Te ine tukunga:
He tohutohu pakihi

Measuring emissions:
A guide for organisations

2023 detailed guide

Ministry for the
Environment
Manatū Mō Te Taiao

Te Kāwanatanga o Aotearoa
New Zealand Government

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Overview of changes since the previous update

This is the 13th version of the publication originally titled *Guidance for Voluntary Greenhouse Gas Reporting*.

For previous versions, see the Ministry's website.

Updates since the 2022 edition

During each successive assessment cycle, the Intergovernmental Panel on Climate Change (IPCC) re-evaluates the science underpinning the Global Warming Potential (GWP) values used for national greenhouse gas (GHG) inventory reports. This edition updates the GWP values to align with the requirements for GHG inventory reporting under the Paris Agreement. As agreed in decisions 18/CMA.1 and 5/CMA.3, Parties to the Paris Agreement are required to use the 100-year time-horizon GWP (GWP100) values, as listed in table 8.A.1 of the Fifth Assessment Report (AR5) of the IPCC, excluding the value for fossil methane.

Other government published emissions factor sets are also moving to the AR5 GWP100 this year. The UK Greenhouse gas reporting: conversion factors 2022, published by the UK Department of Business, Energy & Industrial Strategy, will be provided in AR5 from this year. Likewise, the US GHG Emission Factors Hub, published by the US Environmental Protection Agency will be provided in AR5 from 2024.

A brief outline of the impact of switching to AR5 GWP100 on the emission factor values will be provided in the following sections, under Overview of changes since previous update.

Other updates

Section 3 (Fuel): The emission factors now align with activity data from *New Zealand's Greenhouse Gas Inventory 1990–2021.*

For clarity, biogenic CO_2 emissions for biofuels and biomass are now reported under the new column heading Biogenic CO_2. Previously these were reported under CO_2.

Section 5 (Purchased electricity, heat and steam): Electricity factors for the 2022 calendar year have been incorporated, as opposed to using electricity factors from two years ago as per previous guidance.

Section 7 (Travel): To reflect the increasing diversity of New Zealand's taxi fleet, two new taxi factors were added this year for a petrol hybrid and an electric vehicle.

Section 9 (Water supply and wastewater treatment): Updated emission factors for water supply and domestic wastewater.

Section 10 (Materials and waste): Two additional emission factors for waste wood to landfill, for treated and untreated wood.

Section 11 (Agriculture, forestry, and other land use): The methodology and emission factors now align with *New Zealand's Greenhouse Gas Inventory 1990–2021.*

Appendix D (Spend-based emissions): Auckland Council has published a new report on spend-based emissions – the emissions generated by the whole supply chain for the goods and services that people consume. The study looks at the GHG emissions (per every $ spent) of over

400 products and services commonly used by households and shows how spend-based emissions can be estimated from data readily available from Stats NZ.

Access the Auckland Council Consumption Emissions Modelling report here: https://www.knowledgeauckland.org.nz/publications/consumption-emissions-modelling/.

See appendix D for more information.

1. Introduction

1.1. Purpose of this guide

The Ministry for the Environment supports organisations taking climate action. We recognise there is strong interest, and in some cases requirements, for organisations across New Zealand to measure, report and reduce their emissions. We prepared this guide to help you measure and report your organisation's greenhouse gas (GHG) emissions on a voluntary basis (see section 1.2 for important notes on this guide's use). Measuring and reporting empowers organisations to manage and reduce emissions in line with the transition to a low-emissions, climate-resilient future.

The guide aligns with and endorses the use of the GHG Protocol Corporate Accounting and Reporting Standard (referred to here as the GHG Protocol) and ISO 14064-1:2018 (see section 1.5). It provides information about preparing a GHG inventory (section 2), emission factors (sections 3–10, and the Emission factors workbook) and methods to apply them to activity data. We have updated the guide in line with international best practice and *New Zealand's Greenhouse Gas Inventory 1990–2021* to provide new emission factors.

The majority of the source data which was used in the development of these emission factors is from 2021, unless otherwise mentioned. This is done to align with *New Zealand's Greenhouse Gas Inventory 1990–2021*. This contains data for the calendar years from 1990 to 2021 (inclusive). The inventory is published 15 months after the end of the period being reported on, following the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines on annual inventories for Parties included in Annex I to the Convention. This allows time to collect and process the data and prepare its publication.

This detailed guide is part of a suite of documents that comprise *Measuring emissions: A guide for organisations*, listed in figure 1. The detailed guide explains how we derived these emission factors and sets out the assumptions surrounding their use. The emission factor information contained in this guide is not intended to be an exhaustively detailed explanation of every calculation performed, as this is not practical.

Figure 1: Documents in *Measuring emissions: A guide for organisations*

Measuring emissions: A guide for organisations	
Detailed guide	For users who need to know the data sources, methodologies, uncertainties and assumptions behind the emission factors for each emission source
Emission factors summary	Quick look up tables providing the main emission factors for each emission source
Emission factors workbook	As above but in Excel format across multiple tabs
Emission factors flat file	Simple format for integration with software
Interactive workbook	Use this spreadsheet to input your activity data, in order to work out your organisation's emissions and produce an inventory
Example GHG inventory	Shows what a finished inventory might look like
Example GHG report	Shows what a finished report might look like

1.1.1. Feedback

We welcome your feedback on this update. Please email emissions-guide@mfe.govt.nz

1.2. Important notes

The information in this guide is intended to help organisations that want to report their GHG emissions on a voluntary basis. This guidance does not replace the reporting requirements for:

- Climate-related disclosure statements; or

- Carbon Neutral Government Programme reporting.

However, it may be used as a source of emission factors in climate-related disclosures, and Carbon Neutral Government Programme (CNGP) reporting, but this is not this guidance's main purpose. Guidance on how to report climate-related disclosures is found in the Aotearoa New Zealand Climate Standards. For CNGP reporting guidance can be found in the Carbon Neutral Government Programme: A guide to managing your greenhouse gas emissions – measuring, reporting, target-setting and reduction planning.

The emission factors and methods in this guide are for sources common to many New Zealand organisations and support the recommended disclosure of GHG emissions consistent with the Aotearoa New Zealand Climate Standards (NZCS) and the Carbon Neutral Government Programme (CNGP).

This guide recognises and supports the Government's ambition for its target of Net Zero by 2050, and the many organisations that have already set, or are looking to set, ambitious emission reduction targets aligned with a science-based approach. The Aotearoa New Zealand Climate Standards developed by the External Reporting Board (XRB) contain disclosure requirements for GHG emissions and targets.

The information in this guide is not appropriate for use in an emissions trading scheme. Organisations required to participate in the New Zealand Emissions Trading Scheme (NZ ETS) need to comply with the scheme-specific reporting requirements. The NZ ETS regulations determine which emission factors and methods must be used to calculate and report emissions. Furthermore, this guide is not intended to be an exhaustively detailed explanation of all practicalities of reporting.

Climate-related disclosures

New Zealand's climate-related disclosure framework is made up of three climate standards, referred to as Aotearoa New Zealand Climate Standards (NZCS).

The aim is to support the allocation of capital towards activities that are consistent with a transition to a low-emissions, climate-resilient future. Climate-related disclosures are mandatory for over 200 entities in New Zealand, for reporting periods beginning on or after 1 January 2023. They include disclosure requirements covering governance, strategy, risk management, and metrics and targets. Metrics and targets have the requirement to disclose gross GHG emissions in metric tonnes of carbon dioxide equivalent (CO_2-e) classified as:

- Scope 1
- Scope 2 (calculated using the location-based method)
- Scope 3

The following information must also be disclosed in relation to the reporting entity's GHG emissions:

- a statement describing the standard or standards that GHG emissions have been measured in accordance with;
- the GHG emissions consolidation approach used: equity share, financial control, or operational control;
- the source of emission factors and the GWP values used or a reference to the GWP source;
- a summary of specific exclusions of sources, including facilities, operations, or assets with a justification for their exclusion.

A limited number of adoption provisions apply to Scope 3 emissions.

The Aotearoa New Zealand Climate Standards and Staff Guidance for All Sectors can be found on the XRB's website.

Carbon Neutral Government Programme

The Carbon Neutral Government Programme (CNGP) was set up by the government to accelerate the reduction of emissions within the public sector. The CNGP has published guidance for CNGP organisations on measuring and reporting their GHG emissions.[1] It includes information on what sources of GHG emissions organisations need to collect, standards to follow, methods for calculating emissions, the required information to report, who to report to, and by when.

For further guidance on this consult the CNGP website[2] or contact cngp@mfe.govt.nz

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[1] https://environment.govt.nz/publications/cngp-measuring-and-reporting-ghg-emissions/.

[2] Carbon Neural Government Programme accessed via: https://environment.govt.nz/what-government-is-doing/key-initiatives/carbon-neutral-government-programme/.

This guide, and the emission factors and methods, are not appropriate for a full life-cycle assessment or product carbon foot printing. The factors presented in this guide only include direct emissions from activities, and do not include all sources of emissions required for a full life-cycle assessment. If you want to do a full life-cycle assessment, we recommend using life-cycle assessment databases and/or software tools. A list of relevant life-cycle inventory databases can be found on the LCANZ website.[3]

Measuring your organisation's emissions is the first step in the journey to reducing your emissions. Developing and implementing a reduction plan is the next important step. The New Zealand Government's first emissions reduction plan was published in May 2022. The plan is an example of a national scale plan but is not intended to provide guidance for how organisations should create their own emission reduction plans. Examples of emission reduction plans published by New Zealand corporations are available online.

Measuring your emissions enables you to set reduction targets, take climate action and report quantified progress towards your goals. To reach your organisation's targets see the Ministry's *Interim guidance for voluntary climate change mitigation*.

Users seeking guidance on preparing a regional inventory should refer to the GHG Protocol for Community-scale Greenhouse Gas Emission Inventories.

If emission factors relevant to your organisation are not included in *Measuring emissions: A guide for organisations* or in Auckland Council's spend-based emissions report (see Appendix D), we suggest using alternatives such as those published by the UK Department for Business Energy & Industrial Strategy (BEIS) and the Department for Environment Food & Rural Affairs.

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[3]   https://lcanz.org.nz/lca-guidance/lca-resources/#LCI.

1.3. Gases included in the guide

This guide covers the following GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3)[4] and other gases (eg, Montreal Protocol refrigerant gases or medical gases).

GHGs can trap differing amounts of heat in the atmosphere, meaning they have different relative impacts on climate change. We apply GWPs to the non-CO_2 gases to enable meaningful comparisons among the gas types compared with CO_2. Where GWPs are applied to these gases, GHG emissions are commonly expressed as their carbon dioxide equivalent or CO_2-e. The larger the GWP, the more a given gas warms the earth compared to CO_2 over that time period. The time period usually used for GWPs is 100 years to align with UNFCCC greenhouse gas inventory reporting requirements. This is used throughout the guide.

To do this, we multiply the emissions for each non-CO_2 gas by its 100-year time-horizon GWP (GWP_{100}) value – see table 1. The IPCC provides more information on how these factors are calculated.

As of this update to *Measuring emissions: A guide for organisations*, the 100-year GWPs in the IPCC Fifth Assessment Report (AR5) are used, as we enter the reporting period for the Paris Agreement.

Throughout the guide, kilograms (kg) of methane and nitrous oxide are reported in kg CO_2-e by multiplying the actual methane emissions by the GWP of 28 and actual nitrous oxide emissions by the GWP of 265, as per table 1.

The change from AR4 to AR5 GWPs may cause a significant change in some organisations' inventories, including those that use large quantities of refrigerants, or that use emission factors with relatively high contributions of methane. For those that see increases or reductions in their footprints, it would be misleading to interpret this as a true increase or reduction. It is best practice to recalculate previous inventories based on updated GWPs, to ensure time series consistency.

Table 1 shows the GWPs for nitrous oxide and methane comparing AR4 and AR5 values. The GWP of nitrous oxide has decreased by 11.1 per cent and the GWP of methane has increased by 12 per cent. AR5 GWPs for other gases such as refrigerants are shown in table 7.

Table 1: **Global warming potential (GWP) of GHGs (excluding fossil methane), based on 100-year period**

GHGs	Scientific Formula	GWP (AR4)	GWP (AR5)
Nitrous oxide	N_2O	298	265
Methane	CH_4	25	28
Carbon dioxide	CO_2	1	1

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[4] The GHG Protocol added nitrogen trifluoride in 2013 as a requirement and ISO 14064-1 included nitrogen trifluoride in 2018. This is consistent with *New Zealand's Greenhouse Gas Inventory 1990–2021*.

1.3.1. Kyoto and Montreal protocols and Paris Agreement

The Kyoto Protocol,[5] adopted in 1997, operationalised the UNFCCC by committing developed country parties to limit and reduce GHG emissions in accordance with agreed individual targets. It includes the following gases: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3.

The Montreal Protocol,[6] adopted in 1987, is an international environmental agreement to protect the ozone layer by phasing out production and consumption of ozone-depleting substances (ODS). The Montreal Protocol includes chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrobromofluorocarbons (HBFCs), methyl bromide, carbon tetrachloride, methyl chloroform and halons. New Zealand prohibits imports of CFCs and HCFCs as part of our implementation of the protocol.

Many of the ozone depleting substances controlled by the Montreal Protocol are also powerful greenhouse gases. This, together with the 2016 Kigali Amendment of the Montreal Protocol to include the phase-down of HFCs, means it has a significant role in mitigating climate change.

The Paris Agreement, adopted in 2015, commits Parties to the agreement to put forward their best efforts to limit global temperature rise through nationally determined contributions (NDCs), and to strengthen these efforts over time. From 2024 onwards, *New Zealand's Greenhouse Gas Inventory* reports under the Paris Agreement will apply the 100-year time horizon GWPs from the IPCC's AR5.

1.4. Uncertainties

ISO 14064-1:2018 and the GHG Protocol require consideration of uncertainty: in particular, assessing and disclosing uncertainty associated with the organisation's GHG inventory.

- Compared with financial accounting, carbon accounting operates in a more unpredictable, dynamic and complex environment, where uncertainty is a known and accepted concept.

- Uncertainties associated with GHG inventories can be broadly categorised as scientific uncertainty and estimation uncertainty.

- Scientific uncertainty arises when the science of the actual emission and/or removal process is not completely understood. Quantifying such scientific uncertainty is extremely challenging and is likely beyond the capability of most company inventory programmes.

- Estimation uncertainty arises any time GHG emissions are quantified and can be classed as either model uncertainty or parameter uncertainty. Model uncertainty refers to the uncertainty associated with the mathematical equations and models used to characterise the relationship between activity data and emissions. Parameter uncertainty refers to the uncertainty associated with the assumptions used and the activity data. Organisations that choose to investigate uncertainty in their emission inventories will focus on the latter.

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[5]   UNFCCC, What is the Kyoto Protocol accessed via: https://unfccc.int/kyoto_protocol.

[6]   UNDP, Montreal Protocol, accessed via: www.unep.org/ozonaction/who-we-are/about-montreal-protocol.

We have used the following approach to disclose uncertainty, in order of preference.

- Disclose the quantified uncertainty of the data, if known.

- Disclose the qualitative uncertainty if known based on expert judgement from those providing the data.

- Disclose the uncertainty ranges in the IPCC Guidelines if provided.

- Disclose that the uncertainty is unknown.

1.5. Standards to follow

We recommend following ISO 14064-1:2018 or the GHG Protocol. We wrote this guide to align with both. Depending on your intended final use and users, we recommend downloading the relevant standards and using them in tandem with this guidance:

- ISO 14064-1:2018[7] is shorter and more direct than the GHG Protocol. A PDF copy can be purchased.

- The GHG Protocol[8] gives more description and context around what to do to produce an inventory. It is free to download. The Corporate Value Chain (Scope 3) Accounting and Reporting Standard is also available. It is a guide for companies to assess their entire value chain emissions impact and identify where to focus reduction activities.

These standards provide comprehensive guidance on the core issues of GHG monitoring and reporting at an organisational level, including:

- principles underlying monitoring and reporting

- setting organisational boundaries

- setting reporting boundaries

- establishing a base year

- managing the quality of a GHG inventory

- content of a GHG report.

1.5.1. How emission sources are categorised

The GHG Protocol places emission sources into Scope 1, Scope 2 and Scope 3 activities.

- Scope 1: Direct GHG emissions from sources owned or controlled by the organisation (ie, within the organisational boundary). For example, emissions from combustion of fuel in vehicles owned or controlled by the organisation.

- Scope 2: Indirect GHG emissions from the generation of purchased energy (in the form of electricity, heat or steam) that the organisation uses.

- Scope 3: Other indirect GHG emissions occurring because of the activities of the organisation but generated from sources that it does not own or control (eg, air travel).

ISO 14064-1:2018 categorises emissions as direct or indirect sources. These categories help better describe the activities associated with emissions sources. Choosing the most

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[7] Published by the International Organization for Standardization. This standard is closely based on the GHG Protocol.

[8] Developed jointly by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD).

appropriate subcategory in your inventory will enhance your reporting, as well as helping to translate between ISO Categories and GHG Protocol Scopes. Using categories also helps to manage double counting of emissions (such as between an electricity generator's direct emissions associated with generation and the indirect emissions linked to the user of that electricity).

The terminology of 'Categories' is used in ISO 14064-1:2018, replacing the use of 'Scopes'.

The GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard goes into more detail, providing a method to enable GHG management of organisations' value chains. Users should be aware that in this standard, Scope 3 is broken down into 15 'Categories'. These should not be confused with the Categories outlined in ISO 14064-1:2018.

This guide reports emission factors for direct (Scope 1) and indirect (Scope 2) emissions, and a limited set of indirect (Scope 3) emissions. Table 2 shows the relationship between the GHG Protocol Scopes and the ISO categories.

Table 2: Emissions by scope, category and source[†]

Scopes used in the GHG Protocol	ISO Inventory Category	ISO sub-category (Annex B)	GHG Protocol
1	Direct GHG emissions	Stationary combustion Mobile combustion Process Fugitive Land use, land use change, and forestry (LULUCF)	Stationary combustion Mobile combustion Process Fugitive Land use, land use change, and forestry (LULUCF)
1	Direct GHG removals	Process Land use, land use change, and forestry (LULUCF)	Process Land use, land use change, and forestry (LULUCF)
2	Indirect GHG emissions from imported energy	Electricity Energy	Electricity Energy
3	Indirect GHG emissions from transportation	Upstream transport and distribution for goods Downstream transport and distribution for goods Client and visitor transport Business travel	4. Upstream transportation and distribution 9. Downstream transportation and distribution 7. Employee commuting 6. Business travel 3. Fuel- and energy-related activities
3	Indirect GHG emissions from products used by the organisation	Purchased goods Capital goods Waste disposal (liquid and solid) Equipment leased by reporting organisation Services not described above	1. Purchased goods and services 2. Capital goods 5. Waste generated in operations 8. Upstream leased assets 1. Purchased goods and services
3	Indirect GHG emissions associated with use of products from the organisation	Use stage of product Downstream leased assets End-of-life stage of product	11. Use of sold product 13. Downstream leased assets

Scopes used in the GHG Protocol	ISO Inventory Category	ISO sub-category (Annex B)	GHG Protocol
		Investments	12. End-of-life treatment of sold products 15. Investments 10. Processing of sold products
3	Indirect GHG emissions from other sources		14. Franchises

Note: Depending on your organisation's reporting and financial boundaries, some emission sources may be either Scope 1 or Scope 3.

† Spend-based emission factors might be used for some of the indirect emissions where better quality, activity specific emission factors may be lacking.

* Emissions inventories, in line with the Greenhouse Gas Protocol, report only Kyoto Protocol gases under direct (Scope 1) emissions. All non-Kyoto gases, such as the Montreal Protocol refrigerant gases or medical gases, should be reported separately as 'other gases'. The Interactive workbook has been structured on the ISO 14064-1:2018 standard, which requires all relevant direct (Scope 1) emissions to be reported.

Both the ISO 14064-1:2018 and GHG Corporate Protocol require that organisations calculate the emissions of each GHG separately and quantify them as carbon dioxide equivalents (CO_2-e). Example calculations in this guide show this format (see also the 2019 Example GHG Report). While the NZCS does not mandate a single approach for measuring GHG emissions, the TCFD requires organisations to report in accordance with the GHG Protocol.

2. How to quantify and report GHG emissions

To quantify and report GHG emissions, organisations need data about their activities (for example, the quantity of fuel used). They can then convert this into information about their emissions (measured in tonnes of CO_2-e) using emission factors.

An emission factor allows the estimation of GHG emissions from a unit of available activity data (eg, litres of fuel used). The factors are set out in the Emission factors interactive and the Emission factors workbook.

CALCULATION METHODOLOGY

$E = Q \times F$

Where:

E	=	emissions from the emissions source in kg CO_2-e per year
Q	=	activity data eg, quantity of fuel used
F	=	emission factor for emissions source

This formula applies to the calculation of both CO_2-e emissions and individual carbon dioxide, methane and nitrous oxide emissions, with the appropriate emission factors applied for F.

The preferred form of data is in the units expressed in the emission factor tables, which results in the most accurate emission calculation. If the data cannot be collected in this unit, use the appropriate conversion factors.

A **GHG inventory** (see section 2.1) contains all applicable emissions for an organisation within a defined boundary during a set period. A GHG inventory is key to measuring emissions.

A **GHG report** (see section 2.3) expands on the inventory with context about the organisation, methods used, as well as analysis of drivers and progress over time. A GHG report is key to reporting emissions.

Organisations that wish to report in line with ISO 14064-1:2018 should be aware that the standard has specific requirements about what to include in the inventory and report.

With voluntary reporting, it is best practice for organisations to understand their full Scope 3 (value chain) emissions and report material sources.

Note that the GHG Protocol requires certain information to be reported alongside the GHG emissions totals if these are reported publicly. If you are planning to make a public GHG statement claiming conformity with the ISO standard, note that you are also required to publish a separate GHG report. Organisations that wish to report in line with ISO 14064-1:2018 should also be aware that the standard includes specific requirements about what to include in the inventory and report.

Organisations may opt to verify or obtain assurance over the GHG inventory or GHG report against the measurement standards (see section 2.4).

2.1. Step-by-step inventory preparation

To prepare an inventory:

- Select the boundaries (organisational and reporting[9]) and measurement period (ie, calendar or financial year) you will report against for your organisation, based on the intended uses of the inventory.

- Collect activity data on each emission source within the boundaries for that period.

- Multiply the activity data by the appropriate emission factor for each emission source and record the calculation (eg, in a spreadsheet). See the 2019 Example GHG Inventory.

- Produce a GHG report, if applicable. See section 2.3 and the 2019 Example GHG Report.

If this is the first year your organisation has produced an inventory, you can use it as a base year for measuring the change in emissions over time, as long as the scope and boundaries represent your usual operations, and that comparable reporting is used in future years. Both the ISO 14064-1:2018 and GHG Protocol allow a base year to be quantified using an average of several years. This can be useful as a method of smoothing out unusual fluctuations when a single year's estimate is not representative of normal activity.

Ensuring time series consistency is central to the GHG inventory because it provides information on the emissions trends for your organisation. All emissions estimates in a time series should be estimated consistently. This means that the same methods and data sources should be used across all years covered by the GHG inventory. Using different methods and data in a time series will mask the trend and will not reflect real changes in emissions. To ensure the representativeness of your base year GHG inventory, therefore, it is good practice to undertake a base year review and recalculate the time series to account for any changes that have occurred due to:

- a structural change in your reporting or organisational boundary

- a change or refinement to calculation methodologies or emission factors, or

- the discovery of an error or cumulative errors in your activity data.

Any base year and time series recalculations should be documented in subsequent inventories.

If historic emission factors have changed, we suggest providing these figures in the document itself, or making them available elsewhere.

For some organisations, certain GHG emissions may contribute such a small portion of the inventory that they make up less than (for instance) 1 per cent of the total inventory. These are known as *de minimis*[10] and may be excluded from the total inventory, provided that the total of excluded emissions does not exceed the materiality[11] threshold set by your organisation. For example, if using an overall materiality threshold of 5 per cent, the total of all emission sources excluded as *de minimis* must not exceed 5 per cent of the inventory. Typically, an organisation estimates any emissions considered *de minimis* using simplified methods to justify the classification. It is important these are transparently documented and justified. Often, you only need to re-estimate excluded emissions in subsequent years if the assumptions change.

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[9]   See Glossary for definitions.

[10]   See Glossary for definition.

[11]   See Glossary for definition.

However, if the user needs to report into a particular programme or satisfy an intended use or user, they may decide to, or be required to, include *de minimis* activities. Under the NZCS, information is considered to be 'significant' or 'material' if omitting, misstating or obscuring it could reasonably be expected to influence decisions that primary users make on the basis of those climate-related disclosures.

2.2. Using the emission factors

Emission factors rely on historical data. This version of the guidance is largely based on *New Zealand's Greenhouse Gas Inventory 1990–2021* as this was the latest complete set of data available. We intend to update these emissions factors annually, when more recent data is available.

If you use the Interactive workbook, input your activity data and the emission factors will be applied automatically. If you do not use the Interactive workbook, simplified example calculations are provided throughout section 4 to demonstrate how to use the emission factors.[12]

Most organisations reporting voluntarily do so each calendar year or financial year. However, the Financial Sector (Climate-related Disclosures and Other Matters) Amendment Act 2021 (CRD) and the CNGP requires reporting based on financial year. Most commonly, a single year serves as their base year. However, it is also possible to choose an average of annual emissions over several consecutive years as a base year.

The emission factors in this guide are:

- default factors, used in the absence of better company-specific or industry-specific information.

- consistent with the reporting requirements of ISO 14064-1:2018 and the GHG Protocol

- aligned with *New Zealand's Greenhouse Gas Inventory 1990–2021*

- presented in kg CO_2-e per unit. Under the reporting requirements of ISO 14064-1:2018 and the GHG Protocol, GHG emissions should be reported in tonnes CO_2-e. However, many emission factors are too small to be reported meaningfully in tonnes. Dividing by 1,000 converts kg to tonnes (see example calculations on the following pages).

In line with the reporting requirements of the standards, the emission factors allow calculation of carbon dioxide, methane and nitrous oxide separately, as well as the total carbon dioxide equivalent for direct (Scope 1) emission sources.

Carbon dioxide emission factors are based on the carbon and energy content of a fuel. Therefore, the carbon dioxide emissions remain constant irrespective of how a fuel is combusted.

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[12] The emission factors in the example calculations within this document, the Emission factors summary and the Emission factors workbook are rounded. In the Interactive workbook they are not. For this reason, you may notice small discrepancies between the answers in the example calculations and the answers provided in the Interactive workbook.

Non-carbon dioxide emissions (eg, methane and nitrous oxide) and emission factors depend on the way the fuel is combusted.[13] To reflect this variability, the guide provides uncertainty estimates for direct (Scope 1) emission factors. Table 3 presents separate carbon dioxide equivalent emission factors for residential, commercial and industrial users. It follows the IPCC guidelines for combustion and adopts the uncertainties.[14]

We derived these emission factors primarily from technical information published by New Zealand government agencies. Each section below provides the source for each emission factor and describes how we derived the factors.

2.3. Producing a GHG report

A full GHG report provides context to the GHG inventory by including information about the organisation, comparing annual inventories, discussing significant changes to emissions, listing excluded emissions, and stating the methods and references for the calculations.

A GHG REPORT

To compile a full GHG report, organisations should include:

- a description of the organisation
- the person or entity responsible for the report
- a description of the inventory boundaries
  - organisational boundary
  - reporting boundary
  - measurement period
- the chosen base year (initial measurement period for comparing annual results)
- emissions (and removals where appropriate) for all GHGs, separately reported in metric tonnes CO_2-e
- emissions separated by scope
  - total Scope 1 and 2 emissions
  - total and specified Scope 3 emissions
- emissions from the combustion of biologically sequestered carbon, reported separately from the scopes
- a time series of emissions results from base year to present year
- significant changes to the inventory, including in the context of triggering any base year recalculations
- the methodologies for calculating emissions, and references to key data sources
- impacts of uncertainty on the inventory
- any specific exclusions of sources, facilities or operations.

View an example reporting template on the GHG Protocol Corporate Standard webpage.

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[13]   For example, the methane and nitrous oxide emission factors for diesel used for industrial heating are different from the methane and nitrous oxide emission factors for diesel used in vehicles.

[14]   *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 2, Chapter 2.

2.4. Assurance and verification

Seeking independent[15] third-party assurance of your inventory is a key component of a responsible reporting approach. Obtaining assurance means to appoint an independent practitioner to undertake a selection of procedures to enable them to express an opinion or conclusion of your organisation's reported statement and is intended to increase the confidence that users can place on the reported information.

There are differing levels of assurance which result in different types of reports. Reasonable assurance is the highest level of assurance, where your assurance practitioner will perform procedures to enable them to state, in their opinion, that the subject matter is not materially misstated. Limited assurance provides a lower level of assurance, where the assurance practitioner will perform fewer procedures comparative to reasonable assurance. A limited assurance conclusion will state nothing has come to the assurance practitioner's attention which indicates the information is materially misstated.

It is recommended that you speak to an assurance provider about your GHG data quality, available evidence and the level of assurance you require. Many assurance providers also provide pre-assurance or an assurance gap analysis, with the aim of providing you with a preliminary assessment of whether the pre-conditions to an assurance engagement are met and feedback ahead of formal assurance. The purpose of pre-assurance is to prepare the reporter for attaining assurance, though it will not to provide guidance on whether or not assurance will be attained.

If you are a Climate Reporting Entity (CRE) under the Financial Sector (Climate-related Disclosures and Other Matters) Amendment Act 2021 (CRD) or required to report under the Carbon Neutral Government Programme (CNGP), specific assurance requirements apply:

- If your organisation is a covered entity under the Financial Markets Conduct Act, as amended by the Financial Sector (Climate-related Disclosures and Other Matters) Amendment Act 2021 (the FMC Act as amended), you are required to obtain third-party assurance in relation to the parts of your climate statement that relate to GHG emissions for periods that end on or after 27 October 2024. For more detail, please see (Assurance, XRB).

If your organisation is a participant to the CNGP, please note that you must seek assurance from an independent third-party annually. Please see the CNGP guide to measuring and reporting greenhouse gas emissions for more information.

2.4.1 Choosing an assurance provider

If you are seeking independent assurance over your GHG disclosures, consider the following factors when choosing a verifier:

- independence and objectivity

- sufficient skills, with previous experience in GHG inventory verifications or assurance

- competence and understanding of GHG reporting/accounting standards and frameworks

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[15] An independent assurer or verifier is an organisation or person that has not assisted in the calculation of the emission inventory in any way and does not provide a tool for the calculation of these emissions.

- can carry out GHG inventory assurance in accordance with applicable assurance standards. ISAE 3410 and ISO 14064-3:2019 are widely used for the assurance or verification of GHG emissions reports. One or the other of these standards should be used.

  – ISAE standard – free to download.

  – ISO standard – there is a download charge.

ISO 14064-3:2019 uses the terms 'validation' and 'verification', whereas ISAE 3410 uses 'assurance'. However, assurance engagements undertaken in accordance with the two international assurance standards include the same, or substantively similar, procedures.

The topic of assurance over GHG reports and providers of such assurance is currently evolving in New Zealand. At the time of publication of this guide, the Ministry of Business, Innovation and Employment had not issued its decision following feedback on the licensing regime consultation for assurance providers. We recommend that organisations regularly review developments in this area. See the Ministry of Business, Innovation and Employment's *Assurance over climate-related disclosures: occupational regulation and expanding the scope of assurance.*

We also recommend that organisations covered by the CRD monitor developments of the XRB, following its consultation on assurance of GHG emissions disclosures.

3. Fuel emission factors

Fuel can be categorised by its end-use, i.e., either stationary combustion or transport. This section also includes biofuels and the transmission and distribution losses for reticulated natural gas.

In line with the reporting requirements of ISO 14064-1:2018 and the GHG Protocol, we provide emission factors for direct (Scope 1) sources to allow separate estimation of carbon dioxide, methane and nitrous oxide emissions calculations.

3.1. Overview of changes since previous update

The fuel emissions factors are based on data from *New Zealand's Greenhouse Gas Inventory 1990–2021*. With the change to AR5 values, all fuels have changed since the previous update, but these changes are not large. Fossil-based fuels changed between -2.5 and +1.5 per cent.

Biogenic CO_2 emissions for biofuels and biomass are now reported under the new column heading Biogenic CO_2 (previously under CO_2).

Bioethanol Increased because the *Guidance* 2022 used the T CH_4/TJ and T N_2O/TJ emission factors for fuel oil, instead of bioethanol. As a result, the CH_4 factor is 6.3x higher and the N_2O factor is 13x higher.

Biodiesel Increased because the *Guidance* 2022 used the T CH_4/TJ and T N_2O/TJ emission factors for fuel oil, instead of bioethanol. As a result, the CH_4 factor is 6.3x higher and the N_2O factor is 6.5x higher.

Wood – Residential Increased by 9 per cent, because in the *Guidance* 2022 the T CH_4/TJ emission factor was incorrect by a factor of 10. This is not likely to be a commonly reported emissions source for organisational inventories.

3.2. Stationary combustion fuel

Stationary combustion fuels are burnt in a fixed unit or asset, such as a boiler. Direct (Scope 1) emissions occur from the combustion of fuels within equipment owned or controlled by the reporting organisation. If the organisation does not own or control the assets where combustion takes place, then these emissions are indirect (Scope 3) emissions. For more information see section 1.5.1.

Table 3 contains emission factors for common fuels used for stationary combustion in New Zealand. The Ministry of Business, Innovation and Employment (MBIE) provided the emission factors and supporting data. The same data were used in *New Zealand's Greenhouse Gas Inventory 1990–2021*.

Sectors for consumption statistics are based on Australian and New Zealand Standard Industrial Classification (ANZSIC) codes.

Residential use emission factors are for fuel used primarily at residential properties. Commercial use is for fuels used at properties or sites where commercial activities take place. Industrial use emission factors can be applied where combustion takes place at sites where there are industrial processes or within engines that support industrial activities.

Table 3:   Emission factors for the stationary combustion of fuels

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)	Uncertainties
Residential use						
Coal – Default	kg	2.12	1.95	0.169	0.00800	4.9%
Coal – Bituminous	kg	2.88	2.64	0.236	0.0112	4.8%
Coal – Sub-bituminous	kg	2.17	1.99	0.173	0.00817	4.8%
Coal – Lignite	kg	1.55	1.42	0.122	0.00576	4.8%
Commercial use						
Coal – Default	kg	2.01	1.99	0.00580	0.00823	3.5%
Coal – Bituminous	kg	2.66	2.64	0.00787	0.0112	3.5%
Coal – Sub-bituminous	kg	2.00	1.99	0.00576	0.00817	3.5%
Coal – Lignite	kg	1.43	1.42	0.00406	0.00576	3.5%
Diesel	litre	2.69	2.67	0.0102	0.00581	0.5%
LPG	kg	2.97	2.96	0.00665	0.00126	0.5%
Heavy fuel oil	litre	3.00	2.99	0.0108	0.00615	0.5%
Light fuel oil	litre	2.97	2.95	0.0108	0.00611	0.5%
Natural gas	kWh	0.194	0.193	0.0005	0.00009	2.4%
	GJ	53.8	53.6	0.126	0.0239	2.4%
Industrial use						
Coal – Default	kg	1.96	1.94	0.00564	0.00801	3.5%
Coal – Bituminous	kg	2.66	2.64	0.00787	0.0112	3.5%
Coal – Sub-bituminous	kg	2.00	1.99	0.00576	0.00817	3.5%
Coal – Lignite	kg	1.43	1.42	0.00406	0.00576	3.5%
Diesel	litre	2.68	2.67	0.00307	0.00581	0.5%
LPG	kg	2.97	2.96	0.00133	0.00126	0.5%
Heavy fuel oil	litre	3.00	2.99	0.00325	0.00615	0.5%
Light fuel oil	litre	2.96	2.95	0.00323	0.00611	0.5%
Natural gas	kWh	0.193	0.193	0.00009	0.00009	2.4%
	GJ	53.7	53.6	0.0252	0.0239	2.4%

Notes: Commercial and industrial classifications are based on standard classification.[16]

Use the default coal emission factor if it is not possible to identify the type of coal.

Convert LPG-use data in litres to kilograms by multiplying by the specific gravity of 0.536 kg/litre.

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[16]   ANZSIC – Australian and New Zealand Standard Industrial Classification.

3.2.1. GHG inventory development

To calculate stationary combustion fuel emissions, first collect data on the quantity of fuel used, and then multiply this by the appropriate emission factor from the table. Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   quantity of fuel used (unit)
F   =   appropriate emission factors from table 3.

Organisations typically report emissions using data on the amount of fuel used during the reporting period.

STATIONARY COMBUSTION: EXAMPLE CALCULATION

An organisation uses 1,400 kg of LPG to heat an office building in the reporting year.

CO_2 emissions	= 1,400 × 2.96	= 4,144 kg CO_2
CH_4 emissions	= 1,400 × 0.00665	= 9.31 kg CO_2-e
N_2O emissions	= 1,400 × 0.00126	= 1.764 kg CO_2-e
Total CO_2-e emissions	= 1,400 × 2.97	= 4,158 kg CO_2-e

Note: Numbers may not add due to rounding.

3.2.2. Emission factor derivation methodology

We derived the kg CO_2-e per activity unit emission factors supplied in table 3 using calorific values and emission factors for tonnes (t) of gas per terajoule (TJ). The calorific values are in Appendix A: Derivation of fuel emission factors alongside further information on the methodology.

3.2.3. Assumptions, limitations and uncertainties

We derived the kg CO_2-e per activity unit emission factors in table 3 using calorific values, listed in Appendix A: Derivation of fuel emission factors.

For a breakdown of the uncertainty by gas type see the Emission factors workbook.

The emission factors above account for the direct (Scope 1) emissions from fuel combustion. They are not full fuel-cycle emission factors and do not incorporate indirect (Scope 3) emissions associated with the extraction, production and transport of the fuel.

We calculated the default coal emission factors by weighting the emission factors for the different ranks of coal (bituminous, sub-bituminous and lignite) by the amount of coal used for each sector (commercial, residential, industrial). The guide includes emission factors for residential coal for completeness.

3.3. Transport fuel

Transport fuels are used in an engine to move a vehicle. Table 4 lists the emission factors.

Table 4: Transport fuel emission factors

Fuel type	Unit	kg CO₂-e/ unit	kg CO₂/unit	kg CH₄/unit (kg CO₂-e)	kg N₂O/unit (kg CO₂-e)	Uncertainties
Transport fuels						
Regular petrol	litre	2.46	2.35	0.0309	0.0710	1.8%
Premium petrol	litre	2.46	2.36	0.0309	0.0709	1.8%
Diesel	litre	2.71	2.67	0.00399	0.0378	1.8%
LPG	litre	1.62	1.57	0.0438	0.00134	0.9%
Heavy fuel oil	litre	3.02	2.99	0.00759	0.0205	1.3%
Light fuel oil	litre	2.98	2.95	0.00753	0.0204	0.6%
Aviation fuel (kerosene)	GJ	68.8	68.3	0.0133	0.503	0.6%
	litre	2.56	2.54	0.0005	0.0187	0.1%
Aviation gas	GJ	66.4	65.9	0.0133	0.504	0.1%
	litre	2.25	2.23	0.0005	0.0171	0.1%

Notes: No estimates are available for marine diesel as Marsden Point oil refinery has stopped making the marine diesel blend. If an organisation was using marine diesel, it is now likely to be using light fuel oil; use the corresponding emission factor for light fuel oil instead.

These petrol emission factors may be different from those in the ETS regulations.[17]

3.3.1. GHG inventory development

To calculate transport fuel emissions, first collect data on the quantity of fuel, and then multiply this by the appropriate emission factor from the table. Applying the equation
$E = Q \times F$ (section 2), this means:

E   =   emissions from the emissions source in kg CO₂-e per year
Q   =   quantity of fuel used (unit)
F   =   appropriate emission factors from table 4

All organisations across sectors typically report emissions using data on the amount of fuel used during the reporting period. Quantified units of fuel weight or volume (commonly in litres) are preferable. If this information is unavailable see section 3.3.2.

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[17] Climate Change (Liquid Fossil Fuels) Regulations 2008 (SR 2008/356) (as at 16 May 2023) Schedule Emissions factors for tonnes of carbon dioxide equivalent greenhouse gases per kilolitre – New Zealand Legislation.

> **TRANSPORT FUEL: EXAMPLE CALCULATION**
>
> An organisation has 15 petrol vehicles. They use a total of 40,000 litres of regular petrol in the reporting year.
>
> | | | |
> |---|---|---|
> | CO_2 emissions | = 40,000 × 2.35 | = 94,000 kg CO_2 |
> | CH_4 emissions | = 40,000 × 0.0309 | = 1,236 kg CO_2-e |
> | N_2O emissions | = 40,000 × 0.0710 | = 2,840 kg CO_2-e |
> | Total CO_2-e emissions | = 40,000 × 2.46 | = 98,400 kg CO_2-e |
>
> Note: Numbers may not add due to rounding.

3.3.2 When no fuel data are available

If your records only provide information on kilometres (km) travelled, and you do not have information on fuel use, see section 7: Travel emission factors. Factors such as individual vehicle fuel efficiency and driving efficiency mean that kilometre-based estimates of carbon dioxide equivalent emissions are less accurate than calculating emissions based on fuel-use data. Therefore, only use the emission factors based on distance travelled if information on fuel use is not available.

Calculating transport fuel based on dollars spent is less accurate and should only be applied to taxis. See section 7.2

3.3.3 Emission factor derivation methodology

We applied the same methodology to the transport fuels that we used to calculate the stationary combustion fuels, using the raw data in table 4. The fuel properties of kerosene and aviation gas are 0.0371 and 0.0388 litres per GJ respectively.

3.3.4 Assumptions, limitations and uncertainties

We derived the kg CO_2-e per activity unit emission factors in table 3 using calorific values. All emission factors incorporate relevant oxidation factors sourced from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.

As with the fuels for stationary combustion, these emission factors are not full fuel-cycle emission factors and do not incorporate the indirect (Scope 3) emissions associated with the extraction, production and transport of the fuel.

3.4. Biofuels and biomass

This section provides emission factors for bioethanol, biodiesel and wood emission sources.

The carbon dioxide emitted from the combustion of biofuels and biomass (including wood) is biogenic, meaning it equates to the carbon dioxide absorbed by the feedstock during its lifespan. This means we treat the carbon dioxide portion of the combustion emissions of biofuels as carbon neutral. However, these CO_2 emissions still need to be reported separately in the inventory, under biogenic emissions. This is why the kg CO_2-e/unit figures in table 5 are the sum of the CH_4 and N_2O.

The combustion of biofuels generates anthropogenic methane and nitrous oxide. Organisations should calculate and report these gases as is done at the national level according to the *2006 IPCC Guidelines for National Greenhouse Gas Inventories.*[18]

Table 5 details the emission conversion factors for the GHG emissions from the combustion of biofuels.

Table 5: **Biofuels and biomass emission factors**

Biofuel type	Unit	kg CO$_2$-e/ unit	kg CH$_4$/unit (kg CO$_2$-e)	kg N$_2$O/unit (kg CO$_2$-e)	Biogenic kg CO$_2$/unit	Uncertainties
Biofuel						
Bioethanol	GJ	3.89	0.778	3.11	99.1	0.05%
	litre	0.0917	0.0184	0.0733	2.34	0.05%
Biodiesel	GJ	0.963	0.327	0.636	43.6	0.05%
	litre	0.0351	0.0119	0.0232	1.59	0.05%
Wood – residential	kg	0.0729	0.0647	0.00817	0.862	36.26%
Wood – industrial	kg	0.0146	0.00647	0.00817	0.862	43.68%

Notes

The guide does not expect many commercial or industrial users will burn wood in fireplaces, but this emission factor has been provided for completeness. It is the default residential emission factor.

The total CO$_2$-e emission factor for biofuels and biomass only includes methane and nitrous oxide emissions. This is based on ISO 14064-1:2018 and the GHG Protocol reporting requirements for combustion of biomass as direct (Scope 1) emissions. Carbon dioxide emissions from the combustion of biologically sequestered carbon are reported separately.

3.4.1. GHG inventory development

> Note that although the direct (Scope 1) carbon dioxide emissions of biomass combustion are considered carbon neutral over the short-term carbon cycle, organisations should still report the carbon dioxide released through biofuel and biomass combustion.[19]
>
> Calculate the carbon dioxide emissions in the same way as the direct emissions. Then, instead of including them within the emissions total (where CH$_4$ and N$_2$O gases are reported), list them as a separate line item called 'biogenic emissions'. This ensures the organisation is transparent regarding all potential sources of carbon dioxide from its activities.

To calculate biofuel and biomass emissions, first collect data on the quantity of fuel used then multiply this by the appropriate emission factor from the table. Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO$_2$-e per year
Q   =   quantity of fuel used (unit)
F   =   appropriate emission factors from table 5

Organisations can calculate emissions from biofuel blends if the specific per cent blend is known.

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[18]   *2006 Guidelines for Greenhouse Gas Inventories*, Volume 2, Energy, accessed via: www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html.

[19]   The GHG Protocol guidance on this is accessed via: https://ghgprotocol.org/sites/default/files/Stationary_Combustion_Guidance_final_1.pdf.

The equation used is:

$$X\% \text{ } biofuel \text{ } blend \text{ } emission \text{ } factor =$$
$$(X\% \times \text{pure } biofuel \text{ } emission \text{ } factor) + [(1 - X\%) \times$$
$$fossil \text{ } fuel \text{ } emission \text{ } factor]$$

BIOFUELS AND BIOMASS: EXAMPLE CALCULATION

An organisation uses 100 per cent biofuel in five vehicles. They use 7,000 litres of biodiesel in the reporting year.

CO_2 emissions	= 7,000 × 0.00	= 0.00 kg CO_2
CH_4 emissions	= 7,000 × 0.0119	= 83.3 kg CO_2-e
N_2O emissions	= 7,000 × 0.0232	= 162.4 kg CO_2-e
Total CO_2-e emissions	= 7,000 × 0.0351	= 245.7 kg CO_2-e (reported as Scope/Category 1)
Biogenic CO_2 emissions	= 7,000 x 1.59	= 11,130 kg CO_2 (reported separately)

An organisation wants to report on its Scope 1 fuel emissions (in kg CO_2-e/litre) from a specific biodiesel blend of 10 per cent. It is known that:

mineral diesel emission factor	= 2.72 kg CO_2-e/litre
biodiesel emission factor	= 0.0351 kg CO_2-e/litre

Therefore, 10 per cent biodiesel blend emission factor =

(10% × 0.0351) + [(1-10%) × 2.72]   = 2.4515 kg CO_2-e/litre biofuel blend

Note: Numbers may not add due to rounding.

3.4.2. Emission factor derivation methodology

We applied the same methodology used to calculate the stationary combustion fuels to the biofuels, using the raw data in Appendix A: Derivation of fuel emission factors.

3.4.3. Assumptions, limitations and uncertainties

The same assumptions, limitations and uncertainties associated with transport and stationary combustion apply to biofuels. There is no difference between transport or stationary combustion of biofuels.

3.5. Transmission and distribution losses for reticulated gases

Natural gas reticulation losses decreased by 38 per cent, due to a change in calculation methodology from the 2022 *Guidance*.

For transmission, the fugitive emissions from vented gas and burned gas were previously included but were expanded in 2023 to include fugitive emissions from industry assets.

Distribution fugitive emissions were previously estimated on international default factors but have moved to facility-level estimates of emission factors.

Reticulated gases are delivered via a piped gas system. Users should be aware what type of reticulated gas they are receiving: natural gas or liquefied petroleum gas (LPG).

Fugitive emissions from reticulated natural gas transmission and distribution losses only fall under Scope 1 for specific sectors (eg, gas distribution businesses).

If an organisation consumes reticulated gas eg, for cooking (as shown in the example calculation under 3.5.1) related natural gas transmission and distribution losses emissions would fall under Scope 3/Category 3. See page 41, the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard.

Reticulated LPG is supplied in parts of Canterbury and Otago only (natural gas is not available in the South Island). The guide assumes there are no transmission and distribution losses from reticulated LPG due to the chemical composition of the gas. As LPG is a mixture of propane and butane, it does not emit fugitive greenhouse gases.

The emission factor for reticulated natural gas transmission and distribution losses accounts for fugitive emissions from the transmission and distribution system for natural gas. These emissions occur during the delivery of the gas to the end user.

Table 6 details the emission factors for the transmission and distribution losses for reticulated natural gas. These represent an estimate of the average amount of carbon dioxide equivalents emitted from losses associated with the delivery (transmission and distribution) of each unit of gas consumed through local distribution networks in 2018. They are average figures and therefore make no allowance for distance from off-take point, or other factors that may vary between individual consumers.

Table 6: **Transmission and distribution loss emission factors for natural gas**

Transmission and distribution losses source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)
Natural gas used	kWh	0.00713	0.00006	0.00707	n/a
	GJ	1.98	0.0160	1.96	n/a

3.6.   GHG inventory development

To calculate the emissions from transmission and distribution losses, organisations should first collect data on the quantity of natural gas used and then multiply this by the emission factors for each gas. Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   quantity of fuel used (unit)
F   =   appropriate emission factors from table 6

> **TRANSMISSION AND DISTRIBUTION LOSSES: EXAMPLE CALCULATION**
>
> An organisation uses 800 gigajoules of distributed natural gas in the reporting period.
>
> | | | |
> |---|---|---|
> | CO_2 emissions | = 800 × 0.016 | = 12.8 kg CO_2 |
> | CH_4 emissions | = 800 × 1.96 | = 1,568 kg CO_2-e |
> | N_2O emissions | = 800 × 0.00 | = 0 kg CO_2-e |
> | Total CO_2-e emissions | = 800 × 1.98 | = 1,584 kg CO_2-e |
>
> Note: Numbers may not add due to rounding.

3.6.1. Emission factor derivation methodology

MBIE provided data on losses from transmission and distribution. The fugitive losses of natural gas are predominantly methane but include a component of carbon dioxide. The methodology was revised to be based on higher quality estimates from Firstgas on fugitive emissions.

Transmission emission estimates were modelled to include vented gas, own use gas and fugitive emissions from assets and work undertaken.

For distribution, an emissions estimate model using a best practice MarcoGaz template was applied, along with internationally published emission rates (American Petroleum Institute Compendium of emissions rates) combined with company specific asset values. This is complemented by annual asset level leakage measurements.

3.6.2. Assumptions, limitations and uncertainties

The guide assumes there are no transmission and distribution losses from reticulated LPG.

Emissions from transmission and distribution of natural gas have moved to a higher quality estimation method in this guide. This still requires modelling those fugitive emissions, and therefore uncertainty remains in the estimate.

4. Refrigerant and other gases: emission factors

4.1. Overview of changes since previous update

This guide includes the 100-year global warming potentials (GWPs) of gases reported under the Paris Agreement and the Montreal Protocol.

We use the GWPs published in the IPCC Fifth Assessment Report (IPCC AR5) in this update. This is a change from 2022, which used the IPCC AR4 values where available. Almost all changes in GWP are less than 20 per cent, although there are some significant changes in some gases. The largest reduction was in methyl bromide (decreasing by 60 per cent) and the largest increase was seen in HFE-356pcc3 (increasing by 275 per cent). Only six refrigerants remained unchanged.

4.2. Refrigerant use

GHG emissions from HFCs are associated with unintentional leaks and spills from refrigeration units, HVAC systems, air conditioners and heat pumps. Quantities of HFCs in a GHG inventory may be small, but HFCs have very high GWPs so emissions from this source may be material. Also, emissions associated with this sector have grown significantly as they replace ozone depleting chemicals such as CFCs and HCFCs.

The list of refrigerant gases is continuously evolving with technology and scientific knowledge. We note that if a known gas is not listed in this guide, it does not imply there is no impact.

Emissions from HFCs are determined by estimating refrigerant equipment leakage and multiplying the leaked amount by the GWP of that refrigerant. There are three methods depending on the data available – see section 4.3.1-4.3.4.

If you consider it likely that emissions from refrigerant equipment and leakage are a significant proportion of your total emissions (eg, greater than 5 per cent), include them in your GHG inventory. You may need to carry out a preliminary screening test to determine if this is a material source.

If the reporting organisation owns or controls the refrigeration units, emissions from refrigeration are direct (Scope 1). If the organisation leases the unit, associated emissions should be reported under indirect (Scope 3) emissions.

4.3. Global warming potentials (GWPs) of refrigerants and other GHGs

Table 7 details the GWPs of the refrigerants included in this section. The GWP is effectively the emission factor for each unit of refrigerant gas lost to the atmosphere. The guide uses the 100 year GWPs from the IPCC's Fifth Assessment Report to ensure consistency with the *New Zealand Greenhouse Gas Inventory 1990–2021.*

Some refrigerants are a mixture (or blend) of gases. If you know the blend composition, you can calculate the GWP based on the percentage mass of each gas. Alternatively, for the AR5 GWP of various refrigerant mixtures, see table B2 in Appendix B: Alternative methods of calculating emissions from refrigerants. For the AR5 GWP values, refer to the Fifth IPCC Assessment Report, Appendix 8.A in Chapter 8: Anthropogenic and Natural Radiative Forcing.

Table 7:   Global warming potentials (GWPs) of refrigerants

Industrial designation/common name	Chemical formula	Unit	AR5 GWP100
Industrial designation or common name			
Carbon dioxide (R-744)	CO_2	kg	1
Methane	CH_4	kg	28
Propane (R-290)	C_3H_8	kg	0.02*
Nitrous oxide (R-744a)	N_2O	kg	265
Butane	C_4H_{10}	kg	0.006*
Substances controlled by the Montreal Protocol			
CFC-11 (R-11)	CCl_3F	kg	4660
CFC-12 (R-12)	CCl_2F_2	kg	10200
CFC-13 (R-13)	$CClF_3$	kg	13900
CFC-113 (R-113)	CCl_2FCClF_2	kg	5820
CFC-114 (R-114)	$CClF_2CClF_2$	kg	8590
CFC-115 (R-115)	$CClF_2CF_3$	kg	7670
Halon-1301 (R-1301)	$CBrF_3$	kg	6290
Halon-1211 (R-1211)	$CBrClF_2$	kg	1750
Halon-2402 (R-2402)	$CBrF_2CBrF_2$	kg	1470
Carbon tetrachloride (R-10)	CCl_4	kg	1730
Methyl bromide	CH_3Br	kg	2
Methyl chloroform	CH_3CCl_3	kg	160
HCFC-21	$CHCl_2F$	kg	148
HCFC-22 (R-22)	$CHClF_2$	kg	1760
HCFC-123 (R-123)	$CHCl_2CF_3$	kg	79
HCFC-124 (R-124)	$CHClFCF_3$	kg	527
HCFC-141b (R-141b)	CH_3CCl_2F	kg	782
HCFC-142b (R-142b)	CH_3CClF_2	kg	1980
HCFC-225ca (R-225ca)	$CHCl_2CF_2CF_3$	kg	127
HCFC-225cb (R-225cb)	$CHClFCF_2CClF_2$	kg	525
Hydrofluorocarbons			
HFC-23 (R-23)	CHF_3	kg	12400
HFC-32 (R-32)	CH_2F_2	kg	677
HFC-41	CH_3F	kg	116
HFC-125 (R-125)	CHF_2CF_3	kg	3170
HFC-134	CHF_2CHF_2	kg	1120
HFC-134a (R-134a)	CH_2FCF_3	kg	1300
HFC-143	CH_2FCHF_2	kg	328
HFC-143a (R-143a)	CH_3CF_3	kg	4800
HFC-152	CH_2FCH_2F	kg	16
HFC-152a (R-152a)	CH_3CHF_2	kg	138
HFC-161	CH_3CH_2F	kg	4
HFC-227ea (R-227ea)	CF_3CHFCF_3	kg	3350
HFC-236cb	$CH_2FCF_2CF_3$	kg	1210
HFC-236ea	CHF_2CHFCF_3	kg	1330

Industrial designation/common name	Chemical formula	Unit	AR5 GWP100
HFC-236fa (R-236fa)	$CF_3CH_2CF_3$	kg	8060
HFC-245ca	$CH_2FCF_2CHF_2$	kg	716
HFC-245fa (R-245fa)	$CHF_2CH_2CF_3$	kg	858
HFC-365mfc (R-365mfc)	$CH_3CF_2CH_2CF_3$	kg	804
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	kg	1650
Perfluorinated compounds			
Sulphur hexafluoride	SF_6	kg	23500
Nitrogen trifluoride	NF_3	kg	16100
PFC-14	CF_4	kg	6630
PFC-116	C_2F_6	kg	11100
PFC-218	C_3F_8	kg	8900
PFC-318	$c\text{-}C_4F_8$	kg	9540
PFC-31-10	C_4F_{10}	kg	9200
PFC-41-12	C_5F_{12}	kg	8550
PFC-51-14	C_6F_{14}	kg	7910
PFC-91-18	$C_{10}F_{18}$	kg	7190
Trifluoromethyl sulphur pentafluoride	SF_5CF_3	kg	17400
Perfluorocyclopropane	$c\text{-}C_3F_6$	kg	9200
Fluorinated ethers			
HFE-125	CHF_2OCF_3	kg	12400
HFE-134	CHF_2OCHF_2	kg	5560
HFE-143a	CH_3OCF_3	kg	523
HFE-227ea	$CF_3CHFOCF_3$	kg	6450
HCFE-235da2 (Isoflurane)	$CHF_2OCHClCF_3$	kg	491
HFE-236ea2	$CHF_2OCHFCF_3$	kg	1790
HFE-236fa	$CF_3CH_2OCF_3$	kg	979
HFE-245cb2	$CH_3OCF_2CF_3$	kg	654
HFE-245fa1	$CHF_2CH_2OCF_3$	kg	828
HFE-245fa2	$CHF_2OCH_2CF_3$	kg	812
HFE-254cb1	$CH_3OCF_2CHF_2$	kg	301
HFE-263fb2	$CF_3CH_2OCH_3$	kg	1
HFE-329mcc2	$CHF_2CF_2OCF_2CF_3$	kg	3070
HFE-338mcf2	$CF_3CH_2OCF_2CF_3$	kg	929
HFE-347mcc3	$CH_3OCF_2CF_2CF_3$	kg	530
HFE-347mcf2	$CHF_2CH_2OCF_2CF_3$	kg	854
HFE-347pcf2	$CHF_2CF_2OCH_2CF_3$	kg	889
HFE-356mec3	$CH_3OCF_2CHFCF_3$	kg	387
HFE-356pcc3	$CH_3OCF_2CF_2CHF_2$	kg	413
HFE-356pcf2	$CHF_2CH_2OCF_2CHF_2$	kg	719
HFE-356pcf3	$CHF_2OCH_2CF_2CHF_2$	kg	446
HFE-365mcf3	$CF_3CF_2CH_2OCH_3$	kg	1
HFE-374pc2	$CHF_2CF_2OCH_2CH_3$	kg	627
HFE-449sl (HFE-7100)	$C_4F_9OCH_3$	kg	421
HFE-569sf2 (HFE-7200)	$C_4F_9OC_2H_5$	kg	57
HFE-43-10pccc124 (H-Galden 1040x)	$CHF_2OCF_2OC_2F_4OCHF_2$	kg	2820
HFE-236ca12 (HG-10)	$CHF_2OCF_2OCHF_2$	kg	5350
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCHF_2$	kg	2910
Perfluoropolyethers			
PFPMIE	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$	kg	9710

Industrial designation/common name	Chemical formula	Unit	AR5 GWP100
Hydrocarbons and other compounds – Direct effects			
Chloroform	$CHCl_3$	kg	16
Methylene chloride	CH_2Cl_2	kg	9
Halon-1201	$CHBrF_2$	kg	376
Methyl chloride	CH_3Cl	kg	12
Refrigerant blends – Zeotropes			
ASHRAE Refrigerant designation[20]	Mix (mass %)	Unit	n/a
403B	R-290/22/218 (5.0/56.0/39.0)	kg	4456.75
404A	R-125/143a/134a (44.0/52.0/4.0)	kg	3942.8
406A	R-22/600a/142b (55.0/4.0/41.0)	kg	1779.92
407C	R-32/125/134a (23.0/25.0/52.0)	kg	1624.21
407F	R-32/125/134a (30.0/30.0/40.0)	kg	1674.1
408A	R-125/143a/22 (7.0/46.0/47.0)	kg	3257.1
409A	R-22/124/142b (60.0/25.0/15.0)	kg	1484.75
409B	R-22/124/142b (65.0/25.0/10.0)	kg	1473.75
410A	R-32/125 (50.0/50.0)	kg	1923.5
413A	R-218/134a/600a (9.0/88.0/3.0)	kg	1945.09
416A	R-134a/124/600 (59.0/39.5/1.5)	kg	975.21
417A	R-125/134a/600 (46.6/50.0/3.4)	kg	2127.322
422A	R-125/134a/600a (85.1/11.5/3.4))	kg	2847.272
436A	R-290/600a (56.0/44.0)	kg	3
436B	R-290/600a (52.0/48.0)	kg	3
502	R-22/115 (48.8/51.2)	kg	4785.92
507A	R-125/143a (50.0/50.0)	kg	3985
Medical gases			
HFE-347mmz1 (Sevoflurane)	$(CF_3)_2CHOCH_2F$	kg	216
HCFE-235da2 (Isoflurane)	$CHF_2OCHClCF_3$	kg	491
HFE-236ea2 (Desflurane)	$CHF_2OCHFCF_3$	kg	1790
Medical gas blends – Mix (mass %) – unit			
Entonox	N_2O/O_2 (57.9/42.1) (50.0/50.0 vol.)	kg	153.435

* AR6 values

4.3.1. GHG inventory development

There are three approaches to estimate HFC leakage from refrigeration equipment, depending on the data available. The ideal method is the top-up method, Method A. Method B is the next best option. Method C is the least preferred because it has the most assumptions.

It is stressed that for all methods, users must individually identify the type of refrigerant because the GWPs vary widely.

Organisations should indicate the method(s) used in their inventories to reflect the levels of accuracy and uncertainty.

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[20] Refrigerant blends are sourced from ASHRAE: www.ashrae.org/technical-resources/standards-and-guidelines/ashrae-refrigerant-designations

4.3.2. Method A: Top-up

The best method to determine if emissions have occurred is through confirming if any top-ups were necessary during the measurement period. A piece of equipment is 'charged' with refrigerant gas, and any leaked gas must be replaced. Assuming that the system was at capacity before the leakage occurred and is full again after a top-up, the amount of top-up gas is equal to the gas leaked or lost to the atmosphere. The equipment maintenance service provider can typically provide information about the actual amount of refrigerant used to replace what has leaked.

$$\text{Gas used (kg)} \times \text{GWP} = \text{Emissions (kg } CO_2\text{-e)}$$

Where:

- E = emissions from equipment in kg CO_2-e
- GWP = the 100-year global warming potential of the refrigerant used in equipment (table 7).

4.3.3. Methods B and C: Screening

If top-up amounts are not available, we recommend using one of the following two methods for estimating leakage, depending on the equipment and available information. Appendix B: Alternative methods of calculating emissions from refrigerants details both methods.

Method B is based on default leakage rates and known refrigerant type and volume. Use Method B when the type and amount of refrigerant held in a piece of equipment are known.

Method C is the same as Method B except that it allows default refrigerant quantities to be used as well as default leakage rates. Use Method C to estimate both volume of refrigerant and leakage rate when the amount of refrigerant held in a piece of equipment is not known.

Methods B and C are based on the screening approach outlined in the GHG Protocol HFC tool (WRI/WBCSD, 2005).

For most equipment, Method B is acceptable, especially for factory and office situations where refrigeration and air-conditioning equipment is incidental rather than central to operations. In some cases, Method C is only suitable for a screening estimate. Screening is a way of determining if the equipment should be included or excluded based on materiality of emissions from refrigerants. Organisations should then try to source data based on the top-up-method.

We provide refrigerant emissions calculation examples below.

Company A performs a stocktake of refrigeration-related equipment and identifies the following units:

- one large commercial-sized chiller unit
- one commercial-sized office air conditioning unit.

Using the top-up approach, the calculation is as follows:

REFRIGERANT USE METHOD A: EXAMPLE CALCULATIONS

Method A: Top-up

Chiller unit: During the 2022 calendar year, a service technician confirmed a top-up of 6 kg of HFC-134a (AR5 GWP = 1,300) in December 2022. The technician also confirmed that when last serviced at the end of December 2021, no top-ups were needed. So, we assume all the 6 kg of gas was lost during calendar year 2022.

So, for the 2022 inventory:

6 kg HFC-134a × 1,300 = 7,800 kg CO_2-e

Air conditioning unit: During the 2022 calendar year, a service technician confirmed a top-up of 6 kg of HFC-143a (AR5 GWP = 4,800) in July 2022. The technician also confirmed that when last serviced at the end of July 2021, no top-ups were needed. So, we assume all the gas was lost at an even rate during the 12 months between service visits, and six of those months sit in the 2022 measurement period.

6 kg/12 months = 0.5 kg per month

So, for the 2022 calendar year inventory, 0.5 × 6 months = 3 kg. Emissions calculate as:

3 kg HFC-143a × 4,800 = 14,400 kg CO_2-e

If information was not available from the technician, Company A could use the following approach:

REFRIGERANT USE METHOD B: EXAMPLE CALCULATIONS

Method B: Screening method with default annual leakage rate

Chiller unit: Compliance plates on the equipment confirm the refrigerant is HFC-134a (AR5 GWP = 1,300) and the volume held is 12 kg. For the chiller unit size, the default leakage rate is 8%.

So, for the 2022 calendar year,

12 kg HFC-134a × 8% × 1,300 = 1,248 kg CO_2-e

Air conditioning unit: A service technician confirms the refrigerant is HFC-143a (AR5 GWP = 4,800) and the volume held is 12 kg. For the size of the unit, the default leakage rate is 3%.

So, for the 2022 calendar year,

12 kg HFC-143a × 3% × 4,800 = 1,728 kg CO_2-e

Note: Numbers may not add due to rounding.

The difference between Method A and Method B suggests that the leakage of refrigerant exceeds the default leakage rate, so improved maintenance of the refrigeration systems could help reduce leakage.

4.4. Medical gases use

This section covers emissions from medical gases. Anaesthetic medical gases can be a significant source of direct (Scope 1) emissions in hospitals. The most accurate way to calculate emissions from medical gases is based on consumption data.

4.4.1. Global warming potentials of medical gases

Table 8 details the GWPs of the medical gases included in this section. The GWP is effectively the emission factor for each unit of medical gas lost to the atmosphere. The guide uses IPCC AR5 GWPs.

Some medical gases consist of a mixture (or blend) of gases. If you know the blend composition, you can calculate the GWP based on the percentage of each gas.

Table 8:   GWPs of medical gases

Industrial designation/common name	Chemical formula	Unit	AR5 GWPs in a 100-year period (kg CO_2-e) without climate change feedbacks
Medical gases			
HFE-347mmz1 (Sevoflurane)	$(CF_3)_2CHOCH_2F$	kg	216
HCFE-235da2 (Isoflurane)	$CHF_2OCHClCF_3$	kg	491
HFE-236ea2 (Desflurane)	$CHF_2OCHFCF_3$	kg	1790

4.4.2. GHG inventory development

To calculate medical gas emissions, collect consumption data for each medical gas used by the organisation, and multiply this by the GWP for each gas.

> Gas used (kg) × GWP = Emissions (kg CO_2-e)

Medical gases are supplied in bottles or cylinders. If only the volume of the gas is known, an additional calculation to calculate the mass of the gas is required to estimate emissions. This should be done by multiplying the volume (L) of gas by its density (g/mL or kg/L).

MEDICAL GAS USE: EXAMPLE CALCULATION

An organisation uses 5 bottles of Isoflurane (HCFE-235da2, AR5 GWP = 491) in the reporting period. Each bottle holds 0.3 kg of Isoflurane. Its direct (Scope 1) emissions are:

    5 bottles x 0.3 kg   = 1.5 kg
    Total CO₂-e emissions   = 1.5 × 491   = 736.5 kg CO₂-e

An organisation uses 5 250 mL bottles of Isoflurane (HCFE-235da2, AR5 GWP = 491) in the reporting period. The density of Isoflurane is 1.49 g/mL. Its direct (Scope 1) emissions are:

    5 bottles x 250 mL x 1.49/1,000 = 1.86 kg
    Total CO₂-e emissions   = 1.86 × 491   = 913.26 kg CO₂-e

4.4.3. Assumptions

This approach assumes that all anaesthetic gases used are eventually emitted, including the gases inhaled by patients.

5. Purchased electricity, heat and steam emission factors

Purchased energy, in the form of electricity, heat or steam, is an indirect (Scope 2) emission. This section also includes transmission and distribution losses for purchased electricity, which is an indirect (Scope 3) emissions source.

Note that both the emission factor for purchased electricity and the emission factor for transmission and distribution line losses align with the definitions in the GHG Protocol.

In this guide, we have included a time series of historic electricity emission factors based on annual and quarterly periods. The quarterly time series extends back to March 2020, and the annual time series extends back to 2010. There is also an equivalent time series for transmission and distribution losses.

The guide provides information on reporting imported heat and steam and geothermal energy. It does not provide emission factors for these categories as they are unique to a specific site. Users could liaise directly with their supplier of the imported heat, steam, or geothermal energy, for supplier specific emissions intensities suitable for use in the organisation inventory.

5.1. Overview of changes since previous update

We have incorporated the electricity factors for the 2022 calendar year, as opposed to using electricity factors from two years ago as per previous guidance. This adjustment ensures a more accurate alignment between organisational activity data and electricity emissions for the corresponding period. The transition to AR5 values had only a marginal effect on the electricity factors. However, it is worth noting that the electricity emission factor for 2022 has decreased. This can be attributed to the low GHG emissions reported during the latter half of that year.

5.2. Indirect Scope 2 emissions from purchased electricity from the New Zealand grid – using the location-based method

This guide applies to electricity purchased from a supplier that sources electricity from the national grid (ie, purchased electricity consumed by end users). It does not cover on-site, self-generated-electricity.

The grid-average emission factor best reflects the carbon dioxide equivalent emissions associated with the generation of a unit of electricity purchased from the national grid in New Zealand. We recommend the use of the emissions factors in table 9 for all electricity purchased from the national grid, apart from when a market-based method is being used.

We calculate purchased electricity emission factors on a quarterly and calendar-year basis, using annual and quarterly electricity emissions data provided by MBIE.

The emission factor accounts for the emissions from fuel combustion at thermal power stations (ie, power stations which generate electricity by burning fossil fuels) and fugitive emissions from the generation of geothermal electricity.

The emission factor for purchased grid-average electricity does not include transmission and distribution losses. A separate average emission factor for this as an indirect (Scope 3) emission source is in section 5.3.

The provided emission factors are an average for the whole of New Zealand for a given quarter or year. The actual emissions produced for a given unit of electricity may differ depending on factors such as the time of year, time of day and geographical area. Therefore, a grid-average emission factor may over or underestimate your organisation's GHG emissions.

Detailed additional guidance on reporting electricity emissions is available in the GHG Protocol Scope 2 Guidance.

The emission factors for the annual average purchased electricity based on annual generation from the New Zealand grid is in table 9.

Table 9: Emission factor for purchased grid-average electricity – annual average

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)
2022	kWh	0.0742	0.0721	0.00194	0.0002
2021	kWh	0.115	0.112	0.00301	0.00025
2020	kWh	0.120	0.117	0.00311	0.0002
2019	kWh	0.110	0.107	0.00324	0.0002
2018	kWh	0.0947	0.0913	0.00330	0.0001
2017	kWh	0.0996	0.0959	0.00367	0.00008
2016	kWh	0.0885	0.0845	0.00398	0.00007
2015	kWh	0.112	0.108	0.00439	0.0001
2014	kWh	0.118	0.114	0.00419	0.0001
2013	kWh	0.141	0.137	0.00409	0.0002
2012	kWh	0.167	0.163	0.00385	0.0003
2011	kWh	0.135	0.131	0.00366	0.0002
2010	kWh	0.1457	0.142	0.0036	0.00016

Note: These numbers are rounded to three decimal places unless the number is significantly small.

The emission factors for the calendar quarters (quarter end) for 2020 – 2022 purchased electricity from the New Zealand grid are in table 10.

Table 10: Emission factor for purchased grid-average electricity – calendar quarters

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)
Electricity used					
Dec 2022	kWh	0.0353	0.0353	0.00004	0.0000003
Sep 2022	kWh	0.0554	0.0554	0.00006	0.0000004
Jun 2022	kWh	0.108	0.108	0.0001	0.0000008

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)
Electricity used					
Mar 2022	kWh	0.0991	0.0990	0.0001	0.0000007
Dec 2021	kWh	0.0496	0.0495	0.00005	0.0000004
Sep 2021	kWh	0.0931	0.0930	0.0001	0.0000007
Jun 2021	kWh	0.170	0.170	0.0002	0.000001
Mar 2021	kWh	0.147	0.147	0.0002	0.000001
Dec 2020	kWh	0.103	0.102	0.0001	0.0000006
Sep 2020	kWh	0.147	0.147	0.0002	0.0000009
Jun 2020	kWh	0.111	0.111	0.0001	0.0000007
Mar 2020	kWh	0.117	0.117	0.0001	0.0000007

Note: These numbers are rounded to three decimal places unless the number is significantly small.

5.2.1. GHG inventory development

To calculate the emissions from purchased electricity, first collect data on the quantity of electricity used during the period in kilowatt hours (kWh), then multiply this by the emission factor. Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO_2-e per year
Q = quantity of electricity used (kWh)
F = emission factors from table 9 or table 10

All organisations across sectors typically report emissions using data on the amount of electricity used during the reporting period. Quantified units of electricity consumed are preferable.

PURCHASED ELECTRICITY: EXAMPLE CALCULATION

An organisation uses 800,000 kWh of electricity in the 2022 reporting period. Its indirect (Scope 2) emissions from electricity are:

CO_2 emissions	= 800,000 × 0.0721	= 57,680 kg CO_2
CH_4 emissions	= 800,000 × 0.00194	= 1,522 kg CO_2-e
N_2O emissions	= 800,000 × 0.0002	= 160 kg CO_2-e
Total CO_2-e emissions	= 57,680 + 1,552 + 160	= 59,392 kg CO_2-e

Note: Numbers may not add due to rounding.

5.2.2. Emission factor derivation methodology

Emission factors are calculated by dividing the total national GHG emissions from electricity production by the total electricity generation.

Table 11 details the MBIE data provided to calculate the annual emission factors.[21] *New Zealand's Greenhouse Gas Inventory 1990–2021* also contains this information.

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[21] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/.

Table 11: Information used to calculate the purchased electricity emission factor for 2010–2022

Calculation component	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Public electricity generation (GWh)	43,503	43,270	43,174	43,815	43,419	43,311	42,919	43,333	42,651	42,358	43,149	43,268	43,569
Emissions of CO_2 from public electricity generation (kt)	3,219	4,963	5,184	4,819	4,096	4,298	3,781	4,852	5,016	5,963	7,208	5,807	6,333

Note: These numbers are rounded to 0 decimal places.

5.2.3. Assumptions, limitations and uncertainties

Using an annual average grid emission factor for electricity will inevitably introduce a certain level of inaccuracy, as the generation mix varies depending on your geographical location, by time of day and time of year.

As with the fuels for stationary combustion emission factors, this emission factor does not incorporate emissions associated with the extraction, production and transport of the fuels burnt to produce electricity.

We derived the emission factors in table 9 and table 10 for purchased electricity from generation data rather than consumption data. This emission factor does not account for the emissions associated with the electricity lost in transmission and distribution on the way to the end user. Table 12 contains an emission factor for transmission and distribution line losses.

5.3. Transmission and distribution losses for electricity

The emission factor for transmission and distribution line losses accounts for the additional electricity generated to make up for electricity lost in the transmission and distribution network. Under the GHG Protocol, end users should report emissions from electricity consumed from a transmission and distribution system as an indirect (Scope 3) emission source. Electricity and distribution companies should however report these losses as indirect (Scope 2) emissions.[22]

The emission factor for transmission and distribution line losses is the difference between the generation and consumption emission factors. Table 12 shows the emission factors for transmission and distribution losses from the national grid.

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[22] GHG Protocol Scope 2 Guidance, accessed via:
https://ghgprotocol.org/sites/default/files/standards/Scope%202%20Guidance_Final_Sept26.pdf.

Table 12: Transmission and distribution losses for electricity consumption

Emission source	Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$ e/unit)	CH$_4$ (kg CO$_2$-e/unit)	N$_2$O (kg CO$_2$-e/ unit)
2022	kWh	0.00860	0.00836	0.0002	0.00002
2021	kWh	0.0108	0.0105	0.0003	0.00002
2020	kWh	0.0109	0.0106	0.0003	0.00002
2019	kWh	0.00993	0.00962	0.0003	0.00002
2018	kWh	0.00797	0.00768	0.0003	0.000010
2017	kWh	0.00879	0.00845	0.0003	0.000007
2016	kWh	0.00593	0.00566	0.0003	0.000005
2015	kWh	0.00671	0.00644	0.0003	0.000008
2014	kWh	0.00693	0.00667	0.0002	0.000009
2013	kWh	0.0102	0.00992	0.0003	0.00001
2012	kWh	0.0137	0.0134	0.0003	0.00002
2011	kWh	0.00976	0.00948	0.0003	0.00001
2010	kWh	0.0103	0.0100	0.0003	0.00001

Note: These numbers are rounded to 3 decimal places unless the number is significantly small.

5.3.1 GHG inventory development

To calculate the emissions from transmission and distribution losses for purchased electricity, collect data on the quantity of electricity used during the period in kilowatt hours (kWh) and multiply this by the emission factor. Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO$_2$-e per year
Q = quantity of electricity used (kWh)
F = emission factors from table 12

> **TRANSMISSION AND DISTRIBUTION LOSSES: EXAMPLE CALCULATION**
>
> An organisation uses 800,000 kWh of electricity in the 2022 reporting period. Its indirect (Scope 3) emissions from transmission and distribution losses for purchased electricity are:
>
> | | | |
> |---|---|---|
> | CO$_2$ emissions | = 800,000 × 0.00836 | = 6,688 kg CO$_2$ |
> | CH$_4$ emissions | = 800,000 × 0.0002 | = 160 kg CO$_2$-e |
> | N$_2$O emissions | = 800,000 × 0.00002 | = 16 kg CO$_2$-e |
> | Total CO$_2$-e emissions | = 6,688 + 160 + 16 | = 6,864 kg CO$_2$-e |
>
> Note: Numbers may not add due to rounding.

Alternatively, if your electricity provider gives a breakdown of the transmission and distribution losses this consumption data can be multiplied by a grid-average electricity emission factor from table 9.

5.3.2 Emission factor derivation methodology

Emission factors are derived by calculating the difference between the emission factors for electricity generation and electricity consumption.

Table 9 shows the emission factors for generation. The emission factors for consumption were calculated by dividing the total national GHG emissions from electricity generation by the total electricity consumption.

Table 13 details the MBIE data to calculate the emission factors for consumption.[23]

Table 13: **Information used to calculate the emission factor for electricity consumption 2010–2022**

Calculation component	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Public electricity consumption (GWh)	38,983	39,541	39,596	40,197	40,047	39,801	40,224	40,893	40,287	39,496	39,880	40,342	40,690
Emissions of CO_2 from public electricity generation (kt)	3,219	4,963	5,184	4,819	4,096	4,298	3,781	4,852	5,016	5,963	7,208	5,807	6,333

Note: These numbers are rounded to 0 decimal places.

5.3.3 Assumptions, limitations and uncertainties

This emission factor covers grid-average electricity purchased by an end user. As with all emission factors for purchased electricity, we calculated those for transmission and distribution line losses as a national average.

As it is an average figure, the emission factor makes no allowance for distance from off-take point, or other factors that may vary between individual consumers.

This emission factor does not incorporate the emissions associated with the extraction, production and transport of the fuels burnt to produce the electricity.

5.4. Imported heat and steam

Organisations that have a specific heat or steam external energy source (such as a district heating scheme) can calculate emissions using an emission factor specific to that scheme. This should be available from the owner of the external energy source.

5.5. Geothermal energy

Organisations that have their own geothermal energy source can calculate emissions separately using a unique emission factor. Depending on the steam coming from the borehole, there may or may not be emissions associated with this energy type.

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[23] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/.

6. Indirect business-related emission factors

This section includes guidance and emissions factors relating to indirect (Scope 3) emissions from business activities not covered in other sections.

6.1. Overview of changes since previous update

The methodology for calculating working from home emissions with respect to energy use has not changed since the 2022 guidance. However, during the August 2022 update of the guidance, a 12 per cent reduction in the electricity emission factor was published but the working from home emission factor was not updated. As a result, an 18 per cent reduction in the working from home emission factor is reported in this 2023 guidance.

6.2. Emissions associated with employees working from home

This section provides three emission factors, which incorporate typical emission sources associated with the activities of employees working from home. These emission factors can be used by employers to estimate the indirect (Scope 3) emissions associated with staff working from home. The three emission factors for working from home are:

- Working from home – Default
- Working from home – Without heating
- Working from home – With heating.

All three emission factors have been developed based on typical uses of the following emissions sources by staff members working from home; a laptop plus monitor, lighting and optionally heating. The default factor assumes heating is run for five months of the year and could be used where more granular data on the actual use of home heating is not available.

Should an organisation wish to quantify their employees' working from home emissions in more detail, they can survey staff and use the data provided in table 14, or various emissions factors from other sections in this guide.

Note the Working from home – With heating factor should only be used when heating is additional to what would normally be used. In other words, when the heater is being used over and above the normal home heating use. Noting this factor assumes six hours of heating per day.

Table 14:   Working from home emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2 e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Default	Employee days	0.365	0.354	0.00954	0.0008
Without heating	Employee days	0.054	0.053	0.00142	0.0001
With heating	Employee days	0.799	0.777	0.0209	0.00171

Note: These numbers are rounded to three decimal places unless the number is significantly small.

6.2.1 GHG inventory development

To calculate the emissions for an employee working from home, collect information on the number of days staff have worked from home during the reporting period. You will need to record which of these days heating was used and which it wasn't. If you do not have this data, use the default factor. Applying the equation E = Q x F (section 2), this means:

E	=	emissions from the emissions source in kg CO_2-e per year
Q	=	number of employees working from home without heating (days)
Qh	=	number of employees working from home with heating (days)
F	=	emission factor from the second row of table 14
Fh	=	emission factor from the bottom row of table 14

WORKING FROM HOME EXAMPLE CALCULATION

An organisation has 20 employees and knows through an employee survey or some other means that, on a given day, 12 employees were working from home. Of these, eight used heating each day and four did not use heating. This same daily data was collected over a month and summed as either with or without heating.

Its indirect (Scope 3) emissions from working at home for a given month are:

With heating = 168 employee days

CO_2 emissions	= 168 × 0.777	= 130.536 kg CO_2
CH_4 emissions	= 168 × 0.0209	= 3.511 kg CO_2-e
N_2O emissions	= 168 × 0.00171	= 0.287 kg CO_2-e
Total CO_2-e emissions	= 168 × 0.799	= 134.232 kg CO_2-e

Without heating = 84 employee days

CO_2 emissions	= 84 × 0.0528	= 4.435 kg CO_2
CH_4 emissions	= 84 × 0.00142	= 0.119 kg CO_2-e
N_2O emissions	= 84 × 0.0001	= 0.0084 kg CO_2-e
Total CO_2-e emissions	= 84 × 0.054	= 4.536 kg CO_2-e

Note: Numbers may not add due to rounding.

6.2.2 Emission factor derivation methodology

To calculate the working from home emission factor, we decided the most appropriate unit would be employee days. Therefore, we would need to calculate how much electricity an employee typically used per day.

It is assumed for both the with and without heating emission factors a working day is 8 hours and all staff use a laptop, monitor and a 12W LED light.

Table 15 shows the emission sources used to derive the working from home factors. The default factor assumes heating is run for five months of the year, assuming a mix of heat pump and portable heater use. The without-heating factor only includes the office-based emission sources. The with-heating factor assumes 50 per cent of staff use electric portable heaters while 50 per cent use heat pumps. It is assumed heating used an average of six hours per working day, each heater type operating for three hours.

Table 15:   Data used to calculate the emission factors

Emission source	Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/unit)	CH$_4$ (kg CO$_2$-e/unit)	N$_2$O (kg CO$_2$-e/unit)	Assumptions
Office-based emission sources						
Monitor	Employee days	0.013	0.0129	0.0003	0.00003	20 W 8 hrs per day
Laptop	Employee days	0.033	0.0322	0.0009	0.0001	50 W 8 hrs per day
Light use	Employee days	0.008	0.0077	0.0002	0.00002	12 W 8 hrs per day
Heating						
Heat pump	Employee days	0.248	0.241	0.007	0.0005	4 kW capacity, 3 hrs heating per day 50% of households
Electric heater	Employee days	0.497	0.483	0.013	0.0011	2 kW 3 hrs per day 50% of households

6.2.3 Employee commuting

To account for the emissions produced by employees commuting between their homes and their worksites, refer to travel emissions in section 7.

6.2.4 The emissions benefits of working from home

There is ongoing discussion and research on whether working from home reduces an employee's carbon footprint.

The carbon benefits of working from home will depend on, among other things, whether avoided emissions are seen from employee commuting. For example, an employee who normally commutes by car for a return trip of 40 km will see a decrease in overall emissions from working at home, whereas someone who normally takes the train or drives an EV may see an increase in their overall emissions (the sum of that employee's emissions from working at home and commuting).

Similarly, through the increased use of collaborative technologies such as video conferencing and screen-sharing, there may be less need for certain workers to use company vehicles to visit and meet people in person. This would be expected to reduce the organisation's vehicle fleet emissions and, in combination with working from home, reduces the employee's carbon footprint.

6.2.5 Assumptions, limitations and uncertainties

In the absence of accurate data for New Zealand, a number of assumptions have been made to establish a single default working from home emission factor. It is assumed that all staff use a laptop and one monitor, while in some cases desktops or multiple monitors may be used. There will also be variation in the wattage of the laptops being used, due to factors such as size and the way it is being used.

Acknowledging the likely high variation in the way New Zealand employees heat their office space, there is high uncertainty in this factor. It does not account for situations where unzoned central heating is used to heat the office space, for different heater sizes or for different heating fuels (eg, gas, solid fuels). Further, the assumed six hour running time may not apply in all cases, with some workspaces being better insulated than others. Future updates to the guidance will explore regional averages for heating type and duration.

The default factor assumes heating is used for five months of the year, which again is not likely to reflect all situations.

In light of the above limitations, there is opportunity to improve your quality of data behind your inventory through having effective data collection, such as the staff survey suggested above. Given working from home is now ingrained in many New Zealand workplaces, routines have likely developed where many employees are consistently working from home on the same day(s) of the working week. In such cases, it may be relatively easy to ask employees to record which days they work from home, and which of these heating was used. Building on this with more accurate GHG data on employee commuting (which can be included in travel emissions factors, section 7), will help you understand whether working from home is positively or negatively impacting your carbon footprint.

6.3. Guidance on the use of cloud-based data centres

Emissions from data centres come under indirect (Scope 3) emissions. These emissions may be significant for any organisation that operates with large third-party IT infrastructure.

Due to the diversity and country location of data centres used by organisations in New Zealand it is not possible to produce a single emission factor that would inform users of the kg CO_2-e each gigabyte of data produces.

Therefore, organisations seeking to find out what the footprint is of the data centres where their 'cloud' is stored should contact the providers of their data centre to request this information. Large data centre providers such as Google, Microsoft and Amazon are calculating the total emissions from their data centres and may be able to inform users of the carbon footprint of their usage.

7. Travel emission factors

This travel emissions section provides detail on how to calculate emissions associated with both business travel and staff commuting.

Business travel emissions result from travel associated with (and generally paid for by) the organisation. We provide factors for private and rental vehicles, taxis, public transport, air travel, helicopters and accommodation. Business travel emissions are indirect (Scope 3/ Category 6: Business travel) if the organisation does not directly own or control the vehicles used for travel. If the organisation owns or has an operating lease for the vehicle(s) these emissions are direct (Scope 1/Category 1: Purchased goods and services GHG Protocol) and should be accounted for in transport fuels (see section 3.3).

Staff commuting emissions result from employees travelling between their homes and their worksites. Emissions from staff commuting may arise from the use of private and rental vehicles, taxis, public transport, and air travel. Other emissions associated with working from home can be accounted for in section 6, 'indirect business-related emission factors'.

Staff commuting emissions are indirect (Scope 3/Category 7: Employee commuting).

7.1. Overview of changes since previous update

Emission factors for light passenger vehicles continue to reduce as newer, more fuel-efficient vehicles enter the fleet and older vehicles are retired. Reductions of between one and six per cent are seen across most of the vehicle classes and modes.

The exceptions are factors for plug-in hybrid vehicles (electricity consumption) and electric vehicles, which decreased by between 26 and 28 per cent this year. This reflects the lower electricity emission factor in this guidance but is partly mitigated by the inclusion of electricity transmission and distribution (T & D) losses in the fuel consumption.

In this guidance the assumed date of manufacture of rental vehicles was changed to 2015 onwards. Previously, the assumed date was between 2010 and 2015. This change resulted in a reduction of emission factors across all rental vehicles, apart from the electric vehicles (see previous paragraph).

Two new taxi factors were added in this guidance: a petrol hybrid and an electric vehicle.

The domestic air travel factors have been replicated from the 2022 edition of the guidance due to incomplete data that affected some of the more recent data. Public transport emission factors for rail or bus services have not been updated. No data is currently available for ferries. Furthermore, the emission factors for hotel stays have not been updated.

7.2. Passenger vehicles

This section covers emissions from private vehicles for which mileage is claimed, rental vehicles and taxi travel.

Travel, including rental vehicles, staff mileage and taxi travel are indirect (Scope 3) emissions. This is a change in guidance, to align better with leading practice. As with direct (Scope 1) emissions from transport fuels, the most accurate way to calculate emissions is based on fuel consumption data. Fuel-use data are preferable because factors such as individual vehicle fuel efficiency and driving efficiency mean that kilometre-based estimates of emissions are less accurate. However, this information may not be easily available.

The 2021 fleet statistics (tables 17 to 19) were taken from the Te Manatū Waka Ministry of Transport Vehicle Fleet Emissions Model. This provides energy (fuel and electricity) use per km travelled by vehicle.

Fuel-use based emission factors are above in section 3.

If the only information known is kilometres travelled, use the emission factors in this section. Factors such as individual vehicle fuel efficiency and driving efficiency mean that kilometre-based estimates of carbon dioxide equivalent emissions are less accurate than calculating emissions based on fuel-use data.

If the vehicle size and engine type are known, use the factors in tables 17 to 19. Table 20 lists default private car emission factors, and table 21 lists the rental car emission factors based on distance travelled. Table 22 lists emission factors for taxi travel based on dollars spent and kilometres travelled.

Table 16 details engine sizes and typical corresponding vehicles.

Table 16:   Vehicle engine sizes and common car types

Engine size	Vehicle size	Example vehicles	Comparative electric vehicles
<1350 cc	Very small	Fiat 500	Peugeot iOn
1350–<1600 cc	Small	Suzuki Swift	Renault Zoe
1600–<2000 cc	Medium	Toyota Corolla	Nissan Leaf
2000–<3000 cc	Large	Toyota RAV4	Hyundai Ioniq
>3000	Very large	Ford Ranger	Nissan e-NV200

Table 17:   Pre-2010 vehicle fleet emission factors per km travelled

Emission source category		Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Petrol vehicle	<1350 cc	km	0.195	0.186	0.00245	0.00562
	1350–<1600 cc	km	0.201	0.193	0.00254	0.00582
	1600–<2000 cc	km	0.227	0.217	0.00286	0.00655
	2000–3000 cc	km	0.252	0.241	0.00317	0.00728
	≥3000 cc	km	0.301	0.289	0.00379	0.00871
Diesel vehicle	<1350 cc	km	0.214	0.211	0.0003	0.00298
	1350–<1600 cc	km	0.206	0.203	0.0003	0.00287
	1600–<2000 cc	km	0.218	0.215	0.0003	0.00304
	2000–<3000 cc	km	0.268	0.264	0.0004	0.00374
	≥3000 cc	km	0.298	0.293	0.0004	0.00414

Emission source category		Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Petrol hybrid vehicle	<1350 cc	km	0.154	0.147	0.00193	0.00444
	1350–<1600 cc	km	0.159	0.152	0.00200	0.00459
	1600–<2000 cc	km	0.179	0.172	0.00225	0.00517
	2000–<3000 cc	km	0.199	0.191	0.00250	0.00575
	≥3000 cc	km	0.238	0.228	0.00300	0.00687
Diesel hybrid vehicle	<1350 cc	km	0.192	0.189	0.0003	0.00267
	1350–<1600 cc	km	0.185	0.182	0.0003	0.00257
	1600–<2000 cc	km	0.196	0.193	0.0003	0.00272
	2000–<3000 cc	km	0.241	0.237	0.0004	0.00335
	≥3000 cc	km	0.267	0.263	0.0004	0.00372
Motorcycle	<60 cc, petrol	km	0.0683	0.0654	0.0009	0.00197
	≥60 cc, petrol	km	0.137	0.131	0.00172	0.00395

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Table 18: **2010–2015 vehicle fleet emission factors per km travelled**

Emission source category		Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Petrol vehicle	<1350 cc	km	0.172	0.165	0.00217	0.00498
	1350–<1600 cc	km	0.178	0.171	0.00225	0.00516
	1600–<2000 cc	km	0.201	0.193	0.00253	0.00581
	2000–3000 cc	km	0.223	0.214	0.00281	0.00645
	≥3000 cc	km	0.267	0.256	0.00336	0.00772
Diesel vehicle	<1350 cc	km	0.190	0.187	0.0003	0.00265
	1350–<1600 cc	km	0.183	0.180	0.0003	0.00255
	1600–<2000 cc	km	0.194	0.191	0.0003	0.00270
	2000–<3000 cc	km	0.238	0.235	0.0004	0.00332
	≥3000 cc	km	0.264	0.260	0.0004	0.00368
Petrol hybrid vehicle	<1350 cc	km	0.136	0.130	0.00171	0.00393
	1350–<1600 cc	km	0.141	0.135	0.00177	0.00407
	1600–<2000 cc	km	0.159	0.152	0.00200	0.00458
	2000–<3000 cc	km	0.176	0.169	0.00222	0.00509
	≥3000 cc	km	0.211	0.202	0.00266	0.00609
Diesel hybrid vehicle	<1350 cc	km	0.170	0.167	0.0003	0.00237
	1350–<1600 cc	km	0.164	0.161	0.0002	0.00228
	1600–<2000 cc	km	0.173	0.171	0.0003	0.00241
	2000–<3000 cc	km	0.213	0.210	0.0003	0.00297
	≥3000 cc	km	0.237	0.233	0.0003	0.00329
PHEV (Petrol) – Petrol consumption	<1350 cc	km	0.0712	0.0683	0.0009	0.00206
	1350–<1600 cc	km	0.0737	0.0706	0.0009	0.00213
	1600–<2000 cc	km	0.0830	0.0795	0.00105	0.00240

Emission source category		Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/unit)	CH$_4$ (kg CO$_2$-e/unit)	N$_2$O (kg CO$_2$-e/unit)
	2000–<3000 cc	km	0.0922	0.0884	0.00116	0.00266
	≥3000 cc	km	0.110	0.106	0.00139	0.00319
PHEV (Petrol) – Electricity consumption	<1350 cc	km	0.00736	0.00716	0.0002	0.00002
	1350–<1600 cc	km	0.00762	0.00741	0.0002	0.00002
	1600–<2000 cc	km	0.00858	0.00834	0.0002	0.00002
	2000–<3000 cc	km	0.00953	0.00926	0.0002	0.00002
	≥3000 cc	km	0.0114	0.0111	0.0003	0.00002
PHEV (Diesel) – Diesel consumption	<1350 cc	km	0.0890	0.0876	0.0001	0.00124
	1350–<1600 cc	km	0.0856	0.0843	0.0001	0.00119
	1600–<2000 cc	km	0.0908	0.0894	0.0001	0.00126
	2000–<3000 cc	km	0.112	0.110	0.0002	0.00155
	≥3000 cc	km	0.124	0.122	0.0002	0.00172
PHEV (Diesel) – Electricity consumption	<1350 cc	km	0.00803	0.00780	0.0002	0.00002
	1350–<1600 cc	km	0.00771	0.00750	0.0002	0.00002
	1600–<2000 cc	km	0.00845	0.00821	0.0002	0.00002
	2000–<3000 cc	km	0.00957	0.00930	0.0003	0.00002
	≥3000 cc	km	0.0113	0.0110	0.0003	0.00002
Electric vehicle	<1350 cc	km	0.0154	0.0150	0.0004	0.00003
	1350–<1600 cc	km	0.0160	0.0155	0.0004	0.00003
	1600–<2000 cc	km	0.0180	0.0175	0.0005	0.00004
	2000–<3000 cc	km	0.0200	0.0194	0.0005	0.00004
	≥3000 cc	km	0.0239	0.0232	0.0006	0.00005
Motorcycle	<60cc, petrol	km	0.0605	0.0580	0.0008	0.00175
	≥60cc, petrol	km	0.121	0.116	0.00152	0.00350
	<60 cc, electricity	km	0.00380	0.00369	0.00010	0.000008
	≥60 cc, electricity	km	0.00760	0.00738	0.0002	0.00002

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Table 19:   Post-2015 vehicle fleet emissions per km travelled

Emission source category		Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/unit)	CH$_4$ (kg CO$_2$-e/unit)	N$_2$O (kg CO$_2$-e/unit)
Petrol vehicle	<1350 cc	km	0.159	0.153	0.00201	0.00461
	1350–<1600 cc	km	0.165	0.158	0.00208	0.00477
	1600–<2000 cc	km	0.186	0.178	0.00234	0.00537
	2000–3000 cc	km	0.206	0.198	0.00260	0.00596
	≥3000 cc	km	0.247	0.236	0.00311	0.00713
Diesel vehicle	<1350 cc	km	0.178	0.175	0.0003	0.00247
	1350–<1600 cc	km	0.171	0.168	0.0003	0.00238
	1600–<2000 cc	km	0.181	0.179	0.0003	0.00252

Emission source category		Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/ unit)	CH₄ (kg CO₂-e/ unit)	N₂O (kg CO₂-e/ unit)
	2000–<3000 cc	km	0.223	0.219	0.0003	0.00310
	≥3000 cc	km	0.247	0.243	0.0004	0.00344
Petrol hybrid vehicle	<1350 cc	km	0.126	0.121	0.00158	0.00364
	1350–<1600 cc	km	0.130	0.125	0.00164	0.00376
	1600–<2000 cc	km	0.147	0.140	0.00185	0.00424
	2000–<3000 cc	km	0.163	0.156	0.00205	0.00471
	≥3000 cc	km	0.195	0.187	0.00245	0.00563
Diesel hybrid vehicle	<1350 cc	km	0.157	0.155	0.0002	0.00219
	1350–<1600 cc	km	0.151	0.149	0.0002	0.00211
	1600–<2000 cc	km	0.160	0.158	0.0002	0.00223
	2000–<3000 cc	km	0.197	0.194	0.0003	0.00274
	≥3000 cc	km	0.219	0.215	0.0003	0.00304
PHEV (Petrol) - Petrol consumption	<1350 cc	km	0.0658	0.0631	0.0008	0.00190
	1350–<1600 cc	km	0.0681	0.0653	0.0009	0.00197
	1600–<2000 cc	km	0.0767	0.0735	0.0010	0.00222
	2000–<3000 cc	km	0.0852	0.0817	0.00107	0.00246
	≥3000 cc	km	0.102	0.0977	0.00128	0.00295
PHEV (Petrol) - Electricity consumption	<1350 cc	km	0.00695	0.00675	0.0002	0.00001
	1350–<1600 cc	km	0.00719	0.00699	0.0002	0.00002
	1600–<2000 cc	km	0.00810	0.00787	0.0002	0.00002
	2000–<3000 cc	km	0.00899	0.00874	0.0002	0.00002
	≥3000 cc	km	0.0108	0.0105	0.0003	0.00002
PHEV (Diesel) - Diesel consumption	<1350 cc	km	0.0823	0.0810	0.0001	0.00115
	1350–<1600 cc	km	0.0792	0.0780	0.0001	0.00110
	1600–<2000 cc	km	0.0839	0.0826	0.0001	0.00117
	2000–<3000 cc	km	0.103	0.102	0.0002	0.00144
	≥3000 cc	km	0.114	0.113	0.0002	0.00159
PHEV (Diesel) - Electricity consumption	<1350 cc	km	0.00758	0.00736	0.0002	0.00002
	1350–<1600 cc	km	0.00728	0.00707	0.0002	0.00002
	1600–<2000 cc	km	0.00798	0.00775	0.0002	0.00002
	2000–<3000 cc	km	0.00903	0.00877	0.0002	0.00002
	≥3000 cc	km	0.0107	0.0104	0.0003	0.00002
Electric vehicle	<1350 cc	km	0.0146	0.0142	0.0004	0.00003
	1350–<1600 cc	km	0.0151	0.0147	0.0004	0.00003
	1600–<2000 cc	km	0.0170	0.0165	0.0004	0.00004
	2000–<3000 cc	km	0.0189	0.0183	0.0005	0.00004
	≥3000 cc	km	0.0226	0.0219	0.0006	0.00005

Emission source category		Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/ unit)	CH₄ (kg CO₂-e/ unit)	N₂O (kg CO₂-e/ unit)
Motorcycle	<60 cc, petrol	km	0.0565	0.0541	0.0007	0.00163
	≥60 cc, petrol	km	0.113	0.108	0.00142	0.00327
	<60 cc, electricity	km	0.00372	0.00361	0.00010	0.000008
	≥60 cc, electricity	km	0.00743	0.00722	0.0002	0.00002

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Table 20: **Default private car emission factors per km travelled for default age of vehicle and <3000 cc engine size**

Emission source category	Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/ unit)	CH₄ (kg CO₂-e/ unit)	N₂O (kg CO₂-e/ unit)
Private car default					
Petrol	km	0.252	0.241	0.00317	0.00728
Diesel	km	0.268	0.264	0.0004	0.00374
Petrol hybrid	km	0.199	0.191	0.00250	0.00575
Diesel hybrid	km	0.241	0.237	0.0004	0.00335
PHEV (Petrol) – Petrol consumption	km	0.0922	0.0884	0.00116	0.00266
PHEV (Petrol) – Electricity consumption	km	0.00953	0.00926	0.0002	0.00002
PHEV (Diesel) – Diesel consumption	km	0.112	0.110	0.0002	0.00155
PHEV (Diesel) – Electricity consumption	km	0.00957	0.00930	0.0003	0.00002
Electric	km	0.0200	0.0194	0.0005	0.00004

Notes: These numbers are rounded to three decimal places unless the number is significantly small.

Defaults are based on the average age of the vehicle fleet (pre-2010 for petrol and diesel including hybrids, and 2010–2015 for all plug-in cars) and most common engine size (2000–3000 cc). Source: MoT

Table 21: **Default rental car emission factors per km travelled**

Emission source category	Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/ unit)	CH₄ (kg CO₂-e/ unit)	N₂O (kg CO₂-e/ unit)
Rental car default					
Petrol	km	0.186	0.178	0.00234	0.00537
Diesel	km	0.181	0.179	0.0003	0.00252
Petrol hybrid	km	0.147	0.140	0.00185	0.00424
Diesel hybrid	km	0.160	0.158	0.0002	0.00223
PHEV (Petrol) – Petrol consumption	km	0.0767	0.0735	0.0010	0.00222
PHEV (Petrol) – Electricity consumption	km	0.00810	0.00787	0.0002	0.00002
PHEV (Diesel) – Diesel consumption	km	0.0839	0.0826	0.0001	0.00117
PHEV (Diesel) – Electricity consumption	km	0.00798	0.00775	0.0002	0.00002
Electric	km	0.0170	0.0165	0.0004	0.00004

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Defaults assume a post-2015 fleet for rental cars and engine size of 1600 – <2000 cc.

We were unable to source more up-to-date data on the New Zealand taxi fleet to produce a representative vehicle type for the taxi (regular) factor. Therefore, this factor is derived from an average of the factors for a petrol, diesel, petrol plug-in hybrid and electric vehicle, for a 2000–3000 cc vehicle class. These workings are in table 24.

Table 22:   Emission factors for taxi travel

Emission source category	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/ unit)	CH_4 (kg CO_2-e/ unit)	N_2O (kg CO_2-e/ unit)
Taxi travel					
Regular	km	0.164	0.159	0.00148	0.00373
Regular – dollars spent	$	0.0514	0.0497	0.0005	0.00116
Petrol hybrid	km	0.176	0.169	0.00222	0.00509
Petrol hybrid – dollars spent	$	0.0550	0.0528	0.0007	0.00159
Electric	km	0.0200	0.0194	0.0005	0.00004
Electric – dollars spent	$	0.00625	0.00607	0.0002	0.00001

Note: These numbers are rounded to three decimal places unless the number is significantly small.

7.2.1. GHG inventory development

Organisations should gather the activity data on passenger vehicle use with as much detail as possible, including age of the vehicle, engine size, fuel type and kilometres travelled. If information is not available, we provide conservative defaults to allow for overestimation rather than underestimation.

If fuel-use data are available, see section 3.3.

If fuel-use data are not available, collect data on kilometres travelled by vehicle type and multiply this by the emission factor based on distance travelled for each GHG. If the vehicle is electric and the charging point is within the organisation's boundaries, this is a direct (Scope 1) emission source and emissions are zero. If travel is by rideshare apps (ie, Uber, Zoomy or Ola), we recommend using the taxi travel emission factors by distance travelled (table 22). If this information is not available, use the taxi emission factors per dollars spent.

Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   distance travelled by vehicle type (km)
F   =   emission factors for correlating vehicle type from table 16 to table 22

PASSENGER VEHICLES: EXAMPLE CALCULATION

An organisation has 15 petrol vehicles. They use 40,000 litres of regular petrol in the reporting period.

CO_2 emissions	= 40,000 × 2.35	= 94,000 kg CO_2
CH_4 emissions	= 40,000 × 0.0309	= 1,236 kg CO_2-e
N_2O emissions	= 40,000 × 0.0710	= 2,840 kg CO_2-e
Total CO_2-e emissions	= 40,000 × 2.46	= 98,400 kg CO_2-e

> **PASSENGER VEHICLES: EXAMPLE CALCULATION**
>
> An organisation owns three pre-2010 petrol hybrid vehicles. They are all between 1600 and 2000 cc and travel a total of 37,800 km in the reporting period.
>
> | | | |
> |---|---|---|
> | CO_2 emissions | $= 37{,}800 \times 0.172$ | $= 6{,}501.6$ kg CO_2 |
> | CH_4 emissions | $= 37{,}800 \times 0.00225$ | $= 85.05$ kg CO_2-e |
> | N_2O emissions | $= 37{,}800 \times 0.00517$ | $= 195.4$ kg CO_2-e |
> | Total CO_2-e emissions | $= 37{,}800 \times 0.179$ | $= 6{,}766.2$ kg CO_2-e |
>
> An organisation uses petrol rental cars to travel 12,000 km. It also spends $18,000 on hybrid taxi travel.
>
> | | | |
> |---|---|---|
> | Total CO_2-e emissions from rental cars | $= 12{,}000 \times 0.186$ | $= 2{,}232$ kg CO_2-e |
> | Total CO_2-e emissions from hybrid taxi travel | $= \$18{,}000 \times 0.055$ | $= 990$ kg CO_2-e |
>
> Note: Numbers may not add due to rounding.

7.2.2. Emission factor derivation methodology

The 2021 fleet statistics were taken from the Te Manatū Waka Ministry of Transport Vehicle Fleet Emissions Model. This provides energy (fuel and electricity) use per 100 km travelled by vehicle.

We decided to split the fleet into three categories and develop average emission factors for these.

- Pre-2010 fleet is based on the average fuel consumption data from 1970 to 2010. We assume there are no electric vehicles or plug-in hybrid vehicles.

- 2010–2015 fleet is based on the average fuel consumption data from vehicles produced between 2010 and 2015.

- Post-2015 fleet is based on the average fuel consumption data from vehicles produced from 2016 onwards.

Note that some guidance documents, such as that published by the UK Government Department for Business, Energy and Industrial Strategy (UK BEIS) apply an uplift factor to passenger vehicles. This accounts for the real-world effects on fuel consumption, such as the use of air conditioning, vehicle payload, gradient and weather. We do not apply an uplift factor here, because the Vehicle Fleet Emissions Model is based on real-world driving and fuel use.

For each category, default vehicles are based on the 2000–3000 cc engine size, as it is the most common size for light passenger vehicles in New Zealand based on Motor Vehicle Register open data.[24]

Table 23 details the average fuel consumption rates for the vehicles.

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[24] Motor Vehicle Register: https://www.nzta.govt.nz/vehicles/how-the-motor-vehicle-register-affects-you/motor-vehicle-registrations-dashboard-and-open-data/.

Table 23:   Fuel consumption in litres per 100 km

Emission source	Units		Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
Petrol vehicle	<1350 cc	litres	7.922	7.021	6.490
	1350–<1600 cc	litres	8.199	7.266	6.717
	1600–<2000 cc	litres	9.232	8.181	7.563
	2000–<3000 cc	litres	10.254	9.087	8.401
	≥3000 cc	litres	12.267	10.871	10.050
Diesel vehicle	<1350 cc	litres	7.884	6.999	6.548
	1350–<1600 cc	litres	7.587	6.735	6.301
	1600–<2000 cc	litres	8.042	7.138	6.678
	2000–<3000 cc	litres	9.886	8.775	8.205
	≥3000 cc	litres	10.966	9.734	9.101
Petrol hybrid vehicle	<1350 cc	litres	6.254	5.543	5.122
	1350–<1600 cc	litres	6.473	5.736	5.301
	1600–<2000 cc	litres	7.288	6.459	5.969
	2000–<3000 cc	litres	8.095	7.174	6.630
	≥3000 cc	litres	9.6842	8.5823	7.9312
Diesel hybrid vehicle	<1350 cc	litres	7.0678	6.2636	5.7923
	1350–<1600 cc	litres	6.8015	6.0276	5.5741
	1600–<2000 cc	litres	7.209	6.389	5.908
	2000–<3000 cc	litres	8.862	7.854	7.263
	≥3000 cc	litres	9.831	8.712	8.057
Petrol plug-in hybrid electric vehicle (PHEV) – petrol consumption	<1350 cc	litres	3.273	2.901	2.681
	1350–<1600 cc	litres	3.387	3.002	2.774
	1600–<2000 cc	litres	3.814	3.380	3.124
	2000–<3000 cc	litres	4.237	3.755	3.470
	≥3000 cc	litres	5.068	4.491	4.151
Petrol plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	kWh	10.018	8.895	8.394
	1350–<1600 cc	kWh	10.368	9.206	8.687
	1600–<2000 cc	kWh	11.674	10.366	9.781
	2000–<3000 cc	kWh	12.967	11.514	10.864
	≥3000 cc	kWh	15.512	13.773	12.996
Diesel plug-in hybrid electric vehicle (PHEV) – diesel consumption	<1350 cc	litres	3.699	3.278	3.031
	1350–<1600 cc	litres	3.559	3.154	2.917
	1600–<2000 cc	litres	3.773	3.343	3.092
	2000–<3000 cc	litres	4.638	4.110	3.801
	≥3000 cc	litres	5.145	4.559	4.216
Diesel plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	kWh	10.927	9.702	9.155
	1350–<1600 cc	kWh	10.495	9.318	8.793
	1600–<2000 cc	kWh	11.499	10.210	9.634
	2000–<3000 cc	kWh	13.015	11.556	10.904
	≥3000 cc	kWh	15.393	13.668	12.897
Electric vehicle	<1350 cc	kWh	21.017	18.661	17.609
	1350–<1600 cc	kWh	21.751	19.313	18.224

Emission source		Units	Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
	1600–<2000 cc	kWh	24.491	21.746	20.520
	2000–<3000 cc	kWh	27.203	24.154	22.792
	≥3000 cc	kWh	32.542	28.895	27.265
Motorcycle	<60 cc, petrol	litres	2.780	2.465	2.301
	≥60 cc, petrol	litres	5.561	4.929	4.602
	<60 cc, electricity	kWh	5.137	4.588	4.488
	≥60 cc, electricity	kWh	10.274	9.177	8.976

Source: The Te Manatū Waka Ministry of Transport Vehicle Fleet Emissions Model.

The equation used to calculate the emission factor for each GHG is:

$$\frac{real\ world\ fuel\ consumption\ (litres) \times emission\ conversion\ factor}{100\ (km)}$$

Dividing by 100 gives a factor for litres (or kWh) per fuel per km. Use this with the fuel emission factors to calculate emissions per km.

Multiply the values for fuel consumption by the emission conversion factors in table 4.

NZTA vehicle registration data is unchanged from the 2022 Guidance, where the average year of manufacture for the taxi fleet was 2012, and 2015 for the rental fleet.[25] We assumed a 2010–2015 fleet for taxis and post-2015 fleet for rental cars.

The taxi (regular) factor is derived from an average of the factors for a petrol, diesel, petrol plug-in hybrid and electric vehicle, for a 2000–3000 cc vehicle class. These workings are in table 24.

Table 24:   **Data used for calculating the taxi (regular) emission factor**

Vehicle		Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/ unit)	CH_4 (kg CO_2-e/ unit)	N_2O (kg CO_2-e/ unit)
Petrol	2000–<3000 cc	km	0.223	0.214	0.0028	0.0065
Diesel	2000–<3000 cc	km	0.238	0.235	0.0004	0.0033
Petrol hybrid	2000–<3000 cc	km	0.176	0.169	0.0022	0.0051
Electric	2000–<3000 cc	km	0.0200	0.0194	0.0005	0.00004
Taxi (regular)	**Average**	**km**	**0.164**	**0.159**	**0.00148**	**0.00373**

Note: These numbers are rounded to three decimal places unless the number is significantly small.

TaxiCharge NZ Ltd advised that the current average price per kilometre[26] in a taxi is $3.20. North Island's average rate = $3.02, while South Island's average = $3.52.

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[25]   New Zealand Transport Agency: https://www.transport.govt.nz/assets/Uploads/Data/NZVehicleFleet.xlsx.

[26]   As per communications with TaxiCharge 2 February 2023.

The calculation to develop the emission factors for taxi based by $ spend is:

$$emissions\ per\ \$\ spend = \frac{emissions\ per\ km}{\$3.20\ per\ km}$$

Table 25 shows the fuel economy and emissions per kilometre figures used to derive the taxi regular factor.

Table 25: Figures used to derive the taxi regular factor

Emission source	Units	Units of energy consumed per 100 km	Emissions per km (kg CO₂-e)
Petrol vehicle	Litres	9.087	0.2231
Diesel vehicle	Litres	8.775	0.2382
Petrol hybrid	Litres	7.174	0.1761
Electric vehicle	kWh	24.154	0.0200
Taxi (regular)			**0.16633**

Note: These numbers are rounded to four decimal places unless the number is significantly small.

The private car default is based on the average age of light passenger vehicles in the New Zealand fleet, back-calculated to the year of manufacture, with the fuel consumption factors in table 23 applied.

According to Waka Kotahi NZ Transport Agency (NZTA) *The New Zealand 2020 Vehicle Fleet: Data Spreadsheet*, the average age of light passenger vehicles in 2021 was 14.79 years. This corresponds to a 2006 year of manufacture.

Furthermore, according to MoT[27] the most common size of light passenger vehicle is 2281 cc, which puts it in the 2000–3000 cc category. For hybrid and electric vehicles we assumed a >2015 fleet consumption for a 2000–3000 cc equivalent engine size.

Table 26: Energy consumption per 100 km for average light passenger vehicles

Engine type	Unit	Units per 100 km for a 2000–3000 cc engine
Petrol	litre	10.254
Diesel	litre	9.886
Petrol hybrid	litre	6.630
Diesel hybrid	litre	7.263
Petrol plug-in hybrid (petrol)	litre	3.470
Petrol plug-in hybrid (electricity)	kWh	10.864
Diesel plug-in hybrid (diesel)	litre	3.801
Diesel plug-in hybrid (electricity)	kWh	10.904
Electric	kWh	22.792

Note: These numbers are rounded to three decimal places unless the number is significantly small.

The default emission factor for rental cars is the same as for vehicles in the post-2015 1600–2000 cc category.

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[27] Te Manatū Waka Ministry of Transport:
https://www.transport.govt.nz/assets/Uploads/Data/NZVehicleFleet.xlsx.

7.2.3. Assumptions, limitations and uncertainties

Emission factors from fuel are multiplied by real-world consumption rates for vehicles with different engine sizes. The uncertainties embodied in these figures carry through to the emission factors. For petrol vehicles, we multiplied the real-world consumption by 'regular petrol' emission factors from the fuel emission source category. This may overestimate emissions for some and underestimate emissions for others.

According to MoT[28] the most common size of light passenger vehicle is 2281 cc, which puts it in the 2000–3000 cc category. Therefore, the default emission factors (for vehicles of unknown engine size) are the same as for a <3000 cc vehicle.

The Vehicle Fleet Emissions Model contains uncertainties about the fuel consumption figures provided. Emission factors represent the average fuel consumption of vehicles operating in the real world under different driving conditions, across all vehicle types in that classification.

We assume there are no electric cars or hybrids in the pre-2010 fleet.

7.3. Public transport passenger travel

The emission factors for public transport for passenger travel on buses and trains were not updated this year, as no new datasets were available. The unit used for these emission sources are passenger kilometres (pkm).

Data was sourced from NZTA and KiwiRail for the 2020 calendar year.

Table 27:   Emission factors for public transport

Emission source		Unit	kg CO_2-e/unit	CO_2 (kg CO_2 e/ unit)	CH_4 (kg CO_2-e/ unit)	N_2O (kg CO_2-e/ unit)
Bus	National average for bus	pkm	0.155	0.153	0.0001	0.00213
	Electric	pkm	0.0124	0.0120	0.0004	0.00002
	Diesel	pkm	0.0600	0.0600	0.00005	0.0009
	Average bus	pkm	0.0363	0.0360	0.0001	0.0001
Rail	Metropolitan electric	pkm	0.0130	0.0130	0.00001	0.0000001
	Metropolitan diesel	pkm	0.0460	0.0450	0.00006	0.0007
	Metropolitan average	pkm	0.0190	0.0190	0.00002	0.0001

7.3.1. GHG inventory development

To calculate public transport passenger emissions, collect data on the type of transport and distance travelled, and multiply this by the emission factors for each gas. Organisations could conduct a staff travel survey to quantify these emissions.[29]

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[28]   Te Manatū Waka Ministry of Transport:
https://www.transport.govt.nz/assets/Uploads/Data/NZVehicleFleet.xlsx.

[29]   GHG Protocol Technical Guidance for Calculating Scope 3 Emissions:
https://ghgprotocol.org/sites/default/files/standards_supporting/Chapter6.pdf.

Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year

Q   =   distance travelled, by vehicle type (km)

F   =   emission factors for correlating vehicle type, from table 27

PASSENGER BUS: EXAMPLE CALCULATION

An employee takes a return trip on an electric Wellington bus from the CBD to the airport (9.4 km each way). This happens five times in the reporting year

Passenger kilometres travelled = 2 trips × 9.4 km x 5 times = 94 pkm

CO_2 emissions	= 94 x 0.012	= 1.128 kg CO_2
CH_4 emissions	= 94 x 0.0004	= 0.0376 kg CO_2-e
N_2O emissions	= 94 x 0.00002	= 0.00188 kg CO_2-e
Total CO_2-e emissions from passenger public travel = 94 x 0.0124		= 1.17 kg CO_2-e

Note: Numbers may not add due to rounding.

7.3.2. Emission factor derivation methodology

7.3.2.1. National average bus

To calculate the emission factor for national average bus travel we used the NZTA passenger travel data[30] (table 28) to estimate the national average loading capacity of seven people per bus.

Table 28:   National bus passenger kilometres in 2020/21

Region	Mode	Breakdown	2020/21
NZ	Bus	pkm	534,976,704
NZ	Bus	Service km	122,934,050

The passenger loading per bus for the different regions for 2020/21 is shown in table 29.

Table 29:   National bus passenger loading by region

Region	Unit	End Use
National average	Passenger/bus	7
Auckland	Passenger/bus	7
Bay of Plenty	Passenger/bus	3
Canterbury	Passenger/bus	*Missing data*
Gisborne	Passenger/bus	8
Hawkes Bay	Passenger/bus	1
Manawatū-Whanganui	Passenger/bus	5
Marlborough-Nelson-Tasman	Passenger/bus	6
Northland	Passenger/bus	8
Otago	Passenger/bus	*Missing data*

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[30]   NZTA Passenger data, accessed September 2020, online at: www.nzta.govt.nz/assets/userfiles/transport-data/PTPerformance.xlsx.

Region	Unit	End Use
Southland	Passenger/bus	3
Taranaki	Passenger/bus	12
Waikato	Passenger/bus	4
Wellington	Passenger/bus	20

We then divided the per km emission factor for diesel buses in table 28 by the national passenger/bus loading rate to give the emissions per gas - see table 34.

Table 30: **Emission factor for national average bus**

Bus type	Class	Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/ unit)	CH$_4$ (kg CO$_2$-e/ unit)	N$_2$O (kg CO$_2$-e/ unit)
National average bus	Diesel bus (≥12000 kg)	km	1.088	1.070	0.001	0.017

Note: These numbers are rounded to three decimal places unless the number is significantly small. Based on 2020 data.

7.3.2.2. Wellington buses

To calculate the emissions from Wellington buses we used the most recent data available which was from the year 2020. This information was from Greater Wellington Regional Council. Data for electric buses is in table 31 and data for diesel buses is in table 32.

Table 31: **Greater Wellington Regional Council 2020 data for electric buses**

Wellington electric Buses	Distance (km)	Electric bus average power (kWh/km)	Electricity consumption	pkm
Double decker	431,928	1.3	561,506	4,630,752
Single decker	12,143	1.06	12,872	67,610

Table 32: **Greater Wellington Regional Council 2020 data for diesel buses**

Wellington diesel buses	Fuel consumption (litres)	pkm
Diesel buses	5,601,529	102,013,687

The energy consumption was multiplied by its respective emission factors and divided by the pkm to provide the emission factor. This was calculated using 2018 electricity data.

The average for Wellington was calculated by adding the total pkm and the total GHGs.

7.3.2.3. Wellington trains

To calculate the emissions from Wellington trains we used the most recent data available which was from the year 2021. The energy consumption data in table 33 is from KiwiRail and the passenger kilometres data is from Metlink.

Table 33:   **Wellington train data**

Metro commuter rail	Units	2020	pkm
Electric (Wellington)	kWh	23,242,017	190,659,149
Diesel (Wellington)	litres	699,773	40,765,152

Note: no data has been used from the Palmerston North to Wellington commuter line. For diesel, calculations are based solely on the Wairarapa line.

The energy consumption was multiplied by its respective emission factors (table 9 and table 4) and divided by the pkm to provide the emission factor. This was calculated using 2021 electricity data.

The average was calculated by adding the total pkms and the total GHGs for both the electric and diesel commuter lines.

(total diesel GHG + total electric GHG)/ (diesel pkm + electric pkm)

7.3.3. Assumptions, limitations and uncertainties

Limited data is available for regions outside the Greater Wellington Region. These metro commuter rail emission factors are assumed to be appropriate for use on any commuter rail line in New Zealand.

In most instances the National Average for Bus emission factor is the most appropriate to use. If taking public transport in Auckland or Wellington, we recommend using the Wellington bus data.

7.4. Public transport vehicles

Public transport vehicle emissions include those from buses. Emissions are calculated for the whole vehicle. This approach is appropriate for transport operators or if a bus is chartered. Table 34 details these emission factors.

Buses: We calculated the emissions of different buses using Te Manatū Waka Ministry of Transport Vehicle Fleet Emissions Model data for fuel consumption in litres per 100 kilometres. The guide presents the data in emissions per kilometre.

There are no changes to the data from the previous edition of this guide. The data used is from 2019.

Table 35 details the data provided to calculate the emission conversion factors.

Table 34:   **Bus emission factors per km travelled**

Emission source		Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/ unit)	CH$_4$ (kg CO$_2$-e/ unit)	N$_2$O (kg CO$_2$-e/ unit)
Diesel bus	<7500 kg	km	0.567	0.557	0.0007	0.00888
	7500 - 12000 kg	km	0.785	0.772	0.00103	0.0123
	≥12000 kg	km	1.09	1.07	0.00143	0.0170
Diesel hybrid bus	<7500 kg	km	0.401	0.394	0.0005	0.00628
	7500 - 12000 kg	km	0.556	0.546	0.0007	0.00870

Emission source		Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/ unit)	CH$_4$ (kg CO$_2$-e/ unit)	N$_2$O (kg CO$_2$-e/ unit)
	≥12000 kg	km	0.770	0.757	0.00101	0.0121
Electric bus	<7500 kg	km	0.0552	0.0530	0.00211	0.00008
	7500 - 12000 kg	km	0.0765	0.0735	0.00292	0.0001
	≥12000 kg	km	0.106	0.102	0.00405	0.0001

7.4.1. GHG inventory development

To calculate public transport emissions, collect data on the type of transport and distance travelled, and multiply this by the emission factors for each gas. Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO$_2$-e per year
Q = distance travelled, by vehicle type (km)
F = emission factors for correlating vehicle type, from table 34

DIESEL BUS: EXAMPLE CALCULATION

An organisation charters a diesel bus (<7,500 kg) to travel 500 km. The emissions would be:

CO$_2$ emissions = 500 x 0.557 = 278.5 kg CO$_2$
CH$_4$ emissions = 500 x 0.0007 = 0.35 kg CO$_2$-e
N$_2$O emissions = 500 x 0.00888 = 4.44 kg CO$_2$-e
Total CO$_2$-e emissions from bus travel = 500 km x 0.567 = 283.5 kg CO$_2$-e

This result is for the entire bus.

Note: Numbers may not add due to rounding.

7.4.2. Emission factor derivation methodology

The average age of the bus fleet is 16.4 years (according to Te Manatū Waka Ministry of Transport fleet statistics). Therefore, we applied an average fuel consumption factor for a pre-2010 fleet to the bus fleet from the 2019 Vehicle Fleet Emissions Model.

Table 35:   **Fuel/energy consumption per 100 km for pre-2010 fleet buses**

Emission source		Unit	Pre-2010 units of energy per 100 km
Diesel bus	<7,500 kg	litre	21.043
	<12,000 kg	litre	29.147
	≥12,000 kg	litre	40.397
Diesel hybrid bus	<7,500 kg	litre	14.891
	<12,000 kg	litre	20.626
	≥12,000 kg	litre	28.587
Electric bus	<7,500 kg	kWh	8.690
	<12,000 kg	kWh	12.037
	≥12,000 kg	kWh	16.682

Note: These numbers are rounded to three decimal places.

Using the information in table 35 and appropriate emission factor, the equation is:

$$\frac{energy\ consumption}{100\ (km)} \times emission\ factor = greenhouse\ gas\ emissions\ per\ km$$

Where:

- fuel/energy consumption = units of energy per 100 km travelled

- emission factor = the emission factor from table 4 or table 9

This allows you to use distance travelled as a unit for calculating emissions. If there are data on the quantity of fuel used, refer to transport fuel emission factors.

7.4.3. Assumptions, limitations and uncertainties

The Vehicle Fleet Emissions Model historical year results have been carefully calibrated to give a total road fuel use that matches MBIE's road fuel sales figures. The sources used to develop these emission factors will have inbuilt assumptions, limitations and uncertainties. To investigate these, see the documents referenced.

7.5. Air travel

This section covers emission factors for domestic and international air travel for organisations seeking to determine the emissions from business travel.

7.5.1. Overview of changes since previous update

The domestic air travel factors have been replicated from the 2022 edition of the guidance due to incomplete data that affected some of the more recent data. As such, the AR4 values for aviation fuel have been retained, which aligns with the international air travel factors.

7.5.2. Domestic air travel

This section provides emission factors based on data from 2020. Domestic air travel is a common source of indirect (Scope 3) emissions for many New Zealand organisations.

For air travel emission factors, multipliers or other corrections may be applied to account for the radiative forcing of emissions arising from aircraft transport at altitude (jet aircraft). Radiative forcing helps organisations account for the wider climate effects of aviation, including water vapour and indirect GHGs. This is an area of active research and uncertainty, aiming to express the relationship between emissions and the climate warming effects of aviation, but there is yet to be consensus on this aspect.

In this guidance, emission factors with a radiative forcing multiplier refers to the indirect climate change effects (non-CO_2 emissions eg, water vapour, contrails, NOx). Emission factors without a radiative forcing multiplier refers to the direct climate change effects (CO_2, CH_4 and N_2O). If multipliers are applied, organisations should disclose the specific factor used including its source and produce comparable reporting. Therefore, avoid reporting with air travel conversion factors in one year and without in another year, as this may skew the interpretation of your reporting.

In terms of small aircraft, a radiative forcing multiplier may not be required given the lower altitude at which these aircrafts typically fly. However, these emission factors are provided in the tables below for completeness, and for users wanting to take a conservative approach to their reporting.

Table 36 provides the emission factors without the radiative forcing multiplier applied. Table 37 provides emission factors with a radiative forcing multiplier of 1.9 applied.[31, 32]

Table 36: **Domestic air travel emission factors without a radiative forcing multiplier**

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
National average	pkm	0.164	0.158	0.0011	0.0044
Large aircraft	pkm	0.097	0.093	0.0007	0.0026
Medium aircraft	pkm	0.128	0.124	0.0009	0.0034
Small aircraft	pkm	0.352	0.341	0.0029	0.0090

Note: These numbers are rounded to three decimal places unless the number is significantly small. Based on 2020 data.

Table 37: **Domestic aviation emission factors with a radiative forcing multiplier**

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
National average	pkm	0.306	0.300	0.0011	0.0044
Large aircraft	pkm	0.180	0.177	0.0007	0.0026
Medium aircraft	pkm	0.239	0.235	0.0009	0.0034
Small aircraft	pkm	0.670	0.647	0.0055	0.0172

Note: These numbers are rounded to three decimal places unless the number is significantly small. Based on 2020 data.

We have provided a national average emission factor, and three factors based on the aircraft size: large, medium or small aircraft. A large aircraft in New Zealand would be an Airbus A320, A320neo, A321neo, and A320ceo Domestic. A medium aircraft has between 50 and 70 seats (ie, regional services on an ATR 72 or de Havilland Q300) and a small aircraft has less than 50 seats. If the aircraft type is unknown, we recommend using the national average.

7.5.2.1. GHG inventory development

To calculate emissions for domestic air travel, collect information on passengers flying, their departure and destination airports, and if practical, the size of the aircraft. If the type of aircraft is unknown, use the national average emission factors. Calculate distances using online calculators such as www.airmilescalculator.com. Multiply the number of passengers by the distance travelled to obtain the pkm.

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[31] R Sausen et al. (2005). Aviation radiative forcing in 2000: An update on IPCC (1999) *Meteorologische Zeitschrift* 14: 555-561, available at: https://core.ac.uk/download/pdf/357569099.pdf

[32] CCC (2009). Meeting the UK Aviation Target – Options for Reducing Emissions to 2050: www.theccc.org.uk/publication/meeting-the-uk-aviation-target-options-for-reducing-emissions-to-2050/.

Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO_2-e per year
Q = passengers multiplied by distance flown (pkm)
F = emission factors from table 36 to table 37.

DOMESTIC AIR TRAVEL: EXAMPLE CALCULATION

An organisation flies an employee on a return flight from Christchurch to Wellington (304 km each way). This happens five times in the reporting year on an aircraft of unknown size. The national average emission factor with radiative forcing is used.

Passenger kilometres travelled = (2 × 304) × 5 = 3,040 pkm

Total CO_2-e emissions from domestic air travel = 0.306 x 3,040 = 930.24 kg CO_2-e

Note: Numbers may not add due to rounding.

7.5.2.2. Emission factor derivation methodology

We developed these emission factors with data supplied by Air New Zealand and Te Manatū Waka Ministry of Transport. We calculated an average emission factor for domestic air travel using data from the 2020 calendar years, supplemented with data from 2016.

Table 38 details the types of aircraft running domestic flights, using Air New Zealand data and 2016 Te Manatū Waka Ministry of Transport data to calculate the emission factors.

An average emissions factor has also been provided where the aircraft type is unknown (see tables 36 and 37). Organisations that own aircraft could calculate emissions based on the fuel consumption data.

Table 38:   Domestic aviation data (2020)

Aircraft type	Total seats per flight	Average distance per flight (km)	Total fuel used (kg)	Total flights
Airbus A320*	181	674.16	56,638,617	18,140.75
Aerospatiale/Alenia ATR 72*	68	389.51	35,187,553.59	47,183
British Aerospace Jetstream 32	19	167.78	94,556.00	324
Beechcraft Beech 1900D	19	250.73	2,152,521.40	6,277
Cessna Light Aircraft	6	95.87	1,199,632.30	9,791
De Havilland Canada DHC-8-300 Dash 8/8Q, Q300*	50	313.40	40,934,925.25	53,991
Pilatus PC-12	9	300.72	847,901.49	4,315
Saab SF-340	34	479.70	407,373.70	668
FOKKER F50	53	631.55	12,890.19	11

Note: * Average calculated using data from 2016 and 2020.

To calculate the emission factor, first calculate average fuel (kg) per flight for each aircraft:

$$\frac{average\ total\ fuel\ used\ (kg)}{average\ number\ of\ flights}$$

Then calculate average fuel (kg) per passenger:

$$\frac{average\ fuel\ (kg)\ per\ flight}{average\ seats \times 0.8}$$

Using this, next calculate fuel per passenger per km:

$$\frac{average\ fuel\ (kg)\ per\ passenger}{average\ flight\ distance}$$

The density of kerosene (the assumed aviation fuel) is 0.79 kg/l.[33]

Emission factors for each aircraft were determined by multiplying the fuel (litres) per passenger per kilometre by the kerosene (aviation fuel) emission factor in table 4.

A national average was then calculated using the share of total flights to weight the contributions of each aircraft type.

We then calculated a weighted average emission factor for each size category, using the aircraft types within that size range:

- large aircraft: A320neo, A321neo, A320ceo Domestic

- medium aircraft: ATR 72, De Havilland Canada DHC-8-300 Dash 8/8Q, Q300, FOKKER F50

- small aircraft: British Aerospace Jetstream 32, Cessna Light Aircraft, Pilatus PC-12, Beechcraft Beech 1900D, Saab SF-340

Table 39:   Calculated emissions, without the radiative forcing multiplier, per aircraft type

Aircraft type	Unit	kg CO_2-e/unit	kg CO_2/unit (kg CO_2-e)	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)
Airbus A320*	pkm	0.090	0.087	0.001	0.002
Aerospatiale/Alenia ATR 72*	pkm	0.093	0.090	0.001	0.003
British Aerospace Jetstream 32	pkm	0.237	0.229	0.002	0.006
Beechcraft Beech 1900D	pkm	0.186	0.180	0.002	0.005
Cessna Light Aircraft	pkm	0.552	0.534	0.004	0.014
De Havilland Canada DHC-8-300 Dash 8/8Q*	pkm	0.145	0.140	0.001	0.004

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[33]   Kerosene (ils.co.nz).

Aircraft type	Unit	kg CO₂-e/unit	kg CO₂/unit (kg CO₂-e)	kg CH₄/unit (kg CO₂-e)	kg N₂O/unit (kg CO₂-e)
Pilatus PC-12	pkm	0.188	0.182	0.002	0.005
Saab SF-340	pkm	0.097	0.094	0.001	0.002
FOKKER F50	pkm	0.091	0.088	0.001	0.002

Note: These numbers are rounded to three decimal places unless the number is significantly small. 2020 data unless denoted otherwise. * Average calculated using data from 2016 and 2020.

Table 40: **Calculated emissions, with the radiative forcing multiplier, per aircraft type**

Aircraft type	Unit	kg CO₂-e/unit	kg CO₂/unit (kg CO₂-e)	kg CH₄/unit (kg CO₂-e)	kg N₂O/unit (kg CO₂-e)
Airbus A320*	pkm	0.168	0.165	0.001	0.002
Aerospatiale/Alenia ATR 72*	pkm	0.174	0.171	0.001	0.003
British Aerospace Jetstream 32	pkm	0.450	0.435	0.004	0.011
Beechcraft Beech 1900D	pkm	0.353	0.342	0.004	0.010
Cessna Light Aircraft	pkm	1.049	1.015	0.008	0.027
De Havilland Canada DHC-8-300 Dash 8/8Q, Q300*	pkm	0.270	0.266	0.001	0.003
Pilatus PC-12	pkm	0.357	0.346	0.004	0.010
Saab SF-340	pkm	0.184	0.179	0.002	0.004
FOKKER F50	pkm	0.173	0.167	0.002	0.004

Note: These numbers are rounded to three decimal places unless the number is significantly small. 2020 data unless denoted otherwise. * Average calculated using data from 2016 and 2020.

7.5.2.3. Assumptions, limitations and uncertainties

We assume the fuel for domestic flights is kerosene (aviation fuel) and all the kerosene is combusted. The domestic emission factors are based on fuel delivery data. Therefore, it is not necessary to apply a distance uplift factor to account for delays/circling and non-direct routes (ie, not along the straight-line/great-circle between destinations). However, this should be considered for international air travel.

7.5.3. International air travel

International air travel emission factors are sourced directly from the 2022 conversion factors from the UK Government Department for Business, Energy and Industrial Strategy (UK BEIS). Because these factors were unchanged from the BEIS 2021 edition, the factors in this guidance remain unchanged from the previous edition.

Organisations wishing to report their international air travel emissions based on distance travelled per passenger could use the International Civil Aviation Organisation (ICAO) calculator.[34] This calculator considers aircraft types and load factors for specific airline

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[34] International Civil Aviation Organisation Calculator, accessed via: www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx.

routes but does not apply the radiative forcing multiplier (accounting for the wider climate effect of emissions arising from aircraft transport at altitude) or distance uplift factor to account for delays/circling and non-direct routes (ie, not along the straight-line/great-circle between destinations). If using the ICAO calculator to calculate emissions for international air travel, multiply the output by 1.08 to account for the 8 per cent distance uplift factor (see section 7.5.3.3) and then by 1.9 to apply a radiative forcing multiplier.

If you prefer not to use the ICAO calculator, we recommend the emission factors in tables 41 and 42. These emission factors follow those published online by UK BIES conversion factors (*Conversion factors 2021: condensed set (for most users) – revised January 2022*) and include a distance uplift of 8 per cent, and a radiative forcing multiplier of 1.9.

Table 41:   **Emission factors for international air travel without radiative forcing multiplier**

Emission source	Travel class	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Short haul (<3700 km)	Average passenger	pkm	0.0812	0.0804	0.00001	0.0008
	Economy	pkm	0.0798	0.0791	0.00001	0.0008
	Business	pkm	0.120	0.119	0.00001	0.00112
Long haul (>3700 km)	Average passenger	pkm	0.102	0.101	0.00001	0.0010
	Economy	pkm	0.0782	0.0774	0.00001	0.0007
	Premium economy	pkm	0.125	0.124	0.00001	0.00117
	Business	pkm	0.227	0.225	0.00002	0.00212
	First	pkm	0.313	0.310	0.00002	0.00293

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Table 42:   **Emission factors for international air travel with radiative forcing multiplier**

Emission source	Travel class	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Short-haul (<3700 km)	Average passenger	pkm	0.154	0.153	0.00001	0.0008
	Economy	pkm	0.151	0.150	0.00001	0.0008
	Business	pkm	0.227	0.225	0.00001	0.00112
Long-haul (>3700 km)	Average passenger	pkm	0.193	0.192	0.00001	0.0010
	Economy	pkm	0.148	0.147	0.00001	0.0007
	Premium economy	pkm	0.237	0.235	0.00001	0.00117
	Business	pkm	0.429	0.427	0.00002	0.00212
	First class	pkm	0.591	0.589	0.00002	0.00293

The emission factors from the UK BEIS are calculated regarding the indirect and direct climate change effects. For continuity in this guidance, we have categorised the international air travel emission factors by whether a radiative forcing multiplier was applied, as outlined in this section. Further information can be found in paragraphs 8.37 - 8.41 in the UK BEIS *2022*

7.5.3.1. GHG inventory development

To calculate emissions for international air travel, gather the information on how far each passenger flew for each flight. Multiply this by the factors in table 41. Use the specified emission factors for different cabin classes if information is available. If unknown, use the average emission factors. Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO_2-e per year
Q = passengers multiplied by distance flown (pkm)
F = appropriate emission factors from table 41 or table 42

INTERNATIONAL AIR TRAVEL: EXAMPLE CALCULATION

An organisation makes five flights from Auckland to Shanghai (9,346 km each way). On the first trip, two people flew return to Shanghai on the same flight in economy class. On the second trip, three people flew return to Shanghai and the cabin classes were not recorded. Long-haul (>3,700 km) emission factors with radiative forcing are used.

For the two people who travel economy class:

Passenger kilometres travelled	= (2 × 9,346) × 2	= 37,384 pkm
Their CO_2-e emissions from air travel	= 37,384 × 0.148	= 5,532.8 kg CO_2-e

For the three people with unknown travel classes:

Passenger kilometres travelled	= (3 × 9,346) × 2	= 56,076 pkm
Their CO_2-e emissions from air travel	= 56,076 × 0.193	= 10,822.7 kg CO_2-e
Total CO_2-e emissions from international air travel	= 5,532.8 + 10,822.7	= 16,356 kg CO_2-e

Note: Numbers may not add due to rounding.

7.5.3.2. Emission factor derivation methodology

The UK BEIS emission factors publication discusses the methodology in more detail, including changes over time.

7.5.3.3. Assumptions, limitations and uncertainties

The emission factors in tables 41 and 42 are based on UK and European data. The short-haul emission factor applies to international flights of less than 3,700 km. The long-haul factor applies to flights of more than 3,700 km.

The UK BEIS endorses a great circle distance uplift factor to account for non-direct (ie, not along the straight-line/great-circle between destinations) routes and delays/circling. The 8 per cent uplift factor applied by UK BEIS is based on the analysis of flights arriving and departing from the UK. This figure is likely to be overstated for international flights to/from New Zealand (initial estimates from Airways New Zealand suggest it is likely to be less than 5 per cent). In the absence of a New Zealand-specific figure for international flights, we recommend an 8 per cent uplift factor. This conservative value comes from an IPCC publication, *Aviation and the Global Atmosphere* (refer to section 8.2.2.3) and is based on studies of penalties to air traffic associated with the European ATS Route Network. We recommend applying the 8 per cent uplift factor to international flight emission estimates from the ICAO calculator by multiplying the output by 1.09.

The emission factors refer to aviation's direct GHG emissions including carbon dioxide, methane and nitrous oxide. There is currently uncertainty over the other climate change impacts of aviation (including water vapour and indirect GHGs, among other factors), which the IPCC estimated to be up to two to four times those of carbon dioxide alone. However, the science is currently uncertain and *New Zealand's Greenhouse Gas Inventory 1990-2021* does not use a multiplier.

International travel is divided by class of travel. Emissions vary by class because they are based on the number of people on a flight. Business class passengers use more space and facilities than economy class travellers. If everyone flew business class, fewer people could fit on the flight and therefore emissions per person would be higher.

7.6. Helicopters

This section provides emission factors for some commonly used helicopters in New Zealand. Business activities that require the use of helicopters might include organisations involved in tourism, air transport, agricultural operations, or emergency services.

Table 43: **Emission factors for helicopters**

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/ unit)	CH_4 (kg CO_2-e/ unit)	N_2O (kg CO_2-e/ unit)
Eurocopter AS 350B Squirrel	hours	467	463	0.0901	3.41
Eurocopter AS 350B3 Squirrel	hours	483	479	0.0933	3.53
Robinson R44	hours	186	184	0.0372	1.41
Robinson R22 Beta	hours	129	128	0.0258	0.975
Bell 206B	hours	322	319	0.0621	2.35

7.6.1. GHG inventory development

These emission factors can be used where the amount of fuel used is not known. Obtaining fuel data will provide a more accurate estimate of your carbon emissions.

To calculate emissions from operating helicopters when only the number of operating hours is known. Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   hours of operating time (hours)
F   =   emission factors for correlating helicopter type, from table 43 above

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HELICOPTER USE: EXAMPLE CALCULATION

An agricultural operation used a Eurocopter AS 350B Squirrel to apply topdressing and other spraying activities. They could not obtain data on the amount of fuel used, but had recorded 10 flying hours over a given year.

CO_2 emissions	= 10 × 463	= 4,630 kg CO_2
CH_4 emissions	= 10 × 0.0901	= 0.901 kg CO_2-e
N_2O emissions	= 10 × 3.41	= 34.1 kg CO_2-e
Total CO_2-e emissions	= 10 × 467	= 4,670 kg CO_2-e

Note: Numbers may not add due to rounding.

7.6.2. Emission factor derivation methodology

These emission factors were derived from the Swiss Federal Office of Civil Aviation's (FOCA) *Guidance on the Determination of Helicopter Emissions*. This contains air emissions data (non-GHG) for one hour of flying time, including fuel consumption, for a range of helicopter models. The *one-hour emissions* values are used, which assume a combination of rotations and cruise per flight-hour.

The fuel consumption (provided in kgs) was converted to litres using assumed densities of 0.804 kg per litre and 0.690 kg per litre, for Jet A1 and aviation gas respectively. Turbine engine helicopters are assumed to use Jet A1 while piston helicopters are assumed to use aviation gas. We then applied the Jet A1 and aviation gas emission factors from Transport fuels section above to determine the emission factor for one hour of operation.

We used the aircraft register on the New Zealand Civil Aviation Authority (CAA) website[35] to identify the most commonly registered helicopter models in the country.

7.6.3. Assumptions, limitations and uncertainties

Obtaining the amount of fuel used for helicopter activities would provide a more accurate estimate of carbon emissions, than using this emission factor which is based on operating hours.

A number of factors will influence the accuracy of this emission factor for a given operating hour, such as the cruising speed, the take-off and approach, and the way the helicopter is being used.

Finally, if your organisation has a helicopter model that is not provided here, you may wish to choose the model that seems to be the best fit. However, this approach will have limitations, due to variations that include engine operating power, and the size and number of engines.

7.7. Accommodation

Accommodation is an indirect (Scope 3) emissions source. We obtained the emission factors for accommodation, see table 51, from the Cornell Hotel Sustainability Benchmarking Index (CHSB) Index 2021: Carbon Energy, and Water.[36] The CHSB data remains unchanged from the previous guidance, and the methodology has not been updated. However, we have applied the median emissions factor consistently in this guidance. In previous years the mean value has been used, so there is a change in some factors. This use of the median aligns with the UK BEIS factors from the same course data. The factors are in CO_2-e and are not available by gas type.

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[35] www.aviation.govt.nz/aircraft/aircraft-registration/aircraft-register-search/.

[36] Access the CHSB Index via: Hotel Sustainability Benchmarking Index 2021: Carbon, Energy, and Water (cornell.edu).

Table 44: **Accommodation emission factors by unit (room per night)**

Country	kg CO$_2$-e/unit
Argentina	50.0
Australia	38.9
Austria	11.9
Belgium	11.6
Brazil	14.9
Canada	17.1
Caribbean Region	61.1
Chile	30.8
China	60.7
Colombia	11.0
Costa Rica	7.0
Czech Republic	31.8
Egypt	54.0
Fiji	54.8
Finland	11.1
France	7.5
Germany	18.2
Greece	42.8
Hong Kong	66.2
Hungary	22.0
India	66.0
Indonesia	88.2
Ireland	23.9
Israel	51.8
Italy	23.9
Japan	54.7
Jordan	64.5
Kazakhstan	105.7
Macau	68.1
Malaysia	80.3
Maldives	176.5
Mexico	27.0
Morocco	104.0
Netherlands	21.2
New Zealand	9.4
Oman	117.3
Panama	23.7
Peru	29.9
Philippines	62.9
Poland	35.8
Portugal	27.2

Country	kg CO₂-e/unit
Qatar	104.9
Romania	25.5
Russian Federation	30.9
Saudi Arabia	112.5
Singapore	28.5
South Africa	56.6
South Korea	56.5
Spain	16.3
Switzerland	7.4
Thailand	55.9
Turkey	38.0
United Arab Emirates	95.9
United Kingdom	13.4
United States	19.8
Vietnam	49.2

Note: These numbers are rounded to one decimal place unless the number is small.

7.7.1. GHG inventory development

To calculate emissions from accommodation during business trips, collect data on the number of nights and the country stayed in. Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   rooms per night
F   =   emission factors for the country stayed in from table 44.

EXAMPLE CALCULATION

An organisation sends six people to a conference in Australia. They book three rooms for four nights.

> 3 rooms x 4 nights = 12
> Total CO_2-e emissions from the hotel stay = 12 x 38.9 kg CO_2-e/unit = 466.8 kg CO_2-e

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7.7.2. Assumptions, limitations and uncertainties

The CHSB Index document[37] outlines the limitations of the study and the dataset. These include:

- It is skewed towards upmarket and chain hotels. The results do not distinguish a property's facilities, with the exception of outsourced laundry services, which are taken into consideration. This means it is very difficult to compare two hotels since some may contain distinct attributes, (such as restaurants, fitness centres, swimming pool and spa) while others do not.

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[37]   Access the CHSB Index via: Hotel Sustainability Benchmarking Index 2021: Carbon, Energy, and Water (cornell.edu).

8. Freight transport emission factors

We provide emission factors for freighting goods (in tonne kilometres, tkm) and for the actual freight vehicles (in km). We provide freight vehicle emission factors (in km) for road light commercial and heavy goods vehicles (HGV). Users should note that these are average emission factors for certain vehicle categories of the New Zealand vehicle fleet. The actual emissions for a specific vehicle in a specific trip could be different.

8.1. Overview of changes since previous update

Rail freight emission factors have been updated since the 2022 guidance to align with source data from KiwiRail.

8.2. Road freight

Organisations freighting goods through third-party providers can categorise road freight emissions as indirect (Scope 3). We generated emission factors for freight vehicles (in km travelled) and an average emission factor for freighting goods by road in tonne kilometres (tkm). Where the organisation's goods are only part of the load, the tkm emission factor should be used as the way of allocating emissions between the different goods on the same truck. Downstream and upstream transportation and distribution can also be considered. Refer to the GHG Protocol.

Included in the road freight section are three emissions factors covering urban delivery heavy trucks, long haul heavy trucks and all trucks. Urban delivery heavy trucks include vans and road user charge (RUC) type 2 trucks such as those powered vehicles with two axles. Please note these trucks could carry trailers and most of their travel would be for urban delivery. Long haul heavy trucks include other RUC types such as those powered vehicles with three or more axles. Most of them would be used for relatively long-distance travel. The EF for 'all truck' should be used for a large fleet with a good mix of small and large trucks. Users should be aware that the emission behaviour of individual vehicles could vary largely.

Te Manatū Waka Ministry of Transport's Vehicle Fleet Emissions Model provided the real-world fuel consumption rates of the vehicle fleet. We decided to split the fleet into three categories and develop average emission factors for these.

- Pre-2010 fleet is based on the average fuel consumption data from 1970 to 2010. We assume there are no electric vehicles or diesel hybrids.

- 2010–2015 fleet is based on the average fuel consumption data from vehicles produced between 2010 and 2015.

- Post-2015 fleet is based on the average fuel consumption data from vehicles produced from 2015 onwards.

> **TONNE KILOMETRE (TKM)**
>
> A tkm is the distance travelled multiplied by the weight of freight carried by the LCV or HGV.
>
> For example, an HGV carrying 5 tonnes freight over 100 km has a tkm value of 500 tkm.
>
> The CO_2 emissions are calculated from these factors by multiplying the number of tkm the user has for the distance and weight of the goods being moved by the CO_2 conversion factor in the 'Freight workbook 2023' worksheet of the 2023 Interactive workbook for the relevant LCV or HGV class.

8.2.1. Light commercial vehicle emission factors

Table 45: Emission factors for light commercial vehicles manufactured pre-2010

Emission source		Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Petrol	<1350 cc	km	0.207	0.198	0.00261	0.00598
	1350–<1600 cc	km	0.222	0.213	0.00280	0.00642
	1600–<2000 cc	km	0.300	0.287	0.00378	0.00867
	2000–<3000 cc	km	0.317	0.304	0.00400	0.00917
	≥3000 cc	km	0.362	0.347	0.00456	0.0105
Diesel	<1350 cc	km	0.217	0.214	0.0003	0.00302
	1350–<1600 cc	km	0.209	0.206	0.0003	0.00291
	1600–<2000 cc	km	0.278	0.274	0.0004	0.00387
	2000–<3000 cc	km	0.298	0.294	0.0004	0.00415
	≥3000 cc	km	0.302	0.297	0.0004	0.00421
Petrol hybrid	<1350 cc	km	0.163	0.157	0.00206	0.00472
	1350–<1600 cc	km	0.175	0.168	0.00221	0.00507
	1600–<2000 cc	km	0.237	0.227	0.00298	0.00684
	2000–<3000 cc	km	0.250	0.240	0.00315	0.00724
	≥3000 cc	km	0.286	0.274	0.00360	0.00827
Diesel hybrid	<1350 cc	km	0.195	0.192	0.0003	0.00271
	1350–<1600 cc	km	0.187	0.184	0.0003	0.00261
	1600–<2000 cc	km	0.249	0.246	0.0004	0.00347
	2000–<3000 cc	km	0.267	0.263	0.0004	0.00372
	≥3000 cc	km	0.271	0.267	0.0004	0.00377

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Table 46: Emission factors for light commercial vehicles manufactured between 2010 and 2015

Emission source		Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Petrol	<1350 cc	km	0.195	0.187	0.00246	0.00564
	1350–<1600 cc	km	0.209	0.201	0.00264	0.00606
	1600–<2000 cc	km	0.283	0.271	0.00356	0.00817
	2000–<3000 cc	km	0.299	0.287	0.00377	0.00864
	≥3000 cc	km	0.341	0.327	0.00430	0.00987
Diesel	<1350 cc	km	0.200	0.197	0.0003	0.00279
	1350–<1600 cc	km	0.193	0.190	0.0003	0.00268

Emission source		Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/ unit)	CH$_4$ (kg CO$_2$-e/ unit)	N$_2$O (kg CO$_2$-e/ unit)
	1600–<2000 cc	km	0.256	0.252	0.0004	0.00357
	2000–<3000 cc	km	0.275	0.271	0.0004	0.00383
	≥3000 cc	km	0.278	0.274	0.0004	0.00387
Petrol hybrid	<1350 cc	km	0.154	0.148	0.00194	0.00445
	1350–<1600 cc	km	0.165	0.158	0.00208	0.00478
	1600–<2000 cc	km	0.223	0.214	0.00281	0.00645
	2000–<3000 cc	km	0.236	0.226	0.00297	0.00682
	≥3000 cc	km	0.269	0.258	0.00339	0.00779
Diesel hybrid	<1350 cc	km	0.179	0.177	0.0003	0.00250
	1350–<1600 cc	km	0.173	0.170	0.0003	0.00240
	1600 -<2000 cc	km	0.230	0.226	0.0003	0.00320
	2000–<3000 cc	km	0.247	0.243	0.0004	0.00343
	≥3000 cc	km	0.250	0.246	0.0004	0.00347
PHEV (Petrol) - Petrol consumption	<1350 cc	km	0.0806	0.0772	0.00102	0.00233
	1350–<1600 cc	km	0.0865	0.0829	0.00109	0.00250
	1600–<2000 cc	km	0.117	0.112	0.00147	0.00337
	2000–<3000 cc	km	0.123	0.118	0.00156	0.00357
	≥3000 cc	km	0.141	0.135	0.00178	0.00408
PHEV (Petrol) - Electricity consumption	<1350 cc	km	0.00835	0.00811	0.0002	0.00002
	1350–<1600 cc	km	0.00897	0.00871	0.0002	0.00002
	1600–<2000 cc	km	0.0101	0.00986	0.0003	0.00002
	2000–<3000 cc	km	0.0125	0.0121	0.0003	0.00003
	≥3000 cc	km	0.0146	0.0142	0.0004	0.00003
PHEV (Diesel) - Diesel consumption	<1350 cc	km	0.0939	0.0925	0.0001	0.00131
	1350–<1600 cc	km	0.0904	0.0890	0.0001	0.00126
	1600–<2000 cc	km	0.120	0.118	0.0002	0.00167
	2000–<3000 cc	km	0.129	0.127	0.0002	0.00180
	≥3000 cc	km	0.131	0.129	0.0002	0.00182
PHEV (Diesel) - Electricity consumption	<1350 cc	km	0.00848	0.00824	0.0002	0.00002
	1350–<1600 cc	km	0.00814	0.00791	0.0002	0.00002
	1600–<2000 cc	km	0.00892	0.00867	0.0002	0.00002
	2000–<3000 cc	km	0.0101	0.00981	0.0003	0.00002
	≥3000 cc	km	0.0119	0.0116	0.0003	0.00003
Electric vehicle	<1350 cc	km	0.0175	0.0170	0.0005	0.00004
	1350–<1600 cc	km	0.0188	0.0183	0.0005	0.00004
	1600–<2000 cc	km	0.0213	0.0207	0.0006	0.00005
	2000–<3000 cc	km	0.0262	0.0255	0.0007	0.00006
	≥3000 cc	km	0.0306	0.0298	0.0008	0.00007

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Table 47:   Emission factors for light commercial vehicles manufactured post-2015

Emission source		Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/ unit)	CH₄ (kg CO₂-e/ unit)	N₂O (kg CO₂-e/ unit)
Petrol	<1350 cc	km	0.184	0.176	0.00231	0.00531
	1350–<1600 cc	km	0.197	0.189	0.00248	0.00570
	1600–<2000 cc	km	0.266	0.255	0.00335	0.00769
	2000–<3000 cc	km	0.281	0.270	0.00354	0.00813
	≥3000 cc	km	0.321	0.308	0.00405	0.00929
Diesel	<1350 cc	km	0.190	0.187	0.0003	0.00265
	1350–<1600 cc	km	0.183	0.180	0.0003	0.00255
	1600–<2000 cc	km	0.244	0.240	0.0004	0.00339
	2000–<3000 cc	km	0.261	0.257	0.0004	0.00363
	≥3000 cc	km	0.264	0.260	0.0004	0.00368
Petrol hybrid	<1350 cc	km	0.144	0.138	0.00182	0.00417
	1350–<1600 cc	km	0.155	0.148	0.00195	0.00447
	1600–<2000 cc	km	0.209	0.200	0.00263	0.00604
	2000–<3000 cc	km	0.221	0.212	0.00278	0.00638
	≥3000 cc	km	0.252	0.242	0.00318	0.00729
Diesel hybrid	<1350 cc	km	0.171	0.168	0.0003	0.00238
	1350–<1600 cc	km	0.165	0.162	0.0002	0.00229
	1600–<2000 cc	km	0.219	0.216	0.0003	0.00305
	2000–<3000 cc	km	0.235	0.231	0.0003	0.00327
	≥3000 cc	km	0.238	0.234	0.0003	0.00331
PHEV (Petrol) – Petrol consumption	<1350 cc	km	0.0754	0.0723	0.0010	0.00218
	1350–<1600 cc	km	0.0810	0.0776	0.00102	0.00234
	1600–<2000 cc	km	0.109	0.105	0.00138	0.00316
	2000–<3000 cc	km	0.116	0.111	0.00146	0.00334
	≥3000 cc	km	0.132	0.126	0.00166	0.00382
PHEV (Petrol) – Electricity consumption	<1350 cc	km	0.00808	0.00785	0.0002	0.00002
	1350–<1600 cc	km	0.00868	0.00843	0.0002	0.00002
	1600–<2000 cc	km	0.00982	0.00954	0.0003	0.00002
	2000–<3000 cc	km	0.0121	0.0117	0.0003	0.00003
	≥3000 cc	km	0.0141	0.0137	0.0004	0.00003
PHEV (Diesel) - Diesel consumption	<1350 cc	km	0.0895	0.0881	0.0001	0.00125
	1350–<1600 cc	km	0.0861	0.0848	0.0001	0.00120
	1600–<2000 cc	km	0.115	0.113	0.0002	0.00160
	2000–<3000 cc	km	0.123	0.121	0.0002	0.00171
	≥3000 cc	km	0.124	0.123	0.0002	0.00173
PHEV (Diesel) – Electricity consumption	<1350 cc	km	0.00820	0.00797	0.0002	0.00002
	1350–<1600 cc	km	0.00787	0.00765	0.0002	0.00002
	1600–<2000 cc	km	0.00863	0.00838	0.0002	0.00002
	2000–<3000 cc	km	0.00976	0.00949	0.0003	0.00002

Emission source		Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/unit)	CH$_4$ (kg CO$_2$-e/unit)	N$_2$O (kg CO$_2$-e/unit)
	≥3000 cc	km	0.0115	0.0112	0.0003	0.00002
Electric vehicle	<1350 cc	km	0.0170	0.0165	0.0004	0.00004
	1350–<1600 cc	km	0.0182	0.0177	0.0005	0.00004
	1600–<2000 cc	km	0.0206	0.0200	0.0005	0.00004
	2000–<3000 cc	km	0.0254	0.0247	0.0007	0.00005
	≥3000 cc	km	0.0297	0.0288	0.0008	0.00006

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Table 48: Default light commercial vehicle values (based on pre-2010 fleet and a 2000–3000 cc engine size)

Emission source	Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/unit)	CH$_4$ (kg CO$_2$-e/unit)	N$_2$O (kg CO$_2$-e/unit)
Petrol	km	0.317	0.304	0.004	0.009
Diesel	km	0.298	0.294	0.000	0.004
Petrol hybrid	km	0.250	0.240	0.003	0.007
Diesel hybrid	km	0.267	0.263	0.000	0.004

Note: These numbers are rounded to three decimal places unless the number is significantly small.

8.2.2. Heavy goods vehicles emission factors

Table 49 contains the default emission factors for heavy goods vehicles, based on a pre-2010 fleet.

Table 49: Emission factors for heavy goods vehicles manufactured pre-2010

Emission source		Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/unit)	CH$_4$ (kg CO$_2$-e/unit)	N$_2$O (kg CO$_2$-e/unit)
HGV diesel	< 5,000 kg	km	0.450	0.443	0.0007	0.00626
	5,000–7,500 kg	km	0.515	0.507	0.0008	0.00717
	7,500–10,000 kg	km	0.630	0.620	0.0009	0.00877
	10,000–12,000 kg	km	0.747	0.735	0.00110	0.0104
	12,000–15,000 kg	km	0.849	0.836	0.00125	0.0118
	15,000–20,000 kg	km	0.991	0.976	0.00146	0.0138
	20,000–25,000 kg	km	1.32	1.30	0.00194	0.0184
	25,000–30,000 kg	km	1.56	1.53	0.00229	0.0216
	≥30,000 kg	km	1.56	1.53	0.00229	0.0216
HGV diesel hybrid	<5,000 kg	km	0.362	0.357	0.0005	0.00505
	5,000–7,500 kg	km	0.415	0.409	0.0006	0.00578
	7,500–10,000 kg	km	0.508	0.500	0.0007	0.00707
	10,000–12,000 kg	km	0.602	0.593	0.0009	0.00838
	12,000–15,000 kg	km	0.684	0.673	0.00101	0.00952
	15,000–20,000 kg	km	0.901	0.887	0.00133	0.0125
	20,000–25,000 kg	km	1.20	1.18	0.00176	0.0167
	25,000–30,000 kg	km	1.39	1.36	0.00204	0.0193
	≥30,000 kg	km	1.46	1.44	0.00215	0.0203

Table 50 contains the default emission factors for heavy goods vehicles, based on a 2010–2015 fleet.

Table 50: **Emission factors for heavy goods vehicles manufactured between 2010 and 2015**

Emission source		Unit	kg CO₂-e/unit	CO_2 (kg CO₂-e/unit)	CH_4 (kg CO₂-e/unit)	N_2O (kg CO₂-e/unit)
HGV diesel	<5,000 kg	km	0.427	0.420	0.0006	0.00594
	5,000–7,500 kg	km	0.489	0.481	0.0007	0.00681
	7,500–10,000 kg	km	0.598	0.588	0.0009	0.00832
	10,000–12,000 kg	km	0.706	0.695	0.00104	0.00983
	12,000–15,000 kg	km	0.805	0.793	0.00118	0.0112
	15,000–20,000 kg	km	0.966	0.951	0.00142	0.0135
	20,000–25,000 kg	km	1.29	1.27	0.00189	0.0179
	25,000–30,000 kg	km	1.44	1.41	0.00211	0.0200
	≥30,000 kg	km	1.51	1.49	0.00223	0.0211
HGV diesel hybrid	<5,000 kg	km	0.343	0.338	0.0005	0.00478
	5,000–7,500 kg	km	0.394	0.388	0.0006	0.00548
	7,500–10,000 kg	km	0.481	0.474	0.0007	0.00670
	10,000–12,000 kg	km	0.570	0.562	0.0008	0.00794
	12,000–15,000 kg	km	0.648	0.638	0.0010	0.00902
	15,000–20,000 kg	km	0.878	0.865	0.00129	0.0122
	20,000–25,000 kg	km	1.17	1.15	0.00172	0.0163
	25,000–30,000 kg	km	1.35	1.33	0.00199	0.0188
	≥30,000 kg	km	1.42	1.40	0.00209	0.0198
HGV BEV	<5,000 kg	km	0.0367	0.0357	0.0010	0.00008
	5,000–7,500 kg	km	0.0421	0.0409	0.00110	0.00009
	7,500–10,000 kg	km	0.0515	0.0500	0.00135	0.0001
	10,000–12,000 kg	km	0.0610	0.0593	0.00160	0.0001
	12,000–15,000 kg	km	0.0693	0.0674	0.00181	0.0001

Table 51 contains the default emission factors for heavy goods vehicles, based on a post-2015 fleet.

Table 51: **Emission factors for heavy goods vehicles manufactured post-2015**

Emission source		Unit	kg CO₂-e/unit	CO_2 (kg CO₂-e/unit)	CH_4 (kg CO₂-e/unit)	N_2O (kg CO₂-e/unit)
HGV diesel	<5,000 kg	km	0.425	0.419	0.0006	0.00592
	5,000–7,500 kg	km	0.481	0.474	0.0007	0.00670
	7,500–10,000 kg	km	0.589	0.580	0.0009	0.00819
	10,000–12,000 kg	km	0.698	0.687	0.00103	0.00972
	12,000–15,000 kg	km	0.793	0.781	0.00117	0.0110
	15,000–20,000 kg	km	0.964	0.949	0.00142	0.0134
	20,000–25,000 kg	km	1.28	1.26	0.00189	0.0179
	25,000–30,000 kg	km	1.43	1.41	0.00211	0.0199
	≥30,000 kg	km	1.51	1.49	0.00222	0.0210

Emission source		Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/ unit)	CH_4 (kg CO_2-e/ unit)	N_2O (kg CO_2-e/ unit)
HGV diesel hybrid	<5,000 kg	km	0.335	0.330	0.0005	0.00466
	5,000–7,500 kg	km	0.384	0.378	0.0006	0.00534
	7,500–10,000 kg	km	0.469	0.462	0.0007	0.00653
	10,000–12,000 kg	km	0.557	0.548	0.0008	0.00775
	12,000–15,000 kg	km	0.633	0.623	0.0009	0.00881
	15,000–20,000 kg	km	0.876	0.863	0.00129	0.0122
	20,000–25,000 kg	km	1.17	1.15	0.00172	0.0162
	25,000–30,000 kg	km	1.35	1.33	0.00198	0.0187
	≥30,000 kg	km	1.42	1.40	0.00209	0.0198
HGV BEV	<5,000 kg	km	0.0359	0.0349	0.0009	0.00008
	5,000–7,500 kg	km	0.0412	0.0400	0.00108	0.00009
	7,500–10,000 kg	km	0.0503	0.0489	0.00132	0.0001
	10,000–12,000 kg	km	0.0678	0.0659	0.00177	0.0001
	12,000–15,000 kg	km	0.0761	0.0740	0.00199	0.0002

Table 52 contains the default emission factors for heavy goods vehicles, based on a pre-2010 fleet and a gross vehicle mass of <7500 kg.

Table 52: **Default emission factors for heavy goods vehicles**

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
HGV Diesel	km	0.482	0.475	0.0007	0.00671
HGV Diesel hybrid	km	0.389	0.383	0.0006	0.00541

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Table 53 contains emission factors for freighting goods.

The tkm emission factor should be used where there is a mixed consignment on the same truck.

Table 53: **Emission factors for freighting goods by road**

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/ unit)	CH_4 (kg CO_2-e/ unit)	N_2O (kg CO_2-e/ unit)
Long-haul heavy truck	tkm	0.105	0.103	0.0001	0.00165
Urban delivery heavy truck	tkm	0.390	0.383	0.0005	0.00612
All trucks	tkm	0.135	0.133	0.0002	0.00212

Note: These numbers are rounded to three decimal places unless the number is significantly small.

8.2.3. GHG inventory development

If an organisation uses freight vehicles, they can calculate the emissions from the kilometres travelled. Multiply the distances by the emission factors in tables 45 to 53. Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO_2-e per year
Q = km travelled by specific freight vehicle one way
F = appropriate emission factors from tables 45 to 53

For emissions from freighting goods, users need to know the weight in tonnes of the goods freighted as well as the kilometres travelled. These two numbers multiplied together is the tkm. Multiply the tkm by the emission factors in table 53. Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO_2-e per year
Q = tonne × kilometres travelled one way
F = appropriate emission factors from table 53

ROAD FREIGHT: EXAMPLE CALCULATION

During the reporting period, an organisation moves 10 tonnes of goods by truck 100 km. They also hire a van (a light commercial vehicle) with a two-litre petrol engine, manufactured in 2012. This is used to drive 800 km. The weight of the goods moved by van is unknown.

For the 10 tonnes moved by truck:

CO_2 emissions	= 10 × 100 × 0.133	= 133 kg CO_2
CH_4 emissions	= 10 × 100 × 0.0002	= 0.2 kg CO_2-e
N_2O emissions	= 10 × 100 × 0.00212	= 2.12 kg CO_2-e
Total CO_2-e emissions	= 10 × 100 × 0.135	= 135 kg CO_2-e

For the hired van, use the emission factors for the 2010–2015 fleet, petrol 1600-2000 cc. (Note: if the quantity of fuel used is known, users can more accurately calculate emissions using the litres of fuel used rather than distance). In this example the fuel usage is unknown, so the organisation applies the emission factors for km travelled to calculate the total CO_2-e emissions.

For the goods moved by van:

CO_2 emissions	= 800 × 0.271	= 216.8 kg CO_2
CH_4 emissions	= 800 × 0.00356	= 2.848 kg CO_2-e
N_2O emissions	= 800 × 0.00817	= 6.536 kg CO_2-e
Total CO_2-e emissions	= 800 × 0.283	= 226.4 kg CO_2-e

Total CO_2-e emission from freighted goods = 135 + 226.4 = 361.4 kg CO_2-e

Note: Numbers may not add due to rounding.

For vehicles that run on electricity, care should be taken not to double-count emissions from electricity use that is already captured from reporting of an organisations on-site electricity consumption.[38]

8.2.4. Emission factor derivation methodology

The 2021 fleet statistics were taken from the Te Manatū Waka Ministry of Transport Vehicle Fleet Emissions Model. This provides energy (fuel and electricity) use per 100 km travelled by vehicle. The litres of fuel (or kWh of electricity) consumed per 100 km are provided in tables 54 and 55.

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[38] UK BEIS 2022 Guidance, accessed via:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1083857/2022-ghg-cf-methodology-paper.pdf.

Table 54:   Light commercial vehicles (energy consumption per 100 km)

Emission source		Units	Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
Petrol	<1350 cc	litres	8.43	7.95	7.48
	1350–<1600 cc	litres	9.05	8.53	8.03
	1600–<2000 cc	litres	12.21	11.51	10.83
	2000–<3000 cc	litres	12.92	12.18	11.46
	≥3000 cc	litres	14.75	13.91	13.08
Diesel	<1350 cc	litres	8.00	7.37	7.00
	1350–<1600 cc	litres	7.70	7.09	6.74
	1600–<2000 cc	litres	10.25	9.44	8.97
	2000–<3000 cc	litres	10.99	10.13	9.62
	≥3000 cc	litres	11.13	10.25	9.74
Petrol hybrid	<1350 cc	litres	6.65	6.27	5.87
	1350–<1600 cc	litres	7.14	6.73	6.30
	1600–<2000 cc	litres	9.64	9.08	8.50
	2000–<3000 cc	litres	10.20	9.61	8.99
	≥3000 cc	litres	11.64	10.97	10.27
Diesel hybrid	<1350 cc	litres	7.17	6.61	6.30
	1350–<1600 cc	litres	6.90	6.36	6.06
	1600–<2000 cc	litres	9.19	8.47	8.07
	2000–<3000 cc	litres	9.85	9.08	8.65
	≥3000 cc	litres	9.97	9.19	8.76
Petrol PHEV – petrol consumption	<1350 cc	litres	3.48	3.28	3.07
	1350–<1600 cc	litres	3.74	3.52	3.30
	1600–<2000 cc	litres	5.05	4.75	4.45
	2000–<3000 cc	litres	5.34	5.03	4.71
	≥3000 cc	litres	6.09	5.74	5.38
Petrol PHEV – electricity consumption	<1350 cc	kWh	10.66	10.09	9.76
	1350–<1600 cc	kWh	11.44	10.83	10.48
	1600–<2000 cc	kWh	12.95	12.26	11.86
	2000–<3000 cc	kWh	15.95	15.09	14.61
	≥3000 cc	kWh	18.64	17.64	17.08
Diesel PHEV – diesel consumption	<1350 cc	litres	3.75	3.46	3.30
	1350–<1600 cc	litres	3.61	3.33	3.17
	1600–<2000 cc	litres	4.81	4.43	4.22
	2000–<3000 cc	litres	5.16	4.75	4.53
	≥3000 cc	litres	5.22	4.81	4.58
Diesel PHEV – electricity consumption	<1350 cc	kWh	11.09	10.24	9.90
	1350–<1600 cc	kWh	10.65	9.84	9.51
	1600–<2000 cc	kWh	11.67	10.78	10.42
	2000–<3000 cc	kWh	13.21	12.20	11.80

Emission source		Units	Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
	≥3000 cc	kWh	15.62	14.43	13.95
BEV – electricity consumption	<1350 cc	kWh	22.36	21.16	20.48
	1350–<1600 cc	kWh	24.01	22.72	21.99
	1600–<2000 cc	kWh	27.16	25.71	24.88
	2000–<3000 cc	kWh	33.46	31.67	30.64
	≥3000 cc	kWh	39.11	37.01	35.82

Note: These numbers are rounded to two decimal places.

Table 55:   Heavy goods vehicles (energy consumption per 100 km)

Emission source		Units	Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
HGV diesel	<5,000 kg	litres	16.56	15.72	15.66
	5,000–<7,500 kg	litres	18.97	18.01	17.73
	7,500–<10,000 kg	litres	23.20	22.01	21.68
	10,000–<12,000 kg	litres	27.51	26.01	25.71
	12,000–<15,000 kg	litres	31.26	29.66	29.22
	15,000–<20,000 kg	litres	36.51	35.59	35.50
	20,000–<25,000 kg	litres	48.61	47.37	47.26
	25,000–<30,000 kg	litres	57.28	52.90	52.77
	≥30,000 kg	litres	57.28	55.73	55.60
HGV diesel hybrid	<5,000 kg	litres	13.35	12.65	12.34
	5,000–<7,500 kg	litres	15.29	14.50	14.14
	7,500–<10,000 kg	litres	18.70	17.72	17.29
	10,000–<12,000 kg	litres	22.17	21.01	20.50
	12,000–<15,000 kg	litres	25.19	23.88	23.30
	15,000–<20,000 kg	litres	33.19	32.35	32.27
	20,000–<25,000 kg	litres	44.18	43.06	42.96
	25,000–<30,000 kg	litres	51.02	49.72	49.60
	≥30,000 kg	litres	53.75	52.38	52.26
HGV BEV (battery electric vehicle)	<5,000 kg	kWh	46.81	44.38	43.42
	5,000–<7,500 kg	kWh	53.63	50.85	49.74
	7,500–<10,000 kg	kWh	65.57	62.17	60.82
	10,000–<12,000 kg	kWh	77.75	73.72	81.94
	12,000–<15,000 kg	kWh	88.35	83.77	91.94

Note: These numbers are rounded to two decimal places.

The equation used to calculate the emission factor for each GHG is:

$$\frac{\textit{real-world fuel consumption} \times \textit{emission conversion factor}}{100 \textit{ km}}$$

Dividing by 100 gives a factor for litres (or kWh) per fuel per km. Use this with the fuel emission factors to calculate emissions per km.

We multiplied the values for fuel consumption by the emission conversion factors provided in table 4.

The default emission factors for freighting vehicles include the following assumptions based on the MoT NZ Vehicle Fleet 2020:[39]

- Light commercial vehicles are on average around 12 years old[40] and the most common engine size is 2000-3000 cc, therefore we used a pre-2010 fleet and a 2000-3000 cc engine size for the default values.

- Heavy trucks are on average 18 years old and the most common gross vehicle mass is <7500 kg, therefore we selected a pre-2010 vehicle fleet with a gross vehicle mass of <7500 kg.

- Using the Motor Vehicle Register,[41] 79 per cent of goods vans/trucks and utility vehicles are diesel. Therefore diesel vehicles are assumed for the all-trucks factor.

Emission factors for freighting goods (tkm) are from the MoT presentation 'Real-world fuel economy of heavy trucks'.[42]

Table 56:   **Data used to calculate the road freight (tkm) emission factor**

Truck type	Typical gCO_2/tkm	Source
Long-haul heavy truck	105	MoT
Urban delivery heavy truck	390	MoT
All trucks	135	MoT

As most heavy goods vehicles are diesel, we used the information in table 57 to calculate the ratio of carbon dioxide, methane and nitrous oxide.

Table 57:   **Calculating the ratio of gases in diesel**

Information	kg CO_2-e/litre	kg CO_2/litre	CH_4 (kg CO_2-e / litre)	N_2O (kg CO_2-e / litre)
Diesel emission factors	2.715	2.673	0.0040	0.0378
% of gas type to calculate losses	–	98.46%	0.15%	1.39%

---

[39] Te Manatū Waka Ministry of Transport
https://www.transport.govt.nz/assets/Uploads/Data/NZVehicleFleet.xlsx.

[40] Te Manatū Waka Ministry of Transport RD025 Average vehicle fleet age
https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/vehicle-age#element-413.

[41] Waka Kotahi NZ Transport Agency www.nzta.govt.nz/vehicles/how-the-motor-vehicle-register-affects-you.

[42] Te Manatū Waka Ministry of Transport: https://www.knowledgehub.transport.govt.nz/assets/TKH-Uploads/TKC-2019/Real-world-fuel-economy-of-heavy-trucks.pdf.

We multiplied the 0.135 kg CO_2-e (Road Freight: Example Calculation box) result by the calculated factor to provide emission factors broken down by gas type.

8.2.5. Assumptions, limitations and uncertainties

The Vehicle Fleet Emissions Model historical year results have been carefully calibrated to give a total road fuel use that matches MBIE's road fuel sales figures. The major source of uncertainty for the freighting goods emission factor is that net tonne-kilometres must be inferred from truck (RUC) returns and the Waka Kotahi NZ Transport Agency (NZTA) truck weigh-in-motion statistics.

The sources used to develop these emission factors will have inbuilt assumptions, limitations and uncertainties. To investigate these, see the documents referenced.

8.3. Rail freight

In New Zealand, KiwiRail owns the rail infrastructure and has provided the information to calculate the emission factor. The emission factor for freighting goods by rail is in table 58.

Table 58:   **Emission factors for rail freight**

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Rail freight	tkm	0.0270	0.0266	0.00004	0.0004

8.3.1. GHG inventory development

Users should collect data on the weight of goods freighted (tonnes), and the distance travelled (kilometres). For each journey, multiply the total tonnes by the total km travelled.

Applying the equation E = Q x F (section 2), this means:

E   = emissions from the emissions source in kg CO_2-e per year
Q   = tonnes of freight × km travelled
F   = emission factors in table 58

RAIL FREIGHT: EXAMPLE CALCULATION

During the reporting period, an organisation freights 8 tonnes of materials 150 km by rail. This occurs four times in the reporting year.

To calculate tkm: 8 × 150 × 4 = 4,800 tkm

For the 8 tonnes moved 150 km by rail four times:

CO_2 emissions	= 4,800 × 0.0266	= 127.68 kg CO_2
CH_4 emissions	= 4,800 × 0.00004	= 0.19 kg CO_2-e
N_2O emissions	= 4,800 × 0.0004	= 1.92 kg CO_2-e
Total CO_2-e emissions	= 4,800 × 0.0270	= 129.60 kg CO_2-e

Note: Numbers may not add due to rounding.

8.3.2. Emission factor derivation methodology

KiwiRail provided the following information used to calculate the emission factors.

Table 59: **Information provided by KiwiRail**

Calculation component	Unit	Amount in 2021
Freight-only fuel	litres	42,803,760
Freight volumes (net)	NTKs (000s)	4,333,855
Electricity (net) North Island Main Trunk (NIMT)	kWh	8,851,891

Note: NTK (Net tonne km) is the sum of the tonnes carried multiplied by the distance travelled.

To calculate emissions from freight-only fuel, multiply the litres by the diesel emission factor in table 4:

$$emissions\ from\ fuel = freight\text{-}only\ fuel\ \times\ diesel\ emission\ factors$$

To calculate emissions from electricity, multiply the net kWh by the emission factors in table 9 or table 10:

$$emissions\ from\ electricity \\ = electricity\ NIMT\ \times\ purchased\ electricity\ emission\ factors$$

To calculate emissions from transmission and distribution losses from the purchased electricity, multiply the kWh by the emission factors in table 12:

$$emissions\ from\ T\&D\ losses \\ = electricity\ NIMT \times T\&D\ losses\ for\ purchased\ electricity\ emission\ factors$$

Divide these total emissions by the freight volumes in tonnes to give emissions per tkm:

$$emission\ per\ tkm \\ = \frac{emissions\ from\ fuel + emissions\ from\ electricity + emissions\ from\ T\&D\ losses}{freight\ volumes\ (net) \times 1000}$$

8.3.3. Assumptions, limitations and uncertainties

The figure for net tkm includes the weight for third-party tare weight containers. KiwiRail does not own or control those containers and it is the responsibility of the customer to load and unload them. The alternative for these customers would be to transport freight by road. Therefore, these figures reflect the actual freight (including the weight of empty and loaded containers) that KiwiRail moved.

8.4. Air freight

In the absence of New Zealand data, we have adopted the air freight emission factors from the latest UK BEIS emission factors. These emission factors are Scope 3. Refer to section 7.5 for further guidance on radiative forcing to inform your choice of emission factor. While the radiative forcing multiplier of 1.9 used in this guidance is based on current scientific evidence and research, this figure is subject to significant uncertainty.[43, 44]

Emissions from aviation have both direct (CO_2, CH_4 and N_2O) and indirect (non-CO_2 emissions eg, water vapour, contrails, NOx) climate change effects. Two sets of emission factors for air freight are presented here; one that includes the indirect effects of non-CO_2 emissions and one that represents direct effects only.

The short-haul emission factor applies to international flights of less than 3,700 km. The long-haul factor applies to flights of more than 3,700 km.

Organisations should include the indirect effects of non-CO_2 emissions when reporting air freight emissions to capture the full climate impact of their travel. However, it should be noted that there is significant scientific uncertainty around the magnitude of the indirect effect of non-CO_2 aviation emissions and it is an active area of research. Further information can be found in paragraphs 8.39-8.43 in the UK BEIS emission factors.

Table 60:   Air freight emission factors without radiative forcing multiplier

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Domestic	tkm	2.377	2.352	0.0019	0.022
Short haul	tkm	1.217	1.206	0.00008	0.011
Long haul	tkm	0.539	0.534	0.00004	0.005

Note: These numbers are rounded to three decimal places unless the number is significantly small.

Table 61:   Air freight emissions with radiative forcing multiplier

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Domestic	tkm	4.494	4.469	0.0019	0.022
Short haul	tkm	2.302	2.291	0.00008	0.011
Long haul	tkm	1.019	1.014	0.00004	0.005

8.4.1. GHG inventory development

Users should collect data on the weight in tonnes of goods freighted by air and the distance travelled. For each journey, multiply the total tonnes by the total km travelled.

Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   tonnes of freight × km travelled
F   =   appropriate emission factors in table 60 or table 61

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[43]   R Sausen et al (2005). Aviation radiative forcing in 2000: An update on IPCC (1999) Meteorologische Zeitschrift 14: 555-561, available at: https://core.ac.uk/download/pdf/357569099.pdf .

[44]   CCC (2009). Meeting the UK Aviation Target – Options for Reducing Emissions to 2050: www.theccc.org.uk/publication/meeting-the-uk-aviation-target-options-for-reducing-emissions-to-2050/.

> **AIR FREIGHT: EXAMPLE CALCULATION**
>
> During the reporting period, an organisation air freights 0.5 tonnes of materials 10,000 km. This occurs six times in the reporting year. The organisation decides to use emission factors with the radiative forcing multiplier applied.
>
> To calculate tkm: 0.5 tonnes × 10,000 km × 6 times = 30,000 tkm
>
> Use long-haul emission factors because the journey is more than 3,700 km:
>
> | | | |
> |---|---|---|
> | CO_2 emissions | = 30,000 × 1.014 | = 30,420 kg CO_2 |
> | CH_4 emissions | = 30,000 × 0.00004 | = 1.2 kg CO_2-e |
> | N_2O emissions | = 30,000 × 0.005 | = 150 kg CO_2-e |
> | Total CO_2-e emissions | = 30,000 × 1.019 | = 30,570 kg CO_2-e |
>
> Note: Numbers may not add due to rounding.

8.4.2. Emission factor derivation methodology

The methodology paper for the UK BEIS emission factors contains full details on the derivation of these emission factors.

8.4.3. Assumptions, limitations and uncertainties

As we adopted these emission factors from the UK BEIS emissions for air freight to and from the UK, we assume the same factors apply to New Zealand. We have not considered the difference in the size of aircraft transporting domestic air freight – this limits the accuracy of these emission factors to better reflect New Zealand domestic air freight. The methodology paper for the UK BEIS emission factors goes into more detail behind the GHG conversion factors.

We included the emission factors with radiative forcing to account for additional radiative forcing from emissions arising from aircraft transport at altitude (jet aircraft).

8.5. Coastal and international shipping freight

We calculated the domestic coastal shipping emission factor, table 62 based on the findings from the MoT presentation 'Real-world fuel economy of heavy trucks',[45] prepared for the 2019 Transport Knowledge Conference. We adopted the international shipping emission factors from the UK BEIS emission factors.

Table 62: Coastal shipping emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Oil products	tkm	0.0160	0.0159	0.00004	0.0001
Other bulk	tkm	0.0300	0.0297	0.00008	0.0002
Container freight	tkm	0.0460	0.0456	0.0001	0.0003

Note: These numbers are rounded to three decimal places unless the number is significantly small.

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45 https://www.knowledgehub.transport.govt.nz/assets/TKH-Uploads/TKC-2019/Real-world-fuel-economy-of-heavy-trucks.pdf.

Table 63: International shipping emission factors

Emission source		Unit	kg CO₂-e/ unit	CO₂ (kg CO₂-e/ unit)	CH₄ (kg CO₂-e/ unit)	N₂O (kg CO₂-e/ unit)
Bulk carrier	200,000+ dwt	tkm	0.00253	0.00250	0.000001	0.00003
	100,000–199,999 dwt	tkm	0.00304	0.00300	0.000001	0.00004
	60,000–99,999 dwt	tkm	0.00416	0.00410	0.000001	0.00006
	35,000–59,999 dwt	tkm	0.00578	0.00570	0.000002	0.00008
	10,000–34,999 dwt	tkm	0.00801	0.00790	0.000002	0.0001
	0–9999 dwt	tkm	0.0296	0.0292	0.000009	0.0004
	Average	tkm	0.00355	0.00350	0.000001	0.00005
General cargo	10,000+ dwt	tkm	0.0121	0.0119	0.000004	0.0002
	5000–9999 dwt	tkm	0.0160	0.0158	0.000005	0.0002
	0–4999 dwt	tkm	0.0141	0.0139	0.000004	0.0002
	10,000+ dwt 100+ TEU	tkm	0.0112	0.0110	0.000003	0.0001
	5000–9999 dwt 100+ TEU	tkm	0.0177	0.0175	0.000005	0.0002
	0–4999 dwt 100+ TEU	tkm	0.0201	0.0198	0.000006	0.0003
	Average	tkm	0.0133	0.0131	0.000004	0.0002
Container ship	8000+ TEU	tkm	0.0127	0.0125	0.000004	0.0002
	5000–7999 TEU	tkm	0.0168	0.0166	0.000005	0.0002
	3000–4999 TEU	tkm	0.0168	0.0166	0.000005	0.0002
	2000–2999 TEU	tkm	0.0203	0.0200	0.000006	0.0003
	1000–1999 TEU	tkm	0.0325	0.0321	0.00001	0.0004
	0–999 TEU	tkm	0.0368	0.0363	0.00001	0.0005
	Average	tkm	0.0161	0.0159	0.000005	0.0002
Vehicle transport	4000+ CEU	tkm	0.0324	0.0320	0.00001	0.0004
	0–3999 CEU	tkm	0.0584	0.0576	0.00002	0.0008
	Average	tkm	0.0386	0.0381	0.00001	0.0005
RoRo ferry	2000+ LM	tkm	0.0502	0.0495	0.00002	0.0007
	0–1999 LM	tkm	0.0611	0.0603	0.00002	0.0008
	Average	tkm	0.0517	0.0510	0.00002	0.0007
	Large RoPax ferry	tkm	0.377	0.371	0.0001	0.00506
Refrigerated cargo	All dwt	tkm	0.0131	0.0129	0.000004	0.0002

Note: These numbers are rounded to three decimal places unless the number is significantly small.
dwt = deadweight tonnes. TEU = twenty-foot equivalent unit. CEU = car equivalent unit. LM = lanemetre.

8.5.1. GHG inventory development

Users should collect data on the weight in tonnes of goods freighted, and the distance travelled. For each journey, multiply the total tonnes by the total km travelled.

Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO₂-e per year
Q = tonnes of freight × km travelled
F = appropriate emission factors from table 62 or table 63

> **MULTIPLE FREIGHT MODES: EXAMPLE CALCULATION**
>
> A company sends 300 kg of its product to a customer. It travels by road freight (All trucks) 50 km to the port, then 500 km by coastal shipping (container freight) to another domestic port. It is then loaded onto rail to its destination 250 km from the port.
>
> Road freight emissions:
>
> 0.3 tonnes × 50 km = 15 tkm
>
> 15 tkm × 0.135 = 2.03 kg CO_2-e
>
> Coastal shipping emissions:
>
> 0.3 tonnes × 500 km = 150 tkm
>
> 150 tkm × 0.046 = 6.90 kg CO_2-e
>
> Rail freight emissions:
>
> 0.3 tonnes × 250 km = 75 tkm
>
> 75 tkm × 0.0271 = 2.03 kg CO_2-e
>
> Total freight emissions:
>
> 2.03 + 6.9 + 2.03 = 10.96 kg CO_2-e
>
> Note: Numbers may not add due to rounding.

8.5.2. Emission factor derivation methodology

We based the emission factors for coastal shipping on figures included in the MoT presentation 'Real world fuel economy of heavy trucks',[46] prepared for the 2019 Transport Knowledge Conference.

Table 64:   Coastal shipping data

Mode	Typical kg CO_2/tkm
Coastal shipping (oil products)	0.016
Coastal shipping (other bulk)	0.030
Coastal shipping (container freight)	0.046

We assumed transport fuel for coastal shipping is heavy fuel oil, and therefore applied the ratio of carbon dioxide, methane and nitrous oxide to provide a breakdown by gas.

For international shipping, we used the Freight Information Gathering System (FIGS)[47] to identify which types of ships visit New Zealand, and their average sizes. We then adopted the UK BEIS emission factors for the relevant ships and adapted the average emission factors to reflect ship sizes visiting New Zealand.

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[46] Te Manatū Waka Ministry of Transport: https://www.knowledgehub.transport.govt.nz/assets/TKH-Uploads/TKC-2019/Real-world-fuel-economy-of-heavy-trucks.pdf.

[47] Freight Information Gathering System, accessed via: https://www.transport.govt.nz/statistics-and-insights/freight-and-logistics/.

We identified the following shipping types as visiting New Zealand:

- container ships
- reefer (refrigerated cargo ship)
- bulk carrier
- RoRo (roll-on, roll-off)
- oil/gas tanker
- vehicle carrier
- general cargo.

We used MoT's FIGS[48] to find out the average sizes of ships visiting New Zealand. Ships are measured in deadweight tonnes (dwt), twenty-foot equivalent unit (TEU), car equivalent unit (CEU) or lanemetre (LM).

- Bulk carrier is 36,900 dwt and therefore in the 35,000–59,999 dwt category.
- General cargo is 15,800 dwt and therefore in the 10,000+ dwt category.
- Container ship is 3,194 TEU and therefore in the 3,000–4,999 TEU category.
- Vehicle carrier (transport) is unknown and therefore the same as the UK average.
- RoRo ferry is unknown and therefore the same as the UK average.
- As there is only one emission factor for all refrigerated cargo an average was not necessary.

Emission factors for these have been adopted from the UK BEIS 2022 Guidance[49]. Refer to that document for details on the methodology.

8.5.3. Assumptions, limitations and uncertainties

We assumed the New Zealand coastal shipping fleet is similar to that in the STREAM Freight Handbook. These figures have a high degree of uncertainty as they are based on international data for costal shipping.

We carried over the assumptions for the international shipping emission factors from the 2022 UK BEIS Methodology Paper emission factors.

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[48] Freight Information Gathering System, overseas ships, accessed via:
https://www.transport.govt.nz/statistics-and-insights/freight-and-logistics/.

[49] UK BEIS 2022 Guidance, accessed via:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1083857/2022-ghg-cf-methodology-paper.pdf.

9. Water supply and wastewater treatment emission factors

Emissions result from energy use in water supply and wastewater treatment plants. Some treatment plants also generate emissions from the treatment of organic matter. We calculated the emission factors using data from Water New Zealand and *New Zealand's Greenhouse Gas Inventory 1990–2021*.

9.1. Overview of changes since previous update

There are some changes to water supply and domestic wastewater emission factors, due to the use of the latest population data, energy use emission factors, and water and energy consumption data from Water New Zealand.

The emission factor for water supply increased by 14 to 19 per cent, depending on the unit used. This is due to an increase in energy demand (kWh/m^3) by 39 per cent since the last guidance, and the inclusion of electricity transmission and distribution losses in the methodology this guidance.

The change to AR5 has led to changes to emission factors for industrial wastewater, ranging from -11% for dairy processing to +12% for wine and pulp and paper wastewater treatment. Septic tank emission factors are based on the publication of *Carbon Accounting Guidelines for Wastewater Treatment: CH_4 and N_2O* (Water New Zealand, 2021).[50]

Users seeking emission factors for specific types of wastewater treatment plants are referred to the Water New Zealand's guidelines.[51] Weighted average emission factors for wastewater treatment remain in this guide for general use.

9.2. Water supply

Table 65 provides water supply emission factors. We calculated the factors using Water New Zealand data.

Table 65: Water supply emission factors

Emission source	Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/unit)	CH₄ (kg CO₂-e/unit)	N₂O (kg CO₂-e/unit)
Water supply emission factors	m³	0.0369	0.0359	0.0010	0.00008
	per capita	4.302	4.180	0.112	0.00919

Note: These numbers are rounded to three decimal places unless the number is significantly small.

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[50] Carbon accounting guidelines for wastewater treatment: CH4 and N2O | Water New Zealand (waternz.org.nz).

[51] Ibid.

9.2.1. GHG inventory development

Users should collect data on cubic metres (m^3) of water used, if available. In the absence of this information, the per capita emission factor can be applied.

Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO_2-e per year
Q = quantity of water used (m^3) or persons using water supply (per capita)
F = appropriate emission factors from table 65

WATER SUPPLY: EXAMPLE CALCULATION

An organisation's assets have water meters. Throughout the reporting year they use 1,000 m^3 of water.

CO_2 emissions	= 1,000 × 0.0359	= 35.9 kg CO_2
CH_4 emissions	= 1,000 × 0.0010	= 1 kg CO_2-e
N_2O emissions	= 1,000 × 0.00008	= 0.08 kg CO_2-e
Total CO_2-e emissions	= 1,000 × 0.0369	= 36.9 kg CO_2-e

Note: Numbers may not add due to rounding.

9.2.2. Emission factor derivation methodology

We adopted the Water New Zealand 2020/21 National Performance Review[52] methodology to calculate the water supply emission factors. The Water New Zealand review gathered data from participating water industry bodies, which represent approximately 75 per cent of New Zealand's population. Twenty-seven participants in the survey provided reliable information on the energy use of their water systems, which was used to calculate national averages. In the 2020/21 period, the operation of water supply pumps used 757 TJ of energy to supply 471 million m^3 of water, and treatment plants used an estimated 1,130 TJ of energy in the treatment of about 409 million m^3 of water. This equates to a median energy intensity of 1.6 MJ of energy per cubic metre of water supplied and 2.8 MJ of energy per cubic metre of water treated.

We used a weighted average of participant energy use and water supply data to calculate the emission factors.

We calculated the emission factors for each gas by summing the weighted averages from each participant's data. The basic equation for each gas is as follows:

$$\frac{energy\ use}{water\ supply} \times electricity\ emission\ factor\ \times unit\ conversion\ factor$$

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[52] Water New Zealand 2020/21 National Performance Review from
https://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=5573.

This equation gives the emissions per m³ of water supplied, where the following values were used to calculate the emission factors:

- energy use = the GJ of energy used by the water system that year

- water supply = m³ of water supplied that year

- electricity emission factor = the relevant gas emission conversion factor (ie, CO_2, N_2O, CH_4)

- unit conversion factor = 277.778 (converting GJ to kWh).

If organisations do not know the volume of water used, they can estimate it based on a calculated per capita (per person) emission factor. To develop a per capita emission factor, we used an average of 116 m³ of water per person per year, which is calculated from the following equations and information:

The first equation:

$$
average\ volume\ of\ water\ supplied\ per\ person = \frac{water\ supplied}{population\ served\ by\ WWTP}
$$

The second equation:

$$
average\ volume\ of\ water\ supplied\ per\ person \times \\ emission\ factors\ for\ water\ supplied\ in\ m^3 = emission\ factors\ for\ water\ supplied\ per\ capita
$$

Where the following data were used to calculate the emission factors:
- m³ of water supplied nationwide is 531,000,000[53]

- population served by Wastewater Treatment Plants (WWTPs) is approximately 4.56 million.[54]

9.2.3. Assumptions, limitations and uncertainties

The data adopted from Water New Zealand do not account for emissions outside those associated with the national electricity grid, and therefore, may underestimate the total GHG emissions depending on the water supplier's facilities and processes.

The assumptions used for water supply per person are inherently uncertain and organisations should only use them in the absence of water volume data. They do not account for factors such as: seasonal use of water and water-intensive activities (such as gardening, lifestyle choices and geography). Therefore, per person water supply reflects only an average of the water supply per person. Furthermore, the figure is based on a national average of water usage throughout the year, and may overestimate emissions from office use per capita. This is because employees do not spend all their time in the office, and it is likely that most of their water usage will be outside working hours.

---

[53] Water New Zealand report www.waternz.org.nz/Attachment?Action=Download&Attachment_id=3142.

[54] Ministry for the Environment's WWTP database.

9.3. Wastewater treatment

We recommend that users refer directly to the Water New Zealand's guidelines[55] for emission factors for specific types of wastewater treatment plants. Weighted average emission factors for wastewater treatment remain in the measuring emissions guide for general use.

We converted energy use (kWh) to GHG emissions and added these to the treatment process emissions to give the total emissions from wastewater treatment in New Zealand.

We provide wastewater treatment emission factors in tables 66 and 67. Some industries produce wastewater that is particularly high in biological oxygen demand (BOD). For this reason, we developed industrial wastewater emission factors for the meat, poultry, pulp and paper, wine and dairy sectors. Manufacturing organisations in these sectors should use specific industrial wastewater factors. All other organisations should use the domestic wastewater factors. Where the domestic wastewater treatment type is unknown, we suggest using the average for wastewater treatment plants (see table 66).

Table 66:   **Domestic wastewater treatment emission factors**

Emission source	Unit	kg CO_2-e/ unit	CO_2 (kg CO_2-e/ unit)	CH_4 (kg CO_2-e/ unit)	N_2O (kg CO_2-e/ unit)
Average for wastewater treatment plants	m³ of water supplied	0.508	0.0618	0.198	0.248
	per capita	48.5	5.90	18.9	23.7
Septic tanks	per capita	190	n/a	168	22.5

Table 67:   **Industrial wastewater treatment emission factors**

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/ unit)	CH_4 (kg CO_2-e/ unit)	N_2O (kg CO_2-e/ unit)
Meat (excl. poultry)	tonne of kills	52.6	n/a	50.0	2.53
Poultry	tonne of kills	51.7	n/a	48.1	3.61
Pulp & paper	tonne of product	11.8	n/a	11.8	n/a
Wine	tonne of crushed grapes	5.79	n/a	5.79	n/a
Dairy processing	m³ of milk	0.102	n/a	n/a	0.102

9.3.1. GHG inventory development

Domestic water users should collect data on m³ of water sent to treatment. If metered water data is not available, the per capita emission factor can be applied instead. Industrial organisations can calculate the emissions using appropriate activity data and the correlating emission factors.

Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   quantity of water treated (m³) or persons using water facilities (per capita)
F   =   appropriate emission factors from tables 66 and 67.

---

[55] Carbon accounting guidelines for wastewater treatment: CH4 and N2O | Water New Zealand (waternz.org.nz).

During the reporting period an organisation uses 100 m^3 of water in its offices. They assume that all water is also sent to be treated. This organisation also owns a winery that crushed 10 tonnes of grapes during the reporting period.

The office wastewater is domestic, therefore:

CO_2 emissions	= 100 × 0.0618	= 6.18 kg CO_2
CH_4 emissions	= 100 × 0.198	= 19.8 kg CO_2-e
N_2O emissions	= 100 × 0.248	= 24.8 kg CO_2-e
Total CO_2-e emissions	= 100 × 0.508	= 50.8 kg CO_2-e

The winery wastewater is industrial wastewater (wine), therefore:

CO_2 emissions	= n/a	
CH_4 emissions	= 10 × 5.79	= 57.9 kg CO_2-e
N_2O emissions	= n/a	
Total CO_2-e emissions	= 10 × 5.79 = 57.9 kg CO_2-e	

The total wastewater emissions are:

$$= 50.8 + 57.9 \qquad = 108.7 \text{ kg } CO_2\text{-e}$$

Note: Numbers may not add due to rounding.

9.3.2. Emission factor derivation methodology

9.3.2.1. Domestic wastewater treatment

We derived the domestic wastewater treatment plant emission factors from the total energy use emissions in the wastewater treatment plants, and the gases emitted during the treatment process.

The emission factors for septic tanks are sourced directly from Water New Zealand (2021).

Since direct carbon dioxide emissions from wastewater treatment are biogenic, the methodologies described here for all treatment types other than septic tanks are only for methane and nitrous oxide. We calculated the emission factors using equations in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Updated methodologies for some categories are available in the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Using updated methodologies in the 2019 Refinement would be inconsistent with *New Zealand Greenhouse Gas Inventory 1990–2021* reporting at the time of publication of this guide, because this part of the inventory uses the IPCC 2006 Guidelines. The 2019 Refinement will be considered for future inventories, and the guide will be revised after the relevant NIR has been updated. The example calculations are done using AR4 GWPs.

To calculate methane emissions, first calculate the total organic product in domestic wastewater (TOW):

$$\sum_i P_i \times BOD \times I = total\ organic\ product\ in\ domestic\ wastewater$$

Where the following data were used to calculate the emission factors:

- P = the population for wastewater treatment plant *i*
- *i* = type of treatment plant
- BOD = 26 (kg/capita/year) country-specific, per-capita Biological Oxygen Demand
- I = the correction factor for additional industrial and commercial BOD (default 1.25 or 1.0 for septic tanks, but varies for several sites).

Then calculate methane emissions per capita:

$$\frac{MCF \times B_0 \times TOW \times GWP}{population\ served} = methane\ emissions\ (kg\ CH_4\ per\ capita)$$

Where the following data were used to calculate the emission factors:

- MCF = 0.02528, the weighted-average methane correction factor (MCF) for wastewater treatment plants in 2021
- B_0 = 0.625, converts the BOD to maximum potential methane emissions
- TOW = the total organic product in wastewater from the equation above
- GWP = 28 (IPCC AR5), converts methane into CO_2-e
- population served = the population served by all wastewater treatment plants.

To calculate methane emissions per water volume, divide methane emissions per capita by the average water volume (m^3) treated per capita (101 m^3).

To calculate nitrous oxide emissions from wastewater treatment plants we used two equations. The first equation calculates the amount of nitrogen per person:

$$per\ capita\ nitrogen\ in\ effluent\ (kg\ N\ per\ year)$$
$$= protein \times F_{NPR} \times F_{NON-CON} \times F_{IND-COM}$$

Where the following data were used:

- protein = annual per capita protein consumption (36.135 kg per year from Beca, 2007)
- F_{NPR} = fraction of nitrogen in protein (0.16, IPCC 2006)
- $F_{NON-CON}$ = factor for non-consumed protein added to the wastewater (1.4, IPCC 2006)
- $F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system (1.25, IPCC 2006).

Table 68 details the values used in the equation above.

Table 68: Domestic wastewater treatment emissions calculation components

Calculation component	Number	Additional information	Source
Population	1	This is a per person calculation	
Per capita protein consumption	36.135	kg/year	Beca 2007,[56] 99 g/day
Fraction of N in protein	0.16		IPCC default
Fraction of non-consumption protein	1.4		IPCC default
Fraction of industrial and commercial co-discharged protein	1.25		IPCC default
N removed with sludge	0	Default is zero	IPCC default

Then the second equation calculates nitrous oxide emissions based on the result from the first equation:

$$N_2O \; emissions \; (kg \; CO_2 \; e \; per \; capita)$$
$$= per \; capita \; nitrogen \; in \; effluent \; \times EF_{effluent} \times \frac{44}{28} \times GWP$$

Where the following data were used:

- per capita nitrogen in effluent = from equation above

- effluent = emission factor of 0.005 kg N_2O-N/kg N (IPCC 2006)

- 44/28 ratio of N_2O to N_2

- GWP = 265 (IPCC AR5).

Divide these emissions per capita by the average volume of water treated (95 m^3) per person to give the emissions per m^3.

9.3.2.2. Industrial wastewater treatment

As with domestic wastewater, we derived the emission factors for industrial wastewater treatment from the total energy-use emissions in the wastewater treatment plants and the gases emitted during the treatment process.

For the purpose of this guide, it is assumed there are no direct carbon dioxide emissions from the treatment of wastewater, as all carbon dioxide emissions are biogenic. Therefore, we have calculated only methane and nitrous oxide emissions.

The equation followed to calculate methane emissions is:

$$mbCOD \; \times EF \; \times GWP = methane \; emission \; factor \; (kg/unit)$$

Where:

- mbCOD = the unit biodegradable chemical oxygen demand load in kg per tonne of material processed (specified by industry type in table 57: Calculating the ratio of gases in diesel) (kg CODb)/t

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[56] *National Greenhouse Gas Inventory from Wastewater Treatment and Discharge,* prepared for Ministry for the Environment by Beca Infrastructure Ltd, August 2007.

- EF = emission factor in kg methane/kg COD

- GWP = global warming potential.

The following tables detail the information used in the calculations to provide the industrial wastewater treatment emission factors.

Table 69: **Industrial wastewater treatment methane emissions calculation information**

| Factor | Industry | | | | |
	Pulp and paper	Meat (excluding poultry)	Poultry	Wine	Source
Biodegradable chemical oxygen demand load (kg CODb/tonne)	36	50	50	12.42	Cardno (2015)
CH4 emission factor (kg CH4/kg CODb)	0.0117	0.03575	0.034375	0.016661	Cardno (2015)
GWP	28	28	28	28	IPCC AR5

It is assumed that the methods used to treat wastewater from dairy processing do not result in methane emissions.

The equation used to calculate nitrous oxide emissions is:

$$mbCOD \ \times N{:}COD \ \times EF \ \times \left(\frac{44}{28}\right) \times GWP = N = nitrous\ oxide\ emission\ factor\ (\frac{kg}{tonnes})$$

Where:

- mbCOD = unit biodegradable COD load (kg CODb/t)

- N:COD = total nitrogen to biodegradable COD ratio

- EF = emission factor

- 44/28 = ratio of N_2O to N_2

- GWP = global warming potential.

The following table details the information used in the calculations to provide the industrial wastewater treatment emission factors. Note that for dairy processing, users should first convert the quantity of milk to tonnes using a density factor of 1.031 tonnes per m^3.

Table 70: **Industrial wastewater treatment nitrous oxide emissions calculation information**

| Factor | Industry | | |
	Dairy product processing	Meat (excluding poultry)	Poultry	Source
Biodegradable chemical oxygen demand load (kg CODb/tonne)	2	50	50	Cardno (2015)
Total N:biodegradable COD ratio	0.044	0.09	0.09	Cardno (2015)
Nitrous oxide emission factor (kg N_2O/kg CODb)	0.00279	0.001348	0.001925	Cardno (2015)
GWP	265	265	265	IPCC AR5

Based on the Cardno report[57] we assume that there are no nitrous oxide emissions from the methods used to process wastewater from the wine and pulp and paper industries.

9.3.3. Assumptions, limitations and uncertainties

We calculated these emission factors on the best available data using industry-wide sources and international default factors where appropriate. As the wastewater emissions include electricity emissions, the same electricity emissions uncertainties carry through. Table 71 details the uncertainties with this source category.

Table 71: **Uncertainties with wastewater treatment emission source category**

	Uncertainty in activity data	Uncertainty in emission factors
Domestic and industrial CH_4	±10%	±40%
Domestic and industrial N_2O	±10%	±90%

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[57] Cardno, (2015), Greenhouse Gas Emissions from Industrial Wastewater Treatment – Inventory Basis Review. Accessed via: https://environment.govt.nz/publications/greenhouse-gas-emissions-from-industrial-wastewater-treatment-inventory-basis-review/.

10. Materials and waste emission factors

10.1. Overview of changes since previous update

The increase in the AR5 GWP for methane (from 25 to 28) resulted in a corresponding increase of 12 per cent across the waste to landfill factors. The biological treatment of waste using anaerobic digestion also increased by 12 per cent.

This version of the guide includes two additional emission factors for waste wood to landfill, for treated and untreated wood.

10.2. Construction materials

BRANZ[58] provide the emission conversion factors for the emission sources in their 2021 CO_2NSTRUCT dataset.[59] These emissions are indirect (Scope 3) if the organisation does not own or control the facilities making the materials.

We recommend that users refer directly to the free CO_2NSTRUCT dataset for emission factors for construction materials. The dataset provides embodied greenhouse gas and energy values for building materials including concrete, glass, timber, and metals, as well as products such as bathroom and kitchen fittings.

The CO_2NSTRUCT dataset takes emission factors from EPDs for construction products and is regularly updated. Users could also check the EPD Australasia platform[60] for any interim updates to emission factors.

The Ministry of Business, Innovation and Employment's Building for Climate Change Programme (BfCC) has been set up to reduce emissions from constructing and operating buildings, and to make sure buildings are prepared for the future effects of climate change. Through the BfCC programme, MBIE is leading the Building and Construction Sector policy for New Zealand's Emissions Reduction Plan, setting out policies and strategies to meet the Government's emission budget.

Users should note that in the GHG Protocol, construction materials are classified as Scope 3 Category 1 (emissions from purchased goods and services). Buildings are classified as Scope 3 Category 2 (embodied emissions of new buildings, which includes accounting for the emissions impact of construction materials). These can form a large proportion of an organisation's GHG inventory.

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[58]   BRANZ Ltd, www.branz.co.nz.

[59]   BRANZ CO_2NSTRUCT, www.branz.co.nz/co2nstruct\.

[60]   https://epd-australasia.com/.

10.3. Waste disposal

Waste disposal emissions account only for the GHG emitted from end-of-life waste disposal. Currently, this guide covers emissions from waste-to-landfill for municipal and non-municipal landfills, as well as biological treatment (composting and anaerobic digestion). Users seeking whole-life assessment of waste streams should refer to the UK BEIS emission factors for company reporting.

The units of emissions are kg CO_2-e per kg of material. The anaerobic decomposition of organic waste in landfills generates methane. Organisations should adjust inventories to account for the landfills that collect and destroy landfill gas. Where methane is collected and destroyed by flaring or combustion to generate energy, the carbon dioxide emitted from the combustion process is regarded as part of the natural carbon cycle. Biogenic carbon dioxide, which is part of the natural carbon cycle, is absorbed by living organic matter and released at the end of its life and is not included in these emission factors since it has no net effect on greenhouse gases.

Emission factors for anaerobic digestion and composting are reported as forms of biological treatment of waste.

The type, age, design, engineering, and management practices of the landfill influences the GHG conversion factor, based on whether there is a methane gas collection system. In 2021, 97 per cent of municipal waste was disposed to landfills with gas collection.

Table 72:   **Description of landfill types**

Landfill type	Description
Municipal (class 1) landfills with gas recovery	Municipal, well-managed landfill where a landfill gas recovery system is installed. Some of the CH_4 produced during the organic decomposition of waste is captured and destroyed.
Municipal (class 1) landfills without gas recovery	Municipal, well-managed landfill where all the CH_4 produced during organic decomposition of waste escapes into the atmosphere, apart from that which is oxidised inside the landfill.
Non-municipal (class 2-5) landfills	Non-municipal landfills that accept a broader range of wastes where the CH_4 produced during organic decomposition of waste escapes into the atmosphere.

Appendix C: Landfills with and without landfill gas recovery includes a list of class 1 landfills with gas recovery.

If organisations are interested in calculating the emissions from transporting waste materials, they could do so by independently accounting for the distance travelled, using freight emission factors (see section 8).

We calculated the waste-to-landfill emission conversion factors based on *New Zealand's Greenhouse Gas Inventory 1990–2021*. Table 73 to table 76 show the factors.

Table 73:   Waste disposal to municipal (class 1) landfills with gas recovery

Emission source	Waste type	Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/ unit)	CH₄ (kg CO₂-e/ unit)	N₂O (kg CO₂-e/ unit)
Waste (known composition)	Food	kg	0.674	n/a	0.674	n/a
	Garden	kg	0.552	n/a	0.552	n/a
	Paper	kg	0.981	n/a	0.981	n/a
	Wood (combined)	kg	0.380	n/a	0.380	n/a
	Wood (treated)	kg	0.0613	n/a	0.0613	n/a
	Wood (untreated)	kg	0.858	n/a	0.858	n/a
	Textile	kg	0.490	n/a	0.490	n/a
	Nappies	kg	0.245	n/a	0.245	n/a
	Sludge	kg	0.153	n/a	0.153	n/a
	Other (inert)	kg	n/a	n/a	n/a	n/a
Waste (unknown composition)	General waste	kg	0.232	n/a	0.232	n/a
	Office waste	kg	0.666	n/a	0.666	n/a

Table 74:   Waste disposal to municipal (class 1) landfills without gas recovery

Emission source	Waste type	Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/ unit)	CH₄ (kg CO₂-e/ unit)	N₂O (kg CO₂-e/ unit)
Waste (known composition)	Food	kg	2.11	n/a	2.11	n/a
	Garden	kg	1.72	n/a	1.72	n/a
	Paper	kg	3.06	n/a	3.06	n/a
	Wood (combined)	kg	1.19	n/a	1.19	n/a
	Wood (treated)	kg	0.192	n/a	0.192	n/a
	Wood (untreated)	kg	2.68	n/a	2.68	n/a
	Textile	kg	1.53	n/a	1.53	n/a
	Nappies	kg	0.766	n/a	0.766	n/a
	Sludge	kg	0.479	n/a	0.479	n/a
	Other (inert)	kg	n/a	n/a	n/a	n/a
Waste (unknown composition)	General waste	kg	0.724	n/a	0.724	n/a
	Office waste	kg	2.08	n/a	2.08	n/a

Table 75:   Waste disposal to non-municipal (class 2-5) landfills

Emission source	Waste type	Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/unit)	CH$_4$ (kg CO$_2$-e/unit)	N$_2$O (kg CO$_2$-e/unit)
Waste (known composition)	Biological (sludge)	kg	0.196	n/a	0.196	n/a
	Construction & demolition	kg	0.157	n/a	0.157	n/a
	Bulk waste	kg	1.10	n/a	1.10	n/a
	Food	kg	0.588	n/a	0.588	n/a
	Garden	kg	0.784	n/a	0.784	n/a
	Industrial	kg	0.588	n/a	0.588	n/a
	Wood	kg	1.33	n/a	1.33	n/a
	Inert (all other waste)	kg	n/a	n/a	n/a	n/a
	Average for non-municipal solid waste	kg	0.197	n/a	0.197	n/a

Table 76:   Biological treatment of waste emission factors

Emission source	Unit	kg CO$_2$-e/unit	CO$_2$ (kg CO$_2$-e/unit)	CH$_4$ (kg CO$_2$-e/unit)	N$_2$O (kg CO$_2$-e/unit)
Composting	kg	0.176	n/a	0.112	0.0636
Anaerobic digestion	kg	0.0224	n/a	0.0224	n/a

10.3.1. GHG inventory development

There are two methodologies that organisations can follow for calculating waste emissions.

1.   Where composition of waste is known.

2.   Where composition of waste is unknown.

The choice of methodology depends on organisational knowledge of waste composition. It is preferable to know the composition of waste as it allows more accurate calculation of emissions. The example calculations are done using IPCC AR5 GWPs.

Users should collect data on the quantity (kg) and type of waste disposed.

Applying the equation E = Q x F (section 2), this means:

E	=	emissions from the emissions source in kg CO$_2$-e per year
Q	=	quantity of waste disposed (kg)
F	=	appropriate emission factors from table 73 to table 76

> **WASTE DISPOSAL: EXAMPLE CALCULATION**
>
> A hotel produces waste in its kitchen, guest rooms and garden. They send it to the regional landfill, which is known to have landfill gas recovery.
>
> If the waste comprises 150 kg food waste, 50 kg general waste from guest rooms and 60 kg of garden waste, the hotel calculates emissions as follows:
>
> | | | |
> |---|---|---|
> | Food waste | = 150 × 0.674 | = 101.1 kg CO_2-e |
> | General waste | = 50 × 0.232 | = 11.6 kg CO_2-e |
> | Garden waste | = 60 × 0.552 | = 33.12 kg CO_2-e |
> | Total waste emissions | = 101.1 + 11.6 + 33.12 | = 145.82 kg CO_2-e |
>
> Note: Numbers may not add due to rounding

10.3.2. Emission factor derivation methodologies

We broke down data derived from the National Inventory Report into seven categories. Table 77 identifies these alongside their proportion of the waste to landfills.

Table 77: Composition of waste sent to NZ landfills

Waste category	Description	Estimated composition of waste to municipal landfills	Estimated composition of waste to non-municipal landfills
Food	Food waste	9.0%	0.01%
Garden	Organic material	5.7%	11.0%
Paper	Paper and cardboard waste	5.9%	n/a
Wood	Wood waste	12.6%	6.1%
Textile	Fabrics and other textiles	5.0%	n/a
Nappies	Nappies and similar sanitary waste	2.5%	n/a
Sludge	Sludges from sewer/septic tanks and offal and meat-based waste	1.9%	5.0%
Inert	Waste that does not produce GHG emissions	57.3%	67.4%
C & D	Construction and demolition waste	n/a	9.9%
Industrial	Where specific type of industrial is unknown	n/a	0.7%
Bulk waste	General domestic and farm waste	n/a	0.1%

Note: The composition for municipal landfills is based on a survey of 2018 data, and the composition for non-municipal landfills is based on an estimate for 2015. Columns may not total to 100% due to rounding.

Substances such as plastics, metals and glass are inert because their decomposition in landfills does not directly produce GHG emissions. Only waste that contains degradable organic carbon produces methane as it breaks down.

We provide no methodology for nitrous oxide emissions from waste disposal because the IPCC[61] has found them to be insignificant.

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61   www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf.

10.3.3. When composition of waste is known

If the composition of waste is known, use the specific emission factors for each waste stream based on kilograms of waste produced.

We generated emission factors for each waste category, following a simplification of the IPCC First Order Decay model.

$$emission\ factor = DOC \times DOCf \times F \times MCF \times conversion \times (1 - oxidation) \times (1 - recovery) \times GWP$$

Where:

- DOC = amount of degradable organic carbon in the material

- DOCf = fraction of DOC that degrades in landfill

- F = fraction of CH4 in the gas that is generated inside the landfill

- MCF = methane correction factor (the extent that the landfill is anaerobic)

- conversion = conversion of carbon to methane (molecular weight ratio CH4/C)

- recovery = fraction of methane recovered where landfill gas systems are in place, otherwise use 0

- oxidation = oxidation factor of methane that degrades before being emitted

- GWP = global warming potential of methane.

We used the waste information from the National Inventory Report to develop solid waste emission factors for voluntary reporting.

Table 78:   Information on managed solid waste

Category	DOC	DOCf	F	MCF	Conversion	Ox	R
Food	0.157	0.70	0.57	1	16/12	0.1	0.68
Garden	0.161	0.56	0.57	1	16/12	0.1	0.68
Paper	0.32	0.5	0.57	1	16/12	0.1	0.68
Wood	0.43	0.14	0.57	1	16/12	0.1	0.68
Textiles	0.16	0.5	0.57	1	16/12	0.1	0.68
Nappies	0.08	0.5	0.57	1	16/12	0.1	0.68
Sludge	0.05	0.5	0.57	1	16/12	0.1	0.68
Inert	0	0.5	0.57	1	16/12	0.1	0.68
Source of information	Eunomia (unpublished)	Eunomia (unpublished) except 0.5 is IPCC default for managed landfills	Eunomia (unpublished)	IPCC default for managed landfills		IPCC default for managed landfills	Eunomia (unpublished)

Note: R only applies for landfills with gas recovery.

Table 79: Information on non-municipal solid waste

	DOC	DOCf	F	MCF	Conversion	Ox	R
Sludge	0.05	0.5	0.5	0.42	16/12	0	0
C & D	0.04	0.5	0.5	0.42	16/12	0	0
Bulk waste	0.28	0.5	0.5	0.42	16/12	0	0
Food	0.15	0.5	0.5	0.42	16/12	0	0
Garden	0.2	0.5	0.5	0.42	16/12	0	0
Industrial	0.15	0.5	0.5	0.42	16/12	0	0
Wood	0.34	0.5	0.5	0.42	16/12	0	0
Source of information	Tonkin & Taylor (unpublished) based on IPCC 2006 vol. 5, table 3.1[62]	IPCC default for unmanaged landfills	IPCC default for unmanaged landfills	Tonkin & Taylor (unpublished)		IPCC default for unmanaged landfills	MfE

10.3.4. When composition of waste is unknown

If the composition is unknown, select a general waste or an office waste default emission factor.

We based the default emission factor for general waste on national average composition data from *New Zealand's Greenhouse Gas Inventory 1990–2021* (see table 77 above).

The following is the composition used to calculate office waste data.

Table 80: Composition of typical office waste

Waste component	Percentage
Paper	53.6%
Food	20.8%
Inert	25.6%

10.3.5. Determining with or without landfill gas recovery

If an organisation does not know whether their waste goes to a landfill with or without gas recovery, either find out whether the receiving landfill has gas recovery, or choose one of the conservative assumptions. Nationwide, 97 per cent of waste disposed to municipal (class 1) landfills in 2021 went to a landfill with gas recovery.

We recommend checking appendix C to identify if your region has a landfill with gas capture. If it does, use the value with gas recovery. To be more certain, consider contacting the local council or disposal operator and ask them what landfill the waste is disposed to and if it has gas recovery. If it is not possible to identify the landfill, choose one of the following conservative assumptions:

- For a conservatively high estimate of emissions from waste disposed to a municipal (class 1) landfill, assume it is disposed to a landfill without gas recovery.

- For a conservatively low estimate of emissions avoided by diverting waste away from a municipal (class 1) landfill, assume it is from a landfill with gas capture.

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[62] IPCC 2006, vol.5, table 3.1 www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf.

10.3.6. Composting and anaerobic digestion

We calculated emission factors for composting and anaerobic digestion using IPCC default emission factors as shown in table 81.

Table 81: IPCC default data used to calculate composting and anaerobic digestion

Calculation component	CH_4	N_2O	Anaerobic digestion CH_4	Anaerobic digestion N_2O
EF (kg gas/kg)	0.004	0.00024	0.0008	Assumed negligible
GWP (IPCC AR5)	28	265	28	265
EF (CO_2-e) (kg CO_2-e/kg waste)	0.11	0.064	0.022	0
Combined EF (kg CO_2-e/kg waste)	0.176		0.0224	

10.3.7. Assumptions, limitations and uncertainties

The uncertainties for emission factors used in methane emissions from managed municipal landfills is ±40 per cent. This is consistent with the estimates in the IPCC Guidelines (IPCC, 2006a). *New Zealand's Greenhouse Gas Inventory 1990–2021* states that "the emission factor uncertainty is set at this level, while better-quality parameters are used in this category, most of the parameters are based on international data and are not site specific".

If an organisation has an advanced diversion system (to recycling and composting) then using the 'average waste' category in the methodology will overestimate emissions. If an organisation has no diversion system, then it could underestimate emissions.

The default emission factor for average waste is based on national average composition data from *New Zealand's Greenhouse Gas Inventory 1990–2021*. Only waste to municipal and non-municipal landfills is considered.

The nitrous oxide emissions associated with anaerobic digestion are assumed to be negligible.

The guide does not cover methodologies to determine emissions from solid waste incineration, as we assume emissions are negligible at the individual organisation level.

11. Agriculture, forestry and other land-use emission factors

This category covers emissions produced by land use, land-use change and forestry (LULUCF), livestock enteric fermentation, manure management, agricultural soils and fertiliser use.

We selected the emission factors below, based on appropriate available data and the professional opinions of the Ministry for Primary Industries (MPI) and the Ministry for the Environment.

- Land use, land-use change and forestry
    - forest growth
    - forest harvest and deforestation
- Agriculture
    - enteric fermentation
    - manure management
    - fertiliser use
    - agricultural soils (livestock).

Users should disclose in their inventories if they include animals grazing on land not owned by the organisation.

Users also have the option of estimating farm biological emissions and sequestration with the Ministry for the Environment's Agricultural Emissions Calculator which uses the same methods and emissions factors as the guidance.

11.1. Overview of changes since previous update

This guide uses data from *New Zealand's Greenhouse Gas Inventory 1990–2021* which has revised methodologies and emissions factors from the previous edition. The changes relevant to the updated emission factors included in this version are summarised as:

- the conversion from AR4 to AR5 GWPs. This has affected the emission factors for CH_4 and N_2O which make up a substantial proportion of agricultural emissions
- adoption of new $Frac_{LEACH}$ values for nitrogen applied to grazing systems and from synthetic nitrogen fertilisers
- the inclusion of non-pasture feeds for dairy cattle, beef cattle and sheep (previously assumed to be 100 per cent pasture fed)
- improvement to the estimates of within-year dairy cattle population change
- minor changes to the planted forest emission factors. This comes from updated planted forest area estimates, which are used to derive the emission factors. The yield tables, which are the other component of the emission factor calculations, remain unchanged.
- emission factors from agricultural soils for swine and poultry increased substantially, due to an error correction.

Please refer to section 5.1.5 (and other relevant sections) of *New Zealand's Greenhouse Gas Inventory 1990–2021* for further details.

11.2. Land use, land-use change and forestry (LULUCF)

11.2.1. Overview of the sector

GHG emissions from vegetation and soils due to human activities are reported in the land use, land-use change and forestry (LULUCF) sector. This guide provides emission factors related to forest growth, forest harvest and deforestation only. The term LULUCF is used for consistency with *New Zealand's Greenhouse Gas Inventory 1990–2021*.

The LULUCF sector is responsible for both emitting GHG (primarily carbon dioxide) to the atmosphere (emissions; ie, through harvesting and deforestation) and removing GHG from the atmosphere (removals; ie, through vegetation growth). Most emissions reported in this sector are due to forestry activities such as harvest operations in production forests, and most removals are due to forest growth.

The basis for the methods given here is that the flux of carbon dioxide to and from the atmosphere is due to the changes in carbon stocks in vegetation and soils. When emissions exceed removals, LULUCF is a 'net source', and emissions are positive. When removals exceed emissions, LULUCF is a 'net sink', and emissions are negative.

The guide provides methods to estimate the carbon stock change (or flux) that occurs from forestry activities during the applicable measurement period. We do not include methods to estimate carbon stock changes in non-forest vegetation, soils, harvested wood products, or for the associated nitrous oxide and methane emissions. For more detail, see *New Zealand's Greenhouse Gas Inventory 1990–2021*.

In line with ISO 14064-1:2018 and the GHG Protocol, organisations should consider LULUCF emissions and removals if they have forest land within their measurement boundary, or own land that has been deforested during the measurement period.

> Organisations with LULUCF emissions should calculate and report these separately from direct and indirect (Scope 1, 2 and 3) emissions.

The emission factors in this guide are New Zealand-specific, derived from national averages.

Although the main aim of this section of the guide is to estimate stock changes from forestry activities, it can also be used to estimate the total carbon stored for a given forest type in a given area. This can help organisations understand the potential impact of some forestry activities on emissions, and how to manage land use for carbon.

11.2.2. LULUCF emission factors

11.2.2.1. Planted forests

Two approaches are provided to calculate emissions and removals from planted forests. Only one approach can be used, a mixture of approaches is not permitted.

Approach one – Carbon stock change accounting

This approach estimates the net emissions and removals from forest growth and harvesting each year. The emission factors are based on the Land Use and Carbon Analysis System (LUCAS) national forest inventory.

Annual removals from forest growth (table 82) are estimated as an average annual increment over the average duration of their harvesting cycle. Emission factors are provided for three species groups (*Pinus radiata*, other softwoods, and all hardwoods) and an 'all planted forest category' (this represents an average emission factor for New Zealand's entire planted forest estate, regardless of species). The 'all planted forest' category may only be used when a species breakdown is not available. The emission factors for forest harvesting and deforestation are provided as the entire loss of carbon on the clearing of planted forest at the average harvest (table 83).

Note, if species-specific emission factors for forest growth are used, the corresponding species-specific values must be used to account for land-use change emissions. Likewise, if the 'all planted forest' emission factor is used for forest growth, then it must also be used to account for land-use change emissions.

Approach two – Averaging accounting

The averaging approach estimates carbon dioxide removals from the planting of new forests (afforestation) up to the age when they reach their average long-term carbon stock. The long-term average carbon stock represents the average carbon that is estimated to be stored over successive rotations.

Once carbon dioxide removals have been measured up to the long-term average carbon stock, there are assumed to be no further emissions or removals (ie, no additional removals from growth nor emissions from harvest). The averaging approach requires information on forest plant date, so the age can be determined, and for the forest to be in its first rotation.

The age that the long-term average carbon stock is reached varies depending on species (*Pinus radiata* = 22 years, other softwoods = 28 years, and all hardwoods = 13 years, or for all planted forest = 22 years). Any forest that is over the age of the long-term average carbon stock is considered to have an emission factor of zero. The 'all planted forest' category may only be used when a species breakdown is not available (this represents an average emission factor for New Zealand's planted forest estate, regardless of species).

This approach aligns with the approach that New Zealand will take to account for emissions and removals in first rotation post-1989 planted forest under the Paris Agreement. The averaging approach can be appropriate for participants who can identify the plant date of their forests (and if it is in its first rotation), or do not have data available on harvesting activity.

Deforestation emissions are still accounted in full, as in approach one (table 83). If species-specific emission factors for forest growth are used, the corresponding species-specific values must be used to account for land-use change emissions. Likewise, if the 'all planted forest' emission factor is used for forest growth, then it must also be used to account for land-use change emissions.

> **HARVESTING AND DEFORESTATION**
>
> Deforestation occurs when forest land is cleared for another land use.
>
> Harvesting refers to the harvest of planted production forests for timber, which are then replanted.

11.2.2.2. Natural forests

The emission factors for natural forest growth (shown in table 82) are based on the LUCAS national forest inventory. We provide separate emission factors if the forest is pre-1990 or post-1989. Post-1989 regenerating natural forest is regenerating natural forest that was established from 1 January 1990 onwards. Pre-1990 natural forest is natural forest that was established before 1 January 1990. Within pre-1990 natural forest we provide separate emission factors if the forest is tall or regenerating ie, recovering from conversion from another land use, logging, or other anthropogenic disturbance.

The emission factor for natural forest deforestation (shown in table 83) is based on the average stock at the national level, calculated from the LUCAS national forest inventory.

Table 82:   LULUCF forest growth emission factors

Forest growth removal source	Unit	kg CO$_2$-e/unit	Uncertainty (95% CI)
Planted forests: Approach one – Stock change accounting			
All planted forests	ha	-35,503	±21.9 %
Pinus radiata	ha	-36,655	±21.8 %
Other softwoods	ha	-29,414	±28.4 %
All hardwoods	ha	-16,102	±66.6 %
Planted forests: Approach two – Averaging accounting			
All planted forests – First rotation (age 22 years and under)	ha	-35,503	±21.9 %
Pinus radiata – First rotation (age 22 years and under)	ha	-36,655	±21.8 %
Other softwoods – First rotation (age 28 years and under)	ha	-29,414	±28.4 %
All hardwoods – First rotation (age 13 years and under)	ha	-16,102	±66.6 %
All planted forest above the long-term average age	ha	0000	n/a
Natural forests			
Post-1989 Regenerating natural forest	ha	-7,973	±44.8 %
Pre-1990 Regenerating natural forest	ha	-1,567	±119.6 %
Pre-1990 Tall natural forest	ha	0000	n/a

Source: New Zealand's LUCAS national forest inventory data April 2023.

Table 83:   LULUCF land-use change emission factors

Land-use change emission source		Unit	kg CO$_2$-e/unit	Uncertainty (95% CI)
Planted forests: Approach one – Stock change accounting				
All planted forests	Harvest or deforestation	ha	994,095	±21.9 %
Pinus radiata	Harvest or deforestation	ha	1,026,353	±21.8 %
Other softwoods	Harvest or Deforestation	ha	1,176,533	±28.4 %
All hardwoods	Harvest or deforestation	ha	241,536	±66.6 %

Land-use change emission source		Unit	kg CO_2-e/unit	Uncertainty (95% CI)
Planted forests: Approach two – Averaging accounting				
All planted forests	Harvest	ha	n/a	n/a
	Deforestation	ha	994,095	±21.9 %
Pinus radiata	Harvest	ha	n/a	n/a
	Deforestation	ha	1,026,353	±21.8 %
Other softwoods	Harvest	ha	n/a	n/a
	Deforestation	ha	1,176,533	±28.4 %
All hardwoods	Harvest	ha	n/a	n/a
	Deforestation	ha	241,536	±66.6 %
Natural forests				
Post-1989 Regenerating natural forest	Deforestation	ha	141,350	±27.0 %
Pre-1990 Regenerating natural forest	Deforestation	ha	898,662	±20.9 %
Pre-1990 Tall natural forest	Deforestation	ha	277,161	±27.3 %

Source: New Zealand's LUCAS national forest inventory data April 2023.

11.2.3. GHG inventory development

To calculate LULUCF emissions, organisations need activity data on each forest type, the area harvested and any changes to forested land within the organisational boundary for the measurement period. Different forest types have different emission factors, while deforestation and harvest rates change over time.

First determine the type of forest and the area it covers. The New Zealand parameters to define a forest are a minimum area of 1 hectare, the potential to reach a minimum height of 5 metres and a minimum crown cover of 30 per cent.

Forest types:

Pre-1990 Tall natural forest: areas, that on 1 January 1990, were and presently comprise of mature indigenous forest.

Pre-1990 Regenerating natural forest: areas, that on 1 January 1990, were and presently comprise of indigenous and naturally occurring vegetation, including broadleaved hardwood shrubland, mānuka–kānuka and other woody shrubland, with potential to reach forest definition under its current management. This category represents mid-successional regenerating forest.

Post-1989 Regenerating natural forest: areas of forest established from 1 January 1990 onwards that comprise of indigenous tree species arising from natural regeneration. This category represents early successional regenerating forest.

The following information can be used to determine natural forest types:

(a) The LUCAS Land Use Map[63] can provide area by vegetation type (pre-1990 and post-1989 natural forest) at 1990, 2008, 2012 and 2016. It requires geospatial expertise to analyse and extract the data by region. This is free to use and supports users in monitoring changes in their own land management practices.

(b) The New Zealand Land Cover Database (LCDB)[64] provides multi-temporal land cover. This can be used to differentiate between tall and regenerating pre-1990 natural forest. Two LCDB classes are classified as tall forest; indigenous forest and broadleaved indigenous hardwoods. All other categories are classified as regenerating forest. It requires geospatial expertise to analyse and extract the data for sub-national analysis.

(c) Alternatively, if the age of the forest is known or can be estimated, this can be used to determine forest type:

– Age 0–32 years: post-1989 regenerating natural forest

– Age 32–100 years: pre-1990 regenerating natural forest

– Age 100 years and over: pre-1990 tall natural forest

Planted forest: plantations of forest species mainly used for forestry, including:

– radiata pine (*Pinus radiata*)

– softwoods, such as Douglas fir (*Pseudotsuga menziesii*)

– hardwoods, such as eucalypts (*Eucalyptus* spp.)

– other planted species (with potential to reach ≥5 metre height at maturity in situ).

Organisations will also need records of forest harvest and deforestation activities (including area in ha) to calculate the emissions from LULUCF. Sources of this information include:

• Corporate or farm records for enterprises and organisations

• Geospatial analysis of the property or region

• The LUCAS Land Use Map

• The New Zealand Land Cover Database (LCDB)

• If Approach two (averaging) is used, the planting date (to calculate the age of the forest) will be required as well as evidence that the forest is in its first rotation.

Using the sources detailed above to gather information on the land use, forest type and size, organisations can apply the equation E = Q x F (section 2):

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   area of land (ha)
F   =   appropriate emission factors (for land use) from tables 82 and 83

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[63] LUCAS Land Use Map (MfE Data Service).

[64] The New Zealand Land Cover Database. LCDB v4.1 (Deprecated) - Land Cover Database version 4.1, Mainland New Zealand - Informatics Team | New Zealand | Environment and Land GIS | LRIS Portal (scinfo.org.nz).

LAND USE, LAND-USE CHANGE AND FORESTRY: EXAMPLE CALCULATIONS

Example one (using Approach one for planted forest):

An organisation owns 4 ha of land: 3 ha are planted forest (*Pinus radiata*) and 1 ha is pre-1990 regenerating natural forest. During the reporting year the organisation harvested the planted forest for timber.

3 ha of planted forest (*Pinus radiata)* were harvested, therefore:

CO_2 emissions = 3 × 1,026,353 = 3,079,059 kg CO_2-e

The removals (expressed as a negative) for the regenerating pre-1990 natural forest are:

CO_2 removals = 1 × -1,567 = -1,567 kg CO_2-e

Therefore, total net CO_2-e emissions = 3,079,059 − 1,567 = 3,077,492 kg CO_2-e.

Note: Negative emissions are a carbon sink.

Example two (using Approach two for planted forest):

An organisation owns 40 ha of land: 10 ha are planted forest (Other softwoods) below the long-term average age (< 28 years since time of planting), 20 ha are planted forest (*Pinus radiata*) above the long-term average age (> 22 years since time of planting) and a further 10 ha of planted forest (*Pinus radiata*) were deforested during the reporting year.

The removals (expressed as negative) for the 10 ha of planted forest (Other softwoods) below the long-term average age (< 28 years) are:

CO_2 removals = 10 × -29,414 = -294,140 kg CO_2-e

The removals (expressed as a negative) for the 20 ha of planted forest (*Pinus radiata*) above the long-term average (> 22 years):

CO_2 removals = 20 × 0 = 0 kg CO_2-e

The emissions for the 10 ha of planted forest (*Pinus radiata*) that were deforested:

CO_2 emissions = 10 × 1,026,353 = 10,263,530 kg CO_2-e

Therefore, total net CO_2-e emissions = 10,263,530 − 294,140 − 0 = 9,969,390 kg CO_2-e.

11.2.3.1. Activity data uncertainties

National mapping uncertainty for natural forest and pre-1990 planted forest land is ±5 per cent, and ±8 per cent for post-1989 forest land. As the guide combines planted forest types, we recommend applying the higher uncertainty of ±8 per cent.

11.2.4. Emission factor derivation methodology

As stated above, two approaches are provided to calculate emissions and removals from planted forests. Approach one (carbon stock change accounting) estimates the net emissions and removals from forest growth and harvesting each year. Approach two (averaging accounting) estimates carbon dioxide removals from the planting of new forests up to the age when they reach their average long-term carbon stock.

The approach to emissions estimation for Approach one (stock change accounting) follows this equation:

$$\Delta C = \sum_{ij} \left[A_{ij} * (C_I - C_L)_{ij} \right]$$

Where:

- ΔC = carbon stock change in the pool, kg C yr^{-1}
- A = area of land, ha
- ij = corresponds to forest type, and whether harvested or deforested
- CI = rate of gain of carbon, kg C ha^{-1} yr^{-1}
- CL = rate of loss of carbon, kg C ha^{-1} yr^{-1}

The area refers to the area of each forest type and whether harvested or deforested in the year of the inventory. The general approach is to multiply the area data by an emission factor to provide the source or sink estimates.

Quantities of carbon can be expressed in different ways: carbon (C), CO_2 and CO_2-e.

To convert carbon to carbon dioxide, multiply by $^{44}/_{12}$ (ie, the molecular conversion of carbon to carbon dioxide).

The approach to emissions estimation for Approach two (averaging) follows this equation:

$$\Delta C = \sum \left[A_a * (C_I) + A_b * 0 \right]$$

Where:

- ΔC = carbon stock change in the pool, kg C yr^{-1}
- A_a = area of planted forest land that is yet to reach its long-term average, ha
- A_b = area of planted forest land that *has* reached its long-term average, ha
- CI = rate of gain of carbon, kg C ha^{-1} yr^{-1}.

11.2.5. Assumptions, limitations and uncertainties

The emission factors are based on national average data, therefore the uncertainties will not necessarily reflect sub-national circumstances.

For natural forests, deforestation and harvest loss, data are based on the national stock average, which comes from the most recent carbon stock inventory for these forests.

The emission factors for planted forest (Approach one) and natural forest in this guide are based on *New Zealand's Greenhouse Gas Inventory 1990–2021*. The long-term average carbon stock for planted forest (Approach two) are based on Wakelin et al. (unpublished[65]). These

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[65] Wakelin SJ, Paul THS, West T, Dowling, LJ. Unpublished. Reporting New Zealand's Nationally Determined Contribution under the Paris Agreement using Averaging Accounting for Post-1989 forests. Contract report prepared for the Ministry for the Environment by New Zealand Forest Research Institute Ltd (trading as Scion) in 2021.

emission factors represent the most up-to-date forestry data available. ETS look-up tables are another source of emissions factors; however, these are not updated as frequently. The emission factors are based on national average data and the uncertainties will not necessarily reflect sub-national circumstances and will not be exactly the same as the ETS estimates of carbon sequestration which differentiate based on tree age, region and to a limited extent, the species. Selection of the most appropriate emission factor should be guided by the requirements of the intended use and by the user's inventory.

11.3. Agriculture

Emissions from agriculture are produced in several ways. This section includes emissions from enteric fermentation, manure management and fertiliser use, in more detail:

- Methane from enteric fermentation is a by-product of ruminant digestion. Cattle and sheep are the largest sources of methane in this sector.

- Storing and treating manure, including spreading it onto pasture, produces methane and nitrous oxide.

- Losses also occur from manure that is deposited by livestock directly onto pasture.

- Applying nitrogen (urea-sourced or synthetic) fertiliser onto land produces nitrous oxide and carbon dioxide (urea) emissions.

- Applying lime and dolomite fertilisers results in carbon dioxide emissions.

If an organisation directly owns and manages livestock, agriculture emission sources are direct (Scope 1).

Note the livestock emissions you calculate using these implied emission factors are intended to be an approximate estimate of emissions only, and are based on the average per-animal biological emissions of New Zealand's main farmed livestock categories. Implied emission factors are provided per head of livestock type per year.

Actual livestock emissions for an individual farm will differ depending on a number of factors, including live-weights, productivity, and feed quality. Organisations looking for a more accurate farm-based estimate of their agricultural emissions are encouraged to use alternative GHG calculator tools. The list of tools approved by the He Waka Eke Noa programme can be found here: Know your number – Ag Matters.

11.3.1. Enteric fermentation

Enteric fermentation is the process by which ruminant animals produce methane through digesting feed. We provide emission factors for dairy cattle, non-dairy cattle, sheep and deer and other minor livestock categories in table 84.

Table 84: Implied emission factors from enteric fermentation

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	CH_4 (kg CO_2-e)/ unit	N_2O (kg CO_2-e)/ unit
Enteric fermentation					
Dairy cattle	per head	2423	n/a	2,423	n/a
Non-dairy cattle	per head	1679	n/a	1,679	n/a
Sheep	per head	349	n/a	349	n/a

Emission source	Unit	kg CO$_2$-e/unit	kg CO$_2$/unit	CH$_4$ (kg CO$_2$-e)/unit	N$_2$O (kg CO$_2$-e)/unit
Deer	per head	644	n/a	644	n/a
Swine	per head	29.7	n/a	29.7	n/a
Goats	per head	251	n/a	251	n/a
Horses	per head	504	n/a	504	n/a
Alpaca and llama	per head	224	n/a	224	n/a
Mules and asses	per head	280	n/a	280	n/a
Poultry	per head	0000	n/a	n/a	n/a

11.3.1.1. GHG inventory development

Organisations should collect data on the number and type of livestock as at 30 June during the measurement period (regardless of whether the period is a calendar or financial year; see section 11.3.1) to calculate emissions from enteric fermentation.

Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO$_2$-e per year
Q   =   number of animals (per head per livestock type)
F   =   appropriate emission factors from table 84

ENTERIC FERMENTATION: EXAMPLE CALCULATION

An organisation owns 2,400 sheep and 210 dairy cows on 30 June during the reporting period. They graze on land owned by the organisation.

CO$_2$ emissions	= 0
CH$_4$ emissions	= (2,400 × 349) + (210 × 2,423) = 1,346,430 kg CO$_2$-e
N$_2$O emissions	= 0
Total CO$_2$-e emissions	= 1,346,430 kg CO$_2$-e

Note: Numbers may not add due to rounding.

Implied emission factor derivation methodology

New Zealand's Greenhouse Gas Inventory 1990–2021 publishes total emissions for enteric fermentation per livestock type, along with population numbers. The Ministry for Primary Industries (MPI) publishes total emissions for enteric fermentation per livestock type, along with population numbers. MPI supplied these same data for the creation of implied emission factors. We used this information to calculate the emission factors based on the following equation:

$$Implied\ emission\ factor\ per\ animal = \frac{enteric\ fermentation}{population}$$

Note that the emission factors are based on data supplied for *New Zealand's Greenhouse Gas Inventory 1990–2021*.

To ensure consistency, organisations should report their population of livestock as at 30 June, regardless of the measurement period.

MPI defines non-dairy cattle as beef breeds of cattle, including dairy-beef, as well as any beef breeding stock.

Table 85:   Enteric fermentation figures per livestock type

Animal	2021 population	Enteric fermentation emissions in 2021 (kt CH₄) (as GHG)
Dairy cattle	6,185,435	535.30
Non-dairy cattle	3,964,811	237.76
Sheep	25,732,889	320.48
Deer	813,980	18.73
Swine	248,717	0.26
Goats	116,666	1.05
Horses	40,276	0.72
Alpaca and llama	7,578	0.06
Mules and asses	141	0.001
Poultry	19,346,289	n/a

kt = kilotonne

Source: Based on figures from the Agricultural Inventory Model used in *New Zealand's Greenhouse Gas Inventory 1990–2021*.

Alternative methods and tools

There are alternative calculating tools, such as the Ministry's Agricultural Emissions Calculator, OverseerFM, or the B+LNZ GHG calculator. The implied emission factors in this guide may differ from other tools because of the different in-built assumptions and limitations. It is up to the user to assess the appropriateness of alternative tools.

11.3.1.2. Assumptions, limitations and uncertainties

New Zealand's Greenhouse Gas Inventory 1990–2021 details the uncertainties associated with the activity data used to calculate the emission factors.

The level of uncertainty with enteric fermentation emissions is ±16 per cent.

11.3.2. Manure management emission factors

Manure management refers to the process of managing the excretion of livestock, particularly when they are not on paddocks, but also covers losses from manure that is deposited by livestock directly onto pasture, and it is distinct from losses from agricultural soils. The storage and treatment of manure produces GHG emissions. We provide the manure management emission factors in table 86.

Table 86:   Implied emission factors from manure management

Emission source	Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/unit)	CH₄ (kg CO₂-e/unit)	N₂O (kg CO₂-e/unit)
Manure management					
Dairy cattle	per head	254.5	n/a	242.8	11.7
Non-dairy cattle	per head	23.3	n/a	23.3	n/a
Sheep	per head	3.81	n/a	3.81	n/a

Emission source	Unit	kg CO_2-e/unit	CO_2 (kg CO_2-e/unit)	CH_4 (kg CO_2-e/unit)	N_2O (kg CO_2-e/unit)
Deer	per head	8.33	n/a	8.33	n/a
Swine	per head	218	n/a	166	51.7
Goats	per head	5.60	n/a	5.60	n/a
Horses	per head	65.5	n/a	65.5	n/a
Alpaca and llama	per head	2.84	n/a	2.84	n/a
Mules and asses	per head	30.8	n/a	30.8	n/a
Poultry	per head	1.43	n/a	0.852	0.580

11.3.2.1. GHG inventory development

Organisations should collect data on the number and type of livestock as at 30 June during the measurement period (regardless of whether the period is a calendar or financial year, see section 11.3.2) to calculate emissions from manure management.

Applying the equation E = Q x F (section 2), this means:

E = emissions from the emissions source in kg CO_2-e per year
Q = number of animals (per head per livestock type)
F = appropriate emission factors from table 86

MANURE MANAGEMENT: EXAMPLE CALCULATION

An organisation owns 2,400 sheep and 210 dairy cows on 30 June during the reporting period.

CO_2 emissions   = 0
CH_4 emissions   = (2,400 × 3.81) + (210 × 242.8)   = 60,132 kg CO_2-e
N_2O emissions   = (2,400 × 0.0) + (210 × 11.7)   = 2,457 kg CO_2-e
Total CO_2-e emissions = 62,589 kg CO_2-e

Note: Numbers may not add due to rounding.

Implied emission factor derivation methodology

We calculated the implied emission factors from figures in the Agricultural Inventory Model, used in *New Zealand's Greenhouse Gas Inventory 1990–2021*. MPI provided the data in table 87.

Table 87:   Manure management source data

Animal	Population	Methane from manure management (kt CH_4)	Nitrous oxide from manure management (kt N_2O)
Dairy cattle	6,185,435	53.64	0.27
Non-dairy cattle	3,964,811	3.30	0.00
Sheep	25,732,889	3.50	0.00
Deer	813,980	0.24	0.00
Swine	248,717	1.48	0.05
Goats	116,666	0.02	0.00
Horses	40,276	0.09	0.00
Alpaca and llama	7,578	0.0008	0.00
Mules and asses	141	0.0002	0.00
Poultry	19,345,800	0.59	0.04

kt = kiloton. Source: The Agricultural Inventory Model used in *New Zealand's Greenhouse Gas Inventory 1990–2021.*

Table 88:　　**Emissions from dairy cattle**

Animal	Population	Methane from manure management (kg CH$_4$)	Nitrous oxide from manure management (kg N$_2$O)
Dairy cattle	6,185,435	53,642,309	273,578

> **MANURE MANAGEMENT: EMISSION FACTORS CALCULATIONS FOR LIFESTOCK TYPE**
>
> We calculated the manure management emission factors for each type of livestock as follows:
>
> 1. Convert the units to kg of GHG.
>
> 2. Divide by population to generate kg of GHG per head (ie, per animal).
>
> 3. Calculate kg CO$_2$-e/animal by multiplying each GHG by the IPCC AR5 100-year GWP.
>
> Emission factors for dairy cattle (table 88) were calculated as follows:
>
> | | | |
> |---|---|---|
> | Methane emissions | = 53,642,309 ÷ 6,185,435 | = 8.672 kg CH$_4$ per head |
> | Nitrous oxide emissions = 273,578 ÷ 6,185,435 | | = 0.044 kg N$_2$O per head |
> | Total kg CO$_2$ **equivalent** = (8.672 x 28) + (0.044 x 265) = 254.5 kg CO$_2$-e per head | | |

11.3.2.2. Assumptions, limitations and uncertainties

New Zealand's Greenhouse Gas Inventory 1990–2021 states that the major sources of uncertainty in emissions from manure management are the accuracy of emission factors for manure management system distribution, the activity data on the livestock population and the use of the various manure management systems. Based on the IPCC methodologies[66], the uncertainty factor for methane emissions is ±20 per cent and for nitrous oxide emissions ±100 per cent,[67] although different uncertainty values are reported in the New Zealand Inventory. *New Zealand's Greenhouse Gas Inventory 1990–2021* details the assumptions and limitations of these data.

11.3.2.3. Alternative methods of calculation

See Alternative methods and tools.

11.3.3. Agricultural soils

Agricultural soils emit nitrous oxide due to the addition of nitrogen to soils through manure, dung and urine. The guide provides implied emission factors for the impact of common agricultural livestock categories on soil in table 89.

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[66]　See Volume 4, Chapter 10 of *2006 IPCC Guidelines for National Greenhouse Gas Inventories*: www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf.

[67]　Ibid.

Table 89: Implied emission factors from agricultural soils

Emission source	Unit	kg CO₂-e/unit	CO₂ (kg CO₂-e/unit)	CH₄ (kg CO₂-e/unit)	N₂O (kg CO₂-e/unit)
Agricultural soils (livestock)					
Dairy cattle	per head	377.2	n/a	n/a	377.2
Non-dairy cattle	per head	226.6	n/a	n/a	226.6
Sheep	per head	31.5	n/a	n/a	31.5
Deer	per head	72.5	n/a	n/a	72.5
Swine	per head	42.0	n/a	n/a	42.0
Goats	per head	61.5	n/a	n/a	61.5
Horses	per head	290.9	n/a	n/a	290.9
Alpaca and llama	per head	66.3	n/a	n/a	66.3
Mules and asses	per head	129.6	n/a	n/a	129.6
Poultry	per head	1.54	n/a	n/a	1.54

11.3.3.1. GHG inventory development

Organisations should collect data on the number and type of livestock they had as at 30 June during the measurement period. Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO₂-e per year
Q   =   number of animals (per head per type)
F   =   appropriate emission factors from table 89

> **AGRICULTURAL SOILS: EXAMPLE CALCULATION**
>
> An organisation owns 2,400 sheep and 210 dairy cows on 30 June during the reporting period. They graze on land owned by the organisation.
>
> CO₂ emissions   = n/a
> CH₄ emissions   = n/a
> N₂O emissions   = (2,400 × 31.5) + (210 × 377.2) = 154,812 kg CO₂-e
> Total CO₂-e emissions   = 154,812 kg CO₂-e
>
> Note: Numbers may not add due to rounding.

11.3.3.2. Emission factor derivation methodology

We calculated the emission factors from the Agricultural Inventory Model, used in *New Zealand's Greenhouse Gas Inventory 1990–2021*. These data are in table 90.

Table 90: Agricultural soils source data

Animal	Population	Total agricultural soils (kt N₂O)
Dairy cattle	6,185,435	8.804
Non-dairy cattle	3,964,811	3.391
Sheep	25,732,889	3.061
Deer	813,980	0.223
Swine	248,717	0.039
Goats	116,666	0.027

Animal	Population	Total agricultural soils (kt N_2O)
Horses	40,276	0.044
Alpaca and llama	7,578	0.002
Mules and asses	141	0.0001
Poultry	19,345,800	0.112

11.3.3.3. Assumptions, limitations and uncertainties

New Zealand's Greenhouse Gas Inventory 1990–2021 details the uncertainties associated with the activity data used to calculate the implied emission factors.

The level of uncertainty with N_2O emissions from agricultural soils was ±55 per cent for 2021.

11.3.4. Fertiliser use

The use of fertiliser produces GHG emissions. Nitrogen fertiliser breaks down to produce nitrous oxide and carbon dioxide (urea). Limestone and dolomite fertilisers break down to produce carbon dioxide. *New Zealand's Greenhouse Gas Inventory 1990–2021* reports the total emissions from fertiliser using New Zealand-specific emission factors. We used methodologies supplied by MPI to develop emission factors for:

- the nitrogen content of non-urea nitrogen fertiliser

- the nitrogen content of urea nitrogen fertiliser not coated with urease inhibitor

- the nitrogen content of urea nitrogen fertiliser coated with urease inhibitor

- limestone

- dolomite.

In line with the reporting requirements of ISO 14064-1:2018 and the GHG Protocol, we provide implied emission factors to allow separate calculation of carbon dioxide, methane and nitrous oxide. Table 91 lists emissions from the use of different fertilisers. Table 92 lists example products for the different fertiliser types. For the nitrogen fertilisers listed in table 91, the input amounts are expressed in terms of the nitrogen component of fertiliser only.

Table 91: **Fertiliser use emission factors**

Emission source	Unit	kg CO_2-e/ unit	CO_2 (kg CO_2-e/ unit)	CH_4 (kg CO_2-e/ unit)	N_2O (kg CO_2-e/ unit)
Fertiliser use					
Nitrogen content of non-urea nitrogen fertiliser	kg N	4.80	n/a	n/a	4.80
Nitrogen content of urea nitrogen fertiliser not coated with urease inhibitor	kg N	4.69	1.59	n/a	3.09
Nitrogen content of urea nitrogen fertiliser coated with urease inhibitor	kg N	4.50	1.59	n/a	2.90
Limestone	kg	0.440	0.440	n/a	n/a
Dolomite	kg	0.477	0.477	n/a	n/a

Note: These numbers are rounded to three significant figures unless the number is significantly small.

* Noting that this is the mass of the nitrogen component of fertiliser only.

Table 92: Examples of different categories of fertilisers

Fertiliser type	Example product
Non-urea nitrogen	Diammonium phosphate
Urea nitrogen not coated with urease inhibitor	Nrich urea
Urea nitrogen coated with urease inhibitor	Agrotain, SustaiN, N-Protect

11.3.4.1. GHG inventory development - nitrogen

Organisations should collect data on quantity of nitrogen (in kg) of fertiliser used in the reporting period by type. Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   type of fertiliser used (in kg)
F   =   appropriate emission factors from table 91

FERTILISER USE: EXAMPLE CALCULATION

An organisation uses 80 kg of dolomite and 50 kg of nitrogen from non-urea nitrogen fertiliser in the reporting year.

CO_2 emissions	= (80 × 0.477) + (50 × 0)	= 38.16 kg CO_2-e
CH_4 emissions	= (80 × 0) + (50 × 0)	= 0 kg CO_2-e
N_2O emissions	= (80 × 0) + (50 × 4.80)	= 240 kg CO_2-e
Total CO_2-e emissions	= 278.16 kg CO_2-e	

Note: Numbers may not add due to rounding.

Implied emission factor derivation methodology

MPI provided data on the quantified direct and indirect GHG emissions produced per tonne of nitrogen in fertiliser (tables 93 and 94).

Table 93: Nitrogen fertiliser emission factors

Fertiliser type	Direct emissions of N_2O (kg N_2O/kg of N in fertiliser)	Indirect emissions-volatilisation (kg N_2O/kg of N in fertiliser)	Indirect emissions – leaching (kg N_2O/kg of N in fertiliser)	CO_2 emissions from urea (kg CO_2/ kg of N in fertiliser)
Non-urea nitrogen	0.0157	0.0016	0.0008	n/a
Urea nitrogen not coated with urease inhibitor	0.0093	0.0016	0.0008	1.594
Urea nitrogen coated with urease inhibitor	0.0093	0.0009	0.0008	1.594

Note: These numbers are rounded to three decimal places unless the number is significantly small. Based on 2021 guide.

Table 94: Quantified emissions factors from limestone and dolomite

Fertiliser type	Unit	Emissions (kg CO_2-e /kg fertiliser)
Limestone	kg	0.440
Dolomite	kg	0.477

Note: These numbers are rounded to three decimal places. Based on 2021 guide.

11.3.4.2. GHG inventory development - lime

Organisations should collect data on quantity of lime (in kg) fertiliser used in the reporting period by type. Applying the equation E = Q x F (section 2), this means:

E   =   emissions from the emissions source in kg CO_2-e per year
Q   =   type of fertiliser used (in kg)
F   =   appropriate emission factors from table 94

11.3.4.3. Assumptions, limitations and uncertainties

MPI used the following parameters to calculate the emissions.

Table 95:   Parameters for calculating emissions from fertilisers

Parameter	Value	Source
Direct emission factor non-urea-N	0.01	Based on Kelliher and de Klein, 2006
Direct emission urea-N	0.0059	Based on van der Weerden et al., 2016

Parameter	Value	Source
$Frac_{GASE}$ (UI)	0.055	Saggar, 2013
$Frac_{GASE}$ (non-UI)	0.1	Sherlock et al., 2008
Volatilisation emission factor (EF4)	0.01	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, table 11.3
$Frac_{LEACH}$ (Grassland)	0.08	Welten et al., 2021
$Frac_{LEACH}$ (Cropland)	0.10	Welten et al., 2021
$Frac_{LEACH}$ (Synthetic N Fertiliser)	0.082	Calculated based on Welten et al., 2021
Leaching emission factor (EF5)	0.0075	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, table 11.3
Urea emission factor (CO_2 component)	0.2	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, section 11.4.2
Emission factor for limestone	0.12	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, section 11.4.2
Emission factor for dolomite	0.13	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, section 11.4.2
N content of urea	46%	Agriculture inventory model
Molecular conversion CO_2	3.667	
Molecular conversion N_2O	1.571	
GWP100 N_2O	265	IPCC AR5

New Zealand's Greenhouse Gas Inventory 1990–2021 uses the IPCC (2006) Tier 1 methodology when default emission factors are used, which assume conservatively that all carbon in the fertilisers is emitted as carbon dioxide into the atmosphere.

There is no country-specific methodology on carbon dioxide emissions from urea application for New Zealand. Emissions associated with the application of urea are estimated using a Tier 1 methodology (equation 11.13; IPCC, 2006), using the default emission factor for carbon conversion of 0.20.

Appendix A: Derivation of fuel emission factors

A1 The importance of calorific value

The energy content of fuels may vary within and between fuel types. Emission factors are therefore commonly expressed in terms of energy units (eg, tonnes CO_2-e/TJ) rather than mass or volume. This generally provides more accurate emissions estimates. Converting to emission factors expressed in terms of mass or volume (eg, kg CO_2-e/litre) requires an assumption around which default calorific value should be used.

It is therefore useful to show how we derived the per-activity unit (eg, kg CO_2-e/litre) emission factors, and which calorific values we used. It is important to note that if you can obtain fuel use information in energy units, or know the specific calorific value of the fuel you are using, you can calculate your emissions more accurately.

Note that we have used gross calorific values.

A2 Methane and nitrous oxide emission factors used in this guide

Although carbon dioxide emissions remain constant regardless of how a fuel is combusted, methane and nitrous oxide emissions depend on the precise nature of the activity in which the fuel is being combusted. The emission factors for methane and nitrous oxide therefore vary depending on the combustion process. Table A1 shows the default methane and nitrous oxide emission factors (expressed in energy units) used in this guide. The calculation in section 3.2.2 shows how we converted these to a per activity unit (eg, kg CO_2-e/kg) emission factors. MBIE provided all emission factors in table 3.

Note that we have used gross emission factors.

A3 Oxidation factors used in this guide

We sourced all oxidation factors from MBIE and the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Oxidation factors have only been applied to the carbon dioxide emission factors and have not been applied to the methane and nitrous oxide emission factors.

A4 Sector classification

Emission factors for stationary fuels are provided for the residential, commercial and industrial sectors. Consumption statistics for these sectors are based on Australian and New Zealand Standard Industrial Classification (ANZSIC) codes, with the mappings shown in table A1 used for industrial and commercial sectors.

Table A1:   Mappings used for industrial and commercial sectors

Sector	ANZSIC codes
Agriculture, forestry and fishing	A
Mineral and petroleum extraction	B
Food processing	C11, C12
Textiles and leather	C13
Wood, pulp, paper and printing	C14, C15, C16
Chemicals	C17, C18, C19
Non-metallic minerals	C20
Basic metals	C21, C22
Mechanical/electrical equipment	C23, C24
Industry unallocated	C25, D26, D27, D28, D29
Building and construction	E
Commercial	F-G, H, I, J, K-N, O, P, Q, R-S

Table sourced from MBIE Energy Statistics Sources and Methods, November 2021 v1.2

For more information on ANZSIC 2006, see Stats NZ's Ariā system: www.aria.stats.govt.nz/aria/

A5   Reference data

Table A2:   Underlying data used to calculate fuel emission factors

Emission source	User	Unit	Calorific value (MJ/unit)	t CO_2 / TJ	t CH_4 / TJ	t N_2O / TJ
Stationary combustion						
Coal – bituminous	Residential	kg	29.59	89.13	0.285	0.001425
Coal – sub-bituminous	Residential	kg	21.64	91.99	0.285	0.001425
Coal – lignite	Residential	kg	15.26	93.11	0.285	0.001425
Distributed natural gas	Commercial	kWh	n/a	0.19	0.00002	0.0000003
		GJ	n/a	53.61	0.005	0.00009
Coal – bituminous	Commercial	kg	29.59	89.13	0.0095	0.0014
Coal – sub-bituminous	Commercial	kg	21.64	91.99	0.0095	0.0014
Coal – lignite	Commercial	kg	15.26	93.11	0.0095	0.0014
Diesel	Commercial	litre	38.49	69.45	0.0095	0.0006
LPG	Commercial	kg	50.00	59.27	0.005	0.0001
Heavy fuel oil	Commercial	litre	40.74	73.33	0.010	0.0006
Light fuel oil	Commercial	litre	40.45	73.02	0.010	0.0006
Distributed natural gas	Industry	kWh	n/a	0.19	0.000003	0.0000003
		GJ	n/a	53.61	0.00090	0.00009
Coal – bituminous	Industry	kg	29.59	89.13	0.0095	0.001
Coal – sub-bituminous	Industry	kg	21.64	91.99	0.0095	0.001
Coal – lignite	Industry	kg	15.26	93.11	0.0095	0.001
Diesel	Industry	litre	38.49	69.45	0.0029	0.0006
LPG	Industry	kg	50.00	59.27	0.001	0.0001
Heavy fuel oil	Industry	litre	40.74	73.33	0.003	0.0006

Emission source	User	Unit	Calorific value (MJ/unit)	t CO_2 / TJ	t CH_4 / TJ	t N_2O / TJ
Light fuel oil	Industry	litre	40.45	73.02	0.003	0.0006
Transport fuels						
Regular petrol	Mobile use	litre	35.24	66.77	0.03	0.008
Premium petrol	Mobile use	litre	35.18	66.95	0.03	0.008
Diesel	Mobile use	litre	38.49	69.45	0.004	0.004
LPG	Mobile use	litre	26.54	59.27	0.06	0.0002
Heavy fuel oil	Mobile use	litre	40.74	73.33	0.007	0.002
Light fuel oil	Mobile use	litre	40.45	73.02	0.007	0.002
Jet kerosene / Jet A1	Mobile use	litre	37.19	68.33	0.0005	0.002
Jet aviation gasoline	Mobile use	litre	33.87	65.89	0.0005	0.002
Biofuels and biomass						
Biodiesel	All uses	litre	23.6	67.26	0.018	0.0037
Bioethanol	All uses	litre	36.42	64.20	0.018	0.0076
Wood	Industry	kg	9.63	89.47	0.02	0.003
Wood	Residential	kg	9.63	89.47	0.24	0.003

Note: It is not expected that many commercial or industrial users will burn wood in fireplaces, but this emission factor is included for completeness. It is the default residential emission factor.

Note[2]: The total of each gas contribution is expressed in tonnes of gas (not CO_2-e as presented elsewhere in this guidance).

Note[3]: The solid and gaseous fuel calorific values remain unchanged from last year. Liquid fuel calorific values were updated using the MBIE energy statistics for oil, available at www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/oil-statistics/.

Note[4]: The gross GHG emission factors for fuels are taken from Annex 4 of *New Zealand's Greenhouse Gas Inventory 1990–2021*.

Appendix B: Alternative methods of calculating emissions from refrigerants and medical gases

This appendix outlines two screening methods (Methods B and C) to estimate emissions from refrigerant leakage when top-up information is not available. Method C is the same as Method B except that it allows the use of default refrigerant quantities as well as default leakage rates.

B1   Method B – Default annual leakage rate

$$E = OE \times GWP$$

Where:

- E = emissions from equipment in kg CO_2-e
- OE = operation emissions, kg by gas type
- GWP = the 100-year global warming potential of the refrigerant used in equipment (table 7).

$$OE = C \times ALR$$

Where:

- C = original full refrigerant charge in equipment (kg)
- ALR = the default annual leakage emission factor for equipment (%).

The type and quantity of HFC in the equipment will often be shown on the compliance plate. If not, this method requires service agents' advice for refrigerant type and full refrigerant charge of each piece of equipment.

B2   Method C – Default annual leakage rate and default refrigerant charge

$$E = (IE + DE + (C \times ALR)) \times GWP$$

Where:

- E = emissions from equipment in kg CO_2-e
- IE = installation emissions
- C = default refrigerant charge in each piece of equipment (kg)
- ALR = default annual leakage emission factor for equipment (%)
- DE = disposal emissions (as per method B)
- GWP = the 100-year global warming potential of the refrigerant used in equipment (table 7).

Table B1 contains default refrigerant charge amounts for the New Zealand refrigeration and air-conditioning equipment stock.

Table B1:   Default refrigerant charges for refrigeration and air-conditioning equipment

Refrigeration unit type	Default refrigerant charge (kg)	Default leakage rate (operating– ALR)	Default leakage rate (installation – AEF)[68]	Method B	Method C
Small refrigerator or freezer (<150 litres[69])	0.07	3%	n/a	Recommended	Acceptable
Medium refrigerator or freezer (150–300 litres)	0.11	3%	n/a	Recommended	Acceptable
Large refrigerator or freezer (>300 litres)	0.15	3%	n/a	Recommended	Acceptable
Small commercial stand-alone chiller (<300 litres)	0.25	8%	n/a	Acceptable	Screening method only
Medium commercial stand-alone chiller (300–500 litres)	0.45	8%	n/a	Acceptable	Screening method only
Large commercial stand-alone chiller (>500 litres)	0.65	8%	n/a	Acceptable	Screening method only
Small commercial stand-alone freezer (<300 litres)	0.2	8%	n/a	Acceptable	Screening method only
Medium commercial stand-alone freezer (300–500 litres)	0.3	8%	n/a	Acceptable	Screening method only
Large commercial stand-alone freezer (>500 litres)	0.45	8%	n/a	Acceptable	Screening method only
Water coolers	0.04	3%	n/a	Recommended	Acceptable
Dehumidifiers	0.17	3%	n/a	Recommended	Acceptable
Small self-contained air conditioners (window mounted or through-the-wall)	0.2 kg per kW cooling capacity	1%	0.5%	Acceptable	Screening method only
Non-ducted and ducted split commercial air conditioners (<20 kW)	0.25 kg per kW cooling capacity	3%	0.5%	Acceptable	Screening method only
Commercial air conditioning (>20kW)	Wide range	Wide range	Wide range	Unacceptable	Unacceptable
Cars/vans	0.7	10%	n/a	Recommended	Acceptable
Trucks	1.2	10%	n/a	Acceptable	Screening method only

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[68]   In the absence of consistent information for New Zealand, the default assumption for the assembly (installation) emissions rate is the rounded-off IPCC 2006 mid-range value. It is not applicable (relevant) for many pre-charged units.

[69]   Internal dimensions up to 100x50x30cm for 150 litres; 150x50x40cm for 300 litres; 200x50x50cm for 500 litres.

Refrigeration unit type	Default refrigerant charge (kg)	Default leakage rate (operating– ALR)	Default leakage rate (installation – AEF)[68]	Method B	Method C
Buses	2.5 (but up to 10)	10%	n/a	Acceptable	Screening method only
Refrigerated truck trailer units	10	25%	0.5%	Acceptable	Unacceptable
Self-powered or 'cab-over' refrigerated trucks	6	25%	0.5%	Acceptable	Unacceptable
'Off-engine' or 'direct drive' refrigerated vans and trucks	2.5	25%	0.5%	Acceptable	Unacceptable
Three-phase refrigerated containers	5.5	25%	0.5%	Acceptable	Unacceptable
Single-phase refrigerated containers	3	25%	0.5%	Acceptable	Unacceptable
Centralised commercial refrigeration eg, supermarkets	Wide range	Wide range	Wide range	Unacceptable	Unacceptable
Industrial and commercial cool stores	Wide range	Wide range	Wide range	Unacceptable	Unacceptable

Table B2:   Detailed 100-year GWPs for various refrigerant mixtures

Refrigerant type (trade name)	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	PFC-218	Other*	Total GWP
GWP100 (IPCC Fifth Report, AR5)	12,400	677	3,170	1,300	4,800	138	8,900	0	
R22 (HCFC-22)								100%	1,760
R23	100%								12,400
R134a				100%					1,300
R403B: 5% R290, 56% R22, 39% R218							39%	61%	4,457
R404A: 44% R125, 52% R143a, 4% R134a			44%	4%	52%				3,943
R407C: 23% R32, 25% R125, 52% R134a		23%	25%	52%					1,624
R408A: 7% R125, 46% 143a, 47% R22			7%		46%			47%	3,257
R410A: 50% R32, 50% R125		50%	50%						1,924
R413A: 9% R218, 88% R134a, 3% R600a				88%			9%	3%	1,945
R416A: 59% R134a, 39.5% R124,1.5% R600a				59%				41%	975
R417A: 46.6% R125 50% R134a 3.4% R600a			46.6%	50%				3.4%	2,127
R422A: 85.1% R125, 11.5% R134a, 3.4% R600a			85.1%	11.5%				3.4%	2,847
R507A: 50% R125, 50% R143a			50%		50%				3,985

Note: values might differ from those reported in Table 7 due to rounding.

B3 Assumptions

The default factors in methods B and C for operating refrigerant equipment are derived from a report by CRL Energy Ltd to the Ministry for the Environment on the *Assessment of HFC Emission Factors for GHG Reporting Guidelines* (2008). These are based on data for New Zealand refrigeration and air-conditioning equipment stock.

In the absence of consistent information for New Zealand, the default assumption for the assembly emissions rate is the rounded-off IPCC 2006 mid-range value. This will not apply to many 'pre-charged' units as these are sealed to prevent leakage.

For simplicity, the default operating emission factor does not take account of the variability associated with equipment age.

Appendix C: Landfills with and without landfill gas recovery

Table C1 lists the active landfills in New Zealand with landfill gas recovery (LFGR) in 2021. Users should use emission factors *without* gas capture if the landfill is not listed in the table.

Table C1:   Landfills with landfill gas recovery

Name	Operator	LFGR
AB Lime Ltd (Winton)	AB Lime Ltd	Yes
Bonny Glenn (Rangitikei District)	Midwest Disposal Ltd	Yes
Green Island Landfill	Dunedin City Council	Yes
Hampton Downs Landfill	EnviroWaste Services Ltd	Yes
Kate Valley (Amberley)	Canterbury Waste Services Ltd	Yes
Levin Landfill	Horowhenua District Council	Yes
Marlborough Regional Council (Bluegums)	Marlborough District Council	Yes
Omarunui Landfill	Hastings District Council	Yes
Redruth Landfill	Timaru District Council	Yes
Redvale Landfill	Transpacific waste management	Yes
Silverstream Landfill	Hutt City Council	Yes
Southern Landfill	Wellington City Council	Yes
Spicer Landfill	Porirua City Council	Yes
Tirohia Landfill (Paeroa)	HG Leach & Co. Ltd	Yes
Victoria Flats Landfill (Queenstown/ Cromwell)	Scope Resources Ltd	No
Whangarei Resort	Northland Regional Landfill Ltd. Partnership	Yes
Whitford Landfill – Waste Disposal Services	Transpacific waste management	Yes
York Valley Landfill	Nelson City Council	Yes

Source: Toitu, Ministry for the Environment

We invite users to contribute to the improvement of this table by indicating if it should include any other known active landfill with gas recovery. Please email Emissions-guide@mfe.govt.nz

Appendix D: Spend-based emission factors

Auckland Council has published emission factors using a spend-based emissions accounting approach. Using data from Stats NZ Tatauranga Aotearoa, emission intensities are calculated for 199 commodity types. These can be linked to an organisation's expenditure on goods and services. It is assumed that goods and services purchased from outside of New Zealand generate the same quantities of emissions per dollar of expenditure as equivalent goods and services produced in New Zealand.

In terms of consumption, spend-based emissions accounting focuses on calculating the emissions 'embodied' in the goods and services people consume. In other words, all emissions released directly and indirectly throughout the industrial supply chain that generated each good or service.

Organisations completing a GHG inventory may find this dataset useful for estimating Scope 3 emissions, which may be difficult to do in the absence of activity or supplier specific data. The generated emission intensities and datasets have potential applications beyond GHG inventory management, such as assessing organisations' consumption patterns to identify potential opportunities to reduce GHG emissions, or analysing the impact of different development trajectories.

Note these emission factors will only give you an estimation of your supply chain emissions. We recommend using these factors only if better quality activity data isn't available. These emissions factors do not relate to specific products and to ensure an accurate measure of emissions and reflect choices between different products supplier specific data is required.

Access the Auckland Council *Consumption Emissions Modelling* report here: https://www.knowledgeauckland.org.nz/publications/consumption-emissions-modelling/.

Glossary

AR4	The IPCC Fourth Assessment Report
AR5	The IPCC Fifth Assessment Report
Activity data	Data on the magnitude of human activity resulting in emissions or removals taking place during a given period
Base year	The first year in the reporting series
BEV	Battery electric vehicle
Biodiesel	A type of biofuel similar to diesel that is made from natural elements such as plants, vegetables and reusable materials
Bioethanol	A type of biofuel similar to ethanol that is made from natural elements such as plants, vegetables and reusable materials
Biofuels	Any fuel derived from biomass
Biologically sequestered carbon	The removal of carbon dioxide from the atmosphere and captured by plants and micro-organisms
BOD	Biological oxygen demand, the amount of dissolved oxygen needed by micro-organisms to break down biological organic matter in water
BRANZ	Building Research Association of New Zealand
Carbon sink	A natural or artificial process that removes carbon from the atmosphere
CH_4	Methane
CFCs	Chlorofluorocarbons
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
COD	Chemical oxygen demand
CHSB	The Cornell Hotel Sustainability Benchmarking Index Tool
De minimis	A permissible quantity of emissions that a company can leave out of its inventory, based on an insignificant GHG contribution, usually <1 per cent of an organisation's total inventory for an individual emissions source. The threshold is defined by the organisation.
Deforestation	The clearing of forest land that is then converted to a non-forest land use
EECA	Energy Efficiency and Conservation Authority
Emission factor	A coefficient that quantifies the emissions or removals of a gas per unit activity
Enteric fermentation	The process by which ruminant animals digest feed and produce methane
Forest land	Land containing tree species that will reach a height of at least 5 meters, with a canopy cover of at least 30% and be of at least 1 hectare in size
Fugitive emissions	The emission of gases from pressurised equipment due to leaks or unintended releases of gases, usually from industrial activities
GHG	Greenhouse gas
GHG inventory	A quantification of an organisation's greenhouse gas sources, sinks, emissions and removals
GHG Protocol	The *Greenhouse Gas Protocol Accounting and Reporting Standard* provides guidance for organisations preparing a GHG inventory

GHG report	A standalone report to communicate an organisation's GHG-related information to intended users
GJ	Gigajoule (unit of measure, one billion joules)
Grazing off	Cattle feeding on paddock not owned by their farmer
GWP	Global warming potential, a factor describing the radiative forcing impact of one mass-based unit of a given GHG relative to an equivalent unit of carbon dioxide over a given period (typically 100 years)
HBFCs	Hydrobromofluorocarbons
HCFCs	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbon, an alternative refrigerant gas that minimises damage to the ozone hole
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
Inert	Chemically inactive (eg, plastic waste)
IPCC	Intergovernmental Panel on Climate Change
ISO 14064-1:2018	International Organization for Standardisation standard on greenhouse gases – Part 1: Specification with guidance at the organisation level for quantification and reporting greenhouse gas emissions and removals
kt	Kilotonne (unit of measure, one thousand tonnes)
LULUCF	Land use, land-use change and forestry
Materiality	To be considered as having significance to an organisation
Mature indigenous forest	A forest comprising predominantly native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed. The forest will contain large trees with multi-layered canopies and be considered a climax community
MBIE	Ministry of Business, Innovation and Employment
MfE	Ministry for the Environment
MoT	Te Manatū Waka Ministry of Transport
MPI	Ministry of Primary Industries
Municipal landfill	Landfill that accepts household waste as well as other wastes
NDC	Nationally determined contributions under the Paris Agreement
NF$_3$	Nitrogen trifluoride
N$_2$O	Nitrous oxide
NZ ETS	New Zealand Emissions Trading Scheme
NZTA	Waka Kotahi New Zealand Transport Agency
ODS	Ozone-depleting substances
Organisational boundary	The boundary of the organisation as it applies to measurement of GHG emissions. This typically aligns with legal and/or organisational structure; a financial boundary must be drawn within this too
OverseerFM	A New Zealand software platform that enables farmers and growers to estimate and improve nutrient use on farms
PFC	Perfluorocarbon
PHEV	Plug-in hybrid electric vehicle
pkm	Passenger-kilometre (unit of measure for transport)

Radiative forcing	The difference between solar energy absorbed by the Earth and that radiated back to space. Human activity has impacts which alter radiative forcing
Refrigerants	A substance or mixture used in a heat pump and refrigeration cycle
Removals	Withdrawal of a GHG from the atmosphere by GHG sinks
Reporting boundary	The emission sources included within an organisation's operations, including direct and indirect emission sources. It includes choosing which indirect emission sources to report
Reticulated gas	A piped gas system to deliver a gas such as LPG or natural gas to a consumer
Scope	Emission sources are categorised by Scope to manage risks and impacts of double counting. There are three scopes in greenhouse gas reporting: Scope 1 (direct emissions), Scope 2 (energy indirect emissions) and Scope 3 (other indirect emissions)
SF$_6$	Sulphur hexafluoride
Stationary combustion fuel	Fuel used in an unmoving engine eg, a power plant or boiler
TFCD	Task Force on Climate-related Financial Disclosures
tkm	Tonne-kilometre (unit of measure for freight)
Unique emission factor	A value given to an activity based on how emissions intensive it is. Experienced professionals must verify a unique emission factor. See Climate Change (Unique Emission Factors) Regulations 2009 for further information
Uplift factor	Applied to take into account the combined 'real-world' effects on fuel consumption (such as non-direct flight paths)