Emissions Guidebook

Part 1: GHG emissions 101

Version 2.0

Center of Emissions Excellence

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About the Emissions Guidebook

Purpose

Greenhouse gas (GHG) emissions have emerged as a critical metric for governments and investors given an ever-growing focus on establishing transparent frameworks for measuring, reporting, quantifying and ultimately reducing GHG emissions globally. It is of utmost importance that methodologies used by different entities are transparent and clear so different studies and emission estimates can be compared on a like-for-like basis. Without this transparency, emissions estimates have limited utility in the marketplace. The Emissions Guidebook is an evergreen document that provides the market with unparalleled transparency into S&P Global Energys' approach, methodology and key assumptions behind our emissions work. We hope this document can contribute to advancing consistency in GHG emissions accounting.

Context

The Emissions Guidebook is a product of the S&P Global Energy Center of Emissions Excellence. The "Center" is a dedicated team of carbon accounting specialists focused on ensuring consistency, transparency and credibility of emissions data across any emissions offerings.

About S&P Global Energy

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GHG emissions 101

Greenhouse gases

Greenhouse gases, if released into the atmosphere, can trap heat by allowing infrared radiation to enter but not exit the atmosphere at the same rate, resulting in an increase in the earth's temperature. Air pollutant emissions, on the other hand, are those that contribute to health-related risks and include fine particulate matter, nitrogen oxides, sulphur dioxide and volatile organic compounds.

Numerous gases can contribute to global warming. The seven most referenced gases or groups of gases, and the ones subject to United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Some emissions are not equally relevant to every sector. For example, the F-gases — HFCs, PFCs and SF_6 — are typically part of closed systems, acting as refrigerants or electrical insulators, and are therefore generally released unintentionally and sporadically in small quantities. Unless otherwise noted, S&P Global Energys' GHG estimates include CO_2, CH_4 and N_2O, which account for over 98% of global GHG emissions emitted annually by mass.

Global warming potential

GHGs emitted into the atmosphere trap heat from the sun and contribute to a rise in global temperatures. Once in the atmosphere, various GHGs interact with the environment differently and contribute to varying degrees of global warming. This concept is known as global warming potential (GWP). GHG emissions are often expressed in units of mass of CO_2 equivalent (CO_2e), with GWPs being used to convert different gases into this comparative basis.

Different gases have the ability to live in the atmosphere for different periods of time. The length of time a gas can live in the atmosphere is dependent upon its dispersion within the troposphere and reactions with other gases. Some gases do not easily react with other gases and therefore have the ability to live for longer durations than those that react more readily with surrounding gases.

Table 1

Global warming potential of CH_4 and N_2O over different time horizons

	AR4 100-year	AR5 100-year	AR6 100-year*
CO_2	1	1	1
CH_4	25	28	29.8
N_2O	298	265	273

	AR4 20-year	AR5 20-year	AR6 20-year*
CO_2	1	1	1
CH_4	72	84	82.5
N_2O	289	264	273

CH_4 = methane; N_2O = nitrous oxide.
* With climate-carbon feedbacks and methane oxidation.
Sources: IPCC Fourth Assessment Report (AR4), Fifth Assessment Report (AR5) and Sixth Assessment Report (AR6).

The UNFCCC Intergovernmental Panel on Climate Change (IPCC) publishes Assessment Reports (ARs), which are comprehensive reports detailing the state of climate change, causes and impacts on a very broad scale. These are typically referenced as AR4, AR5 or AR6. Within these detailed reports, GWPs are published for all greenhouse gases according the the latest climate science research. For each GHG, the warming potential of each gas differs depending on the time horizon because each gas has a different lifespan in the atmosphere and a different ability to absorb energy. The UNFCCC publishes two different time horizons to show short- and long-term effects of GHGs on global warming: 20 year and 100 year. Table 1 summarizes the GWPs for different time horizons as per IPCC AR4, AR5 and AR6.

Most regulatory reporting of GHG emissions to local or country-level inventories have historically used the AR4 100-year GWPs. Reporting is changing in some jurisdictions to AR5 (British Columbia in 2022, the US per the Environmental Protection Agency in 2023). Unless otherwise stated S&P Global Energys' emissions estimates use AR4 100-year GWPs to be comparable with regulatory reporting. However, when possible, S&P Global Energy will provide optionality for selection of which GWPs the client prefers to use as a reference. Regardless of which GWPs are used, it is crucial for the emissions estimator to specify this clearly.

Impact of methane in the short term: Methane is a gas that lives for a shorter time in the earth's atmosphere than CO_2 (approximately 12 years). Compared to CO_2, however, it is a more potent GHG and it really packs a punch in that shorter timeframe in its ability to absorb energy and contribute to global warming. Different GWP values apply to methane depending on the time period considered (e.g., a 20-year time horizon versus a 100-year time horizon). According to the most recent assessment report, over a 20-year time horizon (which is close to 2050 — the year that many countries have pledged to be "net-zero"), methane is about 82.5 times more potent as a GHG than CO_2. This fact underscores the importance and interest of reducing methane emissions in the near term to slow the rate of global warming.

Emission sources

Globally, the top 3 GHGs (by mass) are CO_2, CH_4 and N_2O, and they are the primary gases of concern in the energy industry. As previously stated, these are the principal gases of interest in S&P Global Energys' emissions estimates. The origins of these different GHGs can vary from combustion of fuels to land-use change impacts releasing stored CO_2 into the atmosphere. Table 2 summarizes the most common sources of the top 3 GHGs.

Table 2

Common sources of top 3 GHGs

GHG	Common sources
CO_2	Fossil fuel combustion, land-use change and forestry, industrial processes (such as CO_2 emitted from steam-methane reformers when producing hydrogen), formation CO_2 (CO_2 recovered with oil and gas directly entrained within the reservoir)
CH_4	Venting and fugitive emissions from the oil and gas and mining sectors, agricultural sector, landfill emissions
N_2O	Product of incomplete combustion, agricultural sector

Source: S&P Global Energy.

Combustion

CO_2 emissions result from fossil fuel combustion and make up the majority of GHG emissions globally. Combustion emission sources can be stationary fuel combustion, such as in reciprocating engines, turbine engines, heaters, boilers or incinerators. Combustion also occurs from nonstationary sources, such as transportation. Combustion is also attributed to flaring of natural gas and other gaseous fossil fuels or gases. In combustion processes, there will always be some unburned fuel that is emitted into the atmosphere. If the primary fuel is natural gas, methane emissions will also occur.

Venting

Vented emissions are generally emission sources that are intentional or well known, such as venting from pneumatic devices, compressor seals, atmospheric tanks or through planned maintenance events. These sources have potential for control and reduction as they are known and quantifiable. Vented emissions can be controlled by replacing emitting sources with nonemitting alternatives, capturing vapors from tanks and seals, and good maintenance practices, such as drawing down pressures before venting or combusting the gases that would have been vented otherwise. Carbon dioxide is also vented to the atmosphere commonly from oil and gas operations through acid gas removal of entrained CO_2 in the formation of which the oil and gas is extracted.

Fugitives

Methane emissions that are unintentional are referred to as fugitive emissions. Releases can occur intermittently, at low rates, and across dispersed point sources (e.g., small leaks). These factors complicate assessing fugitive methane emissions. There is increasing pressure and effort from governments, regulators, industry and public stakeholders to find and measure methane emissions via remote sensing, such as mobile cameras, satellites and other airborne technologies (e.g., planes, drones, balloons). Companies are in turn beginning to change how they approach the detection and mitigation of unintended methane releases from their assets, shifting from periodic, inspections to greater monitoring. Combined efforts have the ultimate goal of reducing fugitive emissions expeditiously by detecting and resolving leaks found. It is also possible to have fugitive CO_2 emissions. These would be less likely but could be possible in operations that include carbon capture projects.

Emission scope

When looking at a full footprint of operations, it is common to refer to emissions as Scope 1, Scope 2 and Scope 3.

- **Scope 1.** Direct onsite emissions: fuel combustion, flaring, venting and fugitives.
- **Scope 2.** Indirect emissions from energy imported and consumed: imported or exported energy (e.g. electricity, heat/steam, cooling).
- **Scope 3.** All other indirect emissions occurring because of facility, asset or company. Sometimes Scope 3 may be further broken down into Scope 3 upstream and Scope 3 downstream.
  - Scope 3 upstream are all emissions associated upstream of the operations being evaluated: These could include feedstock production (such as natural gas for hydrogen, or ammonia for fertilizers), fuel production of fuels consumed onsite (natural gas, diesel, fuel oil and gasoline), etc.

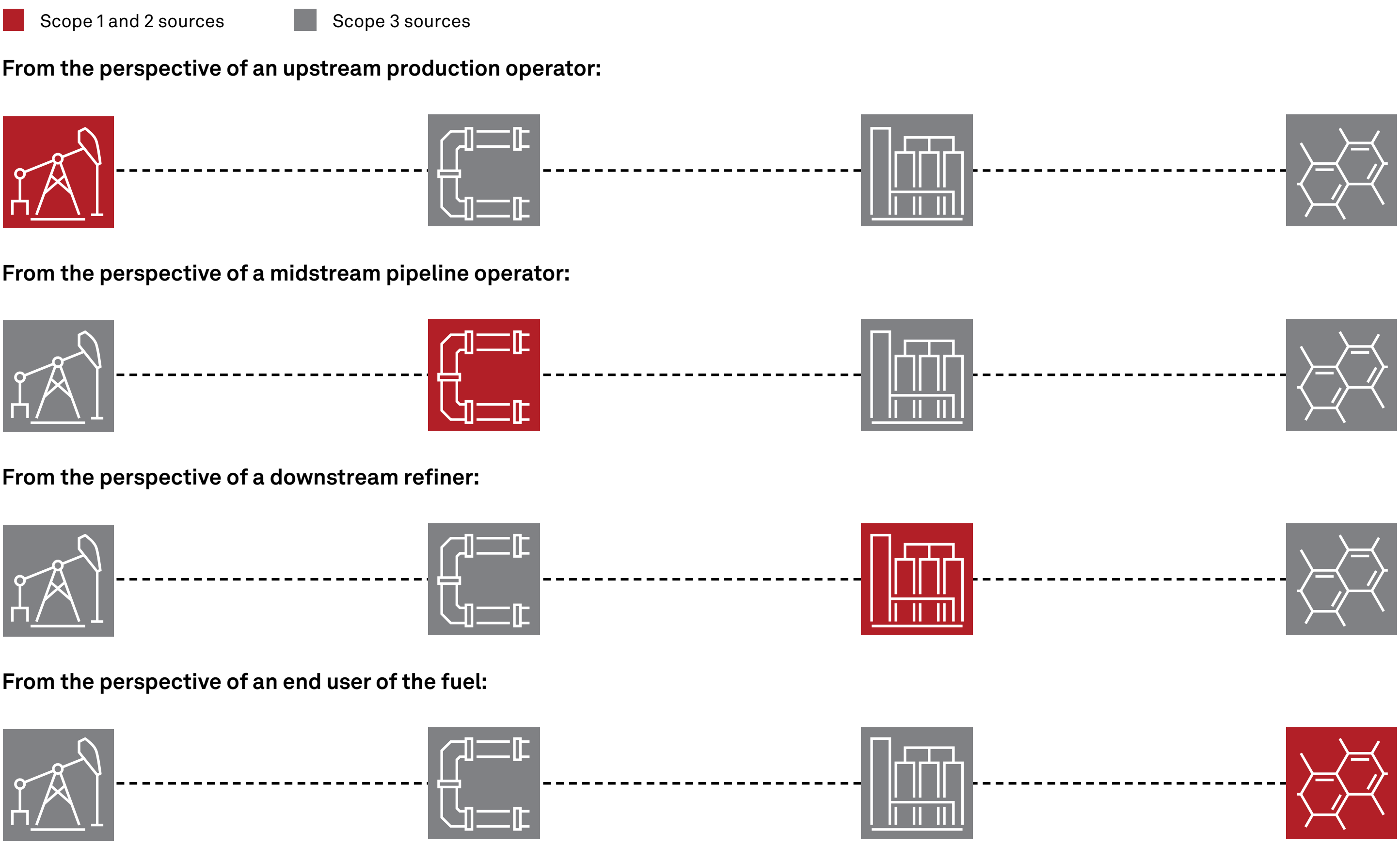
- Scope 3 downstream are all emissions associated with where products or commodities go after leaving the owned or controlled operations. These include end-use combustion of fuels, end-use consumer products, such as petrochemical products, additional processing, transmission of products to market, etc.

Scope 1, 2 and 3 emissions change based on the perspective and placement within a value chain. The position in the value chain impacts which emission sources would be classified as Scope 1, 2 or 3. As an example, the figure below shows various companies operating in a crude oil value chain. For a refiner, Scope 3 upstream emissions would be all emissions associated with getting the oil to the refinery (well production and transport to the refinery gate) and Scope 3 downstream emissions would include end-use combustion of fuels produced at the refinery as well as any emissions associated with further transportation and processing to end-use consumer products such as petrochemical products. For an upstream oil production company, Scope 3 upstream would include emissions associated with fuels and lubricants consumed on site and Scope 3 downstream would include emissions associated with transport of crude oil to the refinery, the refining process, transport of the product to the end-use marketplace (such as a gas station) and finally, the end-use combustion of the fuels.

In the case of fossil-based fuels, Scope 3 downstream emissions can account for over 70% of the emissions associated with a value chain and therefore are very important to quantify when evaluating the full impact of a product's GHG emissions.

Figure 1

Description of emission scopes



Source: S&P Global Energy, based on various market sources including GHG Protocol.

Table 3

Scope definitions

Scope	Type	Definition	Example
Scope 1	Direct	GHG emissions from owned or controlled sources.	Fuel combustion, flaring, venting, and release or leaks of refrigerants.
Scope 2	Indirect	GHG emissions associated with the trade of energy used in owned or controlled sources.	Imported or exported energy such as that from electricity, heat/steam, cooling etc.
Scope 3		All other indirect GHG emissions (not included in Scope 2) that occur through the value chain (including upstream and downstream emissions.	Any upstream GHG emissions the result of delivery of input materials and/or use of outputs in additional processes or end-use.

Source: S&P Global Energy, based on various market sources including GHG Protocol.

Product life-cycle emissions

A product life cycle analysis is a method of accounting for all the emissions over the life of product — from land disruption prior to production of initial feedstock to end use. These analyses are often referred to as life-cycle assessments (LCAs). Typical full LCAs reference the terminology cradle-to-grave or well-to-wheels for transportation fuels. Partial LCAs are not uncommon, particularly for fossil fuels, where the majority of emissions occur when the fuel is ultimately combusted, and end-use combustion emissions are relatively homogenous between pathways. Often these partial LCAs are referenced using the terminology well-to-tank or well-to-city gate.

In life-cycle analyses, the definitions of Scope 1, Scope 2 and Scope 3 are not relevant, as they represent a perspective of one of the segments in the supply chain. An LCA considers the perspective of the product over its life or through each segment of its supply chain. Of critical importance in an LCA is that boundaries or segments of the supply chain are clearly defined.

Carbon intensity or GHG intensity

Emissions intensity is calculated as total emissions divided by output (production, throughput, etc.). The emissions intensities per segment of a supply chain may be added in consistent units to present an overall life-cycle emissions intensity. However, this is a complex evaluation and considerable attention needs to be taken to allocate emissions to the correct product throughout the supply chain.

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