Energy: perspectives and hopes

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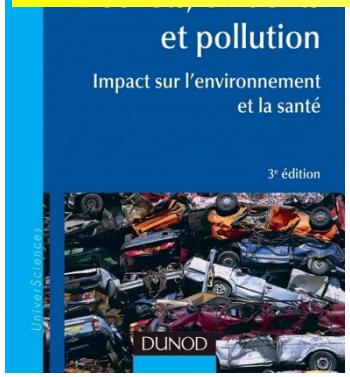
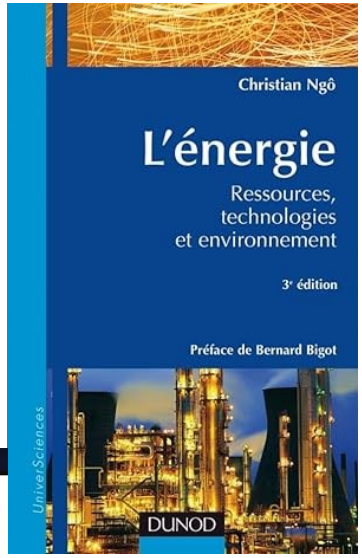
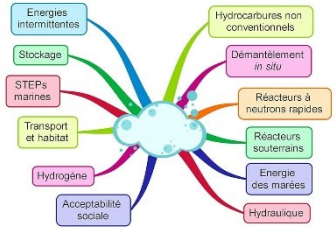
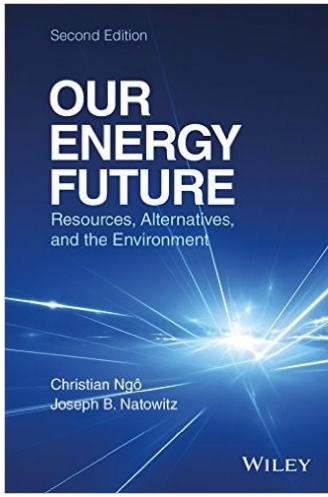
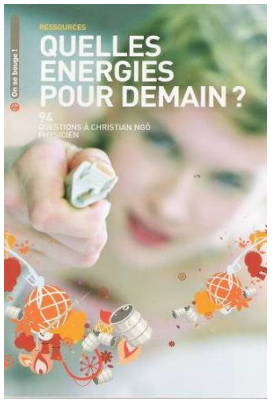
A New Path from Green Hydrogen to Green Energy
Clean Hydrogen Metal Energy Conference.
Strasbourg, September 5, 2024, European Parliament

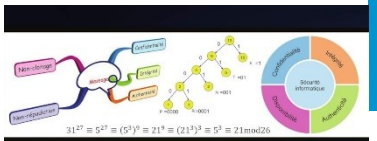


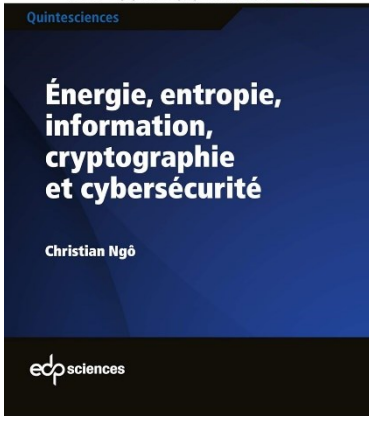


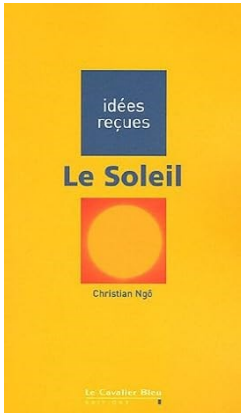


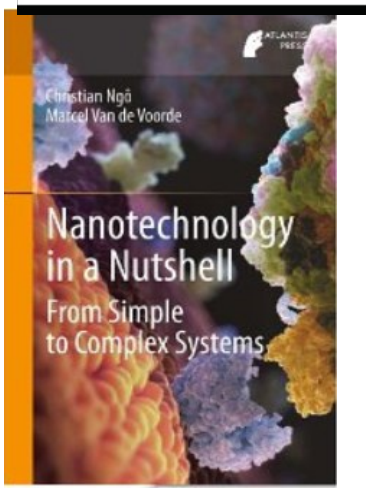


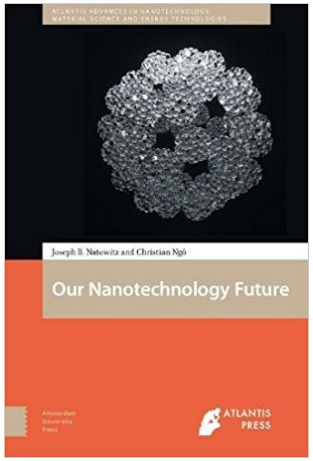


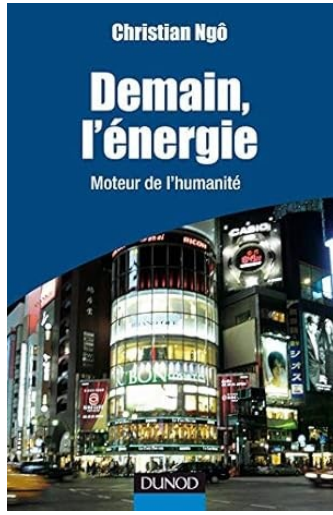






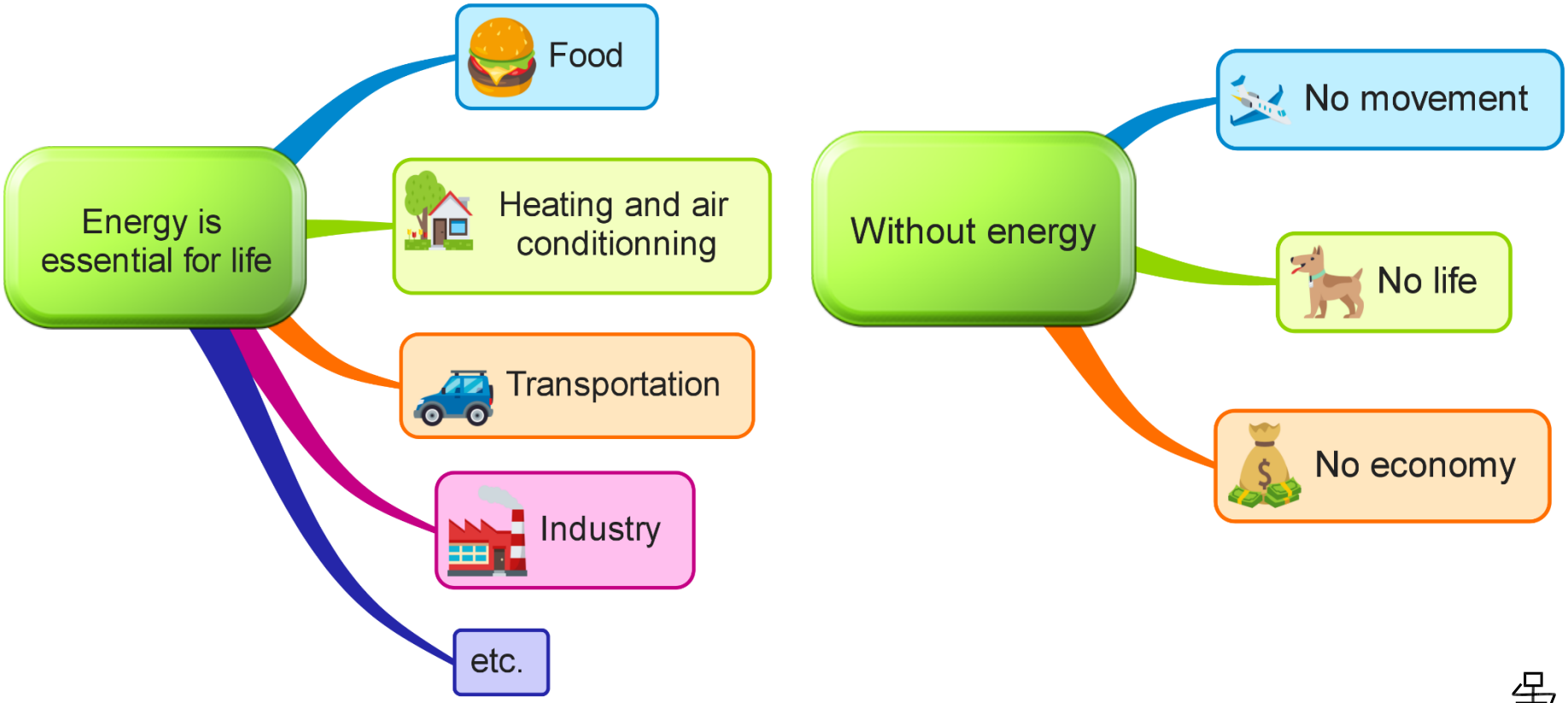




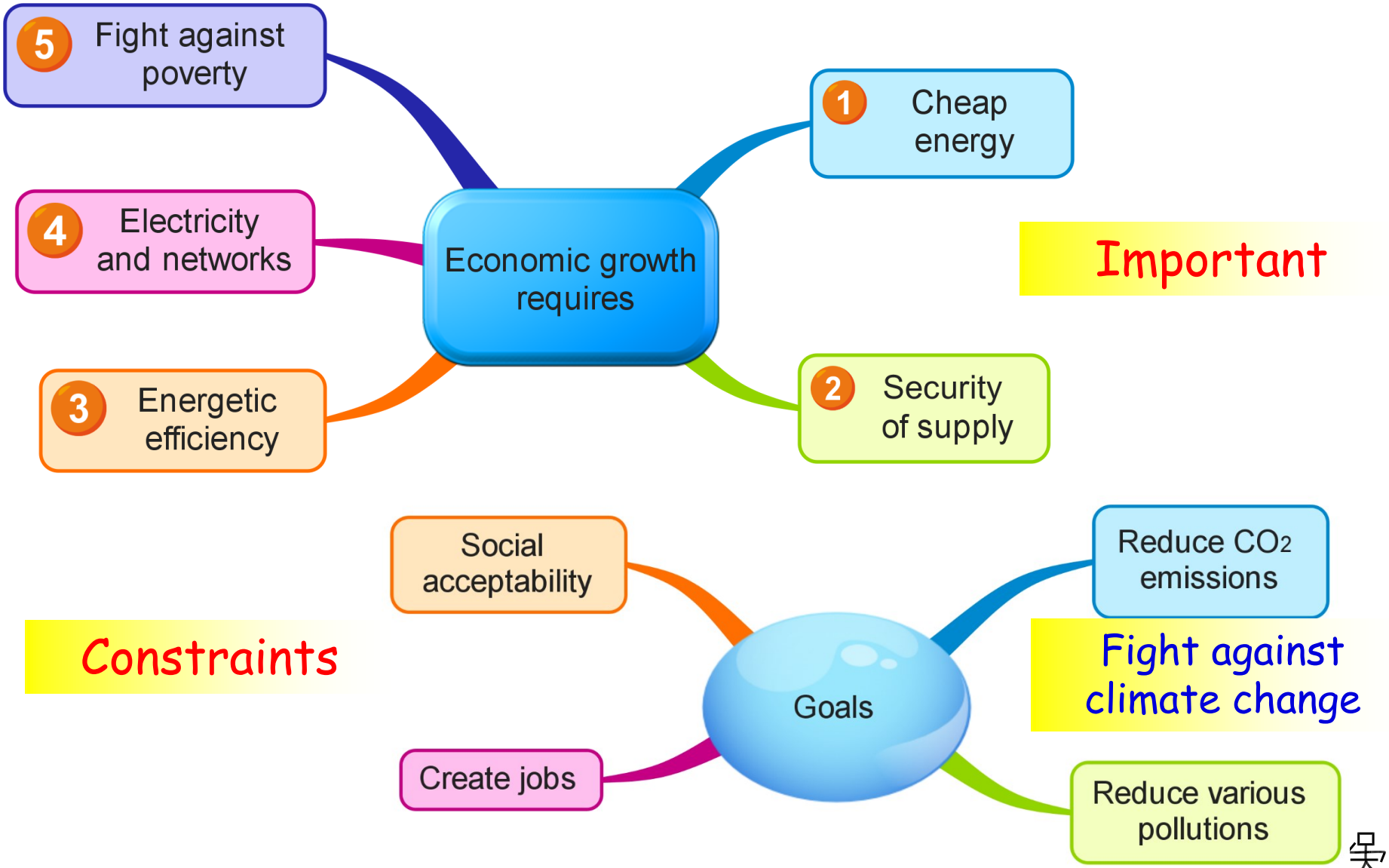


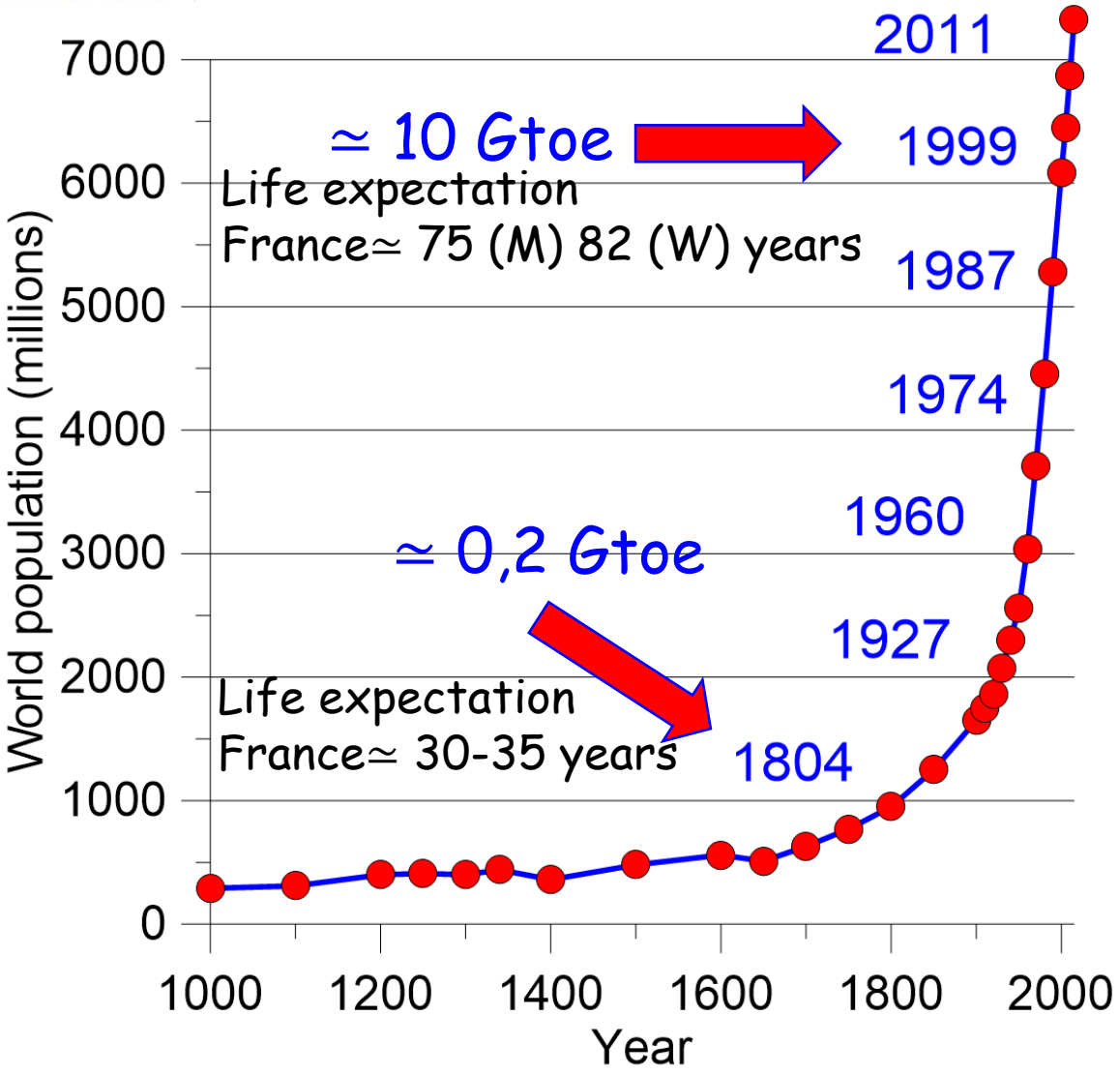
We need energy

- Energy is involved in any physical, chemical or biological process that results in change. Energy can be absorbed or released.
- What is useful for human activities is to transform one form of energy into another to produce heat, work, light, etc.



Energy: the blood of economy





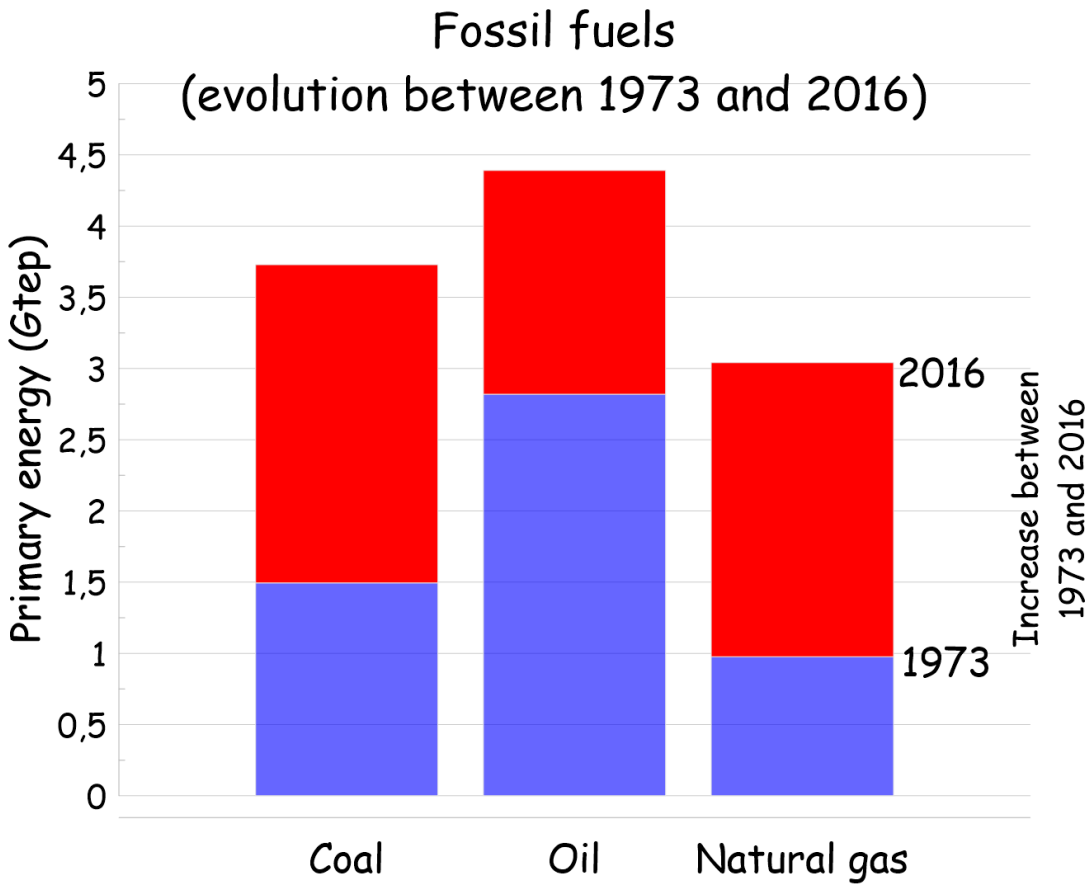
More and more energy!

2020
Total fertility rate
Africa ⇒ 4.3
Europe ⇒ 1.5
Niger ⇒ 7
South Korea ⇒ 0.8
North America ⇒ 1.6
Stability ⇒ 2.1
(Source Katie Grams, Population education)

1. Population growth (≈ 235 000 inhabitants/day)
2. Increase of the standard of living in emerging countries

Fossil fuels (coal, oil and gas)

- Dominance of fossil fuels
- ≃ 80% of primary energy consumption
- Production ↗ with time but investments ↘ are decreasing for ecological reasons



1973 (86.7%) ⇒ 2016 (81.1%). A decrease of 5.6% in 43 years
Primary energy 1973 (5.3 Gtoe) ⇒ 2016 (11.2 Gtoe)

Unconventional oil or gas are becoming more important (shale oil, shale gas, oil shale, extra-heavy oil, etc.

Hydropower and biomass

- Hydropower and biomass have been used for centuries.
- Hydropower is the best renewable energy source to produce electricity and should be used whenever possible
- Hydraulics is also of tremendous importance for large scale electricity storage

- Biomass energy is mostly used to produce heat
- In the future, when oil becomes scarse, it will be an essential source of carbon to synthetize organic products

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Irregular renewable energies

- Wind power and photovoltaic energy are highly developed but irregular

⇒ An erratic connection between supply and demand

- No CO_2 emission in operation but

⇒ An additional energy source (gas fired or coal fired plants) or electricity storage capabilities are needed

⇒ (20% (wind)-80%) ⇒ (400g-800g) CO_2/kWh

⇒ The electricity network needs to be strengthened

⇒ Difficult to manage the electrical network if the amount of intermittent energy is too large

⇒ Photovoltaic is more efficient in southern countries

⇒ Wind power → windy regions, off-shore more efficient (≃35-50%) than on-shore (20-25% in Europe).

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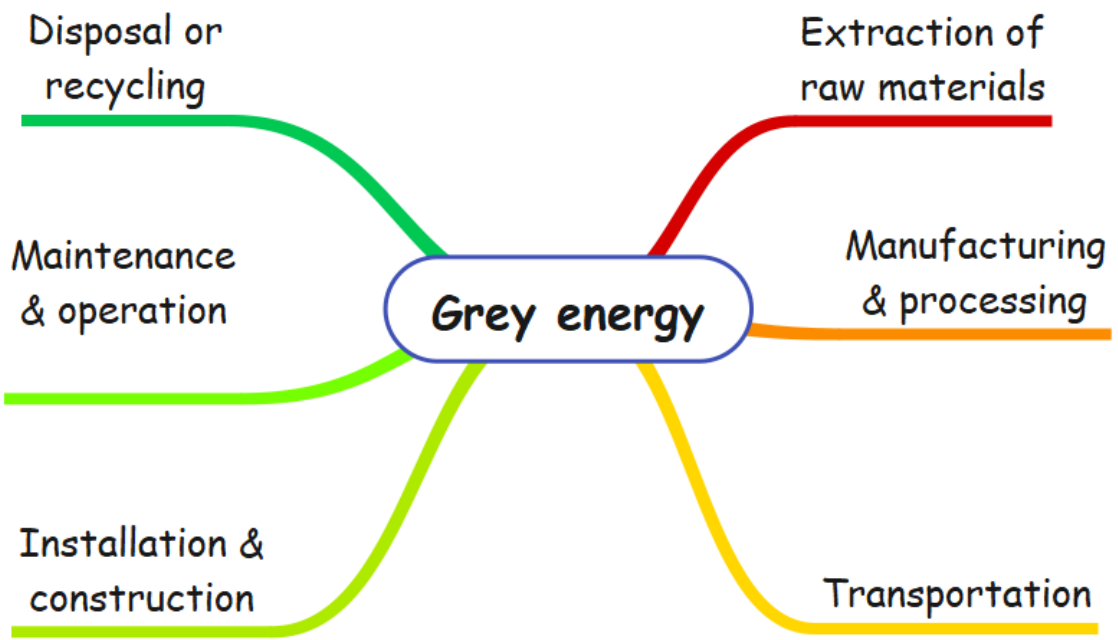
Grey (embodied) energy

Total energy = energy use + grey energy

You pay directly

You pay indirectly

Life cycle assessment method



Grey energy of a car ⇒ 100 GJ ≃ 3000 l gasoline ≃ 50 000 km

It is estimated that Europe grey energy consumption is about twice the value of the operation energy.

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Nuclear energy

A concentrated energy source :
1g of fissile material ≃ 23 000 kWh. 1g of oil ≃ 0.012 kWh

- A cost of electricity that is essentially stable over time

Price natural uranium×10⇒Increase price kWh <40%
Price natural gas ×10⇒Increase price kWh ×10

- Small CO_2 emissions (not during use) ≃ 6g/kWh in France

- The present technology is based on slow neutron reactors. Use ^{235}U (0.7% of natural uranium)

- Goal : develop fast neutron reactors that exploit also ^{238}U

The amount of natural uranium providing electricity over 40 years using slow reactors provides around 5 000 years of electricity with a fast neutron reactor.

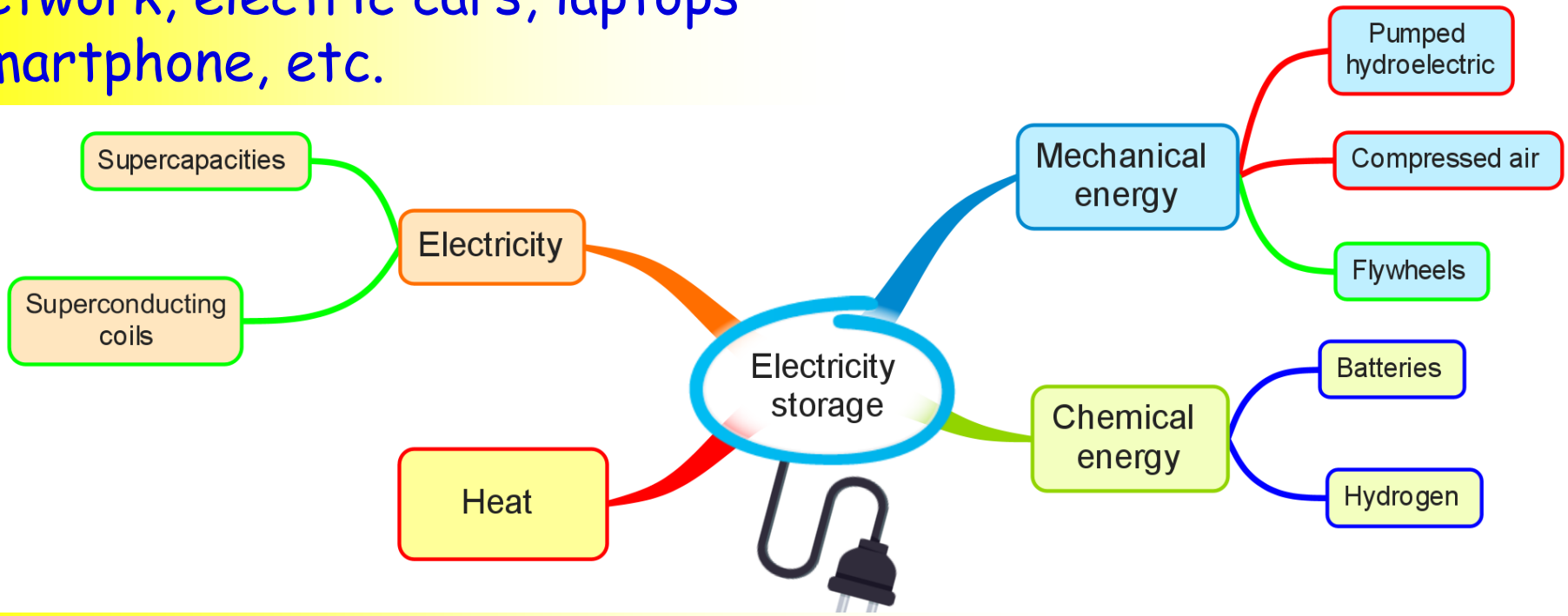
- Thorium (4 times more abundant than uranium) is also a possibility to exploit nuclear energy
- Fusion is probably for a far future
- Hopes ⇒ Chemically assisted nuclear reactions (today's talks)

Energy storage

1kWh → 70g oil
→ 30 kg lead battery
→ 5-8 kg Li-Ion
→ 3600 kg water falling from a height of 100 m

The weak point of the energy supply chain

Electricity storage ⇒ Electrical network, electric cars, laptops smartphone, etc.



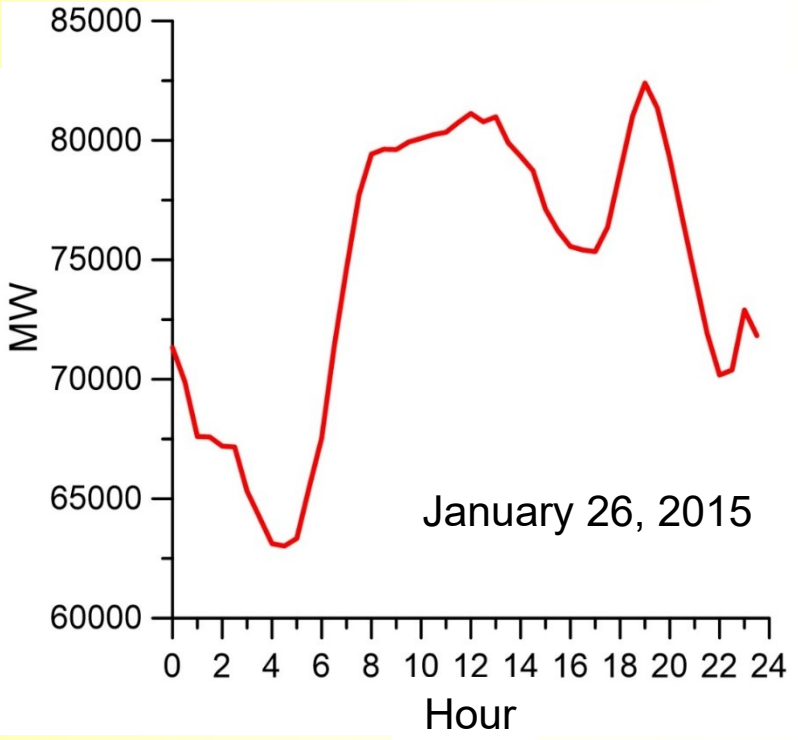
Heat storage ⇒ easy on the short term, difficult on the long term

Electricity

- Energy vector (energy is needed to produce it)
- Constraint : Production = Consumption at every moment
- In 2023, 36% of electricity is produced by coal fired plants

Why store electricity ?

- Smooth out production, store cheaply to sell dearly
- Intermittent energy sources (wind, photovoltaic)
- Portable systems, transport
- Clean energy



- 2017 (France) ⇒ average power 60GW
- But power installed ⇒130 GW (to meet peak demand)

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Hydrogen

- Energy vector (energy is needed to produce it)
- Good news: there are natural H_2 sources. What quantities are available and how to recover it?
- Nowadays mostly produced from CH_4 ($\simeq$150-180 MJ/kg) but coal is also used
- Electrolysis (2-4%) using CO_2 free electricity would be the best ($\simeq$204-238 MJ/kg).
- Looks good in energy density: 1kg H_2=33 kWh $\simeq$ 3ℓ of oil
- But very bulky in volume: 1ℓ gasoline $\simeq$ 7ℓ of 700 bars H_2 or 4ℓ of liquid H_2
- A gas pipeline transports 15 times less H_2 than oil and 3 times less natural gas

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Smart energy consumption

- So far energy has been abundant and cheap

It is gradually becoming scarcer and more expensive before a new technological breakthrough comes into play

To cope with that we need:

- Efficiency (improve a technology that needs less energy to perform the same task). Example: develop a car engine that uses less fuel for equal or better performances.
- Sobriety (use other solutions for the same task). Example: walk 100m instead of driving a car over the same distance
- *Example:The amount of energy required to make a ton of iron was divided by 150 between the Middle Ages and today. It has been divided by 2.5 for cement between 1950 and 2000.*

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Housing

- The building sector in France: ≃ 30 millions of home with a renewal of about a century)

43% of energy used in France, 21% of greenhouse gases

- Heating+driving of a family > 80% of the energy consumption
- Evolution towards a more efficient housing but different regions demand different solutions. It is possible to build houses with an energy consumption of 50-100 kWh/m²/year or even « positive » energy houses
- Do not forget grey energy
- Transportation and housing are closely connected. An insulation gain of 80 kWh/m²/y is canceled out if you have to drive 20 km per working day to reach your workplace
- Renovation is the most important issue (renovation ≃ 500-1500 MJ/m². New building ≃ 5000-15000 MJ/m²

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Road transportation

- France. Road transportation ≃500 TWh. Electricity consumption ≃480 TWh. Oil is important
  - Thermal, hybrid (normal and plug in), electric, hydrogen
- A car needs ≈ 15-20 kWh/100 km but the yield of the propulsion group should be taken into account
- Thermal vehicle 15kWh/100km (yield 25%) ⇒ ≃6ℓ/100km
- Electric vehicle (regenerative braking) 12-16 kWh/100km ⇒ 100kg/100km range of Li-Ion battery
- Quantity of electricity needed to supply the french car fleet: ≃105 TWh/year
- Hydrogen car (fuel cell): ≃1kg H_2/100km.

For the french car fleet ⇒ ≃300 TWh/year

With the same amount of electricity, you can travel 3 times more km with a battery than with a fuel cell powered by hydrogen.

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Conclusion and outlook

- Energy sobriety and efficiency
- We will need all sources of energy
- CO_2 free energy sources (nuclear + renewables +?)
- Exploiting low temperature heat (heat pumps)
- We will need more and more electricity

Bad news for Europe

- Energy is becoming more and more expensive
- Some raw materials are scarcer and more expensive
- Missing of fossil fuels and raw materials, Europe will gradually collapse unless we strongly mobilize scientific excellence and have the will to fight in the new global context while overcoming ideologies. Common sense is urgently needed