Environmental issues of AI
Preliminaries

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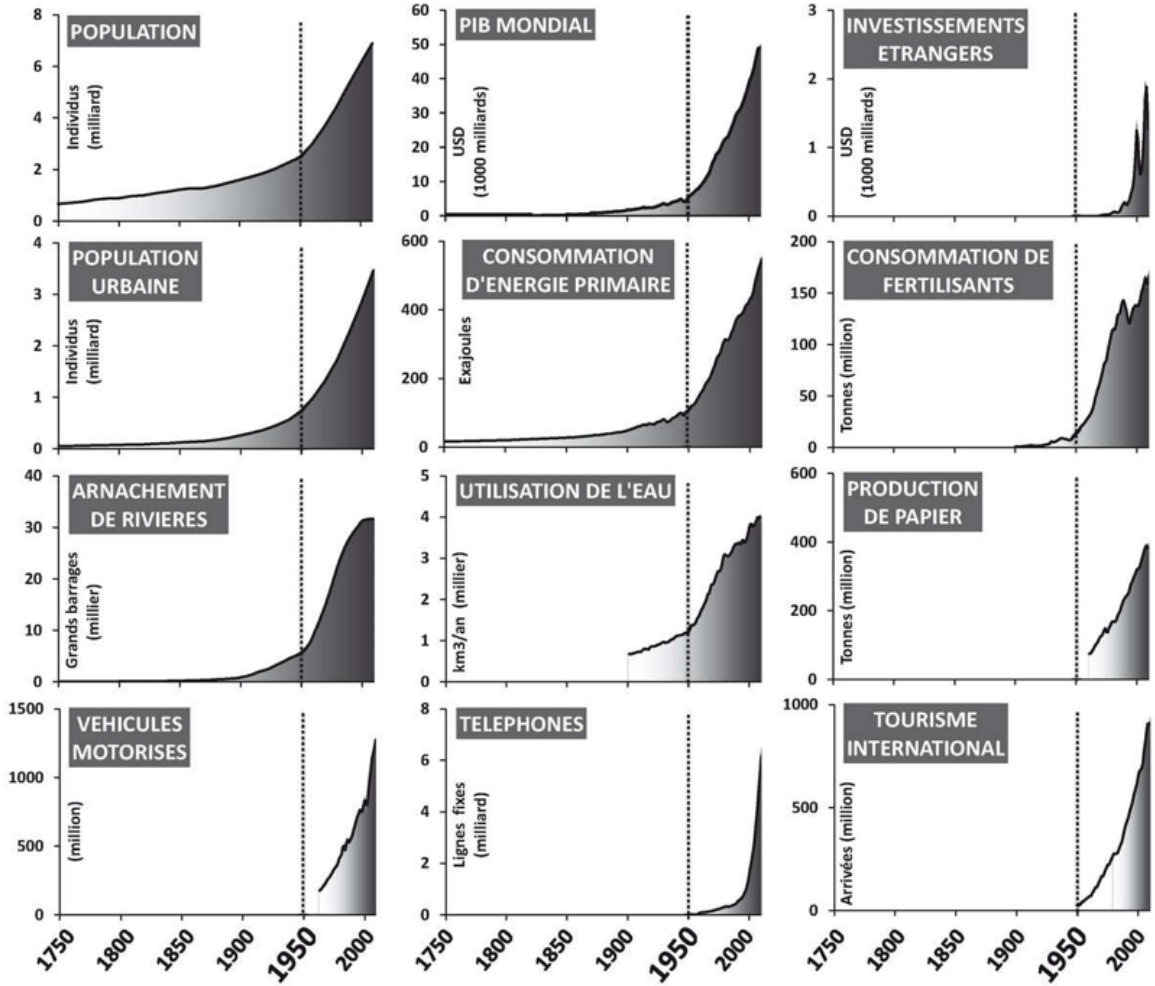
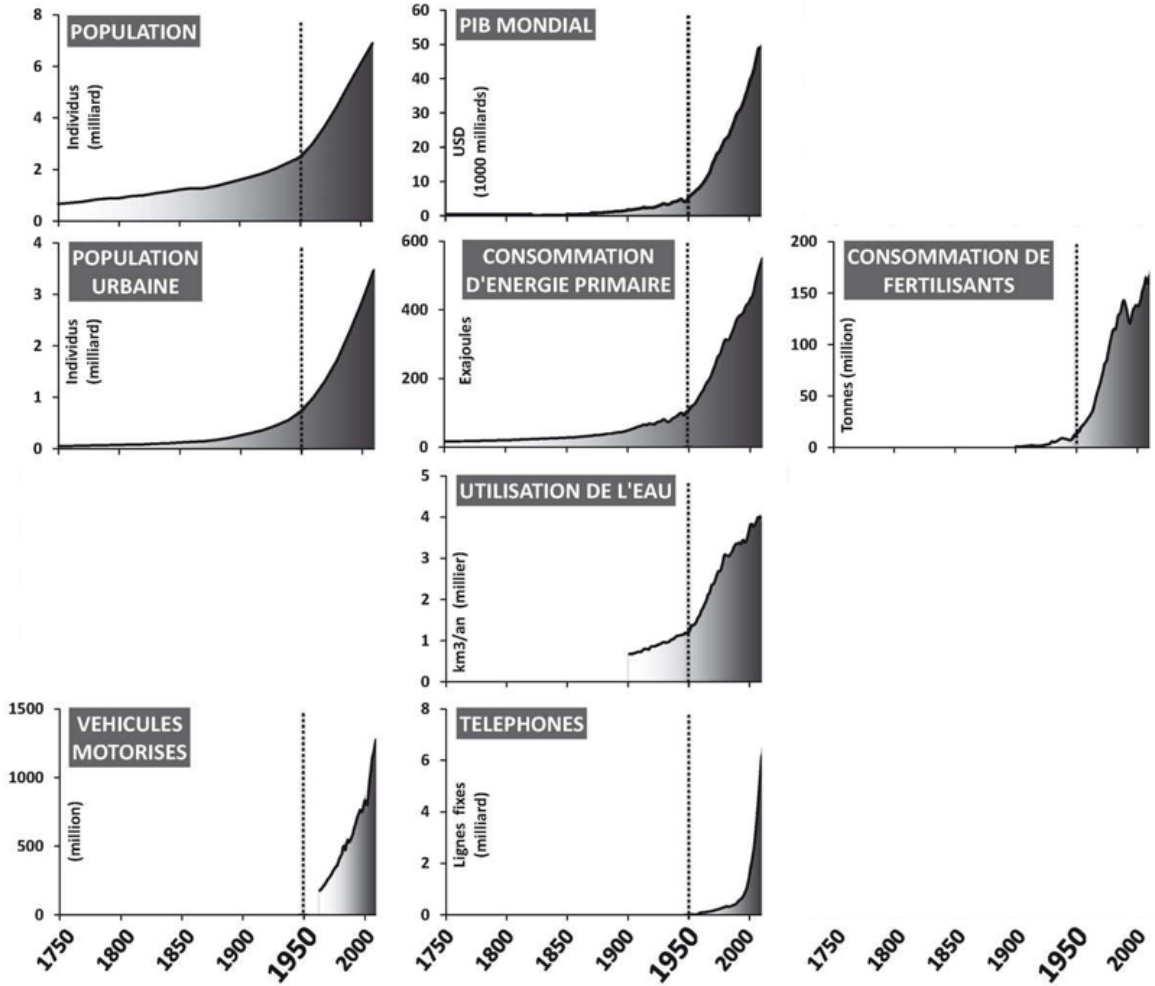
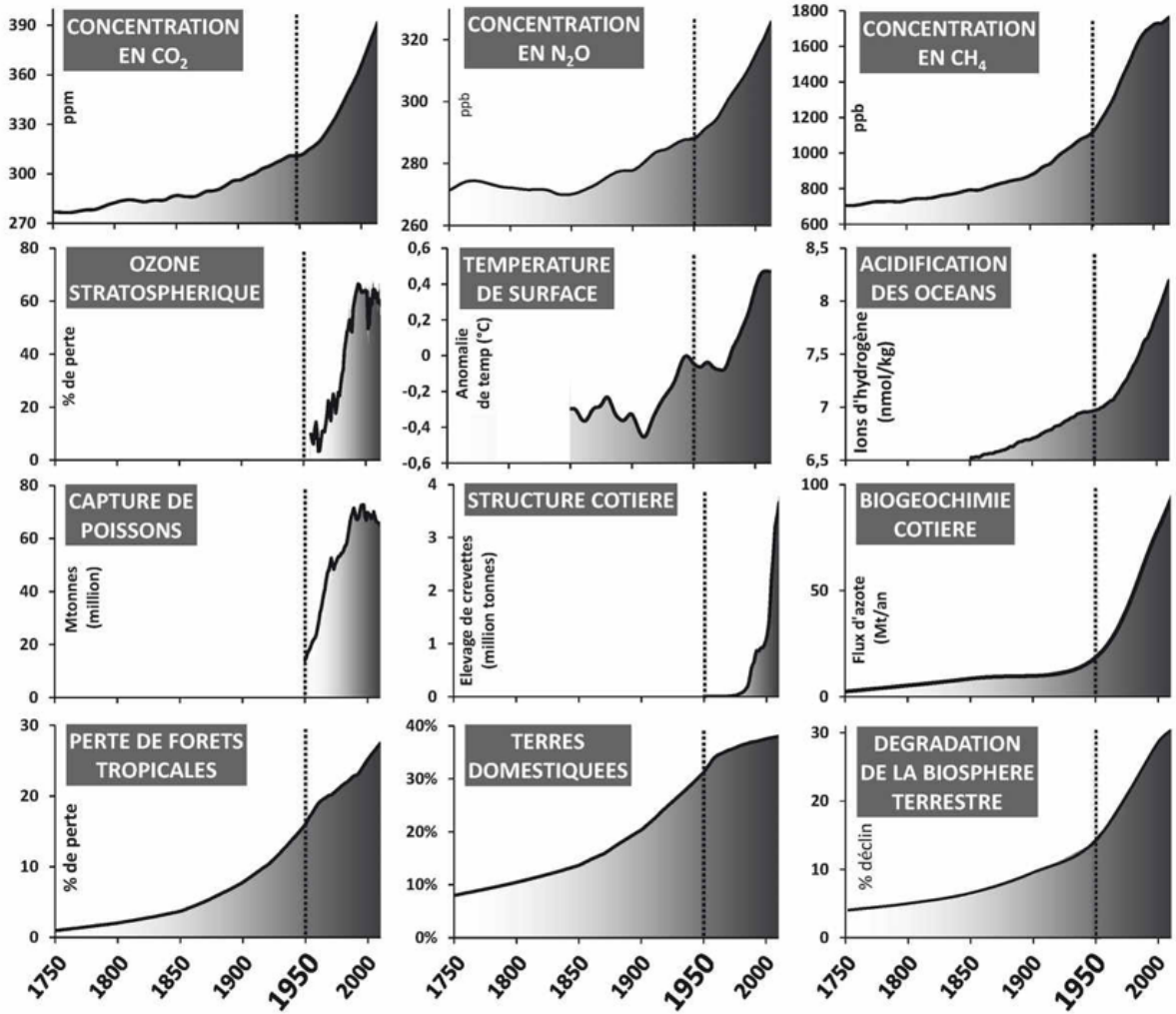
The big acceleration Socio-economic factors



The big acceleration Socio-economic factors – details



The big acceleration Earth system



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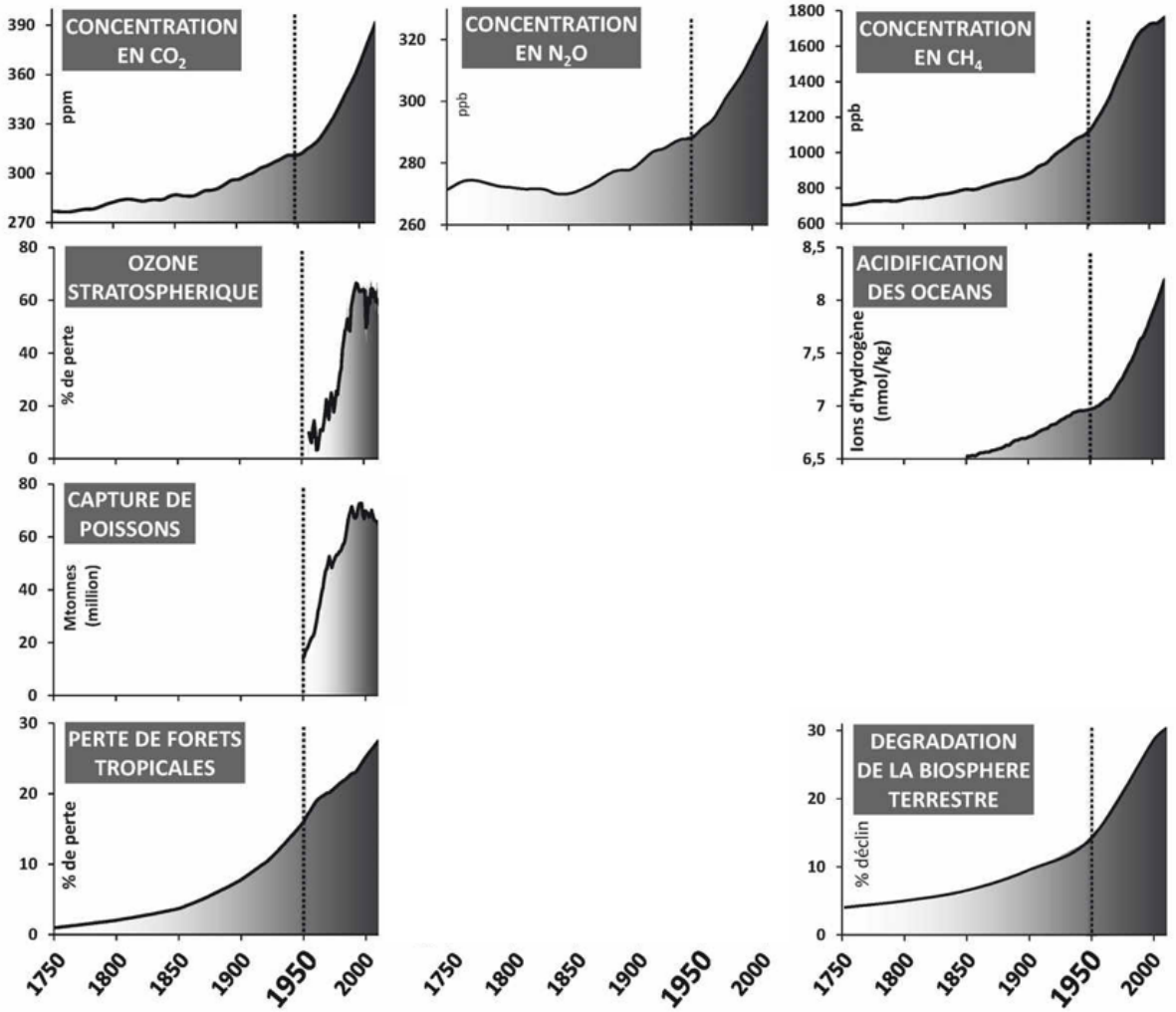
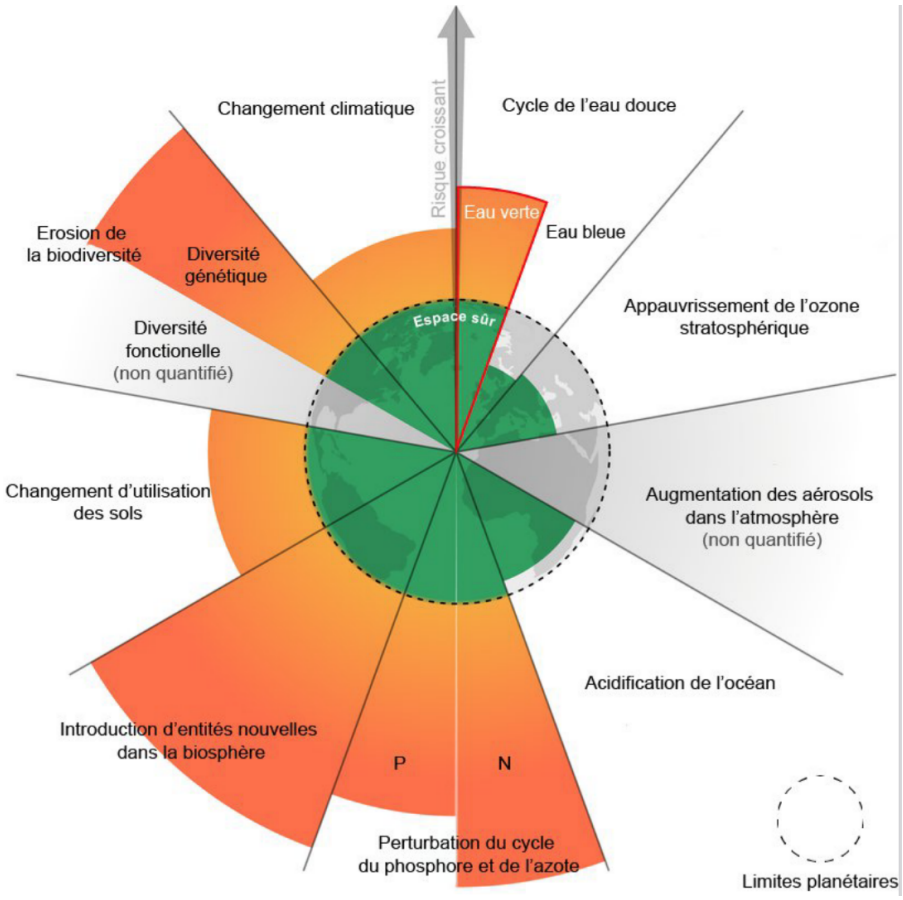


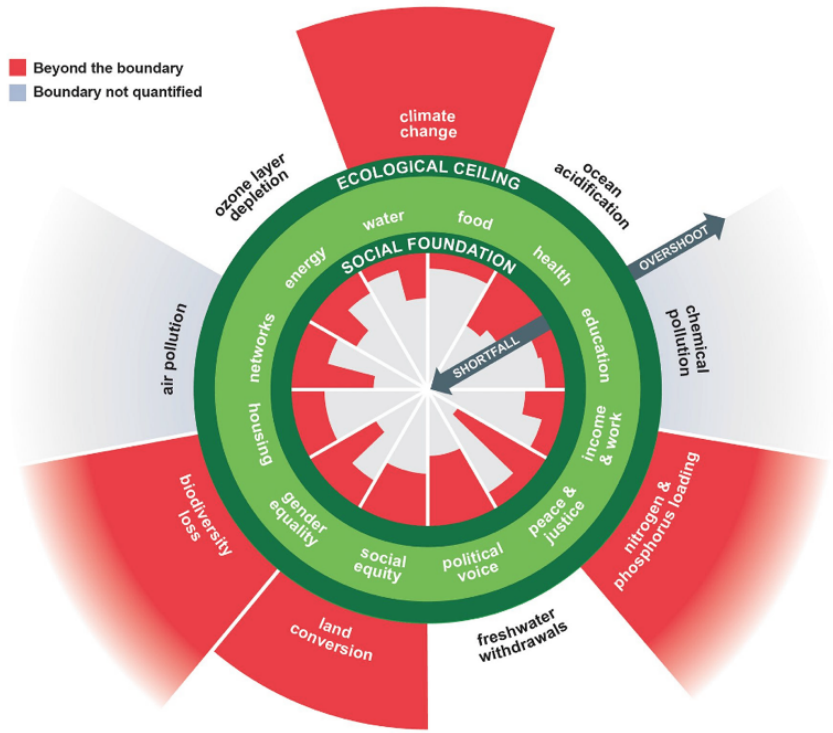
Earth limits

- There are not only Carbon emissions!

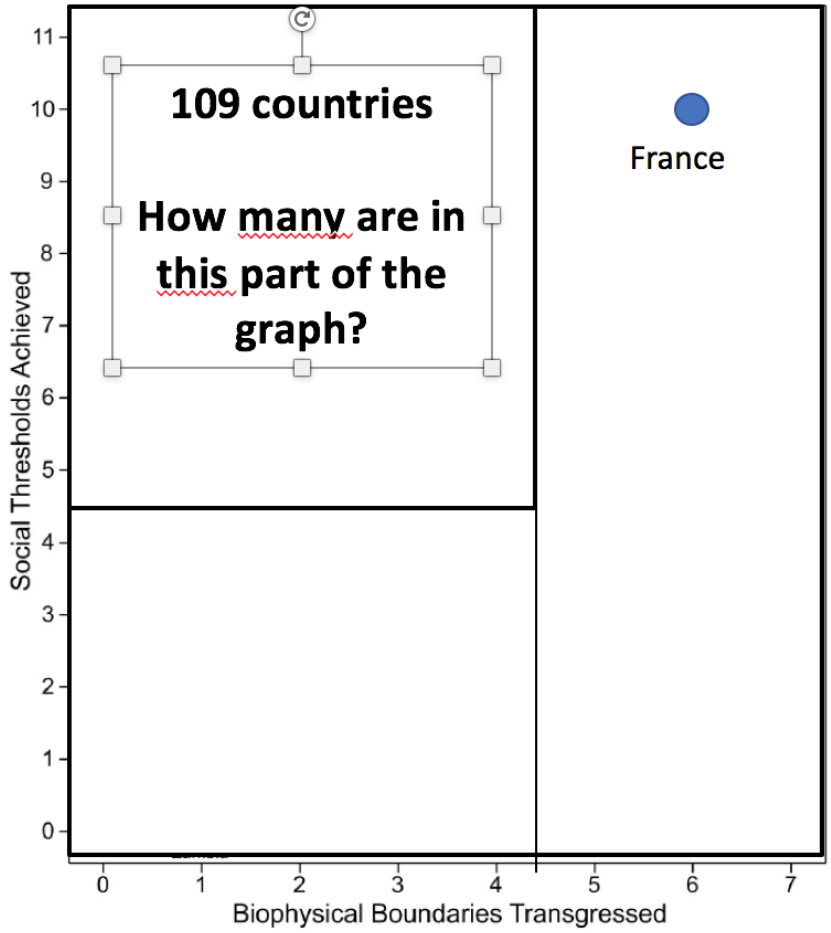


The Donut theory

- 9 earth limits
- 11 social objectives
- The safe and just space for humanity lies between the environmental ceiling and the social floor (Kate Raworth, 2017)



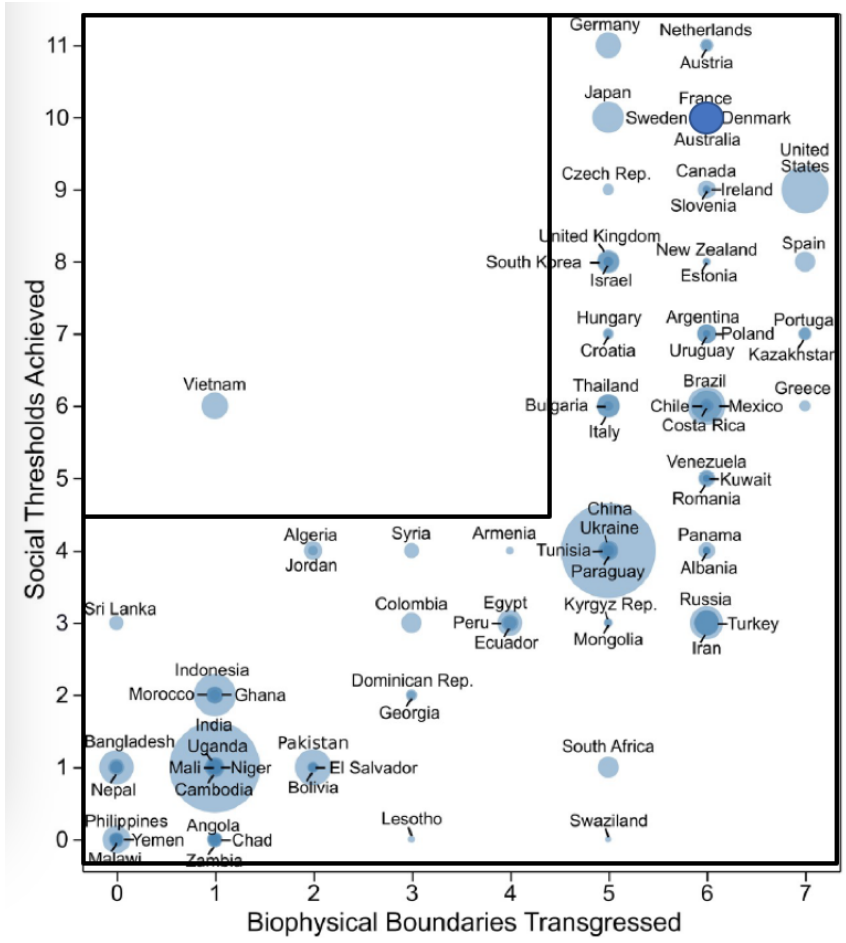
O'Neill et al. A good life for all within planetary boundaries. Nat Sustain (2018).



- Only 1!

Table 1. Country performance with respect to per capita biophysical boundaries

Biophysical Indicator	*N*	Planetary Boundary	Per Capita Boundary	Countries Within Boundary (%)
CO_2 Emissions	145	2 °C warming	1.61 t CO_2 y^{-1}	34
Phosphorus	144	6.2 Tg P y^{-1}	0.89 kg P y^{-1}	44
Nitrogen	144	62 Tg N y^{-1}	8.9 kg N y^{-1}	45
Blue Water	141	4000 km^3 y^{-1}	574 m^3 y^{-1}	84
eHANPP	150	18.2 Gt C y^{-1}	2.62 t C y^{-1}	44
Ecological Footprint	149		1.72 gha y^{-1}	43
Material Footprint	144		7.2 t y^{-1}	44


Germany
Netherlands
Austria
Japan
France
Sweden
Denmark
Australia
United States
Czech Rep.
Canada
Ireland
Slovenia
United Kingdom
South Korea
Israel
New Zealand
Estonia
Spain
Hungary
Croatia
Argentina
Poland
Uruguay
Portuga
Kazakhstar
Vietnam
Thailand
Bulgaria
Italy
Brazil
Chile
Mexico
Costa Rica
Greece
Venezuela
Kuwait
Romania
China
Ukraine
Tunisia
Paraguay
Algeria
Jordan
Syria
Armenia
Panama
Albania
Sri Lanka
Colombia
Egypt
Peru
Ecuador
Kyrgyz Rep.
Mongolia
Russia
Turkey
Iran
Indonesia
Morocco
Ghana
Dominican Rep.
Georgia
India
Bangladesh
Uganda
Mali
Niger
Cambodia
Nepal
Pakistan
El Salvador
Bolivia
South Africa
Philippines
Yemen
Angola
Chad
Malawi
Zambia
Lesotho
Swaziland
Social Thresholds Achieved
Biophysical Boundaries Transgressed
0
1
2
3
4
5
6
7
8
9
10
11

First Message

The big acceleration (from 1950) is:

- Consequence of human activities
- A race to Performance

- What is the cause-and-effect relationship with global warming?

Energetic transition

An historical perspective: Jean-Baptiste Fressoz

- The steam engine in the late 18th century (coal)
- The oil revolution $\rightarrow$ What was the real advantages?

The energy paradox

All activities need energy[1].

Energy is always a superposition of the successive energy types!

Two examples

- In 1900, England was gobbling up 4.5 million m^3 of wood a year for use as props in mine galleries.
  In the 1750s, the English burned 3.6 million m^3. So, just to extract coal, the English used more wood in 1900 than they had burnt in 1750!

[1] this will be developed later

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- Oil is used to run cars.
  Back in the 1930s, it took around 7 tons of coal to make a car, i.e. as much coal by weight as the oil it burned during its lifetime.

[1] this will be developed later

Focus on electricity

- The electricity fairy
  The digital world is mostly based on electricity.
- According to AIE, the proportion of decarbonized electricity will reach 42% in 2030.

GHG and Carbon cycle

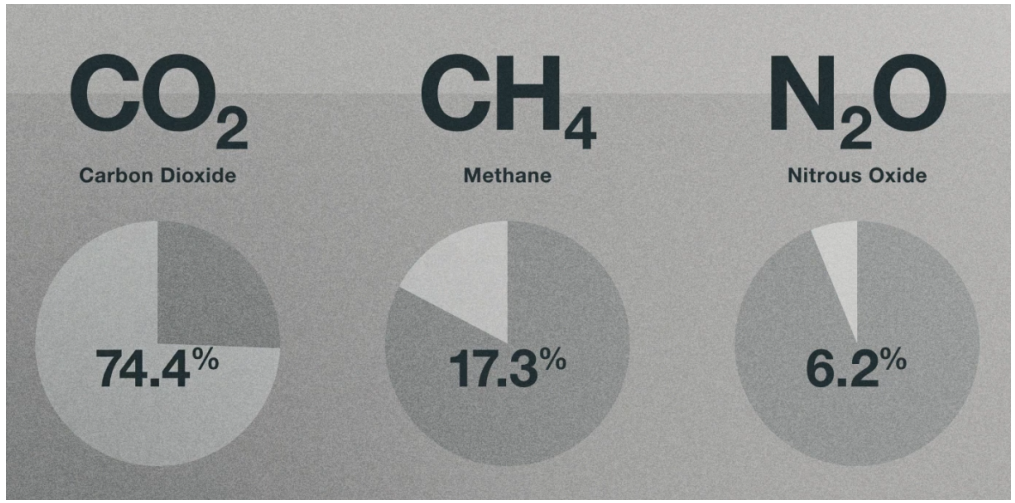
A gas in the atmosphere that intercepts infrared radiation emitted by the earth's surface.

They naturally exist

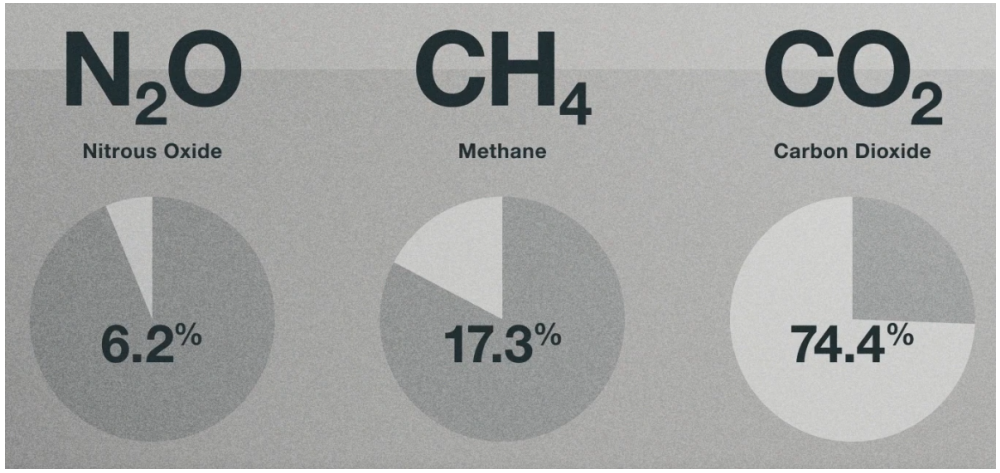
the Earth system was perfectly well-balanced for years.
(750 GTons/year emitted and absorbed by carbon sinks).

- we know: H_2O and CO_2
- we know less CH_4, N_2O and O_3
- The 3 CO_2 CH_4 and N_2O cover more than 96 % of the seven GES of the Kyoto protocol.

Proportion in the atmosphere

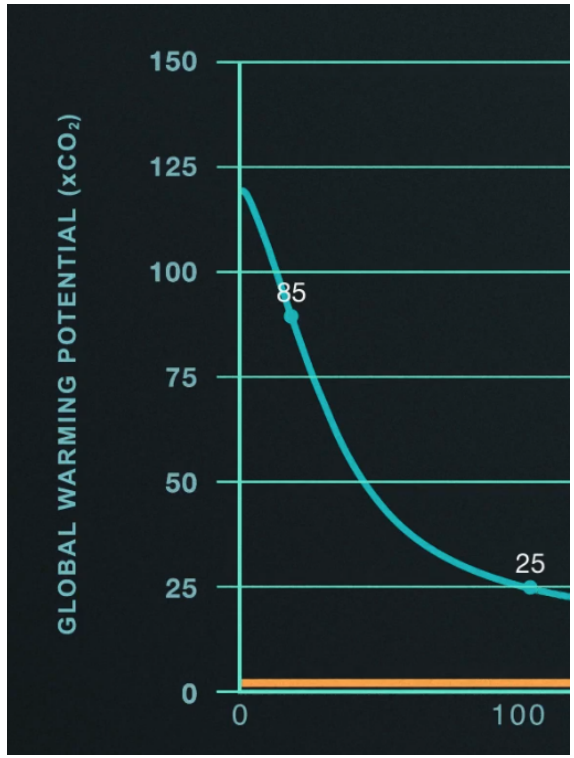


But the warming potentials are reversed



GHGs remain in the atmosphere for a long time: over 100 years for CO_2 !

Comparison on the basis of 100 years



- We need to determine a trade-off.
- CO_2 is taken as the reference.

How to estimate?

- The relative molecular weight of carbon in CO_2 is 12/(16+12+16), thus, roughly a quarter (precisely 0.27)
- The energy consumed is calculated in "carbon equivalent" of CO_2 resulting from the combustion: ($\mathrm{Teq}\,CO_2$)

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- 1 ton of hydrocarbon corresponds roughly to 3 Teq CO_2
- Production of 1 kilo of vegetal: less than1 Keq CO_2
  1 kilo of beef : a hundred Keq CO_2

We measure any human activity using a basis: **kWh**.
This is the energy that corresponds to the consumption of 1000 Watts of electrical equipment for 1 hour.
In France, with a low energy mix, 1 kWh corresponds roughly to 45 gCO_2

Every activity means energy

- A human being burns between 2,000 and 5,000 calories a day.
- That corresponds to a mecanic energy less than 0.5 kWh
- So, roughly speaking, half an hour from a standard electric heater.

Energetic slaves

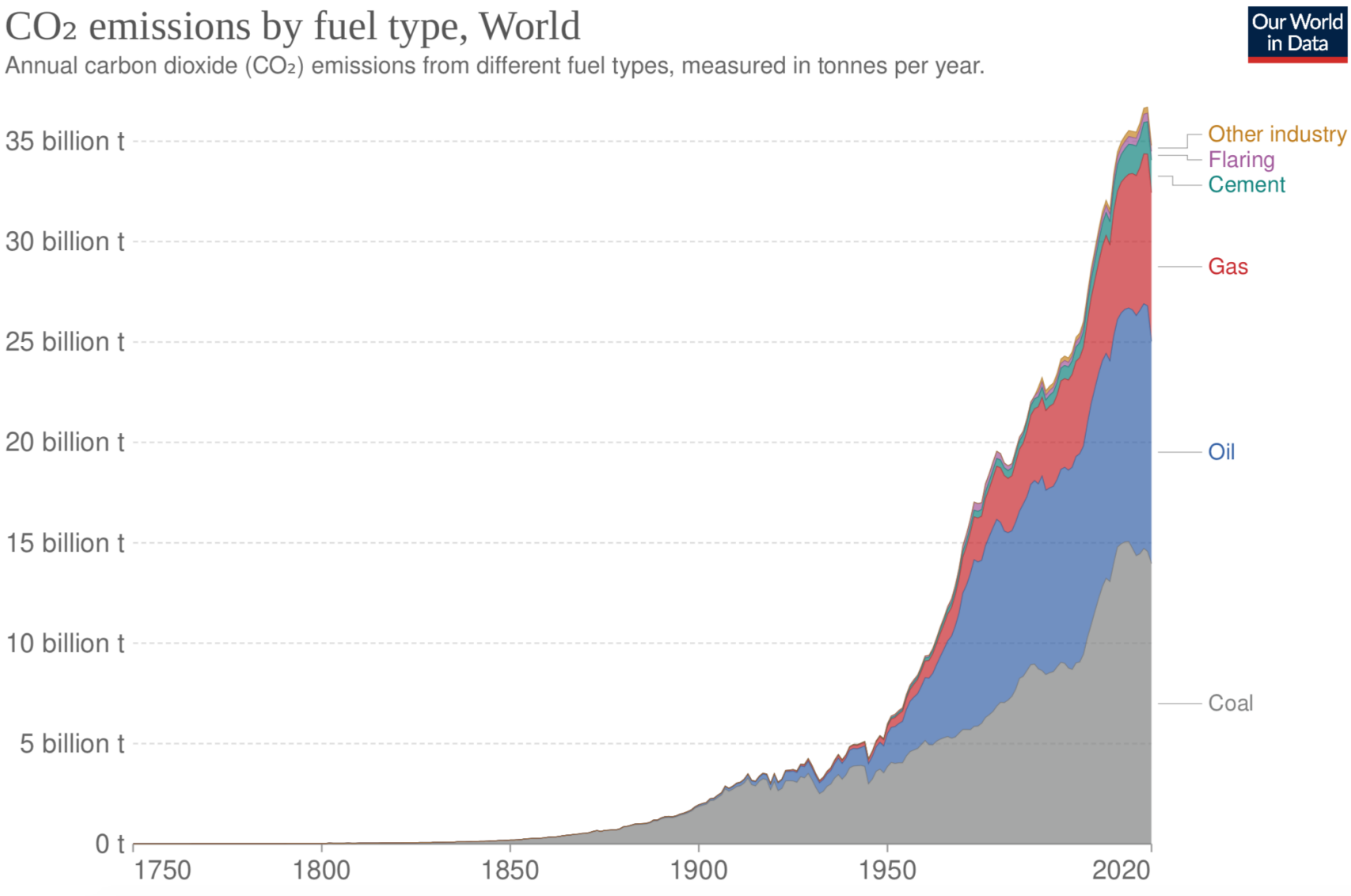
Energetic slaves

- The average French person needs around 600 energy slaves a day to live.

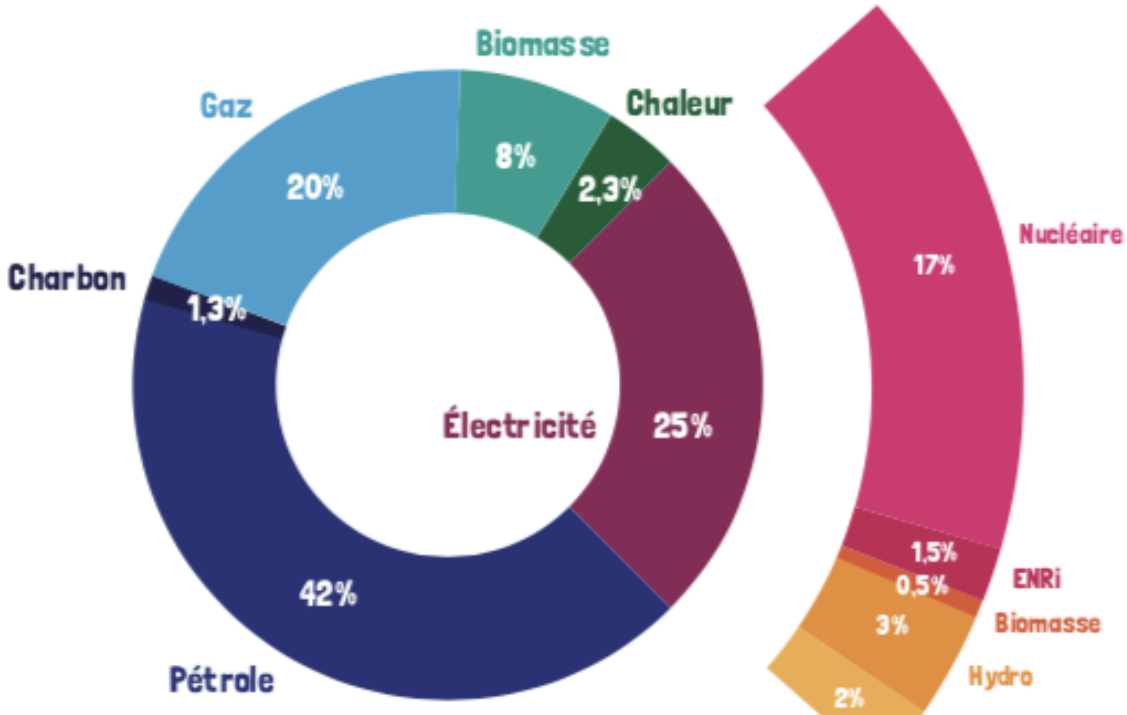
Energy comes from a mix

- All human activity requires energy
- Energy is a material flow that generates emissions CO_2

In the world


CO2 emissions by fuel type, World
Annual carbon dioxide (CO2) emissions from different fuel types, measured in tonnes per year.
Our World in Data
35 billion t
30 billion t
25 billion t
20 billion t
15 billion t
10 billion t
5 billion t
0 t
1750
1800
1850
1900
1950
2020
Other industry
Flaring
Cement
Gas
Oil
Coal

Energy sources in France



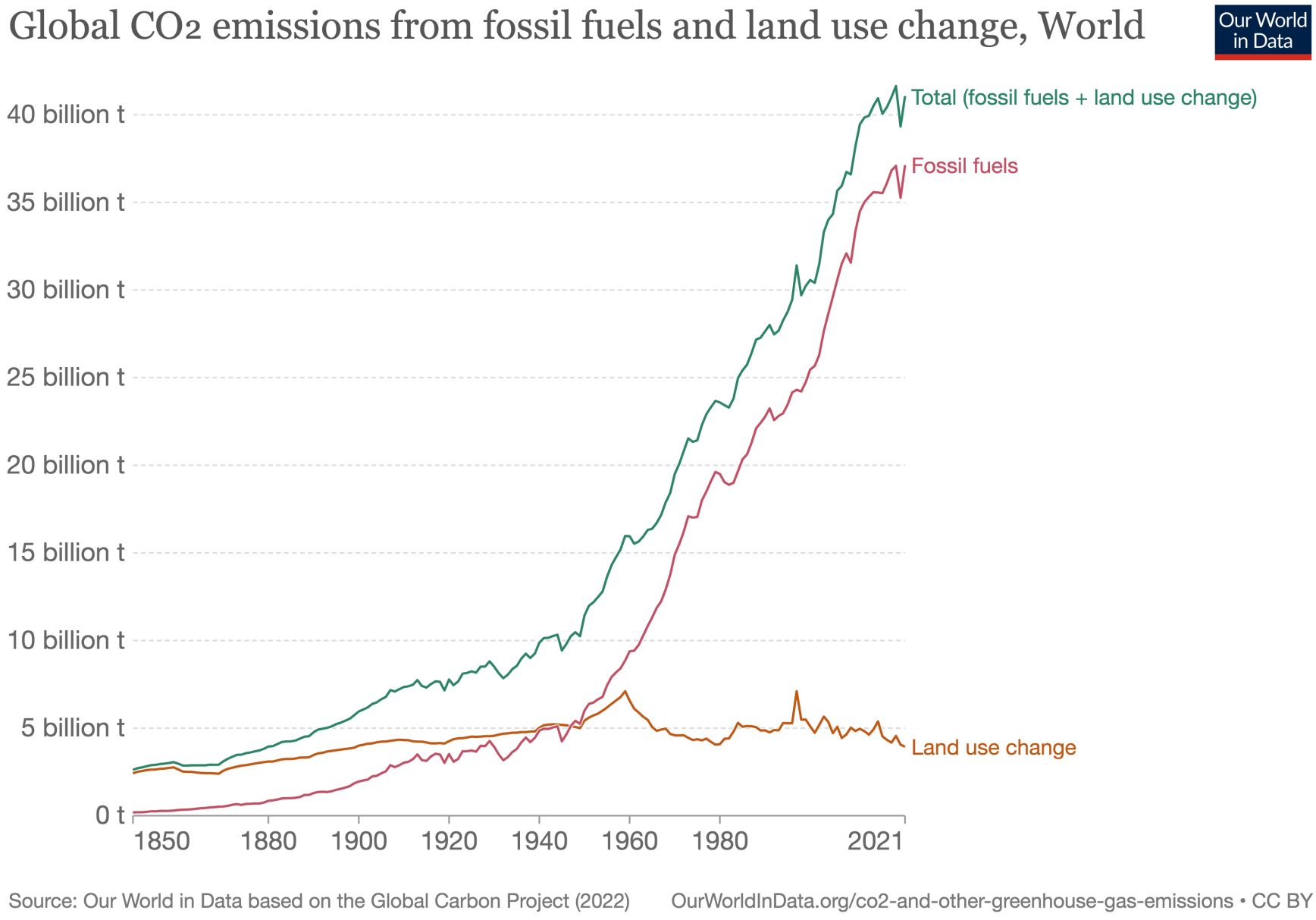
Consommation d'énergie finale en France en 2016
(Mtep = million de tonnes équivalent pétrole)

From Energy to CO_2

- 1 liter of oil corresponds roughly to 1 kWh

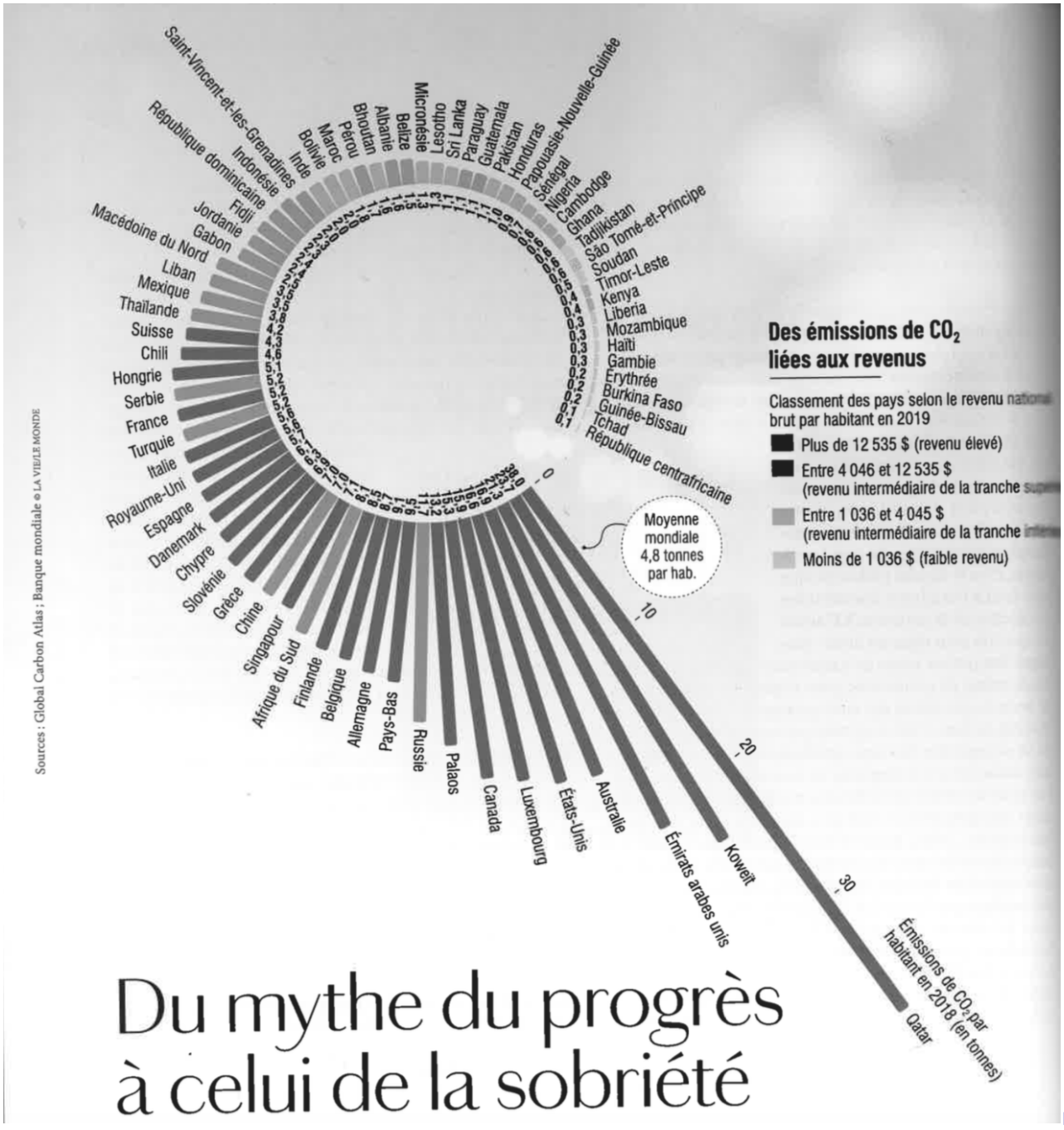
Some examples

- According to automakers, a standard new car consumes an average of 100 gEqCO_2 per kilometer.
- 1 hour of streaming a Netflix series in 4K and 4G corresponds to 2 kms by standard car.



Attention: consider the real footprint!

Repartition amount countries

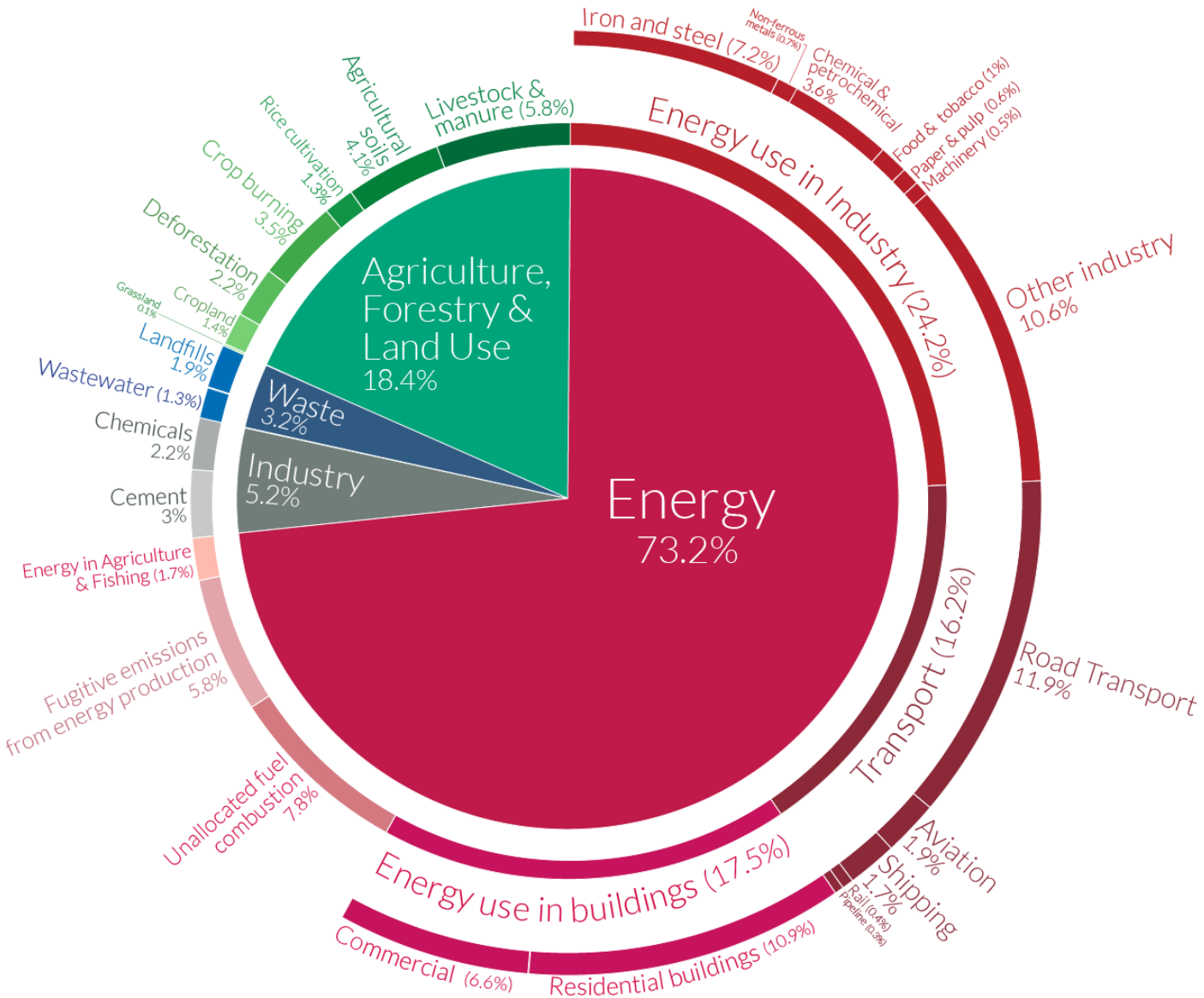


By sectors

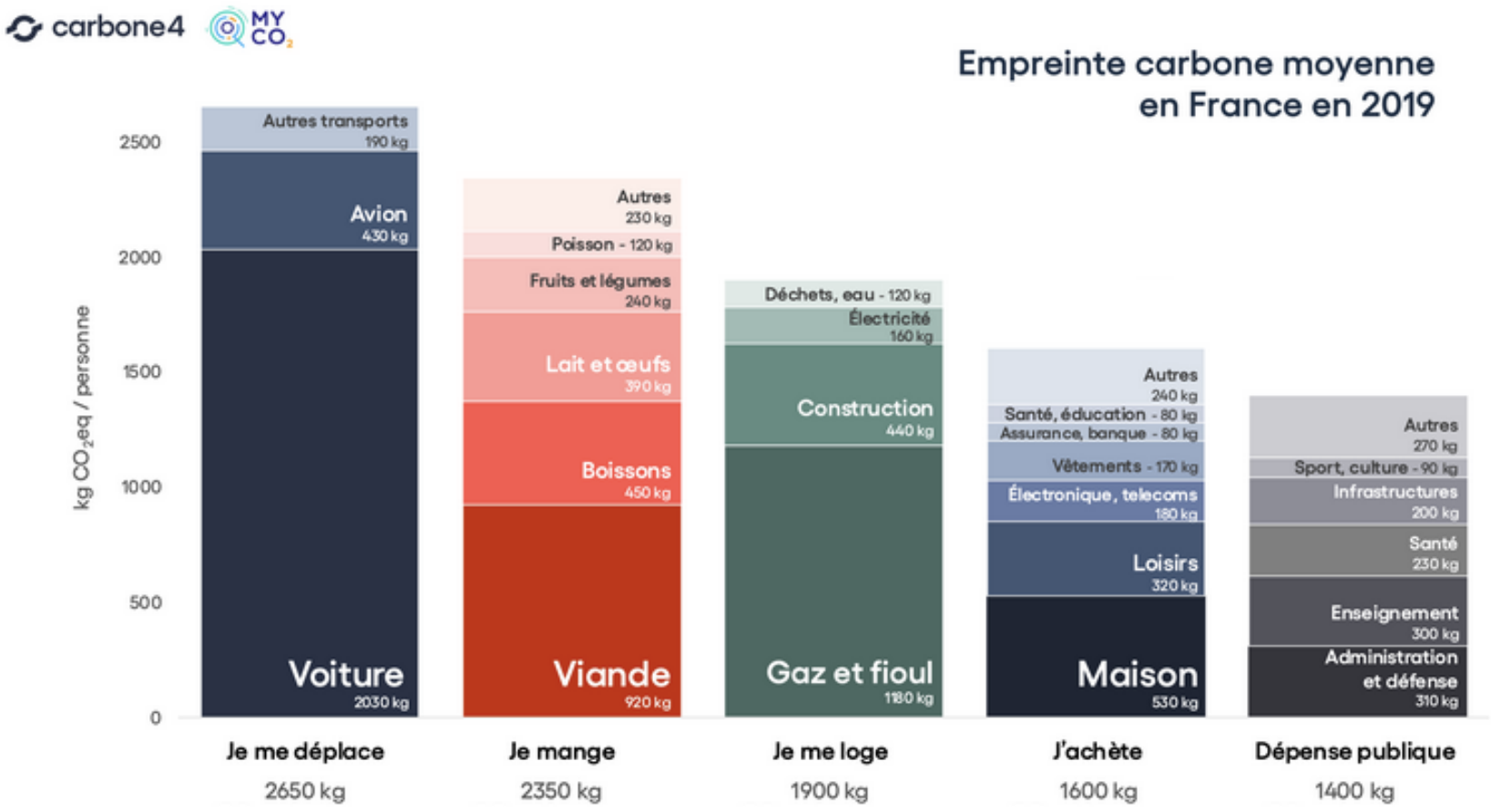
Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO_2eq.

Our World in Data

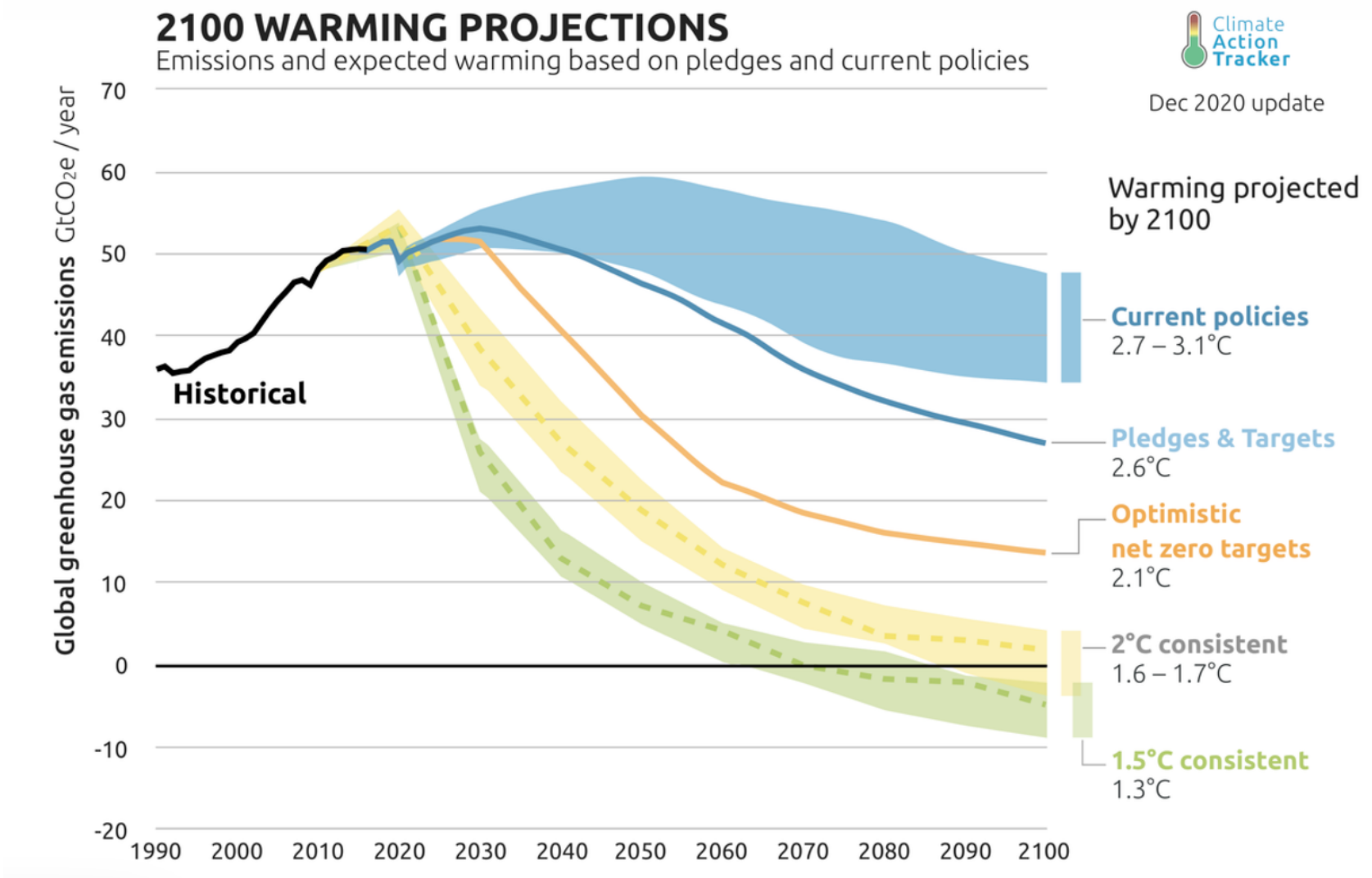


Repartition in France (Users)



- Objective of *accords de Paris* (COP21) : 2 tons /capita

Trajectories



Message

- The problems are well identified
- There is still a long (and difficult) way to go
- Without forgetting the other planetary limits

Message

- It is important to associate a cost with an infrastructure or a use.
- Transforming a given activity into eqCO_2 is educational to raise awareness of impacts.
- Measuring in kWh is more universal.