Greenhouse Gases, CO_2, CO_2e, and Carbon: What Do All These Terms Mean?

There are lots of terms which get used, such as "greenhouse gases", "CO_2", "CO_2e", 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_2), methane (CH_4), nitrous oxide (N_2O) 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".

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_2 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_2. E.g. 1kg of methane causes 25 times more warming over a 100 year period compared to 1kg of CO_2, and so methane as a GWP of 25.

Carbon dioxide

Carbon dioxide (CO_2) 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_2" 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_2e" (explained below).

Because CO_2 is considered the most important greenhouse gas some GHG assessments or reports only include CO_2, 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_2.

Carbon dioxide equivalent (CO_2e)

"Carbon dioxide equivalent" or "CO_2e" is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO_2e signifies the amount of CO_2 which would have the equivalent global warming impact.

A quantity of GHG can be expressed as CO_2e by multiplying the amount of the GHG by its GWP. E.g. if 1kg of methane is emitted, this can be expressed as 25kg of CO_2e (1kg CH_4 * 25 = 25kg CO_2e).

"CO_2e" 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

Greenhouse Gas		Global Warming Potential (GWP)
1.	Carbon dioxide (CO_2)	1
2.	Methane (CH_4)	25
3.	Nitrous oxide(N_2O)	298
4.	Hydrofluorocarbons (HFCs)	124 – 14,800
5.	Perfluorocarbons (PFCs)	7,390 – 12,200
6.	Sulfur hexafluoride (SF_6)	22,800
7.	Nitrogen trifluoride (NF_3)[3]	17,200

Table 1. Kyoto Gases (IPCC 2007[2]).

terms of their total global warming impact). However, one word of caution when comparing CO_2e 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_2e" is also sometimes written as "CO_2eq", "$CO_2equivalent$", or even "CDE", and these terms can be used interchangeably[4].

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_2), and combines with hydrogen to make methane (CH_4). 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_2, or greenhouse gases in general, and it can also be used to express CO_2 emissions in terms of the amount of carbon in the CO_2.

The atomic weight of a carbon atom is 12 and the atomic weight of oxygen is 16, so the total atomic weight of CO_2 is 44 (12 + (16 * 2) = 44). This means that a quantity of CO_2 can be expressed in terms of the amount of carbon it contains by multiplying the amount of CO_2 by 0.27 (12/44). E.g. 1kg of CO_2 can be expressed as 0.27kg of carbon, as this is the amount of carbon in the CO_2.

The term "carbon" can be confusing as it is used as a shorthand expression to refer to either just CO_2 or to greenhouse gases in general (although not all GHGs contain carbon!). In addition, converting CO_2 to carbon is not particularly useful as doing so does not allow comparisons between different GHGs, in the way that converting to CO_2e does. As a result it is less and less common to see CO_2 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".