Khemis Miliana University – Djilali BOUNAAMA
Faculty of Material Science & Computer Science
Department of Physics

جامعة الجيلالي بونعامة خميس مليانة
كلية علوم المادة والإعلام الآلي
قسم الفيزياء

L1 Material Science

Renewable Energies

Discovery Teaching Unit (S2)

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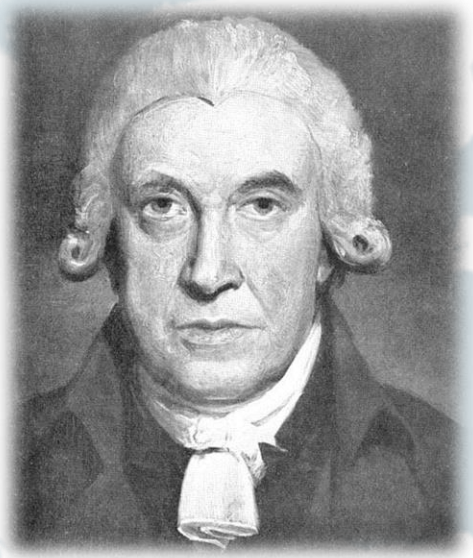
2023/2024

Content

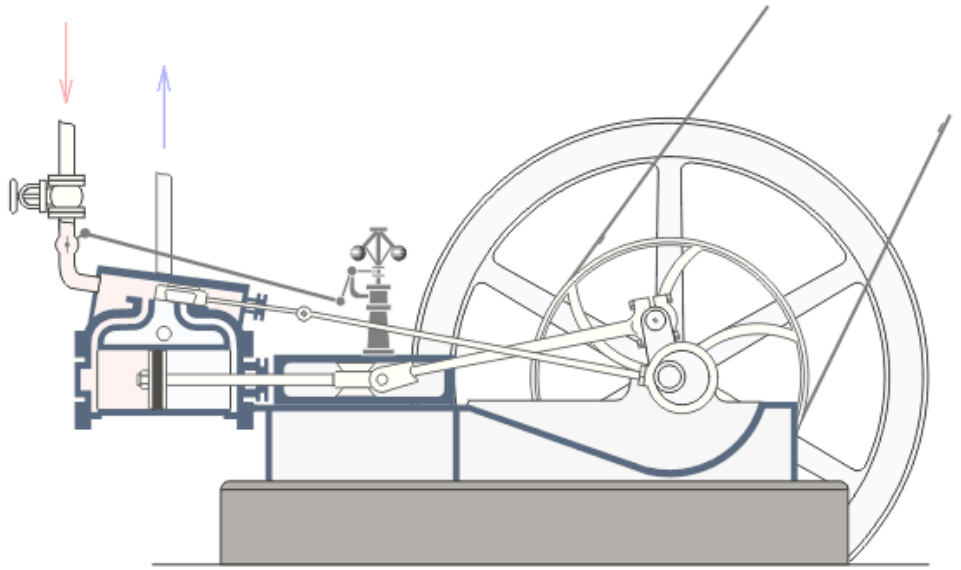
- Forms of Energy
- Conventional sources of energy
- Some key concepts
- Different types of renewable energies
- Energies of the future

Evolution of energy needs

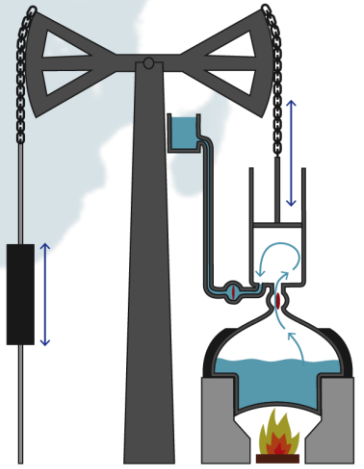
- La 1ère Révolution Industrielle (1.0 IR)



James WATT
1736-1819, Scotland, UK



Enhanced version of NEWCOMEN engine (1712)

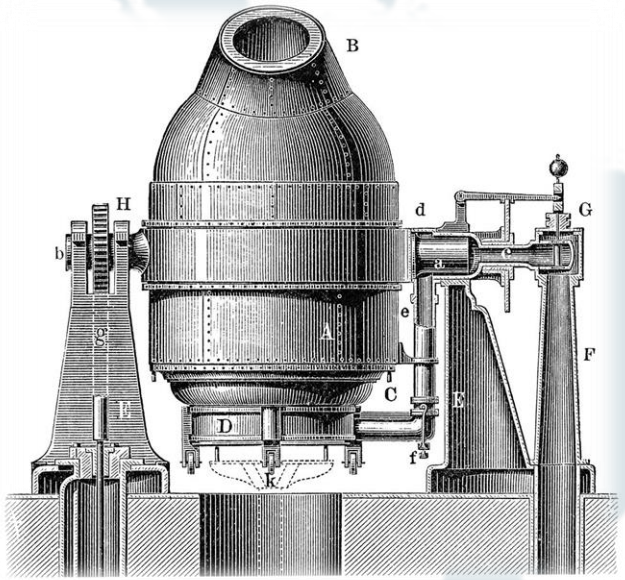


WATT's Steam engine
Imagined in 1764
Patented in 1769
Industrial release in 1775

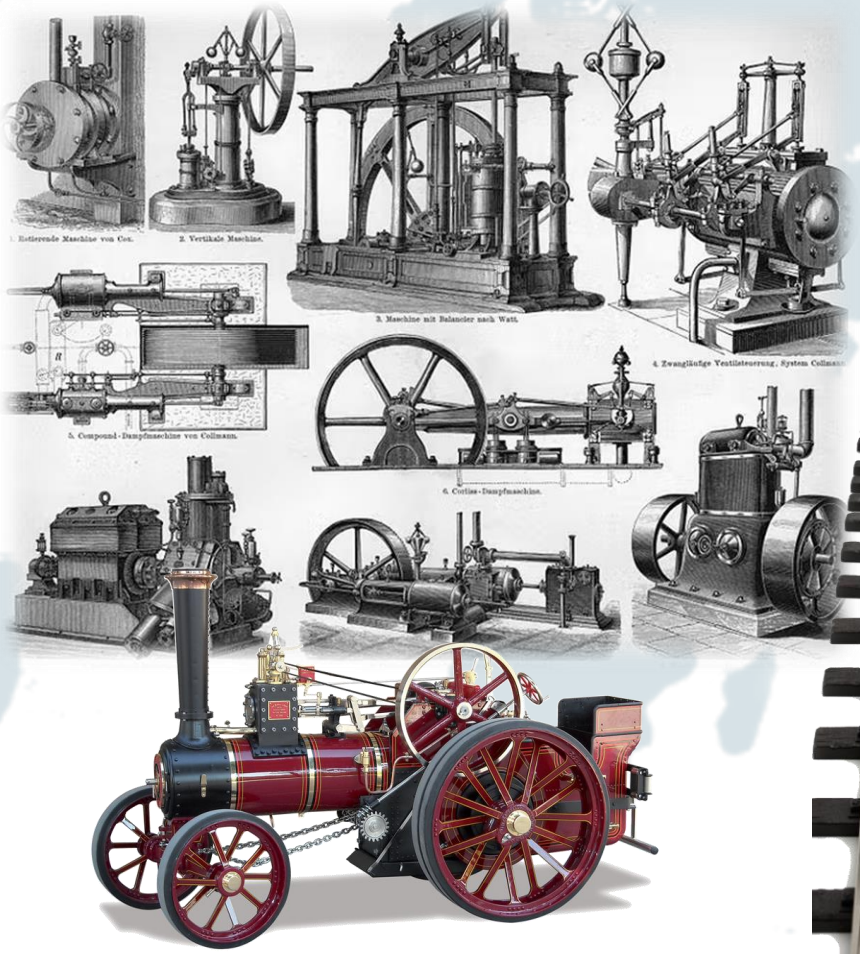
Evolution of energy needs

- The 1st Industrial Revolution (IR1.0)

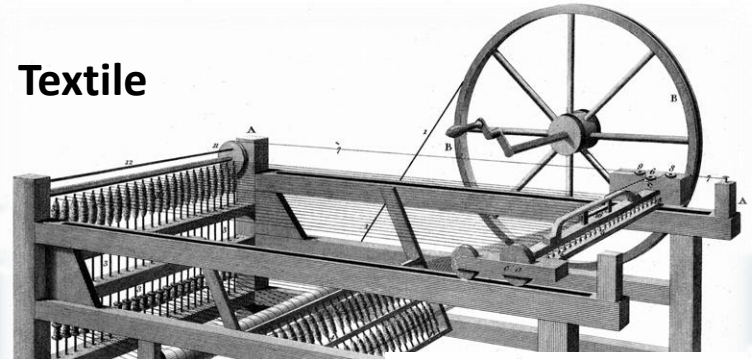
Coal as fuel



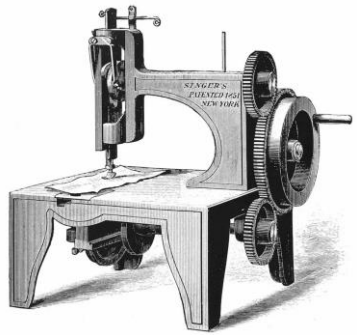
Steel industry

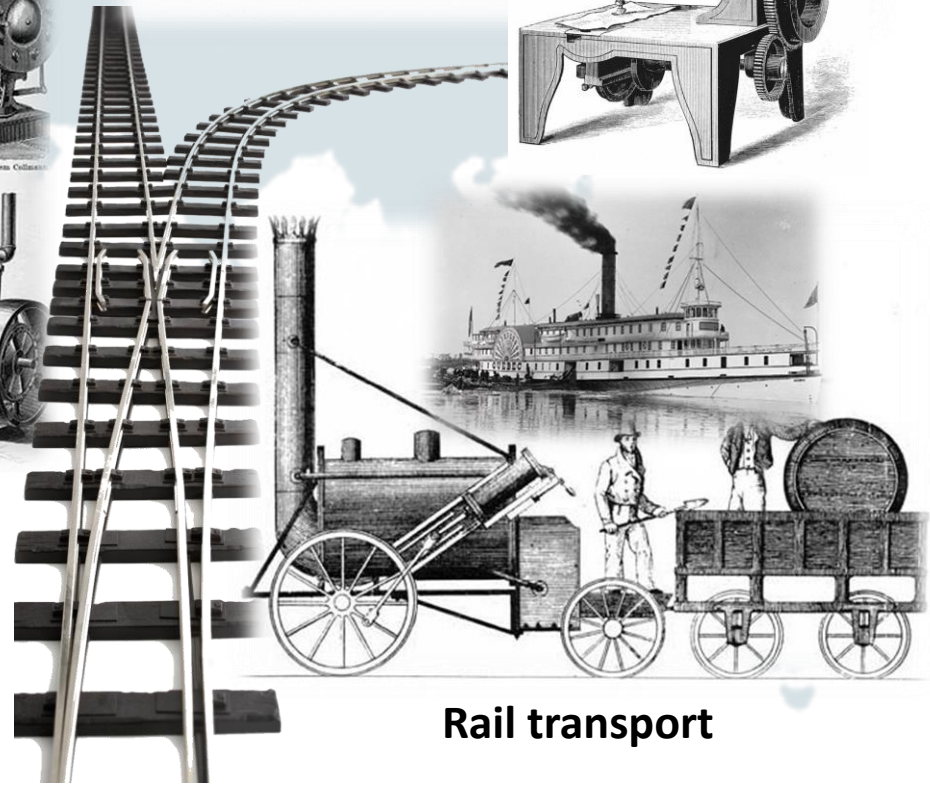


Steam vehicle



Textile





Rail transport

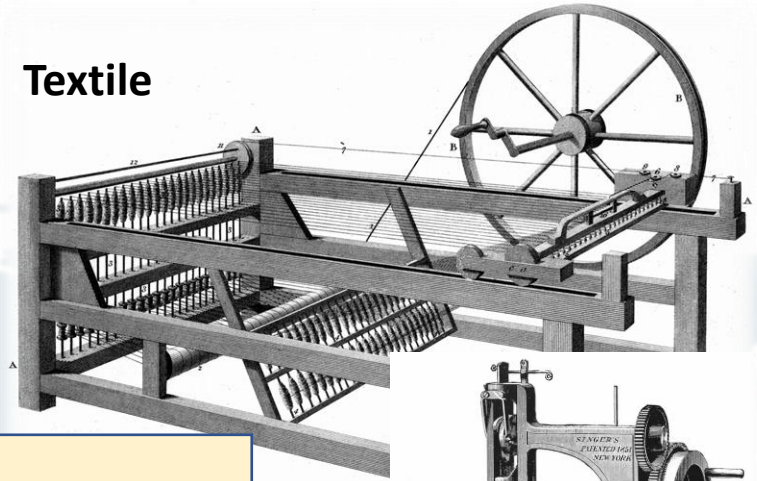
Evolution of energy needs

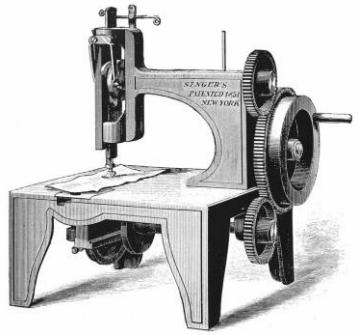
- The 1st Industrial Revolution (IR1.0)

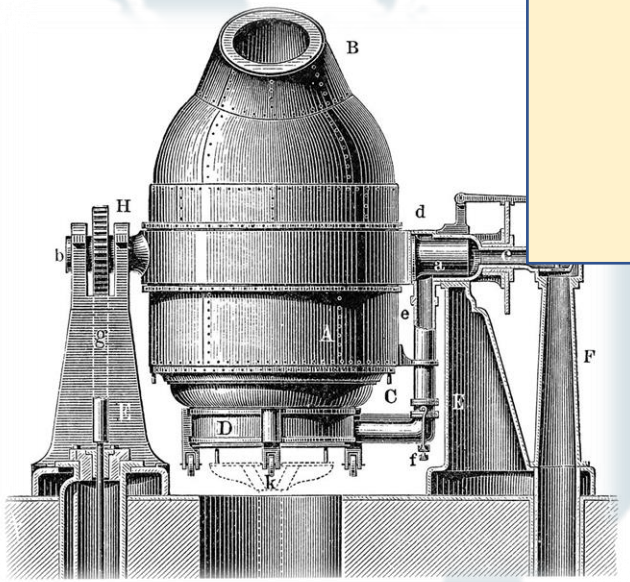
Coal as fuel

1.0 IR (end 18th – end 19th Century)
GB → EU → USA → JP
World Population ~ 1 billion

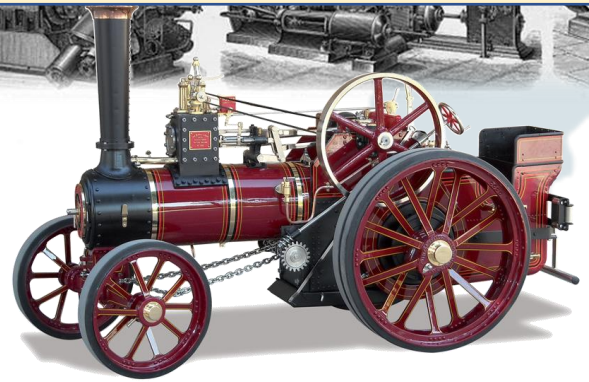
Textile



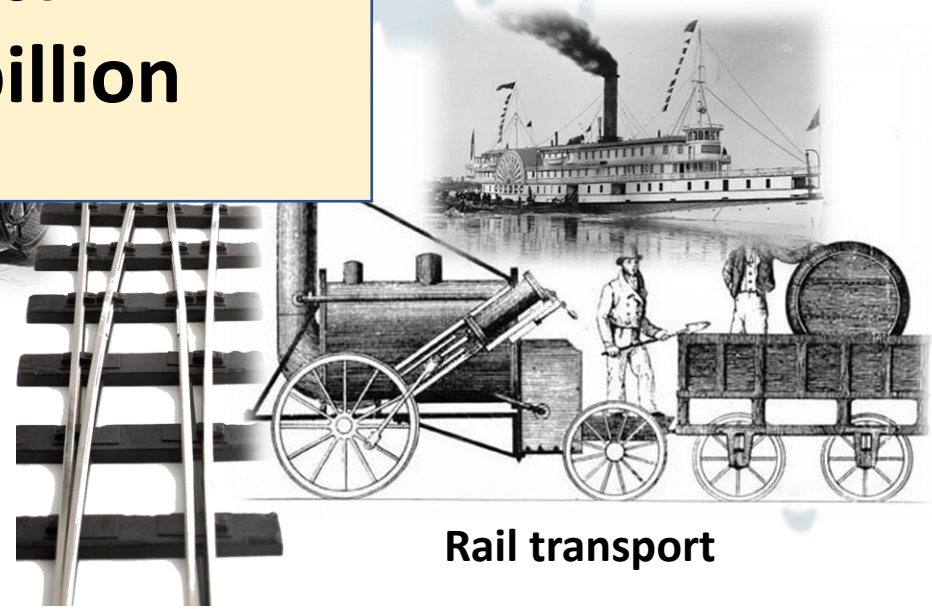




Steel industry



Steam vehicle



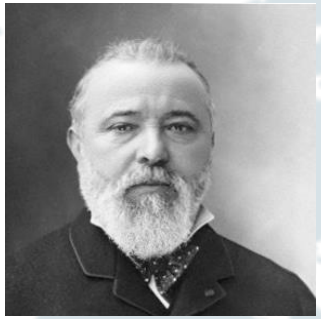
Rail transport

Evolution of energy needs

- The 2nd Industrial Revolution (2.0 IR)

Etienne LENOIR
1822-1900, France

Nikolaus OTTO
1832-1891 Germany

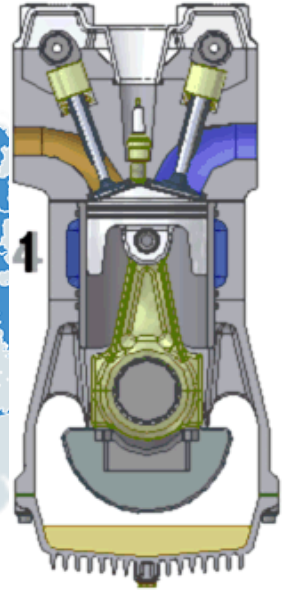


Zénobe GRAMME
1826-1901 Belgium

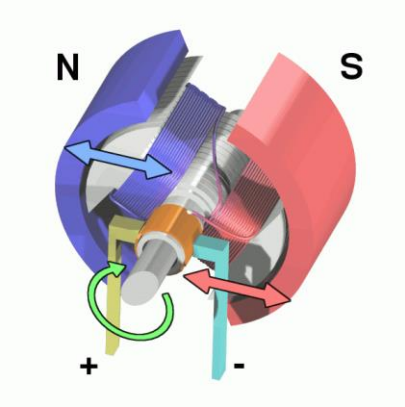
Phone invention by
A.G. BELL in 1876

Electric light bulb by
T. EDISON in 1882

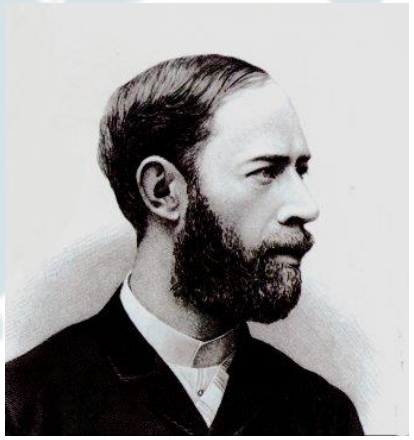
Eugenio BARSANTI
1821-1864, Italy



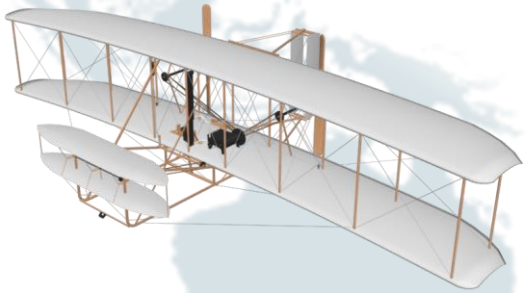
Internal Combustion Engine
(Essence, Diesel)



Dynamo (Electric Motor)



Hertzian waves by
H. HERTZ in 1886

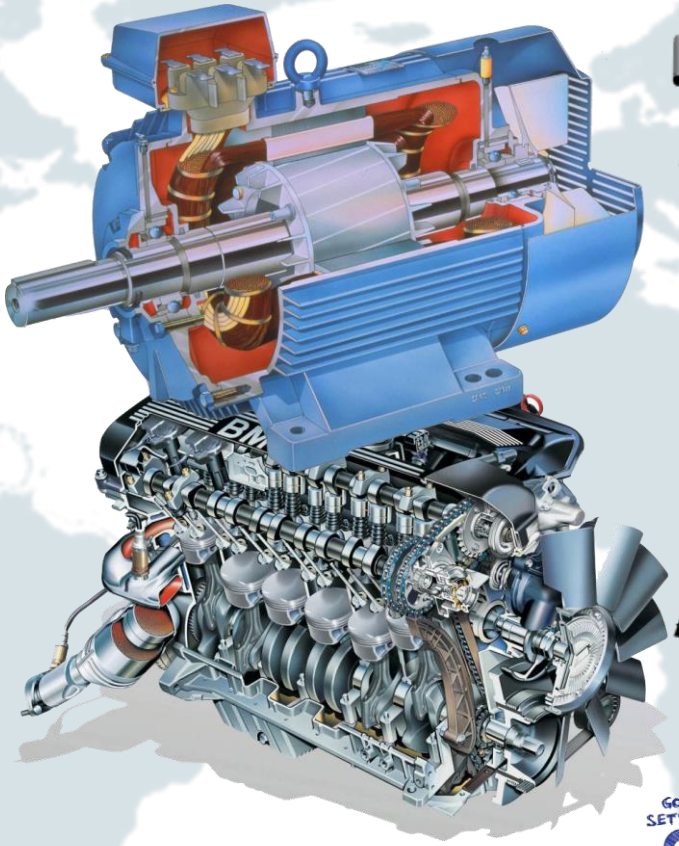


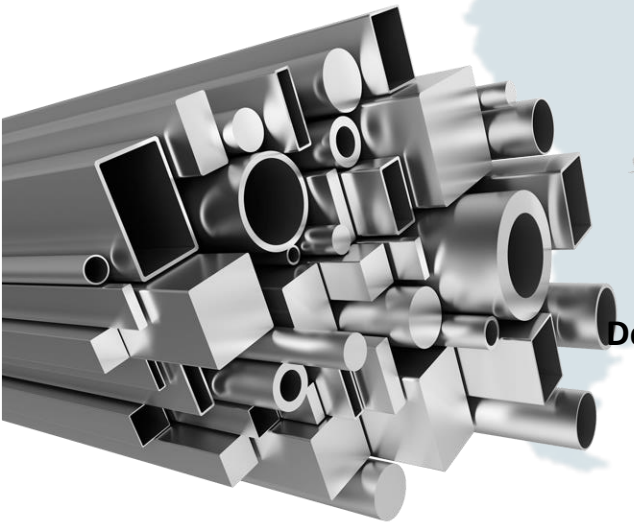
First mechanized flight by
The WRIGHTs bros in 1903

Evolution of energy needs

- The 2nd Industrial Revolution (2.0 IR)

Fossil fuels
(Gaz & Oil)





Development of Steel and alloys industries

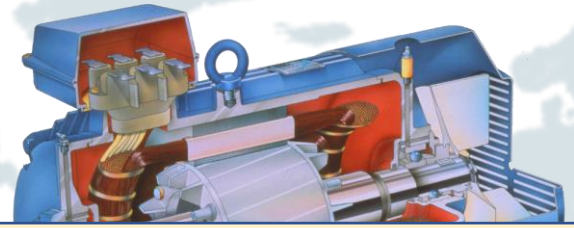
Telecommunications

Large-Scale transport

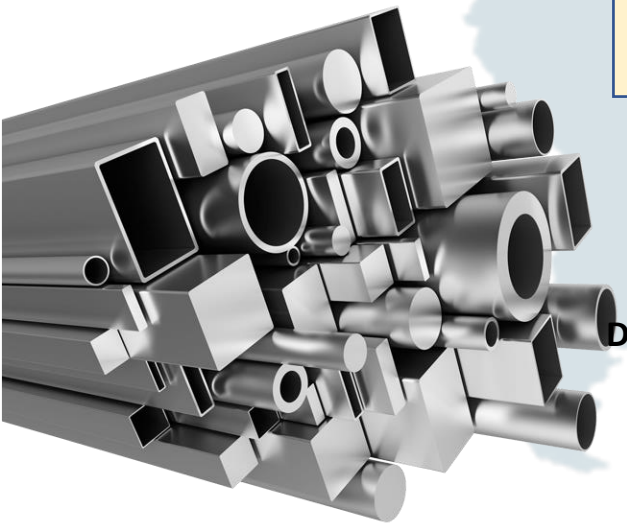
Evolution of energy needs

- The 2nd Industrial Revolution (2.0 IR)

Fossil fuels
(Gaz & Oil)



2.0 IR (end 19th – mid 20th Century)
World Population ~ 2,5 billions



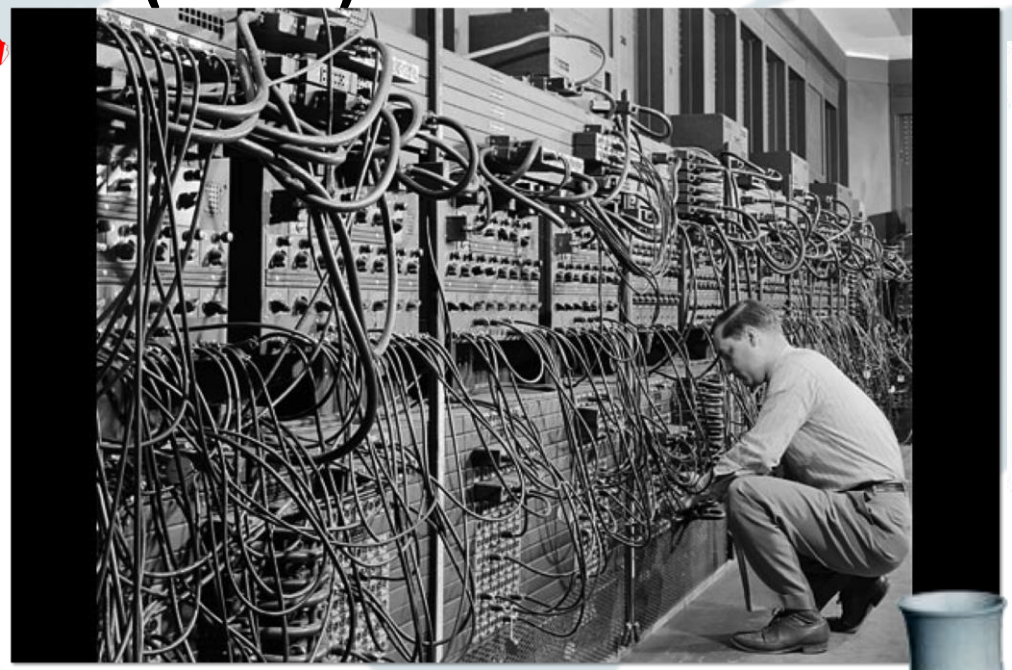
Development of Steel and
alloys industries

Telecommunications

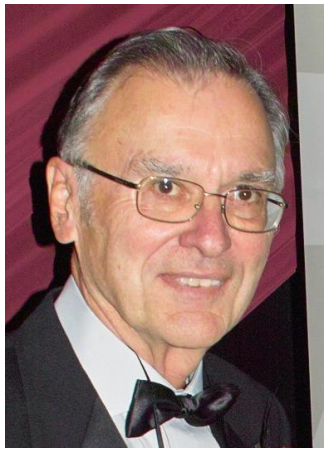
Large-Scale transport

Evolution of energy needs

- The 3rd Industrial Revolution (3.0 IR)

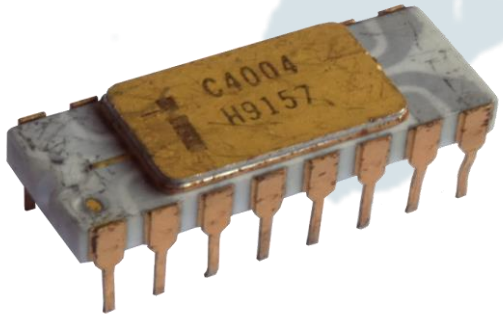


ENIAC, Programable calculator (USA) ~ 1947



Marcian HOFF
1937, USA

Frederico FAGGIN
1941, Italy-USA



First Microprocessor Intel 4004, in 1971

Nuclear Power Plants

Evolution of energy needs

- The 3rd Industrial Revolution (3.0 IR)

Nuclear fuel (Uranium)

GSM™

Airplane and Aerosptial industry

Developpment of Computer Science

Automated industry and robotics

Evolution of energy needs

- The 3rd Industrial Revolution (3.0 IR)

Airplane and Aerosptial industry

Nuclear fuel (Uranium)

Computer Science

3.0 IR (end 20th – start 21st Century)
World Population ~ 6 billions

Automated industry and robotics

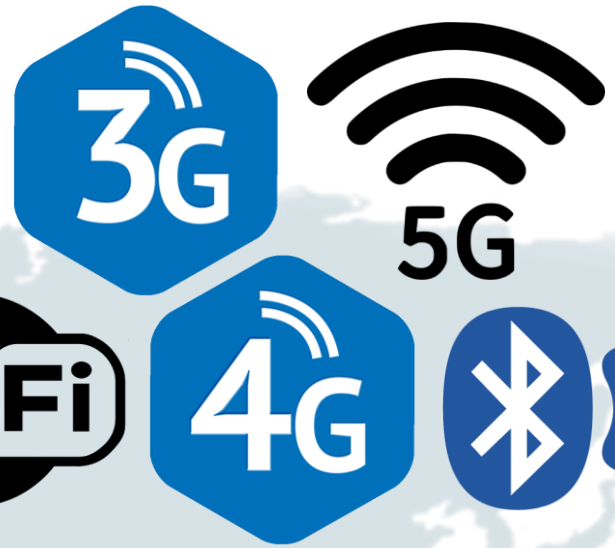
Evolution of energy needs

- The 4th Industrial Revolution (4.0 IR)

Social Networks and News

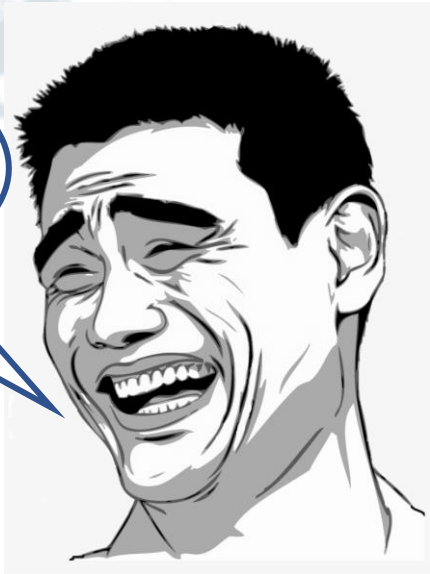
(تقرعيج)

Finance and Market digitization



Internet Access and File Sharing

ENR



Evolution of energy needs

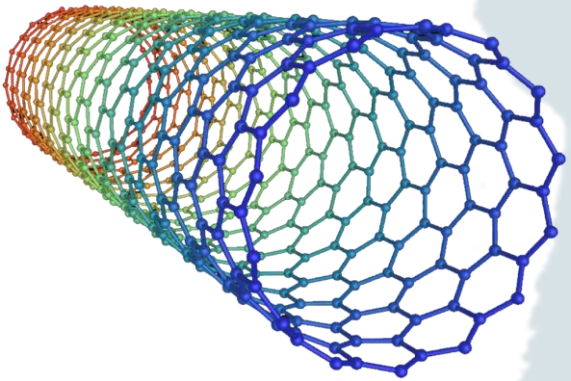
- La 4ème Révolution Industrielle (4.0 IR)

Cryptocurrency

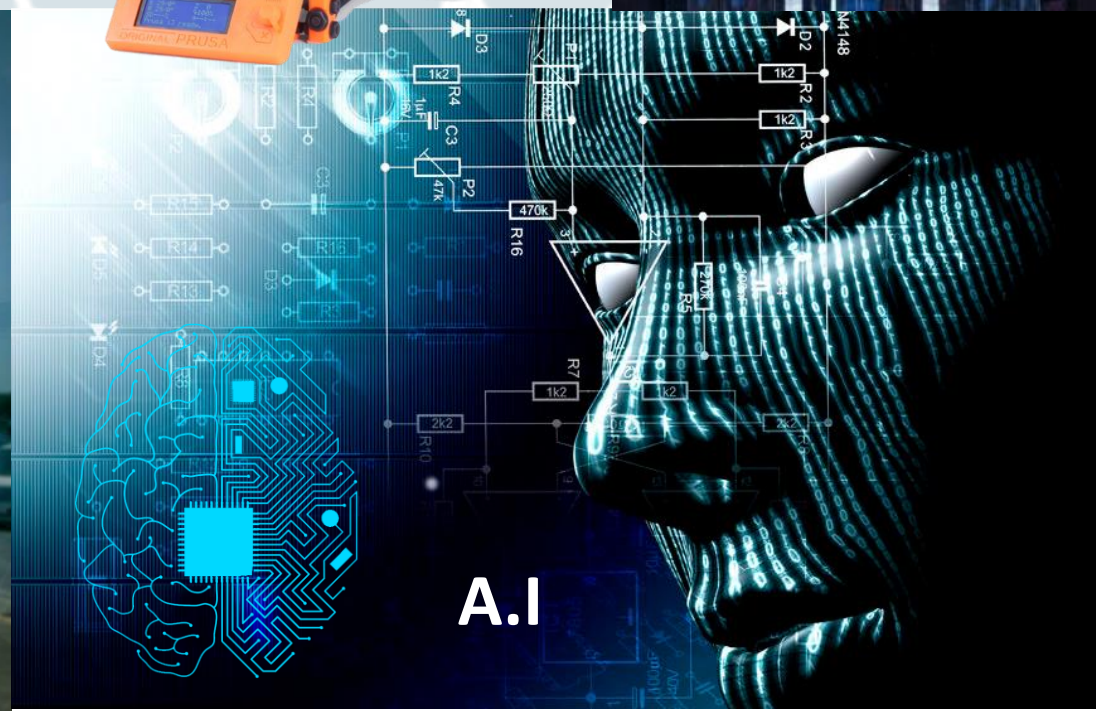
Virtual Reality

3D Printing

Quantum Computer



Nanotechnology



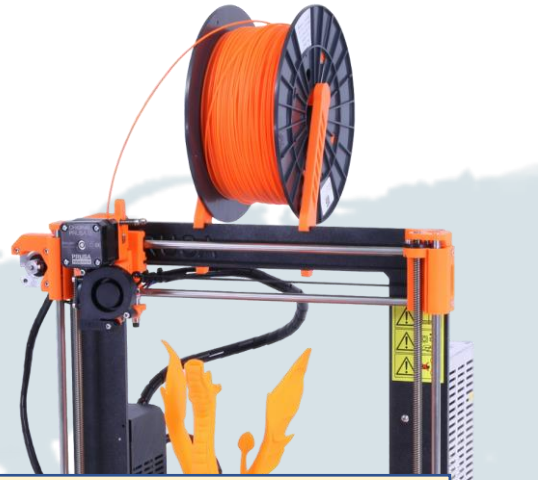
Evolution of energy needs

- La 4ème Révolution Industrielle (4.0 IR)

Cryptocurrency

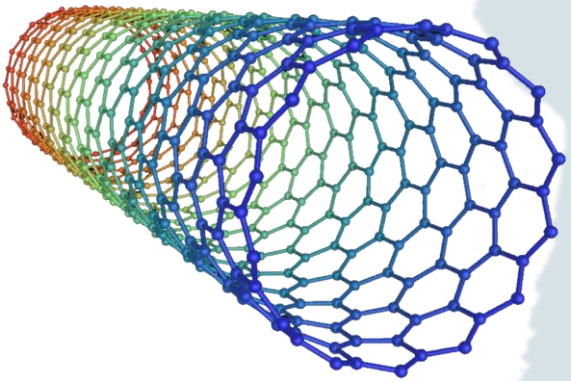
Virtual Reality

3D Printing

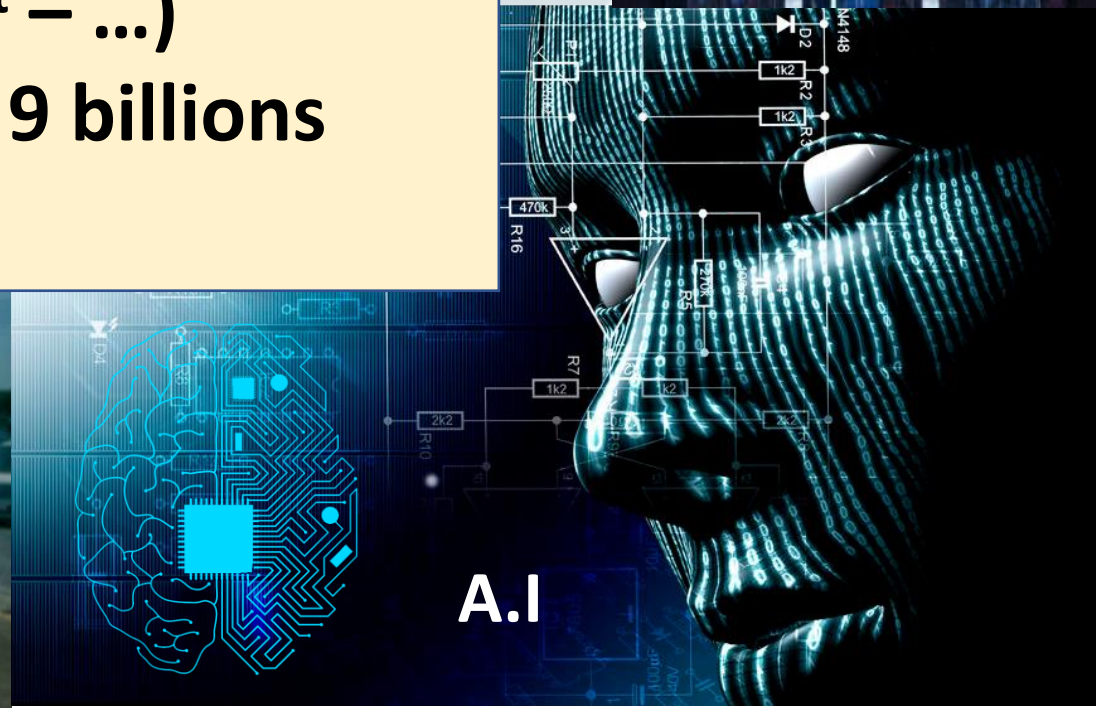


Quantum Computer

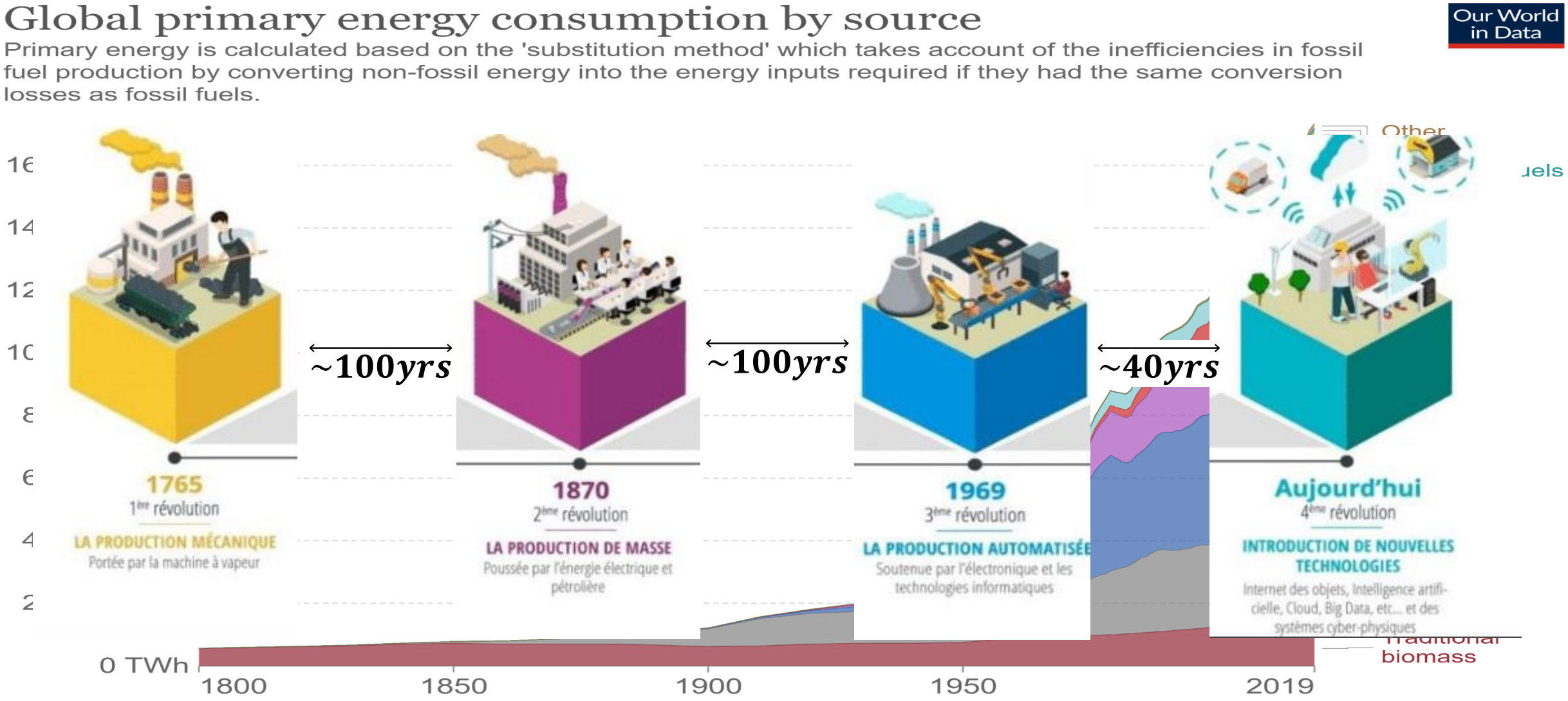
4.0 IR (start 21st – …)
World Population ~ 9 billions



Nanotechnology

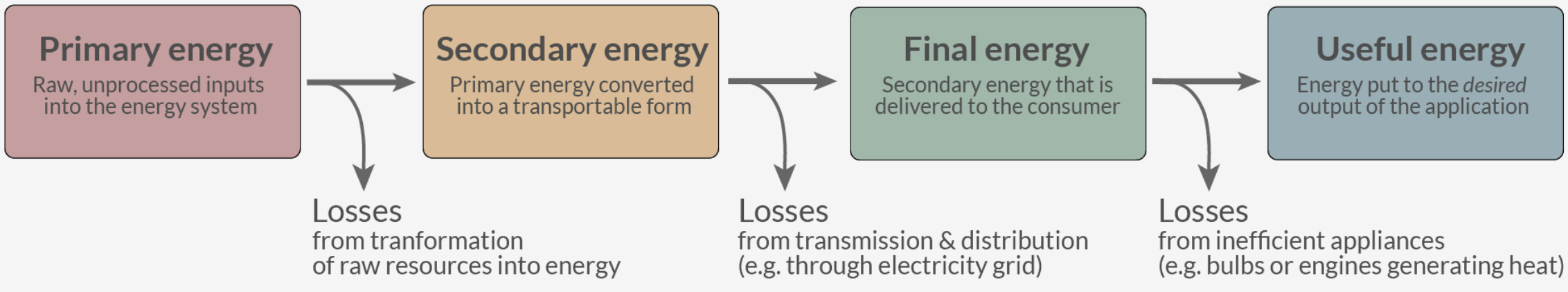


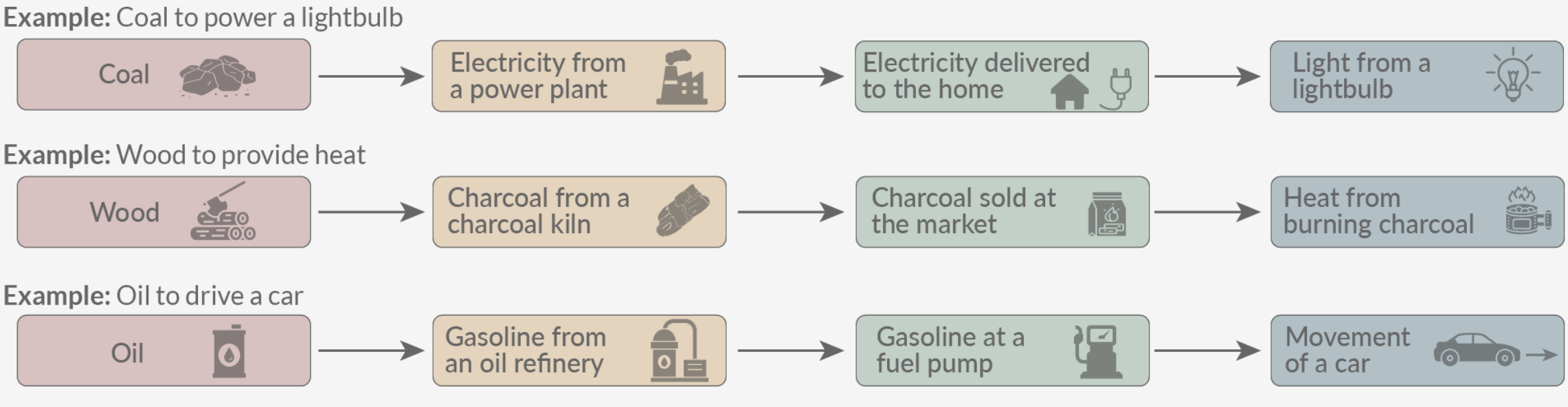
Evolution of energy needs



The four ways of measuring energy

Our World in Data





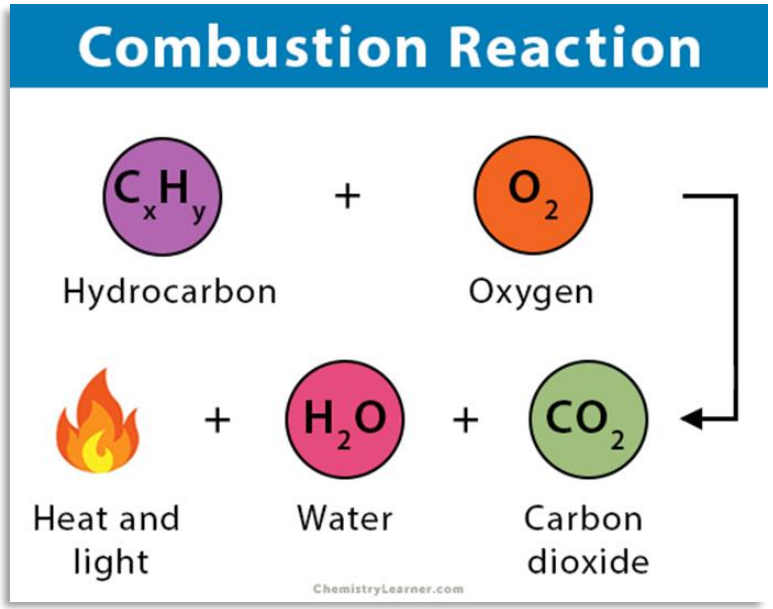
Icon source: Noun Project.

OurWorldinData.org – Research and data to make progress against the world's largest problems.

Licensed under CC-BY by the author Hannah Ritchie.

Conventional energies

- **Chemical energy**
  - Energy obtained due to chemical combustion (Chemical reactions) of chemical/organic (fuels)
  - Conventionally, we use organic or fossil fuels: Woods, Coal, Oil and Gas



- When the chemical energy is transformed into thermal energy, it implies pulsed (explosions) or continuous (combustion) increase of heat in engineered systems known as : **Heat or Thermal Machines**

Fuel	Calorific Value (kJ/kg)
Cow dung cake	6000-8000
Wood	17000-22000
Coal	25000-33000
Petrol	45000
Kerosene	45000
Diesel	45000
Methane	50000
CNG	50000
LPG	55000
Biogas	35000-40000
Hydrogen	150000

Conventional energies

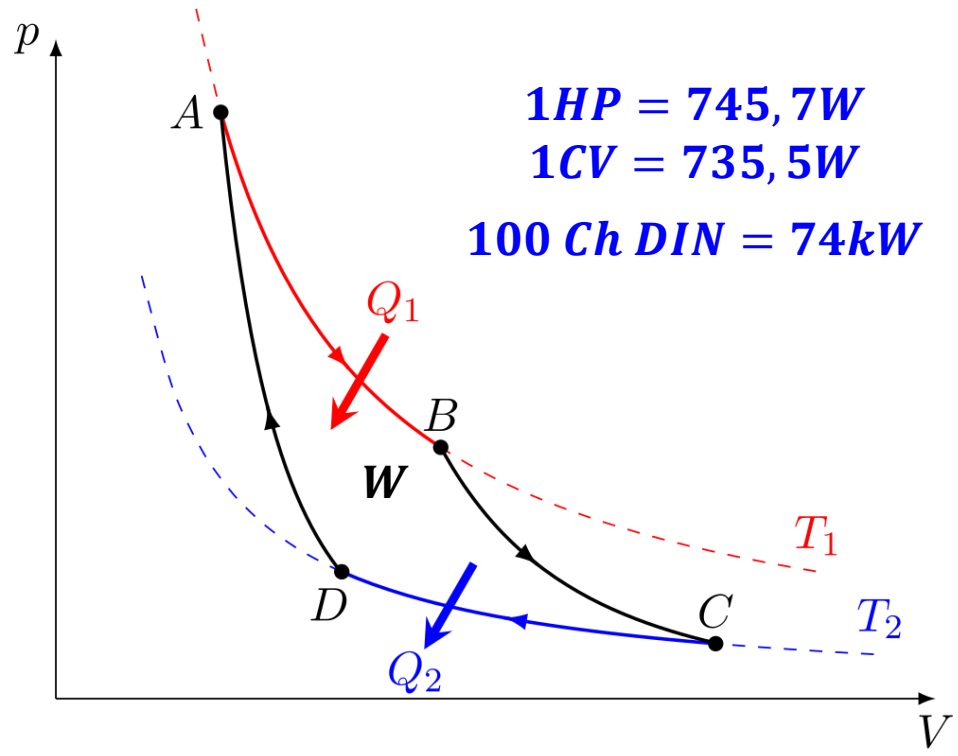
• Thermal Machine

The energy losses in thermal machine are due to:

- **Irreducible losses related to the thermodynamic cycle**
- **Losses related to the cooling of the transformation system itself**
- **Friction losses: Cylinders, Pistons, distribution system, intake and exhaust gases**
- **Necessary energy to accessories operation**

The thermal Machine represent an energy efficiency:

$$\eta = \frac{\text{énergie utile}}{\text{énergie consommée}} = \frac{-W}{Q} = 1 - \frac{T_f}{T_c} < 1$$



$$1HP = 745,7W$$
$$1CV = 735,5W$$
$$100\ Ch\ DIN = 74kW$$

Carnot Cycle (ideal case)

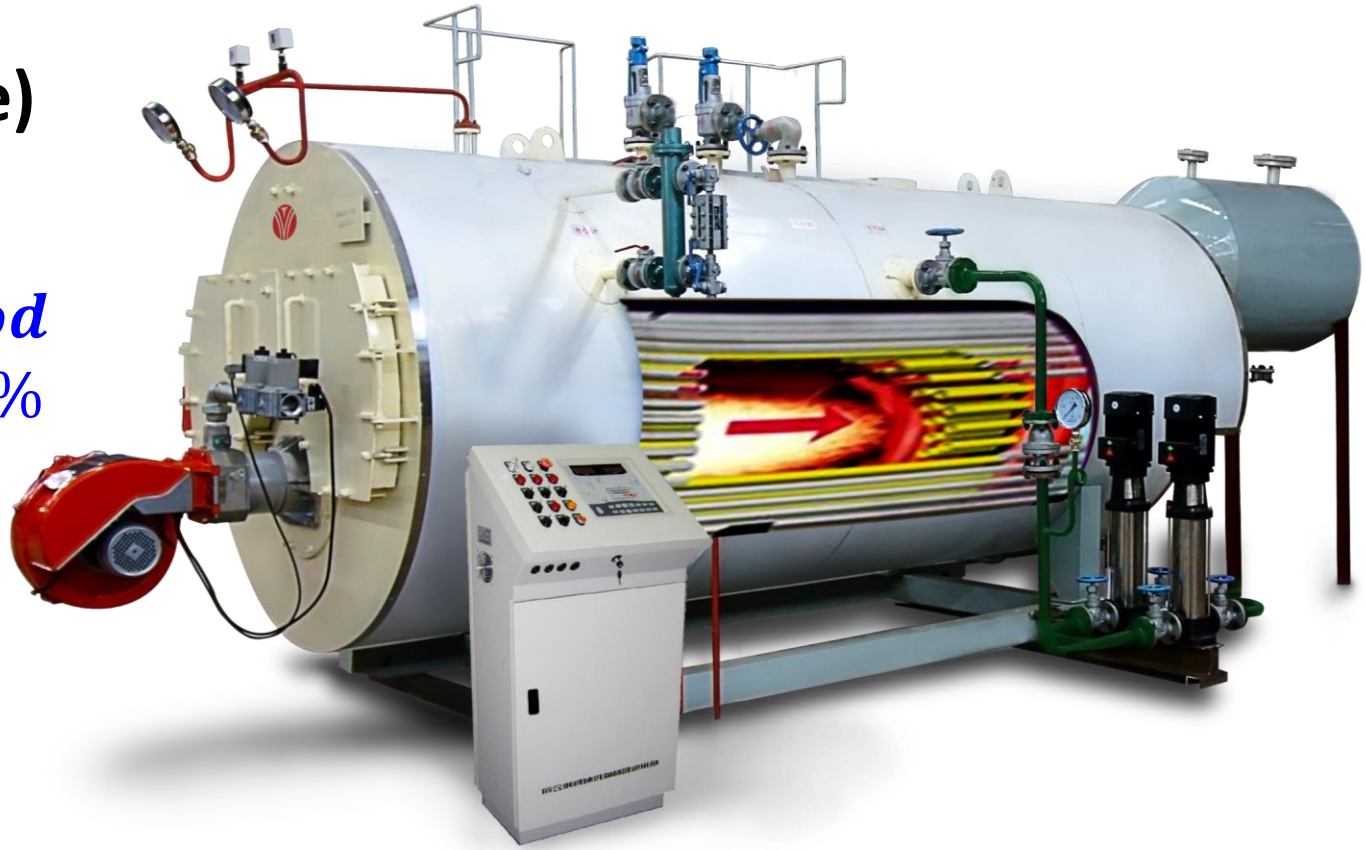
- **AB: isothermal expansion ($T_1 = Cte$)**
- **BC: adiabatic expansion**
- **CD: isothermal compression ($T_2 = Cte$)**
- **DA: adiabatic compression**

Conventional energies

- **Machine thermique (Chaudière)**

$$Gaz, Oil, wood$$

$$70 \leq \eta \leq 95\%$$



Boilers are used to produce heat for:

- **Indoor heating**
- **Cremation of organic/biological waste or substances**

Conventional energies

- **Thermal machine (Combustion engine)**

2-wheels

$4 - 100\ ch.DIN$

4-wheels vehicle

$12 \leq \eta \leq 35\%$

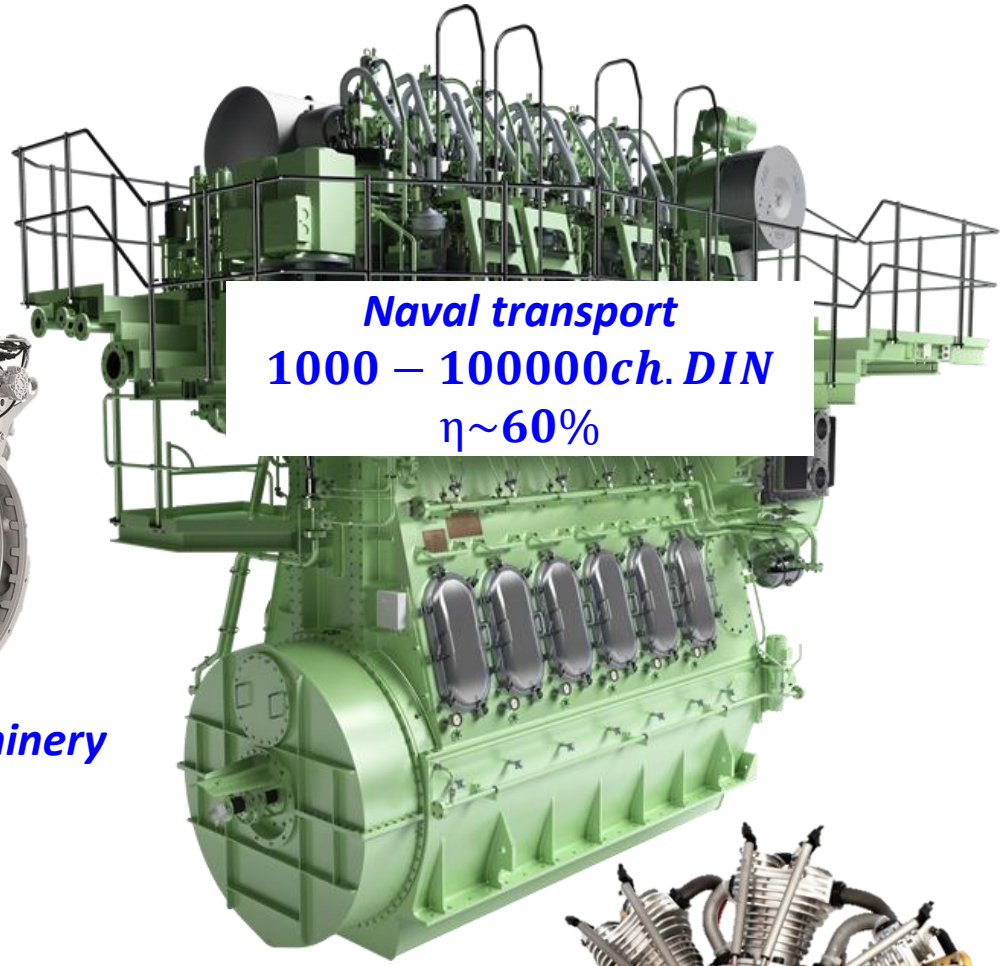
$65 - 200\ ch.DIN$

$15 \leq \eta \leq 45\%$

Trucks, trains, construction machinery

$500 - 4000 ch.DIN$

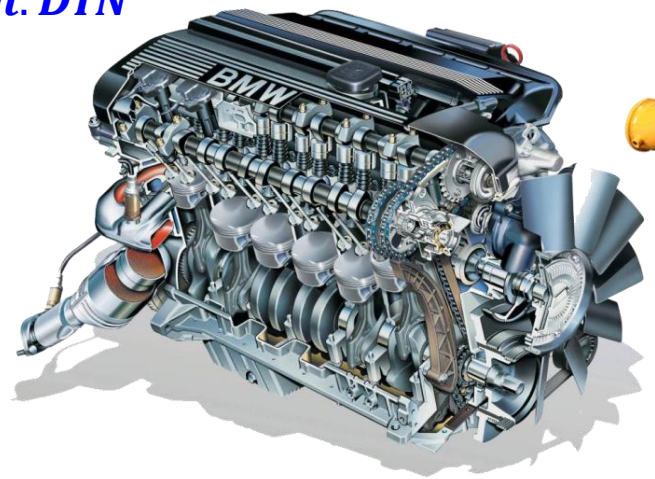
$\eta \sim 50\%$



Naval transport

$1000 - 100000 ch.DIN$

$\eta \sim 60\%$



Air transport

$100 - 4000 ch.DIN$

$\eta \sim 60\%$

Conventional energies

- **Thermal Machine (Combustion engine)**

Electric generator

$\mathbf{1 - 2000\ kW}$

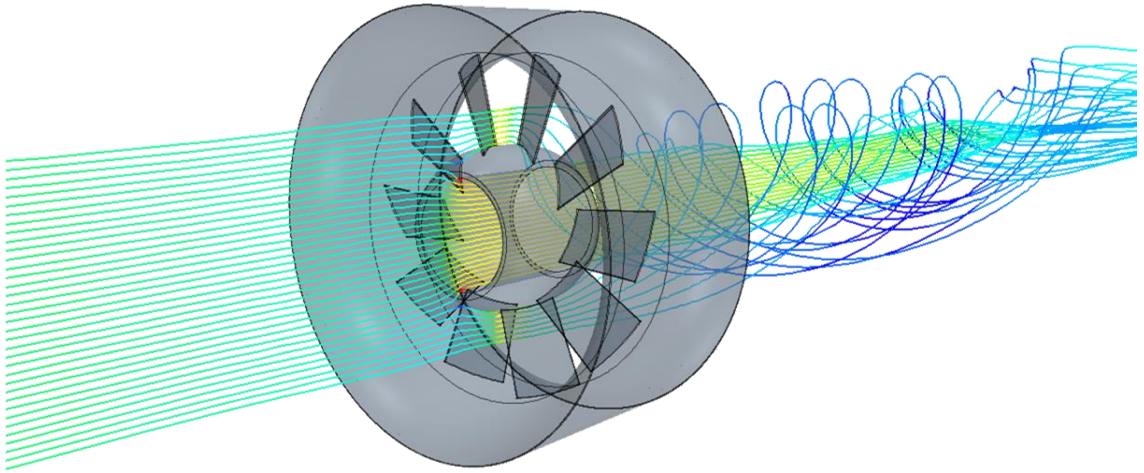
$\eta \sim 50\%$

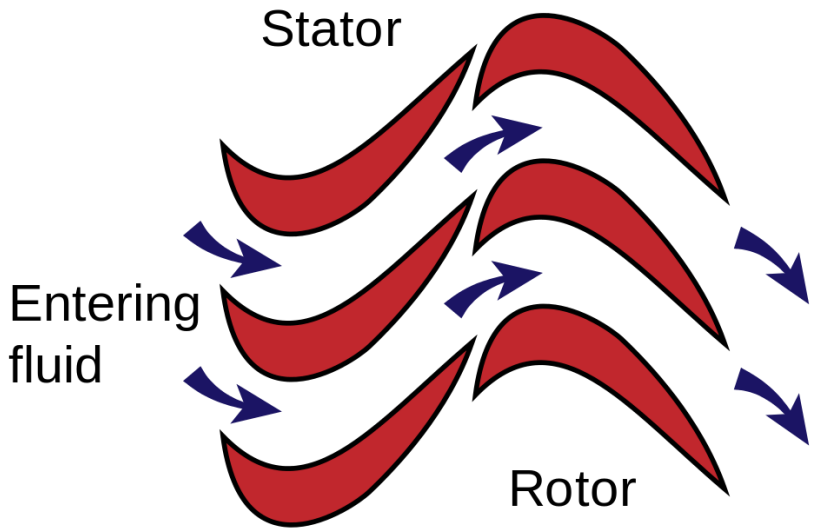
Conventional energies

- **Thermal machine (Turbomachine)**

Turbomachine is an energy system in which an energy transfer take place between a rotating part (rotor) and a fluid:

- **Driven machines : Turbine (gas, steam, hydraulic)**
- **generators: pumps (centrifuge, compressor, ventilator)**





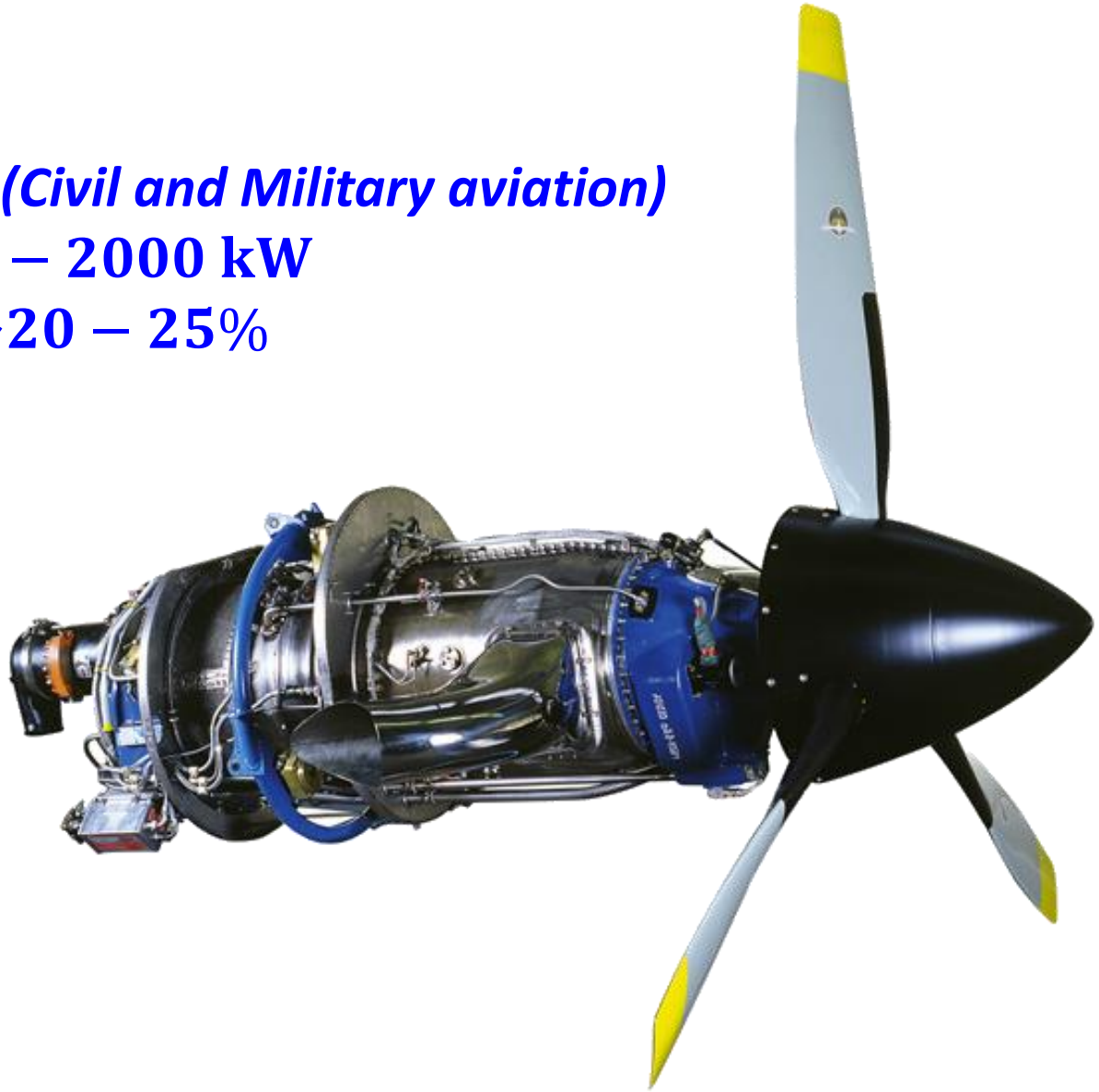
Conventional energies

- **Thermal Machine (Turbomachine)**

Reaction airplanes (Civil and Military aviation)

$$\mathbf{100 - 2000\ kW}$$

$$\eta \sim \mathbf{20 - 25\%}$$



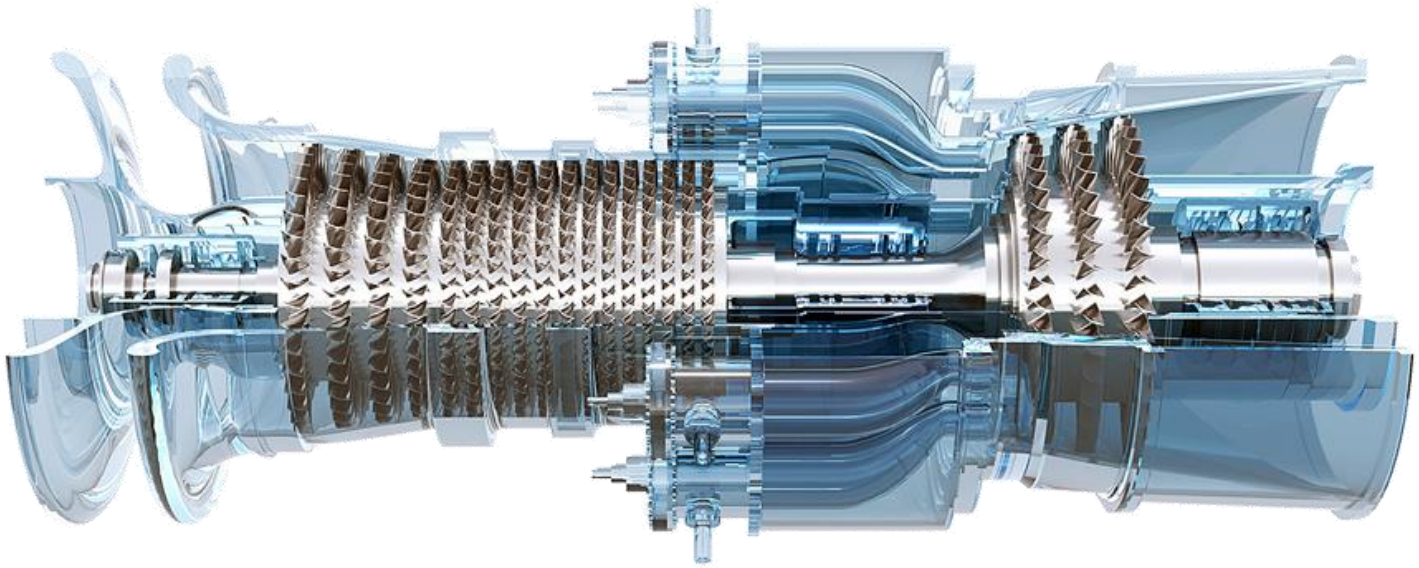
Conventional energies

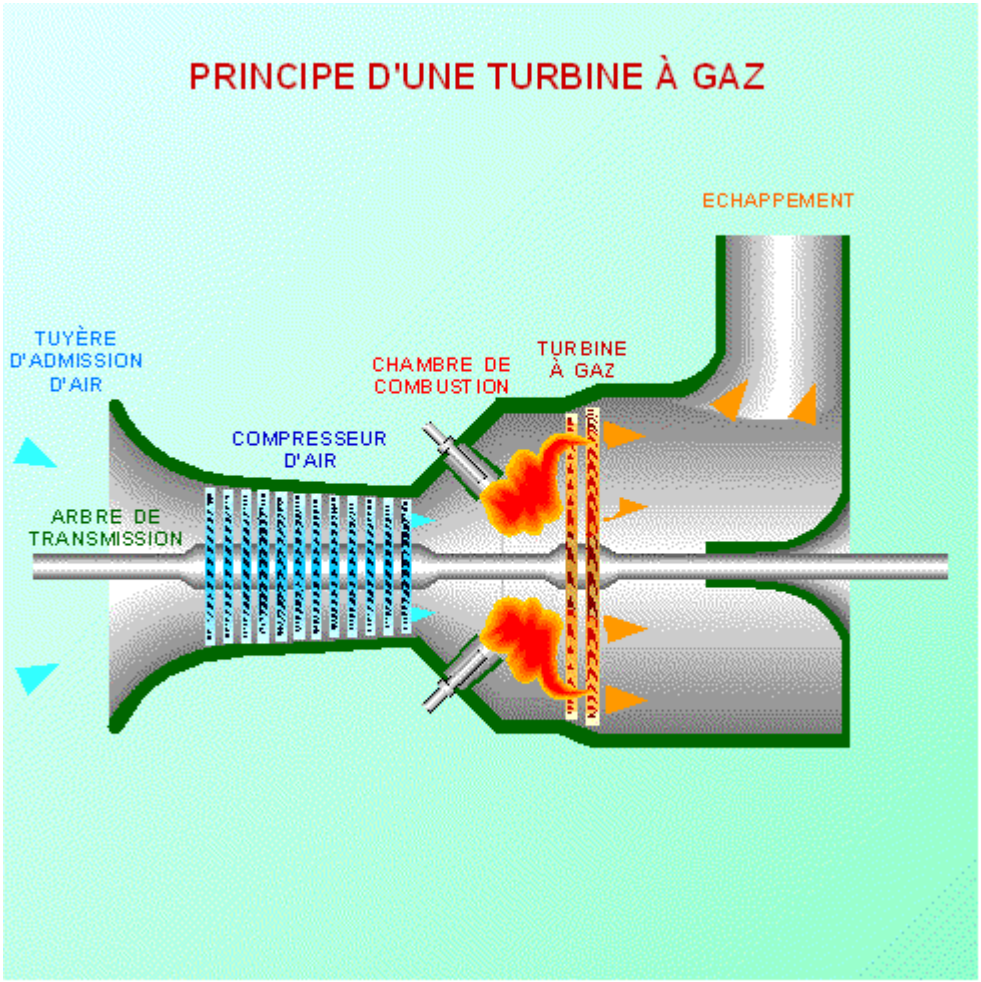
- **Thermal Machine (Turbomachine)**

Gas turbine (Electric power generation)

$$0,1 - 350\ \mathbf{MW}$$

$$\eta \sim 25 - 35\%$$





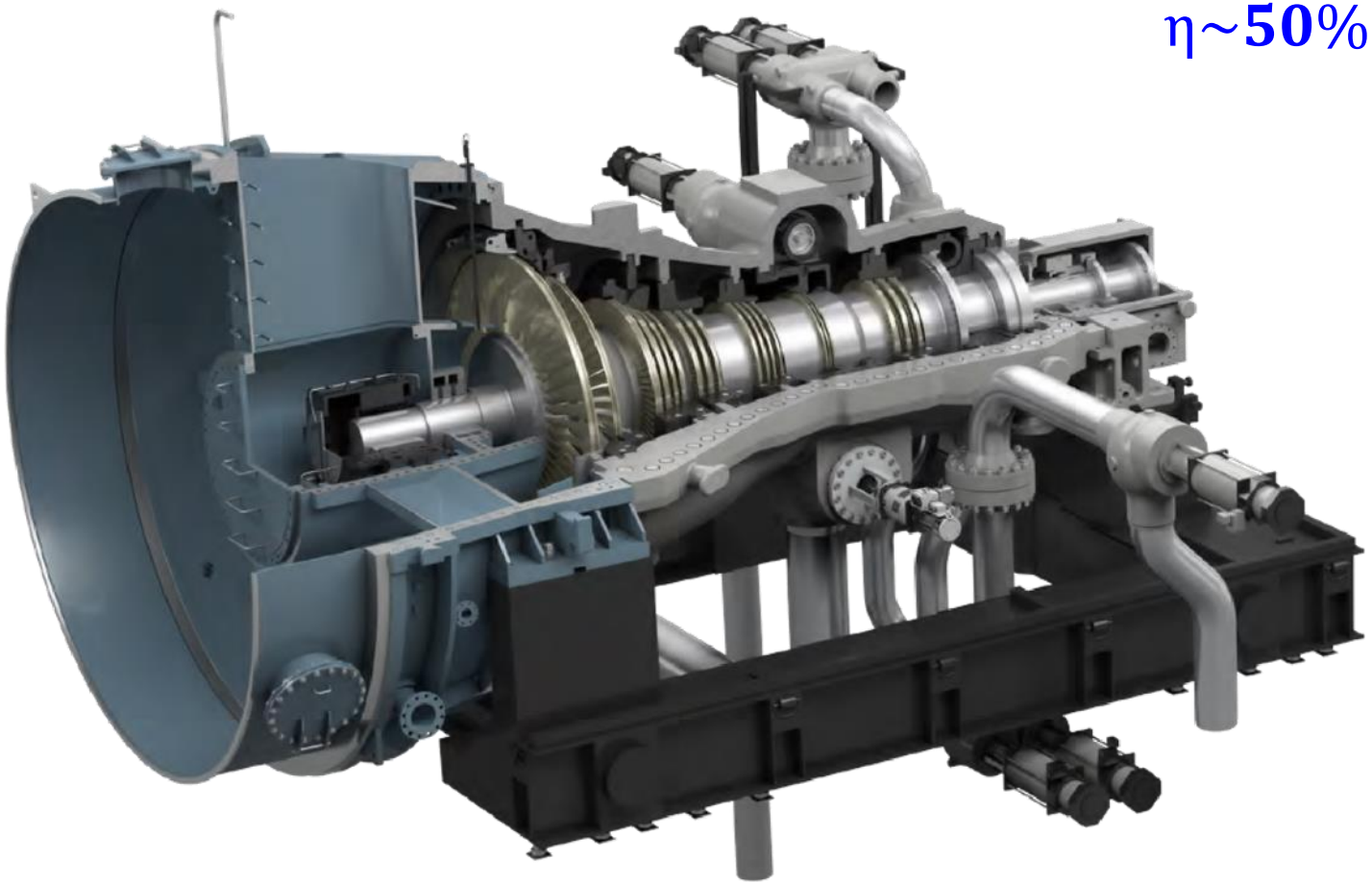
Conventional energies

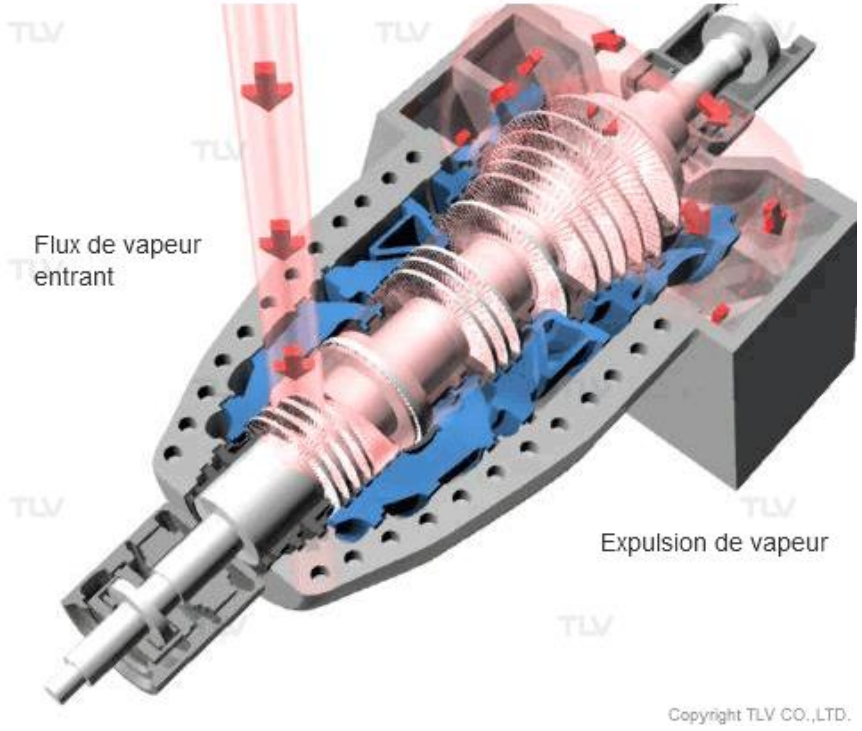
- **Thermal Machine (Turbomachine)**

Steam turbine (Electric power generation)

$$1kW - 1500\ \mathrm{MW}$$

$$\eta \sim 50\%$$





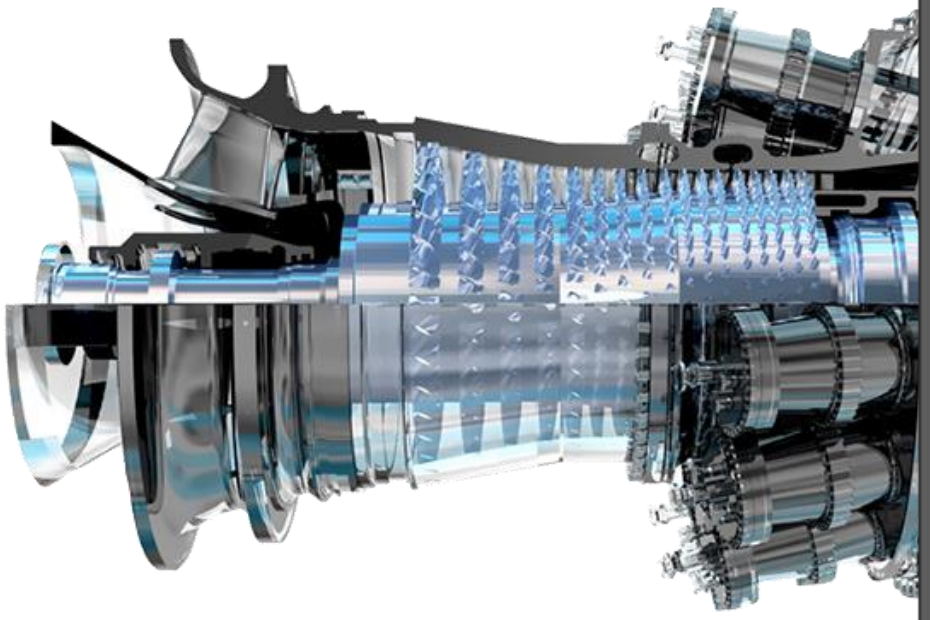
Conventional energies

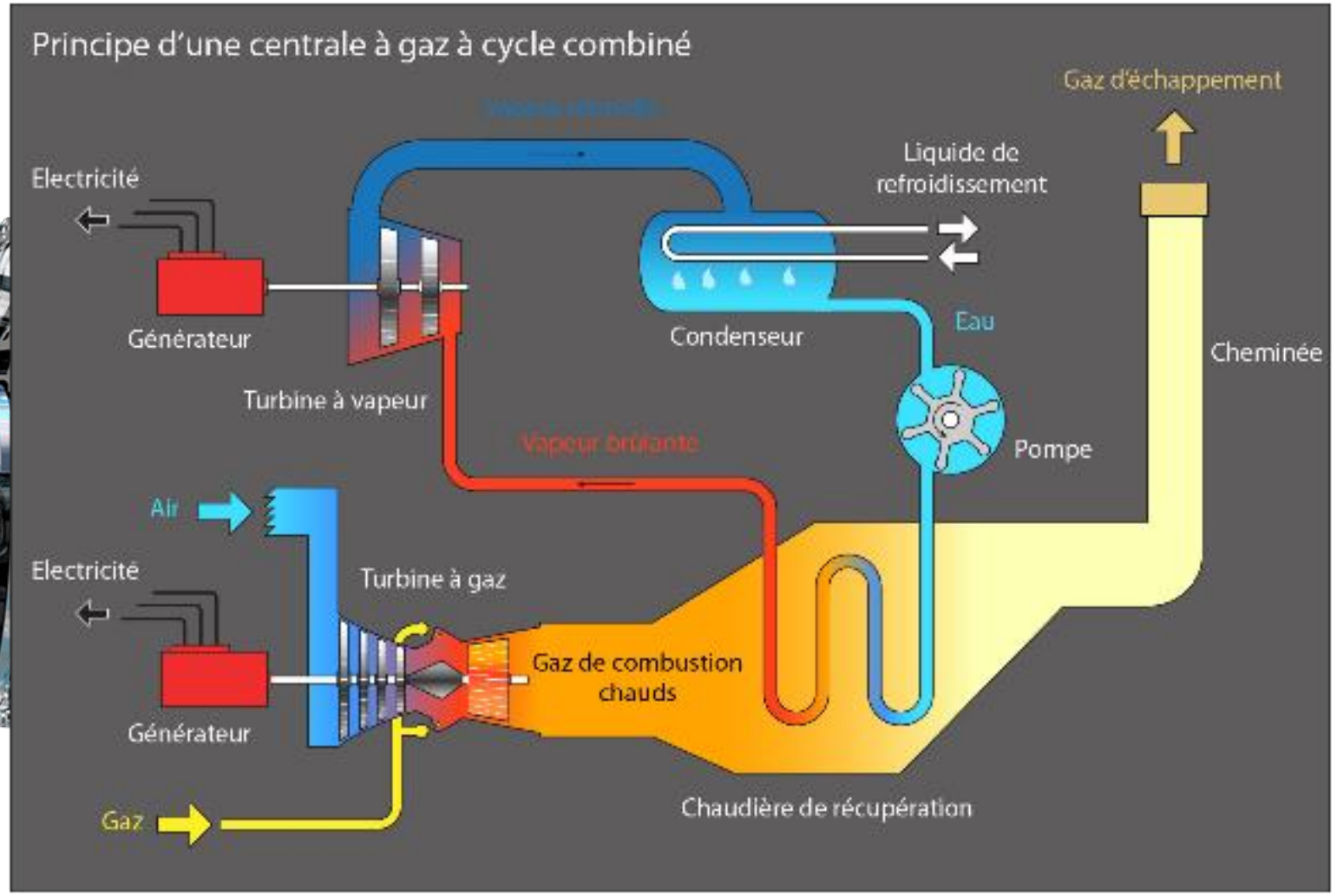
- **Thermal Machine (Turbomachine)**

Combined Cycle gas turbine / cogeneration (Electric power generation)

$$1 - 350\ \mathrm{MW}$$

$$\eta \sim 50 - 62\%$$



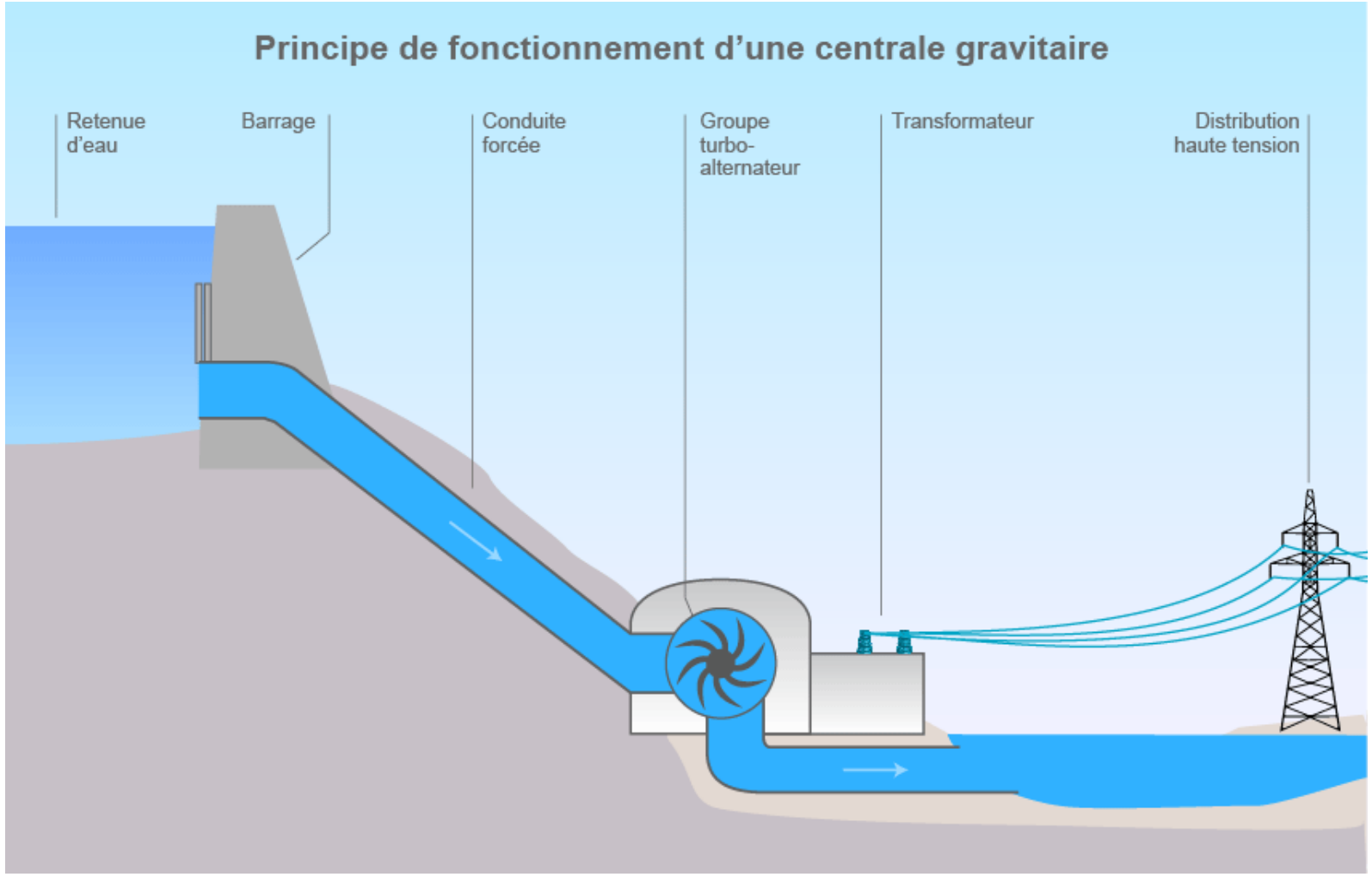


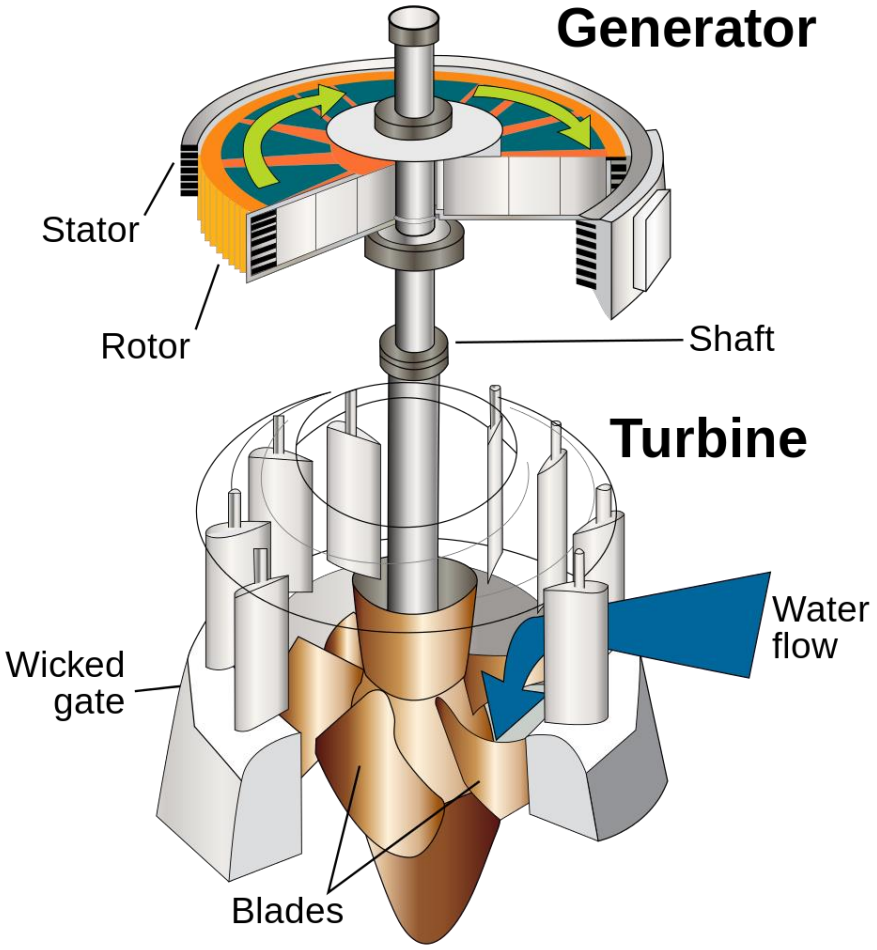
Conventional energies

- **Hydraulic energy (Water turbine`**

Hydroelectric Power Plant

$$20kW - 10\ \mathbf{MW}$$



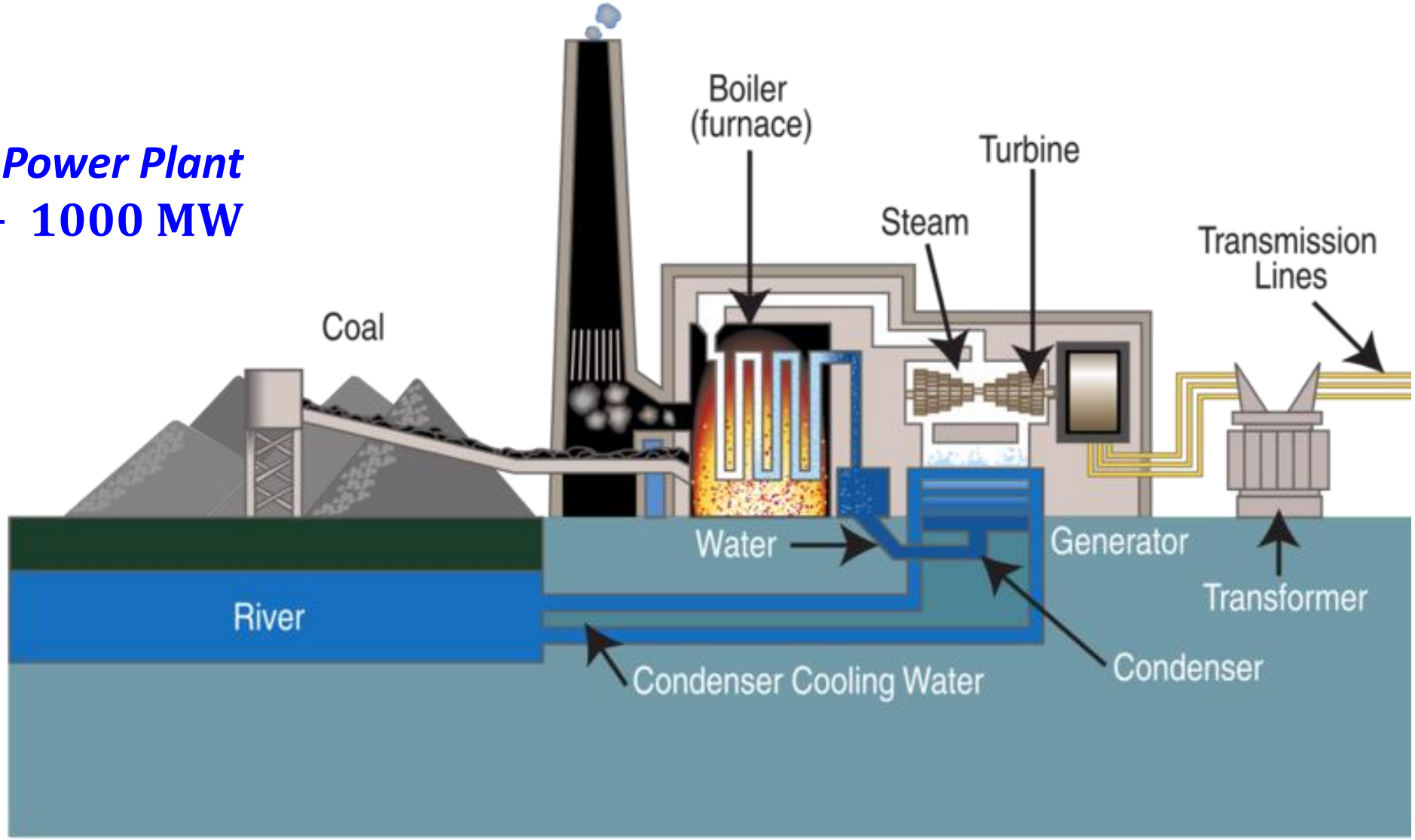


Conventional energies

- **Power Plants**

Coal Power Plant

$$50 - 1000\ \mathbf{MW}$$

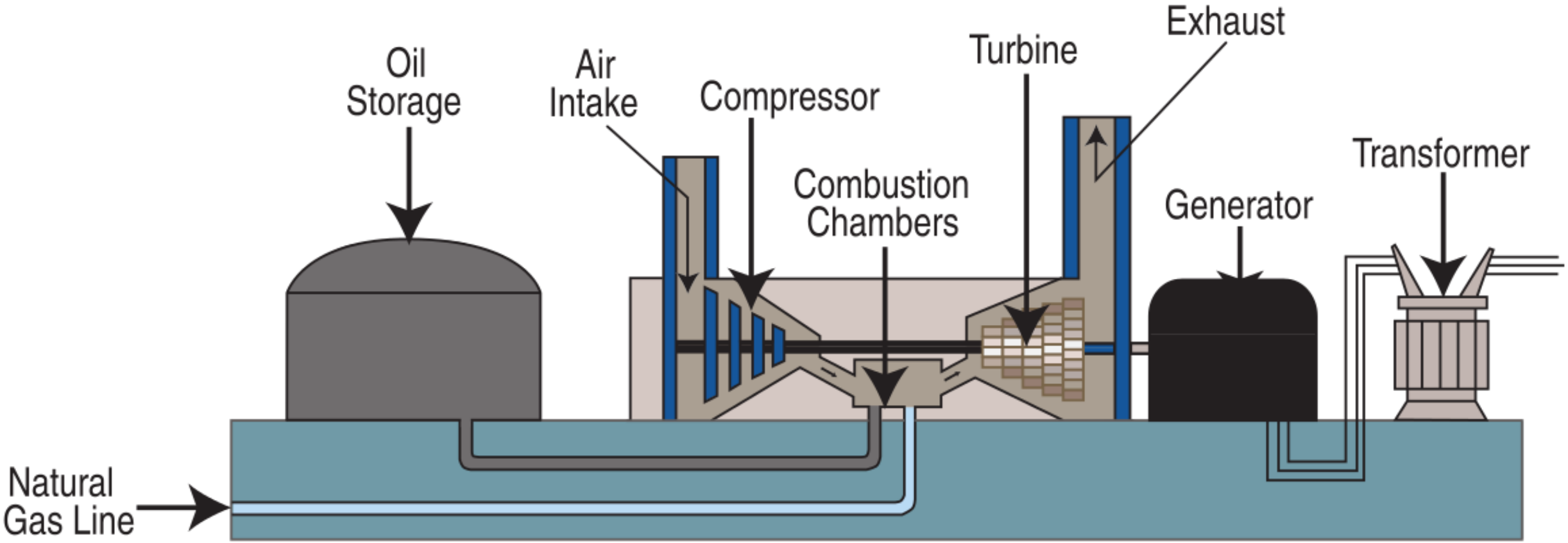


Conventional energies

- **Power Plants**

Gas Power Plant

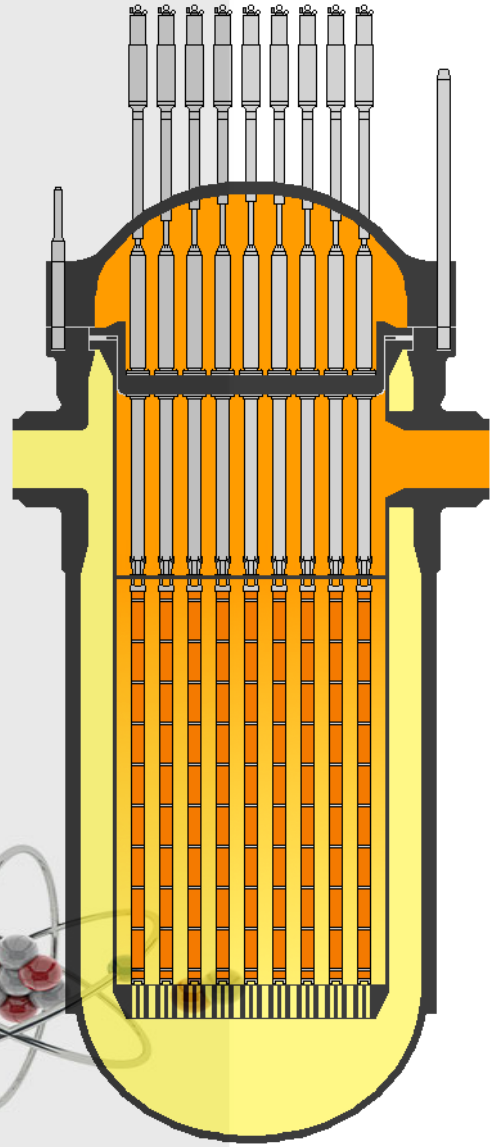
$$\mathbf{50 - 1000\ MW}$$

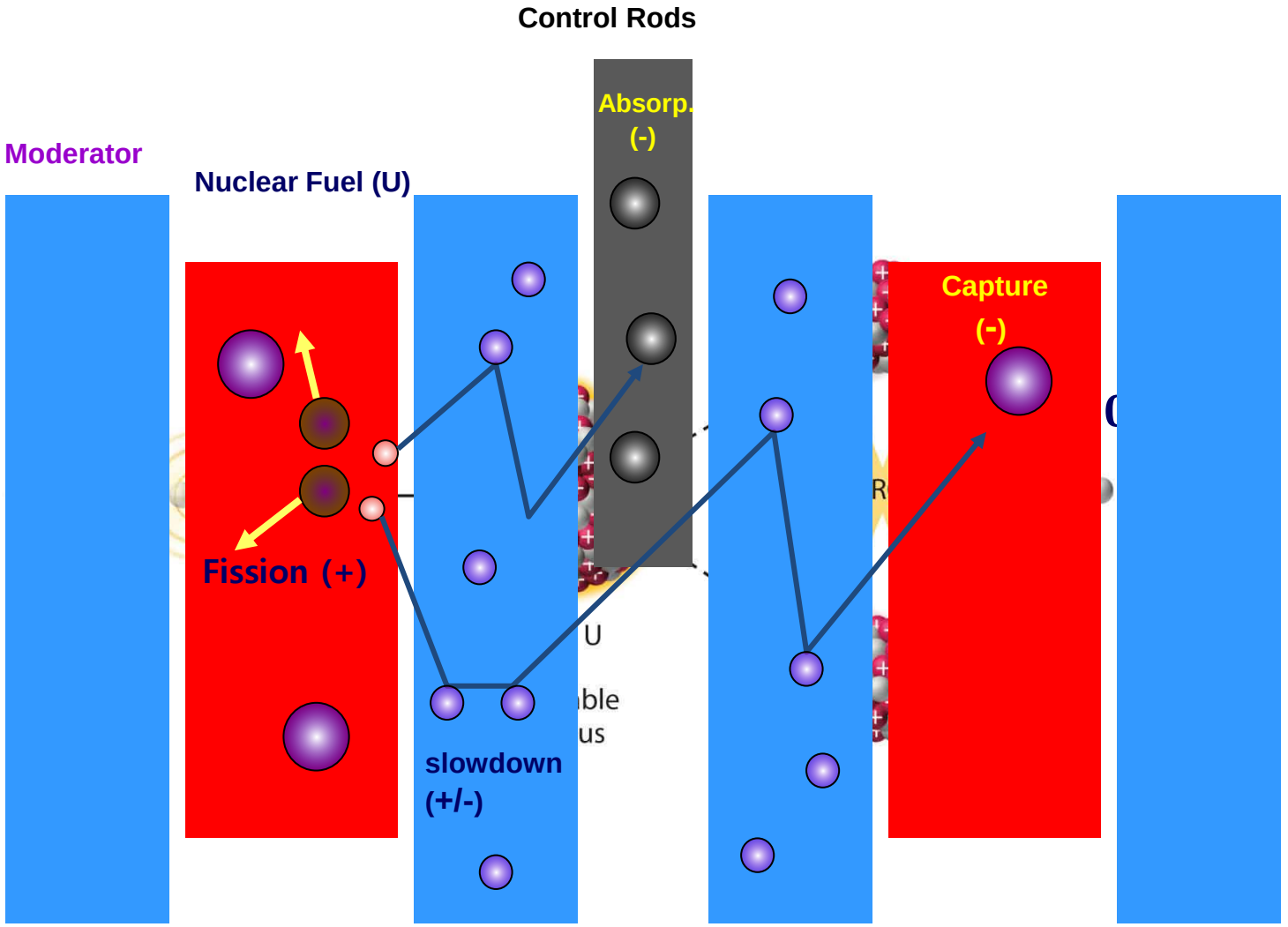


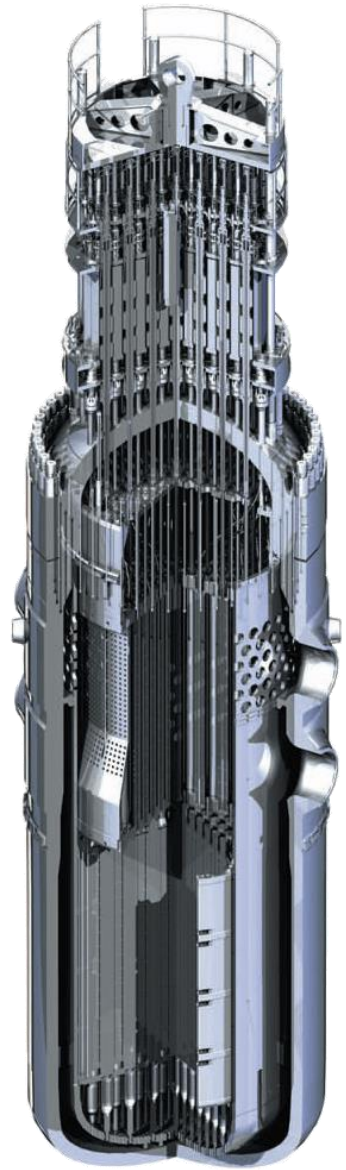
Conventional energies

- Nuclear Power Plants (NPP)

Nuclear Energy





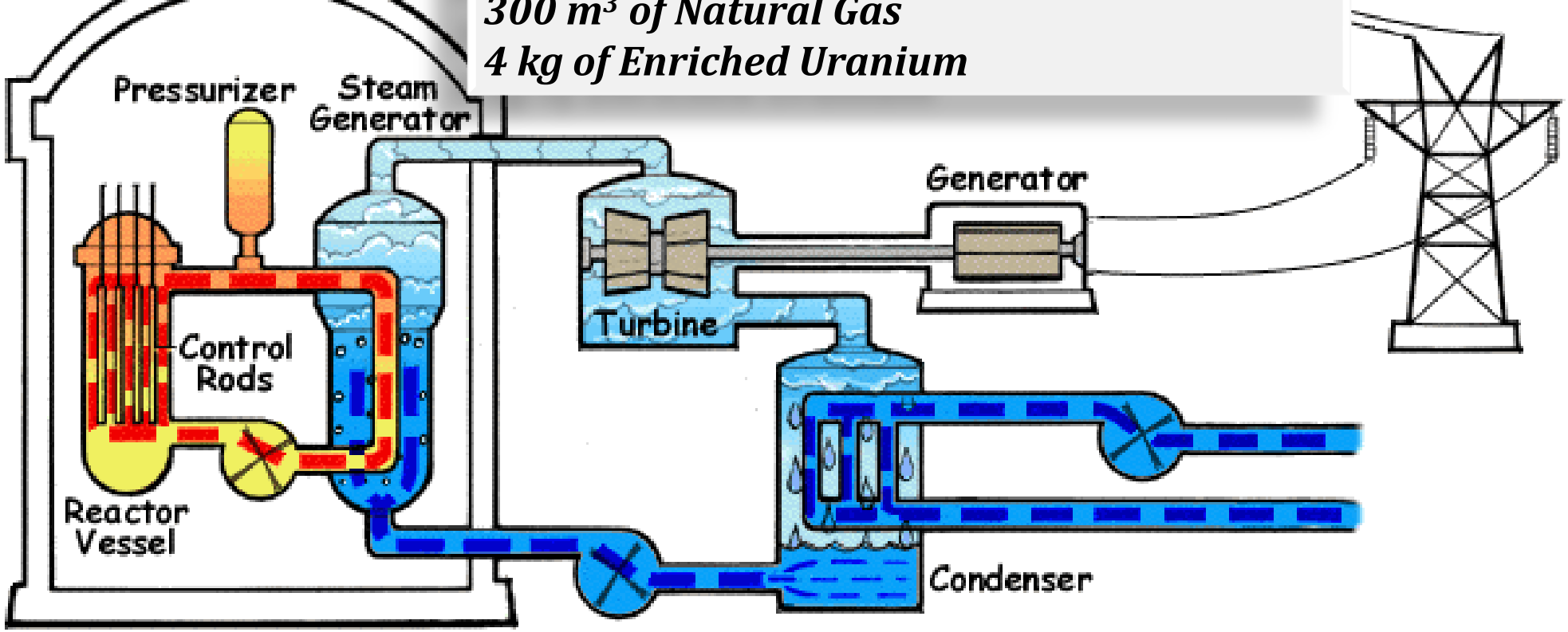


Conventional energies

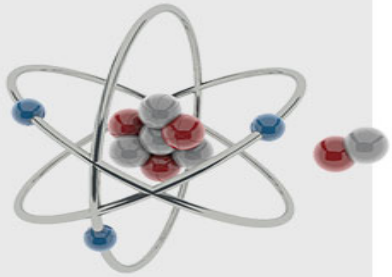
- **Nuclear Power Plants (NPP)**

$300 - 1500MW$

Fuel quantity required to produce 1000Kwh:
350 kg of Coal
250 l of Oil
300 m^3 of Natural Gas
4 kg of Enriched Uranium



Nuclear Energy



Five Major Types of RENEWABLE ENERGY

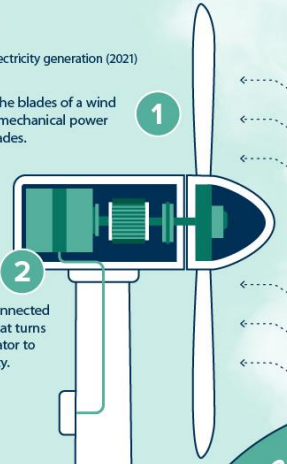
Global renewable energy capacity is expanding at a record pace. What are the major types of renewables, and how do they work?

WIND

6.6% global electricity generation (2021)

$38 cost per MWh

1. Wind flows over the blades of a wind turbine, creating mechanical power by turning the blades.
2. The blades are connected to a drive shaft that turns an electric generator to produce electricity.



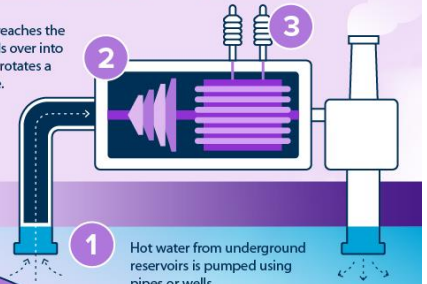
GEOTHERMAL

<1% global electricity generation (2021)

$75 cost per MWh

The turbine is connected to a generator that produces electricity.

As the water reaches the surface, it boils over into steam, which rotates a steam turbine.



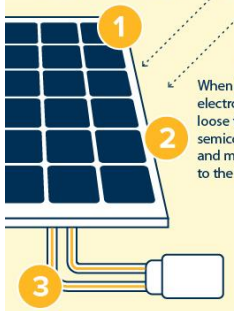
1. Hot water from underground reservoirs is pumped using pipes or wells.

SOLAR

3.7% global electricity generation (2021)

$36 cost per MWh

Photovoltaic (PV) cells contain thin semiconductor wafers, forming an electric field.



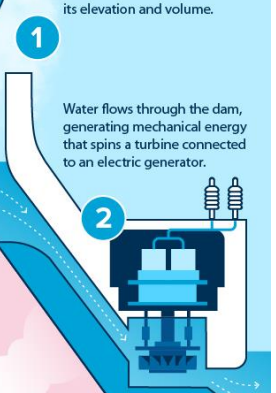
1. When light hits the cell, electrons are knocked loose from the semiconductor material and move in response to the electric field.
2. This generates electricity, transferred through metal conductors on the PV cell.

HYDRO

15.3% global electricity generation (2021)

$64 cost per MWh

Dams or other diversion structures alter the natural flow of water to increase its elevation and volume.

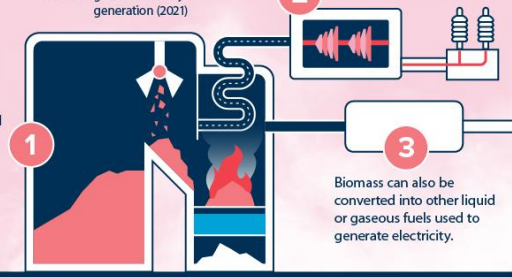


1. Water flows through the dam, generating mechanical energy that spins a turbine connected to an electric generator.

BIOMASS

2.3% global electricity generation (2021)

$114* cost per MWh



1. Biomass is burned in a boiler to produce steam.
2. Steam rotates the blades of a turbine connected to a generator that produces electricity.
3. Biomass can also be converted into other liquid or gaseous fuels used to generate electricity.

** Represents the lifetime cost of a new power plant divided by total generation*

ELEMENTS

Source: Lazard's Levelized Cost of Energy Analysis 15.0, Ember's Global Electricity Review 2022, U.S. Department of Energy, Our World in Data, IEA

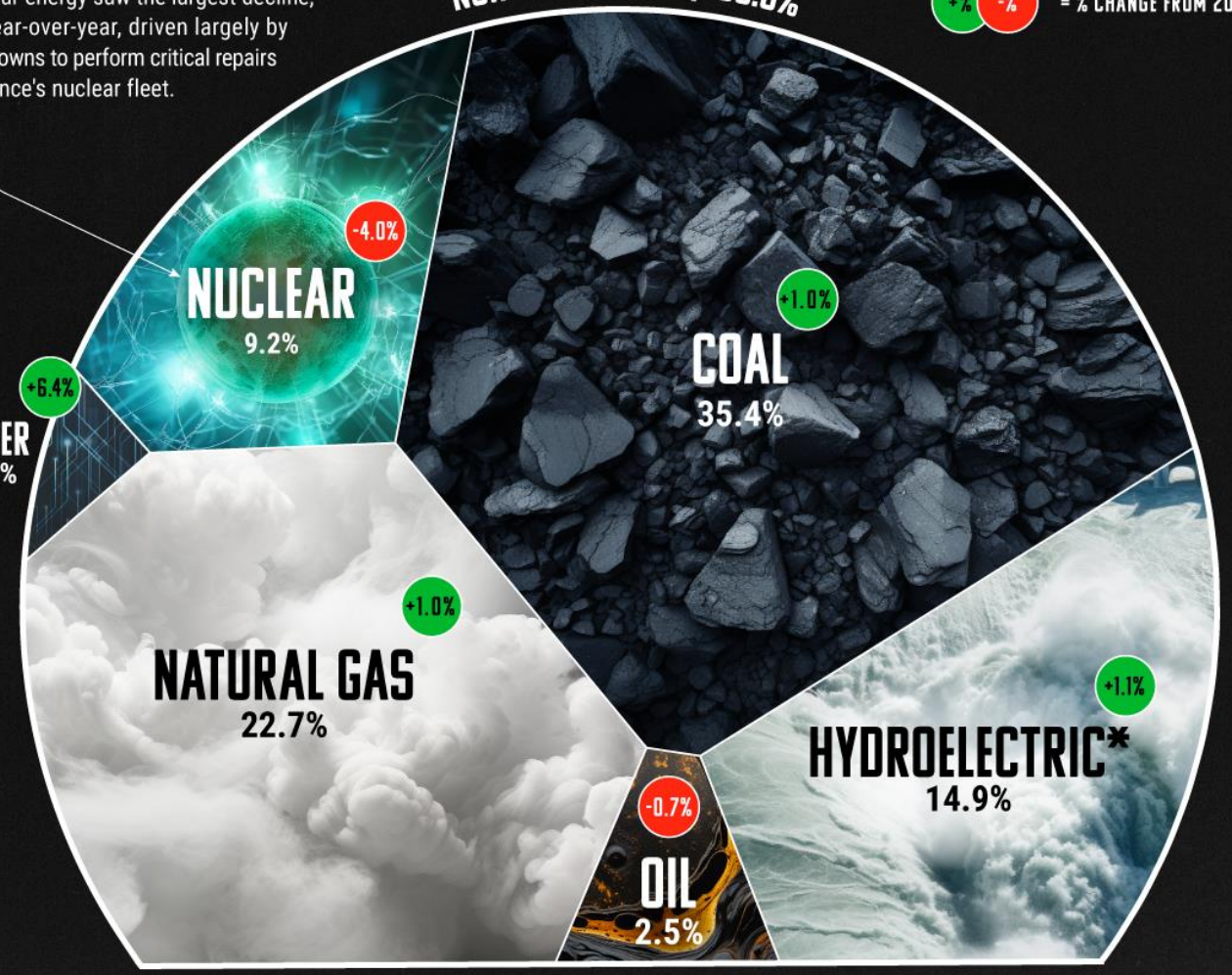
ELEMENTS.VISUALCAPITALIST.COM

Global Electricity production by fuel source 2022

Nuclear energy saw the largest decline, 4% year-over-year, driven largely by shutdowns to perform critical repairs in France's nuclear fleet.

NON-RENEWABLE | 85.6%

+% -% = % CHANGE FROM 2021



RENEWABLES | 14.4%

Renewables experienced an impressive 15% growth rate in 2022, compared to oil, natural gas, coal, and hydro, which together mustered an anemic 0.4%