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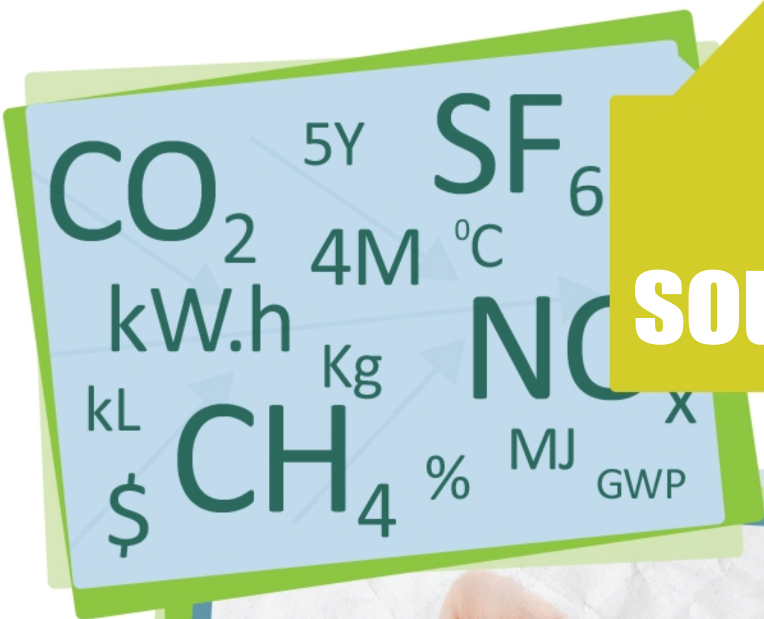


About carbon sources and sinks

This project is supported by the Australian Government through the Clean Sustainable Skills Package

About carbon sources and sinks

This guide provides general information about sources of carbon and 'sinks' that capture or reduce emissions. It explains the basic concepts and demonstrates that a range of options might be relevant, depending on the context.

The information is relevant to several units of competency in the MSS11 Sustainability Training Package, however, the guide is **not** aligned to a specific unit of competency or AQF level.

Definitions

Source: usually refers to the origin or place from which thing comes

Sink: usually means decline or come gradually to a lower level.

While 'sources' and 'sinks' have their traditional dictionary meaning, 'carbon' is used in a highly contextualised way.

In this context 'carbon' means any greenhouse gas (GHG), i.e. any material which is contributing to climate change. It is referred to as 'carbon' because all GHGs are rated by their global warming potential (GWP) equivalence to carbon dioxide (CO_2).

The unit of measurement for this comparison is called carbon dioxide equivalents (CO_2-e). It represents the amount of CO_2 that would generate the equivalent warming effect, usually rated over a 100 year span. Methane is rated with a GWP of 25; this means that 25 units of CO_2 would generate the same amount of GHG as one unit of methane.

The list of GHGs and their equivalence can be found at:
http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

Sources

Carbon sources therefore include any source of any GHG. Typically these will be from natural or commercial/industrial sources.

Natural sources

Natural sources of carbon include:

- swamps
- rotting vegetation
- animal flatulence (methane (CH_4) and hydrogen sulphide (H_2S))
- animal respiration (CO_2)
- decomposing animal manure.

Animal manure is particularly potent when it is concentrated, for example, from intensive agriculture or in a wastewater (sewage) treatment plant. Concentrating manure in the one spot reduces available oxygen. This increases the production of CH_4 which has 25 times greater GWP than CO_2. It also reduces the operation of aerobic bacteria reducing their production of CO_2.

Commercial/industrial sources – energy

The main commercial/industrial sources come from our consumption of energy, either as electricity or directly as fuel. Any electricity or fuel consuming device is a source.

Commercial/industrial sources – other

There are also direct emissions to the environment coming from:

- storage
- process vents
- leaks and spills
- fugitive emissions
- other materials used.

Paints have largely been converted to water based to reduce emissions. Solvent based paints, sealers, and so on, are still a source.

Process vents include those situations where a GHG is released from a process.

Calculating the carbon

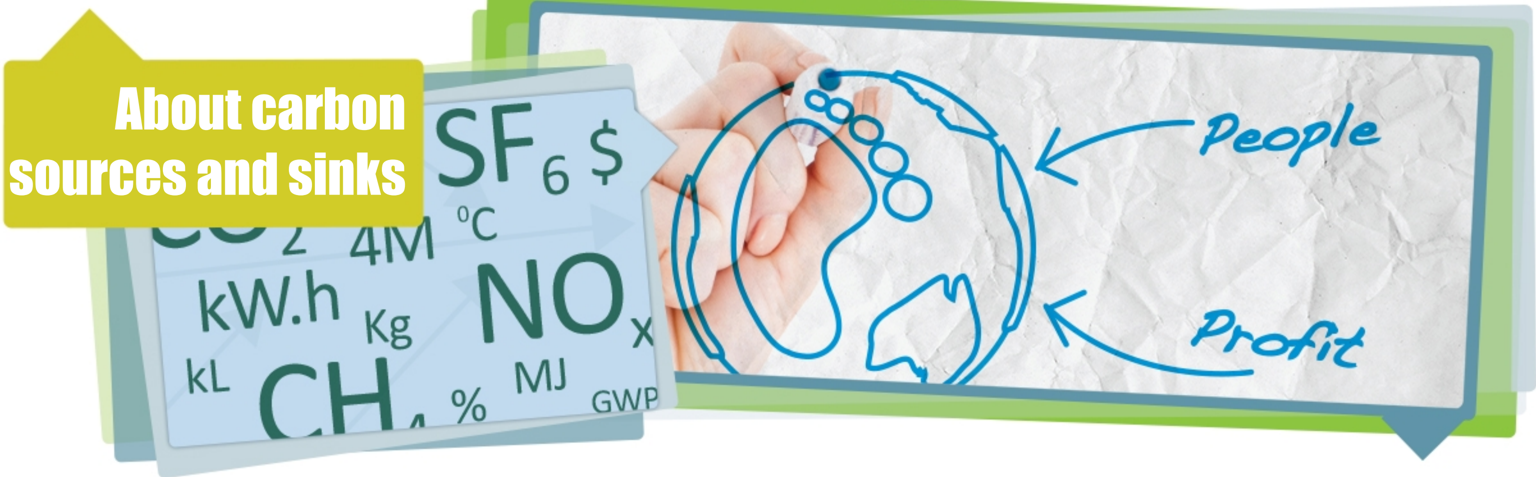
Natural sources

Because of the disperse nature of natural emissions it is difficult to measure them – small amounts emitted over a large area. They can be estimated however based on small studies, for example:

- Intensive metering of a small number of cows indicates that one cow emits between 80–110 kg CH_4 per year – multiply this by the number of cows and it becomes a big number, particularly when multiplied by 25 to get equivalent tonnes of CO_2.
- Studies show rice paddies emit 10–100 g/m^2 of CH_4per year – given the total area subject to rice this is estimated to contribute around 10% of global methane.

These two examples show that you need to find a study which has measured the production rate so allowing you to determine the total emitted by the process in question.

The rates of emission are also the subject of study and by changing agricultural practices the rate of emissions can be lowered significantly, and in the case of cattle this leads to faster growth (less food wasted as CH_4).



Electricity

Calculating the carbon emissions from electricity consumed can be complex. There are many variables to take into account. These include:

- the source of the electricity (black coal, brown coal, gas and hydro)
- the efficiency of generation and transmission
- the distance over which it is transmitted
- the efficiency of the equipment being powered.

Data needs to be researched before making the calculations. So, if consuming electricity from the grid, data suggests[1]:

- 1 kW.h[2] generated requires 0.327 kg of black coal[3]
- transmission efficiency ~97% (this will vary with conditions and distance)
- electric motor efficiency (this is highly variable, but for this example lets pick 85%)
- electric light efficiency (again variable) – incandescent say 15%, fluorescent say 70%.

So, 1 kW.h used by an electric motor requires 1/0.97/0.85 = 1.21 kW.h to be generated so requiring 1.21 x 0.327 = 0.4 kg of black coal to be burned.

Chemical stoichiometry (and the atomic weight of the atoms) tells us:

$$C + O_2 \longrightarrow CO_2$$

$$12 + 32 \longrightarrow 44$$

So, 0.4 kg of coal when burned will produce (44/12) x 0.4 = 1.5 kg of CO_2.

This number will obviously vary depending on the primary source of fuel for the power stations generating your supply.

1 These numbers are for illustration purposes only and should be checked before being used elsewhere.
2 This is the shorthand symbol for kilowatt *times* hours. It is also commonly shown as kWh.
3 This is an average for black coal. Brown coal would require more coal per kW.h.

Fuels

If fuel is burned directly (rather than using electricity generated from fuel) then a similar approach is used. With coal it is a valid assumption that it is almost all straight carbon.

With other fuels this is no longer the case. The calculation involves using the atomic weight of the atoms combined into the chemical formula for the fuel (or a proxy for the formula when the fuel is a mixture) and calculating the mass percentage of carbon in the formula.

For example:

- natural gas is mainly methane (CH_4 – 12/16 = 75% C)
- LPG may be propane (C_3H_8 – 36/44 = 82% C) or butane (C_4H_{10} – 48/58 = 83% C) – either read the label on the gas cylinder or contact the supplier to find out which
- petrol is a mixture of a wide variety of hydrocarbons, but may roughly be assumed to be octane (C_8H_{18} – 96/114 = 84% C) – different petrol grades do have a different composition and different heating value per litre
- diesel also is a mixture, but roughly may be assumed to be dodecane ($C_{12}H_{26}$ –144/170 = 85% C).

Sinks

A sink is any method which captures or reduces the GHGs being emitted.

Natural sinks

These typically include any living plant, land or water based as they use CO_2 to grow and produce carbohydrate (cellulose, plant fibre). Fast growing plants sequester CO_2 more rapidly than slow growing plants. Plantation forests may therefore be better than old growth forests.

There is a problem with short-lived plants which then die and rot so releasing the carbon back into the environment, and perhaps releasing it as CH_4 rather than the CO_2 which it absorbed.

Natural sinks typically only absorb CO_2 whereas there are many GHGs.

Commercial/industrial sinks

Any process which removes GHG from the environment, prevents it from being released, or changes the emission from large/high GWP emissions to smaller/low GWP emissions may be regarded as a sink.

CO_2 sequestering is often mentioned. This is a process for keeping the CO_2 from entering the environment and includes:

- use of plants (biosequestration)
- injecting it underground (geosequestration)
- chemically combining it into some non-volatile compound (chemical sequestration).

Similar processes may be used for other GHGs.

Sulphur dioxide (SO_2) is a by-product of some (mineral processing) processes and is a GHG of high GWP. However, it can be converted into sulphuric acid (H_2SO_4) and so the H_2SO_4 plant is acting as a sink.

High temperature combustion of fuel can produce a range of oxides from nitrogen which are high GWP GHGs (generically referred to as NO_x). This typically occurs in a car engine, gas turbine or furnace/power station. Injecting a spray of water into the engine intake reduces the formation of NO_x and so the water injection is acting as a sink.

Sinks may be highly specialised to the process being studied.

Case studies

Piggeries

Piggeries produce a lot of pig manure, which when left in a pile produces a lot of CH_4. Collecting the pig manure and feeding a CH_4 generator with it allows for the CH_4 to be used in a co-generation system providing both heat and electricity and so this is a sink.

True, the carbon is not removed from the environment, but the emission of CH_4 is replaced by the emission of CO_2. This is a benefit because CH_4 has a GWP of 25, or 25 times that of CO_2. So for every tonne of CH_4 processed the equivalent of 24 tonnes of CO_2 emissions have been avoided.

Wastewater treatment plants

Wastewater treatment (sewage) plants need to process large volumes of water containing very dilute human (and trade) effluent. They can do this in aerobic plants where the aerobic bacteria convert the domestic waste into CO_2 and some nitrogen based products, or they can do it in anaerobic plants where the anaerobic bacteria produce CH_4. The CH_4 can then be used as a plant fuel to drive diesel motors, and so on. In this case CO_2 will still eventually be emitted, but this process has saved on drawing power from the grid, and so it is a sink, not of the GHG which would have been generated by the process itself, but is acting as a sink for the power from the grid which is not used and does not need to be generated.

Hydrocarbon production

Traditional hydrocarbons extract the hydrocarbons (gas and oil) from natural underground storage. Where CO_2 is produced on site, or can be economically transported there, this CO_2 can be injected back into these natural storages. This injection acts as a sink (geosequestration).