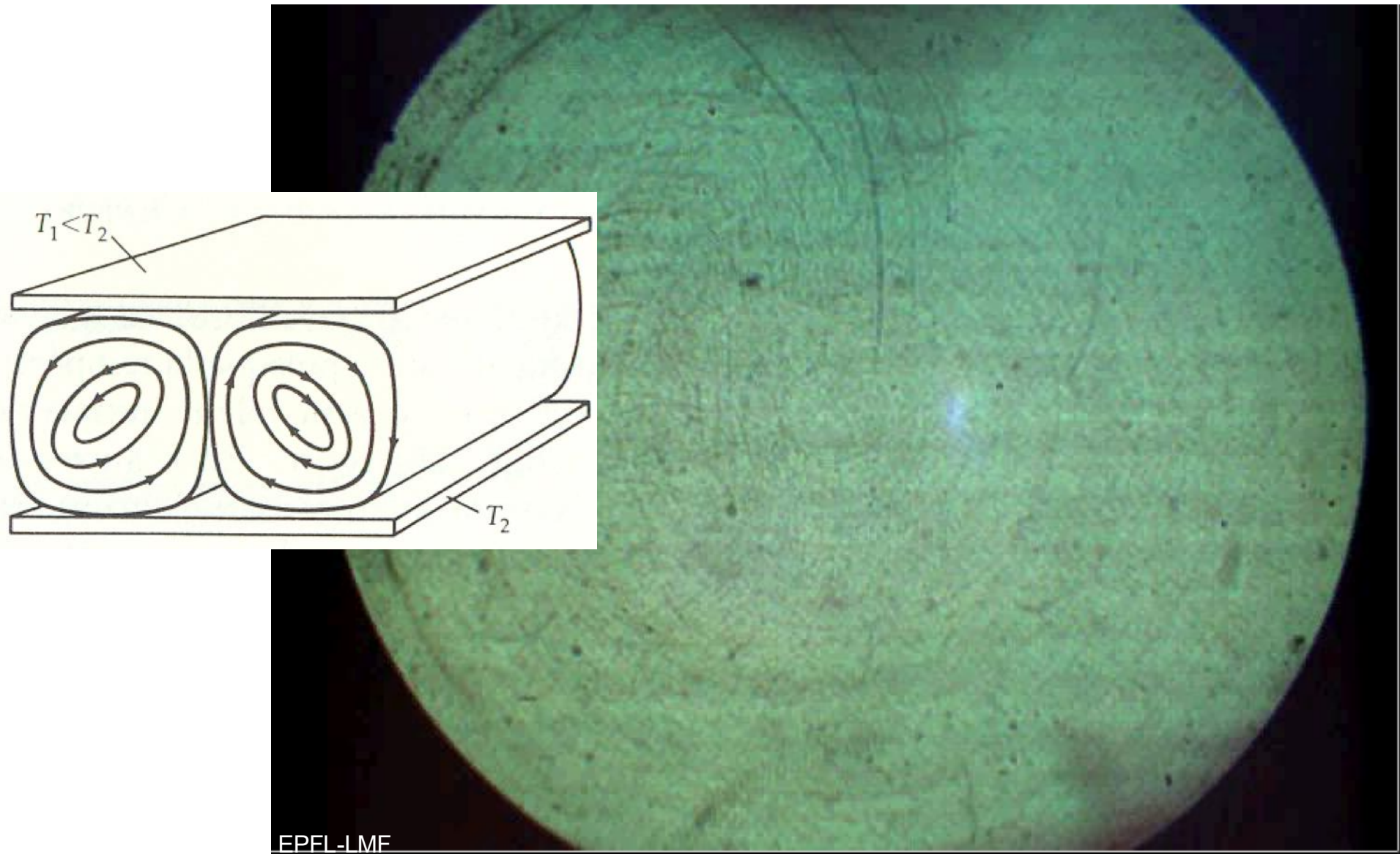
Many challenges

- Communication (fighting for trust in real data, coherent indicators, inertia...)
- Environment (global warming and non linear risks, wastes)
- Time constants (technology implementation, wastes...)
- Resources (natural, geopolitics, finance)
- Technologies (renewable versus fossil, centralized versus decentralized, flexibility storage, resilience,...)



Nature phenomena are not necessarily linear

Example 1: vortices (on a transparent pot linearly heated)

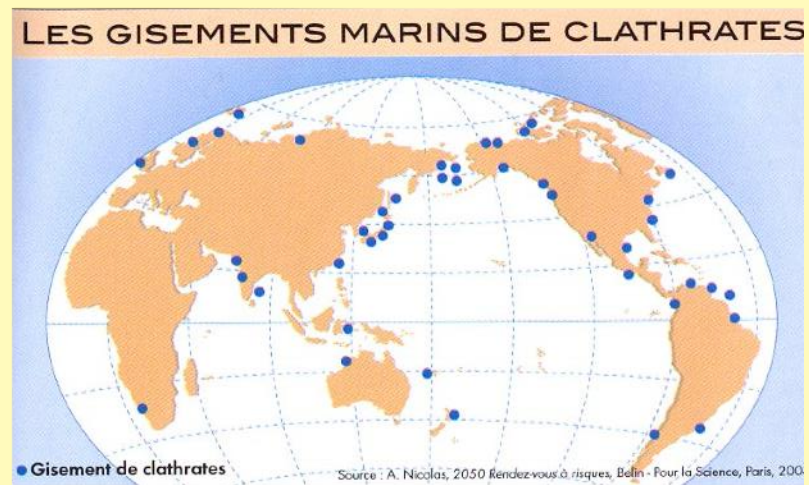


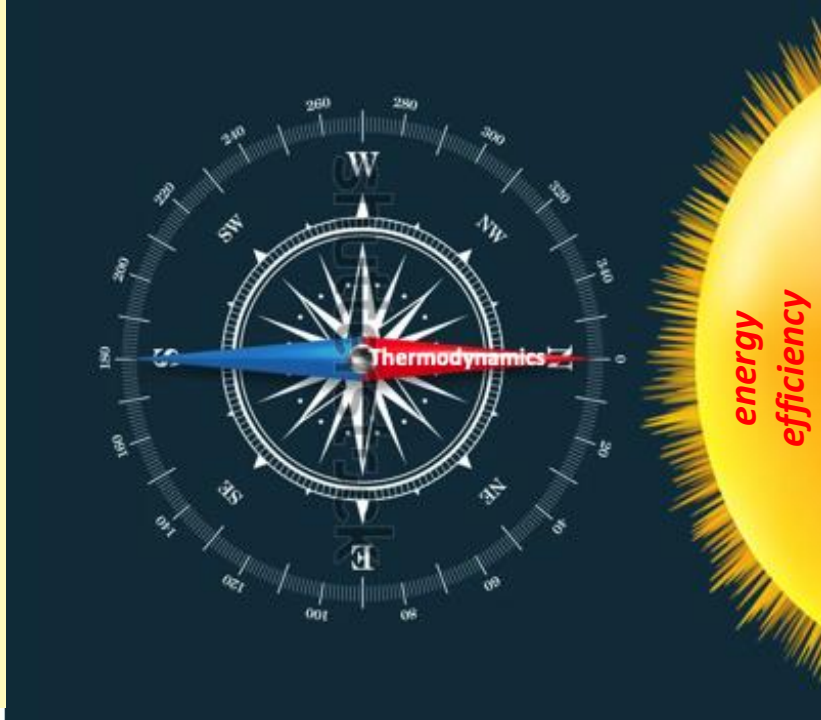
Example 2:

Methane hydrates



- Outgassing of methane
 - from permafrost
 - from marine deposits (clathrate=hydrate)





Thermodynamics: An essential guide to energy technology assessment

*Or the essential compass to help
verify the **feasibility** and **real energy
efficiency** of energy systems*



Mass, energy and entropy

"Die Energie der Welt ist konstant und die Entropie der Welt strebt einem maximum zu"

"The energy of the world is constant and the entropy of the world tends towards a maximum"

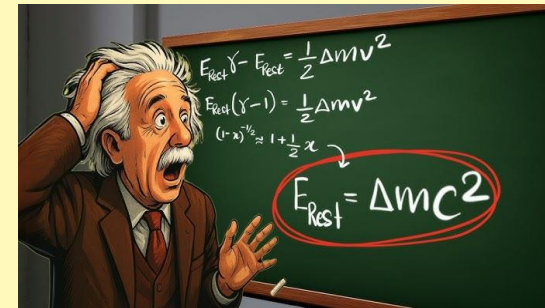


**Rudolf Julius
Emmanuel
Clausius
(1822-1888)**

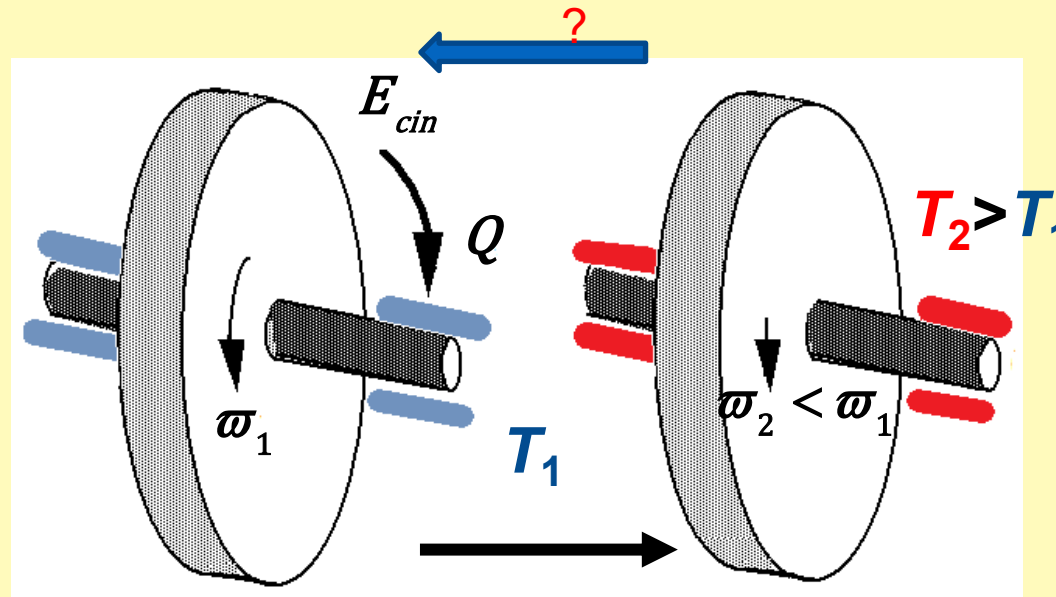
In other words:

Energy can only be converted from one form into another, but ... the **entropy** of the universes is increasing !

The quantity conserved in the universe is energy, unlike mass, which is not conserved during any reaction that results in the release of energy: without a mass defect (Δm), there is no energy release !



The arrow of time



The wheel slows down and finally stop

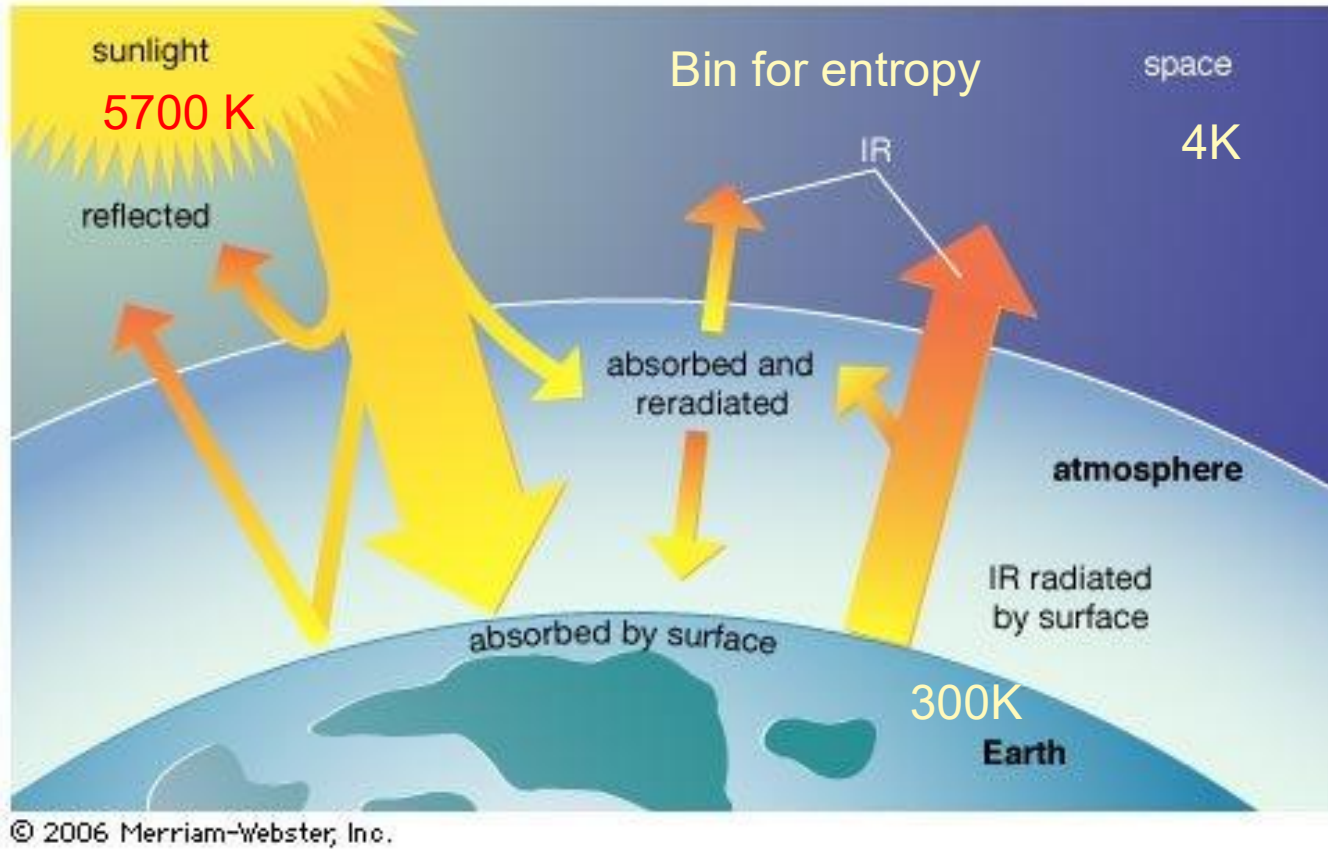
There is no way that it will reaccelerate without an input of work (**exergy**)

There is a degradation of mechanical energy into heat, with creation of entropy

All energy systems need an entropy bin



Energy / entropy balance for the Earth



This also true
for the Earth

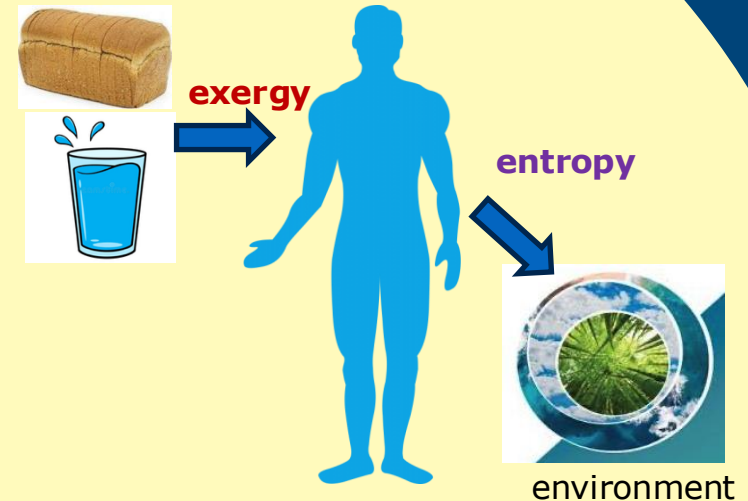
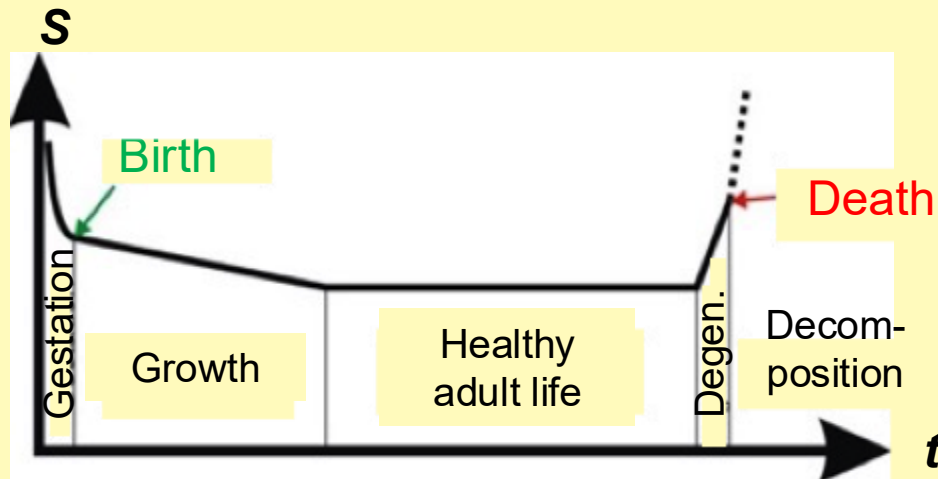
Problem: with our
emissions of GHG
we partially block
reradiation
towards space



We, humans, are all marvelous trigereneration energy systems

But we are not perfect !!

We generate entropy
(disorder)



Did your entropy increase last year?

Was there anytime in your life that your entropy decreased ?

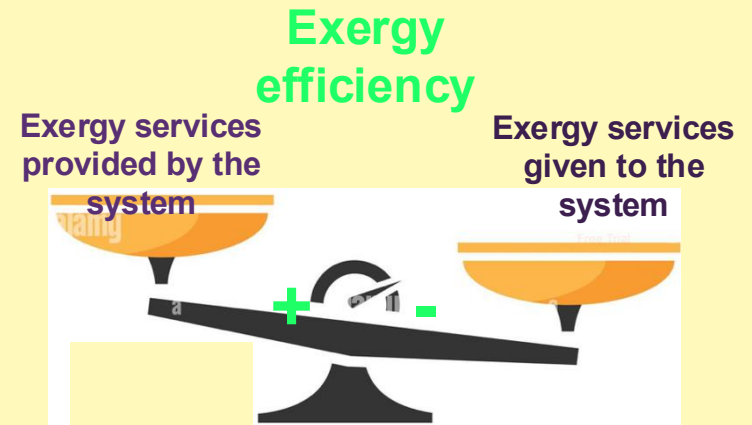
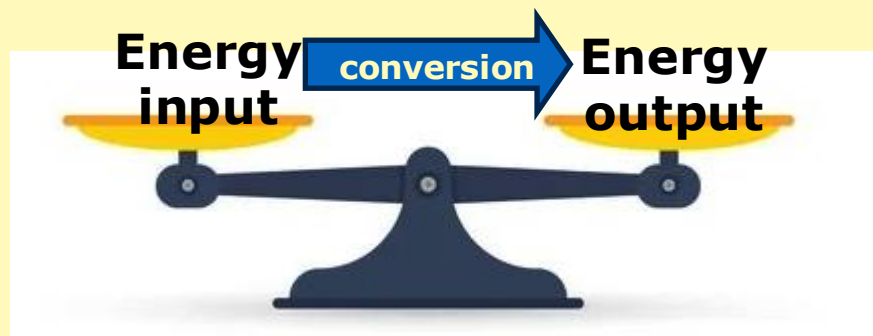
To keep our entropy constant,
we all need a bin for entropy

M.Batato
EPFL thesis
(1988)



Detect “perpetual motion” machines !

Don't get lost in the complexity of the systems presented:
Put a box around it and check the conservation of energy and the
existence of exergy losses



Some common mistakes:

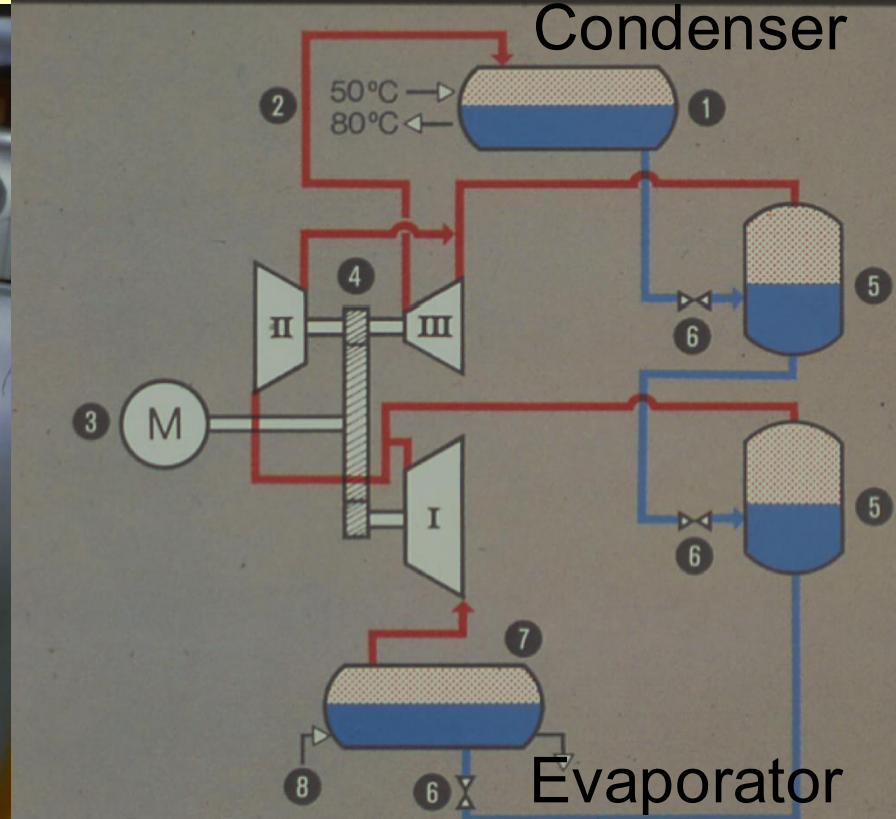
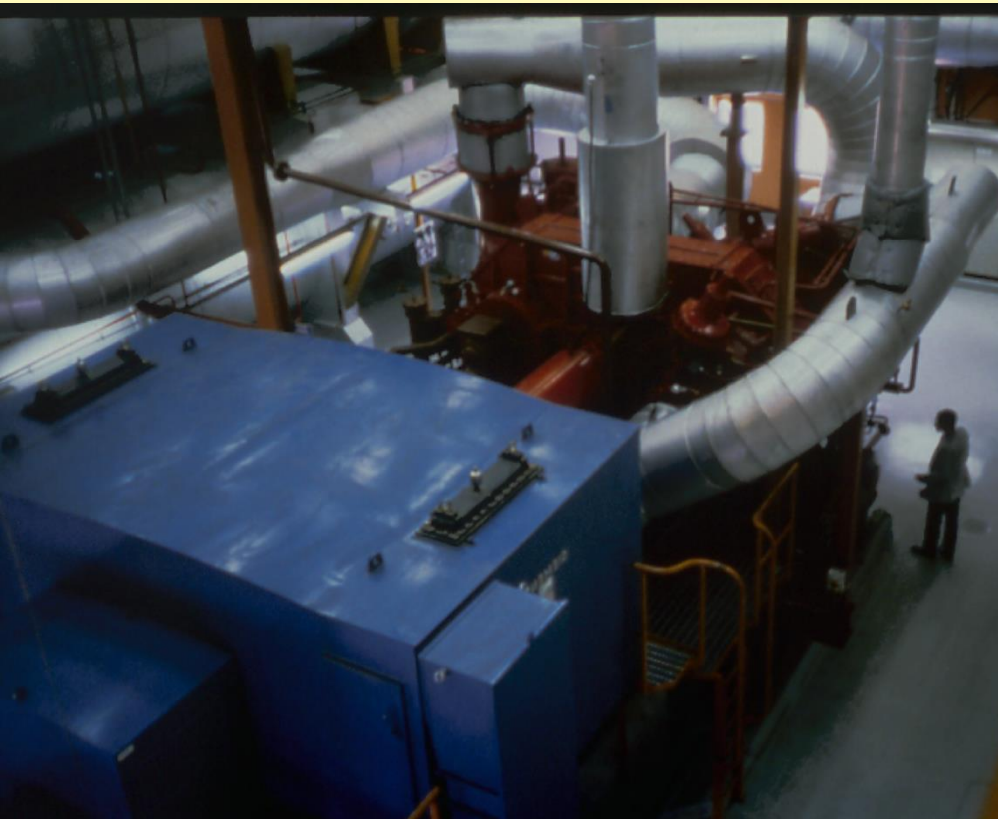
- Carnot battery presented as an engine
- Buckets in water and Archimedes' principle forgetting compressed air needed
- New osmotic fluid and membrane forgetting the regeneration needs



Efficient technologies and oil price:

An opportunity example (40 years lost):

Largest district heating heat pumps in the eighties



Atlas Copco: Goteborg: 45 MW_{th} (From cleaned waste-water or sea)

Fortunately a new one even larger to be soon commissioned in Germany



2024 Energy session

Nuclear fusion

Natural hydrogen

High temperature fuel cells or electrolyzers

2026 Energy session

Energy technology development in China (Prof Li Zheng)

Nuclear fission (Prof Andreas Pautz)

Power needs for digital (Prof. Jean-Claude André)

Data centers and power supply (Prof Mario Paolone)

Exergy of Earth resources (Prof Alicia Valero)

