

# Greenhouse Gases, CO<sub>2</sub>, CO<sub>2</sub>e, and Carbon: What Do All These Terms Mean?

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There are lots of terms which get used, such as “greenhouse gases”, “CO<sub>2</sub>”, “CO<sub>2</sub>e”, and “carbon”, and what they all mean can get confusing. A brief explanation of these key terms is given below.

## **Greenhouse gases**

A greenhouse gas (or GHG for short) is any gas in the atmosphere which absorbs and re-emits heat, and thereby keeps the planet’s atmosphere warmer than it otherwise would be. The main GHGs in the Earth’s atmosphere are water vapour, carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and ozone.

GHGs occur naturally in the Earth’s atmosphere, but human activities, such as the burning of fossil fuels, are increasing the levels of GHG’s in the atmosphere, causing global warming and climate change. The Kyoto Protocol is an international treaty for controlling the release of GHGs from human activities, and the GHGs controlled under the treaty are shown in Table 1 below. Often these GHGs are referred to as the “Kyoto gases”.

Kyoto Gases (IPCC 2021 – 6th Assessment Report Values<sup>2</sup>).

	Greenhouse Gas	Global Warming Potential (GWP)
1.	Carbon dioxide (CO <sub>2</sub> )	1
2.	Methane (CH <sub>4</sub> )	29.8
3.	Nitrous oxide(N <sub>2</sub> O)	273
4.	Hydrofluorocarbons (HFCs)	5 – 14,600
5.	Perfluorocarbons (PFCs)	78 – 12,400
6.	Sulfur hexafluoride (SF <sub>6</sub> )	25,200
7.	Nitrogen trifluoride (NF <sub>3</sub> ) <sup>3</sup>	17,400

It's worth noting that different greenhouse gases last in the atmosphere for different lengths of time, and they also absorb different amounts of heat. The “global warming potential” (or “GWP”) of a GHG indicates the amount of warming a gas causes over a given period of time (normally 100 years). GWP is an index, with CO<sub>2</sub> having the index value of 1, and the GWP for all other GHGs is the number of times more warming they cause compared to CO<sub>2</sub>. E.g. 1kg of methane causes 29.8 times more warming over a 100 year period compared to 1kg of CO<sub>2</sub>, and so methane has a GWP of 29.8

### Carbon dioxide

Carbon dioxide CO<sub>2</sub> is the most common GHG emitted by human activities, in terms of the quantity released and the total impact on global warming. As a result the term "CO<sub>2</sub>" is sometimes used as a shorthand expression for all greenhouse gases, however, this can cause confusion, and a more accurate way of referring to a number of GHGs collectively is to use the term “carbon dioxide equivalent” or "CO<sub>2</sub>e" (explained below).

Because CO<sub>2</sub> is considered the most important greenhouse gas some GHG assessments or reports only include CO<sub>2</sub>, and don't consider the other greenhouse gases, and this can lead to an understatement of total global warming impact. Greenhouse gas inventories are more complete if they include all GHGs and not just CO<sub>2</sub>.

### Carbon dioxide equivalent (CO<sub>2</sub>e)

“Carbon dioxide equivalent” or “CO<sub>2</sub>e” is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO<sub>2</sub>e signifies the amount of CO<sub>2</sub> which would have the equivalent global warming impact.

A quantity of GHG can be expressed as CO<sub>2</sub>e by multiplying the amount of the GHG by its GWP. E.g. if 1kg of methane is emitted, this can be expressed as 29.8kg of CO<sub>2</sub>e (1kg CH<sub>4</sub> \* 29.8 = 29.8kg CO<sub>2</sub>e).

“CO<sub>2</sub>e” is a very useful term for a number of reasons: it allows “bundles” of greenhouse gases to be expressed as a single number; and it allows different bundles of GHGs to be easily compared (in

<sup>2</sup> IPCC (2021). IPCC Sixth Assessment Report: Climate Change 2021. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

<sup>3</sup> Nitrogen trifluoride will be included in the second Kyoto Protocol commitment period (from 2013 to either 2017 or 2020). For the first commitment period (2008 to 2012) only the first six gases were included.

terms of their total global warming impact). However, one word of caution when comparing CO<sub>2</sub>e totals is that it is important to know that the same GHGs are included in the totals being compared, in order to be sure that like-for-like comparisons can be made.

It is also worth noting that “CO<sub>2</sub>e” is also sometimes written as “CO<sub>2</sub>eq”, “CO<sub>2</sub>equivalent”, or even “CDE”, and these terms can be used interchangeably<sup>4</sup>.

## Carbon

Carbon is a chemical element which is present in many gases and compounds. For example, carbon combines with oxygen to make carbon dioxide (CO<sub>2</sub>), and combines with hydrogen to make methane (CH<sub>4</sub>). The term “carbon” is used in a variety of ways when talking about greenhouse gas emissions, and therefore tends to be ambiguous and potentially confusing. “Carbon” is sometimes used as a shorthand for referring to CO<sub>2</sub>, or greenhouse gases in general, and it can also be used to express CO<sub>2</sub> emissions in terms of the amount of carbon in the CO<sub>2</sub>.

The atomic weight of a carbon atom is 12 and the atomic weight of oxygen is 16, so the total atomic weight of CO<sub>2</sub> is 44 (12 + (16 \* 2) = 44). This means that a quantity of CO<sub>2</sub> can be expressed in terms of the amount of carbon it contains by multiplying the amount of CO<sub>2</sub> by 0.27 (12/44). E.g. 1kg of CO<sub>2</sub> can be expressed as 0.27kg of carbon, as this is the amount of carbon in the CO<sub>2</sub>.

The term “carbon” can be confusing as it is used as a shorthand expression to refer to either just CO<sub>2</sub> or to greenhouse gases in general (although not all GHGs contain carbon!). In addition, converting CO<sub>2</sub> to carbon is not particularly useful as doing so does not allow comparisons between different GHGs, in the way that converting to CO<sub>2</sub>e does. As a result it is less and less common to see CO<sub>2</sub> emissions reported in terms of “carbon”, though shorthand terms such as “carbon accounting” and “low carbon economy” are still used as popular proxies for “GHG accounting” or “low GHG economy”.

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<sup>4</sup> It’s also worth noting however that the letters “CO<sub>2</sub>e” are also occasionally used to refer to the concept of “equivalent carbon dioxide”, which is the amount of global warming caused by a quantity of GHG at a specific point in time, expressed in terms of the amount of CO<sub>2</sub> which would have the same instantaneous warming effect. This is an uncommon usage of “CO<sub>2</sub>e”, and in the majority of cases “CO<sub>2</sub>e” means “carbon dioxide equivalent”.