2.2 INTRODUCTION TO CLIMATE CHANGE

Greenhouse gases, sinks and sources

Important notice
This unit is part of a package of learning materials designed to support understanding of foundational concepts relating to climate-related financial disclosures. These learning materials do not constitute application or regulatory guidance for the preparation of climate-related financial disclosures and are not intended to represent legal or professional advice. We encourage you to seek your own professional advice to find out how the Corporations Act 2001 (Corporations Act) and other relevant laws may apply to you and your circumstances, as it is your responsibility to determine your obligations and comply with them.

Key topics

- Greenhouse gas types
- Greenhouse gas sources
- Greenhouse gas sinks

Relevance for climate-related disclosures

In this unit, you will learn about greenhouse gas sources and sinks, to support understanding and identification of climate-related risks and opportunities for your entity.

Overview

There are seven key greenhouse gases (or GHGs)**:** carbon dioxide, methane, nitrous oxide, and fluorinated gases including hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride.

Greenhouse gases are released through both human activities and natural processes. Human activities include energy (power, transport, buildings, industry, fuel production), agriculture and land use, industrial processes and waste. These activities have substantially increased the concentration of greenhouse gases in the atmosphere.

Greenhouse gases are also absorbed by natural carbon sinks on land (including forests, wetlands and soil) and in the ocean (including coastal ecosystems and the deep ocean). Technology for greenhouse gas removal and storage exists, but it is yet to be proven at scale.

What are greenhouse gases?

Greenhouse gases (or GHGs) are gases that trap heat in the atmosphere. Outlined below are the seven key greenhouse gases and their main sources from human activity:[1,2]

1. Carbon dioxide (CO_2) released from the burning of fossil fuels, waste, decaying organic matter and some chemical processes
2. Methane (CH_4) released during the extraction and production of fossil fuels, agriculture, and decay of organic waste in landfill
3. Nitrous oxide (N_2O) emitted through agricultural and industrial activities, burning of fossil fuels and solid waste and treatment of wastewater

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Fluorinated gases are emitted from a range of household, commercial and industrial processes. They include:

1. Hydrofluorocarbons (HFCs)
2. Perfluorocarbons (PFCs)
3. Sulphur hexafluoride (SF_6)
4. Nitrogen trifluoride (NF_3)

Water vapour is also a greenhouse gas. While it is the most abundant greenhouse gas, its presence in the atmosphere is largely influenced by temperature and, it is not a primary driver of global warming.

What do carbon dioxide equivalent and global warming potential mean?

Carbon dioxide equivalent

Greenhouse gas emissions are commonly reported in carbon dioxide equivalent units (CO_2 equivalent, CO_2e or CO_2-e). This reflects the global warming potential (GWP) of each greenhouse gas expressed in terms of the global warming potential of one unit of carbon dioxide. This unit is used to evaluate releasing (or avoiding releasing) different greenhouse gases against a common basis.

Carbon dioxide equivalents are often expressed as metric tonnes of carbon dioxide equivalent (tCO_2-e), such as million tonnes of carbon dioxide equivalent ($MtCO_2$-e) or gigatonnes of carbon dioxide equivalent ($GtCO_2$-e). For example, greenhouse gas emissions of 1Mt CO_2-e reflects the equivalent of 1 million tonnes of carbon dioxide being emitted into the atmosphere. For further information about emissions accounting, see Module 6.

Global warming potential (GWP)

Greenhouse gases differ in their contribution to global warming. GWP is a factor describing the radiative forcing impact (degree of harm to the atmosphere) of one unit of a given greenhouse gas relative to one unit of carbon dioxide. GWP is typically measured over 100 years. The greater the GWP, the more the greenhouse gas warms Earth compared to carbon dioxide over that period. GWP values change over time as climate science evolves. The GWP values quoted in Table 1 are from the Intergovernmental Panel on Climate Change (IPCC)'s most recent assessment report (the Sixth Assessment report [AR6])

Table 1: Greenhouse gases in ascending order of GWP over 100 years from IPCC AR6 [3]

Greenhouse gas	GWP
Carbon dioxide (CO2)	1
Methane (non-fossil) (CH4)	27
Methane (fossil) (CH4)	29.8
Nitrous oxide (N2O)	273
Nitrogen trifluoride (NF3)	17,400
Sulphur hexafluoride (SF6)	24,300
Hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs)	dependent on type

While GWP is typically measured over 100 years, some greenhouse gases remain in the atmosphere for a relatively short period of time but have a very high GWP over that shorter period. For example, methane has a GWP of 81 compared to carbon dioxide when measured over 20 years.[4]

What are the key sources of greenhouse gas emissions?

Greenhouse gases are emitted from both human activities and natural sources. However, human activities, mainly burning of fossil fuels (coal, oil and gas), are by far the biggest contributor to the increase in greenhouse gas concentrations in the atmosphere.

Burning of fossil fuels accounts for 75% of global greenhouse gas emissions and nearly 90% of all carbon dioxide emissions.[5] In 2022, emissions from fuel combustion were primarily from coal (45%), followed by oil (33%) and natural gas (22%).[6] Table 2 shows human sources of greenhouse gases by sector in 2023.

Table 2: Human sources of greenhouse gas emissions[7]

Human source of GHG emissions	Sector	% of total GHG emissions in 2023	Description
Energy	**Power**	26	From burning coal, oil and gas at power stations for heat and electricity
	Industry	11	From fossil fuels used in manufacturing, mining and construction
	Transport	15	From petrol, diesel, heavy oil shipping fuels and aviation fuels for land, maritime and aviation vehicles
	Buildings	6	From burning fossil fuels within buildings for heating and cooling
	Fuel production	10	From the extraction, processing, refining, and transport and distribution of fossil fuels
Process	**Industrial process**	9	From the manufacture of cement, chemicals, metals and other materials
Agriculture, forestry and other land-use change	**Agriculture**	11	From livestock, and fertiliser use
	Land use, land-use change, and forestry	7	From deforestation and damage of other ecosystems including peatlands, grasslands and wetlands
Waste and other	**Waste and other**	4	From landfill as organic waste decomposes, and from wastewater treatment

Table 3 shows net natural sources—natural processes that emit more greenhouse gases to the atmosphere than they remove.

Table 3: Net natural sources of greenhouse gas emissions[8]

Natural source of GHG emissions	Description
Bushfires	Release carbon dioxide previously absorbed by plants.
Volcanic eruptions	Release volcanic gases into the atmosphere, including carbon dioxide and methane
Earthquakes	Directly release carbon dioxide from the Earth.
Permafrost	Frozen ground, typically found in Siberia, Canada and Alaska, releases carbon dioxide, methane and nitrous oxide from organic matter when it melts

Wetlands	Both a source and a sink of greenhouse gas emissions. Wetlands including marshes, peatlands and lakes are a natural source of methane emissions
Oceans	Both a source and a sink of greenhouse gas emissions, oceans can release greenhouse gases under certain conditions

What are key greenhouse gas sinks?

Greenhouse gas or carbon sinks are natural or human processes, activities or mechanisms that remove a greenhouse gas from the atmosphere.[9] Efforts to enhance or restore natural carbon sinks are known as a nature-based solution.

Conserving and restoring nature could deliver one-third of the emission reductions needed in the next decade to limit global temperature increases.[10]

Technologies known as carbon capture and storage (CCS) are intended to capture and store carbon dioxide underground. Some also aim to reuse this captured carbon in new products such as building materials. (This is known as carbon capture *utilisation* and storage, CCUS). Despite CCS existing for over two decades, it has not been widely adopted to date.

Natural greenhouse gas emissions sinks are found on land and in the water**.** Table 4 shows the main natural carbon sinks.

Table 4: Summary of natural carbon sinks[11,12]

Natural carbon sink	Description
Wetlands	Wetlands are land areas saturated or flooded with water permanently or seasonally, including marshes, ponds, lakes, swamps and peatlands. Peatlands only cover 3% of the world's land but store twice as much carbon as all the forests.
Forests	Despite deforestation, forests still cover more than 30% of land on Earth and offer two-thirds of the total mitigation potential of all nature-based solutions on land.
Soil	When plants absorb carbon dioxide for photosynthesis, a portion is captured and stored in the soil. Careful land management, particularly in the agriculture sector, can increase the amount of carbon stored in soil.
Ocean	The ocean absorbs 30% of all carbon dioxide emissions and has absorbed more than 90% of the extra heat trapped in the earth system by the increased concentration of greenhouse gases. (Since 1993 the rate of ocean warming has more than doubled, increasing the frequency and intensity of marine heatwaves.) By absorbing carbon dioxide, the ocean helps to slow down warming. However, this also makes the ocean more acidic, harming marine species and ecosystems.
Coastal wetlands	Mangroves, salt marshes and seagrass beds can absorb and store carbon from the atmosphere at an annual rate 10 times greater than mature tropical forests. They store three to five times more carbon per equivalent area than tropical forests.[13]

Natural carbon sinks play a role in mitigating climate change by absorbing greenhouse gases. However, their capacity to do so is being affected by changing climate conditions. These ecosystems also contribute to biodiversity and provide other ecological benefits. [14]

Key takeaways

- Carbon dioxide, methane, nitrous oxide and fluorinated gases are the key greenhouse gases, with differing contributions to global warming.
- Burning of fossil fuels for energy (power, transport, buildings, industry and fuel production) by humans is the largest source of greenhouse gas emissions.
- Natural carbon sinks on land and water provide significant emissions reduction potential, although this is also being undermined by global warming.

Sources and explanatory notes

[1] Greenhouse Gas Protocol (2013) *Required Greenhouse Gases in Inventories*
[2] United States Environmental Protection Agency (2025) *Overview of Greenhouse Gases*
[3] Greenhouse Gas Protocol (2024) *IPCC Global Warming Potential Values*
[4] Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang (2021) *The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*
[5] United Nations *Causes and Effects of Climate Change*
[6] International Energy Agency (2024) *Greenhouse Gas Emissions from Energy Data Explorer*
[7] United Nations Environment Programme (2024) *Emissions Gap Report 2024*
[8] Xi-Liu, Y. U. E., & Qing-Xian, G. A. O. (2018) Contributions of natural systems and human activity to greenhouse gas emissions. *Advances in Climate Change Research*, *9*(4), 243-252
[9] United Nations Framework Convention on Climate Change, Article 1.8 refers to a sink as any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere
[10] United Nations Environment Programme (2021) *Nature for Climate Action*
[11] United Nations Environment Programme (2019) *Peatlands store twice as much carbon as all the world's forests*
[12] Intergovernmental Panel on Climate Change (2019) *Special Report on the Ocean and Cryosphere in a Changing Climate*
[13] National Oceanic and Atmospheric Administration *Coastal blue carbon*
[14] United Nations *Biodiversity – our strongest natural defense against climate change*