CLIMATE ACADEMY®

The Scientific Supplement

Chapter Seven

CutX

Global Warming Potential (GWP), CO_2 Equivalent

Summary

This supplement explains global warming potential, or GWP, and why climate science often compares gases in terms of "CO2 equivalent". Different greenhouse gases persist in the atmosphere for very different lengths of time and trap heat with very different intensities, so a simple comparison by mass is misleading. The text shows that methane warms far more strongly than carbon dioxide over shorter periods, while gases such as SF6 can remain effective for extremely long times and have astonishingly high warming potential. By converting these impacts into a CO2-equivalent measure, scientists and policymakers can compare gases on a common scale. The supplement also stresses that time horizon matters: short-, medium- and long-term GWPs can tell different stories depending on the gas involved. This supports the chapter's broader emphasis on climate numeracy. Without a clear grasp of how gases differ in potency and persistence, discussions about emissions, responsibility and carbon budgets easily become vague or misleading.

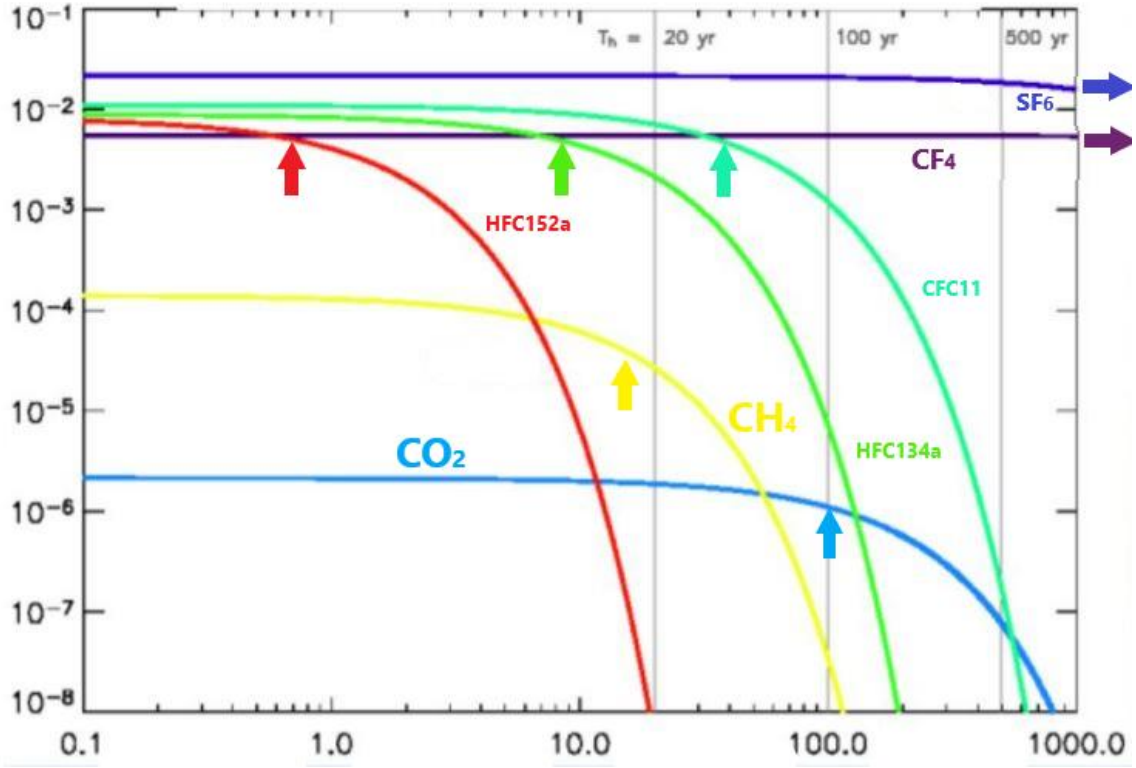
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More or less persistent greenhouse gases

It was the GIEC, in its first assessment report, that proposed the use of the unit of CO_2 equivalent (or CO_2eq) to facilitate the comparison of the various gases involved in the warming process.

As shown in the graph below, greenhouse gases eventually disappear from the atmosphere over very different timescales. This is the main reason for establishing the Global Warming Potential.



If we pay attention to the logarithmic time scale used by the authors of this graph, we can see from the thick coloured arrows that CO_2 starts to disappear significantly from the atmosphere after about 100 years; CH_4 takes about 10 years, HFCs less than 10 years. However, fluorocarbon (CF4) and fluorosulphur (SF6) compounds do not decay for several hundred to thousands of years.

Understanding that the persistence of greenhouse gases in the atmosphere is highly variable, it is absolutely necessary to compare each of their respective impacts to that of CO_2 in the global warming of the atmosphere. Using the unit of CO2 eq, it is possible to assign a global warming potential (GWP) for each greenhouse gas for a given period of time. The GWP is therefore considered to be 1 for the CO_2 used as a reference.

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3
Concentration atmosphérique 2016 (en 2005 entre parenthèses)	403 ppm (379 ppm)	1 842 ppb (1 773 ppb)	329 ppb (320 ppb)	> 183 ppt (> 49 ppt)	> 88 ppt (> 4,1 ppt)	8,9 ppt (5,6 ppt)	1,4 ppt (> 0 ppt)
Potentiel de réchauffement global (cumulé sur cent ans)	1	28-30	265	[1,4 ; 14 800]	[6 630 ; 11 100]	23 500	16 100

Sources : Giec, 1er groupe de travail, 2013 ; NOAA, 2018 ; Agage, 2018
Microsoft Word - Global-Warming-Potential-Values.docx (ghgprotocol.org)

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The comparisons in the table above show that 1 kg of CH_4 will contribute as much to global warming as 28-30 kg of CO_2. 1 kg of SF6 will warm the atmosphere as much as 23.5 tonnes of CO_2.

In other words, 1 kg of CH_4 = 28 kg CO_2eq **1 kg of SF6 = 23,500 kg CO_2eq**

Short, medium and long term GWPs.

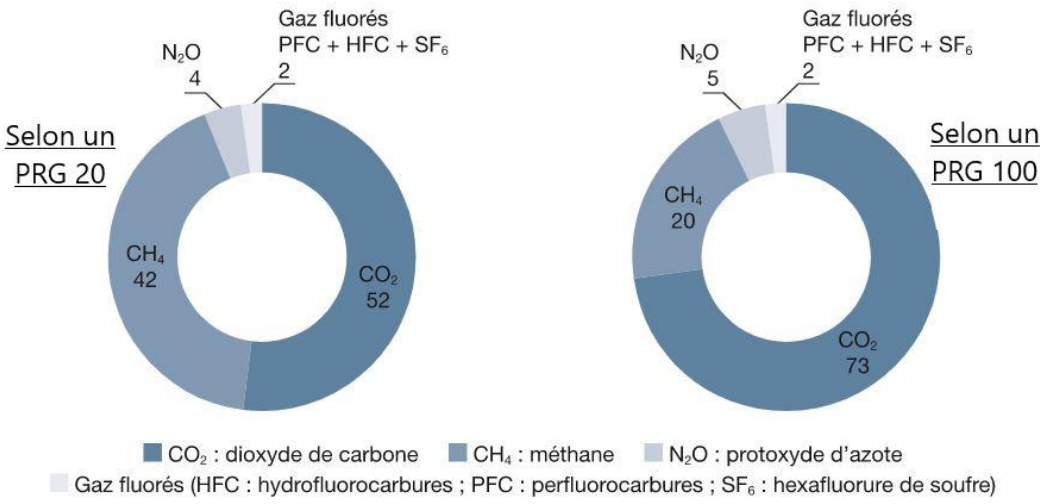
However, a clarification is needed on the expression of the global warming potential. As previously stated, the reference greenhouse gas is CO_2, the impact of which is assessed over a given period of time. This last parameter has been arbitrarily fixed at 100 years, but more and more publications take into account GWPs for 20 years or 500 years. A distinction is then made between short, medium and long term GWPs.

This may seem anecdotal but calculating the 20-year GWP or 100-year GWP highlights the different impact of GHGs according to their duration of persistence in the atmosphere.

Thus CO_2, which by convention has a GWP20 equal to the GWP100 of a value of 1, CH_4, which is not very persistent, has a GWP100 of 28, but a GWP20 equal to 82

It can therefore be seen that, depending on the method of calculation used, the impact of persistent GHGs (GWP100 and CO_2) or the impact of non-persistent GHGs (GWP20 and CH_4) will be highlighted, as clearly illustrated in the 2014 GIEC document.

Répartition des émissions mondiales des GES exprimées en % (2010)



The carbon footprint

Taking into account the values provided by the GIEC, in 2010 the volume of GHGs was 49 Gigatonnes CO2eq and will reach 59.1 Gigatonnes CO_2eq in 2019.

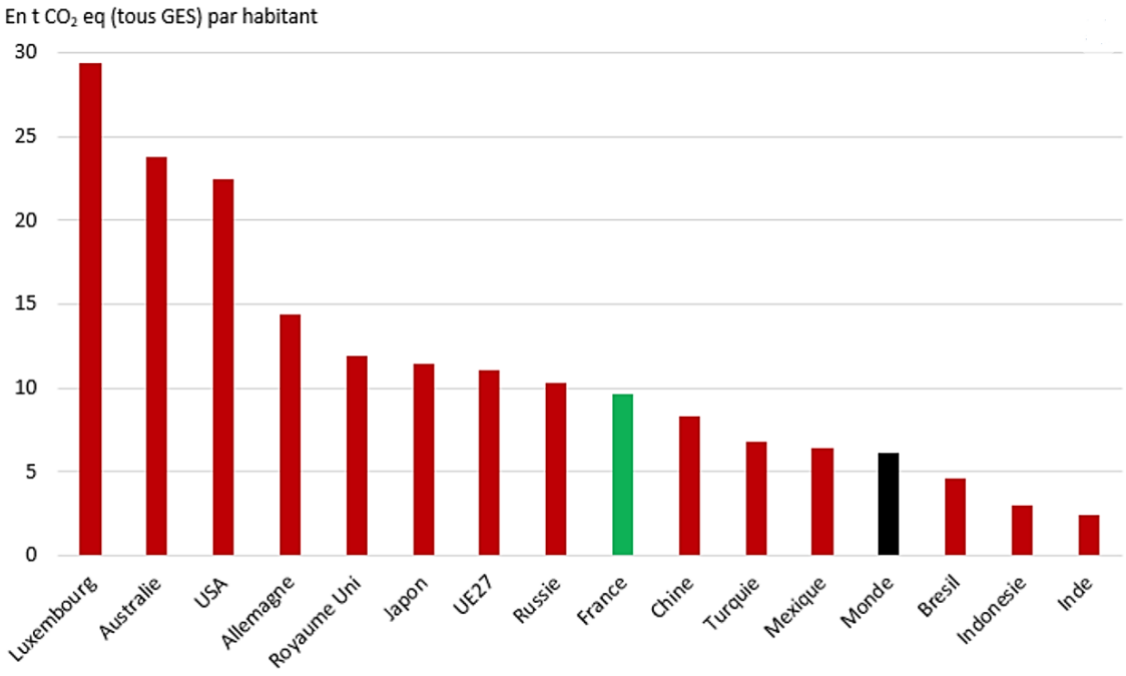
Thanks to a good understanding of the concept of CO_2 equivalent, it is now possible to accurately establish the carbon footprint of a product or service; compare the carbon footprint of a plane flight with the consumption of a beef steak.

The carbon footprint is calculated by adding up all the greenhouse gas emissions at each stage of the product's life cycle (construction materials, production, use, waste treatment) or of a service. The carbon footprint is then expressed in units of mass of CO_2 equivalents.

The domestic carbon footprint is useful for highlighting differences between inhabitants of different countries.

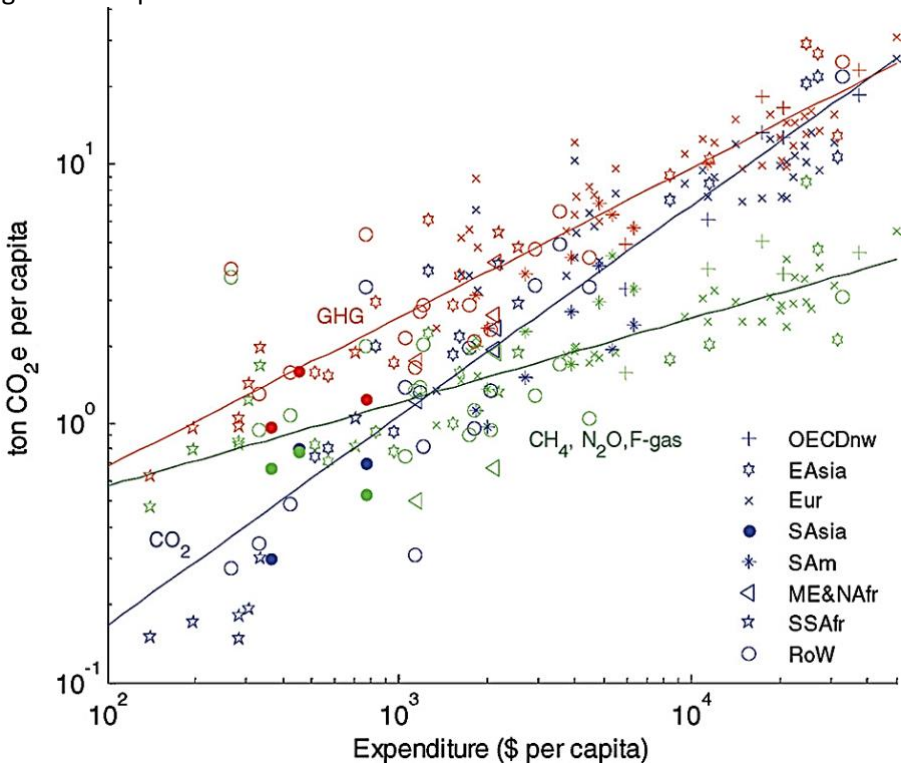
Source : *Giec, 3e groupe de travail, 2014*

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CO_2, CH_4 and N_2O and other GHG emissions- © Source: Exiobase 3.7. Traitements SDES, 2021.

Carrying out these calculations on a national scale makes it possible to determine the national carbon footprint of GHGs induced by the direct emissions of inhabitants (housing and transport), production emissions (food, consumer goods) and all emissions from external activities intended for import.
In a 2009 study of more than 70 countries, the authors draw some remarkable conclusions: Food and services are more important in developing countries, while mobility and manufactured goods are the 2 activities that have the greatest impact as income levels increase.



- Blue indicates CO_2,
- green other GHGs,
- red total GHGs measured in GWP-100.

The regions are:

- OECD new world,
- East Asia,
- Europe,
- South Asia,
- South America,
- Middle East and North Africa,
- Sub-Saharan Africa,
- Rest-of-World.

Per capital GHG emissions due to the consumption in different countries as a function of consumption volume, base year 2001.

Such work makes it possible to adjust GHG emission reduction policies according to the level of development.

Hertwich, E. G., & Peters, G. P. (2009b). Carbon footprint of nations : a global, trade-linked analysis. Environmental Science & Technology, 43(16), 6414-6420. https://doi.org/10.1021/es803496a

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