



# Questions énergétiques et climatiques globales : des données, aux indicateurs, aux actions

## Energetics and Climate Global Issues: From data to indicators and actions

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**Arnaud Delebarre, 2021**



## Plan

### **Fundamentals of Energy**

Data on Greenhouse Gases (GHG) Climate & Energy

Indicators on Climate, Energy, Mixed/Elaborated

Actions on Climate, Energy, Companies/Individuals

Conclusion

## Fundamentals of Energy

Energy = To extract resource from environment and to convert it into work+heat

Example of converter: Human being who being fed, produces W and Heat:



Examples of conversion more powerful than human beings:



# Energy: Man compared to Oil

## Energy: comparison of human being with 1 gasoline liter

Human work by legs:

80 kg (man) + 10 kg (rucksack) x 2000 m (elevation)  $\approx$  0,5 kWh

Every other day, i.e., 100 kWh/year

Accounting for a minimum wage (20 k€/year) : 200 €/kWh



Human works by arms:

6 m<sup>3</sup> of soil elevated at 1 meter  $\approx$  0,05 kWh

Every other day, i.e., 10 kWh/year

At minimum wage : 2000 €/kWh



Energy developed by 1 unique liter of gasoline:

10 kWh (2 to 4 kWh mechanical), i.e. 10 to 100 times more than legs or arms

1,5 €/liter thus 0,4 €/kWh i.e. 500 to 5000 times less expensive



After Jean-Marc Jancovici, 2019

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Fundamentals of Energy

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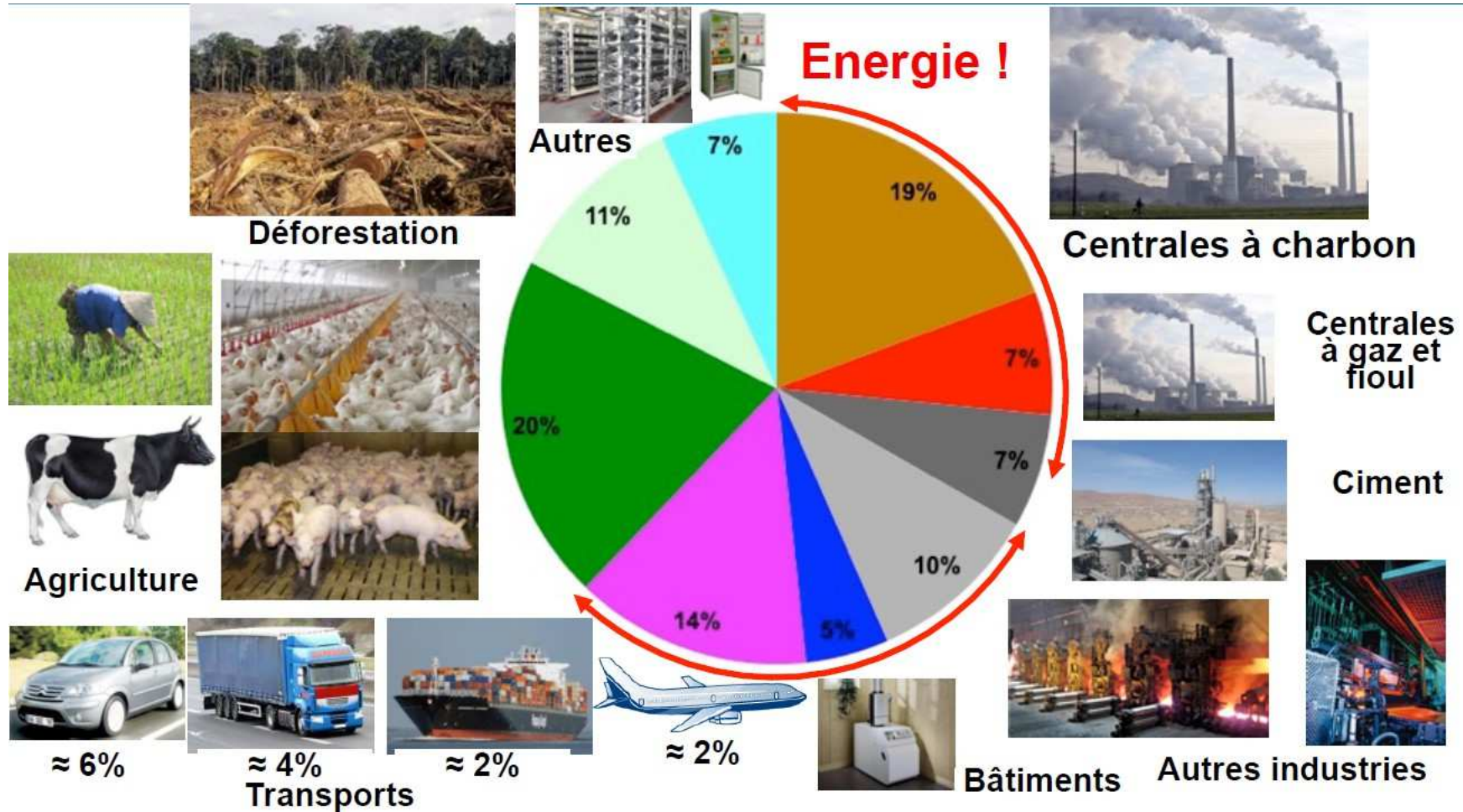
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# Sources of Greenhouse Gas (GHG) emissions

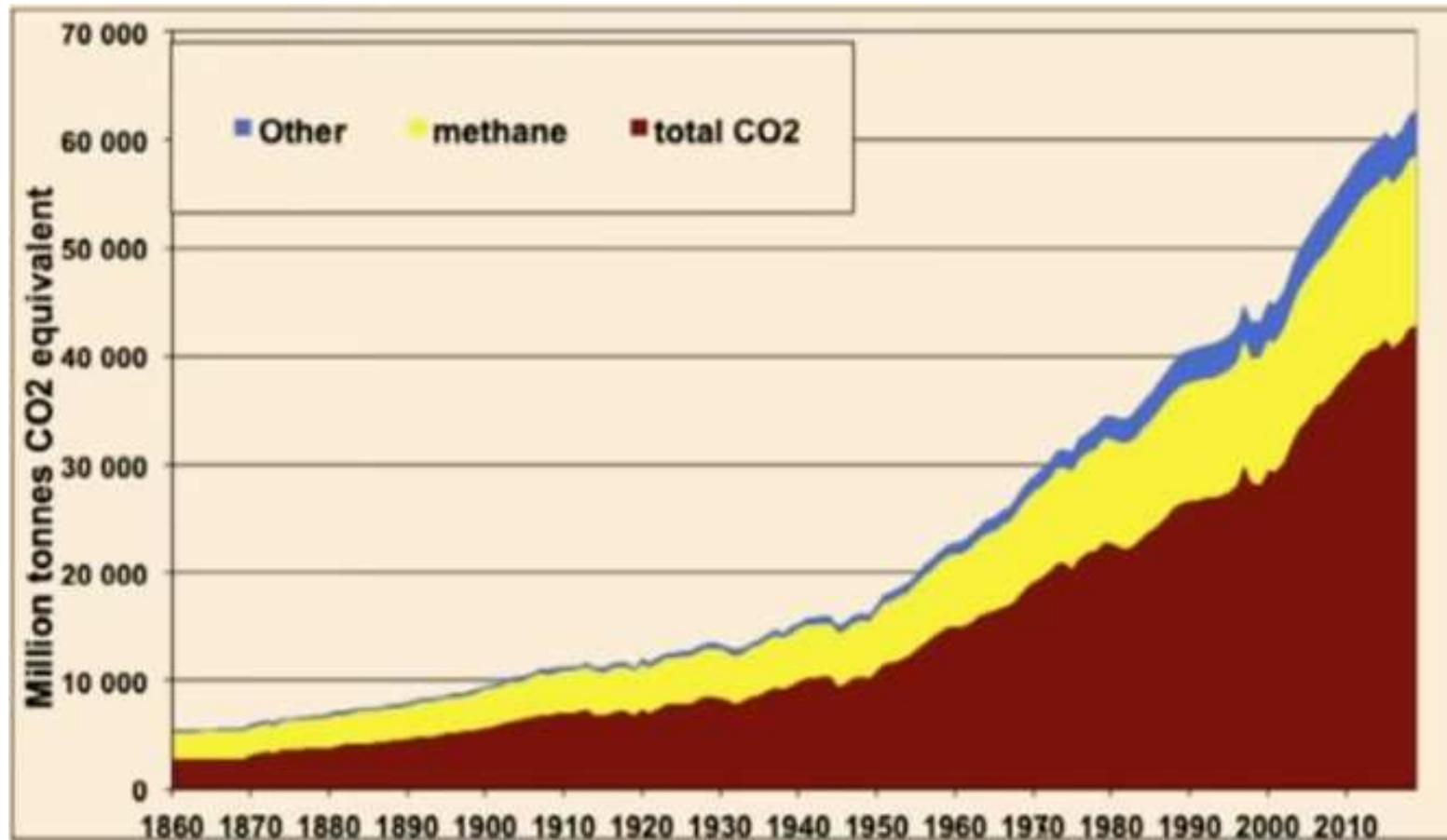
- **Annual worldwide GHG emissions 2019: 60 Gigatonnes CO<sub>2</sub>eq**
  - Energy: 19%+7%+(40% of 7%)+10%+5%+14% = 58%
  - Food: 20%+11% = 31 %





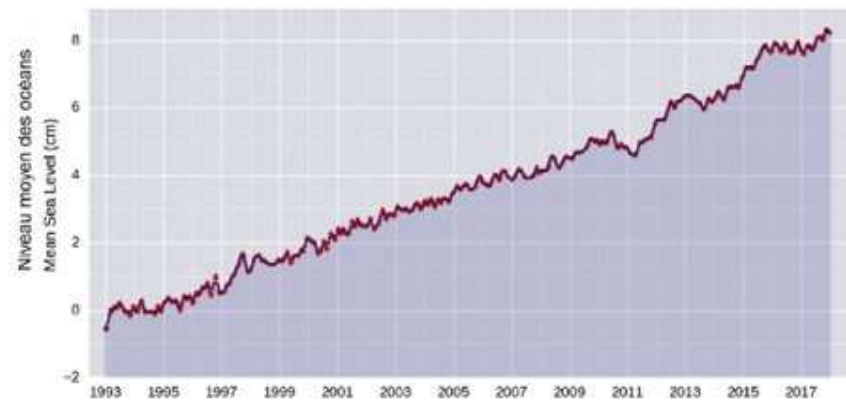
# Greenhouse Gas (GHG): Emissions vs time

- Introduction de nouvelles méthodes de production de l'énergie, de la mobilité, de la sobriété, de la digitalisation..., mais ça continue de croître

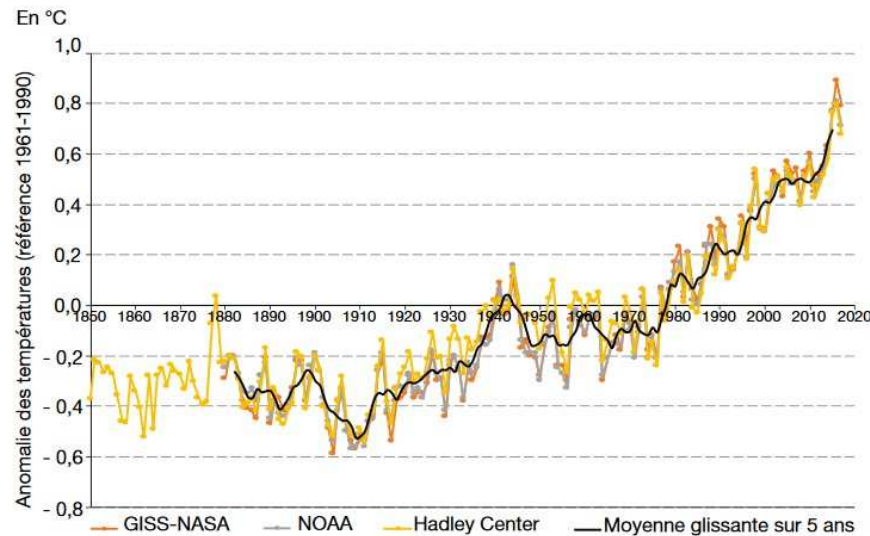
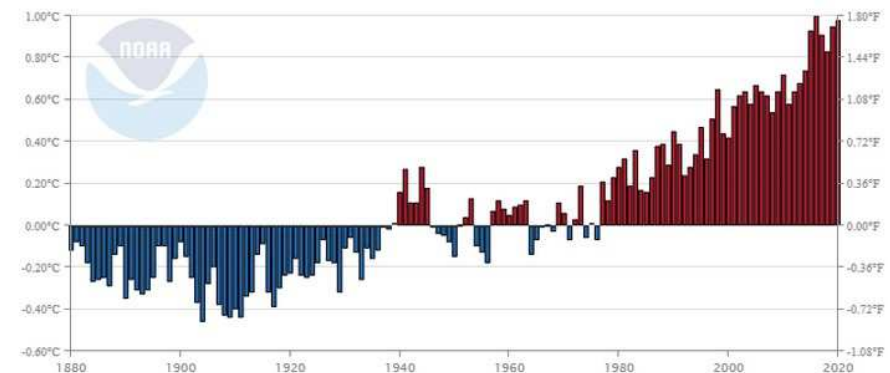


# Temperature and Sea level Increase

- Sea level: >1,7 mm/year ; +26 à +98 cm en 2100 after IPCC
- Temperature increase is evaluated by so-called "anomaly": **+0.08°C/decade since 1880; +0.18°C/decade since 1981; +0.82°C/2011-2020**. Thus 2040 +1,5°C and 2060 +2°C. In these cases anomaly is the difference with 1901–2000 average temperature that is 13.9°C)



Global Land and Ocean  
January–December Temperature Anomalies



RANK 1 = WARMEST PERIOD OF RECORD: 1880–2020	YEAR	ANOMALY °C	ANOMALY °F
1	2016	1.00	1.80
2	2020	0.98	1.76
3	2019	0.95	1.71
4	2015	0.93	1.67
5	2017	0.91	1.64
6	2018	0.83	1.49
7	2014	0.74	1.33
8	2010	0.72	1.30
9	2013	0.68	1.22
10	2005	0.67	1.21



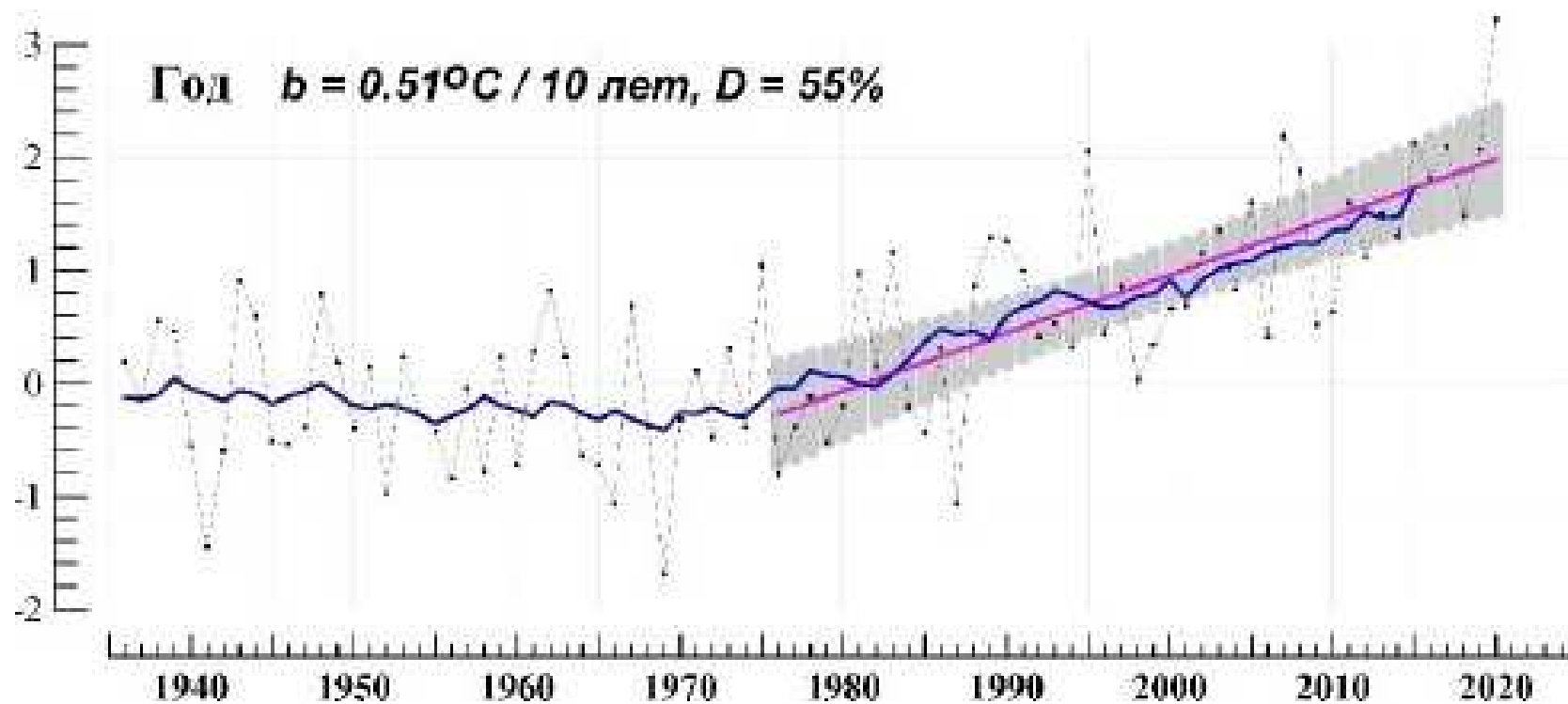
## Temperature in Mountain and Arctic regions increase faster

- **Russia and France have in common a greatest temperature increase compared to the average of earth because of Mountains or Latitude**
- **French Alps compared to earth:**
  - From 1880 to 2012, mean temperature in French Alps increased of 2°C
  - From 1880 to 2012, mean temperature earth surface increased of 0.85 °C
- Ossoue Glacier (Pyrénées) lost 112 m length and 16 m thickness from 2005 to 2015



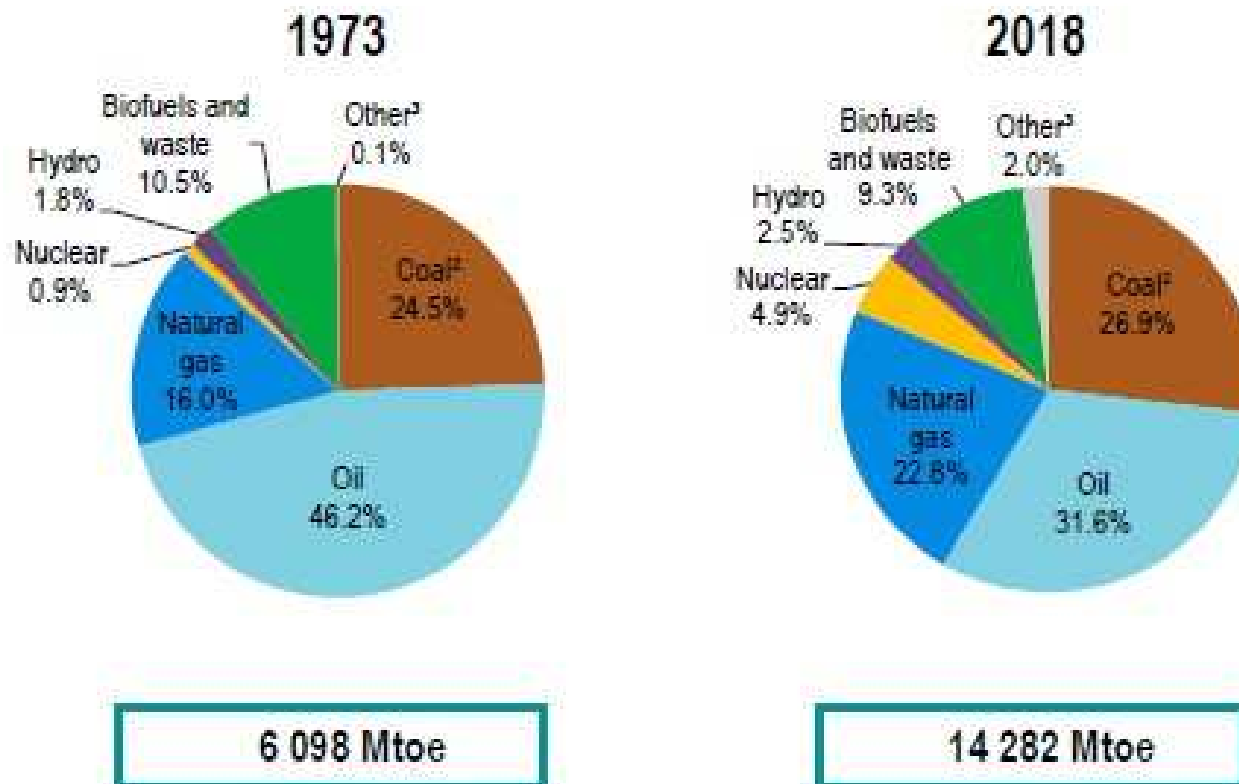
## Temperature in Mountain and Arctic regions increase faster (Ctd)

- On 3rd March 2021: Federal Service for Hydrometeorology and Environmental Monitoring of Russia (НИУ Росгидромета) published :
  - **+0.51°C/decade in Russia compared to average 1961-1990**
  - **+3.22°C in Russia in 2020 compared to average 1961-1990**
  - Remind for whole earth: **+0.18°C/decade compared to 1901–2000 avg. temperature**



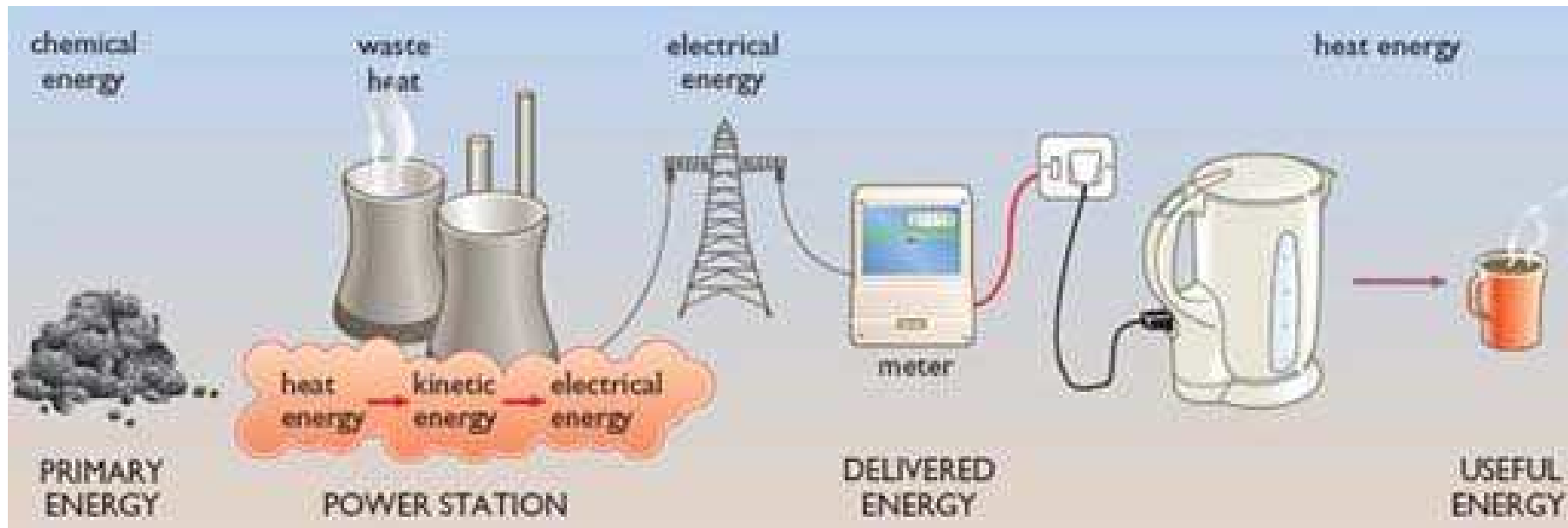
# Energy: Total Primary Energy Supply (TES) vs Sources

1973 and 2018 source shares of TES

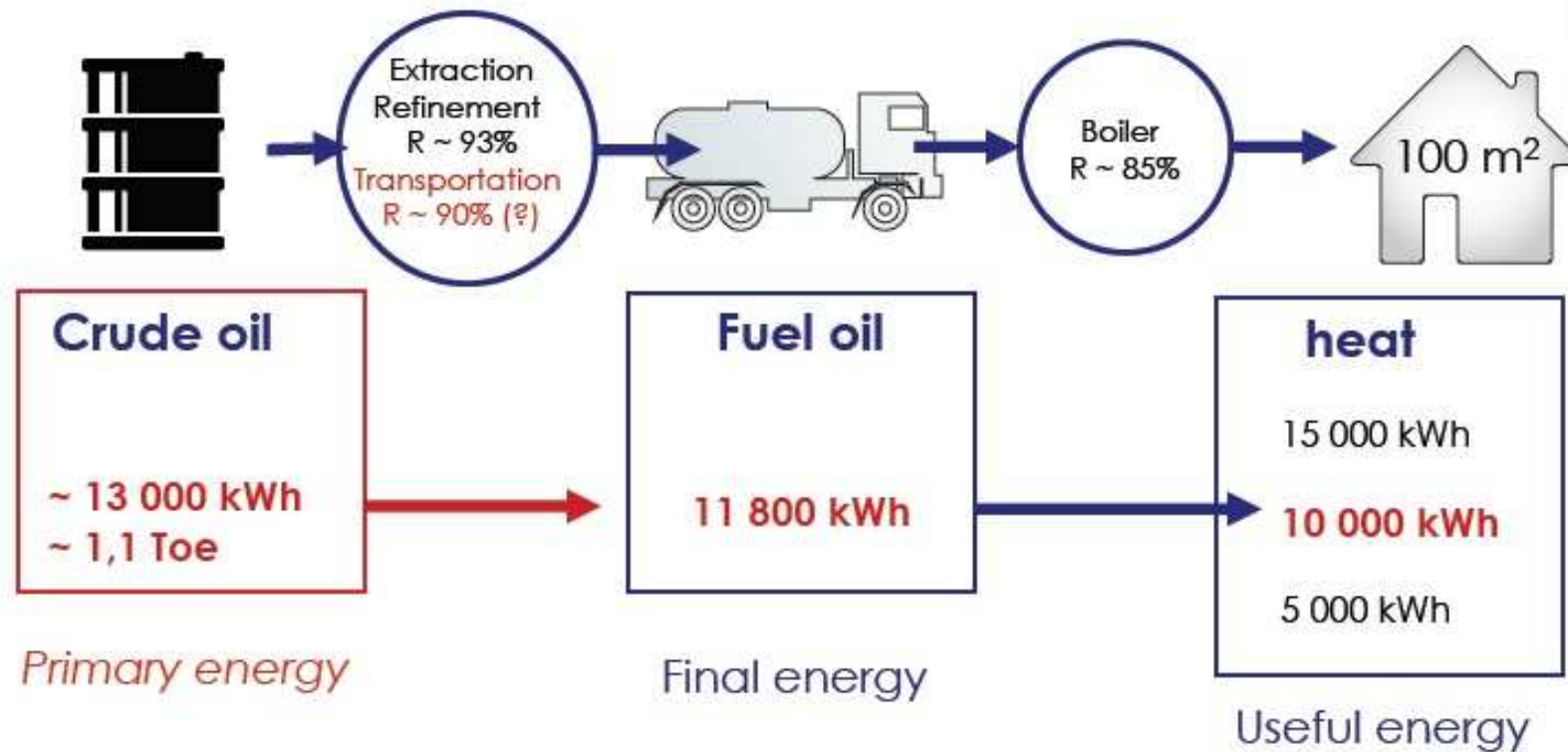


1. World includes international aviation and international marine bunkers.
2. In these graphs, peat and oil shale are aggregated with coal.
3. Includes geothermal, solar, wind, tide/wave/ocean, heat and other sources.

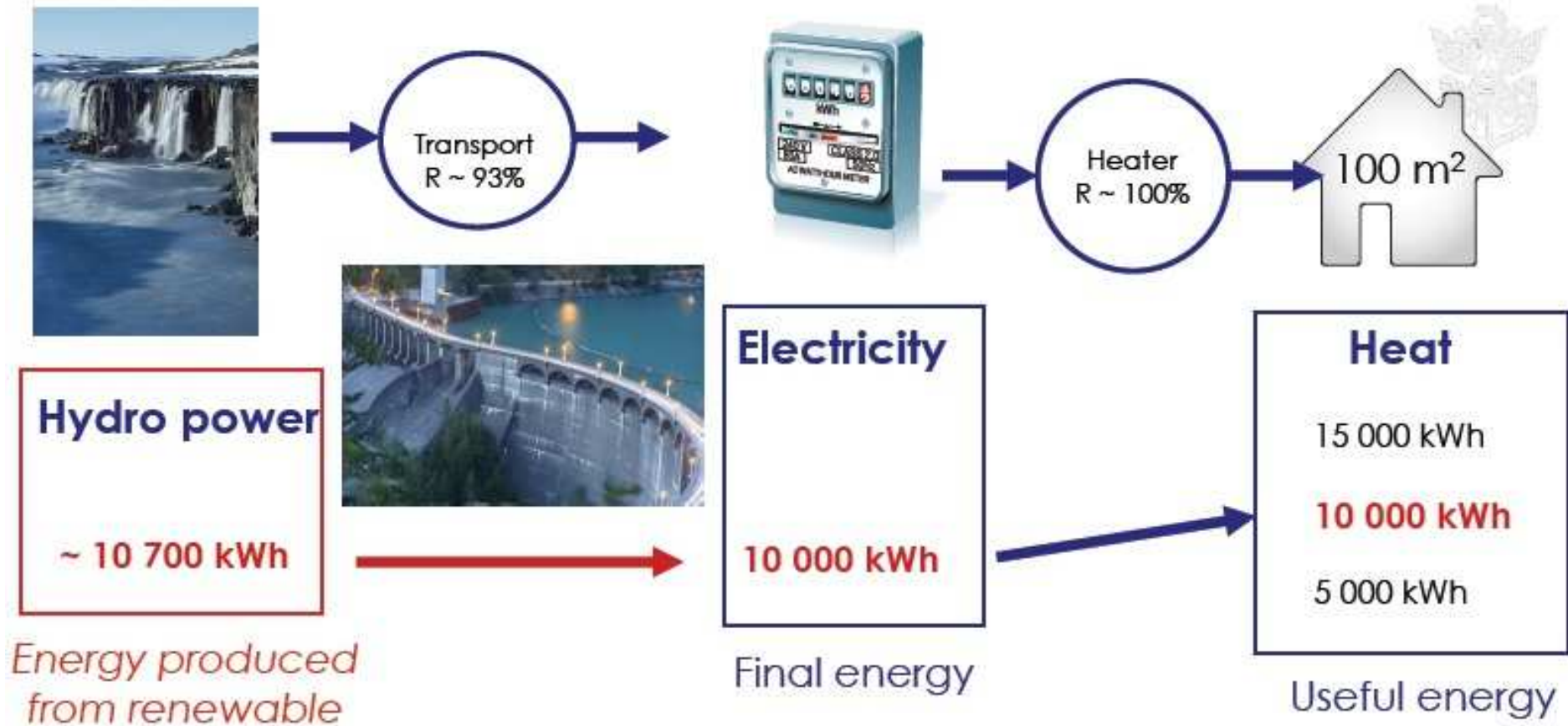
# Primary Energy and Useful Energy



# Energy : primary, secondary, final, useful...



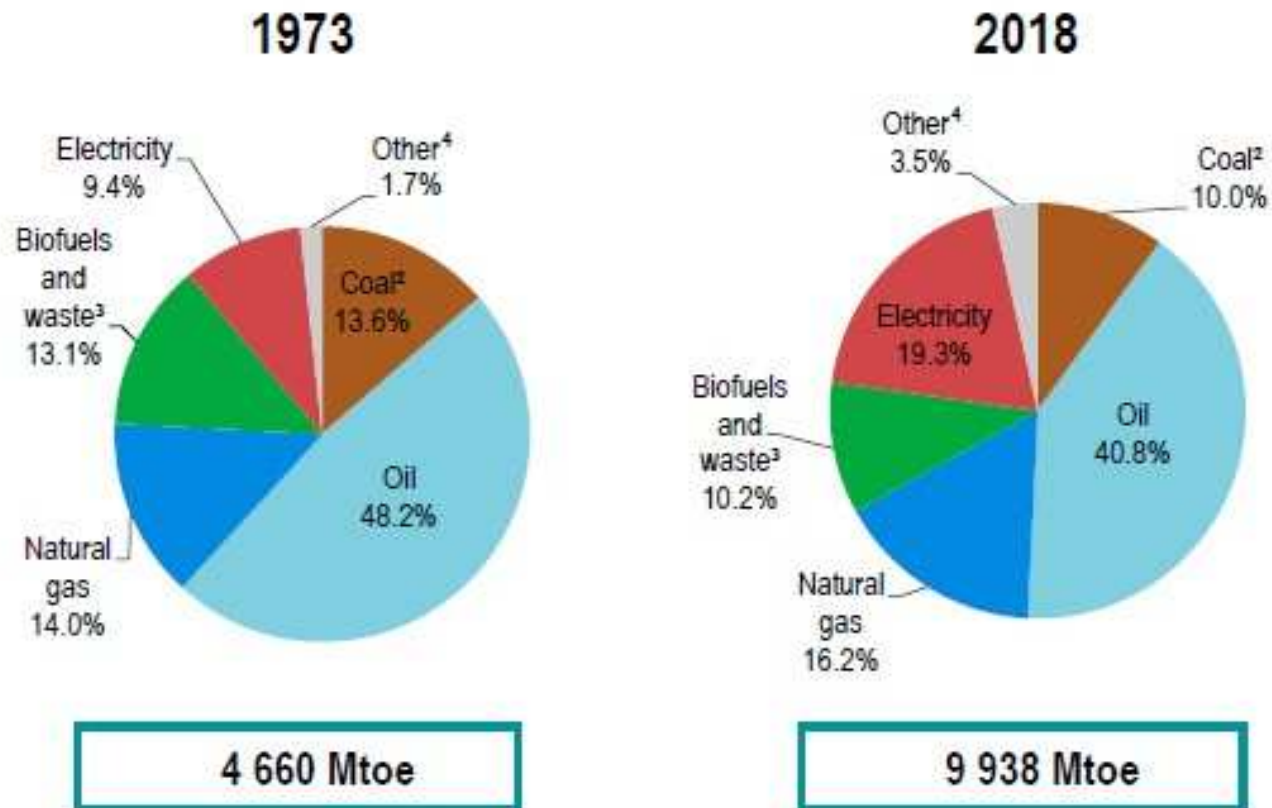
# Energy : primary, secondary, final, useful...





# Total (Energy) Final Consumption (TFC) vs Sources

## 1973 and 2018 source shares of TFC



1. World includes international aviation and international marine bunkers.
  2. In these graphs, peat and oil shale are aggregated with coal.
  3. Data for biofuels and waste final consumption have been estimated for a number of countries.
  4. Includes heat, solar thermal and geothermal.
- Source: [IEA, World Energy Balances, 2020](#).

# Electricity: Notion of (national) mix

- Electricity generation in Russian Federation in 2019 : **Total = 1118.1 TWh**  
Oil = 6.9 TWh; **Gas= 519.5 TWh (46%)** Coal 182.2 TWh; Nuclear 209.0 TWh (18,7%); Hydro 194.4 TWh; **Renewables 1.8 TWh (0,16%)**; Other 4.3 TWh 1118.1
- Electricity generation in China in 2019 : **Total = 7503.4 TWh**  
Oil = 6.0 TWh; Gas= 236.5 TWh; **Coal 4853.7 TWh (65%)** ; Nuclear 348.7 TWh (4,7%); Hydro 1269.7 TWh; **Renewables 732.3 TWh (9,8%)**; Other 56.5 TWh
- Electricity generation in France in 2019 : **Total = 537.7 TWh**  
**Nuclear 70.6 %**; Hydro 11.2%; **Renewables 10.3%**
- World: **non-hydro Renewable 2806 TWh** > Nuclear production 2657 TWh in 2019

Coal <sup>1</sup>	TWh
People's Rep. of China	4 773
United States	1 272
India	1 163
Japan	339
Korea	258
Germany	239
South Africa	227
Russian Federation	178
Indonesia	160
Australia	158
Rest of the world	1 393
<b>World</b>	<b>10 160</b>

2018 data

Oil	TWh
Saudi Arabia	160
Japan	52
United States	43
Iraq	40
Mexico	35
Pakistan	31
Kuwait	31
Islamic Rep. of Iran	29
Egypt	23
Lebanon	21
Rest of the world	319
<b>World</b>	<b>784</b>

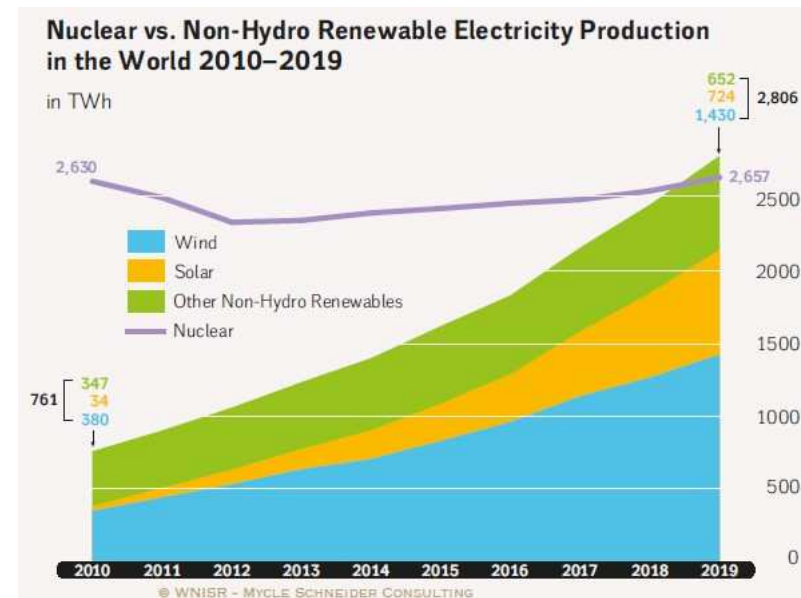
2018 data

Natural gas	TWh
United States	1 519
Russian Federation	528
Japan	378
Islamic Rep. of Iran	256
People's Rep. of China	224
Saudi Arabia	218
Mexico	202
Korea	156
Egypt	155
United Arab Emirates	134
Rest of the world	2 380
<b>World</b>	<b>6 150</b>

2018 data

Renewables <sup>2</sup>	TWh
People's Rep. of China	1 833
United States	743
Brazil	495
Canada	434
India	300
Germany	225
Russian Federation	193
Japan	177
Norway	143
Italy	114
Rest of the world	2 043
<b>World</b>	<b>6 700</b>

2018 data



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# Indicators for energy : consumption per capita

Annual energy<sup>(1)</sup> consumption  
per capita (France 2014)

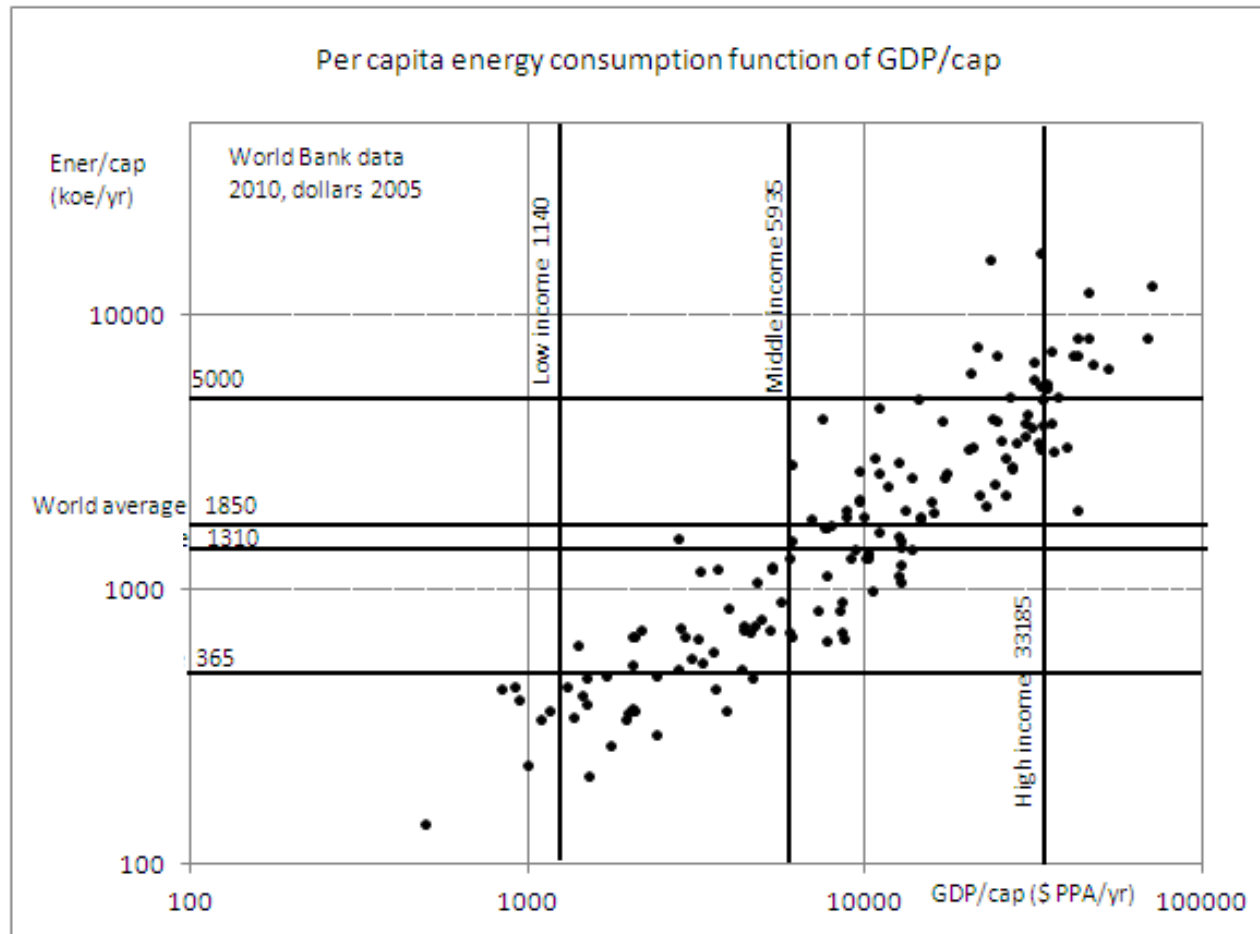
Total ~ 27 000 kWh

Electric ~ 7 000 kWh

<sup>(1)</sup> final energy



# Per capita commercial energy consumption and per capita income (\$PPA = \$Purchasing power parity) 2010





## CO<sub>2</sub> emissions, standard of living and demography

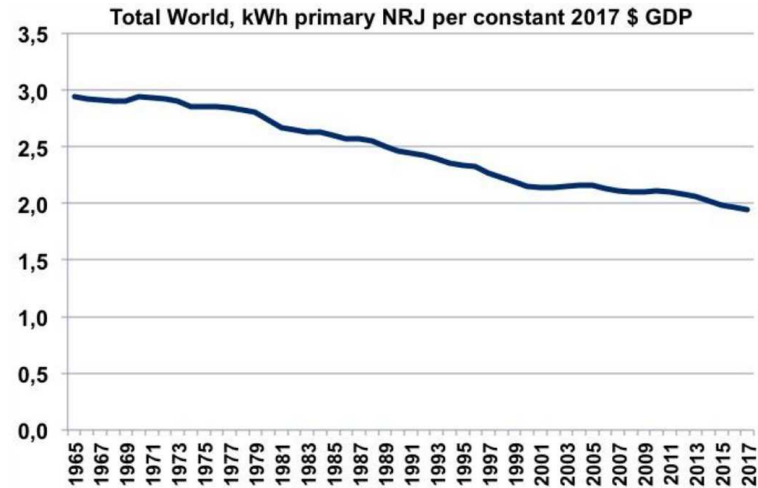
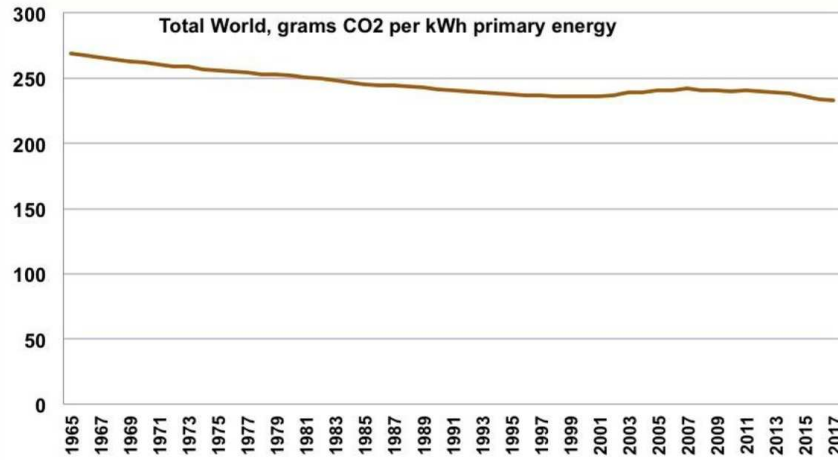
- 2016: 4,8 t CO<sub>2</sub>/capita, namely -0.8% / 2015. Emissions +0,3 % population growth +1,2 %

En t CO <sub>2</sub> /habitant	1990	2015	2016	Évolution (%) 2015-2016	Évolution (%) 1990-2016
<b>Amérique du Nord</b>	<b>16,0</b>	<b>13,0</b>	<b>12,6</b>	<b>- 2,8</b>	<b>- 21,3</b>
dont Canada	20,0	19,1	18,6	- 2,2	- 6,6
États-Unis	19,9	15,9	15,5	- 2,7	- 21,9
<b>Amérique centrale et du Sud</b>	<b>1,8</b>	<b>2,6</b>	<b>2,5</b>	<b>- 2,9</b>	<b>+ 40,8</b>
dont Brésil	1,4	2,4	2,2	- 6,8	+ 54,3
<b>Europe et ex-URSS</b>	<b>10,7</b>	<b>7,4</b>	<b>7,4</b>	<b>- 0,4</b>	<b>- 31,3</b>
dont Russie	16,0	11,8	11,5	- 2,3	- 28,2
UE à 28	9,1	6,7	6,7	- 0,1	- 25,9
<i>Allemagne</i>	12,6	9,4	9,4	+ 0,5	- 25,4
<i>Espagne</i>	5,8	5,6	5,4	- 3,2	- 6,7
<b>France</b>	<b>6,4</b>	<b>4,9</b>	<b>5,0</b>	<b>+ 1,7</b>	<b>- 23,0</b>
<i>Italie</i>	7,5	5,8	5,9	+ 1,0	- 20,8
<i>Royaume-Uni</i>	10,1	6,0	5,6	- 7,1	- 44,2
<i>Pologne</i>	9,4	7,6	7,8	+ 2,7	- 17,0
<b>Afrique sub-saharienne</b>	<b>0,8</b>	<b>0,7</b>	<b>0,7</b>	<b>- 2,1</b>	<b>- 18,9</b>
<b>Moyen-Orient et Afrique du Nord</b>	<b>3,4</b>	<b>5,6</b>	<b>5,7</b>	<b>+ 0,6</b>	<b>+ 67,8</b>
dont Arabie saoudite	10,3	16,2	16,0	- 1,3	+ 55,8
<b>Asie</b>	<b>1,8</b>	<b>4,2</b>	<b>4,2</b>	<b>+ 0,1</b>	<b>+ 137,2</b>
dont Chine	2,0	7,6	7,6	- 0,8	+ 272,6
Corée du Sud	6,3	11,8	11,8	+ 0,0	+ 88,5
Inde	0,8	1,8	1,9	+ 3,5	+ 154,0
Japon	9,4	9,9	9,8	- 1,1	+ 4,1
<b>Océanie</b>	<b>11,7</b>	<b>12,2</b>	<b>11,9</b>	<b>- 2,4</b>	<b>+ 1,7</b>
<b>Pays de l'annexe I</b>	<b>12,4</b>	<b>9,9</b>	<b>9,7</b>	<b>- 1,6</b>	<b>- 21,6</b>
<b>Pays hors de l'annexe I</b>	<b>1,7</b>	<b>3,5</b>	<b>3,5</b>	<b>- 0,1</b>	<b>+ 108,0</b>
<b>Monde</b>	<b>4,2</b>	<b>4,8</b>	<b>4,8</b>	<b>- 0,8</b>	<b>+ 13,1</b>



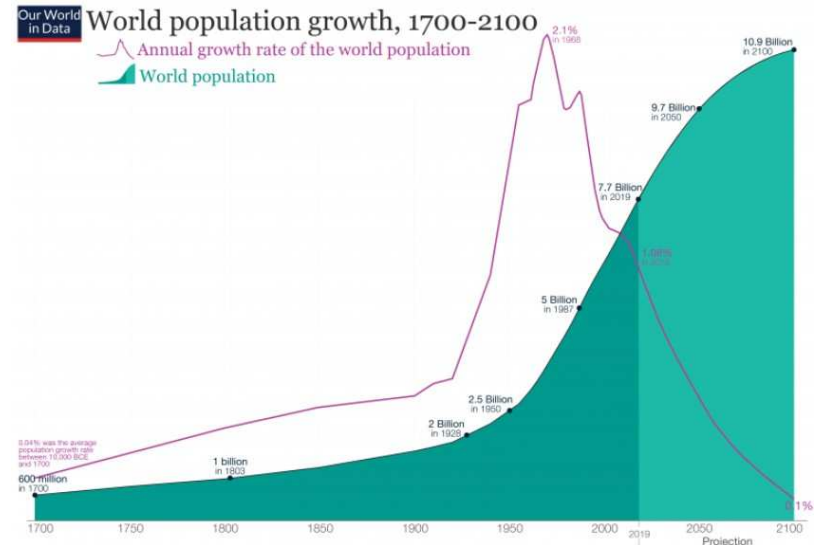
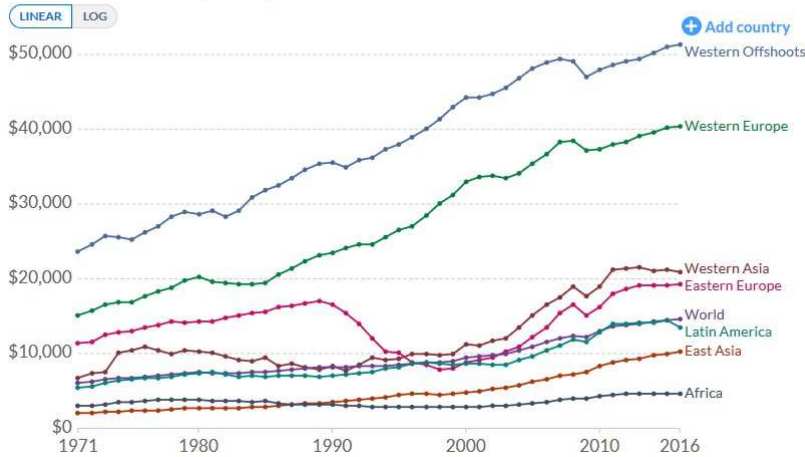
# Indicator of CO2: Kaya relationship

$$\text{CO2} = [\text{CO2/TPES}] * [\text{TPES/GDP}] * [\text{GDP/People}] * [\text{People}]$$



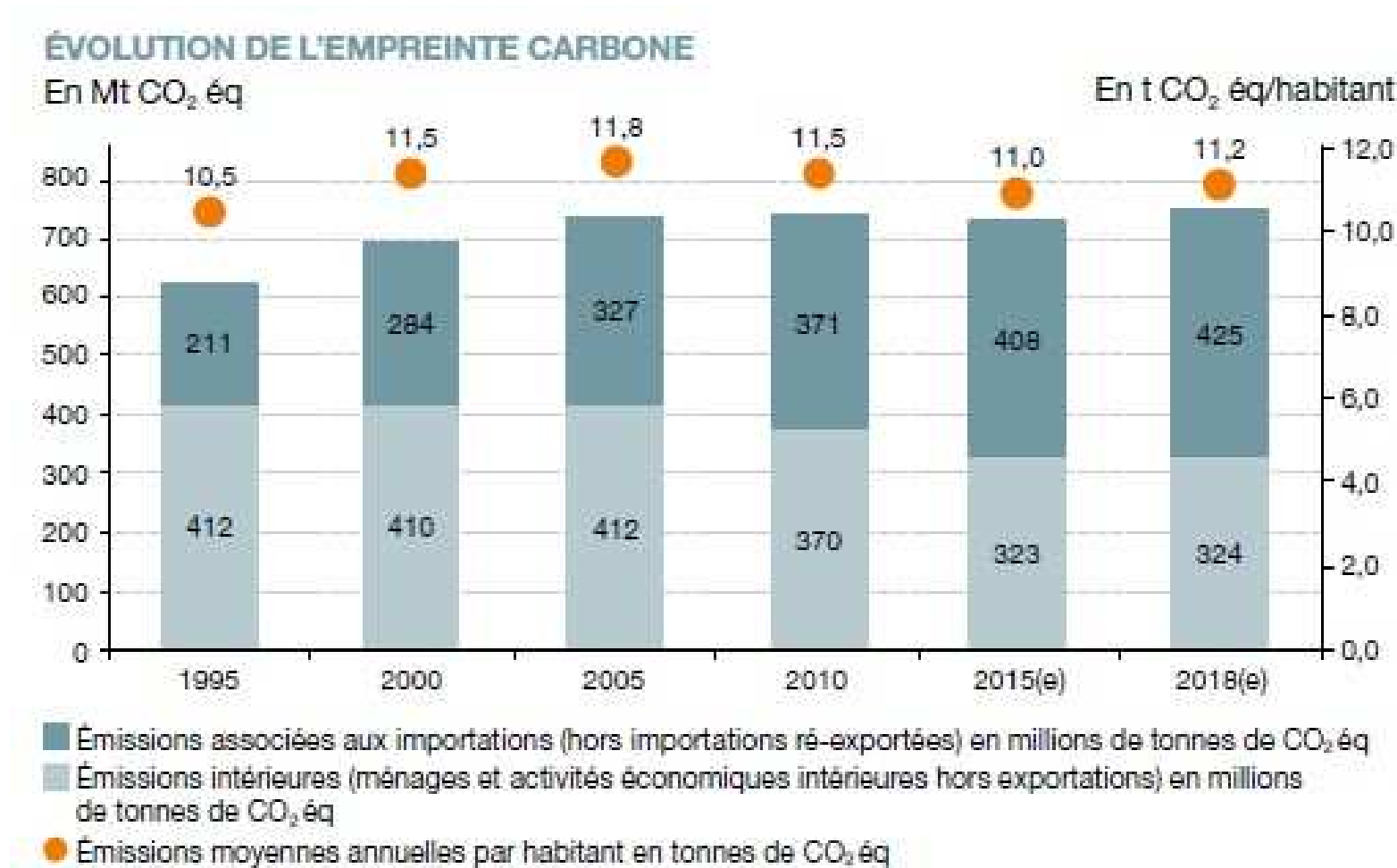
## GDP per capita, 1971 to 2016

GDP per capita adjusted for price changes over time (inflation) and price differences between countries - it is measured in International-\$ in 2011 prices.



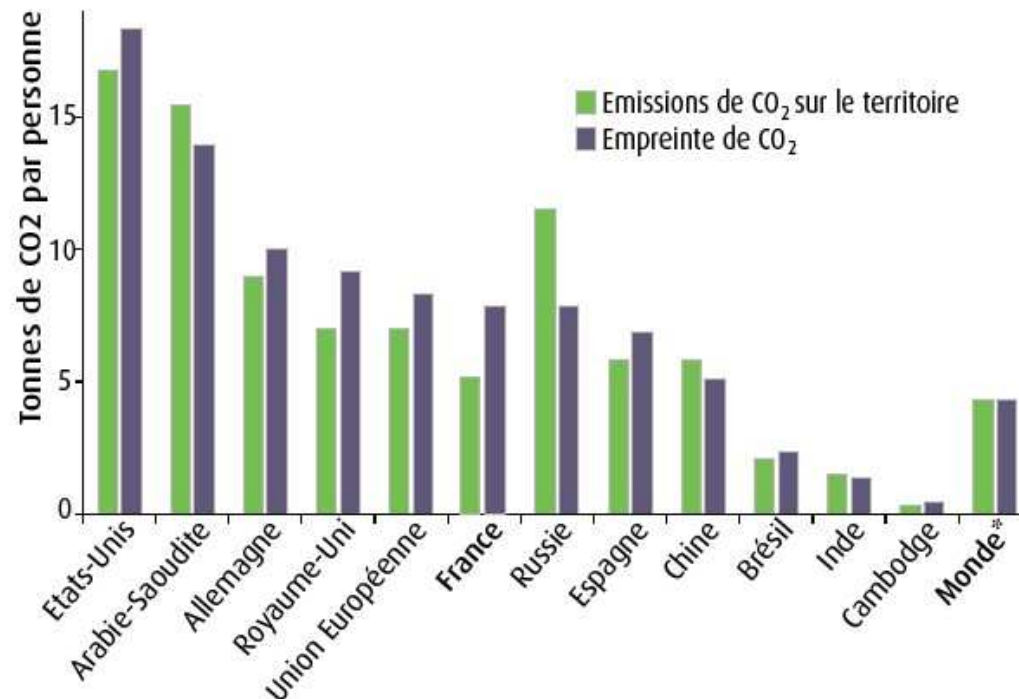
# Indicator of GHG emissions: Inventory and Footprint

## Green House Gases (GHG) emissions: national inventory and footprint accounting for imports, inventory per capita, France



## National inventory and footprint accounting for imports in CO<sub>2</sub> emissions per capita in 2011 in Europe

- Russia and France: same carbon footprint (7,5 tCO<sub>2</sub>/capita) with different territory emissions (5 tCO<sub>2</sub>/capita in France vs 12 tCO<sub>2</sub>/capita in Russia)



Note : émissions de CO<sub>2</sub> de la combustion des énergies fossiles. \* A l'échelle mondiale, l'empreinte CO<sub>2</sub> moyenne par personne est égale à la moyenne des émissions par habitant.

Sources : AIE et OCDE, 2015. Traitement : SOeS, 2015.

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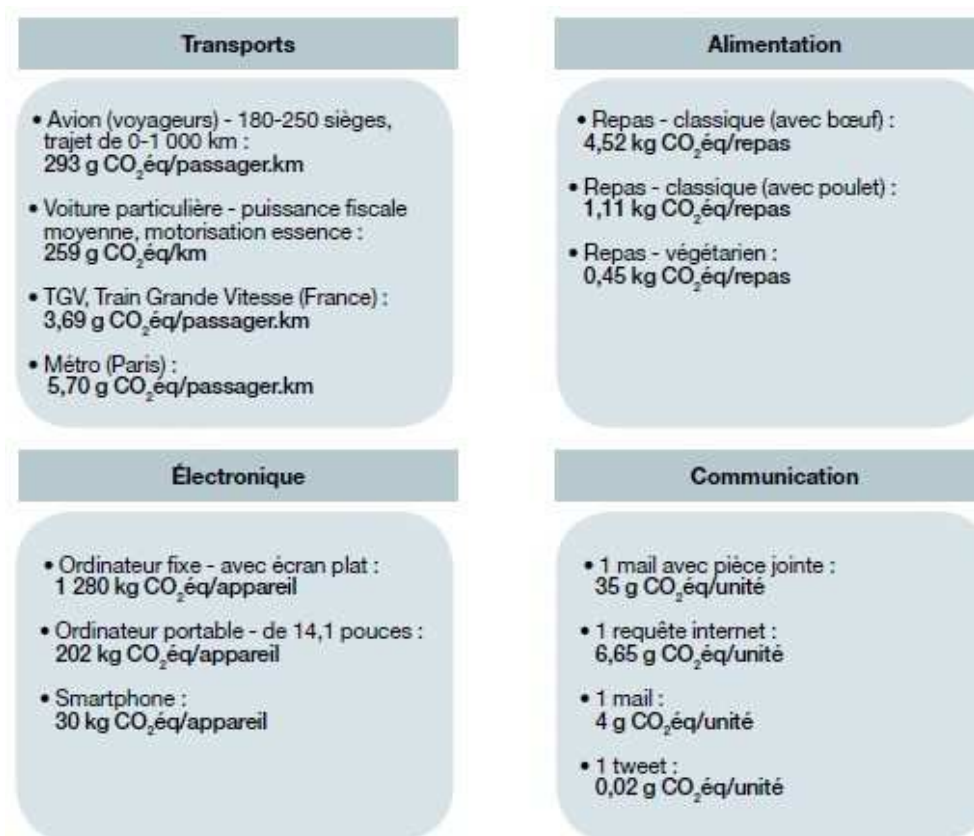
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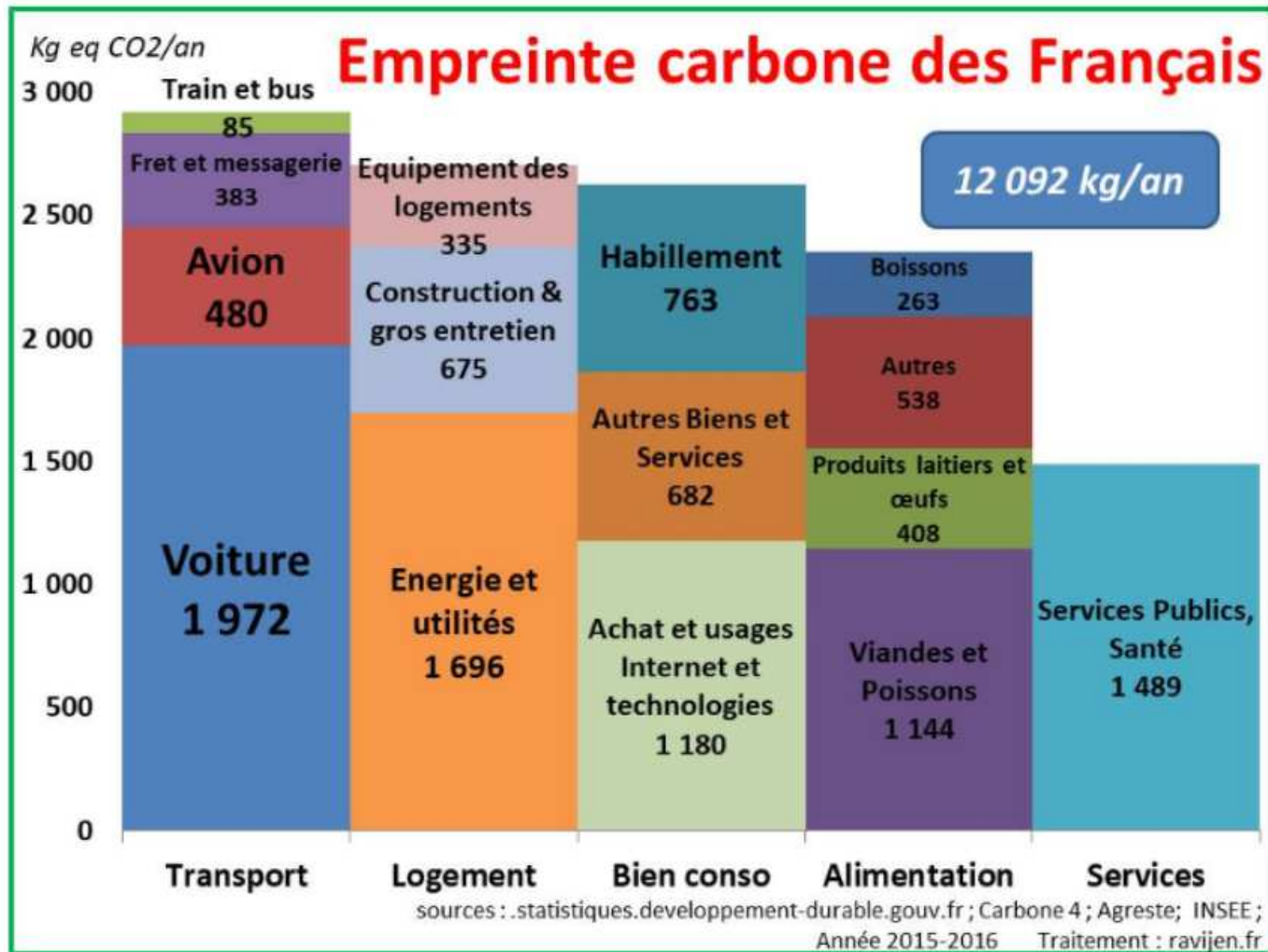
# Individual footprint: if individual CO<sub>2</sub> quota were existing

- Imagine if there were an annual allocation of CO<sub>2</sub> emission for each. E.g. 20 billion tonnes of CO<sub>2</sub> eq for 7 billion people, that's 3 per person, for 9 billion, roughly 2:
  - 15 000 km en avion (un A/R Paris Chicago) OR
  - 6000 à 8000 km in a car in a urban zone ; 2 times minus if it is a 4 x 4 wheels OR
  - 7 000 kWh natural gas heating (few months) OR
  - 500 kg manufactured products...



# Individual footprint: Example of a French Individual

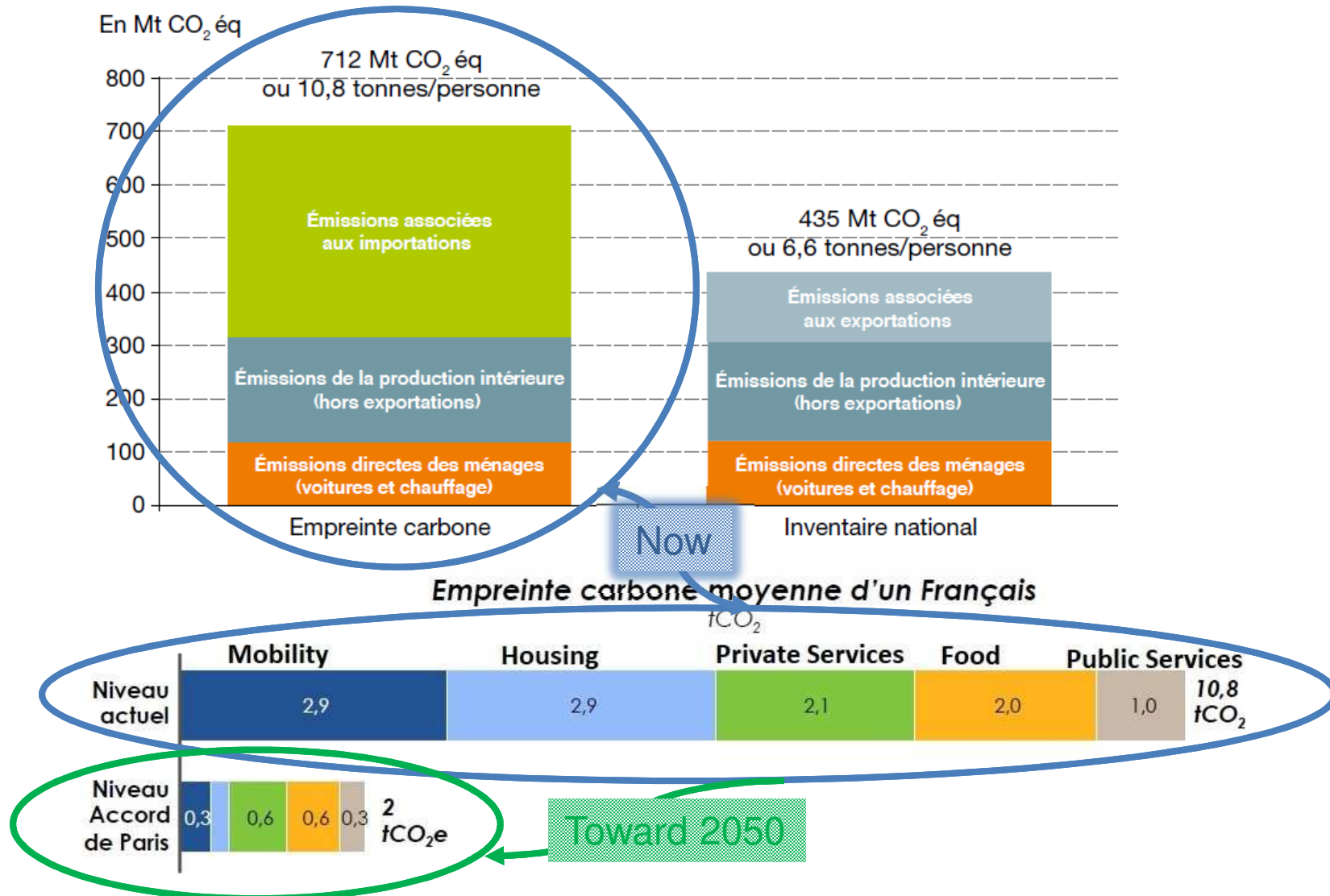
- <https://ecolab.ademe.fr/apps/climat>





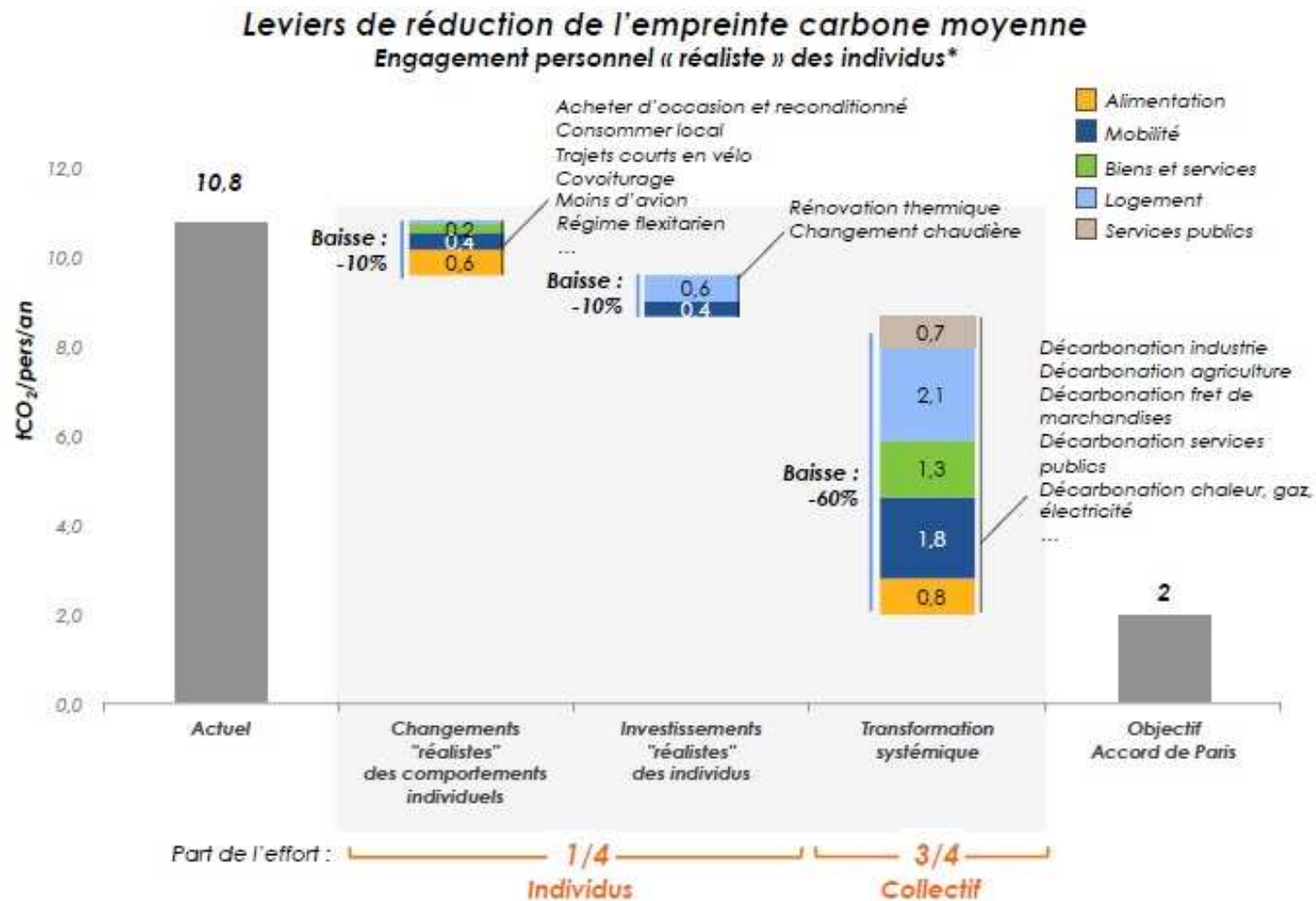
# Individual and collective contribution to emission reduction

- Emissions by individual and by activities in France: 10.8 tonnes CO<sub>2</sub>eq/capita vs target 2050 of 2 tCO<sub>2</sub>eq



# Individual and Collective contributions (ctd)

- To each his share of effort: -10% individual way of life ; -10% home renovation ; -60% companies and organizations



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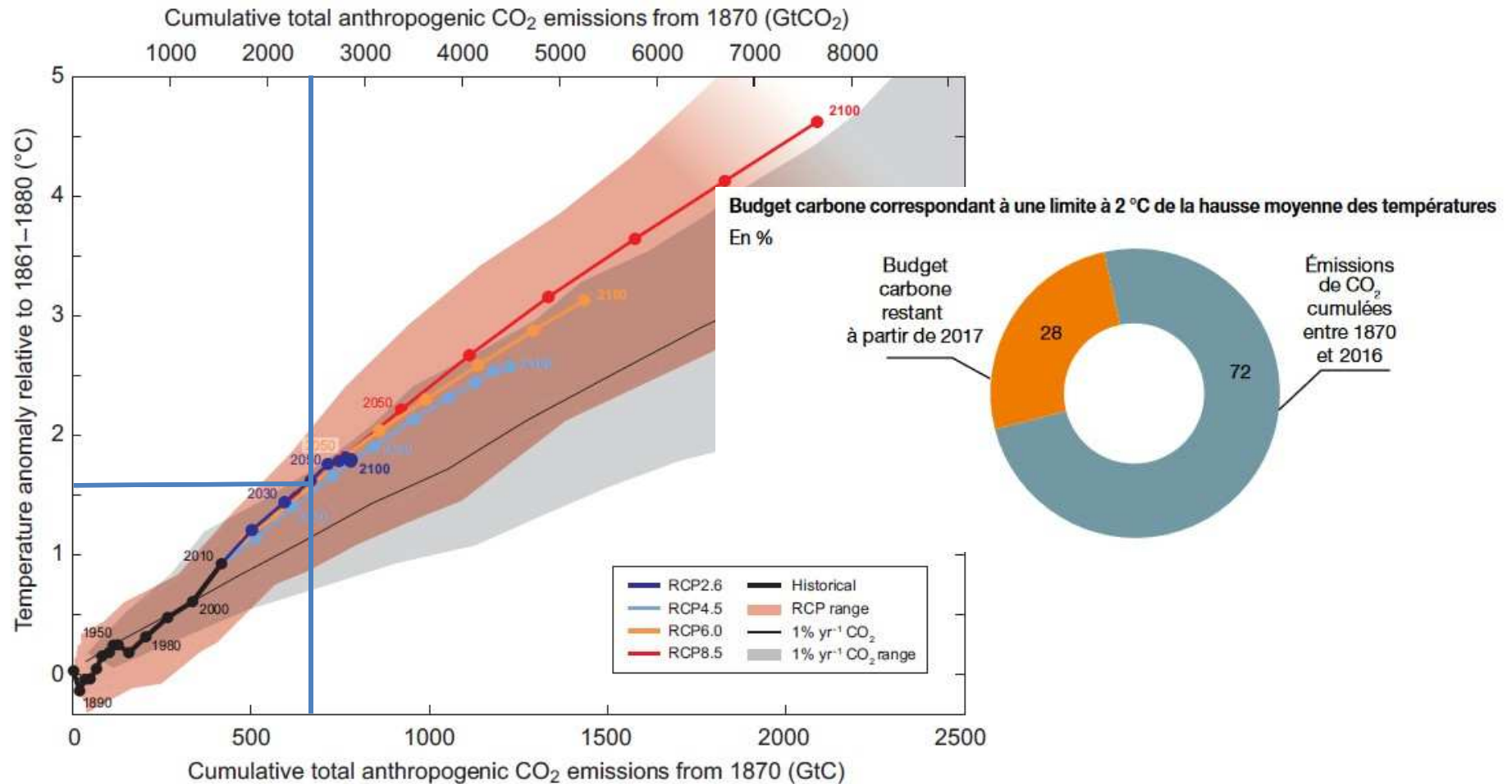
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# Conclusion: Carbon budget

- <https://openclimatedata.net/climate-spirals/from-emissions-to-global-warming-line-chart/>
- End of 2019, cumulated CO<sub>2</sub> emissions = 2 400 Gt, hence 1.5 °C [emissions during 1850-2019: 1 649 Gt from fossil fuels + 751 Gt CO<sub>2</sub> change of land use (after CITEPA, 2020)]



## Conclusion: Two types of economical impacts

- To be impacted by decisions of changes of climate policies OR by changes due to climate change ?

