# Énergie solaire low-tech : de la chaleur à l'électricité

NASA image
Solar eruption
July 19 of 2012

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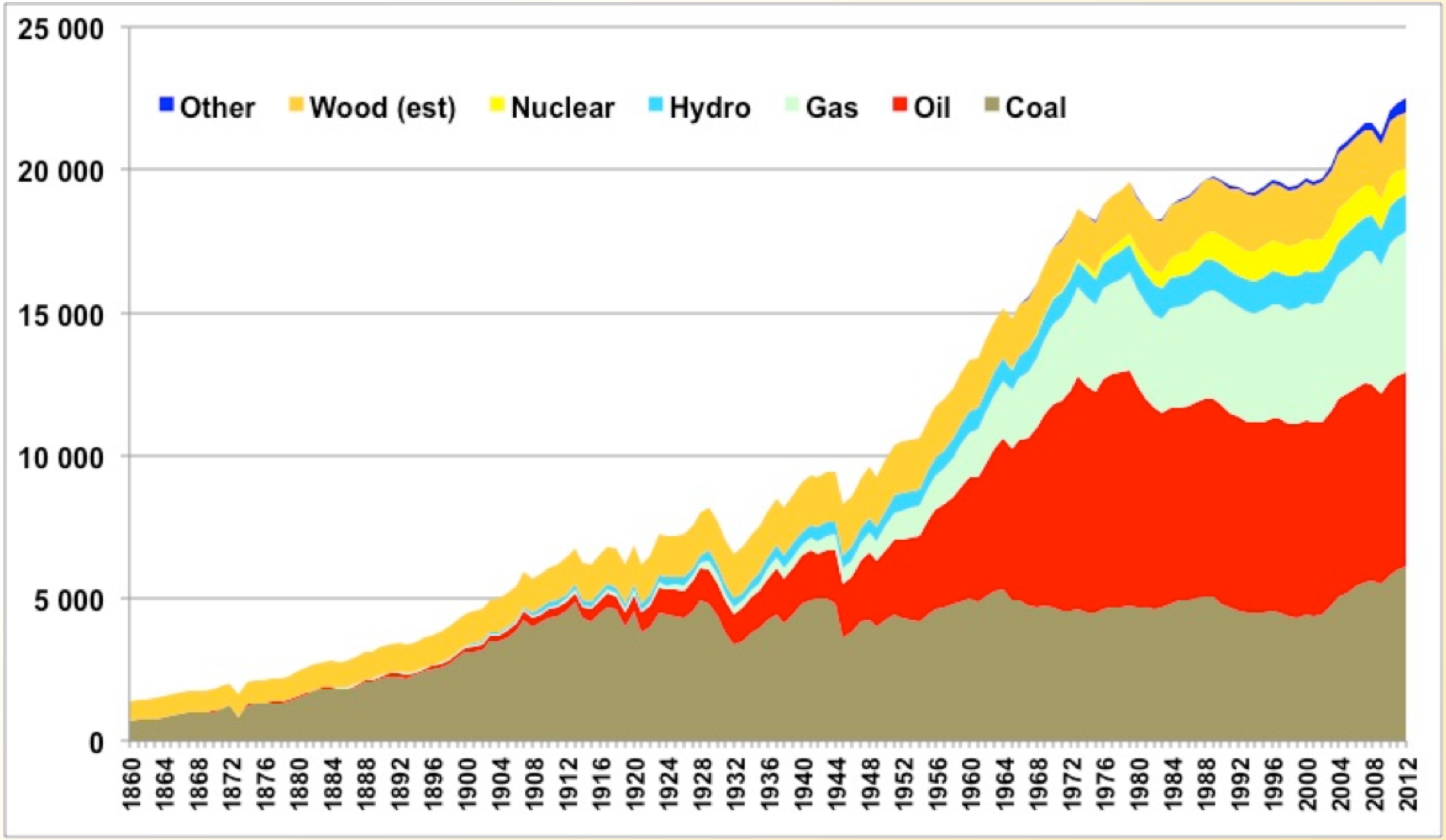
**Géosciences Montpellier**

*Apero technique OREME « low-tech » – Montpellier – 14 février 2023*

# Shale gas play: not a good way

# « Energy Shift » : inappropriate name !

Evolution consumed energy (en GTEP/an)




19$^{th}$ century : wood + coal – 20$^{th}$ century : + oil + nuclear

21$^{th}$ century : + solar + wind + …. ?

# Energy in France : **X 16** since year 1800

Can one citizen decay its energy consumption from

**4 T**ons **O**il **E**quivalent**/yr to**
**0.4 TOE/yr or to**
**0.04 TOE/yr**

…without a strong social decay ?

**Energy** : type, systems, by-products, use, etc

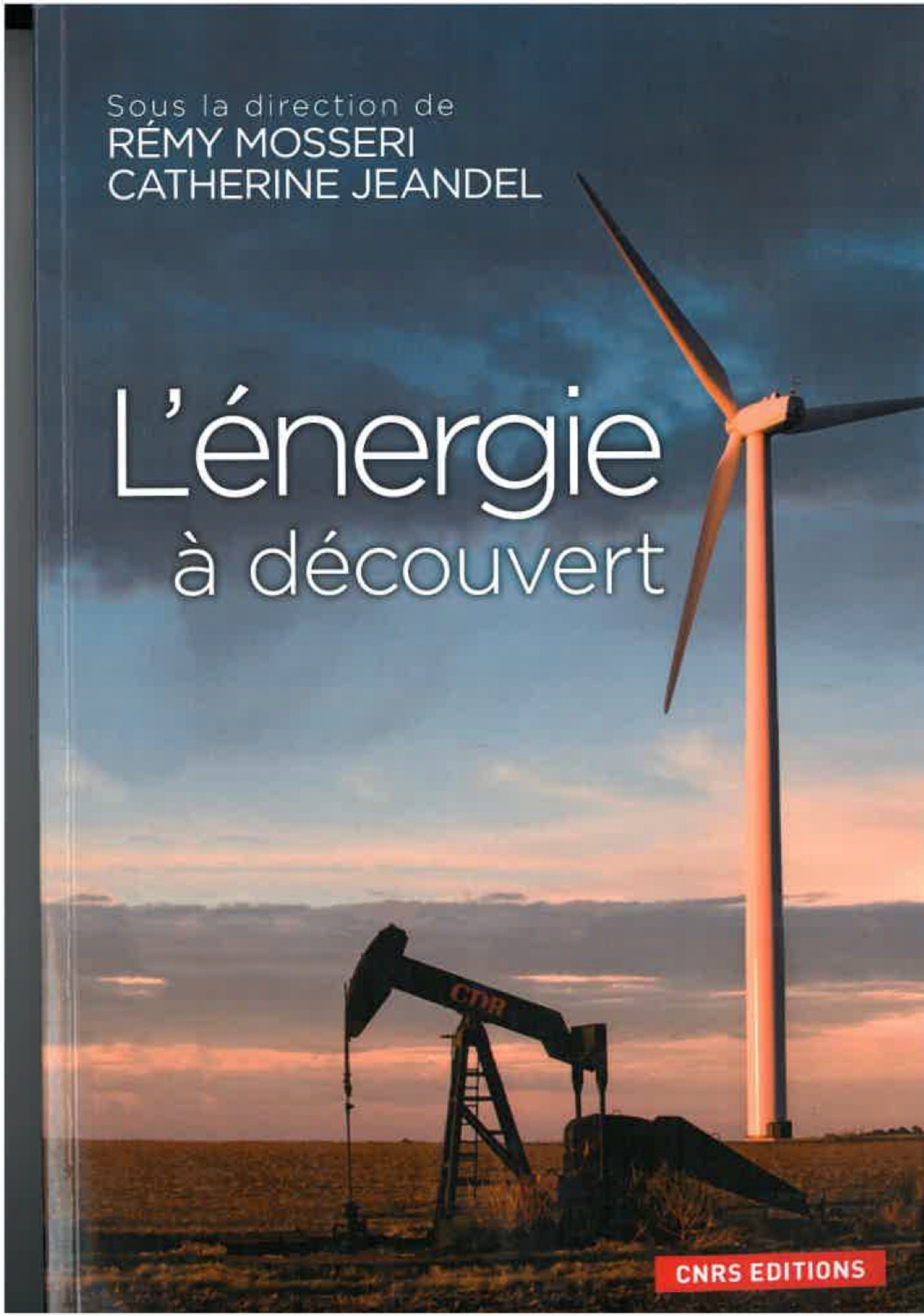
**Flow** : Solar power at Earth's surface (1m$^2$) : 1000 W forever … but transient
Geothermal (1m$^2$) : 0.1 W forever. … but small
**Stock** : Gasoline combustion (1kg) : 1000 W during 10h … but CO2
Reaction of natural Uranium (1kg) : 1000 W during 17 years … but waste

# What to do ?

Are the solutions
in energy books ?

Hundred of high-tech
solutions and processes

… but no holistic view :
+ economic
+ political
+ moral
issues of energy



# From ends to means : a virtuous* energy system must satisfy 3 postulates

**Postulat 1 : Spatial extent**

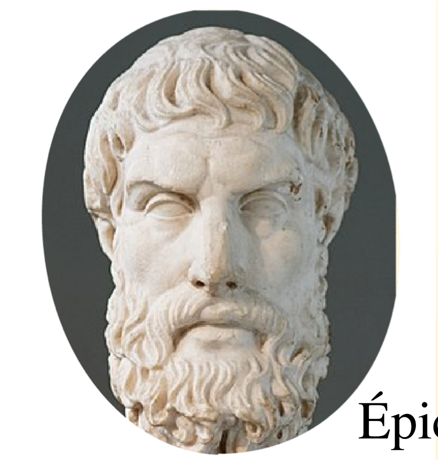
Abundance et availability of sources and raw materials

**Postulat 2 : Long term use**

Stable, local and repairable by user → low-tech, long lifecycle

**Postulat 3 : Prioritize needs !**

Primary energy needs are homes. Transportation and heavy industry are subordinated needs (mostly related to war and market economy)

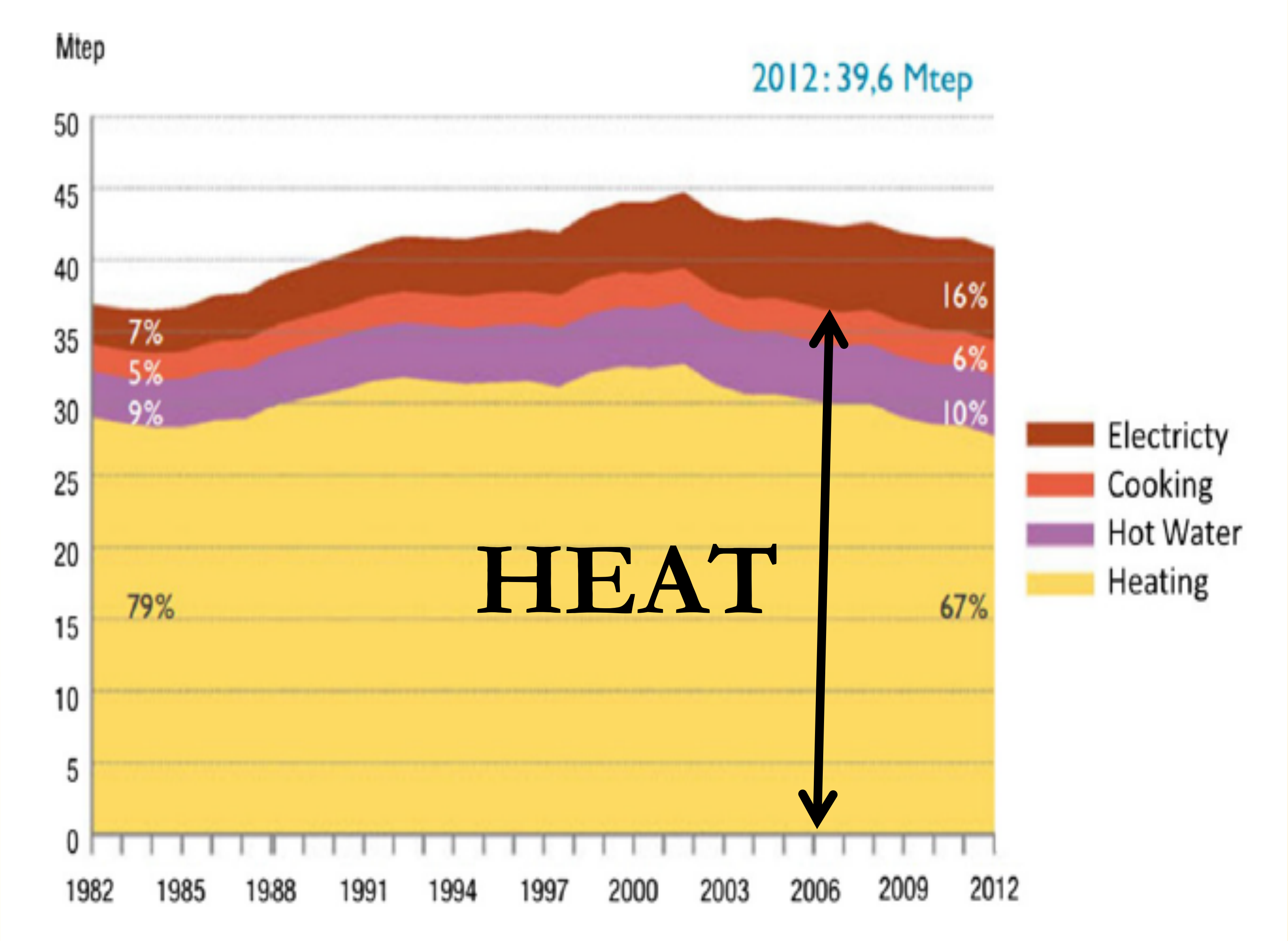


Épicure

Postulate 1 → 2 primary sources : Sun and wind

*or « democratic » from demos=people; kratos=power

# Final energy of buildings/dwelling




Quénard, D. (2017). Buildings: The new energy nexus. *Comptes Rendus Physique*, *18*(7-8), 415-427.

# Sun or Wind ?

## >80 % building energy needs are thermal

Postulates 1, 2 et 3 → optimized energy scheme for homes
**Solar heat (concentration or planar devices)**
**+ heat storage + thermodynamic power**

### How to store energy in a low-tech way ?

**Thermal energy of 1 Ton** of water heated from **20 à 90 ° C**

$E = m\ C\ \Delta T$
$E = 1000 * 4185 * 70 =$
$2.92\ 10^{8}$ Joules = **81 kWh**

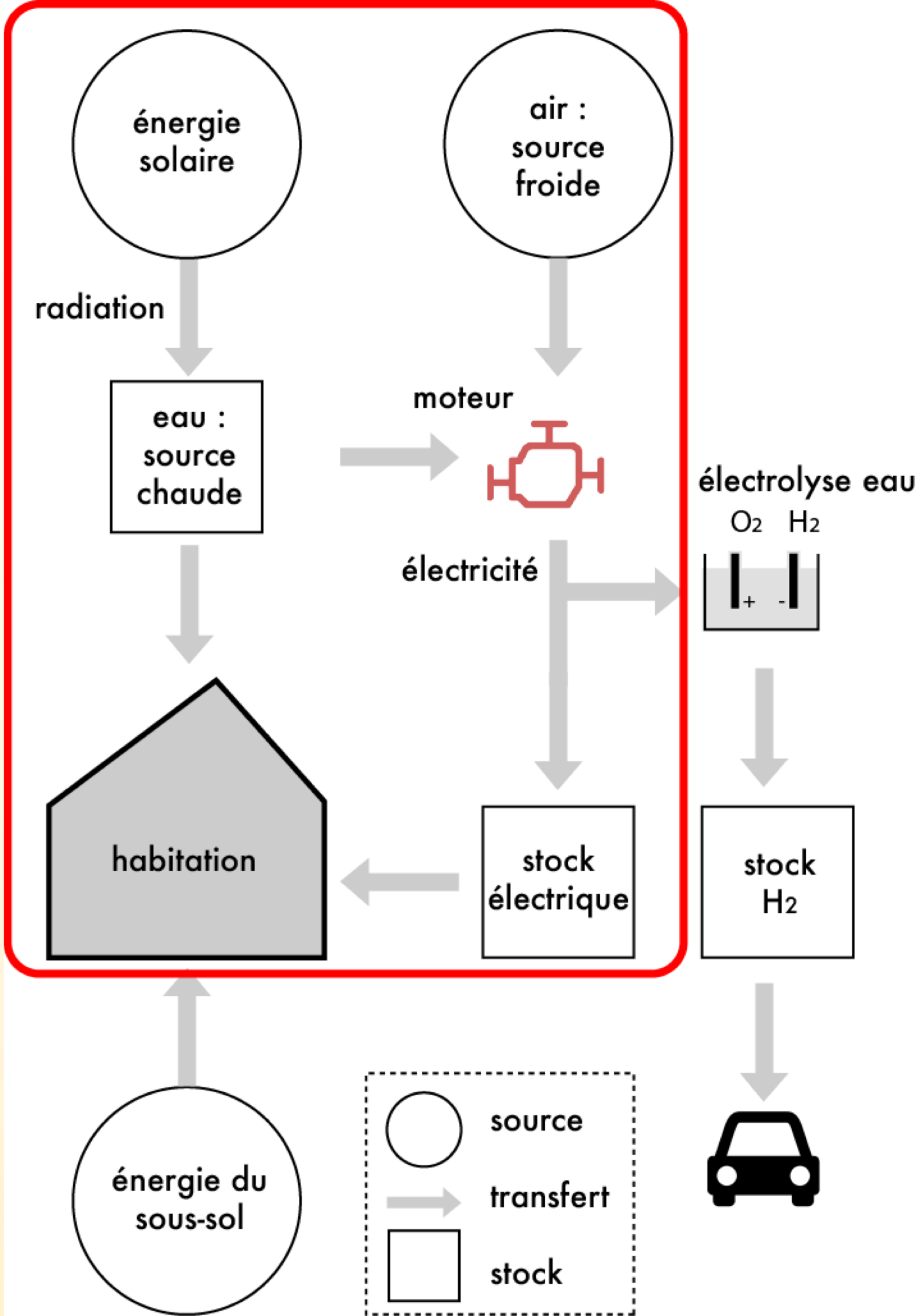
**Potential energy of 1 Ton** in earth gravity field over **1 km heigth**

$E = m\ g\ \Delta h$
$E = 1000 * 9.81 * 1000 = 9.81\ 10^{6}$ Joules = **3 kWh**

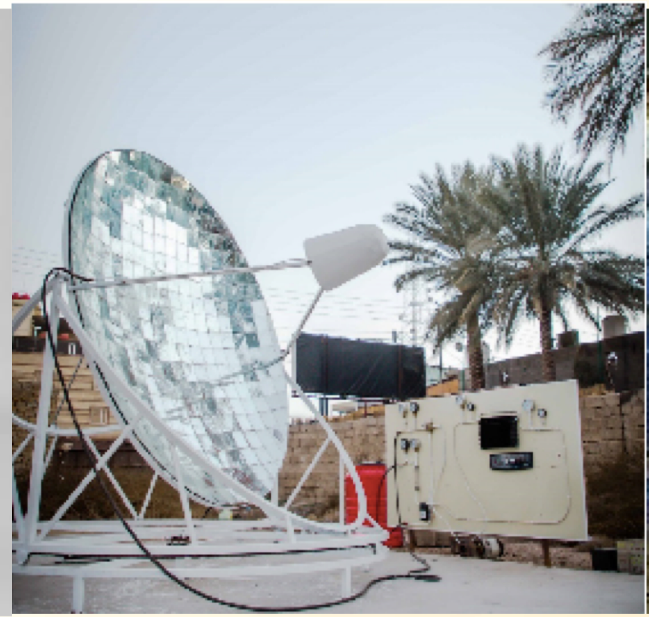
**Electric energy of 1 Ton** (100 12V lead batteries of 100x50 Ah)
$E = N * Ah * U$
$E = 100*50*3600*12 = 2.92\ 10^{8}$ Joules = **60 kWh**

# Domestic use of solar energy

- Solar heat production
- Mass storage
- Heat use for cooking/ heating / hot water
- Thermodynamic electricity generation



## Concentrated Solar Power : heat → electric power
## Low $CO_2$/kWh : CSP < PV&Wind < gas < oil < coal



**--------- parabols -----------** **flat mirrors**

Mouchot et Pifre (1880) Basem et al. (2022)

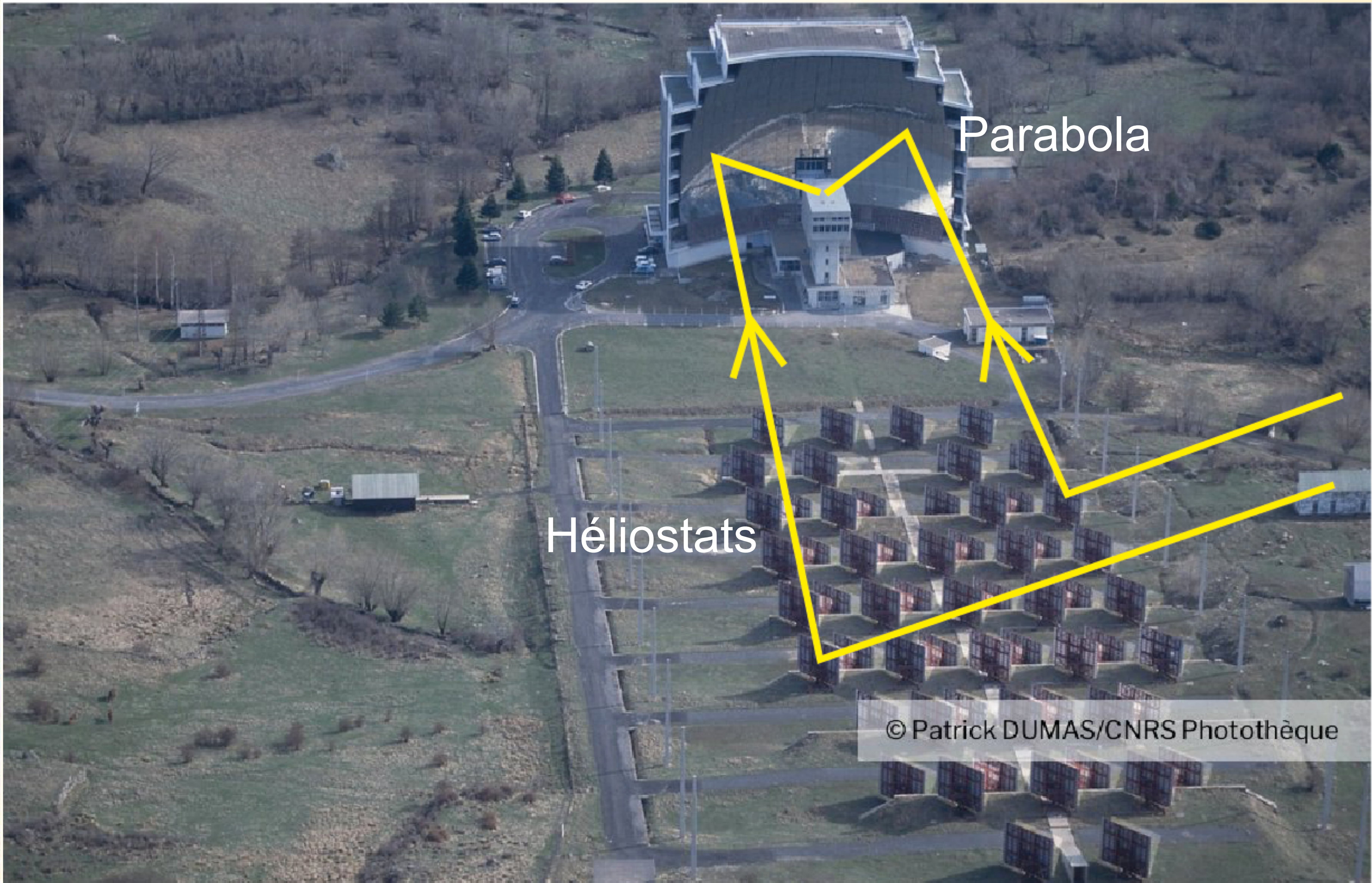
**However :**

Electric storage is still difficult to achieve

Fossil fuels are major players of heat production

Solar heat : 1% of renewable heat (Carbone 4 think tank, 2022)

# Félix Trombe parabol at Font-Romeu : two reflections system

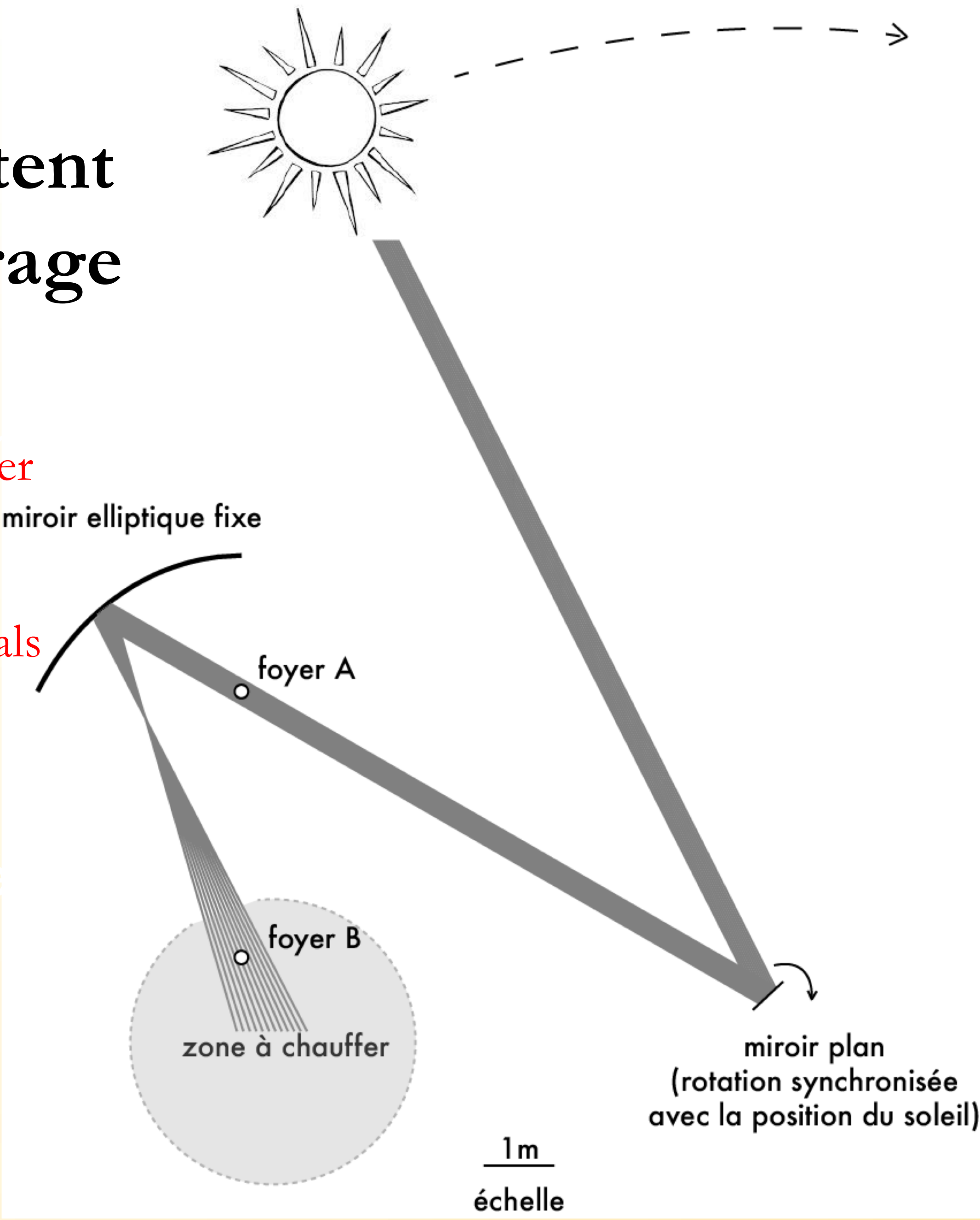


# Solution to intermittent flow : solar heat storage

**Store energy at ground level :**

- Low T (30-90) → heat & hot water
- Mean T (200-400) → electricity

- High T (800-1200) → raw materials transformation




**Low-Tech system :**

Heliostat field
+
Elliptical secondary miror
+
Insulated mass storage

# More technical : heat to power

# Few frugal thermodynamic solutions

**Low-tech Rule** : use only friendly and widely available raw material (eg. air, water, steel, aluminium, ceramic)

1/ **Stirling** air engine (close system, free piston or thermoacoustic)

2/ **Ericsson** air engine (open system)

3/ **Rankine** engine (close system water/steam, not organic Rankine)

# Low cost heat+power : 2009 NSF project
# Low temp. Stirling engine

Seth Sanders (energy Lab, Berkeley U.)

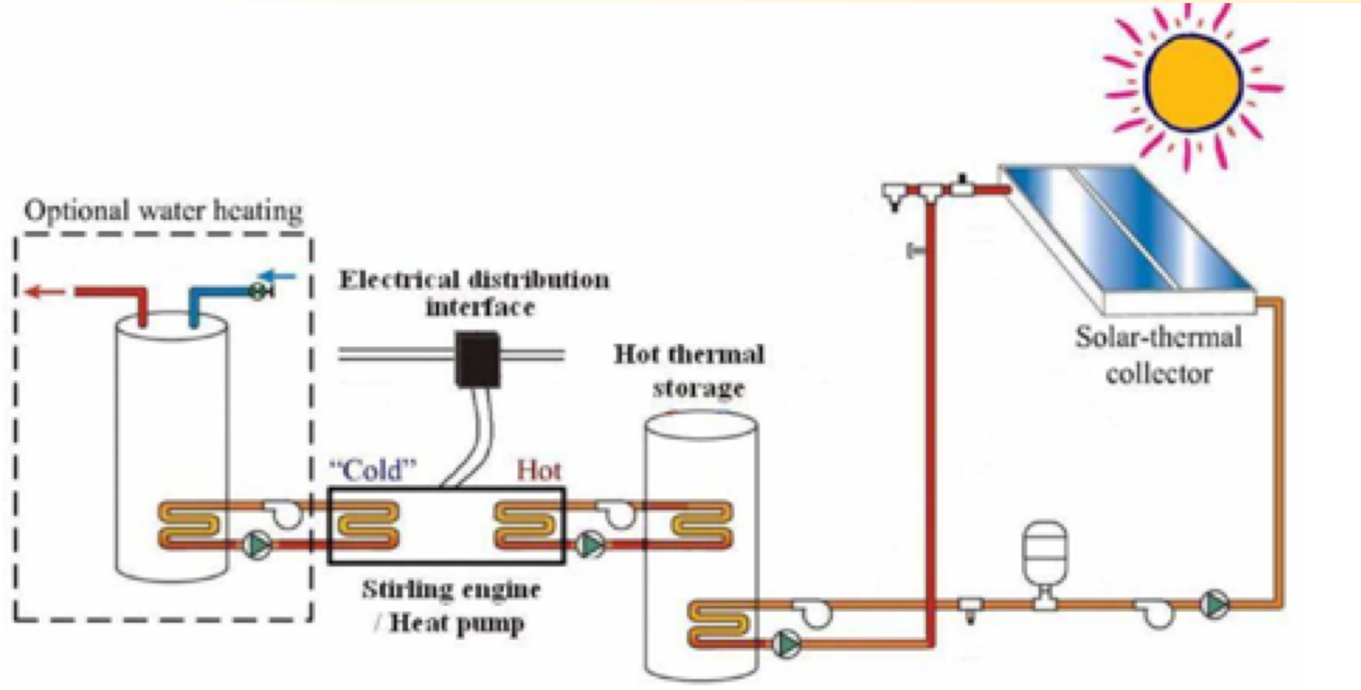



Fig. 1 Schematic diagram of the solar-thermal-electric power generation system

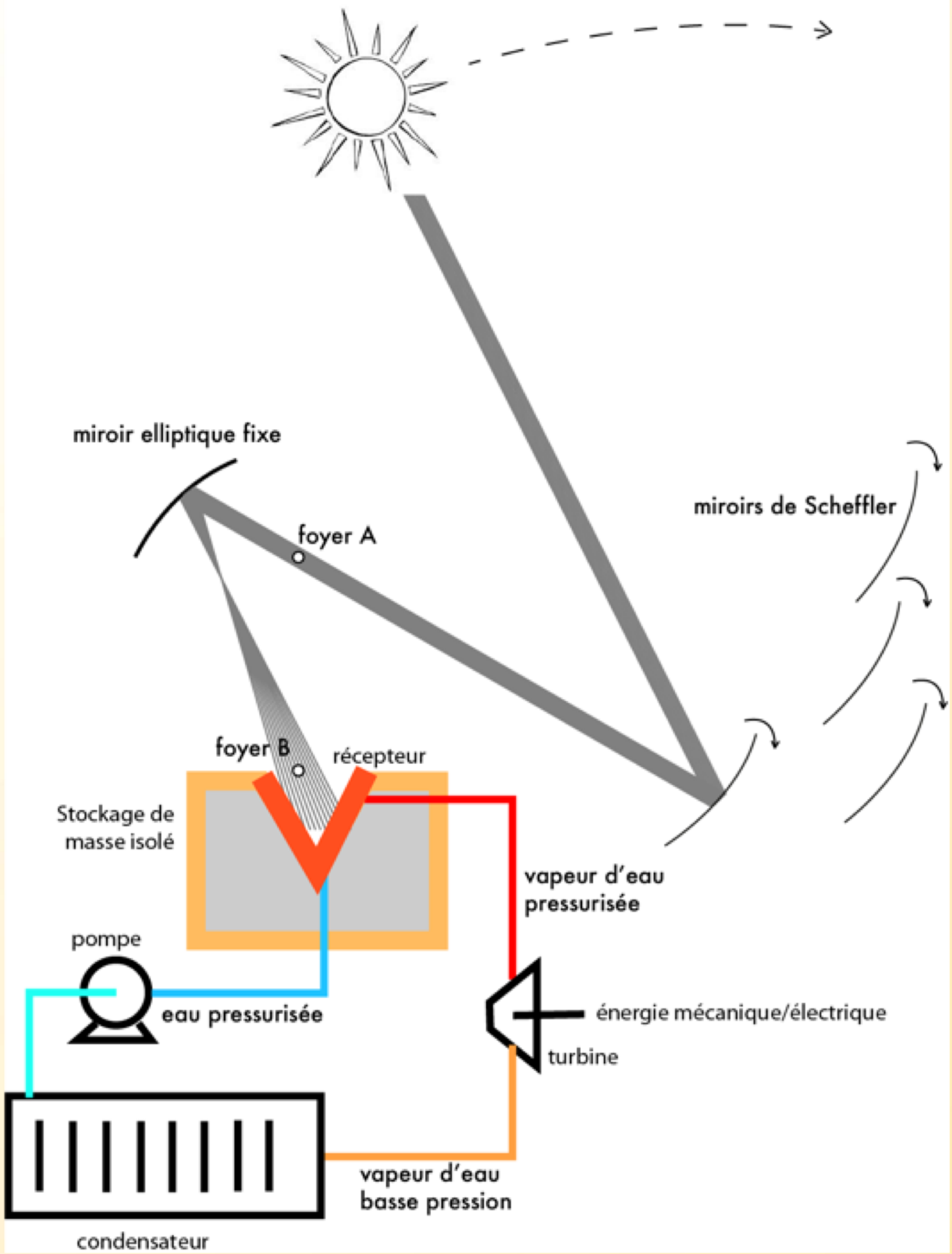
Der Minassians, A., & Sanders, S. R. (2011). Stirling engines for distributed low-cost solar-thermal-electric power generation. *Journal of Solar Energy Engineering*, *133*(1), 011015.

# Solar steam power project

Héliostat field of 20m2
+ Insulated ground heat receiver
+ Thermal storage

→3-4 KW of continuous electric power + residual heat use (cogeneration)

Appel d'offres MITI/CNRS-IRD 2023 :
« La prise de conscience de l'impact de nos sociétés en termes énergétique et d'usage de ressources naturelles impose une réflexion sur l'élaboration d'approches plus frugales de la recherche » → **ECHEC**




Adapted from Basem et al. (2022)

# Low-tech solar energy : worldwide consequences

New relation between energy and land use :

Coal/oil/nuclear = concentrated sources

→ optimum = **dense** cities through **large** energy networks

Solar heat = distributed sources

→ optimum = **low density** population model and **small** energy networks

… promise of conflict with market economy !

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«They did not know **it was impossible** so they did it »

– Mark Twain


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