Te ine tukunga: He tohutohu pakihi

Measuring emissions: A guide for organisations

2024 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 14th version of the publication originally titled *Guidance for Voluntary Greenhouse Gas Reporting*.

For previous versions, see the Ministry for the Environment's website.

Updates since the 2023 edition

The Ministry for the Environment publishes updated emission factors annually. Compared with the previous year's emission factors, changes may be made due to new data availability, methodology improvements or corrections to errors in methodology. 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 continues the use of GWP values from the IPCC Fifth Assessment Report (AR5) that were introduced in the previous edition. These GWP values are published by the IPCC and are used 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 AR5 of the IPCC, excluding the value for fossil methane.

The *UK Greenhouse gas reporting: Conversion factors 2023*, published by the UK Department for Energy Security and Net Zero, formerly published by the Department of Business, Energy and Industrial Strategy, first provided AR5 values from 2023. The US GHG Emission Factors Hub, published by the US Environmental Protection Agency first provided AR5 values in 2024.

For an outline of the impact of switching to AR5 GWP100 on the emission factor values see the previous guidance.

Other updates

Section 3 (Fuel): Four new biofuel blends were added this year: two bioethanol blends (E3 and E10) and two biodiesel blends (B5 and B20). Five new wood biomass factors were also added; three for use in manufacturing applications and two for use in commercial applications.

Section 5 (Purchased electricity, heat and steam): A new method of calculating the purchased electricity, and transmission and distribution loss emission factors are adopted.

Section 7 (Travel): A new age category has added for Post-2020 passenger vehicles, with the Post-2015 category being renamed to 2015–2020. A new factor for a passenger ferry was added. Also, the multiplier applied to account for the non-carbon dioxide climate change effects of aviation has been revised downwards from 1.9 to 1.7, to be in line with the latest scientific evidence.[1]

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[1] Lee DS, Fahey DW, Skowron A, Allen MR, Burkhardt U, Chen Q, Doherty SJ, Freeman S, Forster PM, Fuglestvedt J, Gettelman A, De León RR, Lim LL, Lund MT, Millar RJ, Owen B, Penner JE, Pitari G, Prather MJ, Sausen R, Wilcox LJ. 2021. The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. *Atmospheric Environment* 244.

Section 8 (Freight): A new age category has added for Post-2020 light commercial vehicles, with the Post-2015 category being renamed to 2015–2020.

Section 11 (Agriculture, forestry, and other land use): Improvements have been made to beef cattle population and liveweight estimates and to the planted forest emission factors and uncertainty estimates.

Appendix D (Spend-based emissions): In the previous edition, we provided appendix D to communicate the release of Auckland Council's Consumption Emissions Modelling report on spend-based emissions. We continue to provide this appendix in this edition.

Organisation/entity: In previous editions, entities to which this guide applies (companies, organisations, government departments, territorial authorities, charities and so on) were largely referred to as organisations. In line with development of standard approaches, we now refer to all of these as **entity** and/or **entities**. An exception is where ISO standards refer to an organisation or organisational boundary and these are quoted in tables or text.

1 Introduction

1.1 Purpose of this guide

The Ministry for the Environment supports entities taking climate action. We recognise there is strong interest, and in some cases requirements, for entities across New Zealand to measure, report and reduce their emissions. We prepared this guide to help you measure and report your entity or 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 entities 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 3–11, 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 1990–2022* to provide new emission factors.

Numbers in the tables are largely presented to three significant figures or three decimal places, whichever is the most appropriate. Where a number is smaller than 0.001 then four or more decimal places may be shown. For your carbon inventory, use the *Emission factors workbook*.

Most of the source data used in the development of these emission factors is from 2022, unless otherwise mentioned. This is done to align with *New Zealand's Greenhouse Gas Inventory 1990–2022*. This contains data for the calendar years from 1990 to 2022 (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, because 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 (THIS DOCUMENT)
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 sections 1 and 2 is intended as guidance only. This guidance does not replace any mandatory reporting requirements that entities may have, for example, climate-related disclosures in line with the Aotearoa New Zealand Climate Standards (NZCS) or the Carbon Neutral Government Programme (CNGP).

Emission factors contained within this guide may be used by entities in both voluntary and mandatory GHG inventory preparation and reporting.

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 NZCS and CNGP.

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 Energy Security and Net Zero (formerly published by the Department for Business Energy and Industrial Strategy) and the US Environmental Protection Agency.

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.

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

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.

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 here 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 Life Cycle Association of New Zealand website.[2]

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

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 around 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 greenhouse gas (GHG) emissions in metric tonnes of carbon dioxide equivalent (CO_2-e) classified as:

- Scope 1: Direct GHG emissions from sources owned or controlled by the entity.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- Scope 3: Other indirect GHG emissions not covered in scope 2 that occur in the value chain of the reporting entity, including upstream and downstream GHG emissions.

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 Global Warming Potential (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 External Reporting Board's website. These standards contain additional requirements, especially related to disclosures for methods, risk, reporting requirements and uncertainty management.

2 See Life Cycle Association of New Zealand, for more information.

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 entities on measuring and reporting their GHG emissions.[3] It includes information on what sources of GHG emissions entities 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, see the CNGP website[4] or contact cngp@mfe.govt.nz.

Measuring your entity'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 entities should create their own emission reduction plans. Examples of emission reduction plans published by New Zealand corporations are available online.

Measuring emissions enables you to set reduction targets, take climate action and report quantified progress towards your goals. To reach your 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.

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) and other gases (eg, Montreal Protocol refrigerant gases or medical gases).

Global Warming Potential (GWP) is an index to translate the level of emissions of various gases into a common measure in order to compare the relative radiative forcing of different gases. GWPs are calculated as the ratio of the radiative forcing that would result from the emissions of one kilogram (kg) of a greenhouse gas to that from the emission of one kg of CO_2 over a period of time (usually 100 years).

GWPs are applied 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 with CO_2 over that 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, the emissions for each non-CO_2 gas is multiplied by its 100-year time-horizon GWP (GWP_{100}) value (see table 1). The IPCC provides more information on how these factors are calculated.

3 Ministry for the Environment: https://environment.govt.nz/publications/cngp-measuring-and-reporting-ghg-emissions/.

4 Ministry for the Environment: https://environment.govt.nz/what-government-is-doing/key-initiatives/carbon-neutral-government-programme/.

Throughout the guide, kg of CH_4 and N_2O are reported in kg CO_2-e by multiplying the actual CH_4 emissions by the GWP of 28 and actual N_2O emissions by the GWP of 265, as per table 1.

The GWP index value depends on two things: how effective the gas is at trapping heat while it is in the atmosphere, and how long it stays in the atmosphere before it breaks down. For example, CH_4 breaks down relatively quickly, the average CH_4 molecule stays in the atmosphere for around 12 years. On the other hand, CH_4 traps heat more effectively than CO_2, which has a much longer lifetime.

Changes in GWP values can be due to updated scientific estimates of the energy absorption, lifetime of the gases, or to changing atmospheric concentrations of GHGs that result in a change in the energy absorption of an additional tonne of emitted gas relative to another.

The change introduced in the previous edition from the IPCC Fourth Assessment Report (AR4) to AR5 GWPs may cause a significant change in some entities' inventories, including those that use large quantities of refrigerants, or that use emission factors with relatively high contributions of CH_4. For those that see increases or reductions in their footprints, it would be misleading to interpret this as a true increase or reduction.

Table 1 shows the GWPs for N_2O and CH_4 comparing AR4 and AR5 values. The GWP of N_2O has decreased by 11.1 per cent and the GWP of CH_4 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 greenhouse gases (excluding fossil methane), based on 100-year period

Greenhouse gases	Chemical formula	GWP (AR4)	GWP (AR5)
Nitrous oxide	N_2O	298	265
Methane	CH_4	25	28
Carbon dioxide	CO_2	1	1

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 nitrogen trifluoride (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 its implementation of the protocol.

Many of the ODS 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.

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5 UNFCCC: https://unfccc.int/kyoto_protocol.

6 United Nations Environment Programme: www.unep.org/ozonaction/who-we-are/about-montreal-protocol.

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 a 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 entity 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. Entities that choose to investigate uncertainty in their emission inventories will focus on the latter.

The following approach is used 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[7] or the *GHG Protocol Corporate Accounting and Reporting Standard*[8]; and this guide is written 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 is shorter and more direct than the GHG Protocol. A PDF copy can be purchased.
- The *GHG Protocol Corporate Accounting and Reporting Standard* gives more description and context around what to do to produce an inventory. It is free to download. The *GHG*

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[7] Published by the International Organization for Standardisation. 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).

Protocol 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 entity/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 Corporate Accounting and Reporting Standard places emission sources into Scope 1, Scope 2 and Scope 3 activities.

- Scope 1: Direct GHG emissions from sources owned or controlled by the entity (ie, within the organisational boundary). For example, emissions from combustion of fuel in vehicles owned or controlled by the entity.
- Scope 2: Indirect GHG emissions from the generation of purchased energy (in the form of electricity, heat or steam) that the entity uses.
- Scope 3: Other indirect GHG emissions occurring because of the activities of the entity but generated from sources that it does not own or control (eg, air travel).

The *GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard* goes into more detail, providing a method to enable GHG management of the entities' value chain emissions. In this standard, Scope 3 is broken down into 15 'categories' that cover the upstream and downstream emissions associated with the entity's activities. Some of the categories include purchased goods and services, upstream transportation and distribution, business travel and the use of sold products.

The *GHG Protocol Technical Guidance for Calculating Scope 3 Emissions*[9] provides detailed guidance for each of its 15 Scope 3 categories, along with a useful table that summarises the different calculation methods available for each of these categories.

ISO 14064-1:2018 also categorises emissions as direct or indirect sources, and breaks Scope 3 down into six categories.

- Category 1: *Direct GHG emissions and removals* covers the same kind of activities reported under the GHG Protocol Scope 1.
- Category 2: *Indirect GHG emissions from imported energy* is the same as the GHG Protocol Scope 2.

The main difference with this standard is that Scope 3 emissions are separated into the following categories.

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9 Greenhouse Gas Protocol: https://ghgprotocol.org/scope-3-calculation-guidance-2.

- Category 3: *Indirect GHG emissions from transportation*, where emissions from transportation sources outside the organisation boundary are reported, such as business travel in a car that is not owned by the reporting entity.
- Category 4: *Indirect GHG emissions from products used by an entity*, which covers emissions associated with goods used by the reporting entity, such as office paper.
- Category 5: *Indirect GHG emissions associated with the use of products from the organisation*, which covers emissions associated with goods sold by the reporting entity, such as the lifetime usage of a car where the reporting entity is a car manufacturer.
- Category 6: *Indirect GHG emissions from other sources*, which is for any emissions source (or removal) that cannot be reported in any other category.

Compared with the traditional Scope 1, Scope 2 and Scope 3 approach used in the *GHG Protocol Corporate Accounting and Reporting Standard*, the categories provided in the *GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard* and ISO 14064:2018 enable a more granular approach to GHG reporting.

The category names help better describe the activities associated with emissions sources. They enhance the quality and clarity of reporting by enabling the inclusion and expansion of indirect emissions throughout the value chain. They help identify environmental hotspots inside and outside the entity's boundaries, which helps inform the identification of carbon reduction opportunities. 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).

A similar approach of breaking down Scope 3 emissions into categories is also used by ISO 14064:2018.

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	Category 1: Direct GHG emissions and removals	Stationary combustion Mobile combustion Chemical and industrial processes Fugitive emissions Land use, land use change and forestry (LULUCF)	Scope 1
2	Category 2: Indirect GHG emissions from imported energy	Purchased (imported) electricity and steam Energy	Scope 2
3	Category 3: Indirect GHG emissions from transportation	Upstream emissions from fuel generation Upstream transport and distribution of goods purchased	3. Fuel- and energy-related activities 4. Upstream transportation and distribution

Scopes used in the GHG Protocol	ISO inventory category	ISO sub-category (annex B)	GHG Protocol
		Downstream transport and distribution of goods sold Employee commuting Business travel in vehicles not owned or operated by the organisation Client and visitor transport Business hotel stay	9. Downstream transportation and distribution 7. Employee commuting 6. Business travel
3	Category 4: Indirect GHG emissions from products used by the organisation	Purchased goods and services, including upstream emissions Capital goods, including upstream emissions Transmission of energy (transmission and distribution losses) Waste disposal and treatment (liquid and solid) Equipment leased by reporting organisation	1. Purchased goods and services 2. Capital goods 5. Waste generated in operations 8. Upstream leased assets
3	Category 5: Indirect GHG emissions associated with use of products from the organisation	Processing of sold goods, or intermediate products sold by the organisation to another Use stage of product sold Downstream leased assets owned by the organisation and leased to others End-of-life stage of product sold Investments such as equity debt, investment debt, project finance and others	10. Processing of sold products 11. Use of sold product 12. End-of-life treatment of sold products 13. Downstream leased assets 14. Franchises 15. Investments
3	Category 6: Indirect GHG emissions from other sources		

Notes: Depending on your entity'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'.

Both the ISO 14064-1:2018 and GHG Corporate Protocol require that entities calculate the emissions of each GHG separately and quantify them as CO_2-e. Example calculations in this guide show this format (see also the *2024 example report for greenhouse gas emissions*). While the NZCS does not mandate a single approach for measuring GHG emissions, the International Sustainability Standards Board requires entities to report in accordance with the GHG Protocol, unless there are other requirements, for instance, from an exchange they are listed on.

2 How to quantify and report GHG emissions

To quantify and report GHG emissions, entities 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 workbook* 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 entity 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 entity, methods used, as well as analysis of drivers and progress over time. A GHG report is key to reporting emissions.

Entities 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 entities 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.

Entities may obtain assurance or verification over the GHG inventory or GHG report against the measurement (see section 2.4).

2.1 Step-by-step inventory preparation

To prepare an inventory:

- select the boundaries (organisational and reporting[10]) and measurement period (ie, calendar or financial year) you will report against for your entity, 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 *2024 example report for greenhouse gas emissions*
- produce a GHG report, if applicable. See section 2.3 and the 2024 example report for greenhouse gas emissions.

If this is the first year your entity 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 entity, such as any carbon reduction strategies you have undertaken. 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 entities, 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*[11] and may be excluded from the total inventory, provided that the total of excluded emissions does not exceed the materiality[12] threshold set by your entity. 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 entity estimates any emissions considered *de minimis* using simplified methods to justify the classification. It is

[10] See Glossary for definitions.

[11] See Glossary for definition.

[12] See Glossary for definition.

important these are transparently documented and justified. Often, you only need to re-estimate excluded emissions in subsequent years if the assumptions change.

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.

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

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 1990–2022* because this was the latest complete set of data available. Emission factors will be updated annually, when more recent data is available.

If you use the *Emission factors 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 sections 3 to 11 to demonstrate how to use the emission factors.[13]

The emission factors in this guide are:

- default factors, used in the absence of better entity-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 1990–2022*
- 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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[13] The emission factors in the example calculations within this document and the *Emission factors summary* are rounded. In the *Emission factors workbook* and *Emission factors 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 workbooks.

Non-carbon dioxide emissions (eg, methane and nitrous oxide) and emission factors depend on the way the fuel is combusted.[14] 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.[15]

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 entity, 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, entities should include:

- a description of the entity/organisation
- the person or entity responsible for the report
- a description of the inventory boundaries
  - entity/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
- a statement describing the recognised standard or standards that the GHG emissions have been measured in accordance with.

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

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[14] For example, the nitrous oxide emission factor for diesel used for industrial heating is different from the nitrous oxide emission factor for diesel used in vehicles.

[15] See *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, volume 2, chapter 2.

2.4 Assurance and verification

Seeking independent[16] 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 entity'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 provide guidance on whether or not assurance will be attained.

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

- If your entity is a covered entity under the Financial Markets Conduct Act 2013, as amended by the Financial Sector (Climate-related Disclosures and Other Matters) Amendment Act 2021 (the Financial Markets Conduct Act 2013 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, External Reporting Board [XRB]).

If your entity 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 and accounting standards and frameworks

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[16] An independent assurer or verifier is an organisation or person who has not helped 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 entities 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 entities 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, that is, 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 emission factors are based on data from *New Zealand's Greenhouse Gas Inventory 1990–2022*.

Four new biofuel blends were added this year: two bioethanol blends, E3 and E10. The E3 and E10 blends consist of 3 per cent and 10 per cent bioethanol respectively, with the remaining contribution made up of diesel. For the two biodiesel blends, B5 and B20, each consists of 5 per cent and 20 per cent biodiesel respectively, with the remaining contribution made up of diesel.

Five new wood biomass factors were also added; three for use in manufacturing applications and two for use in commercial applications.

The emission factor value for bioethanol decreased by 35 per cent, and the value for biodiesel increased by 54 per cent, because in the previous edition incorrect calorific values were being applied.

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 entity. If the entity 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 1990–2022*.

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	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)	Uncertainties kg CO_2-e/unit
Residential use						
Coal – Default	kg	2.09	1.91	0.166	0.00786	± 4.5%
Coal – Bituminous	kg	2.88	2.64	0.236	0.01117	± 4.6%
Coal - Sub-bituminous	kg	2.17	1.99	0.173	0.00817	± 4.5%
Coal – Lignite	kg	1.55	1.42	0.122	0.00576	± 4.4%
Commercial use						
Coal – Default	kg	2.11	2.09	0.00611	0.00867	± 2.2%
Coal – Bituminous	kg	2.66	2.64	0.00787	0.01117	± 2.2%
Coal – Sub-bituminous	kg	2.00	1.99	0.00576	0.00817	± 2.2%
Coal – Lignite	kg	1.43	1.42	0.00406	0.00576	± 2.2%
Diesel	litre	2.68	2.66	0.0102	0.00581	± 0.5%
LPG	kg	2.97	2.96	0.00665	0.00126	± 2.4%
Heavy fuel oil	litre	3.05	3.04	0.0108	0.00615	± 0.5%
Light fuel oil	litre	2.97	2.95	0.0108	0.00611	± 0.5%
Natural gas	kWh	0.195	0.194	0.0005	0.00009	± 2.4%
	GJ	54.1	54.0	0.1260	0.02385	± 2.4%
Industrial use						
Coal – Default	kg	1.93	1.92	0.00557	0.00791	± 2.2%
Coal – Bituminous	kg	2.66	2.64	0.00787	0.01117	± 2.2%
Coal – Sub-bituminous	kg	2.00	1.99	0.00576	0.00817	± 2.2%
Coal – Lignite	kg	1.43	1.42	0.00406	0.00576	± 2.2%
Diesel	litre	2.67	2.66	0.00307	0.00581	± 0.5%
LPG	kg	2.97	2.96	0.00133	0.00126	± 2.4%
Heavy fuel oil	litre	3.05	3.04	0.00325	0.00615	± 0.5%
Light fuel oil	litre	2.96	2.95	0.00323	0.00611	± 0.5%
Natural gas	kWh	0.195	0.194	0.00009	0.00009	± 2.4%
	GJ	54.0	54.0	0.02520	0.02385	± 2.4%

Notes: Commercial and industrial classifications are based on standard classification.[17] 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 0.534 kg/litre.

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.

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

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

STATIONARY COMBUSTION: EXAMPLE CALCULATION

An entity 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	= 1.76 kg CO_2-e
Total CO_2-e emissions	= 1,400 × 2.97	= 4,155.07 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 of gas per terajoule (t/TJ). These are either sourced from *New Zealand's Greenhouse Gas Inventory 1990–2022* or default emission factors from the IPCC.

To calculate the final emission factors for CO_2, CH_4 and N_2O, the calorific value is multiplied by the emission factor (t/TJ) for each gas type. The CH_4 and N_2O vales are then multiplied by their global warming potentials, 28 and 265 respectively.

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 CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)	Uncertainties kg CO_2-e/unit
Transport fuels						
Regular petrol	Litre	2.37	2.27	0.0303	0.0695	± 1.6%
Premium petrol	Litre	2.41	2.31	0.0307	0.0704	± 1.6%
Diesel	Litre	2.68	2.64	0.0040	0.0374	± 0.7%
LPG	Litre	1.62	1.57	0.0438	0.0013	± 2.7%
Heavy fuel oil	Litre	3.06	3.04	0.0076	0.0205	± 0.4%
Light fuel oil	Litre	2.98	2.95	0.0075	0.0204	± 0.4%
Aviation fuel (kerosene)	GJ	68.6	68.0	0.0133	0.5035	± 1.1%
	Litre	2.52	2.50	0.0005	0.0185	± 1.1%
Aviation gas	GJ	66.4	65.9	0.0133	0.5035	± 1%
	Litre	2.25	2.23	0.0005	0.0171	± 1%

Note: No estimates are available for marine diesel because Marsden Point Oil Refinery has stopped making the marine diesel blend. If an entity 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.[18]

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 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 4.

All entities 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.

18 Climate Change (Liquid Fossil Fuels) Regulations 2008 (SR 2008/356) (as at 10 May 2024) Schedule Emission factors for tonnes of carbon dioxide equivalent greenhouse gases per kilolitre – New Zealand legislation.

TRANSPORT FUEL: EXAMPLE CALCULATION

An entity has 15 petrol vehicles. They use a total of 40,000 litres of regular petrol in the reporting year.

CO_2 emissions	= 40,000 × 2.27	= 90,800 kg CO_2
CH_4 emissions	= 40,000 × 0.0303	= 1,212 kg CO_2-e
N_2O emissions	= 40,000 × 0.0695	= 2,780 kg CO_2-e
Total CO_2-e emissions	= 40,000 × 2.37	= 94,792 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 Appendix A: Derivation of fuel emission factors. The fuel properties of kerosene and aviation gas are 0.0371 and 0.0339 litres per gigajoule respectively.

3.3.4 Assumptions, limitations and uncertainties

We derived the kg CO_2-e per activity unit emission factors in table 4 using calorific values. All emission factors incorporate relevant oxidation factors sourced from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*[19].

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

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

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 emissions.

The combustion of biofuels generates anthropogenic methane and nitrous oxide. Entities should calculate and report these gases as is done at the national level according to the *2006 IPCC Guidelines for National Greenhouse Gas Inventories.*[20]

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	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)	Biogenic kg CO_2-e/unit
Biofuel						
Bioethanol	GJ	2.52	0	0.504	2.01	64.2
	Litre	0.0594	0	0.0119	0.0475	1.52
Bioethanol blend E3	Litre	2.30	2.205	0.0297	0.0688	0.0455
Bioethanol blend E10	Litre	2.17	2.075	0.0288	0.0681	0.152
Biodiesel	GJ	1.49	0	0.504	0.982	67.3
	Litre	0.0541	0	0.0184	0.0358	2.45
Biodiesel blend B5	Litre	2.55	2.504	0.00467	0.0373	0.122
Biodiesel blend B20	Litre	2.15	2.109	0.00683	0.0371	0.490
Biomass – Manufacturing use						
Wood – Chips	kg	0.0230	0	0.0102	0.0128	1.36
Wood – Pellets	kg	0.0289	0	0.0128	0.0161	1.70
Wood – Green	kg	0.0135	0	0.00597	0.00754	0.795
Biomass – Commercial use						
Wood – Chips	kg	0.1147	0	0.102	0.0128	1.36
Wood – Pellets	kg	0.1437	0	0.128	0.0161	1.70

Notes: The total CO_2-e emission factor for biofuels and biomass (not the biofuel blends) 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.

20 See *2006 Guidelines for Greenhouse Gas Inventories*, Volume 2, Energy: www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html.

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, entities should still report the carbon dioxide released through biofuel and biomass combustion.[21]

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_2O gases are reported), list them as a separate line item called 'biogenic emissions'. This ensures the entity 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.

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

The equation used is:

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

BIOFUELS AND BIOMASS: EXAMPLE CALCULATION

An entity 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 × 0.0184	= 128.8 kg CO_2-e
N_2O emissions	= 7,000 × 0.0358	= 250.6 kg CO_2-e
Total CO_2-e emissions	= 7,000 × 0.0541	= 379.4 kg CO_2-e (reported as Scope/Category 1)
Biogenic CO_2 emissions	= 7,000 x 2.32	= 17,150 kg CO_2 (reported separately)

An entity 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 = 2.68 kg CO_2-e/litre

biodiesel emission factor = 0.0541 kg CO_2-e/litre

Therefore, 10 per cent biodiesel blend emission factor =

(10% × 0.0541) + [(1-10%) × 2.68] = 2.417 kg CO_2-e/litre biofuel blend

Note: Numbers may not add due to rounding.

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

3.4.2 Emission factor derivation methodology

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

As stated in section 3.1, four new biofuel blends were added this year: two bioethanol blends, E3 and E10. The E3 and E10 blends consist of 3 per cent and 10 per cent bioethanol respectively, with the remaining contribution made up of diesel. For the two biodiesel blends, B5 and B20, each consists of 5 per cent and 20 per cent biodiesel respectively, with the remaining contribution made up of diesel.

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

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.

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

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

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).

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. Because LPG is a mixture of propane and butane, it does not emit fugitive greenhouse gases.

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 2022. 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	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Natural gas used	kWh	0.00723	0.00006	0.00717	n/a
	GJ	2.01	0.0175	1.99	n/a

3.5.1 GHG inventory development

To calculate the emissions from transmission and distribution losses, entities 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 entity uses 800 gigajoules of distributed natural gas in the reporting period.

CO_2 emissions	= 800 × 0.0175	= 14 kg CO_2
CH_4 emissions	= 800 × 1.99	= 1,592 kg CO_2-e
N_2O emissions	= 800 × 0.00	= 0 kg CO_2-e
Total CO_2-e emissions	= 800 × 2.01	= 1,606 kg CO_2-e

Note: Numbers may not add due to rounding.

3.5.2 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.

We derived the emission factor by using MBIE data for distribution and transmission gas losses, which is based on estimates provided by Firstgas.

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

For distribution, an emissions estimate model using a best practice MarcoGaz template was applied, along with internationally published emission rates in the American Petroleum Institute's *Compendium of Greenhouse Gas Emissions Methodologies for the Natural Gas and Oil Industry*, combined with company specific asset values. This is complemented by annual asset level leakage measurements.

The CO_2 values from these datasets are summed, and the CH_4 values are summed and then multiplied by the global warming potential of 28. These total losses are then divided by the total reticulated natural gas delivered.

3.5.3 Assumptions, limitations and uncertainties

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

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.

As with the previous edition, we use the GWPs published in the IPCC's Fifth Assessment Report (AR5) in this update. This is a change from 2022, which used the IPCC's Fourth Assessment Report (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 hydrofluorocarbons (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 to section 4.3.3.

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 entity owns or controls the refrigeration units, emissions from refrigeration are direct (Scope 1). If the entity 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 AR5 to ensure consistency with *New Zealand's Greenhouse Gas Inventory 1990–2022*.

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.

These emission factors refer to direct emissions, not the indirect emissions associated with the production and supply of these refrigerants.

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	3
Nitrous oxide (R-744a)	N_2O	kg	265
Isobutane(R-600a)	C_4H_{10}	kg	3
Substances controlled by the Montreal Protocol			
CFC-11 (R-11)	CCl_3F	kg	4,660
CFC-12 (R-12)	CCl_2F_2	kg	10,200
CFC-13 (R-13)	$CClF_3$	kg	13,900
CFC-113 (R-113)	CCl_2FCClF_2	kg	5,820
CFC-114 (R-114)	$CClF_2CClF_2$	kg	8,590
CFC-115 (R-115)	$CClF_2CF_3$	kg	7,670
Halon-1301 (R-1301)	$CBrF_3$	kg	6,290
Halon-1211 (R-1211)	$CBrClF_2$	kg	1,750
Halon-2402 (R-2402)	$CBrF_2CBrF_2$	kg	1,470
Carbon tetrachloride (R-10)	CCl_4	kg	1,730
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	1,760
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	1,980
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	12,400

Industrial designation/common name	Chemical formula	Unit	AR5 GWP100
HFC-32 (R-32)	CH_2F_2	kg	677
HFC-41	CH_3F	kg	116
HFC-125 (R-125)	CHF_2CF_3	kg	3,170
HFC-134	CHF_2CHF_2	kg	1,120
HFC-134a (R-134a)	CH_2FCF_3	kg	1,300
HFC-143	CH_2FCHF_2	kg	328
HFC-143a (R-143a)	CH_3CF_3	kg	4,800
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	3,350
HFC-236cb	$CH_2FCF_2CF_3$	kg	1,210
HFC-236ea	CHF_2CHFCF_3	kg	1,330
HFC-236fa (R-236fa)	$CF_3CH_2CF_3$	kg	8,060
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	1,650
Perfluorinated compounds			
Sulphur hexafluoride	SF_6	kg	23,500
Nitrogen trifluoride	NF_3	kg	16,100
PFC-14	CF_4	kg	6,630
PFC-116	C_2F_6	kg	11,100
PFC-218	C_3F_8	kg	8,900
PFC-318	$c\text{-}C_4F_8$	kg	9,540
PFC-31-10	C_4F_{10}	kg	9,200
PFC-41-12	C_5F_{12}	kg	8,550
PFC-51-14	C_6F_{14}	kg	7,910
PFC-91-18	$C_{10}F_{18}$	kg	7,190
Trifluoromethyl sulphur pentafluoride	SF_5CF_3	kg	17,400
Perfluorocyclopropane	$c\text{-}C_3F_6$	kg	9,200
Fluorinated ethers			
HFE-125	CHF_2OCF_3	kg	12,400
HFE-134	CHF_2OCHF_2	kg	5,560
HFE-143a	CH_3OCF_3	kg	523
HFE-227ea	$CF_3CHFOCF_3$	kg	6,450
HCFE-235da2 (Isoflurane)	$CHF_2OCHClCF_3$	kg	491
HFE-236ea2	$CHF_2OCHFCF_3$	kg	1,790
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-254cb2	$CH_3OCF_2CHF_2$	kg	301
HFE-263fb2	$CF_3CH_2OCH_3$	kg	1

Industrial designation/common name	Chemical formula	Unit	AR5 GWP100
HFE-329mcc2	$CHF_2CF_2OCF_2CF_3$	kg	3,070
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	2,820
HFE-236ca12 (HG-10)	$CHF_2OCF_2OCHF_2$	kg	5,350
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCHF_2$	kg	2,910
Perfluoropolyethers			
PFPMIE	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$	kg	9,710
Hydrocarbons and other compounds – Direct effects			
Chloroform	$CHCl_3$	kg	16
Dimethylether	CH_3OCH_3	kg	1
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	Mix (mass %)	Unit	GWP (calculated)
403B	R-290/22/218 (5.0/56.0/39.0)	kg	4,457
404A	R-125/143a/134a (44.0/52.0/4.0)	kg	3,943
406A	R-22/600a/142b (55.0/4.0/41.0)	kg	1,780
407C	R-32/125/134a (23.0/25.0/52.0)	kg	1,624
407F	R-32/125/134a (30.0/30.0/40.0)	kg	1,674
408A	R-125/143a/22 (7.0/46.0/47.0)	kg	3,257
409A	R-22/124/142b (60.0/25.0/15.0)	kg	1,485
409B	R-22/124/142b (65.0/25.0/10.0)	kg	1,474
410A	R-32/125 (50.0/50.0)	kg	1,924
413A	R-218/134a/600a (9.0/88.0/3.0)	kg	1,945
416A	R-134a/124/600a (59.0/39.5/1.5)	kg	975
417A	R-125/134a/600a (46.6/50.0/3.4)	kg	2,127
422A	R-125/134a/600a (85.1/11.5/3.4)	kg	2,847
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	4,786
Refrigerant blends: Azeotropes			
507A	R-125/143a (50.0/50.0)	kg	3,985

Industrial designation/common name	Chemical formula	Unit	AR5 GWP100
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	1,790
Medical gas blends – Mix (mass %) – Unit			
Entonox	N_2O/O_2 (57.9/42.1) (50.0/50.0 vol.)	kg	153

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.

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

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. Entities 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 GWP100
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	1,790
Entonox	N_2O/O_2 (57.9/42.1) (50.0/50.0 vol.)	kg	153

4.4.2 GHG inventory development

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

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

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 entity 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 CO_2-e emissions = 1.5 × 491 = 736.5 kg CO_2-e

An entity 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 CO_2-e emissions = 1.86 × 491 = 913.26 kg CO_2-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 2021, and the annual time series extends back to 2011. 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 entity inventory.

5.1 Overview of changes since previous update

In this edition, a new method of calculating the purchased electricity, and transmission and distribution loss emission factors are adopted. Previously, the factor was calculated as the difference between the generation and consumption emission factors. This new method directly uses MBIE's transmission and distribution line losses data, to more accurately reflect actual losses on the electricity grid.

As a result, the emission factor for transmission and distribution losses has decreased by 38 per cent from the previous edition.

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 emission factors in table 9 and table 10 for all electricity purchased from the national grid, apart from when a market-based method is being used.

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.

Using quarterly emission factors accounts for the high seasonal variation seen in electricity emission factors. This variation is generally a result of the higher proportion of fossil-based electricity generation typically used in the winter months. Therefore, using an annual emission factor may over or underestimate your entity's GHG emissions.

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

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

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

Year	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
2023	kWh	0.0729	0.0702	0.00260	0.00008
2022	kWh	0.0772	0.0744	0.00273	0.00009
2021	kWh	0.1190	0.116	0.00282	0.0003
2020	kWh	0.1191	0.116	0.00291	0.0002
2019	kWh	0.1106	0.107	0.00305	0.0002
2018	kWh	0.0979	0.0943	0.00341	0.0001
2017	kWh	0.1031	0.0992	0.00380	0.00009
2016	kWh	0.0915	0.0874	0.00411	0.00007
2015	kWh	0.1163	0.112	0.00454	0.0001
2014	kWh	0.1221	0.118	0.00433	0.0002
2013	kWh	0.1462	0.142	0.00423	0.0002
2012	kWh	0.1730	0.169	0.00398	0.0003
2011	kWh	0.1387	0.135	0.00377	0.0002

The emission factors for the calendar quarters (quarter end) for 2021–2023 purchased electricity from the New Zealand grid are in Table 10.

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

Quarter	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Electricity used					
Dec-2023	kWh	0.0717	0.0688	0.00274	0.0001
Sep-2023	kWh	0.0952	0.0924	0.00262	0.0001
Jun-2023	kWh	0.0503	0.0480	0.00227	0.00002
Mar-2023	kWh	0.0727	0.0699	0.00278	0.00006
Dec-2022	kWh	0.0369	0.0342	0.00268	0.00002
Sep-2022	kWh	0.0578	0.0551	0.00262	0.00003
Jun-2022	kWh	0.1130	0.110	0.00285	0.0002
Mar-2022	kWh	0.1039	0.101	0.00277	0.0002
Dec-2021	kWh	0.0514	0.0486	0.00275	0.00002
Sep-2021	kWh	0.0965	0.0938	0.00249	0.0002
Jun-2021	kWh	0.1767	0.173	0.00275	0.0005
Mar-2021	kWh	0.1526	0.149	0.00335	0.0004

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 entities 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 entity uses 800,000 kWh of electricity in the 2023 reporting period. Its indirect (Scope 2) emissions from electricity are:

CO_2 emissions	= 800,000 × 0.0702	= 56,160 kg CO_2
CH_4 emissions	= 800,000 × 0.0026	= 2,080 kg CO_2-e
N_2O emissions	= 800,000 × 0.00008	= 64 kg CO_2-e
Total CO_2-e emissions	= 56,160 + 2,080 + 64	= 58,304 kg CO_2-e

Note: Numbers may not add due to rounding.

5.2.2 Emission factor derivation methodology

MBIE calculated the generation emission factors based on emissions from the generation of public electricity and the amount of electricity generated

Table 11 details the MBIE data provided to calculate the annual emission factors.

Table 11: Information used to calculate the purchased electricity emission factor for 2011–2023

Calculation component	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
Public electricity generation (GWh)	41,917	41,920	41,682	41,706	42,278	41,999	41,850	41,501	41,881	41,232	40,916	41,762	41,975
Emissions of CO_2 from public electricity generation (kt)	3,055	3,237	4,962	4,967	4,674	4,110	4,315	3,799	4,872	5,035	5,981	7,224	5,823

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.

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 the emission factors 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]

Table 12 shows the emission factors for transmission and distribution losses from the national grid.

Table 12: Transmission and distribution losses for electricity consumption

Year	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
2023	kWh	0.00533	0.00514	0.0002	0.000006
2022	kWh	0.00603	0.00581	0.0002	0.000007
2021	kWh	0.00922	0.00898	0.0002	0.00002
2020	kWh	0.00914	0.00890	0.0002	0.00001
2019	kWh	0.00845	0.00820	0.0002	0.00001

22 *GHG Protocol Scope 2 Guidance*: https://ghgprotocol.org/sites/default/files/standards/Scope%202%20Guidance_Final_Sept26.pdf.

Year	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
2018	kWh	0.00737	0.00711	0.0003	0.000009
2017	kWh	0.00780	0.00751	0.0003	0.000006
2016	kWh	0.00702	0.00670	0.0003	0.000006
2015	kWh	0.00864	0.00830	0.0003	0.00001
2014	kWh	0.00907	0.00874	0.0003	0.00001
2013	kWh	0.0111	0.0108	0.0003	0.00002
2012	kWh	0.0134	0.0131	0.0003	0.00002
2011	kWh	0.0107	0.0104	0.0003	0.00001

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 entity uses 800,000 kWh of electricity in the 2023 reporting period. Its indirect (Scope 3) emissions from transmission and distribution losses for purchased electricity are:

CO_2 emissions	= 800,000 × 0.00514	= 4,112 kg CO_2
CH_4 emissions	= 800,000 × 0.0002	= 160 kg CO_2-e
N_2O emissions	= 800,000 × 0.000006	= 4.8 kg CO_2-e
Total CO_2-e emissions	= 4,112 + 160 + 4.8	= 4,276.8 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

In previous editions of this guide, MBIE's electricity consumption data series was used to calculate the consumption emission factor, which in turn was used to calculate the transmission and distribution loss factor.

In this new methodology, with emission factors provided directly by MBIE, actual transmission and distribution losses data are used, which more accurately reflect actual losses on the electricity grid.

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

Entities 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

Entities that have their own geothermal energy source can calculate emissions separately using a unique emission factor. Noting carbon emissions from geothermal power stations can be variable over time, this would consider factors such as the measured CO_2 output from the production wells and the CO_2 output at the surface, along with how the water by-product is used, for example, as industrial process heat.

Depending on the steam coming from the borehole, there may or may not be emissions associated with this energy type.

6 Indirect business-related emission factors

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

6.1 Overview of changes since previous update

The three working from home emission factors decreased by around 5.5 per cent, as a result of the lower electricity, and electricity transmission and distribution loss emission factors.

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. Employers can use these emission factors 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 entity wish to quantify their employees' working from home emissions in more detail, they can survey staff and use the data provided in Table 13, or various emission 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 13: Working from home emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Default	Employee days	0.345	0.332	0.0123	0.0004
Without heating	Employee days	0.0515	0.0496	0.00184	0.00005
With heating	Employee days	0.756	0.728	0.0269	0.0008

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 13

Fh = emission factor from the bottom row of Table 13.

WORKING FROM HOME EXAMPLE CALCULATION

An entity 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 × 0.728	= 122.3 kg CO_2
CH_4 emissions	= 168 × 0.0269	= 4.52 kg CO_2-e
N_2O emissions	= 168 × 0.0008	= 0.13 kg CO_2-e
Total CO_2-e emissions	= 168 × 0.756	= 126.95 kg CO_2-e

Without heating = 84 employee days

CO_2 emissions	= 84 × 0.0496	= 4.17 kg CO_2
CH_4 emissions	= 84 × 0.00184	= 0.15 kg CO_2-e
N_2O emissions	= 84 × 0.00005	= 0.004 kg CO_2-e
Total CO_2-e emissions	= 84 × 0.0515	= 4.32 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 14 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 14: Data used to calculate the emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)	Assumptions
Office-based emission sources						
Monitor	Employee days	0.013	0.0122	0.0005	0.00001	20 W 8 hrs per day
Laptop	Employee days	0.031	0.0301	0.0011	0.00003	50 W 8 hrs per day
Light use	Employee days	0.008	0.0072	0.0003	0.00001	12 W 8 hrs per day
Heating						
Heat pump	Employee days	0.235	0.2261	0.0084	0.00024	4 kW capacity, 3 hrs heating per day 50% of households
Electric heater	Employee days	0.469	0.4521	0.0167	0.00049	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 electric vehicle 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 entity'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.

Given 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. Since 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 days where heating was used. Building on this with more accurate GHG data on employee commuting (which can be included in travel emission 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 entity that operates with large third-party IT infrastructure.

Due to the diversity and country location of data centres used by entities 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, entities 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 are calculating the total emissions from their data centres and may be able to inform users of the carbon footprint of their usage. Examples of products or tools offered by data centre providers include the Google management tool Carbon Footprint, Microsoft’s Emissions Impact Dashboard and Amazon’s Customer Carbon Footprint Tool.

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 entity. 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 entity does not directly own or control the vehicles used for travel. If the entity 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

A new age category has been added for Post-2020 passenger vehicles, with the Post-2015 category being renamed to 2015–2020 passenger vehicles. Because newer vehicles tend to be more fuel efficient, the emission factors within this new category are between 3.5 per cent and 5.5 per cent lower than the 2015–2020 age category.

In this edition of the guide, the weighting methodology used to create the domestic average, large and medium sized aircraft is modified. These emission factors are now calculated using the annual flight domestic distance travelled and the total number of domestic flights, for each aircraft type. Previously, the weighting applied was based on the share of total domestic traffic. The multiplier that is applied to account for the non-CO_2 climate change effects of aviation has been revised downwards from 1.9 to 1.7, to be in line with the latest scientific evidence.[23]

A new factor for a passenger ferry was added this year, using data from Auckland Transport.

The three taxi spend-based emission factors reduced by between 11 per cent and 14 per cent, as a result of reductions in the applied fuel factor values, and the increased applied tariff rate from $3.20 to $3.52 per km.

The emission factors for hotel stays have been updated using factors from the 2023 edition of the Cornell Hotel Sustainability Benchmarking Index (CHSB) Index.

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[23] Lee, DS, Fahey, DW, Skowron, A, Allen MR, Burkhardt U, Chen Q, Doherty SJ, Freeman S, Forster PM, Fuglestvedt J, Gettelman A, De León RR, Lim LL, Lund MT, Millar RJ, Owen B, Penner JE, Pitari G, Prather MJ, Sausen R, Wilcox LJ. 2021. The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. *Atmospheric Environment* 244.

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 2022 fleet statistics (table 16, table 17, table 18 and table 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 table 16, table 17, table 18 and table 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 15 details engine sizes and typical corresponding vehicles.

Table 15: 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 16: Pre-2010 vehicle fleet emission factors per km travelled

Emission source category		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol vehicle	<1350 cc	km	0.188	0.180	0.00240	0.00550
	1350–<1600 cc	km	0.195	0.186	0.00248	0.00569
	1600–<2000 cc	km	0.219	0.210	0.00279	0.00641
	2000–3000 cc	km	0.243	0.233	0.00310	0.00712
	≥3000 cc	km	0.291	0.279	0.00371	0.00852
Diesel vehicle	<1350 cc	km	0.211	0.208	0.0003	0.00295
	1350–<1600 cc	km	0.203	0.200	0.0003	0.00284
	1600–<2000 cc	km	0.215	0.212	0.0003	0.00301

Emission source category		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
	2000–<3000 cc	km	0.265	0.261	0.0004	0.00370
	≥3000 cc	km	0.294	0.289	0.0004	0.00410
Petrol hybrid vehicle	<1350 cc	km	0.148	0.142	0.00189	0.00434
	1350–<1600 cc	km	0.154	0.147	0.00196	0.00450
	1600–<2000 cc	km	0.173	0.166	0.00221	0.00506
	2000–<3000 cc	km	0.192	0.184	0.00245	0.00562
	≥3000 cc	km	0.230	0.220	0.00293	0.00673
Diesel hybrid vehicle	<1350 cc	km	0.189	0.186	0.0003	0.00264
	1350–<1600 cc	km	0.182	0.179	0.0003	0.00255
	1600–<2000 cc	km	0.193	0.190	0.0003	0.00270
	2000–<3000 cc	km	0.237	0.234	0.0004	0.00332
	≥3000 cc	km	0.263	0.259	0.0004	0.00368
Motorcycle	<60cc, petrol	km	0.0660	0.0632	0.0008	0.00193
	≥ 60cc, petrol	km	0.132	0.126	0.00168	0.00386

Table 17: Vehicle fleet emission factors per km travelled, 2010–2015

Emission source category		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol vehicle	<1350 cc	km	0.167	0.160	0.00213	0.00488
	1350–<1600 cc	km	0.172	0.165	0.00220	0.00505
	1600–<2000 cc	km	0.194	0.186	0.00248	0.00568
	2000–3000 cc	km	0.216	0.207	0.00275	0.00631
	≥3000 cc	km	0.258	0.247	0.00329	0.00755
Diesel vehicle	<1350 cc	km	0.187	0.185	0.0003	0.00262
	1350–<1600 cc	km	0.180	0.178	0.0003	0.00252
	1600–<2000 cc	km	0.191	0.188	0.0003	0.00267
	2000–<3000 cc	km	0.235	0.231	0.0003	0.00328
	≥3000 cc	km	0.261	0.257	0.0004	0.00364
Petrol hybrid vehicle	<1350 cc	km	0.132	0.126	0.00168	0.00385
	1350–<1600 cc	km	0.136	0.130	0.00174	0.00398
	1600–<2000 cc	km	0.153	0.147	0.00196	0.00449
	2000–<3000 cc	km	0.170	0.163	0.00217	0.00498
	≥3000 cc	km	0.204	0.195	0.00260	0.00596
Diesel hybrid vehicle	<1350 cc	km	0.168	0.165	0.0002	0.00234
	1350–<1600 cc	km	0.161	0.159	0.0002	0.00226
	1600–<2000 cc	km	0.171	0.168	0.0003	0.00239
	2000–<3000 cc	km	0.210	0.207	0.0003	0.00294
	≥3000 cc	km	0.233	0.230	0.0003	0.00326
PHEV (Petrol) – Petrol consumption	<1350 cc	km	0.0688	0.0659	0.0009	0.00201
	1350–<1600 cc	km	0.0712	0.0682	0.0009	0.00209
	1600–<2000 cc	km	0.0802	0.0768	0.00102	0.00235

Emission source category		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
	2000–<3000 cc	km	0.0891	0.0853	0.00114	0.00261
	≥3000 cc	km	0.107	0.102	0.00136	0.00312
PHEV (Petrol) – Electricity consumption	<1350 cc	km	0.00696	0.00670	0.0002	0.000007
	1350–<1600 cc	km	0.00720	0.00694	0.0003	0.000008
	1600–<2000 cc	km	0.00811	0.00781	0.0003	0.000008
	2000–<3000 cc	km	0.00901	0.00868	0.0003	0.000009
	≥3000 cc	km	0.0108	0.0104	0.0004	0.00001
PHEV (Diesel) – Diesel consumption	<1350 cc	km	0.0878	0.0864	0.0001	0.00123
	1350–<1600 cc	km	0.0845	0.0832	0.0001	0.00118
	1600–<2000 cc	km	0.0895	0.0881	0.0001	0.00125
	2000–<3000 cc	km	0.110	0.108	0.0002	0.00154
	≥3000 cc	km	0.122	0.120	0.0002	0.00171
PHEV (Diesel) – Electricity consumption	<1350 cc	km	0.00759	0.00731	0.0003	0.000008
	1350–<1600 cc	km	0.00729	0.00702	0.0003	0.000008
	1600–<2000 cc	km	0.00799	0.00769	0.0003	0.000008
	2000–<3000 cc	km	0.00904	0.00871	0.0003	0.000009
	≥3000 cc	km	0.0107	0.0103	0.0004	0.00001
Electric vehicle	<1350 cc	km	0.0146	0.0141	0.0005	0.00002
	1350–<1600 cc	km	0.0151	0.0146	0.0005	0.00002
	1600–<2000 cc	km	0.0170	0.0164	0.0006	0.00002
	2000–<3000 cc	km	0.0189	0.0182	0.0007	0.00002
	≥3000 cc	km	0.0226	0.0218	0.0008	0.00002
Motorcycle	<60cc, petrol	km	0.0585	0.0560	0.0007	0.00171
	≥ 60cc, petrol	km	0.117	0.112	0.00149	0.00342
	<60cc, electricity	km	0.00359	0.00346	0.0001	0.000004
	≥ 60cc, electricity	km	0.00718	0.00691	0.0003	0.000007

Table 18: Vehicle fleet emissions per km travelled, 2015–2020

Emission source category		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol vehicle	<1350 cc	km	0.157	0.150	0.00200	0.00460
	1350–<1600 cc	km	0.163	0.156	0.00207	0.00476
	1600–<2000 cc	km	0.183	0.175	0.00234	0.00536
	2000–3000 cc	km	0.203	0.195	0.00259	0.00595
	≥3000 cc	km	0.243	0.233	0.00310	0.00712
Diesel vehicle	<1350 cc	km	0.178	0.175	0.0003	0.00249
	1350–<1600 cc	km	0.172	0.169	0.0003	0.00240
	1600–<2000 cc	km	0.182	0.179	0.0003	0.00254
	2000–<3000 cc	km	0.223	0.220	0.0003	0.00312
	≥3000 cc	km	0.248	0.244	0.0004	0.00346

Emission source category		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol hybrid vehicle	<1350 cc	km	0.124	0.119	0.00158	0.00363
	1350–<1600 cc	km	0.128	0.123	0.00164	0.00376
	1600–<2000 cc	km	0.145	0.138	0.00184	0.00423
	2000–<3000 cc	km	0.161	0.154	0.00205	0.00470
	≥3000 cc	km	0.192	0.184	0.00245	0.00562
Diesel hybrid vehicle	<1350 cc	km	0.158	0.156	0.0002	0.00221
	1350–<1600 cc	km	0.152	0.150	0.0002	0.00213
	1600–<2000 cc	km	0.161	0.159	0.0002	0.00225
	2000–<3000 cc	km	0.198	0.195	0.0003	0.00277
	≥3000 cc	km	0.220	0.217	0.0003	0.00307
PHEV (Petrol) – Petrol consumption	<1350 cc	km	0.0649	0.0622	0.0008	0.00190
	1350–<1600 cc	km	0.0672	0.0644	0.0009	0.00197
	1600–<2000 cc	km	0.0756	0.0725	0.0010	0.00221
	2000–<3000 cc	km	0.0840	0.0805	0.00107	0.00246
	≥3000 cc	km	0.101	0.0963	0.00128	0.00294
PHEV (Petrol) – Electricity consumption	<1350 cc	km	0.00666	0.00641	0.0002	0.000007
	1350–<1600 cc	km	0.00689	0.00664	0.0002	0.000007
	1600–<2000 cc	km	0.00776	0.00747	0.0003	0.000008
	2000–<3000 cc	km	0.00862	0.00830	0.0003	0.000009
	≥3000 cc	km	0.0103	0.00993	0.0004	0.00001
PHEV (Diesel) – Diesel consumption	<1350 cc	km	0.0828	0.0815	0.0001	0.00116
	1350–<1600 cc	km	0.0797	0.0784	0.0001	0.00111
	1600–<2000 cc	km	0.0844	0.0831	0.0001	0.00118
	2000–<3000 cc	km	0.104	0.102	0.0002	0.00145
	≥3000 cc	km	0.115	0.113	0.0002	0.00161
PHEV (Diesel) – Electricity consumption	<1350 cc	km	0.00726	0.00699	0.0003	0.000008
	1350–<1600 cc	km	0.00697	0.00672	0.0002	0.000007
	1600–<2000 cc	km	0.00764	0.00736	0.0003	0.000008
	2000–<3000 cc	km	0.00865	0.00833	0.0003	0.000009
	≥3000 cc	km	0.0102	0.00985	0.0004	0.00001
Electric vehicle	<1350 cc	km	0.0140	0.0135	0.0005	0.00001
	1350–<1600 cc	km	0.0145	0.0139	0.0005	0.00002
	1600–<2000 cc	km	0.0163	0.0157	0.0006	0.00002
	2000–<3000 cc	km	0.0181	0.0174	0.0006	0.00002
	≥3000 cc	km	0.0216	0.0208	0.0008	0.00002
Motorcycle	<60 cc, petrol	km	0.0555	0.0532	0.0007	0.00163
	≥60 cc, petrol	km	0.107	0.102	0.00136	0.00313
	<60 cc, electricity	km	0.00366	0.00353	0.0001	0.000004
	≥60 cc, electricity	km	0.00705	0.00679	0.0003	0.000007

Table 19: Post-2020 vehicle fleet emissions per km travelled

Emission source category		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol vehicle	<1350 cc	km	0.149	0.143	0.00190	0.00435
	1350–<1600 cc	km	0.154	0.147	0.00196	0.00451
	1600–<2000 cc	km	0.173	0.166	0.00221	0.00507
	2000–3000 cc	km	0.193	0.184	0.00246	0.00564
	≥3000 cc	km	0.230	0.221	0.00294	0.00674
Diesel vehicle	<1350 cc	km	0.170	0.168	0.0003	0.00238
	1350–<1600 cc	km	0.164	0.161	0.0002	0.00229
	1600–<2000 cc	km	0.174	0.171	0.0003	0.00243
	2000–<3000 cc	km	0.214	0.210	0.0003	0.00298
	≥3000 cc	km	0.237	0.233	0.0003	0.00331
Petrol hybrid vehicle	<1350 cc	km	0.117	0.112	0.00150	0.00343
	1350–<1600 cc	km	0.121	0.116	0.00155	0.00355
	1600–<2000 cc	km	0.137	0.131	0.00174	0.00400
	2000–<3000 cc	km	0.152	0.145	0.00194	0.00444
	≥3000 cc	km	0.182	0.174	0.00232	0.00532
Diesel hybrid vehicle	<1350 cc	km	0.150	0.148	0.0002	0.00210
	1350–<1600 cc	km	0.144	0.142	0.0002	0.00202
	1600–<2000 cc	km	0.153	0.151	0.0002	0.00214
	2000–<3000 cc	km	0.188	0.185	0.0003	0.00263
	≥3000 cc	km	0.209	0.205	0.0003	0.00291
PHEV (Petrol) – Petrol consumption	<1350 cc	km	0.0614	0.0588	0.0008	0.00180
	1350–<1600 cc	km	0.0635	0.0609	0.0008	0.00186
	1600–<2000 cc	km	0.0715	0.0685	0.0009	0.00209
	2000–<3000 cc	km	0.0795	0.0761	0.00101	0.00233
	≥3000 cc	km	0.0950	0.0911	0.00121	0.00278
PHEV (Petrol) – Electricity consumption	<1350 cc	km	0.00641	0.00618	0.0002	0.000007
	1350–<1600 cc	km	0.00664	0.00639	0.0002	0.000007
	1600–<2000 cc	km	0.00747	0.00720	0.0003	0.000008
	2000–<3000 cc	km	0.00830	0.00800	0.0003	0.000009
	≥3000 cc	km	0.00993	0.00956	0.0004	0.00001
PHEV (Diesel) – Diesel consumption	<1350 cc	km	0.0785	0.0773	0.0001	0.00110
	1350–<1600 cc	km	0.0755	0.0744	0.0001	0.00106
	1600–<2000 cc	km	0.0800	0.0788	0.0001	0.00112
	2000–<3000 cc	km	0.0984	0.0969	0.0001	0.00138
	≥3000 cc	km	0.109	0.107	0.0002	0.00153
PHEV (Diesel) – Electricity consumption	<1350 cc	km	0.00699	0.00674	0.0002	0.000007
	1350–<1600 cc	km	0.00672	0.00647	0.0002	0.000007
	1600–<2000 cc	km	0.00736	0.00709	0.0003	0.000008

Emission source category		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
	2000–<3000 cc	km	0.00833	0.00803	0.0003	0.000009
	≥3000 cc	km	0.00985	0.00949	0.0004	0.00001
Electric vehicle	<1350 cc	km	0.0135	0.0130	0.0005	0.00001
	1350–<1600 cc	km	0.0139	0.0134	0.0005	0.00001
	1600–<2000 cc	km	0.0157	0.0151	0.0006	0.00002
	2000–<3000 cc	km	0.0174	0.0168	0.0006	0.00002
	≥3000 cc	km	0.0208	0.0201	0.0007	0.00002
Motorcycle	<60 cc, petrol	km	0.0530	0.0508	0.0007	0.00155
	≥60 cc, petrol	km	0.106	0.101	0.00135	0.00309
	<60 cc, electricity	km	0.00350	0.00337	0.0001	0.000004
	≥60 cc, electricity	km	0.00697	0.00671	0.0002	0.000007

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 CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Private car default					
Petrol	km	0.243	0.233	0.00310	0.00712
Diesel	km	0.265	0.261	0.0004	0.00370
Petrol hybrid	km	0.192	0.184	0.00245	0.00562
Diesel hybrid	km	0.237	0.234	0.0004	0.00332
PHEV (Petrol) – Petrol consumption	km	0.0891	0.0853	0.00114	0.00261
PHEV (Petrol) – Electricity consumption	km	0.00901	0.00868	0.0003	0.000009
PHEV (Diesel) – Diesel consumption	km	0.110	0.108	0.0002	0.00154
PHEV (Diesel) – Electricity consumption	km	0.00904	0.00871	0.0003	0.000009
Electric	km	0.0189	0.0182	0.0007	0.00002

Note: 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: Te Manatū Waka Ministry of Transport

Table 21: Default rental car emission factors per km travelled

Emission source category	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Rental car default					
Petrol	km	0.183	0.175	0.00234	0.00536
Diesel	km	0.182	0.179	0.0003	0.00254
Petrol hybrid	km	0.145	0.138	0.00184	0.00423
Diesel hybrid	km	0.161	0.159	0.0002	0.00225
PHEV (Petrol) – Petrol consumption	km	0.0756	0.0725	0.0010	0.00221
PHEV (Petrol) – Electricity consumption	km	0.00776	0.00747	0.0003	0.000008
PHEV (Diesel) – Diesel consumption	km	0.0844	0.0831	0.0001	0.00118
PHEV (Diesel) – Electricity consumption	km	0.00764	0.00736	0.0003	0.000008
Electric	km	0.0163	0.0157	0.0006	0.00002

Note: Defaults assume a 2015–2020 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 2010–2015 fleet and 2000–3000 cc vehicle class.

Table 22: Emission factors for taxi travel

Emission source category	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Taxi travel					
Regular	km	0.160	0.155	0.00149	0.00365
Regular – dollars spent	$	0.0454	0.0440	0.0004	0.00104
Petrol hybrid	km	0.170	0.163	0.00217	0.00498
Petrol hybrid – dollars spent	$	0.0484	0.0463	0.0006	0.00142
Electric	km	0.0189	0.0182	0.0007	0.00002
Electric – dollars spent	$	0.00537	0.00517	0.0002	0.000006

7.2.1 GHG inventory development

Entities 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 entity's boundaries, this is a direct (Scope 1) emission source and emissions are zero. If travel is by rideshare apps (ie, Uber, YourRide, Waka Rider, Ola or Share Your Ride) 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.

Because plug-in hybrids operate on both a fossil fuel and electricity, two separate emission factors should be applied, that for the fossil fuel (petrol or diesel) and that for electricity. The plug-in hybrid electric vehicle electricity factor includes both the electricity and the electricity transmission and distribution loss 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 = distance travelled by vehicle type (km)

F = emission factors for correlating vehicle type from table 16 to table 22.

PASSENGER VEHICLES: EXAMPLE CALCULATION

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

CO_2 emissions	= 40,000 × 2.27	= 90,800 kg CO_2
CH_4 emissions	= 40,000 × 0.0303	= 1,212 kg CO_2-e
N_2O emissions	= 40,000 × 0.0695	= 2,780 kg CO_2-e
Total CO_2-e emissions	= 40,000 × 2.37	= 94,792 kg CO_2-e

An entity owns three post-2020 petrol plug-in hybrid electric vehicles (PHEVs). They are all between 1600 and 2000 cc and travel a total of 37,800 km in the reporting period. We need to capture both the fossil fuel and electricity-based emissions.

For the petrol-based emissions, use the PHEV (Petrol) – Petrol consumption emission factor:

CO_2 emissions	= 37,800 × 0.0685	= 2,589.3 kg CO_2
CH_4 emissions	= 37,800 × 0.0009	= 34.02 kg CO_2-e
N_2O emissions	= 37,800 × 0.00209	= 79.002 kg CO_2-e
Total CO_2-e emissions	= 37,800 × 0.0715	= 2,702.32 kg CO_2-e

Then also use the PHEV (Petrol) – Electricity consumption emission factor:

CO_2 emissions	= 37,800 × 0.0072	= 272.16 kg CO_2
CH_4 emissions	= 37,800 × 0.0003	= 11.34 kg CO_2-e
N_2O emissions	= 37,800 × 0.000008	= 0.302 kg CO_2-e
Total CO_2-e emissions	= 37,800 × 0.179	= 283.80 kg CO_2-e

The sum of the above totals is the total emissions:

2,702.32 kg CO_2-e + 283.80 kg CO_2-e = 2,986.12 kg CO_2-e

An entity 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 × 0.183	= 2,196 kg CO_2-e
Total CO_2-e emissions from hybrid taxi travel	= \$18,000 × 0.0484	= 871.2 kg CO_2-e

Note: Numbers may not add due to rounding.

7.2.2 Emission factor derivation methodology

The 2022 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 split the fleet into four categories and develop average emission factors for these.

- The 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.
- The 2010–2015 fleet is based on the average fuel consumption data from vehicles produced between 2010 and 2015.
- The 2015–2020 fleet is based on the average fuel consumption data from vehicles produced between 2015 and 2020.
- The post-2020 fleet is based on the average fuel consumption data from vehicles produced from 2021 onwards.

Note that some guidance documents, such as those published by the UK Department for Energy Security and Net Zero (formerly published by the Department of Business, Energy and Industrial Strategy), 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.

Table 23: Fuel consumption in litres per 100 km

Emission source		Units	Units of energy consumed per 100 km			
			Pre-2010	2010-2015	2015-2020	Post-2020
Petrol vehicle	<1350 cc	Litres	7.922	7.021	6.622	6.270
	1350–<1600 cc	Litres	8.199	7.266	6.853	6.489
	1600–<2000 cc	Litres	9.232	8.181	7.716	7.306
	2000–<3000 cc	Litres	10.254	9.087	8.571	8.115
	≥3000 cc	Litres	12.267	10.871	10.253	9.708
Diesel vehicle	<1350 cc	Litres	7.884	6.999	6.657	6.366
	1350–<1600 cc	Litres	7.587	6.735	6.406	6.126
	1600–<2000 cc	Litres	8.042	7.138	6.789	6.493
	2000–<3000 cc	Litres	9.886	8.775	8.342	7.976
	≥3000 cc	Litres	10.966	9.734	9.254	8.848
Petrol hybrid vehicle	<1350 cc	Litres	6.254	5.543	5.228	4.944
	1350–<1600 cc	Litres	6.473	5.736	5.410	5.117
	1600–<2000 cc	Litres	7.288	6.459	6.092	5.761
	2000–<3000 cc	Litres	8.095	7.174	6.766	6.399
	≥3000 cc	Litres	9.6842	8.5823	8.0942	7.6550
Diesel hybrid vehicle	<1350 cc	Litres	7.0678	6.2636	5.9074	5.6004
	1350–<1600 cc	Litres	6.8015	6.0276	5.6848	5.389
	1600–<2000 cc	Litres	7.209	6.389	6.025	5.712
	2000–<3000 cc	Litres	8.862	7.854	7.407	7.022
	≥3000 cc	Litres	9.831	8.712	8.217	7.790
Petrol plug-in hybrid electric vehicle (PHEV) – Petrol consumption	<1350 cc	Litres	3.273	2.901	2.736	2.587
	1350–<1600 cc	Litres	3.387	3.002	2.831	2.678
	1600–<2000 cc	Litres	3.814	3.380	3.188	3.015
	2000–<3000 cc	Litres	4.237	3.755	3.541	3.349
	≥3000 cc	Litres	5.068	4.491	4.236	4.006

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

Emission source		Units	Units of energy consumed per 100 km Pre-2010	2010-2015	2015-2020	Post-2020
Petrol plug-in hybrid electric vehicle (PHEV) – Electricity consumption	<1350 cc	kWh	10.018	8.895	8.510	8.198
	1350–<1600 cc	kWh	10.368	9.206	8.807	8.484
	1600–<2000 cc	kWh	11.674	10.366	9.917	9.553
	2000–<3000 cc	kWh	12.967	11.514	11.015	10.611
	≥3000 cc	kWh	15.512	13.773	13.177	12.693
Diesel plug-in hybrid electric vehicle (PHEV) – Diesel consumption	<1350 cc	Litres	3.699	3.278	3.092	2.9309
	1350–<1600 cc	Litres	3.559	3.154	2.975	2.8204
	1600–<2000 cc	Litres	3.773	3.343	3.153	2.989
	2000–<3000 cc	Litres	4.638	4.110	3.876	3.675
	≥3000 cc	Litres	5.145	4.559	4.300	4.077
Diesel plug-in hybrid electric vehicle (PHEV) – Electricity consumption	<1350 cc	kWh	10.927	9.702	9.282	8.941
	1350–<1600 cc	kWh	10.495	9.318	8.915	8.588
	1600–<2000 cc	kWh	11.499	10.210	9.768	9.410
	2000–<3000 cc	kWh	13.015	11.556	11.056	10.650
	≥3000 cc	kWh	15.393	13.668	13.076	12.596
Electric vehicle	<1350 cc	kWh	21.017	18.661	17.853	17.198
	1350–<1600 cc	kWh	21.751	19.313	18.477	17.799
	1600–<2000 cc	kWh	24.491	21.746	20.805	20.042
	2000–<3000 cc	kWh	27.203	24.154	23.108	22.261
	≥3000 cc	kWh	32.542	28.895	27.644	26.630
Motorcycle	<60 cc, petrol	Litres	2.780	2.465	2.340	2.234
	≥60 cc, petrol	Litres	5.561	4.929	4.508	4.4544
	<60 cc, electricity	kWh	5.137	4.588	4.680	4.4688
	≥60 cc, electricity	kWh	10.274	9.177	9.017	8.909

Source: 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.

New Zealand Transport Agency 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.

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

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/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
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

TaxiCharge NZ Ltd advised that the current average price per kilometre in a taxi is $3.52. North Island's average rate = $3.35, while South Island's average = $3.81.

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 CO_2-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**

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 26 applied.

According to Te Manatū Waka Ministry of Transport's *The New Zealand 2022 Vehicle Fleet: Data Spreadsheet*,[26] the average age of light passenger vehicles in 2021 was 14.87 years. This corresponds to a 2007 year of manufacture.

Furthermore, according to the above source, the most common size of light passenger vehicles is between 1600 cc and 2000 cc, which puts it in the 2000–3000 cc category. For hybrid and electric vehicles, we assumed a 2015–2020 fleet consumption for a 2000–3000 cc equivalent engine size.

[26] Te Manatū Waka Ministry of Transport: www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/annual-fleet-statistics

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	6.766
Diesel hybrid	Litre	7.407
Petrol plug-in hybrid (petrol)	Litre	3.541
Petrol plug-in hybrid (electricity)	kWh	11.015
Diesel plug-in hybrid (diesel)	Litre	3.876
Diesel plug-in hybrid (electricity)	kWh	11.056
Electric	kWh	23.108

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

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 Te Manatū Waka Ministry of Transport's *The New Zealand 2022 Vehicle Fleet: Data Spreadsheet*, the most common size of light passenger vehicle is between 1600 cc and 2000 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, trains and a ferry were provided by Auckland Transport. The unit used for these emission sources are passenger kilometres (pkm).

The national average for the bus factor is unchanged from the previous edition.

Table 27: Emission factors for public transport

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Bus	National average for bus	pkm	0.155	0.153	0.0001	0.00213
	Electric bus	pkm	0.0154	0.0148	0.0005	0.00002
	Diesel bus	pkm	0.162	0.160	0.0002	0.00227
	Hydrogen bus	pkm	0.0286	0.0275	0.00105	0.00003

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
	Average bus	pkm	0.150	0.148	0.0003	0.00209
Rail	Metropolitan electric	pkm	0.0148	0.0143	0.0005	0.00002
	Metropolitan diesel	pkm	0.275	0.270	0.0004	0.00384
	Metropolitan average	pkm	0.0222	0.0216	0.0005	0.0001
Ferry	Ferry average	pkm	0.284	0.280	0.0004	0.00397

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. Entities could conduct a staff travel survey to quantify these emissions.[27]

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 0.0148 = 1.39 kg CO_2

CH_4 emissions = 94 x 0.0005 = 0.05 kg CO_2-e

N_2O emissions = 94 x 0.00002 = 0.002 kg CO_2-e

Total CO_2-e emissions from passenger public travel = 94 x 0.0154 = 1.44 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 New Zealand Transport Agency passenger travel data[28] (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
New Zealand	Bus	pkm	534,976,704
New Zealand	Bus	Service km	122,934,050

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

28 New Zealand Transport Agency, Passenger data, accessed September 2020: www.nzta.govt.nz/assets/userfiles/transport-data/PTPerformance.xlsx.

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
Southland	Passenger/bus	3
Taranaki	Passenger/bus	12
Waikato	Passenger/bus	4
Wellington	Passenger/bus	20

We then divided the per kilometre emission factor for diesel buses in table 28 by the national passenger/bus loading rate to give the emissions per gas, see table 35.

Table 30: Emission factor for national average bus

Bus type	Class	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
National average bus	Diesel bus (≥12000 kg)	km	1.088	1.070	0.001	0.017

7.3.2.2 Auckland buses

To calculate the emissions from Auckland buses we used the most recent data available, which were from the year 2023. This information was from Auckland Transport.

Data for the electric and hydrogen buses are in table 31. The distance travelled by electric and hydrogen buses for each 2023 quarter was multiplied by an estimated average bus power rating of 1.075 kWh and 7.05 kWh per kilometre respectively.[29] The resultant energy consumption was multiplied by its respective quarterly electricity emission factor (including the transmission and distribution loss factor of electricity) to produce quarterly emissions totals. These totals were then divided by the quarterly totals for passenger kilometres travelled. The final emission factor is weighted based on the quarterly emissions totals and quarterly passenger kilometres travelled.

[29] These network average rates for Auckland were based on Auckland Transport's GHG inventory of 2022/23.

Table 31: Auckland Transport 2023 data for electric and hydrogen buses

Bus type	2023 Quarter	Distance (km)	Fuel consumption rate (kWh/km)	Electricity consumption	pkm
Electric	Q1	1,179,085	1.07	1,267,504	5,847,186
Electric	Q2	1,410,283	1.07	1,516,039	7,441,030
Electric	Q3	1,816,925	1.07	1,953,175	8,769,390
Electric	Q4	2,214,167	1.07	2,380,206	12,071,136
Hydrogen	Q1	1,088	7.05	7,674	15,996
Hydrogen	Q2	1,544	7.05	10,895	29,302
Hydrogen	Q3	1,089	7.05	7,685	20,566
Hydrogen	Q4	1,226	7.05	8,650	20,057

Data for the diesel buses are in Table 32. The annual distance travelled was multiplied by an estimated fuel efficiency of 0.433 litres per kilometre travelled.[30] The resultant energy consumption was multiplied by the diesel emission factor, to produce an annual emissions total. This total was then divided by the annual passenger kilometres travelled, to produce the final emission factor.

Table 32: Auckland Transport 2023 data for diesel buses

Distance (km)	Fuel consumption rate (l/km)	Fuel consumption (litres)	pkm
54,023,206	0.433	23,373,644	385,250,034

7.3.2.3 Auckland trains

To calculate the emissions from Auckland trains we used the most recent data available, which were from the year 2023 and 2021/22 for electric and diesel trains respectively. Diesel trains stopped operating in the region in August 2022. This information was from Auckland Transport.

Data for the electric and diesel trains are in table 33. The diesel fuel used by diesel trains was multiplied by the diesel emission factor (in table 4) to produce an annual emissions total. This total was then divided by the annual passenger kilometres travelled, to produce the final emission factor.

The electricity used by electric trains for each year 2023 quarter, was multiplied by the respective quarterly electricity emission factors (including the transmission and distribution loss factor of electricity) to produce quarterly emissions totals. These totals were then divided by the quarterly totals for passenger kilometres travelled. The final emission factor is weighted based on the quarterly emissions totals and quarterly passenger kilometres travelled.

The diesel fuel used by diesel trains was multiplied by the diesel emission factor (in table 4) to produce an annual emissions total. This total was then divided by the annual passenger kilometres travelled, to produce the final emission factor.

[30] The average fuel efficiency was based on Auckland Transport's GHG inventory of 2022/23.

Table 33: Auckland train data

Train type	Quarter/Year	Unit	Fuel consumption per unit	pkm
Electric	2023 Q1	kWh	6,563,953	30,239,201
Electric	2023 Q2	kWh	7,638,147	38,479,643
Electric	2023 Q3	kWh	8,271,508	39,934,857
Electric	2023 Q4	kWh	7,447,841	38,607,309
Diesel	2021/22	Litres	443,997	4,330,313

The train average factor is weighted based on the emission factors for electric and diesel trains and the respective passenger kilometres travelled.

7.3.3 Auckland ferry

To calculate the emissions from ferry travel we used the most recent data available, which were from the year 2023. This information was from Auckland Transport and covers the 30 ferries operating in the Auckland region.

The annual distance travelled by diesel ferries in the year 2023 was multiplied by an estimated average fuel consumption rate of 4.84 l/km to estimate the diesel used by public transport ferries in Auckland region.[31] The diesel used was then multiplied by the diesel emission factor (in table 4) to produce an annual emissions total. This total was then divided by the annual passenger kilometres travelled, to produce the final emission factor.

Table 34: Ferry data

Distance	Fuel consumption (litres)	pkm
1,448,946	7,015,602	66,144,312

7.3.4 Assumptions, limitations and uncertainties

Limited data are available for areas outside the Auckland region. These metro commuter rail emission factors are assumed to be appropriate for use on any commuter rail line in New Zealand.

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 35 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 are from 2019.

[31] The average fuel efficiency was based on Auckland Transport's GHG inventory of 2022/23.

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

Table 35: Bus emission factors per km travelled

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Diesel bus	<7,500 kg	km	0.563	0.554	0.0008	0.00787
	7,500–12,000 kg	km	0.780	0.767	0.00115	0.0109
	≥12,000 kg	km	1.08	1.06	0.00160	0.0151
Diesel hybrid bus	<7,500 kg	km	0.398	0.392	0.0006	0.00557
	7,500–12,000 kg	km	0.552	0.543	0.0008	0.00771
	≥12,000 kg	km	0.765	0.753	0.00113	0.0107
Electric bus	<7,500 kg	km	0.0451	0.0435	0.00161	0.00005
	7,500–12,000 kg	km	0.0625	0.0602	0.00223	0.00007
	≥12,000 kg	km	0.0866	0.0835	0.00309	0.00009

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 35.

DIESEL BUS: EXAMPLE CALCULATION

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

CO_2 emissions = 500 x 0.554 = 277 kg CO_2

CH_4 emissions = 500 x 0.0008 = 0.40 kg CO_2-e

N_2O emissions = 500 x 0.00787 = 3.935 kg CO_2-e

Total CO_2-e emissions from bus travel = 500 km x 0.563 = 281.34 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 36: 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

Using the information in table 36 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 entities seeking to determine the emissions from business travel.

7.5.1 Domestic air travel

This section provides emission factors based on data from 2023. Domestic air travel is a common source of indirect (Scope 3) emissions for many New Zealand entities.

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 high altitude (jet aircraft). Radiative forcing helps entities 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, entities 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.

The decision to apply the Radiative Forcing Index, and to what type of air travel (flight altitude) should be guided by the requirements of your intended use and users.

In terms of the small and medium 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 37 provides the emission factors without the radiative forcing multiplier applied. Table 38 provides emission factors with a radiative forcing multiplier of 1.7 applied.

Table 37: Domestic air travel emission factors without a radiative forcing multiplier

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
National average	pkm	0.115	0.114	0.00002	0.0008
Large aircraft	pkm	0.104	0.103	0.00002	0.0008
Medium aircraft	pkm	0.120	0.119	0.00002	0.0009
Small aircraft	pkm	0.352	0.341	0.00288	0.00904

Table 38: Domestic aviation emission factors with a radiative forcing multiplier

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
National average	pkm	0.194	0.193	0.00002	0.0008
Large aircraft	pkm	0.176	0.176	0.00002	0.0008
Medium aircraft	pkm	0.203	0.202	0.00002	0.0009
Small aircraft	pkm	0.591	0.579	0.00288	0.00904

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 A320neo, A320ceo and A321neo. 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 fewer than 50 seats. If the aircraft type is unknown, we recommend using the national average.

7.5.1.1 GHG inventory development

To calculate emissions for domestic air travel, collect information on passengers flying, their departure and destination airports, flight length, travel class and, if practical, the type of aircraft. Your travel provider may be able to provide this information.

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.

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 37 to table 38.

DOMESTIC AIR TRAVEL: EXAMPLE CALCULATION

An entity 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 = 0.139 x 3,040 = 422.56 kg CO_2-e

Note: Numbers may not add due to rounding.

7.5.1.2 Emission factor derivation methodology

We developed emission factors for aircraft type 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 2016, 2020 and 2023 calendar years. Table 39 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 emission factor has also been provided where the aircraft type is unknown (see Table 37 and table 38). Entities that own aircraft could calculate emissions based on the fuel consumption data.

Table 39: Domestic aviation data (2016, 2020 and 2023)

Aircraft type	Total seats per flight	Average distance per flight (km)	Total fuel used (kg)	Total flights
Airbus A320*	173	670.16	107,713,747	33,920
Aerospatiale/Alenia ATR 72*	68	394.31	37,409,624	49,225
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 Q300*	50	313.33	51,220,006	62,557
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, 2020 and 2023.

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.[32]

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.

Table 40: Calculated emissions, without the radiative forcing multiplier, per aircraft type

Aircraft type	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Airbus A320*	pkm	0.1104	0.1095	0.00002	0.0008
Aerospatiale/Alenia ATR 72*	pkm	0.1134	0.1125	0.00002	0.0008
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 Q300*	pkm	0.2198	0.2181	0.00004	0.0016
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: 2016 or 2020 data unless denoted otherwise. * Updated using 2023 data.

Table 41: Calculated emissions, with 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	0.1870	0.1862	0.00002	0.0008
Aerospatiale/Alenia ATR 72*	pkm	0.1922	0.1913	0.00002	0.00008
Beechcraft Beech 1900D	pkm	0.353	0.342	0.004	0.010
De Havilland Q300*	pkm	0.3725	0.3708	0.00004	0.0016
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: 2016 or2020 data unless denoted otherwise. * Updated using 2023 data.

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

For situations where the aircraft type is unknown, average emission factors are also provided for a domestic average, and for large, medium and small aircraft (see table 37 and table 38).

We then calculated a weighted average emission factor for each size category, using the aircraft types within that size range. The weighted averages are calculated using the annual flight domestic distance travelled and the total number of domestic flights for each aircraft type. This method applies an equal weighting of 50 per cent to both distance travelled and number of flights.

- large aircraft: A320neo, A320ceo and A321neo
- medium aircraft: ATR 72 and Q300
- small aircraft: British Aerospace Jetstream 32, Cessna Light Aircraft.

A national average emission factor was calculated using the same weighted average approach described above, this time considering the contribution each of the five large and medium aircraft types make to the overall distance travelled and number of flights.

7.5.1.3 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.

7.5.2 International air travel

International air travel emission factors are sourced directly from the *UK Greenhouse gas reporting: conversion factors 2022*, published by the UK Department for Energy Security and Net Zero (DESNZ) and have not been updated to the DESNZ 2023 factors. This is because the 2022 factors (unchanged from 2021) are calculated from 2018 and 2019 flight passenger data. The DESNZ 2023 update uses data from 2021, a period of significant impact because of the COVID-19 pandemic, specifically load factors. The implication of this update is significant because the 2023 updated factors are not at all reflective of reporting periods after the COVID-19 pandemic.

Because the DESNZ 2022 emission factors were developed using the GWP values from the AR4, the factors presented here have been converted to AR5 GWP values.

Entities wishing to report their international air travel emissions based on distance travelled per passenger could use the International Civil Aviation Organisation (ICAO) calculator.[33] This calculator considers aircraft types and load factors for specific airline 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 1.7 to apply a radiative forcing multiplier.

33 International Civil Aviation Organisation Calculator: www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx.

If you prefer not to use the ICAO calculator, we recommend the emission factors in table 42 and table 43. These emission factors follow those published online by the UK Department of Business, Energy and Industrial Strategy conversion factors (*Conversion factors 2022: condensed set (for most users))* and include a distance uplift of 8 per cent and a radiative forcing multiplier of 1.7.

Table 42: Emission factors for international air travel without radiative forcing multiplier

Emission source	Travel class	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Short-haul (<3,700 km)	Average passenger	pkm	0.0811	0.0804	0.00001	0.0007
	Economy class	pkm	0.0798	0.0791	0.00001	0.0007
	Business class	pkm	0.120	0.119	0.00001	0.0010
Long-haul (>3,700 km)	Average passenger	pkm	0.102	0.101	0.00001	0.0009
	Economy class	pkm	0.0781	0.0774	0.00001	0.0006
	Premium economy class	pkm	0.125	0.124	0.00001	0.00104
	Business class	pkm	0.226	0.225	0.00002	0.00189
	First class	pkm	0.312	0.310	0.00002	0.00261

Table 43: Emission factors for international air travel with radiative forcing multiplier

Emission source	Travel class	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Short-haul (<3,700 km)	Average passenger	pkm	0.153	0.153	0.00001	0.0007
	Economy class	pkm	0.151	0.150	0.00001	0.0007
	Business class	pkm	0.226	0.225	0.00001	0.0010
Long-haul (>3,700 km)	Average passenger	pkm	0.193	0.192	0.00001	0.0009
	Economy class	pkm	0.148	0.147	0.00001	0.0006
	Premium economy class	pkm	0.236	0.235	0.00001	0.00104
	Business class	pkm	0.429	0.427	0.00002	0.00189
	First class	pkm	0.591	0.589	0.00002	0.00261

The emission factors from the UK DESNZ 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 to 8.41 in the 2023 UK DESNZ Methodology Paper for Conversion Factors.

7.5.2.1 GHG inventory development

To calculate emissions for international air travel, collect information on passengers flying, their departure and destination airports, flight length, travel class and, if practical, the type of aircraft. Your travel provider may be able to provide this information. Information on flight distance will be required to determine whether the short- or long-haul factors should be used.

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 42 or table 43. 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 42 or table 43.

INTERNATIONAL AIR TRAVEL: EXAMPLE CALCULATION

An entity 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 × 0.1478 = 5,525.36 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	= 5,525.36 + 10,822.7 = 16,348.1 kg CO_2-e

Note: Numbers may not add due to rounding.

7.5.2.2 Emission factor derivation methodology

The 2023 UK DESNZ Methodology Paper for Conversion Factors publication discusses the methodology in more detail, including changes over time.

7.5.2.3 Assumptions, limitations and uncertainties

The emission factors in table 42 and table 43 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 DESNZ 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 DESNZ is based on the analysis of flights arriving and departing from the United Kingdom. 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 figure is comparable to an IPCC publication, *Aviation and the Global Atmosphere* (refer to section 8.2.2.3[34]), which suggests for European flights the average flight distance is about 9 per cent to 10 per cent greater than the actual flight track distance.

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 1990–2022* does not use a multiplier.

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[34] https://archive.ipcc.ch/ipccreports/sres/aviation/121.htm#8223.

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 entities involved in tourism, air transport, agricultural operations, or emergency services.

Table 44: Emission factors for helicopters

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Eurocopter AS 350B Squirrel	Hours	458	455	0.0889	3.37
Eurocopter AS 350B3 Squirrel	Hours	480	471	0.0920	3.48
Robinson R44	Hours	184	184	0.0372	1.41
Robinson R22 Beta	Hours	126	128	0.0258	0.975
Bell 206B	Hours	319	314	0.0613	2.32

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 44.

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 × 455	= 4,550 kg CO_2
CH_4 emissions	= 10 × 0.0889	= 0.89 kg CO_2-e
N_2O emissions	= 10 × 3.37	= 33.7 kg CO_2-e
Total CO_2-e emissions	= 10 × 458	= 4,584.59 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 entity 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 associated with business travel. The emission factors for hotel stays have been updated using factors from the 2023 edition of the Cornell Hotel Sustainability Benchmarking Index (CHSB) Index,[36] which provides data for the 2021 calendar year.

We obtained the emission factors from the M1 tab of the source spreadsheet, using the median values for all hotels. The factors are in CO_2-e and are not available by gas type. For more information on the Cornell methodology, see the Hotel Sustainability Benchmarking Index 2023 guidance document.[37]

Note these emission factors are based on either AR4 or AR5 GWP values, depending on the country. The reason is some countries submit their emission factors to this study in terms of CO_2-e, while other countries break it down into the three main GHG types. In the latter cases, the AR5 GWPs were applied.

The provision of these emission factors can be limited by the availability of data in different countries. If the factor for a certain country is not available in table 45, we recommend using factors from a previous edition of this guidance.

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

36 https://ecommons.cornell.edu/bitstreams/3b5be73e-3c37-40a2-b124-430b8b697086/download.

37 https://ecommons.cornell.edu/bitstreams/220e2386-fac7-4985-8825-a901176b161f/download.

Table 45: Accommodation emission factors by unit (room per night)

Country	Unit	kg CO_2-e/unit
Argentina	Room per night	23.8
Australia	Room per night	43.2
Austria	Room per night	19.3
Bahrain	Room per night	91.2
Belgium	Room per night	29.0
Brazil	Room per night	12.9
Canada	Room per night	12.5
Caribbean Region	Room per night	53.8
Chile	Room per night	41.9
China	Room per night	58.1
Colombia	Room per night	15.8
Costa Rica	Room per night	9.50
Czech Republic	Room per night	46.1
Egypt	Room per night	75.4
Fiji	Room per night	n/a
Finland	Room per night	n/a
France	Room per night	9.68
Germany	Room per night	19.5
Greece	Room per night	56.7
Hong Kong	Room per night	93.8
Hungary	Room per night	36.7
India	Room per night	52.6
Indonesia	Room per night	68.4
Ireland	Room per night	n/a
Israel	Room per night	n/a
Italy	Room per night	20.3
Japan	Room per night	50.1
Jordan	Room per night	67.1
Kazakhstan	Room per night	75.1
Macau	Room per night	98.7
Malaysia	Room per night	70.9
Maldives	Room per night	n/a
Mexico	Room per night	23.1
Morocco	Room per night	n/a
Netherlands	Room per night	27.0
New Zealand	Room per night	11.6
Oman	Room per night	88.1
Panama	Room per night	35.4
Peru	Room per night	15.6
Philippines	Room per night	46.5
Poland	Room per night	49.0
Portugal	Room per night	29.5
Qatar	Room per night	87.7

Country	Unit	kg CO_2-e/unit
Romania	Room per night	n/a
Russian Federation	Room per night	n/a
Saudi Arabia	Room per night	93.1
Singapore	Room per night	24.1
South Africa	Room per night	n/a
South Korea	Room per night	59.1
Spain	Room per night	11.1
Switzerland	Room per night	8.77
Thailand	Room per night	77.9
Turkey	Room per night	40.3
United Arab Emirates	Room per night	62.1
United Kingdom	Room per night	10.5
United States	Room per night	15.1
Vietnam	Room per night	121

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 45.

EXAMPLE CALCULATION

An entity 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 43.2 kg CO_2-e/unit = 518.4 kg CO_2-e

7.7.2 Assumptions, limitations and uncertainties

The Hotel Sustainability Benchmarking Index 2023 guidance document[38] outlines the limitations of the study. These include:

- it is skewed towards upmarket and chain hotels, meaning the data may not be representative of the entire hotel industry, particularly the economy and midscale segments
- the results do not distinguish a property's facilities, except for outsourced laundry services, which are taken into consideration. This means it is difficult to compare two hotels because some may contain distinct attributes (such as restaurants, fitness centres and swimming pools) while others do not
- the data have not been independently verified by a third-party provider.

[38] https://ecommons.cornell.edu/bitstreams/220e2386-fac7-4985-8825-a901176b161f/download.

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 (HGVs). 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 using 2023 source data from KiwiRail.

8.2 Road freight

Entities 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 tkm. Where the entity'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.

The three road freight emission factors provided in tkm are for 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 emission factor for 'all trucks' 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 greatly.

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 KILOMETRES (TKM)

A tkm is the distance travelled multiplied by the weight of freight carried by the Light Commercial Vehicle or Heavy Goods Vehicle.

For example, a Heavy Goods Vehicle carrying 5 tonnes freight over 100 km has a tkm value of 500 tkm.

The carbon 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 emission factors provided in table 55.

8.2.1 Light commercial vehicle emission factors

Table 46: Emission factors for light commercial vehicles manufactured pre-2010

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol	km	0.213	0.204	0.00271	0.00623
	km	0.228	0.219	0.00291	0.00669
	km	0.308	0.295	0.00393	0.00902
	km	0.326	0.312	0.00416	0.00954
	km	0.372	0.357	0.00475	0.0109
Diesel	km	0.222	0.219	0.0003	0.00311
	km	0.214	0.211	0.0003	0.00299
	km	0.285	0.280	0.0004	0.00398
	km	0.305	0.301	0.0005	0.00427
	km	0.309	0.304	0.0005	0.00432
Petrol hybrid	km	0.168	0.161	0.00214	0.00492
	km	0.180	0.173	0.00230	0.00528
	km	0.243	0.233	0.00310	0.00712
	km	0.257	0.247	0.00328	0.00753
	km	0.294	0.282	0.00375	0.00860
Diesel hybrid	km	0.199	0.196	0.0003	0.00278
	km	0.192	0.189	0.0003	0.00268
	km	0.255	0.251	0.0004	0.00357
	km	0.274	0.269	0.0004	0.00382
	km	0.277	0.273	0.0004	0.00387

Table 47: Emission factors for light commercial vehicles manufactured between 2010 and 2015

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol	<1350 cc	km	0.188	0.181	0.00240	0.00552
	1350–<1600 cc	km	0.202	0.194	0.00258	0.00592
	1600–<2000 cc	km	0.273	0.262	0.00348	0.00799
	2000–<3000 cc	km	0.289	0.277	0.00369	0.00846
	≥3000 cc	km	0.330	0.316	0.00421	0.00966
Diesel	<1350 cc	km	0.197	0.194	0.0003	0.00275

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
	1350–<1600 cc	km	0.189	0.187	0.0003	0.00265
	1600–<2000 cc	km	0.252	0.248	0.0004	0.00352
	2000–<3000 cc	km	0.270	0.266	0.0004	0.00378
	≥3000 cc	km	0.274	0.270	0.0004	0.00383
Petrol hybrid	<1350 cc	km	0.149	0.143	0.00190	0.00436
	1350–<1600 cc	km	0.160	0.153	0.00204	0.00468
	1600–<2000 cc	km	0.216	0.207	0.00275	0.00631
	2000–<3000 cc	km	0.228	0.218	0.00291	0.00668
	≥3000 cc	km	0.260	0.249	0.00332	0.00762
Diesel hybrid	<1350 cc	km	0.177	0.174	0.0003	0.00247
	1350–<1600 cc	km	0.170	0.167	0.0003	0.00237
	1600–<2000 cc	km	0.226	0.223	0.0003	0.00316
	2000–<3000 cc	km	0.243	0.239	0.0004	0.00339
	≥3000 cc	km	0.246	0.242	0.0004	0.00343
PHEV (Petrol) – Petrol consumption	<1350 cc	km	0.0779	0.0746	0.0010	0.00228
	1350–<1600 cc	km	0.0836	0.0801	0.00107	0.00245
	1600–<2000 cc	km	0.113	0.108	0.00144	0.00330
	2000–<3000 cc	km	0.119	0.114	0.00152	0.00349
	≥3000 cc	km	0.136	0.131	0.00174	0.00399
PHEV (Petrol) – Electricity consumption	<1350 cc	km	0.00789	0.00760	0.0003	0.000008
	1350–<1600 cc	km	0.00847	0.00816	0.0003	0.000009
	1600–<2000 cc	km	0.00958	0.00923	0.0003	0.000010
	2000–<3000 cc	km	0.0118	0.0114	0.0004	0.00001
	≥3000 cc	km	0.0138	0.0133	0.0005	0.00001
PHEV (Diesel) – Diesel consumption	<1350 cc	km	0.0924	0.0910	0.0001	0.00129
	1350–<1600 cc	km	0.0889	0.0876	0.0001	0.00124
	1600–<2000 cc	km	0.118	0.117	0.0002	0.00165
	2000–<3000 cc	km	0.127	0.125	0.0002	0.00177
	≥3000 cc	km	0.129	0.127	0.0002	0.00180
PHEV (Diesel) – Electricity consumption	<1350 cc	km	0.00800	0.00771	0.0003	0.000008
	1350–<1600 cc	km	0.00769	0.00740	0.0003	0.000008
	1600–<2000 cc	km	0.00842	0.00811	0.0003	0.000009
	2000–<3000 cc	km	0.00953	0.00918	0.0003	0.000010
	≥3000 cc	km	0.0113	0.0109	0.0004	0.00001
Electric vehicle	<1350 cc	km	0.0166	0.0159	0.0006	0.00002
	1350–<1600 cc	km	0.0178	0.0171	0.0006	0.00002
	1600–<2000 cc	km	0.0201	0.0194	0.0007	0.00002
	2000–<3000 cc	km	0.0248	0.0239	0.0009	0.00003
	≥3000 cc	km	0.0289	0.0279	0.00103	0.00003

Table 48: Emission factors for light commercial vehicles manufactured between 2015 and 2020

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol	<1350 cc	km	0.178	0.171	0.00228	0.00522
	1350–<1600 cc	km	0.192	0.184	0.00245	0.00561
	1600–<2000 cc	km	0.259	0.248	0.00330	0.00757
	2000–<3000 cc	km	0.274	0.262	0.00349	0.00801
	≥3000 cc	km	0.312	0.299	0.00399	0.00914
Diesel	<1350 cc	km	0.186	0.184	0.0003	0.00261
	1350–<1600 cc	km	0.179	0.177	0.0003	0.00251
	1600–<2000 cc	km	0.239	0.235	0.0004	0.00334
	2000–<3000 cc	km	0.256	0.252	0.0004	0.00358
	≥3000 cc	km	0.259	0.255	0.0004	0.00362
Petrol hybrid	<1350 cc	km	0.141	0.135	0.00180	0.00412
	1350–<1600 cc	km	0.151	0.145	0.00193	0.00443
	1600–<2000 cc	km	0.204	0.196	0.00260	0.00598
	2000–<3000 cc	km	0.216	0.207	0.00276	0.00632
	≥3000 cc	km	0.247	0.236	0.00315	0.00722
Diesel hybrid	<1350 cc	km	0.168	0.165	0.0002	0.00234
	1350–<1600 cc	km	0.161	0.159	0.0002	0.00226
	1600–<2000 cc	km	0.215	0.212	0.0003	0.00300
	2000–<3000 cc	km	0.230	0.227	0.0003	0.00322
	≥3000 cc	km	0.233	0.230	0.0003	0.00326
PHEV (Petrol) – Petrol consumption	<1350 cc	km	0.0737	0.0706	0.0009	0.00216
	1350–<1600 cc	km	0.0792	0.0759	0.00101	0.00232
	1600–<2000 cc	km	0.107	0.102	0.00136	0.00313
	2000–<3000 cc	km	0.113	0.108	0.00144	0.00331
	≥3000 cc	km	0.129	0.124	0.00165	0.00378
PHEV (Petrol) – Electricity consumption	<1350 cc	km	0.00761	0.00733	0.0003	0.000008
	1350–<1600 cc	km	0.00817	0.00787	0.0003	0.000009
	1600–<2000 cc	km	0.00924	0.00891	0.0003	0.000010
	2000–<3000 cc	km	0.0114	0.0110	0.0004	0.00001
	≥3000 cc	km	0.0133	0.0128	0.0005	0.00001
PHEV (Diesel) – Diesel consumption	<1350 cc	km	0.0878	0.0864	0.0001	0.00123
	1350–<1600 cc	km	0.0845	0.0832	0.0001	0.00118
	1600–<2000 cc	km	0.112	0.111	0.0002	0.00157
	2000–<3000 cc	km	0.121	0.119	0.0002	0.00169
	≥3000 cc	km	0.122	0.120	0.0002	0.00171
PHEV (Diesel) – Electricity consumption	<1350 cc	km	0.00772	0.00744	0.0003	0.000008
	1350–<1600 cc	km	0.00741	0.00714	0.0003	0.000008
	1600–<2000 cc	km	0.00812	0.00783	0.0003	0.000008

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
	2000–<3000 cc	km	0.00919	0.00886	0.0003	0.000010
	≥3000 cc	km	0.0109	0.0105	0.0004	0.00001
Electric vehicle	<1350 cc	km	0.0160	0.0154	0.0006	0.00002
	1350–<1600 cc	km	0.0171	0.0165	0.0006	0.00002
	1600–<2000 cc	km	0.0194	0.0187	0.0007	0.00002
	2000–<3000 cc	km	0.0239	0.0230	0.0009	0.00002
	≥3000 cc	km	0.0279	0.0269	0.0010	0.00003

Table 49: Emission factors for light commercial vehicles manufactured after 2020

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol	<1350 cc	km	0.170	0.163	0.00217	0.00497
	1350–<1600 cc	km	0.182	0.175	0.00233	0.00534
	1600–<2000 cc	km	0.246	0.236	0.00314	0.00720
	2000–<3000 cc	km	0.260	0.249	0.00332	0.00762
	≥3000 cc	km	0.297	0.285	0.00379	0.00870
Diesel	<1350 cc	km	0.178	0.175	0.0003	0.00249
	1350–<1600 cc	km	0.172	0.169	0.0003	0.00240
	1600–<2000 cc	km	0.228	0.225	0.0003	0.00319
	2000–<3000 cc	km	0.245	0.241	0.0004	0.00342
	≥3000 cc	km	0.248	0.244	0.0004	0.00346
Petrol hybrid	<1350 cc	km	0.135	0.129	0.00172	0.00396
	1350–<1600 cc	km	0.145	0.139	0.00185	0.00425
	1600–<2000 cc	km	0.196	0.188	0.00250	0.00573
	2000 - <3000 cc	km	0.207	0.198	0.00264	0.00606
	≥3000 cc	km	0.237	0.227	0.00302	0.00692
Diesel hybrid	<1350 cc	km	0.161	0.159	0.0002	0.00225
	1350–<1600 cc	km	0.155	0.153	0.0002	0.00217
	1600–<2000 cc	km	0.206	0.203	0.0003	0.00288
	2000–<3000 cc	km	0.221	0.218	0.0003	0.00309
	≥3000 cc	km	0.224	0.221	0.0003	0.00313
PHEV (Petrol) – Petrol consumption	<1350 cc	km	0.0707	0.0678	0.0009	0.00207
	1350–<1600 cc	km	0.0759	0.0728	0.0010	0.00222
	1600–<2000 cc	km	0.102	0.0982	0.00131	0.00300
	2000–<3000 cc	km	0.108	0.104	0.00138	0.00317
	≥3000 cc	km	0.124	0.119	0.00158	0.00362
PHEV (Petrol) – Electricity consumption	<1350 cc	km	0.00741	0.00713	0.0003	0.000008
	1350–<1600 cc	km	0.00795	0.00766	0.0003	0.000008
	1600–<2000 cc	km	0.00900	0.00867	0.0003	0.000009
	2000–<3000 cc	km	0.0111	0.0107	0.0004	0.00001
	≥3000 cc	km	0.0130	0.0125	0.0005	0.00001

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
PHEV (Diesel) – Diesel consumption	<1350 cc	km	0.0843	0.0830	0.0001	0.00118
	1350–<1600 cc	km	0.0811	0.0799	0.0001	0.00113
	1600–<2000 cc	km	0.108	0.106	0.0002	0.00151
	2000–<3000 cc	km	0.116	0.114	0.0002	0.00162
	≥3000 cc	km	0.117	0.115	0.0002	0.00164
PHEV (Diesel) – Electricity consumption	<1350 cc	km	0.00751	0.00724	0.0003	0.000008
	1350–<1600 cc	km	0.00721	0.00695	0.0003	0.000008
	1600–<2000 cc	km	0.00791	0.00762	0.0003	0.000008
	2000–<3000 cc	km	0.00895	0.00862	0.0003	0.000009
	≥3000 cc	km	0.0106	0.0102	0.0004	0.00001
Electric vehicle	<1350 cc	km	0.0155	0.0150	0.0006	0.00002
	1350–<1600 cc	km	0.0167	0.0161	0.0006	0.00002
	1600–<2000 cc	km	0.0189	0.0182	0.0007	0.00002
	2000–<3000 cc	km	0.0232	0.0224	0.0008	0.00002
	≥3000 cc	km	0.0272	0.0262	0.0010	0.00003

Table 50: 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/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Petrol	km	0.326	0.312	0.00416	0.00954
Diesel	km	0.305	0.301	0.0005	0.00427
Petrol hybrid	km	0.257	0.247	0.00328	0.00753
Diesel hybrid	km	0.274	0.269	0.0004	0.00382

8.2.2 Heavy goods vehicles emission factors

Table 51 contains the default emission factors for heavy goods vehicles, based on a pre-2010 fleet.

Table 51: Emission factors for heavy goods vehicles manufactured pre-2010

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
HGV diesel	<5,000 kg	km	0.443	0.437	0.0007	0.00620
	5,000–7,500 kg	km	0.508	0.500	0.0008	0.00710
	7,500–10,000 kg	km	0.621	0.612	0.0009	0.00868
	10,000–12,000 kg	km	0.737	0.725	0.00109	0.0103
	12,000–15,000 kg	km	0.837	0.824	0.00124	0.0117
	15,000–20,000 kg	km	0.978	0.962	0.00144	0.0137
	20,000–25,000 kg	km	1.30	1.28	0.00192	0.0182
	25,000–30,000 kg	km	1.53	1.51	0.00226	0.0214
	≥30,000 kg	km	1.53	1.51	0.00226	0.0214

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
HGV diesel hybrid	<5,000 kg	km	0.357	0.352	0.0005	0.00500
	5,000–7,500 kg	km	0.409	0.403	0.0006	0.00572
	7,500–10,000 kg	km	0.501	0.493	0.0007	0.00700
	10,000–12,000 kg	km	0.594	0.584	0.0009	0.00830
	12,000–15,000 kg	km	0.674	0.664	0.0010	0.00943
	15,000–20,000 kg	km	0.889	0.875	0.00131	0.0124
	20,000–25,000 kg	km	1.18	1.16	0.00175	0.0165
	25,000–30,000 kg	km	1.37	1.34	0.00202	0.0191
	≥30,000 kg	km	1.44	1.42	0.00213	0.0201

Table 52 contains the default emission factors for heavy goods vehicles, based on a 2010–2015 fleet.

Table 52: Emission factors for heavy goods vehicles manufactured between 2010 and 2015

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
HGV diesel	<5,000 kg	km	0.421	0.414	0.0006	0.00588
	5,000–7,500 kg	km	0.482	0.475	0.0007	0.00674
	7,500–10,000 kg	km	0.589	0.580	0.0009	0.00824
	10,000–12,000 kg	km	0.696	0.686	0.00103	0.00973
	12,000–15,000 kg	km	0.794	0.782	0.00117	0.0111
	15,000–20,000 kg	km	0.953	0.938	0.00141	0.0133
	20,000–25,000 kg	km	1.27	1.25	0.00187	0.0177
	25,000–30,000 kg	km	1.42	1.39	0.00209	0.0198
	≥30,000 kg	km	1.49	1.47	0.00220	0.0209
HGV diesel hybrid	<5,000 kg	km	0.339	0.333	0.0005	0.00473
	5,000–7,500 kg	km	0.388	0.382	0.0006	0.00543
	7,500–10,000 kg	km	0.474	0.467	0.0007	0.00663
	10,000–12,000 kg	km	0.563	0.554	0.0008	0.00786
	12,000–15,000 kg	km	0.639	0.630	0.0009	0.00894
	15,000–20,000 kg	km	0.866	0.853	0.00128	0.0121
	20,000–25,000 kg	km	1.15	1.14	0.00170	0.0161
	25,000–30,000 kg	km	1.33	1.31	0.00197	0.0186
	≥30,000 kg	km	1.40	1.38	0.00207	0.0196
HGV BEV	<5,000 kg	km	0.0347	0.0334	0.00124	0.00004
	5,000–7,500 kg	km	0.0398	0.0383	0.00142	0.00004
	7,500–10,000 kg	km	0.0486	0.0468	0.00173	0.00005
	10,000–12,000 kg	km	0.0577	0.0556	0.00206	0.00006
	12,000–15,000 kg	km	0.0655	0.0631	0.00234	0.00007

Table 53 contains the default emission factors for heavy goods vehicles, based on a post-2015 fleet.

Table 53: Emission factors for heavy goods vehicles manufactured post-2015

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
HGV diesel	<5,000 kg	km	0.419	0.413	0.0006	0.00586
	5,000–7,500 kg	km	0.475	0.467	0.0007	0.00663
	7,500–10,000 kg	km	0.580	0.572	0.0009	0.00811
	10,000–12,000 kg	km	0.688	0.678	0.00102	0.00962
	12,000–15,000 kg	km	0.782	0.770	0.00116	0.0109
	15,000–20,000 kg	km	0.951	0.936	0.00140	0.0133
	20,000–25,000 kg	km	1.27	1.25	0.00187	0.0177
	25,000–30,000 kg	km	1.41	1.39	0.00209	0.0197
	≥ 0,000 kg	km	1.49	1.47	0.00220	0.0208
HGV diesel hybrid	<5,000 kg	km	0.330	0.325	0.0005	0.00462
	5,000–7,500 kg	km	0.379	0.373	0.0006	0.00529
	7,500–10,000 kg	km	0.463	0.456	0.0007	0.00647
	10,000–12,000 kg	km	0.549	0.540	0.0008	0.00767
	12,000–15,000 kg	km	0.624	0.614	0.0009	0.00872
	15,000–20,000 kg	km	0.864	0.851	0.00128	0.0121
	20,000–25,000 kg	km	1.15	1.13	0.00170	0.0161
	25,000–30,000 kg	km	1.33	1.31	0.00196	0.0186
	≥30,000 kg	km	1.40	1.38	0.00207	0.0196
HGV BEV	<5,000 kg	km	0.0340	0.0327	0.00121	0.00004
	5,000–7,500 kg	km	0.0389	0.0375	0.00139	0.00004
	7,500–10,000 kg	km	0.0476	0.0458	0.00170	0.00005
	10,000–12,000 kg	km	0.0641	0.0617	0.00229	0.00007
	12,000–15,000 kg	km	0.0719	0.0693	0.00256	0.00008

Table 54 contains the default emission factors for heavy goods vehicles, based on a pre-2010 fleet and a gross vehicle mass of <7500 kg.

Table 54: Default emission factors for heavy goods vehicles

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
HGV diesel	km	0.476	0.468	0.0007	0.00665
HGV diesel hybrid	km	0.383	0.377	0.0006	0.00536

Table 55 contains emission factors for freighting goods.

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

Table 55: Emission factors for freighting goods by road

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Long-haul heavy truck	tkm	0.105	0.103	0.0002	0.00147
Urban delivery heavy truck	tkm	0.390	0.384	0.0006	0.00545
All trucks	tkm	0.135	0.133	0.0002	0.00189

8.2.3 GHG inventory development

If an entity uses freight vehicles, they can calculate the emissions from the kilometres travelled. Multiply the distances by the emission factors in table 46 to table 54. 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 table 46 to table 54.

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 55. 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 55.

ROAD FREIGHT: EXAMPLE CALCULATION

During the reporting period, an entity 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 × 0.00189 = 1.89 kg CO_2-e

Total CO_2-e emissions = 10 × 100 × 0.135 = 135.09 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 entity 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 × 0.262 = 209.6 kg CO_2

CH_4 emissions = 800 × 0.00348 = 2.78 kg CO_2-e

N_2O emissions = 800 × 0.00799 = 6.392 kg CO_2-e

Total CO_2-e emissions = 800 × 0.273 = 218.78 kg CO_2-e

Total CO_2-e emission from freighted goods = 135.09 + 218.78 = 353.87 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 entities on-site electricity consumption.

8.2.4 Emission factor derivation methodology

The 2022 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 Table 56 and Table 57. Note the figures in table 57 are unchanged from the previous edition as updated figures were not available.

Table 56: Light commercial vehicles (energy consumption per 100 km)

Emission source		Units	Units of energy consumed per 100 km			
			Pre-2010	2010-2015	2015-2020	Post-2020
Petrol	<1350 cc	Litres	8.97	7.94	7.52	7.16
	1350–<1600 cc	Litres	9.63	8.53	8.08	7.69
	1600–<2000 cc	Litres	12.99	11.51	10.90	10.37
	2000–<3000 cc	Litres	13.74	12.17	11.53	10.97
	≥3000 cc	Litres	15.69	13.90	13.17	12.53
Diesel	<1350 cc	Litres	8.30	7.35	6.96	6.66
	1350–<1600 cc	Litres	7.99	7.08	6.70	6.41
	1600–<2000 cc	Litres	10.63	9.42	8.92	8.53
	2000–<3000 cc	Litres	11.40	10.10	9.56	9.14
	≥3000 cc	Litres	11.54	10.23	9.68	9.26
Petrol hybrid	<1350 cc	Litres	7.08	6.27	5.94	5.70
	1350–<1600 cc	Litres	7.60	6.73	6.38	6.12
	1600–<2000 cc	Litres	10.26	9.09	8.60	8.25
	2000–<3000 cc	Litres	10.85	9.61	9.10	8.73
	≥3000 cc	Litres	12.39	10.98	10.39	9.97
Diesel hybrid	<1350 cc	Litres	7.44	6.60	6.26	6.02
	1350–<1600 cc	Litres	7.16	6.35	6.03	5.79
	1600–<2000 cc	Litres	9.53	8.45	8.02	7.71
	2000–<3000 cc	Litres	10.22	9.06	8.60	8.26
	≥3000 cc	Litres	10.35	9.17	8.71	8.37
Petrol PHEV – Petrol consumption	<1350 cc	Litres	3.70	3.28	3.11	2.98
	1350–<1600 cc	Litres	3.98	3.52	3.34	3.20
	1600–<2000 cc	Litres	5.37	4.76	4.50	4.32
	2000–<3000 cc	Litres	5.68	5.03	4.76	4.57
	≥3000 cc	Litres	6.48	5.74	5.44	5.22
Petrol PHEV – Electricity consumption	<1350 cc	kWh	11.34	10.09	9.73	9.47
	1350–<1600 cc	kWh	12.18	10.83	10.45	10.17
	1600–<2000 cc	kWh	13.77	12.25	11.82	11.50
	2000–<3000 cc	kWh	16.97	15.09	14.56	14.16
	≥3000 cc	kWh	19.83	17.64	17.01	16.56

Emission source		Units	Units of energy consumed per 100 km Pre-2010	2010-2015	2015-2020	Post-2020
Diesel PHEV – Diesel consumption	<1350 cc	Litres	3.89	3.45	3.28	3.15
	1350–<1600 cc	Litres	3.75	3.32	3.15	3.03
	1600–<2000 cc	Litres	4.99	4.42	4.20	4.03
	2000–<3000 cc	Litres	5.35	4.74	4.50	4.32
	≥3000 cc	Litres	5.42	4.80	4.56	4.38
Diesel PHEV – Electricity consumption	<1350 cc	kWh	11.50	10.23	9.87	9.60
	1350–<1600 cc	kWh	11.05	9.83	9.48	9.22
	1600–<2000 cc	kWh	12.10	10.77	10.38	10.11
	2000–<3000 cc	kWh	13.70	12.19	11.75	11.44
	≥3000 cc	kWh	16.20	14.41	13.90	13.53
BEV – Electricity consumption	<1350 cc	kWh	23.79	21.16	20.41	19.86
	1350–<1600 cc	kWh	25.54	22.72	21.91	21.33
	1600–<2000 cc	kWh	28.90	25.71	24.79	24.13
	2000–<3000 cc	kWh	35.59	31.66	30.54	29.72
	≥3000 cc	kWh	41.61	37.01	35.70	34.74

Table 57: 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

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

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

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 Te Manatū Waka Ministry of Transport's *The New Zealand 2022 Vehicle Fleet: Data Spreadsheet*.

- Light commercial vehicles are on average 12.5 years old,[39] which corresponds to a 2010 year of manufacture.
- 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,[40] 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 Te Manatū Waka Ministry of Transport's presentation 'Real-world fuel economy of heavy trucks'.[41]

This source provides emission factors in terms of g CO_2-e/tkm, not for each of the three GHGs (see table 58). Therefore, we calculated emission factors for carbon dioxide, methane and nitrous oxide based on the GHG split ratio of the fuel used, which was diesel (see table 59). This ratio is applied to produce the emission factors provided in table 55.

Table 58: Data used to calculate the road freight (tkm) emission factor

Truck type	Typical g CO_2-e/tkm
Long-haul heavy truck	105
Urban delivery heavy truck	390
All trucks	135

Table 59: Calculating the ratio of gases in diesel

Information	Unit	kg CO_2-e/unit	kg CO_2/unit	CH_4 /unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Diesel emission factors	Litre	2.7	2.66	0.00399	0.0378

39 Te Manatū Waka Ministry of Transport: www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/annual-fleet-statistics.

40 Waka Kotahi New Zealand Transport Agency: www.nzta.govt.nz/vehicles/how-the-motor-vehicle-register-affects-you.

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

Percentage of gas type		–	98.46%	0.15%	1.39%

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 60.

Table 60: Emission factors for rail freight

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Rail freight	tkm	0.0276	0.0272	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 60.

RAIL FREIGHT: EXAMPLE CALCULATION

During the reporting period, an entity 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 × 0.0272 = 130.56 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 × 0.0276 = 132.67 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 61: Information provided by KiwiRail

Calculation component	Unit	Amount in 2023
Freight-only fuel	Litres	37,297,652
Freight volumes (net)	NTKs (000s)	3,626,140
Electricity (net) North Island Main Trunk (NIMT)	kWh	3,589,959

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 Greenhouse gas reporting: Conversion factors 2023*. 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 1.7 used in this guidance is based on current scientific evidence and research, this figure is subject to significant uncertainty.

Emissions from aviation have both direct (CO_2, CH_4 and N_2O) and indirect (non-CO_2 emissions eg, water vapour, contrails, NO_x) 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.

Entities 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 8.40 to 8.45 in the 2023 UK DESNZ Methodology Paper for Conversion Factors.

Table 62: Air freight emission factors without radiative forcing multiplier

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Domestic	tkm	2.76	2.73	0.00393	0.0230
Short haul	tkm	0.985	0.976	0.00008	0.00822
Long haul	tkm	0.649	0.643	0.00006	0.00542

Table 63: Air freight emissions with radiative forcing multiplier

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Domestic	tkm	4.67	4.65	0.00393	0.0230
Short haul	tkm	1.67	1.66	0.00008	0.00822
Long haul	tkm	1.10	1.09	0.00006	0.00542

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 62 or Table 63.

AIR FREIGHT: EXAMPLE CALCULATION

During the reporting period, an entity air freights 0.5 tonnes of materials 10,000 km. This occurs six times in the reporting year. The entity 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 × 1.09	= 32,700 kg CO_2
CH_4 emissions	= 30,000 × 0.00006	= 1.8 kg CO_2-e
N_2O emissions	= 30,000 × 0.00542	= 162.6 kg CO_2-e
Total CO_2-e emissions	= 30,000 × 1.10	= 32,864.4 kg CO_2-e

Note: Numbers may not add due to rounding.

8.4.2 Emission factor derivation methodology

The 2023 UK DESNZ Methodology Paper for Conversion 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 DESNZ 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 2023 UK DESNZ Methodology Paper for Conversion 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 64 based on the findings from the Te Manatū Waka Ministry of Transport presentation 'Real-world fuel economy of heavy trucks',[42] prepared for the 2019 Transport Knowledge Conference. We adopted the international shipping emission factors from the *UK Greenhouse gas reporting: Conversion factors 2023*.

Table 64: Coastal shipping emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Oil products	tkm	0.0160	0.0159	0.00004	0.0001
Other bulk	tkm	0.0300	0.0297	0.00007	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.

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

Table 65: International shipping emission factors

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
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	0.00415	0.00410	0.000001	0.00005
	35,000–59,999 dwt	tkm	0.00577	0.00570	0.000002	0.00007
	10,000–34,999 dwt	tkm	0.00800	0.00790	0.000002	0.00010
	0–9999 dwt	tkm	0.0296	0.0292	0.00001	0.0004
	Average	tkm	0.00353	0.00349	0.000001	0.00004
General cargo	10,000+ dwt	tkm	0.0120	0.0119	0.000004	0.0001
	5000–9999 dwt	tkm	0.0160	0.0158	0.000006	0.0002
	0–4999 dwt	tkm	0.0141	0.0139	0.000004	0.0002
	10,000+ dwt 100+ TEU	tkm	0.0111	0.0110	0.000003	0.0001
	5000–9999 dwt 100+ TEU	tkm	0.0177	0.0175	0.000006	0.0002
	0–4999 dwt 100+ TEU	tkm	0.0200	0.0198	0.000007	0.0002
	Average	tkm	0.0132	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	0.000006	0.0002
	3000–4999 TEU	tkm	0.0168	0.0166	0.000006	0.0002
	2000–2999 TEU	tkm	0.0202	0.0200	0.000007	0.0002
	1000–1999 TEU	tkm	0.0325	0.0321	0.00001	0.0004
	0–999 TEU	tkm	0.0368	0.0363	0.00001	0.0004
	Average	tkm	0.0161	0.0159	0.000006	0.0002
Vehicle transport	4000+ CEU	tkm	0.0324	0.0320	0.00001	0.0004
	0–3999 CEU	tkm	0.0583	0.0576	0.00002	0.0007
	Average	tkm	0.0385	0.0380	0.00001	0.0005
RoRo-Ferry	2000+ LM	tkm	0.0501	0.0495	0.00002	0.0006
	0–1999 LM	tkm	0.0611	0.0603	0.00002	0.0007
	Average	tkm	0.0516	0.0510	0.00002	0.0006
	Large RoPax ferry	tkm	0.376	0.371	0.0001	0.00450
Refrigerated cargo	All dwt	tkm	0.0131	0.0129	0.000004	0.0002

Note: CEU = car equivalent unit; dwt = deadweight tonnes; LM = lanemetre; TEU = twenty-foot equivalent unit.

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 CO_2-e per year

Q = tonnes of freight × km travelled

F = appropriate emission factors from Table 64 or Table 65.

MULTIPLE FREIGHT MODES: EXAMPLE CALCULATION

An entity 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 × 0.0276 = 2.07 kg CO_2-e

Total freight emissions:

2.03 + 6.9 + 2.07 = 11 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 Te Manatū Waka Ministry of Transport presentation 'Real world fuel economy of heavy trucks',[43] prepared for the 2019 Transport Knowledge Conference.

This source provides emission factors in terms of g CO_2-e/tkm, not for each of the three GHGs (see Table 66). Therefore, we calculated emission factors for carbon dioxide, methane and nitrous oxide based on the GHG split ratio of the fuel used, which was heavy fuel oil. This ratio is applied to produce the emission factors provided in Table 64.

Table 66: Coastal shipping data

Mode	Typical g CO_2-e/tkm
Coastal shipping (oil products)	16
Coastal shipping (other bulk)	30
Coastal shipping (container freight)	46

For international shipping, we used the Freight Information Gathering System (FIGS)[44] to identify which types of ships visit New Zealand, and their average sizes. We then adopted the *UK Greenhouse gas reporting: Conversion factors 2023* for the relevant ships and adapted the average emission factors to reflect ship sizes visiting New Zealand.

We identified the following shipping types as visiting New Zealand:

- container ships

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

[44] Freight Information Gathering System: www.transport.govt.nz/statistics-and-insights/freight-and-logistics/.

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

We used MoT's FIGS[45] 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 Greenhouse gas reporting: Conversion factors 2023*. 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 2023 UK DESNZ Methodology Paper for Conversion Factors.

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45 Freight Information Gathering System, overseas ships: www.transport.govt.nz/statistics-and-insights/freight-and-logistics/.

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 1990–2022*.

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, the revision of energy use emission factors, and water and energy consumption data from Water New Zealand.

The emission factor for water supply decreased by 5.5 per cent.

Septic tank emission factors are based on the publication of *Carbon Accounting Guidelines for Wastewater Treatment: CH_4 and N_2O*.[46]

Users seeking emission factors for specific types of wastewater treatment plants are referred to Water New Zealand's guidelines.[47] Weighted average emission factors for wastewater treatment remain in this guide for general use.

9.2 Water supply

Table 67 provides water supply emission factors. We calculated the factors using Water New Zealand data.

Table 67: Water supply emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Water supply emission factors	Cubic metres	0.0349	0.0336	0.00124	0.00004
	Per capita	4.08	3.93	0.145	0.00425

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 67.

[46] Water New Zealand, *Carbon Accounting Guidelines for Wastewater Treatment: CH_4 and N_2O*.

[47] Ibid

WATER SUPPLY: EXAMPLE CALCULATION

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

CO_2 emissions	= 1,000 × 0.0336	= 33.6 kg CO_2
CH_4 emissions	= 1,000 × 0.00124	= 1.24 kg CO_2-e
N_2O emissions	= 1,000 × 0.00004	= 0.04 kg CO_2-e
Total CO_2-e emissions	= 1,000 × 0.0349	= 34.9 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[48] 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 megajoules (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:

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

This equation gives the emissions per m^3 of water supplied, where the following values were used to calculate the emission factors:

- energy use = the gigajoule (GJ) of energy used by the water system that year
- water supply = m^3 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 entities 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 m^3 of water per person per year, which is calculated from the following equations and information:

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48 Water New Zealand 2020/21 National Performance Review: www.waternz.org.nz/Attachment?Action=Download&Attachment_id=5573.

The first equation:

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

The second equation:

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

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

- m^3 of water supplied nationwide is 531,000,000[49]
- population served by wastewater treatment plants is approximately 4.54 million.[50]

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 entities 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.

9.3 Wastewater treatment

We recommend that users refer directly to the Water New Zealand's guidelines[51] 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 Table 68 and Table 69. 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 entities in these sectors should use specific

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49 Water New Zealand report: www.waternz.org.nz/Attachment?Action=Download&Attachment_id=3142.

50 Ministry for the Environment's wastewater treatment plants database.

51 Water New Zealand, *Carbon Accounting Guidelines for Wastewater Treatment: CH_4 and N_2O*.

industrial wastewater factors. All other entities 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 68).

Table 68: Domestic wastewater treatment emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Average for wastewater treatment plants	Cubic metres of water supplied	0.476	0.0578	0.199	0.220
	Per capita	45.6	5.54	19.0	21.1
Septic tanks	Per capita	175.2	n/a	149.9	25.3

Table 69: Industrial wastewater treatment emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
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 and 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	Cubic metres of milk	0.102	n/a	n/a	0.102

9.3.1 GHG inventory development

Domestic water users should collect data on m^3 of water sent to treatment. If metered water data is not available, the per capita emission factor can be applied instead. Industrial entities 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 (m^3) or persons using water facilities (per capita)

F = appropriate emission factors from table 68 and table 69.

WASTEWATER: EXAMPLE CALCULATION

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

The office wastewater is domestic, therefore:

CO_2 emissions	= 100 × 0.0578	= 5.78 kg CO_2
CH_4 emissions	= 100 × 0.199	= 19.9 kg CO_2-e
N_2O emissions	= 100 × 0.220	= 22.0 kg CO_2-e
Total CO_2-e emissions	= 100 × 0.476	= 47.68 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:

= 47.68 + 57.9 = 105.58 kg CO_2-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 1990–2022* 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 National Inventory Report has been updated. The example calculations are done using AR5 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:

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

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)
- $F_{NON\text{-}CON}$ = factor for non-consumed protein added to the wastewater (1.4, IPCC 2006)
- $F_{IND\text{-}COM}$ = factor for industrial and commercial co-discharged protein into the sewer system (1.25, IPCC 2006).

Table 70 details the values used in the equation above.

Table 70: 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,[52] 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 (96 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
- EF = emission factor in kg methane/kg COD
- GWP = global warming potential.

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52 *National Greenhouse Gas Inventory from Wastewater Treatment and Discharge,* prepared for Ministry for the Environment by Beca Infrastructure Ltd, August 2007.

The following tables detail the information used in the calculations to provide the industrial wastewater treatment emission factors.

Table 71: 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)[53]
CH_4 emission factor (kg CH_4/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:

$$mbCOD \times N{:}COD \times EF \times \left(\frac{44}{28}\right) \times GWP = N = nitrous\ oxide\ emission\ factor\ \left(\frac{kg}{tonnes}\right)$$

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.

Table 72 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 72: 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

[53] 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/.

Based on the Cardno report[54] 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 73 details the uncertainties with this source category.

Table 73: 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%

[54] 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

There are no updates in this edition.

10.2 Construction materials

In June 2023, BRANZ published version 3 of its CO_2NSTRUCT dataset.[55] These emissions are indirect (Scope 3) if the entity 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[56] for any interim updates to emission factors.

Other useful sources for construction emission factors include the Waka Kotahi New Zealand Transport Agency's Project Emissions Estimation Tool (PEET),[57] which can be used to estimate GHG emissions in the early stages of a land transport infrastructure project.

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: *Purchased goods and services*. Buildings are classified as Scope 3, Category 2: *Capital goods*, which includes the upstream or cradle-to-gate emissions associated with the production of capital goods, such as construction materials. These can form a large proportion of an entity's GHG inventory.

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55 BRANZ CO_2NSTRUCT: www.branz.co.nz/co2nstruct\.

56 Environmental Product Declaration: epd-australasia.com/.

57 Waka Kotahi New Zealand Transport Agency: www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/environment-and-sustainability-in-our-operations/environmental-technical-areas/climate-change/climate-change-mitigation/project-emissions-estimation-tool-peet.

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).

The units of emissions are kg CO_2-e per kg of material. The anaerobic decomposition of organic waste in landfills generates methane. Entities 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 2022, 96 per cent of municipal waste was disposed to landfills with gas collection.

Table 74: 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 entities 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 1990–2022*. Table 75, Table 76 and table 77 show the factors.

Table 75: Waste disposal to municipal (class 1) landfills with gas recovery

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Waste (known composition)	Waste – Food	kg	0.674	n/a	0.674	n/a
	Waste – Garden	kg	0.552	n/a	0.552	n/a
	Waste – Paper	kg	0.981	n/a	0.981	n/a
	Waste – Wood (combined)	kg	0.380	n/a	0.380	n/a
	Wood (treated)	kg	0.061	n/a	0.061	n/a

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
	Wood (untreated)	kg	0.858	n/a	0.858	n/a
	Waste – Textile	kg	0.490	n/a	0.490	n/a
	Waste – Nappies	kg	0.245	n/a	0.245	n/a
	Waste – Sludge	kg	0.153	n/a	0.153	n/a
	Waste – 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 76: Waste disposal to municipal (class 1) landfills without gas recovery

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Waste (known composition)	Waste – Food	kg	2.107	n/a	2.107	n/a
	Waste – Garden	kg	1.724	n/a	1.724	n/a
	Waste – Paper	kg	3.064	n/a	3.064	n/a
	Waste – Wood (combined)	kg	1.187	n/a	1.187	n/a
	Wood (treated)	kg	0.192	n/a	0.192	n/a
	Wood (untreated)	kg	2.681	n/a	2.681	n/a
	Waste – Textile	kg	1.532	n/a	1.532	n/a
	Waste – Nappies	kg	0.766	n/a	0.766	n/a
	Waste – Sludge	kg	0.479	n/a	0.479	n/a
	Waste – 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	2.081	n/a	2.081	n/a

Table 77: Waste disposal to non-municipal (class 2–5) landfills

Emission source		Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Waste (known composition)	Biological (sludge)	kg	0.196	n/a	0.196	n/a
	Construction and demolition	kg	0.157	n/a	0.157	n/a
	Bulk waste	kg	1.098	n/a	1.098	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	1.333	n/a	1.333	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 78: Biological treatment of waste emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Composting	kg	0.1756	n/a	0.112	0.0636
Anaerobic digestion	Kg	0.0224	n/a	0.022	n/a

10.3.1 GHG inventory development

There are two methodologies that entities 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 the 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 75 to table 77.

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 79 identifies these alongside their proportion of the waste to landfills.

Table 79: 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

Waste category	Description	Estimated composition of waste to municipal landfills	Estimated composition of waste to non-municipal landfills
Wood (combined)	Wood waste, mix of treated and untreated	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[58] has found them to be insignificant.

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 CH_4 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 CH_4/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.

58 www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf.

We used the waste information from the National Inventory Report to develop solid waste emission factors for voluntary reporting.

Table 80: Information on managed solid waste

Category	DOC	DOCf	F	MCF	Conversion	Ox	R
Food	0.157	0.70	0.57	1	4/3	0.1	0.68
Garden	0.161	0.56	0.57	1	4/3	0.1	0.68
Paper	0.32	0.5	0.57	1	4/3	0.1	0.68
Wood (combined)	0.43	0.14	0.57	1	4/3	0.1	0.68
Wood (treated)	0.43	0.02	0.57	1	4/3	0.1	0.68
Wood (untreated)	0.43	0.33	0.57	1	4/3	0.1	0.68
Textiles	0.16	0.5	0.57	1	4/3	0.1	0.68
Nappies	0.08	0.5	0.57	1	4/3	0.1	0.68
Sludge	0.05	0.5	0.57	1	4/3	0.1	0.68
Inert	0	0	0.57	1	4/3	0.1	0.68
Source of information	Eunomia (unpublished)[59]	Eunomia (unpublished) except 0.5 is IPCC default for managed landfills	Eunomia (unpublished)	IPCC default for managed landfills[60]		IPCC default for managed landfills	Eunomia (unpublished)

Note: R only applies for landfills with gas recovery.

Table 81: Information on non-municipal solid waste

	DOC	DOCf	F	MCF	Conversion	Ox	R
Sludge	0.05	0.5	0.5	0.42	4/3	0	0
C & D	0.04	0.5	0.5	0.42	4/3	0	0
Bulk waste	0.28	0.5	0.5	0.42	4/3	0	0
Food	0.15	0.5	0.5	0.42	4/3	0	0
Garden	0.2	0.5	0.5	0.42	4/3	0	0
Industrial	0.15	0.5	0.5	0.42	4/3	0	0
Wood	0.34	0.5	0.5	0.42	4/3	0	0
Source of information	Tonkin & Taylor (unpublished)[61] based on IPCC 2006 vol. 5, table 3.1[62]	IPCC default for unmanaged landfills[63]	IPCC default for unmanaged landfills	Tonkin & Taylor (unpublished)		IPCC default for unmanaged landfills	MfE

59 Eunomia. Unpublished. 2020. Report commissioned by the Ministry for the Environment. *Improvements to Estimates of Greenhouse Gas Emissions from Landfills*.

60 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, volume 5, waste.

61 Tonkin and Taylor Ltd. Unpublished. 2014. Report commissioned by the Ministry for the Environment. *GHG Estimates from Non-municipal Landfills New Zealand.*

62 IPCC 2006, volume 5, table 3.1: www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf.

63 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, volume 5, waste.

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 1990–2022* (see table 79).

The following is the composition used to calculate office waste data.

Table 82: 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 you do not know whether the 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, 96 per cent of waste disposed to municipal (class 1) landfills in 2022 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.

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 83.

Table 83: IPCC default data used to calculate composting and anaerobic digestion

Calculation component	Composting CH_4	Composting 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)	0.112	0.064	0.0224	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. *New Zealand's Greenhouse Gas Inventory 1990–2022* 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 entity has an advanced diversion system (to recycling and composting) then using the 'average waste' category in the methodology will overestimate emissions. If an entity 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 1990–2022*. 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 entity 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 from livestock
  - manure management from livestock
  - agricultural soils from livestock
  - fertiliser and lime use.

Users should disclose in their inventories if they include animals grazing on land not owned by the entity.

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 emission factors as the guidance.

11.1 Overview of changes since previous update

This guide uses data from *New Zealand's Greenhouse Gas Inventory 1990–2022*, which has revised methodologies and emission factors from the previous edition. The changes relevant to the updated emission factors included in this version are summarised as:

- improvements to beef cattle population and liveweight estimates, which had led to an increase in the dairy and non-dairy cattle factors of between 4 per cent to 10 per cent
- improvements to the planted forest emission factors and uncertainty estimates. These come from updated yield tables using data collected up to 2022 and updated area estimates for planted forests. These data are combined to derive the emission factors
- the lime emission factor decreased by 18 per cent, because of the introduction of a correction factor to account for the impurities in agricultural lime.

Please refer to section 5.1.5 (and other relevant sections) of *New Zealand's Greenhouse Gas Inventory 1990–2022* for further details.

11.2 Land use, land-use change and forestry

11.2.1 Overview of the sector

GHG emissions from vegetation and soils due to human activities are reported in the 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 1990–2022*.

The LULUCF sector is responsible for both emitting GHGs (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 1990–2022*.

In line with ISO 14064-1:2018 and the GHG Protocol, entities 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.

> Entities 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 entities 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 84) 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 85).

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 (forests that have been replanted following a harvesting event are beyond their long-term average carbon stock).

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[64] 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 broadly aligns with the approach that New Zealand will take to account for emissions and removals in 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, or do not have data available on harvesting activity.

Deforestation emissions are still accounted in full, as in approach one (table 85). 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.

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[64] Age is defined as the number of years since afforestation.

AFFORESTATION, DEFORESTATION AND HARVESTING

Afforestation occurs when forest is established on previously unforested land.

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 84) 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 85) is based on the average stock at the national level, calculated from the LUCAS national forest inventory.

Table 84: LULUCF forest growth emission factors

Forest growth removal source	Unit	CO_2/unit (kg CO_2-e)	Uncertainty (95% CI)
Planted forests: Approach one – Stock change accounting			
All planted forests	ha	-35,220	±13.3%
Pinus radiata	ha	-36,609	±13.2%
Other softwoods	ha	-29,956	±23.6%
All hardwoods	ha	-18,669	±149.7%
Planted forests: Approach two – Averaging accounting			
All planted forests – First rotation (age 23 years and under)	ha	-35,220	±13.3%
Pinus radiata – First rotation (age 22 years and under)	ha	-36,609	±13.2%
Other Softwoods – First rotation (age 28 years and under)	ha	-29,956	±23.6%
All hardwoods – First rotation (age 13 years and under)	ha	-18,669	±149.7%
All planted forest above the long-term average age	ha	0	n/a
Natural forests			
Post-1989 Regenerating natural forest	ha	-7,973	±44.8
Pre-1990 Regenerating natural forest	ha	-1,566	±119.6
Pre-1990 Tall natural forest	ha	0	n/a

Table 85: LULUCF land-use change emission factors

Land-use change emission source		Unit	CO_2/unit (kg CO_2-e)	Uncertainty (95% CI)
Planted forests: Approach one – Stock change accounting				
All planted forests	Harvest or deforestation	ha	986,156	±21.8%
Pinus radiata	Harvest or deforestation	ha	1,025,053	±21.8%
Other softwoods	Harvest or deforestation	ha	1,198,253	±29.3%
All hardwoods	Harvest or deforestation	ha	280,036	±150.7%

Land-use change emission source		Unit	CO_2/unit (kg CO_2-e)	Uncertainty (95% CI)
Planted forests: Approach two – Averaging accounting				
All planted forests	Harvest	ha	n/a	n/a
	Deforestation	ha	986,156	±21.8%
Pinus radiata	Harvest	ha	n/a	n/a
	Deforestation	ha	1,025,053	±21.8%
Other softwoods	Harvest	ha	n/a	n/a
	Deforestation	ha	1,198,253	±29.3%
All hardwoods	Harvest	ha	n/a	n/a
	Deforestation	ha	280,036	±150.7%
Natural forests				
Post-1989 Regenerating natural forest	Deforestation	ha	141,350	±27.0
Pre-1990 Regenerating natural forest	Deforestation	ha	278,727	±27.2
Pre-1990 Tall natural forest	Deforestation	ha	898,620	±21.0

11.2.3 GHG inventory development

To calculate LULUCF emissions, entities 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:

1. **Pre-1990 Tall natural forest**: Areas, that on 1 January 1990, were and presently comprise of mature indigenous forest.
2. **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.
3. **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 and may also have some exotic species present.

The following information can be used to determine natural forest types:

(a) The LUCAS Land Use Map[65] can provide area by vegetation type (pre-1990 and post-1989 natural forest) at 1990, 2008, 2012, 2016 and 2020. 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.

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65 LUCAS Land Use Map (MfE Data Service).

(b) The New Zealand Land Cover Database (LCDB)[66] 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 0–34 years: post-1989 regenerating natural forest
– age 35–99 years: pre-1990 regenerating natural forest
– age 100 years and over: pre-1990 tall natural forest.

4. **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).

Entities 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 entities
- 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, entities 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 table 84 and table 85.

[66] New Zealand Land Cover Database: https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/.

LAND USE, LAND-USE CHANGE AND FORESTRY: EXAMPLE CALCULATIONS

Example one (using Approach one for planted forest):

An entity 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 entity harvested the planted forest for timber.

3 ha of planted forest (*Pinus radiata)* were harvested, therefore:

CO_2 emissions = 3 × 1,025,053 = 3,075,159 kg CO_2-e

The removals (expressed as a negative) for the regenerating pre-1990 natural forest are:

CO_2 removals = 1 × -1,566 = -1,566 kg CO_2-e

Therefore, total net CO_2-e emissions = 3,075,159 + -1,567 = 3,073,593 kg CO_2-e.

Note: Negative emissions are a carbon sink.

Example two (using Approach two for planted forest):

An entity 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 × -29,956 = -299,563 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 × 1,025,053 = 10,250,530 kg CO_2-e

Therefore, total net CO_2-e emissions = 10,250,530 – 299,563 – 0 = 9,950,966 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:

$$\Delta C = \sum_{ij} [A_{ij} * (C_{\mathrm{I}} - C_L)_{ij}]$$

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:

$$\Delta C = \sum_{i} [A_{ai} * (C_{I}) + A_{b} * 0]$$

Where:

- ΔC = carbon stock change in the pool, kg C yr^{-1}
- i = corresponds to forest type
- 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 1990–2022*. These emission factors represent the most up-to-date forestry data available. ETS look-up tables are another source of emission 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. The age at which the long-term average carbon stock is reached for planted forests (Approach two) are based on Wakelin et al.[67]

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 entity 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. Entities 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 86.

Table 86: Implied emission factors from enteric fermentation

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Enteric fermentation					
Dairy cattle	Per head	2,628	0	2,628	0
Non-dairy cattle	Per head	1,849	0	1,849	0
Sheep	Per head	350	0	350	0

[67] 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 source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Deer	Per head	641	0	641	0
Swine	Per head	29.7	0	29.7	0
Goats	Per head	251	0	251	0
Horses	Per head	504	0	504	0
Alpaca and llama	Per head	224	0	224	0
Mules and asses	Per head	280	0	280	0
Poultry	Per head	0	0	NE	0

11.3.1.1 GHG inventory development

Entities 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 86.

ENTERIC FERMENTATION: EXAMPLE CALCULATION

An entity owns 2,400 sheep and 210 dairy cows on 30 June during the reporting period. They graze on land owned by the entity.

CO_2 emissions	= 0
CH_4 emissions	= (2,400 × 350) + (210 × 2,628) = 1,391,880 kg CO_2-e
N_2O emissions	= 0
Total CO_2-e emissions	= 1,391,880 kg CO_2-e

Note: Numbers may not add due to rounding.

11.3.1.2 Emission factor derivation methodology

New Zealand's Greenhouse Gas Inventory 1990–2022 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 1990–2022*.

To ensure consistency, entities 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 87: Enteric fermentation figures per livestock type

Animal	2022 population	Enteric fermentation emissions (kt CH_4)
Dairy cattle	6,086,282	571.16
Non-dairy cattle	3,895,101	257.25
Sheep	25,333,562	316.63
Deer	792,090	18.14
Swine	243,505	0.26
Goats	88,428	0.79
Horses	33,531	0.60
Alpaca and llama	7,288	0.06
Mules and asses	141	0.001
Poultry	18,018,550	NE

Note: kt = kilotonne.

Source: Based on figures from the Agricultural Inventory Model used in *New Zealand's Greenhouse Gas Inventory 1990–2022*.

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.

11.3.1.3 Assumptions, limitations and uncertainties

New Zealand's Greenhouse Gas Inventory 1990–2022 details the uncertainties associated with the activity data used to calculate the emission factors.

The level of uncertainty with enteric fermentation emissions is ±15.5 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 88.

Table 88: Implied emission factors from manure management

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Manure management					
Dairy cattle	Per head	266	0	253	12.3
Non-dairy cattle	Per head	25.6	0	25.6	0
Sheep	Per head	3.82	0	3.82	0

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Deer	Per head	8.29	0	8.29	0
Swine	Per head	218	0	166	52.0
Goats	Per head	5.60	0	5.60	0
Horses	Per head	65.5	0	65.5	0
Alpaca and llama	Per head	2.84	0	2.84	0
Mules and asses	Per head	30.8	0	30.8	0
Poultry	Per head	1.47	0	0.885	0.583

11.3.2.1 GHG inventory development

Entities 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 88.

MANURE MANAGEMENT: EXAMPLE CALCULATION

An entity owns 2,400 sheep and 210 dairy cows on 30 June during the reporting period.

CO_2 emissions	= 0	
CH_4 emissions	= (2,400 × 3.82) + (210 × 253)	= 62,298 kg CO_2-e
N_2O emissions	= (2,400 × 0.0) + (210 × 12.3)	= 2,583 kg CO_2-e
Total CO_2-e emissions	= 64,881 kg CO_2-e	

Note: Numbers may not add due to rounding.

11.3.2.2 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 1990–2022*. MPI provided the data in table 89.

Table 89: Manure management source data

Animal	2022 population	Methane from manure management (kt CH_4)	Nitrous oxide from manure management (kt N_2O)
Dairy cattle	6,086,282	55.05	0.28
Non-dairy cattle	3,895,101	3.56	0.00
Sheep	25,333,562	3.46	0.00
Deer	792,090	0.23	0.00
Swine	243,505	1.45	0.05
Goats	88,428	0.02	0.00
Horses	33,531	0.08	0.00
Alpaca and llama	7,288	0.00074	0.00

Animal	2022 population	Methane from manure management (kt CH_4)	Nitrous oxide from manure management (kt N_2O)
Mules and asses	141	0.00016	0.00
Poultry	18,018,550	0.57	0.04

Note: kt = kilotonne.

Source: The Agricultural Inventory Model used in *New Zealand's Greenhouse Gas Inventory 1990–2022.*

Table 90 provides the data used in the manure management emission factor calculations box below.

Table 90: Data used to calculate manure management emissions from dairy cattle

Animal	Population	Methane from manure management (kg CH_4)	Nitrous oxide from manure management (kg N_2O)
Dairy cattle	6,086,282	55,046,724	281,811

MANURE MANAGEMENT: EMISSION FACTORS CALCULATIONS FOR LIVESTOCK 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 90) were calculated as follows:

Methane emissions = 55,046,724 ÷ 6,086,282 = 9.044 kg CH_4 per head

Nitrous oxide emissions = 281,811 ÷ 6,086,282 = 0.046 kg N_2O per head

Total kg CO_2 equivalent = (9.044 x 28) + (0.046 x 265) =265.42 kg CO_2-e per head

Note: The final emission factor derived in this example calculation is marginally different to the emission factor in table 88 due to rounding.

11.3.2.3 Assumptions, limitations and uncertainties

New Zealand's Greenhouse Gas Inventory 1990–2022 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,[68] the uncertainty factor for methane emissions is ±20 per cent and for nitrous oxide emissions ±100 per cent,[69] although different uncertainty values are reported in the New Zealand Inventory. *New Zealand's Greenhouse Gas Inventory 1990–2022* details the assumptions and limitations of these data.

11.3.2.4 Alternative methods of calculation

See Alternative methods and tools.

[68] 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.

[69] Ibid.

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 91.

Table 91: Implied emission factors from agricultural soils

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Agricultural soils (livestock)					
Dairy cattle	Per head	414	0	0	414
Non-dairy cattle	Per head	244	0	0	244
Sheep	Per head	29.8	0	0	29.8
Deer	Per head	70.8	0	0	70.8
Swine	Per head	42.2	0	0	42.2
Goats	Per head	61.5	0	0	61.5
Horses	Per head	291	0	0	291
Alpaca and llama	Per head	63.1	0	0	63.1
Mules and asses	Per head	130	0	0	130
Poultry	Per head	1.55	0	0	1.55

11.3.3.1 GHG inventory development

Entities 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 CO_2-e per year

Q = number of animals (per head per type)

F = appropriate emission factors from table 91.

AGRICULTURAL SOILS: EXAMPLE CALCULATION

An entity owns 2,400 sheep and 210 dairy cows on 30 June during the reporting period. They graze on land owned by the entity.

CO_2 emissions = n/a

CH_4 emissions = n/a

N_2O emissions = (2,400 × 29.8) + (210 × 414) = 158,460 kg CO_2-e

Total CO_2-e emissions = 158,460 kg CO_2-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 1990–2022*. These data are in Table 92.

Table 92: Agricultural soils source data

Animal	2022 population	Agricultural soils emissions (kt CH_4)
Dairy cattle	6,086,282	9.506
Non-dairy cattle	3,895,101	3.580
Sheep	25,333,562	2.845
Deer	792,090	0.212
Swine	243,505	0.039
Goats	88,428	0.021
Horses	33,531	0.037
Alpaca and llama	7,288	0.002
Mules and asses	141	0.000
Poultry	18,018,550	0.105

Note: kt = kilotonne.

11.3.3.3 Assumptions, limitations and uncertainties

New Zealand's Greenhouse Gas Inventory 1990–2022 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 ±54.1 per cent for 2022.

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 1990–2022* reports the total emissions from fertiliser using New Zealand-specific emission factors. We used emission factors 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 93 lists the nitrogen fertiliser, limestone and dolomite emission factors. Note for nitrogen fertilisers, the input amounts are expressed in terms of the nitrogen component of fertiliser only. Table 94 lists example products for the different fertiliser types.

Table 93: Nitrogen fertiliser, limestone and dolomite emission factors

Emission source	Unit	kg CO_2-e/unit	CO_2/unit (kg CO_2-e)	CH_4/unit (kg CO_2-e)	N_2O/unit (kg CO_2-e)
Fertiliser use					
Nitrogen content of non-urea nitrogen fertiliser	kg N	4.84	0	0	4.84
Nitrogen content of urea nitrogen fertiliser not coated with urease inhibitor	kg N	4.72	1.59	0	3.13
Nitrogen content of urea nitrogen fertiliser coated with urease inhibitor	kg N	4.54	1.59	0	2.94
Limestone	kg	0.361	0.361	0	0
Dolomite	kg	0.477	0.477	0	0

Table 94: 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

11.4.1.1 GHG inventory development - nitrogen

Entities 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 93.

FERTILISER USE: EXAMPLE CALCULATION

An entity 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 × 4.84) = 242 kg CO_2-e

Total CO_2-e emissions = 280.16 kg CO_2-e

Note: Numbers may not add due to rounding.

Entities 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 93.

LIME USE: EXAMPLE CALCULATION

An entity uses 1,600 kg of lime fertiliser in the reporting year.

CO_2 emissions	= (1,600 x 0.361)	= 577.6 kg CO_2-e
CH_4 emissions	= (1,600 × 0)	= 0 kg CO_2-e
N_2O emissions	= (1,600 × 0)	= 0 kg CO_2-e
Total CO_2-e emissions	= 577.6 kg CO_2-e	

Note: Numbers may not add due to rounding.

11.4.1.2 Emission factor derivation methodology

MPI provided data on the quantified direct and indirect GHG emissions produced per tonne of nitrogen in fertiliser in Table 95. The final emission factor is the sum of adding the three N_2O columns and multiplying this by the global warming potential of N_2O, which is 265. This sum is then added to the value in the CO_2 column on the far right, to produce the final emission factor.

Table 95: Data used to calculate 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	0.01571	0.00157	0.00097	n/a
Urea nitrogen not coated with urease inhibitor	0.00927	0.00157	0.00097	1.594
Urea nitrogen coated with urease inhibitor	0.00927	0.00086	0.00097	1.594

The input parameters used to calculate the limestone and dolomite emission factors are in Table 96, where the final emission factor is the product of multiplying these three inputs.

Table 96: Data used to calculate limestone and dolomite emission factors

Fertiliser type	Concentration factor	Emission factor	Molecular conversion CO_2
Limestone	0.82 or 82%	0.440	3.667
Dolomite	1	0.477	3.667

Note: These numbers are rounded to three decimal places.

It is assumed that the lime applied to soils is 100 per cent pure calcium carbonate. The correction factor in the table 96 accounts for the impurities of the lime, as well as its moisture content. No correction factor is required for dolomite.

Table 97 provides the full list of parameters used to calculate the emission factors for nitrogen fertiliser, lime and dolomite.

Table 97: Parameters for calculating emissions from fertilisers

Parameter	Value	Source
Direct emission factor non-urea-N	0.01	Based on Kelliher and de Klein, 2006[70]
Direct emission urea-N	0.0059	Based on van der Weerden et al, 2016[71]
$Frac_{GASE}$ (UI)	0.055	Saggar, 2013[72]
$Frac_{GASE}$ (non-UI)	0.1	Sherlock et al, 2008[73]
Volatilisation emission factor (EF4)	0.01	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, table 11.3[74]
$Frac_{LEACH}$ (Grassland)	0.08	Welten et al, 2021[75]
$Frac_{LEACH}$ (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
Lime purity (national default)	0.82	Thomson et al (2021)[76]
Dolomite purity (national default)	1	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, chapter 11
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)

[70] Landcare Research and AgResearch. Unpublished. 2006. Report prepared for the Ministry for the Environment. Review of New Zealand's Fertiliser Nitrous Oxide Emission Factor (EF1) Data.

[71] van der Weerden T, Cox N, Luo J, Di HJ, Podolyan A, Phillips RL, Saggar S, de Klein CAM, Ettema P, Rys G. 2016. Refining the New Zealand nitrous oxide emission factor for urea fertiliser and farm dairy effluent. Agriculture Ecosystems & Environment 222: 133–137.

[72] Saggar S, Singh J, Giltrap DL, Zaman M, Luo J, Rollo M, Kim D-G, Rys G, van der Weerden TJ. 2013. Quantification of reductions in ammonia emissions from fertiliser urea and animal urine in grazed pastures with urease inhibitors for agriculture inventory: New Zealand as a case study. Science of the Total Environment 465: 136–146.

[73] Sherlock RR, Jewell P, Clough T. 2008. Review of New Zealand Specific FracGASM and FracGASF Emissions Factors. Report prepared for the Ministry of Agriculture and Forestry by Landcare Research and AgResearch. Wellington: Ministry of Agriculture and Forestry.

[74] IPCC. 2006c. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (eds). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4. Agriculture, Forestry and Other Land Use. IPCC National Greenhouse Gas Inventories Programme. Japan: Institute for Global Environmental Strategies for IPCC.

[75] Welten B, Mercer G, Smith C, Sprosen M, Ledgard S. 2021. Refining estimates of nitrogen leaching for the New Zealand agricultural greenhouse gas inventory. Report prepared for the Ministry for Primary Industries.

[76] Thomson BC, Ward KR, Muir PD. 2021. Purity of agricultural lime and dolomite used in New Zealand. Final report prepared for the Ministry for Primary Industries. Wellington: Ministry for Primary Industries.

11.4.1.3 Assumptions, limitations and uncertainties

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 A2 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.

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/

The gross GHG emission factors for fuels are taken from Annex 4 of *New Zealand's Greenhouse Gas Inventory 1990–2022*.

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	53.99	0.0045	0.00009
Coal – bituminous	Commercial	kg	29.59	89.13	0.0095	0.001425
Coal – sub-bituminous	Commercial	kg	21.64	91.99	0.0095	0.001425
Coal – lignite	Commercial	kg	15.26	93.11	0.0095	0.001425
Diesel	Commercial	litre	38.49	69.17	0.0095	0.00057
LPG	Commercial	kg	50.00	63.27	0.0048	0.000095
Heavy fuel oil	Commercial	litre	40.74	74.54	0.0095	0.00057
Light fuel oil	Commercial	litre	40.45	73.02	0.0095	0.00057
Distributed natural gas	Industry	kWh	n/a	0.19	0.000003	0.0000003
		GJ	n/a	53.61	0.0009	0.00009
Coal – bituminous	Industry	kg	29.59	89.13	0.0095	0.001425
Coal – sub-bituminous	Industry	kg	21.64	91.99	0.0095	0.001425
Coal – lignite	Industry	kg	15.26	93.11	0.0095	0.001425
Diesel	Industry	litre	38.49	69.17	0.0029	0.00057

Emission source	User	Unit	Calorific value (MJ/unit)	t CO_2 / TJ	t CH_4 / TJ	t N_2O / TJ
LPG	Industry	kg	50.00	63.27	0.001	0.000095
Heavy fuel oil	Industry	Litre	40.74	74.54	0.0029	0.00057
Light fuel oil	Industry	Litre	40.45	73.02	0.0029	0.00057
Transport fuels						
Regular petrol	Mobile use	Litre	35.24	65.91	0.031	0.0076
Premium petrol	Mobile use	Litre	35.18	65.98	0.031	0.0076
Diesel	Mobile use	Litre	38.49	69.17	0.0037	0.0037
LPG	Mobile use	Litre	26.54	63.27	0.059	0.00019
Heavy fuel oil	Mobile use	Litre	40.74	74.54	0.0067	0.0019
Light fuel oil	Mobile use	Litre	40.45	73.02	0.0067	0.0019
Jet kerosene / Jet A1	Mobile use	Litre	37.19	65.89	0.0005	0.0019
Jet aviation gasoline	Mobile use	Litre	33.87	76.83	0.0005	0.0019
Biofuels and biomass						
Biodiesel	All uses	Litre	36.42	59.27	0.018	0.0037
Bioethanol	All uses	Litre	23.60	68.04	0.018	0.0076
Wood	Industry	kg	9.63	89.47	0.024	0.0032
Wood – chips	Manufacturing	kg	15.15	89.47	0.024	0.0032
Wood – pellets	Manufacturing	kg	18.99	89.47	0.024	0.0032
Wood – green	Manufacturing	kg	8.89	89.47	0.024	0.0032
Wood – chips	Commercial	kg	15.15	89.47	0.24	0.0032
Wood – pellets	Commercial	kg	18.99	89.47	0.24	0.0032

Note[1]: The total of each gas contribution is expressed in tonnes of gas (not CO_2-e as presented elsewhere in this guidance).

Note[2]: 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[3]: The gross GHG emission factors for fuels are taken from Annex 4 of *New Zealand's Greenhouse Gas Inventory 1990–2022*.

Note[4]: The assumed moisture content for wood chips, pellets and green is 25%, 6% and 56% respectively.

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.

B.1 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.

B.2 Method C – Default annual leakage rate and default refrigerant charge

$$E = (IE + DE + (C \, x \, ALR)) \, x \, GWP$$

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)[77]	Method B	Method C
Small refrigerator or freezer (<150 litres[78])	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

77 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.

78 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)[77]	Method B	Method C
Trucks	1.2	10%	n/a	Acceptable	Screening method only
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

Refrigerant type (trade name)	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	PFC-218	Other*	Total GWP
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.

B.3 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 2022. Users should use emission factors *without* gas capture if the landfill is not listed in the table.

Table C1: Active landfills with landfill gas recovery

Name	Operator
AB Lime Ltd (Winton)	AB Lime Ltd
Bonny Glenn (Rangitikei District)	Midwest Disposal Ltd
Green Island Landfill	Dunedin City Council
Hampton Downs Landfill	EnviroWaste Services Ltd
Kate Valley (Amberley)	Canterbury Waste Services Ltd
Marlborough Regional Council (Bluegums)	Marlborough District Council
Omarunui Landfill	Hastings District Council
Redruth Landfill	Timaru District Council
Redvale Landfill	Transpacific waste management
Silverstream Landfill	Hutt City Council
Southern Landfill	Wellington City Council
Spicer Landfill	Porirua City Council
Tirohia Landfill (Paeroa)	HG Leach & Co. Ltd
Victoria Flats Landfill (Queenstown/ Cromwell)	Scope Resources Ltd
Whangarei Resort	Northland Regional Landfill Ltd. Partnership
Whitford Landfill – Waste Disposal Services	Transpacific waste management
York Valley Landfill	Nelson City Council

Source: Ministry for the Environment

We invite users to contribute to the improvement of table C1 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

In 2023, 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 entity'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.

Entities 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 entities' 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 emission 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
ANZSIC	Australian and New Zealand Standard Industrial Classification
Base year	The first year in the reporting series
BEV	Battery electric vehicle
BfCC	Building for Climate Change
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
CAA	Civil Aviation Authority
Carbon sink	A natural or artificial process that removes carbon from the atmosphere
CEU	Car equivalent unit
CFCs	Chlorofluorocarbons
CH_4	Methane
CNGP	Carbon Neutral Government Programme
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 entity's total inventory for an individual emissions source. The threshold is defined by the entity
Deforestation	The clearing of forest land that is then converted to a non-forest land use
DESNZ	Department for Energy Security and Net Zero
dwt	Deadweight tonnes
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
FIGS	Freight Information Gathering System
FOCA	Federal Office of Civil Aviation
Forest land	Land containing tree species that will reach a height of at least 5 metres, 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 entity's greenhouse gas sources, sinks, emissions and removals
GHG Protocol	The *Greenhouse Gas Protocol Accounting and Reporting Standard* provides guidance for entities preparing a GHG inventory
GHG report	A standalone report to communicate an entity'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
HGV	Heavy goods vehicles
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)
LCDB	Land Cover Database
LFGR	Landfill gas recovery
LM	Lanemetre
LPG	Liquefied petroleum gas
LUCAS	Land Use and Carbon Analysis System
LULUCF	Land use, land-use change and forestry
Materiality	To be considered as having significance to an entity

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
MCF	Methane correction factor
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_2O	Nitrous oxide
NTK	Net tonne km
NZ ETS	New Zealand Emissions Trading Scheme
NZCS	New Zealand Climate Standards
NZTA	Waka Kotahi New Zealand Transport Agency
ODS	Ozone depleting substances
Organisational boundary	The boundary of the entity/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 entity's/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
RUC	Road user charge
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

TEU	Twenty-foot equivalent unit
TFCD	Task Force on Climate-related Financial Disclosures
tkm	Tonne-kilometre (unit of measure for freight)
UNFCCC	United Nations Framework Convention on Climate Change
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 account for the combined 'real-world' effects on fuel consumption (such as non-direct flight paths)