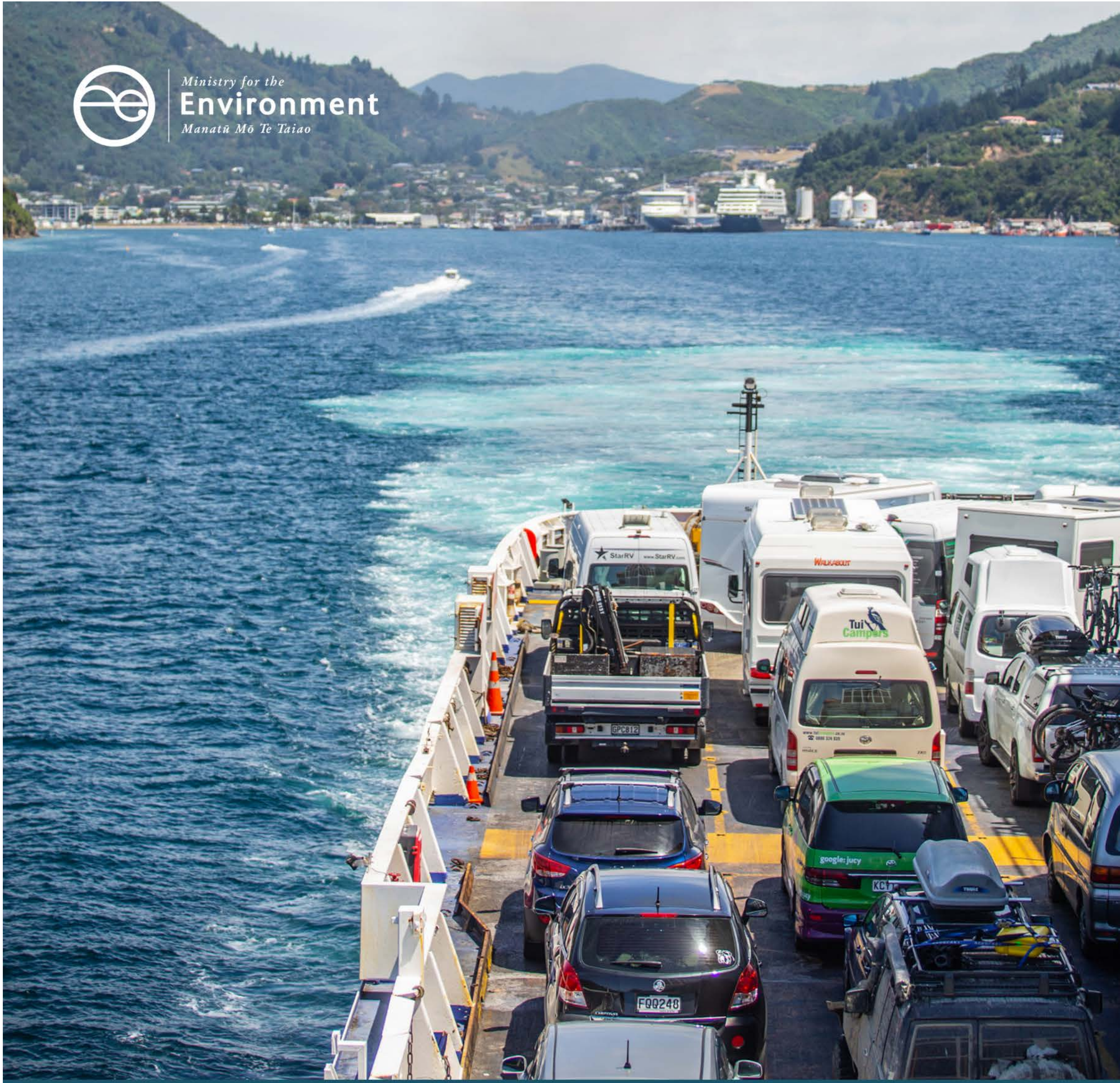

Ministry for the Environment
Manatū Mō Te Taiao

Measuring Emissions: A Guide for Organisations

2019 DETAILED GUIDE

New Zealand Government

Acknowledgements

Prepared for the Ministry for the Environment by Enviro-Mark Solutions Ltd.

The Ministry for the Environment thanks the following government agencies for their contribution to the production of *Measuring Emissions: A Guide for Organisations*.

Energy Efficiency and Conservation Authority, Ministry of Business, Innovation and Employment, Ministry for Primary Industries, Ministry of Transport.

This document may be cited as: Ministry for the Environment. 2019. *Measuring Emissions: A Guide for Organisations. 2019 Detailed Guide*. Wellington: Ministry for the Environment.

Published in May 2019 by the
Ministry for the Environment
Manatū Mō Te Taiao
PO Box 10362, Wellington 6143, New Zealand

ISBN: 978-1-98-857919-1 (online)

Publication number: ME 1414

This document is available on the Ministry for the Environment website: *www.mfe.govt.nz.*

Ministry for the Environment
Manatū Mō Te Taiao

Making Aotearoa New Zealand the most liveable place in the world

Contents

Tables

Figures

Overview of changes since the previous update

This is the tenth version of the publication previously titled *Guidance for Voluntary Greenhouse Gas Reporting*.

There have been several major updates since the ninth edition of the guidance in 2016.

- This document has a new title: *Measuring Emissions: A Guide for Organisations*.
- Two documents supplement the emission factors:
  - The Quick Guide explains how to apply the emission factors in a greenhouse gas (GHG) inventory for your organisation. This is suitable for most users.
  - The Detailed Guide contains the data sources, methods and calculations that underpin the emission factors for those who require this information.
- We have provided an example GHG report and workbook to show what they might look like. We use a fictional organisation's data to show how to apply emission factors.
- The workbook includes clearer formatting and instructions for use.
- "Operational boundaries" has been renamed "reporting boundaries" to align with *ISO 14064-1:2018*.
- There are several new categories:
  - freight transport, including domestic rail, road and shipping freight, and international air and shipping freight
  - water supply and wastewater treatment, including water supply, domestic wastewater treatment, septic tanks and industrial wastewater treatment
  - agriculture, forestry and other land use, including land use, land-use change and forestry (LULUCF), enteric fermentation, manure management, agricultural soils and fertiliser use.
- Some categories have been updated:
  - purchased energy: replaces purchased electricity to also include guidance on heat and steam and geothermal emissions
  - business travel: includes passenger vehicles, public transport and air travel, as well as electric vehicles, plug-in hybrid and hybrid vehicles
  - materials and waste: replaces waste and now includes construction materials and compost
  - fuel: includes biofuels and aviation fuels
  - travel: includes transport by distance and taxis/rental cars, as well as air travel. Domestic emission factors have been generated for jet, medium and small aircraft
  - refrigerant use: includes the global warming potential of an extended list of refrigerants used in New Zealand.

This guide has been prepared in accordance with *ISO 14064-1:2018* and the *GHG Protocol Corporate Accounting and Reporting Standard*.

1. Introduction

1.1. Purpose of this guide

The Ministry for the Environment supports organisations acting on climate change. We recognise there is strong interest from organisations across New Zealand to measure, report and reduce their emissions. We prepared this guide to help you measure and report your organisation's greenhouse gas (GHG) emissions. Measuring and reporting empowers organisations to manage and reduce emissions more effectively over time.

The guide aligns with and endorses the use of the *GHG Protocol Corporate Accounting and Reporting Standard* (referred to as the *GHG Protocol* throughout the rest of the document) and *ISO 14064-1:2018* (see section 1.5). It provides information about preparing a GHG inventory (section 2), emission factors (see sections 3–10, and the *Emission Factors Workbook*) and methods to apply them to activity data.

We update the guide in line with international best practice and the New Zealand Government's *Greenhouse Gas Inventory* to provide new emission factors.

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.

Figure 1: Documents in *Measuring Emissions: A Guide for Organisations*

Measuring Emissions: A Guide for Organisations	
Quick Guide	The go-to document explaining changes since the last update, how to produce an inventory and what data you need to work out emissions from your activities
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

Feedback

We welcome your feedback on this update. Please email emissions-guide@mfe.govt.nz with the subject line 'Measuring Emissions: A Guide for Organisations'.

1.2. Important notes

The information in this guide is intended to help organisations that want to report their greenhouse gas emissions on a voluntary basis. This guide does not represent, or form part of, any mandatory reporting framework or scheme.

The emission factors and methods contained in this guide are for sources common to many New Zealand organisations.

This guide, and the emission factors and methods, are not appropriate for a full life-cycle assessment or product carbon footprinting. These factors only include direct emissions from activities, and do not include all sources of emissions required for a full life-cycle analysis. If you want to do a full life-cycle assessment, we recommend using *UK BEIS emission factors*, which account for the life-cycle of those activities for a number of emission sources, including well-to-tank for some categories. The GHG Protocol has also published standards for the calculation of life-cycle emissions.[1]

This information 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.

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

If emission factors relevant to your organisation are not included in Measuring Emissions: A Guide for Organisations, we suggest using alternatives such as those published by the UK government: *http://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018*

1.3. Gases included in the guide

This guide covers the following greenhouse gases (GHGs): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).[2]

GHGs can trap differing amounts of heat in the atmosphere, meaning they have different relative impacts on climate change. These are known as global warming potentials (GWPs).[3] To

---

1 GHG Protocol Product Standard accessed via: *https://ghgprotocol.org/product-standard*

2 The *GHG Protocol* added NF_3 in 2013 as a requirement and *ISO 14064-1* included NF_3 in 2018. This is consistent with the national inventory.

3 We use the 2007 IPCC GWPs to ensure consistency with the national inventory. These can be found in the *IPCC Annual Report 4 Climate Change 2007: The physical science basis* accessed via: *www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf*

enable a meaningful comparison between the seven gases, GHG emissions are commonly expressed as carbon dioxide equivalent or CO_2-e. This is used throughout the guide.

To do this, we multiply the emissions for each gas by the GWP in a 100-year period – see table 1. The IPCC provides more information on how these factors are calculated.[4]

Throughout the guide, kilograms (kg) of methane and nitrous oxide are reported in kg CO_2-e by multiplying the actual methane emissions by the global warming potential of 25 and actual nitrous oxide emissions by the global warming potential of 298, as per table 1.

Table 1: Global warming potential (GWP) of greenhouse gases based on 100-year period

Greenhouse Gases	Scientific Formula	GWP
Nitrous Oxide	N_2O	298
Methane	CH_4	25
Carbon Dioxide	CO_2	1

1.3.1. Kyoto and Montreal protocols and Paris Agreement

The Kyoto Protocol,[5] agreed in 1997, is linked to the United Nations Framework Convention on Climate Change (UNFCCC). It commits developed country parties to reducing GHG emissions and covers seven gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride.

The Montreal Protocol,[6] agreed 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), chlorocarbons, bromocarbons and halons. New Zealand prohibits imports of CFCs and HFCs as part of our implementation of the protocol.

The Montreal Protocol added HFCs in 2016. The Montreal Protocol requires phasing out of HFCs and therefore has a significant role in mitigating climate change.

The 2016 Paris Agreement commits parties to put forward their best efforts to limit global temperature rise through nationally determined contributions (NDCs), and to strengthen these efforts over time. Currently, New Zealand's Paris Agreement commitments apply to the same gases and use the same GWPs.

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, should be reported separately.

4 IPCC Annual Report 4 Climate Change 2007: The physical science basis accessed via: *www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf*

5 UNFCCC, What is the Kyoto Protocol accessed via: *https://unfccc.int/process-and-meetings/the-kyoto-protocol/what-is-the-kyoto-protocol/what-is-the-kyoto-protocol*

6 UNDP, Montreal Protocol, accessed via: *www.undp.org/content/undp/en/home/sustainable-development/environment-and-natural-capital/montreal-protocol.html*

1.4. Uncertainties

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

- Disclose the data on the quantified uncertainty 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* and the *GHG Protocol Corporate Accounting and Reporting Standard*. We wrote this guide to align with both.

- *ISO 14064-1:2018*[7] is shorter and more direct than the *GHG Protocol*. A PDF copy costs 158 Swiss francs.
- The *GHG Protocol*[8] gives more description and context around what to do to produce an inventory. It is free to download.

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

- principles underlying monitoring and reporting
- setting organisational boundaries
- setting reporting boundaries
- establishing a base year
- managing the quality of a GHG inventory
- content of a GHG report.

1.5.1. How emission sources are categorised

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

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

---

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

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

ISO 14064-1:2018 categorises emissions as direct or indirect sources. This is to manage double counting of emissions (such as between an electricity generator's direct emissions associated with generation and the indirect emissions linked to the user of that electricity).

The guide combines these in the form of direct (Scope 1), indirect (Scope 2) or indirect (Scope 3) emissions, as summarised in table 2.

Table 2: Emissions by scope and source category

Scope	Direct/indirect emissions	Source category	New for this guide?
Scope 1	Direct GHG emissions and removals	Fuel	
		Refrigerant use	
		Agriculture, forestry and other land uses	Yes
Scope 2	Indirect GHG emissions from imported energy	Purchased energy	
Scope 3	Indirect GHG emissions from transportation	Business travel	Yes
		Freight transport	Yes
		Refrigerant use (from chilled transport or air conditioner)	
	Indirect GHG emissions from products an organisation uses	Transmission and distribution losses	
		Water supply and wastewater treatment	Yes
		Materials and waste	

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

Currently for direct emissions, *ISO 14064-1:2018* requires that organisations report emissions by GHG as well as in carbon dioxide equivalents (CO_2-e). Example calculations in this guide do so. See the Example GHG Report and Example GHG Inventory for further examples.

2. How to quantify and report GHG emissions

To quantify and report GHG emissions, organisations need data about their activities (eg, 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 Summary* and the *Emission Factors Workbook*.

CALCULATION METHODOLOGY

E = Q × 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.

To view example calculations, see the *Example GHG Report* and *Example GHG Inventory*.

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

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

Organisations that wish to be 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.

Organisations may opt to verify the GHG inventory or report against the measurement standards (see section 2.4). While verification is optional, this can give confidence that the inventory is accurate and complete, so that organisations can effectively manage and reduce their emissions.

2.1. Step-by-step inventory preparation

To prepare an inventory:

1. Select the boundaries (organisational and reporting[9]) and measurement period (ie, calendar or financial year) you will report against for your organisation.
2. Collect activity data on each emission source within the boundaries for that period.
3. Multiply the quantity used by the appropriate emission factor in a spreadsheet. See *Example GHG Inventory*.
4. Produce a GHG report, if applicable. See section 2.3 and *Example GHG Report*.

If this is the first year your organisation has produced an inventory, you can use it as a base year for measuring the change in emissions over time (as long as the scope and boundaries represent your usual operations, and that comparable reporting is used in future years).

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

2.2. Using the emission factors

Emission factors rely on historical data. This 2019 guide is based on *New Zealand's Greenhouse Gas Inventory 1990-2016* as this was the latest complete set of data available.

If you use the *Interactive Workbook*, input your activity data and the emission factors will be applied automatically. If you do not use the Interactive Workbook, simplified example calculations are provided throughout chapter 4 to demonstrate how to use the emission factors.[11]

Organisations can choose to report on a calendar- or financial-year basis. The chosen period determines which historical factors to use.

---

9 See Glossary for definitions.

10 See Glossary for definition.

11 Note that the emission factors in the example calculations within this document, the Emission Factors Summary and the Emission Factors Workbook are rounded. In the Interactive Workbook they are not. For this reason, you may notice small discrepancies between the answers in the example calculations and the answers provided in the Interactive Workbook.

Calendar year: If you are reporting on a calendar-year basis, use the latest published emission factors. For example, if you are reporting emissions for the 2018 calendar year, use this 2019 guide, which relies on 2016 data.

> We published the previous guide in 2016, and there is a gap for the reporting period in 2017 and 2018. If you want to account for your 2017 or 2018 inventory, use this version (2019, the tenth iteration) as the next most appropriate and accurate source of emission factors.

Financial year: If you are reporting on a financial-year basis, use the guide that the greatest portion of your data falls within. For example, if you are reporting for the 2018/2019 financial year, use this 2019 guide. For a July to June reporting year, apply the more recent set of factors.

The emission factors in this guide are:

- default factors, used in the absence of better company- 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 1990-2016*. This also means we use the 2007 IPCC GWPs to ensure consistency.

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, therefore this guide presents emission factors in kg CO_2-e per unit. Dividing by 1000 converts kg to tonnes (see example calculations on the following pages).

In line with the reporting requirements of *ISO 14064-1:2018*, 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 however a fuel is combusted.

Non-carbon dioxide emissions (ie, methane and nitrous oxide) and emission factors depend on the way the fuel is combusted.[12] To reflect this variability, the guide provides uncertainty estimates for direct (Scope 1) emission factors. Table 4 presents separate carbon dioxide equivalent emission factors for residential, commercial and industrial users. It follows the IPCC guidelines for combustion and adopts the uncertainties.[13]

We mainly derived these emission factors 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.

---

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

[13] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 2, Chapter 2.

2.3. Producing a GHG report

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

A GHG REPORT

To compile a full GHG report, organisations should include:

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

View an example reporting template on the *GHG Protocol Corporate Standard webpage*. See also the *Example GHG Report*.

2.4. Verification

Verification[14] gives confidence about the GHG inventory and report. If you intend to publicly release the inventory, we recommend it is independently verified to confirm calculations are accurate, the inventory is complete and you have followed the correct methodology.

2.4.1. Who should verify my inventory?

If you opt for verification, we recommend using verifiers who:

- are independent
- are members of a suitable professional organisation
- have experience with emissions inventories

[14] See Glossary for definition.

- understand *ISO 14064* and the *GHG Protocol*
- have effective internal peer review and quality control processes.

To help organisations assess a verifier's qualifications, users may choose to use an accredited body. For example, accreditation under the *ISO 14065* standard confirms that verifiers are suitably qualified and enables them to certify an inventory as being prepared in accordance with *ISO 14064-1:2018*.

In New Zealand, the Joint Accreditation System of Australia and New Zealand (JAS-ANZ) issues accreditations and publishes a list of accredited bodies on its website.[15]

[15] View accredited bodies on the JAS-ANZ Register at www.jas-anz.org/accredited-bodies/all

3. Fuel emission factors

Fuel can be categorised as 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 carbon dioxide, methane and nitrous oxide calculations.

3.1. Overview of changes since previous update

We added four new emission sources to the fuel category – see table 3. We moved wood, along with biofuels, to a new category, Biofuels and biomass.

Emission factors for transmission and distribution losses for reticulated natural gas are now included in this section. Previously these were included in the Scope 3: Other indirect emissions chapter.

Table 3: Additional emission sources to the fuel category

Emission source		Unit
Biofuels	Biodiesel	litre
	Bioethanol	litre
Jet kerosene / Jet A1		litre
Aviation gasoline		litre

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 from sources owned or controlled by the reporting organisation. If the organisation does not own or control the assets where combustion takes place, then these emissions are indirect (Scope 3) emissions. For more information see section 1.5.1.

Table 4 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 the *national inventory*.

Table 4: Emission factors for the stationary combustion of fuels

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit	Uncertainties kg CO_2-e/unit
Residential use						
Coal – default	kg	1.88	1.74	0.134	0.00800	4.9%
Coal – bituminous	kg	2.86	2.64	0.211	0.0126	4.8%
Coal – sub-bituminous	kg	2.15	1.99	0.154	0.00919	4.8%
Coal – lignite	kg	1.54	1.42	0.109	0.00648	4.8%
Commercial use						
Coal – default	kg	1.77	1.76	0.00452	0.00808	3.5%
Coal – bituminous	kg	2.66	2.64	0.00703	0.0126	3.5%
Coal – sub-bituminous	kg	2.01	1.99	0.00514	0.0092	3.5%
Coal – lignite	kg	1.43	1.42	0.00362	0.0065	3.5%
Diesel	litre	2.66	2.65	0.00907	0.0065	0.5%
LPG	kg	3.03	3.02	0.00594	0.0014	0.5%
Heavy fuel oil	litre	3.03	3.01	0.00971	0.0069	0.5%
Light fuel oil	litre	2.93	2.92	0.00958	0.00685	0.5%
Natural gas	kWh	0.195	0.194	0.000405	0.0000966	2.4%
	GJ	54.1	54.0	0.113	0.0268	2.4%
Industrial use						
Coal – default	kg	2.05	2.03	0.00529	0.00946	3.5%
Coal – bituminous	kg	2.66	2.64	0.00703	0.0126	3.5%
Coal – sub-bituminous	kg	2.01	1.99	0.00514	0.00919	3.5%
Coal – lignite	kg	1.43	1.42	0.00362	0.00648	3.5%
Diesel	litre	2.66	2.65	0.00272	0.00649	0.5%
LPG	kg	3.02	3.02	0.00119	0.00142	0.5%
Heavy fuel oil	litre	3.02	3.01	0.00291	0.00695	0.5%
Light fuel oil	litre	2.92	2.92	0.00287	0.00685	0.5%
Natural gas	kWh	0.194	0.194	0.0000810	0.0000966	2.4%
	GJ	54.0	54.0	0.0225	0.0268	2.4%

Notes

- These numbers are rounded to three significant figures.
- The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.
- Commercial and industrial classifications are based on standard classification.[16]
- Use the default coal emission factor if it is not possible to identify the type of coal.
- Convert LPG-use data in litres to kilograms by multiplying by the specific gravity of 0.536 kg/litre.

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

The New Zealand Emissions Trading Scheme (NZ ETS) requires participants to use emission factors provided in the emissions trading regulations covering their sector. Or, in some cases, participants may apply for Unique Emission Factors. Emission factors used in the NZ ETS may differ from those in this guide. For example, this guide gives emission factors for coal in terms of kilograms of coal used, because this is the most accessible information for most coal users. The NZ ETS measures coal in terms of its energy content, and participants carry out analysis to ensure they know the heating value of the coal they use.

3.2.1. GHG inventory development

To calculate stationary combustion fuel emissions, collect data on the quantity of fuel used in the unit expressed. Applying the equation in section 2, this means:

Q = quantity of fuel used (unit)
F = appropriate emission factors from table 4.

All organisations across sectors typically report emissions using data on the amount of fuel used during the reporting period.

STATIONARY COMBUSTION: EXAMPLE CALCULATION

An organisation uses 1400 kg of LPG to heat an office building in the reporting year.

CO_2 emissions	= 1,400 × 3.02	= 4,228 kg CO_2
CH_4 emissions	= 1,400 × 0.00594	= 8.32 kg CO_2-e
N_2O emissions	= 1,400 × 0.00142	= 1.99 kg CO_2-e
Total CO_2-e emissions	= 1,400 × 3.03	= 4,242 kg CO_2-e

Note: Numbers may not add due to rounding.

3.2.2. Emission factor derivation methodology

MBIE derived the kg CO_2-e per activity unit emission factors supplied in table 4 using calorific values[17] and emission factors for tonnes (t) of gas per terajoule (TJ). The calorific values are in appendix A alongside further information on the methodology.

The equation used is:

$$\frac{Calorific\ value\ of\ fuel\ \left(\frac{MJ}{kg}\right) \times emission\ factor\ \left(\frac{t\ gas}{TJ}\right)}{1000} = emission\ factor\ kg\ gas/kg\ fuel$$

* t is tonnes

** MJ is megajoules (10^6 J); TJ is terajoules (10^{12} J)

3.2.3. Assumptions, limitations and uncertainties

MBIE derived the kg CO_2-e per activity unit emission factors supplied in table 4 using calorific values, listed in appendix A.

For a breakdown of the uncertainty by gas type see the *Emission Factors Workbook*.

[17] See appendix A for more information

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 factor 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 5 lists the emission factors.

Table 5: Transport fuel emission factors

Fuel type	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit	Uncertainties kg CO_2-e/unit
Regular petrol	litre	2.45	2.35	0.0276	0.0797	1.8%
Premium petrol	litre	2.45	2.34	0.0277	0.0801	1.8%
Petrol – default*	litre	2.45	2.34	0.0276	0.0798	1.8%
Diesel	litre	2.69	2.65	0.00354	0.0422	0.9%
LPG	litre	1.64	1.60	0.0391	0.00150	1.3%
Heavy fuel oil	litre	3.04	3.01	0.00680	0.0232	0.6%
Light fuel oil	litre	2.94	2.92	0.00670	0.0228	0.6%
Aviation fuel (kerosene) / Jet A1	GJ	70.6	68.2	0.480	1.90	0.1%
	litre	2.63	2.54	0.0179	0.0707	0.1%
Aviation gasoline	GJ	68.3	65.9	0.480	1.90	0.1%
	litre	2.31	2.23	0.0163	0.0643	0.1%

Note: These numbers are rounded to three significant figures. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

3.3.1. GHG inventory development

To calculate transport fuel emissions, collect data on the quantity of fuel used in the unit expressed. Applying the equation in section 2, this means:

Q = quantity of fuel used (unit)
F = appropriate emission factors from table 5

All organisations across sectors typically report emissions using data on the amount of fuel used during the reporting period. Quantified units of fuel weight or volume (commonly in litres) are preferable. If this information is unavailable see section 3.3.2: When no fuel data are available.

TRANSPORT FUEL: EXAMPLE CALCULATION

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

CO_2 emissions	= 40,000 × 2.35	= 94,000 kg CO_2
CH_4 emissions	= 40,000 × 0.0276	= 1,103 kg CO_2-e
N_2O emissions	= 40,000 × 0.0797	= 3,186 kg CO_2-e
Total CO_2-e emissions	= 40,000 × 2.45	= 98,000 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 6 on 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 can currently only be applied to taxis. See section 6.2.

3.3.3. Emission factor derivation methodology

We applied the same methodology to the transport fuels that we used to calculate the stationary combustion fuels, using the raw data in table 5.

3.3.4. Assumptions, limitations and uncertainties

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

The default petrol factor is a weighted average of regular and premium petrol based on 2016 sales volume data from *Energy in New Zealand 2016* (MBIE, 2016). Use this default factor when petrol-use data do not distinguish between regular and premium petrol.

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 category is a new addition to this guide. It provides emission factors for bioethanol and biodiesel and wood emission sources, previously listed in stationary combustion.

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, the combustion of biofuels generates anthropogenic methane and nitrous oxide. Organisations should calculate and report these gases, as required by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories.*[18]

Table 6 details the emission conversion factors for the GHG emissions from the combustion of biofuels.

Table 6: Biofuels and biomass emission factors

Biofuel type	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit	Uncertainties kg CO_2-e/unit
Bioethanol	GJ	3.42	64.2	2.85	0.570	0.1%
	litre	0.0000807	1.52	0.0000673	0.0000135	0.1%
Biodiesel	GJ	3.42	67.3	2.85	0.570	0.1%
	litre	0.000125	2.45	0.000104	0.0000208	0.1%
Wood – fireplaces	kg	0.0670	0.862	0.0578	0.00918	36.3%
Wood – industrial	kg	0.0150	0.862	0.00578	0.00918	43.7%

Notes

- These numbers are rounded to three significant figures.
- The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.
- The guide does not expect many commercial or industrial users will burn wood in fireplaces, but this emission factor has been provided for completeness. It is the default residential emission factor.
- The total CO_2-e emission factor for biofuels and biomass only includes methane and nitrous oxide emissions. This is based on *ISO 14064-1:2018* and the *GHG Protocol* reporting requirements for combustion of biomass as direct (Scope 1) emissions. Carbon dioxide emissions from the combustion of biologically sequestered carbon are reported separately.

3.4.1. GHG inventory development

Note that although the direct (Scope 1) carbon dioxide emissions are carbon neutral, organisations should still report the carbon dioxide released through biofuel and biomass combustion. Calculate these emissions in the same way as the direct emissions. Then, instead of including them within the emissions total, list them as a separate line item called ‘outside of scopes’.[19] This ensures the organisation is transparent regarding all potential sources of carbon dioxide from its activities.

To calculate biofuel and biomass emissions, collect data on the quantity of fuel used in the unit expressed. Applying the equation in section 2, this means:

Q = quantity of fuel used (unit)
F = appropriate emission factors from table 6

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

---

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

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

The equation used is:

$$X\%\ biofuel\ blend\ conversion\ factor\ = (X\%\ \times biofuel\ emission\ factor) + [(1 - X\%) \times fossil\ fuel\ emission\ factor]$$

BIOFUELS AND BIOMASS: EXAMPLE CALCULATION

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

CO_2 emissions	= 7,000 × 2.45	= 17,150 kg CO_2-e
CH_4 emissions	= 7,000 × 0.000104	= 0.728 kg CO_2-e
N_2O emissions	= 7,000 × 0.0000208	= 0.146 kg CO_2-e
Total CO_2-e emissions	= 7,000 × 0.000125	= 0.875 kg CO_2-e

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

mineral diesel conversion factor	= 2.69 kg CO_2-e/litre
biodiesel conversion factor	= 0.000125 kg CO_2-e/litre

Therefore, 10 per cent biodiesel blend conversion factor =

(10% × 0.000125) + [(1-10%) × 2.69] = 2.42 kg CO_2-e/litre biofuel blend

Note: Numbers may not add due to rounding.

3.4.2. Emission factor derivation methodology

We applied the same methodology used to calculate the stationary combustion fuels to the biofuels, using the raw data in appendix A.

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

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 only. The guide assumes there are no transmission and distribution losses from reticulated LPG due to the chemical composition of the gas. As a mixture of propane and butane, it does not emit fugitive methane or nitrous oxide.

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

Table 7 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 2016. 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 7: Transmission and distribution loss emission factors for natural gas

Transmission and distribution losses source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Natural gas used	kWh	0.0228	n/a	0.0228	n/a
	GJ	6.34	n/a	6.34	n/a

Note: These numbers are rounded to three significant figures. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

3.5.1. GHG inventory development

To calculate the emissions from transmission and distribution losses, organisations should collect data on the quantity of natural gas used in the unit expressed and multiply this by the emission factors for each gas. Applying the equation in section 2, this means:

Q = quantity of fuel used (unit)
F = appropriate emission factors from table 7

TRANSMISSION AND DISTRIBUTION LOSSES: EXAMPLE CALCULATION

An organisation uses 800 gigajoules of distributed natural gas in the reporting period.

CO_2 emissions	= 800 × 0.00	= 0 kg CO_2
CH_4 emissions	= 800 × 6.34	= 5,072 kg CO_2-e
N_2O emissions	= 800 × 0.00	= 0 kg CO_2-e
Total CO_2-e emissions	= 800 × 6.34	= 5,072 kg CO_2-e

Note: Numbers may not add due to rounding.

3.5.2. Emission factor derivation methodology

MBIE provided the transmission and distribution losses emission factor in kg CO_2-e. We assume that natural gas is predominantly methane, so all leakage is methane.

3.5.3. Assumptions, limitations and uncertainties

We assume that all emissions from transmission and distribution of natural gas are due to methane leakage.

The figures assume that all losses are attributable to gas consumed via local distribution networks. A small amount (less than 1 per cent) of emissions is attributable to losses occurring from delivery of gas to consumers who are directly connected to a high-pressure transmission pipeline.

4. Refrigerant use emission factors

4.1. Overview of changes since previous update

The tenth version of the guide now includes the 100-year global warming potentials (GWPs) of the Kyoto and Montreal Protocol gases. This is consistent with the national inventory. We use the GWPs published in the *IPCC Fourth Assessment Report (IPCC 4AR)*, in line with the UNFCCC, to which we submit *New Zealand's Greenhouse Gas Inventory*.

Estimation Method A has changed significantly in this version. Method A, which is preferred, relies on gathering data about refrigerants added to equipment during the measurement period.

4.2. Refrigerant use

GHG emissions from hydrofluorocarbons (HFCs) are associated with unintentional leaks and spills from refrigeration units, air conditioners and heat pumps. Quantities of HFCs in a GHG inventory may be small, but HFCs have very high GWPs (commonly 1300 to 3300 times more potent than carbon dioxide) so emissions from this source may be material. Also, emissions associated with this sector have grown significantly as they replace chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs).

The list of refrigerant gases is continuously evolving with technology and scientific knowledge. Be aware 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 4.2.2.

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

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

4.2.1. Global warming potentials (GWPs) of refrigerants

Table 8 details the GWPs of the refrigerants included in this chapter. The GWP is effectively the emission factor for each unit of refrigerant gas lost to the atmosphere. The guide uses the 2007 IPCC GWPs[20] to ensure consistency with the national inventory.

[20] IPCC Fourth Assessment Report: Climate Change 2007, Working Group 1: The Physical Science Basis, 2.10.2. Direct Global Warming Potentials: *www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf*

Some refrigerants 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. Alternatively, for the GWP of various refrigerant mixtures, please see table B2 in appendix B.

Table 8: Global warming potentials of refrigerants

Industrial designation/common name	Chemical formula	Unit	GWPs in a 100-year period (kg CO_2-e)
Substances controlled by the Montreal Protocol			
CFC-11	CCl_3F	kg	4750
CFC-12	CCl_2F_2	kg	10,900
CFC-13	$CClF_3$	kg	14,400
CFC-113	CCl_2FCClF_2	kg	6,130
CFC-114	$CClF_2CClF_2$	kg	10,000
CFC-115	$CClF_2CF_3$	kg	7,370
Halon-1301	$CBrF_3$	kg	7,140
Halon-1211	$CBrClF_2$	kg	1,890
Halon-2402	$CBrF_2CBrF_2$	kg	1,640
Carbon tetrachloride	CCl_4	kg	1,400
Methyl bromide	CH_3Br	kg	5
Methyl chloroform	CH_3CCl_3	kg	146
HCFC-22	$CHClF_2$	kg	1,810
HCFC-123	$CHCl_2CF_3$	kg	77
HCFC-124	$CHClFCF_3$	kg	609
HCFC-141b	CH_3CCl_2F	kg	725
HCFC-142b	CH_3CClF_2	kg	2,310
HCFC-225ca	$CHCl_2CF_2CF_3$	kg	122
HCFC-225cb	$CHClFCF_2CClF_2$	kg	595
Hydrofluorocarbons			
HFC-23	CHF_3	kg	14,800
HFC-32	CH_2F_2	kg	675
HFC-125	CHF_2CF_3	kg	3,500
HFC-134a	CH_2FCF_3	kg	1,430
HFC-143a	CH_3CF_3	kg	4,470
HFC-152a	CH_3CHF_2	kg	124
HFC-227ea	CF_3CHFCF_3	kg	3,220
HFC-236fa	$CF_3CH_2CF_3$	kg	9,810
HFC-245fa	$CHF_2CH_2CF_3$	kg	1030
HFC-365mfc	$CH_3CF_2CH_2CF_3$	kg	794
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	kg	1,640

Industrial designation/common name	Chemical formula	Unit	GWPs in a 100-year period (kg CO_2-e)
Perfluorinated compounds			
Sulphur hexafluoride	SF_6	kg	22,800
Nitrogen trifluoride	NF_3	kg	17,200
PFC-14	CF_4	kg	7,390
PFC-116	C_2F_6	kg	12,200
PFC-218	C_3F_8	kg	8,830
PFC-318	$c\text{-}C_4F_8$	kg	10,300
PFC-3-1-10	C_4F_{10}	kg	8,860
PFC-4-1-12	C_5F_{12}	kg	9,160
PFC-5-1-14	C_6F_{14}	kg	9,300
PFC-9-1-18	$C_{10}F_{18}$	kg	7,500
Trifluoromethyl sulphur pentafluoride	SF_5CF_3	kg	17,700
Fluorinated ethers			
HFE-125	CHF_2OCF_3	kg	14,900
HFE-134	CHF_2OCHF_2	kg	6,320
HFE-143a	CH_3OCF_3	kg	756
HCFE-235da2	$CHF_2OCHClCF_3$	kg	350
HFE-245cb2	$CH_3OCF_2CF_3$	kg	708
HFE-245fa2	$CHF_2OCH_2CF_3$	kg	659
HFE-254cb2	$CH_3OCF_2CHF_2$	kg	359
HFE-347mcc3	$CH_3OCF_2CF_2CF_3$	kg	575
HFE-347pcf2	$CHF_2CF_2OCH_2CF_3$	kg	580
HFE-356pcc3	$CHF_2OCF_2CF_2OCHF_2$ $CH_3OCF_2CF_2CHF_2$	kg	110
HFE-449sl (HFE-7100)	$C4F_9OCH_3$	kg	297
HFE-569sf2 (HFE-7200)	$C_4F_9OC_2H_5$	kg	59
HFE-43-10pccc124 (H-Galden 1040x)	$CHF_2OCF_2OC_2F_4OCHF_2$	kg	1,870
HFE-236ca12 (HG-10)	$CHF_2OCF_2OCHF_2$	kg	2,800
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCHF_2$	kg	1,500
Perfluoropolyethers			
PFPMIE	$CF_3OCF(CF_3)\ CF_2OCF_2OCF_3$	kg	10,300
Hydrocarbons and other compounds – direct effects			
Dimethylether	CH_3OCH_3	kg	1
Methylene chloride	CH_2Cl_2	kg	8.7
Methyl chloride	CH_3Cl	kg	13

4.2.2. GHG inventory development

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

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

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

4.2.3. Method A: Top-up

The best method to determine emissions confirms if any top-ups occurred during the measurement period. A piece of equipment is 'charged' with refrigerant gas, and any leaked gas must be replaced. Assuming that before top-up the system was at full capacity, the amount of top-up gas is equivalent to the gas leaked or lost to the atmosphere. This is Method A. It uses the actual amount of refrigerant used to replace what has leaked. The equipment maintenance service provider can typically provide this information.

E = kg of gas replaced during measurement period × GWP

Where:

- E = emissions from equipment in kg CO_2-e
- GWP = the 100-year global warming potential of the refrigerant used in equipment (table 8).

4.2.4. Methods B and C: Screening

If top-up amounts are not available, we recommend two methods for estimating leakage, depending on the equipment and available information. Appendix B details both methods.

Use Method B when the type and amount of refrigerant held in a piece of equipment are known.

Use Method C to estimate both volume of refrigerant and leakage rate.

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 would be 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 excluded based on significance of emissions from refrigerants. Organisations should then try to source data based on the top-up method.

4.2.5. 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.

4.2.6. Example calculations

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 2018 calendar year, a service technician confirmed a top-up of 6 kg of HFC-134a in December 2018. The technician also confirmed that when last serviced at the end of December 2017, no top-ups were needed. So we assume all the gas was lost during calendar year 2018.

So, for the 2018 inventory:

6 kg HFC-134a × EF 1,430 = 8,580 kg CO_2e

Air conditioning unit: During the 2018 calendar year, a service technician confirmed a top-up of 6 kg of HFC-143a in July 2018. The technician also confirmed that when last serviced at the end of July 2017, 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 2018 measurement period.

6 kg /12 months = 0.5 kg per month

So, for the 2018 calendar year inventory, 0.5 × 6 months = 3 kg. Emissions calculate as:

3 kg HFC-143a × EF 4,470 = 13,410 kg CO_2e

Note: Numbers may not add due to rounding.

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 and the volume held is 12 kg. For the chiller unit size, the default leakage rate is 8%.

So, for the 2018 calendar year,

12 kg HFC-134a × 8% × EF 1,430 = 1,372.8 kg CO_2e

Air conditioning unit: A service technician confirms the refrigerant is HFC-143a and the volume held is 10 kg. For the size of the unit, the default leakage rate is 3%.

So, for the 2018 calendar year,

12 kg HFC-143a × 3% × EF 4,470 = 1,609.2 kg CO_2e

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.

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*.

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.

5.1. Overview of changes since previous update

In the tenth version of the guide, we renamed this chapter from 'Scope 2: Electricity indirect emissions' to reflect the new inclusion of imported heat and steam. This chapter also now includes the transmission and distribution losses of purchased electricity.

5.2. Direct emissions from purchased electricity from New Zealand grid

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. Retailer-specific electricity factors for grid electricity are also out of scope.

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

We calculate purchased electricity emission factors on a calendar-year basis, and based on the average grid mix of generation types for the 2016 year. The emission factor accounts for the emissions from fuel combustion at thermal power stations and fugitive geothermal emissions. Thermal electricity is generated by burning fossil fuels. Renewable generation such as hydro, wind and solar has no associated combustion or fugitive GHG emissions, so for this guide we consider these methods to be carbon neutral.

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 in 2018.

However, the emission factor for purchased grid-average electricity does not include transmission and distribution losses. We provide a separate average emission factor for this as an indirect (Scope 3) emission source in section 5.3.

This emission factor also doesn't reflect the real-world factors that influence the carbon intensity of the grid such as time of year, time of day and geographical area. Therefore, a grid-average emission factor may over- or underestimate your organisation's GHG emissions.

The emission factor for purchased electricity from the New Zealand grid is in table 9.

Table 9: Emission factor for purchased grid-average electricity

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Electricity used	kWh	0.0977	0.0932	0.00439	0.000861

Note: These numbers are rounded to three significant figures. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

5.2.1. GHG inventory development

To calculate the emissions from 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 in section 2, this means:

Q = quantity of electricity used (kWh)
F = emission factors from table 9

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

PURCHASED ELECTRICITY: EXAMPLE CALCULATION

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

CO_2 emissions	= 800,000 × 0.0932	= 74,560 kg CO_2-e
CH_4 emissions	= 800,000 × 0.00439	= 3,512 kg CO_2-e
N_2O emissions	= 800,000 × 0.0000861	= 68.9 kg CO_2-e
Total CO_2-e emissions	= 800,000 × 0.0977	= 78,160 kg CO_2-e

Note: Numbers may not add due to rounding.

5.2.2. Emission factor derivation methodology

Table 10 details the data provided by MBIE to calculate the emission factors. The national inventory also contains this information.

Table 10: Information used to calculate the purchased electricity emission factor

Calculation component	Public electricity consumed
Consumption (GWh)	39,616
Emissions of CO_2 from public electricity generation (kt)	3033.97
Geothermal fugitive emissions of CO_2 (kt)	659.15
Emissions of CH_4 from public electricity generation (kt)	0.05
Geothermal fugitive emissions of CH_4 (kt)	6.91
Emissions of N_2O from public electricity generation (kt)	0.01
Geothermal fugitive emissions of N_2O (kt)	n/a

Note: These figures have been rounded.

To calculate the emission factor, first convert public electricity consumption to kilowatt hours (kWh) by multiplying by 1,000,000.

The equations used to calculate the emission factors from this data are as follows:

$$
\begin{aligned}
&public\ electricity\ consumption\ (GWh) \times 1{,}000{,}000 \\
&\qquad = public\ electricity\ consumption\ (kWh)
\end{aligned}
$$

Where:

- 1,000,000 is the factor applied to convert GWh to kWh.

$$
\begin{aligned}
&public\ electricity\ consumption \div (total\ emissions\ of\ gas\ \times 1{,}000{,}000) \\
&\qquad = emission\ factor\ (kg\ of\ \mathrm{GHG}\ per\ kWh\ of\ electricity)
\end{aligned}
$$

Where:

- total emissions of gas = emissions from public electricity generation + geothermal fugitive emissions
- 1,000,000 is the factor applied to convert kilotonnes to kilograms.

5.2.3. Assumptions, limitations and uncertainties

The emission factor for electricity is inherently uncertain as the energy mix varies depending on your geographical location, time of day and time of year.

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

We derived the emission factor in table 9 for purchased electricity from consumption data rather than generation 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 11 contains an emission factor for transmission and distribution line losses.

5.3. Transmission and distribution losses for electricity

This emission factor 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.

The emission factor for transmission and distribution line losses is the difference between the generation and consumption emission factors. Table 11 shows the emission factor for the 2018 calendar year.

Table 11: Transmission and distribution losses for electricity consumption

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Electricity used	kWh	0.00740	0.00706	0.000333	0.00000653

Note: These numbers are rounded to three significant figures. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

5.3.1. GHG inventory development

To calculate the emissions from transmission and distribution losses for purchased electricity, collect data on the kWh of electricity used in the reporting period and multiply this by the emission factor. Applying the equation in section 2, this means:

Q = quantity of electricity used (kWh)
F = emission factors from table 11

TRANSMISSION AND DISTRIBUTION LOSSES: EXAMPLE CALCULATION

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

CO_2 emissions	= 800,000 × 0.00706	= 5,648 kg CO_2-e
CH_4 emissions	= 800,000 × 0.000333	= 266.4 kg CO_2-e
N_2O emissions	= 800,000 × 0.00000653	= 5.22 kg CO_2-e
Total CO_2-e emissions	= 800,000 × 0.00740	= 5,920 kg CO_2-e

Note: Numbers may not add due to rounding.

5.3.2. Emission factor derivation methodology

MBIE provided an emission factor based on carbon dioxide equivalents. We derived the breakdown by GHG based on the split between gases for electricity generation. See table 12.

Table 12: Calculating the ratio of each gas from electricity emissions

	kg CO_2-e	kg CO_2	kg CH_4	kg N_2O
Electricity emission factor (per kWh)	0.0074			
Per cent breakdown by gas		95.41%	4.50%	0.09%
Calculation of component EF		= 0.9541 x 0.0074	= 0.0045 x 0.0074	= 0.009 x 0.0074
Breakdown by GHG		0.00706	0.00033	0.0000065

Note: These numbers are rounded to three significant figures. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

We then multiplied the transmission and distribution losses in kg CO_2-e by these factors to give the breakdown by gas type.

5.3.3. Assumptions, limitations and uncertainties

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

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

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

5.4. Imported heat and steam

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

5.5. Geothermal energy

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

6. Travel emission factors

Travel emissions result from travel associated with (and generally paid for by) the organisation. We provide factors for private and rental vehicles, taxis, public transport, air travel and accommodation.

Travel emissions are indirect (Scope 3) if the organisation does not directly own or control the vehicles used for travel. If the organisation owns or has an operating lease for the vehicle(s) these emissions are direct (Scope 1) and should be accounted for in transport fuels (see section 3.3).

Travel emission factors are in line with *ISO 14064-1:2018* and the *GHG Protocol*. We also include the methodology of the corresponding emission factors.

6.1. Overview of changes since previous update

There have been major changes to travel emission factors since the ninth version.

- We merged private and rental cars as they fall under the same assumptions and generate equal emission factors.
- The vehicles included for passenger transport (formerly 'Transport where no fuel data are available') previously assumed that cars were only petrol or petrol-hybrid. We generated emission factors for an increased number of fuel types using the real-world energy use data from Emission Impossible. [21]
- We added a category for rental cars whose age and engine size are unknown.
- We added accommodation, described as kg CO_2-e per hotel night, for organisations that pay for employee accommodation while they are working away from home.

6.2. Passenger vehicles

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

Travel in taxis and rental cars is a common source of direct (Scope 1) emissions for many organisations. 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, particularly for business travel in taxis.

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

---

[21] Real world energy use projections for VFEM (Report prepared for MoT), Emission Impossible, 2016. Online: *https://www.transport.govt.nz/assets/Uploads/Research/Transport-Outlook/Documents/a9189b9da0/Emission-Impossible-Real-World-Energy-Use-Projections-for-VFEM-20160905.pdf*

If you only have information on 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 14 to table 16. Table 17 details default private car emission factors, and table 18 lists the rental car emission factors based on distance travelled. Table 19 lists emission factors for taxi travel based on dollars spent and kilometres travelled.

The data used to prepare these factors come from a report by Emission Impossible (EI) Ltd.[22] The report includes a dataset of projected real-world fuel consumption rates from 1970 to 2018. For simplicity we divided the fleet into three categories depending on age: pre-2010, 2010–2015 and post-2015.

Table 13 details engine sizes and typical corresponding vehicles.

Table 13: 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 Env200

[22] Real world energy use projections for VFEM (Report prepared for MoT), Emission Impossible, 2016. Online: *https://www.transport.govt.nz/assets/Uploads/Research/Transport-Outlook/Documents/a9189b9da0/Emission-Impossible-Real-World-Energy-Use-Projections-for-VFEM-20160905.pdf*

Table 14: Pre-2010 vehicle fleet emission factors per km travelled

Emission source category		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Petrol vehicle	<1350 cc	km	0.215	0.205	0.002	0.007
	1350 - <1600 cc	km	0.206	0.197	0.002	0.007
	1600 - <2000 cc	km	0.248	0.238	0.003	0.008
	2000 - <3000 cc	km	0.268	0.257	0.003	0.009
	≥3000 cc	km	0.334	0.320	0.004	0.011
Diesel vehicle	<1350 cc	km	0.215	0.211	0.0003	0.003
	1350 - <1600 cc	km	0.207	0.204	0.0003	0.003
	1600 - <2000 cc	km	0.219	0.216	0.0003	0.003
	2000 - <3000 cc	km	0.270	0.266	0.0004	0.004
	≥3000 cc	km	0.300	0.295	0.0004	0.005
Petrol hybrid vehicle	<1350 cc	km	0.170	0.162	0.002	0.006
	1350 - <1600 cc	km	0.163	0.156	0.002	0.005
	1600 - <2000 cc	km	0.178	0.171	0.002	0.006
	2000 - <3000 cc	km	0.202	0.193	0.002	0.007
	≥3000 cc	km	0.239	0.228	0.003	0.008
Diesel hybrid vehicle	<1350 cc	km	0.193	0.190	0.000	0.003
	1350 - <1600 cc	km	0.186	0.182	0.000	0.003
	1600 - <2000 cc	km	0.197	0.193	0.000	0.003
	2000 - <3000 cc	km	0.242	0.238	0.000	0.004
	≥3000 cc	km	0.268	0.264	0.000	0.004
Motorcycle	<60cc, petrol	km	0.066	0.063	0.001	0.002
	≥60 cc, petrol	km	0.121	0.116	0.001	0.004

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 15: 2010–2015 vehicle fleet emission factors per km travelled

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Petrol vehicle	<1350 cc	km	0.196	0.188	0.002	0.006
	1350 - <1600 cc	km	0.188	0.180	0.002	0.006
	1600 - <2000 cc	km	0.207	0.198	0.002	0.007
	2000 - <3000 cc	km	0.234	0.224	0.003	0.008
	≥3000 cc	km	0.277	0.265	0.003	0.009
Diesel vehicle	<1350 cc	km	0.197	0.194	0.0003	0.003
	1350 - <1600 cc	km	0.190	0.186	0.0002	0.003
	1600 - <2000 cc	km	0.201	0.198	0.0003	0.003
	2000 - <3000 cc	km	0.247	0.243	0.0003	0.004
	≥3000 cc	km	0.274	0.270	0.0004	0.004
Petrol hybrid vehicle	<1350 cc	km	0.154	0.147	0.002	0.005
	1350 - <1600 cc	km	0.148	0.141	0.002	0.005
	1600 - <2000 cc	km	0.162	0.155	0.002	0.005
	2000 - <3000 cc	km	0.183	0.175	0.002	0.006
	≥3000 cc	km	0.216	0.207	0.002	0.007
Diesel hybrid vehicle	<1350 cc	km	0.176	0.173	0.0002	0.003
	1350 - <1600 cc	km	0.169	0.166	0.0002	0.003
	1600 - <2000 cc	km	0.179	0.176	0.0002	0.003
	2000 - <3000 cc	km	0.220	0.217	0.0003	0.003
	≥3000 cc	km	0.244	0.240	0.0003	0.004
Petrol plug-in hybrid electric vehicle (PHEV) – petrol consumption	<1350 cc	km	0.080	0.077	0.001	0.003
	1350 - <1600 cc	km	0.077	0.074	0.001	0.003
	1600 - <2000 cc	km	0.085	0.081	0.001	0.003
	2000 - <3000 cc	km	0.096	0.092	0.001	0.003
	≥3000 cc	km	0.113	0.108	0.001	0.004
Petrol plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.009	0.0004	0.00001
	1350 - <1600 cc	km	0.010	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.010	0.010	0.0005	0.00001
	2000 - <3000 cc	km	0.012	0.011	0.001	0.00001
	≥3000 cc	km	0.014	0.013	0.001	0.00001
Diesel plug-in hybrid electric vehicle (PHEV) – diesel consumption	<1350 cc	km	0.092	0.090	0.0001	0.001
	1350 - <1600 cc	km	0.089	0.087	0.0001	0.001
	1600 - <2000 cc	km	0.094	0.092	0.0001	0.001
	2000 - <3000 cc	km	0.115	0.113	0.0002	0.002
	≥3000 cc	km	0.128	0.126	0.0002	0.002

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Diesel plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.009	0.0004	0.00001
	1350 - <1600 cc	km	0.010	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.010	0.010	0.0005	0.00001
	2000 - <3000 cc	km	0.012	0.011	0.001	0.00001
	≥3000 cc	km	0.014	0.013	0.001	0.00001
Electric vehicle	Very small	km	0.021	0.020	0.001	0.00002
	Small	km	0.020	0.019	0.001	0.00002
	Medium	km	0.022	0.021	0.001	0.00002
	Large	km	0.025	0.024	0.001	0.00002
	Very large	km	0.029	0.028	0.001	0.00003
Motorcycle	<60 cc, petrol	km	0.060	0.058	0.001	0.002
	≥60 cc, petrol	km	0.113	0.108	0.001	0.004
	<60 cc, electricity	km	0.005	0.005	0.0002	0.000004
	≥60 cc, electricity	km	0.009	0.009	0.0004	0.00001

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 16: Post-2015 vehicle fleet emissions per km travelled

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Petrol vehicle	<1350 cc	km	0.186	0.178	0.002	0.006
	1350 - <1600 cc	km	0.179	0.171	0.002	0.006
	1600 - <2000 cc	km	0.196	0.187	0.002	0.006
	2000 - <3000 cc	km	0.222	0.212	0.002	0.007
	≥3000 cc	km	0.262	0.251	0.003	0.009
Diesel vehicle	<1350 cc	km	0.189	0.186	0.0002	0.003
	1350 - <1600 cc	km	0.182	0.179	0.0002	0.003
	1600 - <2000 cc	km	0.193	0.189	0.0003	0.003
	2000 - <3000 cc	km	0.237	0.233	0.0003	0.004
	≥3000 cc	km	0.263	0.258	0.000	0.004
Petrol hybrid vehicle	<1350 cc	km	0.142	0.136	0.002	0.005
	1350 - <1600 cc	km	0.136	0.130	0.002	0.004
	1600 - <2000 cc	km	0.149	0.143	0.002	0.005
	2000 - <3000 cc	km	0.169	0.162	0.002	0.005
	≥3000 cc	km	0.200	0.191	0.002	0.006

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Diesel hybrid vehicle	<1350 cc	km	0.166	0.163	0.0002	0.003
	1350 - <1600 cc	km	0.159	0.157	0.0002	0.002
	1600 - <2000 cc	km	0.169	0.166	0.0002	0.003
	2000 - <3000 cc	km	0.208	0.204	0.0003	0.003
	≥3000 cc	km	0.230	0.226	0.0003	0.004
Petrol plug-in hybrid electric vehicle (PHEV) – petrol consumption	<1350 cc	km	0.074	0.071	0.001	0.002
	1350 - <1600 cc	km	0.071	0.068	0.001	0.002
	1600 - <2000 cc	km	0.078	0.075	0.001	0.003
	2000 - <3000 cc	km	0.088	0.085	0.001	0.003
	≥3000 cc	km	0.105	0.100	0.001	0.003
Petrol plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.009	0.0004	0.00001
	1350 - <1600 cc	km	0.009	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.010	0.010	0.0005	0.00001
	2000 - <3000 cc	km	0.011	0.011	0.001	0.00001
	≥3000 cc	km	0.014	0.013	0.001	0.00001
Diesel plug-in hybrid electric vehicle (PHEV) – diesel consumption)	<1350 cc	km	0.087	0.085	0.0001	0.001
	1350 - <1600 cc	km	0.083	0.082	0.0001	0.001
	1600 - <2000 cc	km	0.088	0.087	0.0001	0.001
	2000 - <3000 cc	km	0.109	0.107	0.0001	0.002
	≥3000 cc	km	0.120	0.118	0.0002	0.002
Diesel plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.009	0.0004	0.00001
	1350 - <1600 cc	km	0.009	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.010	0.010	0.0005	0.00001
	2000 - <3000 cc	km	0.011	0.011	0.001	0.00001
	≥3000 cc	km	0.014	0.013	0.001	0.00001
Electric vehicle	Very small	km	0.020	0.019	0.001	0.00002
	Small	km	0.019	0.018	0.001	0.00002
	Medium	km	0.021	0.020	0.001	0.00002
	Large	km	0.024	0.023	0.001	0.00002
	Very large	km	0.028	0.027	0.001	0.00002
Motorcycle	<60 cc, petrol	km	0.058	0.055	0.001	0.002
	≥60 cc, petrol	km	0.058	0.055	0.001	0.002
	<60 cc, electricity	km	0.005	0.004	0.0002	0.000004
	≥60 cc, electricity	km	0.005	0.004	0.0002	0.000004

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 17: Default private car emission factors per km travelled for default age of vehicle and <3000 cc engine size

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Private car default	Petrol	km	0.268	0.257	0.003	0.009
	Diesel	km	0.270	0.266	0.0004	0.004
	Petrol hybrid	km	0.202	0.193	0.002	0.007
	Diesel hybrid	km	0.242	0.238	0.0003	0.004
	Petrol plug-in hybrid (petrol consumption)	km	0.096	0.092	0.001	0.003
	Petrol plug-in hybrid (electricity consumption)	km	0.012	0.011	0.001	0.000
	Diesel plug-in hybrid (diesel consumption)	km	0.115	0.113	0.0002	0.002
	Diesel plug-in hybrid (electricity consumption)	km	0.012	0.011	0.0005	0.000
	Electric	km	0.025	0.024	0.001	0.00002

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e. Defaults are based on the average age of the vehicle fleet (pre-2010 for petrol and diesel, and 2010–2015 for all other cars) and most common engine size (2000–3000 cc). Source: MoT

Table 18: Default rental car emission factors per km travelled

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Rental car default	Petrol	km	0.207	0.198	0.002	0.007
	Diesel	km	0.201	0.198	0.0003	0.003
	Petrol hybrid	km	0.162	0.155	0.002	0.005
	Diesel hybrid	km	0.179	0.176	0.0002	0.003
	Petrol plug-in hybrid (petrol consumption)	km	0.085	0.081	0.001	0.003
	Petrol plug-in hybrid (electricity consumption)	km	0.020	0.010	0.010	0.0005
	Diesel plug-in hybrid (diesel consumption)	km	0.094	0.092	0.0001	0.001
	Diesel plug-in hybrid (electricity consumption)	km	0.020	0.010	0.0096	0.0005
	Electric	km	0.022	0.021	0.001	0.00002

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 19: Emission factors for taxi travel

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Taxi travel	Distance travelled	km	0.224	0.220	0.0003	0.004
	Dollars spent	$	0.075	0.073	0.0001	0.001

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

6.2.1. GHG inventory development

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

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

If fuel-use data are not available, collect data on kilometres travelled by vehicle type and multiply this by the emission factor based on distance travelled for each GHG. If the vehicle is electric and the charging point is within the organisation's boundaries, this is a direct (Scope 1) emission source and emissions are zero. If travel is by rideshare apps (ie, Uber, Zoomy or Ola), we recommend using the taxi travel emission factors by distance travelled (table 19). If this information is not available, use the taxi emission factors per dollars spent (table 19).

Applying the equation in section 2, this means:

Q = distance travelled by vehicle type (km)
F = emission factors for correlating vehicle type from table 14 to table 19

PASSENGER VEHICLES: EXAMPLE CALCULATION

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

CO_2 emissions	= 40,000 × 2.35	= 94,000 kg CO_2
CH_4 emissions	= 40,000 × 0.0276	= 1,104 kg CO_2-e
N_2O emissions	= 40,000 × 0.0797	= 3,188 kg CO_2-e
Total CO_2-e emissions	= 40,000 × 2.45	= 98,000 kg CO_2-e

An organisation owns three pre-2010 petrol hybrid vehicles. They are all between 1600 and 2000 cc and travel a total of 37,800 km in the reporting period.

CO_2 emissions	= 37,800 × 0.171	= 6,646 kg CO_2
CH_4 emissions	= 37,800 × 0.002	= 76 kg CO_2-e
N_2O emissions	= 37,800 × 0.006	= 227 kg CO_2-e
Total CO_2-e emissions	= 37,800 × 0.178	= 6,728 kg CO_2-e

An organisation uses petrol rental cars to travel 12,000 km in 2018. It also spends $18,000 on taxi travel.

Total CO_2-e emissions from rental cars	= 12,000 × 0.207	= 2,484 kg CO_2-e
Total CO_2-e emissions from taxi travel	= $18,000 × 0.0747	= 1,345 kg CO_2-e

Note: Numbers may not add due to rounding.

6.2.2. Emission factor derivation methodology

The *EI report* provided real-world fuel consumption rates of the vehicle fleet. The data apply to the vehicle fleet dating back to 1970 and forecasting to 2019. We decided to split the fleet into three categories and develop average emission factors for these – see table 20.

- Pre-2010 fleet is based on the average fuel consumption data from 1970 to 2010. We assume there are no electric vehicles or plug-in hybrid vehicles.
- 2010–2015 fleet is based on the average fuel consumption data from vehicles produced between 2010 and 2015.
- Post-2015 fleet is based on the average fuel consumption data from vehicles produced from 2015 onwards.

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.[23]

Table 20 details the average fuel consumption rates for the vehicles.

Table 20: Fuel consumption in litres per 100 km

			Units of energy consumed per 100 km		
Emission source		**Units**	**Pre-2010**	**2010–2015**	**Post-2015**
Petrol vehicle	<1350 cc	litres	8.75	8.00	7.59
	1350 - <1600 cc	litres	8.41	7.68	7.29
	1600 - <2000 cc	litres	10.13	8.43	7.99
	2000 - <3000 cc	litres	10.93	9.53	9.04
	≥3000 cc	litres	13.62	11.29	10.70
Diesel vehicle	<1350 cc	litres	7.99	7.31	7.01
	1350 - <1600 cc	litres	7.69	7.04	6.74
	1600 - <2000 cc	litres	8.15	7.46	7.15
	2000 - <3000 cc	litres	10.03	9.18	8.79
	≥3000 cc	litres	11.13	10.18	9.75
Petrol hybrid vehicle	<1350 cc	litres	6.91	6.26	5.78
	1350 - <1600 cc	litres	6.64	6.01	5.55
	1600 - <2000 cc	litres	7.27	6.59	6.08
	2000 - <3000 cc	litres	8.23	7.46	6.89
	≥3000 cc	litres	9.73	8.82	8.14

23 Motor Vehicle Register: *https://opendata-nzta.opendata.arcgis.com/datasets/ce0ec40427b24e90b26bd5e0852cb76b_0*

Emission source		Units	Units of energy consumed per 100 km Pre-2010	2010–2015	Post-2015
Diesel hybrid vehicle	<1350 cc	litres	n/a	6.52	6.14
	1350 - <1600 cc	litres	n/a	6.28	5.91
	1600 - <2000 cc	litres	n/a	6.65	6.27
	2000 - <3000 cc	litres	n/a	8.18	7.70
	≥3000 cc	litres	n/a	9.07	8.55
Petrol plug-in hybrid electric vehicle (PHEV) – petrol consumption	<1350 cc	litres	n/a	3.28	3.03
	1350 - <1600 cc	litres	n/a	3.15	2.91
	1600 -<2000 cc	litres	n/a	3.45	3.18
	2000 - <3000 cc	litres	n/a	3.90	3.60
	≥3000 cc	litres	n/a	4.62	4.26
Petrol plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	kWh	n/a	10.16	9.82
	1350 - <1600 cc	kWh	n/a	9.76	9.43
	1600 - <2000 cc	kWh	n/a	10.69	10.33
	2000 - <3000 cc	kWh	n/a	12.10	11.69
	≥3000 cc	kWh	n/a	14.32	13.83
Diesel plug-in hybrid electric vehicle (PHEV) – diesel consumption	<1350 cc	litres	n/a	3.41	3.22
	1350 - <1600 cc	litres	n/a	3.29	3.09
	1600 - <2000 cc	litres	n/a	3.48	3.28
	2000 - <3000 cc	litres	n/a	4.28	4.03
	≥3000 cc	litres	n/a	4.75	4.47
Diesel plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	kWh	n/a	10.16	9.82
	1350 - <1600 cc	kWh	n/a	9.76	9.43
	1600 - <2000 cc	kWh	n/a	10.69	10.33
	2000 - <3000 cc	kWh	n/a	12.10	11.69
	≥3000 cc	kWh	n/a	14.32	13.83
Electric vehicle	<1350 cc	kWh	n/a	21.32	20.59
	1350 - <1600 cc	kWh	n/a	20.48	19.78
	1600 - <2000 cc	kWh	n/a	22.43	21.67
	2000 - <3000 cc	kWh	n/a	25.39	24.53
	≥3000 cc	kWh	n/a	30.03	29.01
Motorcycle	<60 cc, petrol	litres	2.68	2.45	2.35
	≥60 cc, petrol	litres	4.94	4.59	4.58
	<60 cc, electricity	kWh	n/a	4.90	4.71
	≥60 cc, electricity	kWh	n/a	9.17	9.17

Source: The Emission Impossible report and supporting data

The *EI report* categorises the vehicles included for private, rental and taxi vehicles as light passenger vehicles.

The equation used to calculate the emission factor for each greenhouse gas 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 5.

According to the Motor Industry Association, the most common taxi vehicle uses diesel (see table 22). We based the default factor for taxis on the average of <2000 cc and <3000 cc diesel vehicles from table 15. Data from the Motor Industry Association New Vehicle Sales database show that for the calendar-year period 2016, 62 per cent of taxis purchased were in this class. According to the Motor Vehicle Register[24] the average age of the taxi fleet is 8.6 years and the average age of the rental fleet is 5.5 years. For consistency we assumed a 2010–2015 fleet for both taxis and rental cars.

Taxicharge advised that since 2014, the price per kilometre in a taxi has remained stable at $3.

The calculation to work out the emission factors for taxi by distance is an average between the Diesel 1600–2000 cc and the 2000–3000 cc from table 15. Table 21 shows this.

Table 21: Data used for calculating the taxi emission factors

		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Diesel vehicle	1600 - <2000 cc	km	0.201	0.198	0.0003	0.003
	2000 - <3000 cc	km	0.247	0.243	0.0003	0.004
Taxi	Average	km	0.224	0.220	0.0003	0.004

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

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

$$emissions\ per\ \$\ spend = \frac{emissions\ per\ km}{\$3\ per\ km}$$

[24] *https://www.nzta.govt.nz/vehicles/how-the-motor-vehicle-register-affects-you/* as at 24 October 2018

Table 22: Data on the number of taxis purchased by fuel type

Taxi cars purchased by year		2015	2016	2017
Taxi commercial passenger (MIA NZTA – vehicle sales data)	Petrol	85	88	181
	Diesel	113	177	302
	Electric	0	0	2
	Petrol hybrid	55	79	44
	Petrol plug-in hybrid	0	1	1

Source: Motor Industry Authority

The private car default is based on the average age of the New Zealand fleet, back-calculated to the year of manufacture, with the real-world fuel consumption factor applied. According to the Ministry of Transport (MoT)[25] the average age of light passenger vehicles in 2016 was 14.3 years. This correlates to a 2001 year of manufacture. Also, according to MoT[26] the most common size of light passenger vehicle is 2289 cc, which puts it in the 2000–3000 cc category. For electric vehicles we assumed a 2010-2015 fleet consumption for a 2000–3000 cc equivalent engine size, in the absence of detailed information about fleet age.

Table 23: Energy consumption per 100 km for light passenger vehicles manufactured in 2001

Engine type	Unit	Units per 100 km for a 2000–3000cc engine in 2001
Petrol	litre	10.657
Diesel	litre	9.673
Petrol hybrid	litre	7.931
Diesel hybrid	litre	8.650
Petrol plug-in hybrid (petrol)	litre	4.150
Petrol plug-in hybrid (electricity)	litre	12.703
Diesel plug-in hybrid (diesel)	litre	4.527
Diesel plug-in hybrid (electricity)	litre	12.703
Electric*	kWh	25.393

Note: *Electric vehicle consumption is based on a 2010–2015 vehicle fleet.

The default emission factor for rental cars is the same as for vehicles in the 1600–2000 cc category. Data from the Motor Industry Association New Vehicle Sales database show that for the 2016 period, an average of 39 per cent of rental vehicles purchased were in the category 1751–2150 cc. This correlates closest to the 1600–2000 cc category. We assumed that the average rental car was manufactured between 2010 and 2015.

25 *www.transport.govt.nz/resources/transport-dashboard/2-road-transport/rd025-average-vehicle-fleet-age-years/*

26 *www.transport.govt.nz/resources/transport-dashboard/2-road-transport/rd023-vehicle-fleet-composition-by-region/rd034-average-engine-size-of-light-vehicle-fleet-by-region-cc/*

6.2.3. 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.

The default emission factors (for vehicles of unknown engine size) are the same as those of a <3000 cc vehicle. Using the Motor Vehicle Register[27] we calculated that the most common private passenger vehicle in 2016 had an engine size 2000–3000 cc. Therefore this is the default engine size used. The average age of a private car is 14.6 years, so for the 2016 period we assume 2001 as the year of manufacture.

The *EI report* provided all real-world fuel consumption rates. The data in the EI report are inherently uncertain as they model the real-world fuel consumption of new vehicles sold that calendar year. 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.

6.3. Public transport

Public transport emissions include those from buses. Air travel is in a separate section below. No data are currently available on ferry and commuter rail travel.

Due to a lack of passenger loading data, it has not been possible to provide emission factors for public transport modes based on passenger kilometres (pkm). For an organisational inventory this category is usually *de minimis* and therefore this emission source will not typically impact the inventory.

However, it is possible to calculate the emissions from the whole vehicle. Table 24 details these emission factors.

Buses: We calculated the emissions of different buses using the *EI report* data for fuel consumption in litres per 100 kilometres. The guide presents the data in emissions per kilometre.

Table 25 details the data provided to calculate the emission conversion factors.

---

27 *https://www.nzta.govt.nz/vehicles/how-the-motor-vehicle-register-affects-you/*

Table 24: Bus emission factors per km travelled

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Diesel bus	<7,500 kg	km	0.566	0.557	0.0007	0.009
	<12,000 kg	km	0.784	0.771	0.001	0.012
	≥12,000 kg	km	1.087	1.069	0.001	0.017
Diesel hybrid bus	<7,500 kg	km	0.401	0.394	0.0005	0.006
	<12,000 kg	km	0.555	0.546	0.0007	0.009
	≥12,000 kg	km	0.769	0.756	0.001	0.012
Electric bus	<7,500 kg	km	0.056	0.054	0.003	0.00005
	<12,000 kg	km	0.078	0.074	0.004	0.0001
	≥12,000 kg	km	0.108	0.103	0.005	0.0001

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

6.3.1. 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 in section 2, this means:

Q = distance travelled, by vehicle type (km)
F = emission factors for correlating vehicle type, from table 24

DIESEL BUS: EXAMPLE CALCULATION

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

Total CO_2-e emissions from bus travel = 500 km x 0.566 = 283 kg CO_2-e

This result is for the entire bus.

Note: Numbers may not add due to rounding.

6.3.2. Emission factor derivation methodology

The average age of the bus fleet is 12 years (according to the Motor Vehicle Register). Therefore, we applied an average fuel consumption factor for a pre-2010 fleet to the bus fleet from the EI report and the raw data the report used.

Table 25: 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	21.019
	<12,000 kg	litre	29.11
	≥12,000 kg	litre	40.35
Diesel hybrid bus	<7,500 kg	litre	14.87
	<12,000 kg	litre	20.60
	≥12,000 kg	litre	28.55
Electric bus	<7,500 kg	kWh	57.69
	<12,000 kg	kWh	79.91
	≥12,000 kg	kWh	110.7

Using the information in table 25 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 5 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.

6.3.3. Assumptions, limitations and uncertainties

The assumptions, limitations and uncertainties of the data come from the EI report prepared for MoT. The data are projections and therefore these fuel consumption rates are uncertain. However, there is no quantified uncertainty.

6.4. Air travel

6.4.1. Domestic air travel

This is a new emission factor for this guide based on New Zealand data from 2016. The previous version only provided a domestic air travel emission factor based on international data. Domestic air travel is a common source of indirect (Scope 3) emissions for many New Zealand organisations.

For air travel emission factors, multipliers or other corrections may be applied to account for the global warming potential (GWP) of emissions arising from aircraft transport at altitude (jet aircraft). Radiative forcing helps organisations account for the wider climate effects of aviation, including water vapour and indirect GHGs. This is an area of active research, aiming to express the relationship between emissions and the climate warming effects of aviation, which is yet to be agreed. If multipliers are applied, organisations should disclose the specific factor used 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.

Table 26 provides the emission factors without the radiative forcing multiplier applied. Table 27 provides emission factors with a radiative forcing multiplier of 1.9 applied.[28,29]

Table 26: Domestic air travel emission factors without radiative forcing

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
National average	pkm	0.130	0.125	0.0009	0.003
Jet aircraft	pkm	0.072	0.069	0.0005	0.002
Medium aircraft	pkm	0.114	0.110	0.0008	0.003
Small aircraft	pkm	0.353	0.341	0.0024	0.009

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 27: Domestic aviation emission factors with radiative forcing

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
National average	pkm	0.242	0.238	0.0009	0.003
Jet aircraft	pkm	0.134	0.132	0.0005	0.002
Medium aircraft	pkm	0.213	0.210	0.0008	0.003
Small aircraft	pkm	0.659	0.647	0.0024	0.009

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

We have provided a national average emission factor, and three factors based on the aircraft size: jet, medium or small aircraft. A jet is a large aircraft (in New Zealand this would be an Airbus A320), a medium aircraft has between 50 and 70 seats (ie, regional services on an ATR 72 or Dash 8-300) and a small aircraft has less than 50 seats. If the aircraft type is unknown, we recommend using the national average.

6.4.2. GHG inventory development

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

Applying the equation in *section 2*, this means:

Q = passengers multiplied by distance flown (pkm)

---

[28] R Sausen et al (2005). Aviation radiative forcing in 2000: An update on IPCC (1999) Meteorologische Zeitschrift 14: 555-561, available at: *http://elib.dlr.de/19906/1/s13.pdf*

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

F = emission factors from table 26 or table 27

DOMESTIC AIR TRAVEL: EXAMPLE CALCULATION

An organisation flies an employee on a return flight from Christchurch to Wellington (304 km each way). This happens five times in the reporting year on an aircraft of unknown size. The national average emission factor without radiative forcing is used.

Person kilometres travelled = 2 × 304 × 5 = 3,040 pkm
Total CO_2-e emissions from domestic air travel = 0.130 x 3,040 = 395 kg CO_2-e

Note: Numbers may not add due to rounding.

6.4.3. Emission factor derivation methodology

MoT developed the 'Domestic aviation projection model' to calculate domestic aviation emissions. We calculated an average emission factor for domestic air travel using the 2016 data in this model.

Table 28 details the types of aircraft running domestic flights in 2016, and the data[30] used to calculate the emission factor. We assumed the average user is unaware of the type of aircraft they are flying on, and therefore an average factor would be the most applicable. Organisations that own aircraft could calculate emissions based on the fuel consumption data.

Table 28: Domestic aviation data

Aircraft type	Total seats per flight	Average distance per flight (km)	Total fuel used (kg)	Total flights
Airbus A320	173	666.15	158,788,876.47	49,699
Aerospatiale/Alenia ATR 72	68	399.11	39,631,695.18	51,267
British Aerospace Jetstream 32	19	167.78	94,556.00	324
Beechcraft Beech 1900D	19	250.73	2,152,521.40	6,277
Cessna Light Aircraft	6	95.87	1,199,632.30	9,791
De Havilland Canada DHC-8-300 Dash 8/8Q	50	313.25	61,505,087.49	71,122
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

To calculate the emission factor, first calculate fuel per flight for each aircraft:

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

[30] Data from The Transport Outlook Aircraft Movement and Greenhouse Gas (GHG) Emission Model

Then calculate fuel per passenger:

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

The total seats do not necessarily reflect the total passengers flying. The International Air Transport Association (IATA) states that on average 79.6 per cent of seats are occupied on a plane. We factored this into the emissions calculation by multiplying seats by 0.8.

Using this, next calculate fuel per passenger per km:

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

The density of kerosene (the assumed aviation fuel) is 0.79 kg/l .[31]

See table 29 for the calculated figures.

Table 29: Calculating domestic air travel emissions

Aircraft type	Fuel (kg) per flight	Assumed passengers per flight	Fuel (kg) per passenger	Fuel (kg) per passenger per km	Fuel (litres) per passenger per km
Airbus A320	3,195.01	138.4	23.085	0.0347	0.0220
Aerospatiale/Alenia ATR 72	773.04	54.4	14.210	0.0356	0.0226
British Aerospace Jetstream 32	291.84	15.2	19.200	0.1144	0.0727
Beechcraft Beech 1900D	342.92	15.2	22.561	0.0900	0.0572
Cessna Light Aircraft	122.52	4.8	25.526	0.2663	0.1690
De Havilland Canada DHC-8-300 Dash 8/8Q	864.78	40	21.620	0.0690	0.0438
Pilatus PC-12	196.50	7.2	27.292	0.0908	0.0576
Saab SF-340	609.84	27.2	22.421	0.0467	0.0297
FOKKER F50	1,171.84	42.4	27.638	0.0438	0.0278

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 5. A national average was then calculated using the share of total flights to weight the contributions of each aircraft, see table 30.

31 Z Energy: *https://z.co.nz/assets/SDS/Kerosene_2.pdf*

Table 30: Calculated emissions, without radiative forcing, per aircraft type and the average used for the emission factors

Aircraft type	Share of total flights	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Airbus A320	25.69%	pkm	0.072	0.069	0.001	0.002
Aerospatiale/Alenia ATR 72	26.50%	pkm	0.074	0.072	0.001	0.002
British Aerospace Jetstream 32	0.17%	pkm	0.237	0.229	0.002	0.006
Beechcraft Beech 1900D	3.24%	pkm	0.186	0.180	0.002	0.005
Cessna Light Aircraft	5.06%	pkm	0.552	0.534	0.004	0.014
De Havilland Canada DHC-8-300 Dash 8/8Q	36.76%	pkm	0.143	0.138	0.001	0.004
Pilatus PC-12	2.23%	pkm	0.188	0.182	0.002	0.005
Saab SF-340	0.35%	pkm	0.097	0.094	0.001	0.002
FOKKER F50	0.01%	pkm	0.091	0.088	0.001	0.002
Weighted average		pkm	0.130	0.125	0.001	0.003

Note: These numbers are rounded to three decimal places. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

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

- Jet aircraft: Airbus A320
- Medium aircraft: Aerospatiale/Alenia ATR 72, De Havilland Canada DHC-8-300 Dash 8/8Q, FOKKER F50
- Small aircraft: British Aerospace Jetstream 32, Cessna Light Aircraft, Pilatus PC-12, Beechcraft Beech 1900D, Saab SF-340.

6.4.4. 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.

6.4.5. International air travel

Organisations wishing to report their international air travel emissions based on distance travelled per passenger should use the International Civil Aviation Organisation (ICAO) calculator.[32] 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

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

delays/circling and non-direct routes (ie, not along the straight-line/great-circle between destinations).

If you prefer not to use the ICAO calculator, we recommend the emission factors provided in table 31 and table 32. These emission factors follow those published online by *UK BEIS emission factors* and include a distance uplift of 8 per cent.

Table 31: Emission factors for international air travel with radiative forcing

Emission source	Travel class	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Short haul (<3700 km)	Average passenger	pkm	0.162	0.162	0.00001	0.001
	Economy	pkm	0.160	0.159	0.00001	0.001
	Business	pkm	0.240	0.238	0.00001	0.001
Long haul (>3700 km)	Average passenger	pkm	0.213	0.212	0.00001	0.001
	Economy	pkm	0.163	0.162	0.00001	0.001
	Premium economy	pkm	0.260	0.259	0.00001	0.001
	Business	pkm	0.472	0.470	0.00002	0.002
	First	pkm	0.651	0.648	0.00002	0.003

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 32: Emission factors for international air travel without radiative forcing

Emission source	Travel class	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Short haul (<3700 km)	Average passenger	pkm	0.086	0.085	0.00001	0.001
	Economy	pkm	0.084	0.084	0.00001	0.001
	Business	pkm	0.127	0.125	0.00001	0.001
Long haul (>3700 km)	Average passenger	pkm	0.112	0.111	0.00001	0.001
	Economy	pkm	0.086	0.085	0.00001	0.001
	Premium economy	pkm	0.138	0.136	0.00001	0.001
	Business	pkm	0.250	0.247	0.00002	0.002
	First	pkm	0.344	0.341	0.00002	0.003

Note that these numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

6.4.6. GHG inventory development

To calculate emissions for international air travel, use the *ICAO calculator*. Multiply the output by 1.09 to account for the distance uplift factor (see section 6.4.8).

Alternatively, gather the information on how far each passenger flew for each flight. Multiply this by the factors in table 31. Use the specified emission factors for different cabin classes if information is available. If unknown, use the average emission factors. Applying the equation in section 2, this means:

Q = passengers multiplied by distance flown (pkm)
F = appropriate emission factors from table 31 or table 32

INTERNATIONAL AIR TRAVEL: EXAMPLE CALCULATION

An organisation makes five flights from Auckland to Shanghai (9,346 km each way). On the first trip, two people flew return to Shanghai on the same flight in economy class. On the second trip, three people flew return to Shanghai and the cabin classes were not recorded. Long-haul (>3700 km) emission factors with radiative forcing are used.

For the two people who travel economy class:

Person kilometres travelled = 2 × 9,346 × 2 = 37,384 pkm
Their CO_2-e emissions from air travel = 37,384 × 0.163 = 6,093 kg CO_2-e

For the three people with unknown travel classes:

Person kilometres travelled = 3 × 9,346 × 2 = 56,076 pkm
Their CO_2-e emissions from air travel = 56,076 × 0.213 = 11,944 kg CO_2-e
Total CO_2-e emissions from international air travel = 6,094 + 11,944 = 18,038 kg CO_2-e
Total CO_2-e with distance uplift = 18,038 × 1.09 = 19,661 kg CO_2-e

Note: Numbers may not add due to rounding.

6.4.7. Emission factor derivation methodology

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

6.4.8. Assumptions, limitations and uncertainties

The emission factors in table 31 and table 32 are based on UK and European data. The short-haul emission factor applies to international flights of less than 3,700 km. The long-haul factor applies to flights of more than 3,700 km.

The UK BEIS endorses a great circle distance uplift factor to account for non-direct (ie, not along the straight-line/great-circle between destinations) routes and delays/circling. The 8 per cent uplift factor applied by UK BEIS is based on the analysis of flights arriving and departing from the UK. This figure is likely to be overstated for international flights to/from New Zealand (initial estimates from Airways New Zealand suggest it is likely to be less than 5 per cent). In the absence of a New Zealand-specific figure for international flights, we recommend a 9 per cent uplift factor. This conservative value comes from an IPCC publication, *Aviation and the Global Atmosphere* (refer to section 8.2.2.3) and is based on studies of penalties to air traffic associated with the European ATS Route Network. We recommend applying the 9 per cent uplift factor to international flight emission estimates from the ICAO calculator by multiplying the output by 1.09.

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

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

6.5. Accommodation

Accommodation is an indirect (Scope 3) emissions source. We obtained the emission factors for accommodation, see table 33, directly from the Cornell Hotel Sustainability Benchmarking Index (CHSB) Tool.[33] The International Tourism Partnership (ITP) and Greenview produce the CHSB tool. The factors are in CO_2-e and are not available by gas type.

Table 33: Accommodation emission factors

Country	Unit	$kgCO_2$-e/unit
Argentina	Room per night	57.3
Australia	Room per night	65.1
Austria	Room per night	19.0
Belgium	Room per night	13.9
Brazil	Room per night	14.1
Canada	Room per night	19.6
Caribbean region	Room per night	64.0
Chile	Room per night	56.0
China	Room per night	72.3
China (Hong Kong)	Room per night	93.3
Colombia	Room per night	15.5
Costa Rica	Room per night	16.1
Czech Republic	Room per night	29.7
Egypt	Room per night	67.8
France	Room per night	6.6
Germany	Room per night	20.8
India	Room per night	103.1
Indonesia	Room per night	126.7
Ireland	Room per night	30.0
Italy	Room per night	24.9
Japan	Room per night	75.5
Jordan	Room per night	98.3
Malaysia	Room per night	92.6
Mexico	Room per night	30.3
Netherlands	Room per night	21.7
New Zealand	Room per night	12.3
Panama	Room per night	31.1
Poland	Room per night	53.8
Portugal	Room per night	19.2

[33] The Cornell Hotel Sustainability Benchmarking Index (CHSB) Tool can be accessed via: *https://greenview.sg/chsb-index/*

Country	Unit	$kgCO_2$-e/unit
Qatar	Room per night	140.9
Russian Federation	Room per night	38.7
Saudi Arabia	Room per night	108.5
Singapore	Room per night	48.4
South Africa	Room per night	62.2
South Korea	Room per night	80.3
Spain	Room per night	23.5
Switzerland	Room per night	8.9
Thailand	Room per night	64.7
Turkey	Room per night	56.6
United Arab Emirates	Room per night	117.0
United Kingdom	Room per night	26.4
United States	Room per night	25.6
Vietnam	Room per night	63.5

6.5.1. 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 in section 2, this means:

Q = rooms per night
F = emission factors for the country stayed in from table 33

EXAMPLE CALCULATION

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

Total CO_2-e emissions from the hotel stay = 3 × 4 × 65.1 = 781.2 kg CO_2-e

Note: Numbers may not add due to rounding.

6.5.2. Assumptions, limitations and uncertainties

The CHSB Guidance document[34] outlines the limitations of the study and the dataset.

- It is skewed towards upmarket and chain hotels.
- Most of the dataset covers the United States.
- The results do not distinguish a property's amenities, for example swimming pools, spas or a laundry.
- The data have not been verified.
- District heating and cooling remain a challenge.

[34] Access the CHSB Guidance document via: *https://scholarship.sha.cornell.edu/cgi/viewcontent.cgi?article=1255&context=chrpubs*

7. Freight transport emission factors

7.1. Overview of changes since previous update

Freight transport emission factors are new in this version of the guide. We provide emission factors for freighting goods (in tonne kilometres, tkm) and for the actual freight vehicles (in km). The emission factors include those for freighting goods for road, rail, domestic coastal shipping, international shipping and air freight. We provide freight vehicle emission factors (in km) for road light commercial and heavy goods vehicles.

7.2. Road freight

Organisations freighting goods through third-party providers can categorise road freight emissions as indirect (Scope 3). We generated emission factors for freight vehicles (in km travelled) and an average emission factor for freighting goods by road in tonne kilometres (tkm).

Included in road freight are light commercial vehicles (eg, vans) and heavy goods vehicles (eg, trucks). The *EI report*[35] provided the real-world fuel consumption rates of the vehicle fleet. The data for the vehicle fleet date back to 1970 and forecasts to 2019. 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.

[35] Real-world energy use projections for VFEM (report prepared for MoT), Emission Impossible, 2016

7.2.1. Light commercial vehicle emission factors

Table 34: Emission factors for light commercial vehicles manufactured pre-2010

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Petrol	<1350 cc	km	0.215	0.205	0.002	0.007
	1350 - <1600 cc	km	0.206	0.197	0.002	0.007
	1600 - <2000 cc	km	0.269	0.258	0.003	0.009
	2000 - <3000 cc	km	0.262	0.251	0.003	0.009
	≥3000 cc	km	0.303	0.289	0.003	0.010
Diesel	<1350 cc	km	0.215	0.211	0.0003	0.003
	1350 - <1600 cc	km	0.207	0.204	0.0003	0.003
	1600 - <2000 cc	km	0.276	0.271	0.0004	0.004
	2000 - <3000 cc	km	0.296	0.291	0.0004	0.005
	≥3000 cc	km	0.183	0.178	0.004	0.000
Petrol hybrid	<1350 cc	km	0.170	0.162	0.002	0.006
	1350 - <1600 cc	km	0.163	0.156	0.002	0.005
	1600 - <2000 cc	km	0.213	0.203	0.002	0.007
	2000 - <3000 cc	km	0.207	0.198	0.002	0.007
	≥3000 cc	km	0.239	0.229	0.003	0.008
Diesel hybrid	<1350 cc	km	0.193	0.190	0.0003	0.003
	1350 - <1600 cc	km	0.186	0.182	0.0002	0.003
	1600 - <2000 cc	km	0.247	0.243	0.0003	0.004
	2000 - <3000 cc	km	0.265	0.260	0.0003	0.004
	≥3000 cc	km	0.268	0.264	0.0004	0.004

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 35: Emission factors for light commercial vehicles manufactured between 2010 and 2015

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Petrol	<1350 cc	km	0.196	0.188	0.002	0.006
	1350 - <1600 cc	km	0.188	0.180	0.002	0.006
	1600 - <2000 cc	km	0.246	0.235	0.003	0.008
	2000 - <3000 cc	km	0.239	0.229	0.003	0.008
	≥3000 cc	km	0.276	0.264	0.003	0.009
Diesel	<1350 cc	km	0.267	0.194	0.037	0.037
	1350 - <1600 cc	km	0.190	0.186	0.0002	0.003
	1600 - <2000 cc	km	0.252	0.248	0.0003	0.004
	2000 - <3000 cc	km	0.271	0.266	0.0004	0.004
	≥3000 cc	km	0.274	0.269	0.0004	0.004
Petrol hybrid	<1350 cc	km	0.211	0.148	0.032	0.032
	1350 - <1600 cc	km	0.149	0.142	0.002	0.005
	1600 - <2000 cc	km	0.194	0.186	0.002	0.006
	2000 - <3000 cc	km	0.189	0.180	0.002	0.006
	≥3000 cc	km	0.218	0.208	0.002	0.007
Diesel hybrid	<1350 cc	km	0.177	0.174	0.0002	0.003
	1350 - <1600 cc	km	0.170	0.167	0.0002	0.003
	1600 - <2000 cc	km	0.226	0.223	0.0003	0.004
	2000 - <3000 cc	km	0.243	0.239	0.0003	0.004
	≥3000 cc	km	0.246	0.242	0.0003	0.004
Petrol plug-in hybrid electric vehicle (PHEV) – petrol consumption	<1350 cc	km	0.081	0.077	0.001	0.003
	1350 - <1600 cc	km	0.078	0.074	0.001	0.003
	1600 - <2000 cc	km	0.102	0.097	0.001	0.003
	2000 - <3000 cc	km	0.099	0.094	0.001	0.003
	≥3000 cc	km	0.114	0.109	0.001	0.004
Petrol plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.009	0.0004	0.00001
	1350 - <1600 cc	km	0.010	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.010	0.010	0.0005	0.00001
	2000 - <3000 cc	km	0.012	0.011	0.001	0.00001
	≥3000 cc	km	0.014	0.013	0.001	0.00001
Diesel plug-in hybrid electric vehicle (PHEV) – diesel consumption	<1350 cc	km	0.093	0.091	0.0001	0.001
	1350 - <1600 cc	km	0.089	0.088	0.0001	0.001
	1600 - <2000 cc	km	0.119	0.117	0.0002	0.002
	2000 - <3000 cc	km	0.127	0.125	0.0002	0.002
	≥3000 cc	km	0.129	0.127	0.0002	0.002

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Diesel plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.009	0.0004	0.00001
	1350 - <1600 cc	km	0.010	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.010	0.010	0.0005	0.00001
	2000 - <3000 cc	km	0.012	0.011	0.001	0.00001
	≥3000 cc	km	0.014	0.013	0.001	0.00001
Electricity: BEV (battery electric vehicle)	Very small	km	0.021	0.020	0.001	0.00002
	Small	km	0.020	0.019	0.001	0.00002
	Medium	km	0.022	0.021	0.001	0.00002
	Large	km	0.025	0.024	0.001	0.00002
	Very large	km	0.029	0.028	0.001	0.00003

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 36: Emission factors for light commercial vehicles manufactured post-2015

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Petrol	<1350 cc	km	0.186	0.178	0.002	0.006
	1350 - <1600 cc	km	0.179	0.171	0.002	0.006
	1600 - <2000 cc	km	0.234	0.224	0.003	0.008
	2000 - <3000 cc	km	0.227	0.217	0.003	0.007
	≥3000 cc	km	0.263	0.251	0.003	0.009
Diesel	<1350 cc	km	0.189	0.186	0.0002	0.003
	1350 - <1600 cc	km	0.182	0.179	0.0002	0.003
	1600 - <2000 cc	km	0.242	0.238	0.0003	0.004
	2000 - <3000 cc	km	0.259	0.255	0.0003	0.004
	≥3000 cc	km	0.263	0.258	0.0003	0.004
Petrol hybrid	<1350 cc	km	0.146	0.140	0.002	0.005
	1350 - <1600 cc	km	0.140	0.134	0.002	0.005
	1600 - <2000 cc	km	0.183	0.175	0.002	0.006
	2000 - <3000 cc	km	0.178	0.171	0.002	0.006
	≥3000 cc	km	0.206	0.197	0.002	0.007
Diesel hybrid	<1350 cc	km	0.170	0.167	0.0002	0.003
	1350 - <1600 cc	km	0.163	0.161	0.0002	0.003
	1600 - <2000 cc	km	0.218	0.214	0.0003	0.003
	2000 - <3000 cc	km	0.233	0.229	0.0003	0.004
	≥3000 cc	km	0.236	0.232	0.0003	0.004

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Petrol PHEV	<1350 cc	km	0.077	0.073	0.001	0.002
	1350 - <1600 cc	km	0.073	0.070	0.001	0.002
	1600 - <2000 cc	km	0.096	0.092	0.001	0.003
	2000 - <3000 cc	km	0.093	0.089	0.001	0.003
	≥3000 cc	km	0.108	0.103	0.001	0.004
Electricity: petrol PHEV	<1350 cc	km	0.010	0.009	0.0004	0.00001
	1350 - <1600 cc	km	0.009	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.010	0.010	0.0005	0.00001
	2000 - <3000 cc	km	0.012	0.011	0.001	0.00001
	≥3000 cc	km	0.012	0.011	0.001	0.00001
Diesel PHEV	<1350 cc	km	0.089	0.087	0.0001	0.001
	1350 - <1600 cc	km	0.086	0.084	0.0001	0.001
	1600 - <2000 cc	km	0.114	0.112	0.0001	0.002
	2000 - <3000 cc	km	0.122	0.120	0.0002	0.002
	≥3000 cc	km	0.124	0.122	0.0002	0.002
Electricity: diesel PHEV	<1350 cc	km	0.010	0.009	0.0004	0.00001
	1350 - <1600 cc	km	0.009	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.010	0.010	0.0005	0.00001
	2000 - <3000 cc	km	0.012	0.011	0.001	0.00001
	≥3000 cc	km	0.014	0.013	0.001	0.00001
Electricity: BEV	Very small	km	0.020	0.019	0.001	0.00002
	Small	km	0.019	0.019	0.001	0.00002
	Medium	km	0.021	0.020	0.001	0.00002
	Large	km	0.024	0.023	0.001	0.00002
	Very large	km	0.029	0.027	0.001	0.00003

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 37: 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	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Petrol	km	0.262	0.251	0.003	0.009
Diesel	km	0.296	0.291	0.0004	0.005
Petrol hybrid	km	0.207	0.198	0.002	0.007
Diesel hybrid	km	0.265	0.260	0.0003	0.004

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

7.2.2. Heavy goods vehicles emission factors

Table 38: Emission factors for heavy goods vehicles manufactured pre-2010

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
HGV diesel	<5,000 kg	km	0.451	0.444	0.001	0.007
	5,000 - <7,500 kg	km	0.455	0.447	0.001	0.007
	7,500 - <10,000 kg	km	0.630	0.619	0.001	0.010
	10,000 - <12,000 kg	km	0.706	0.694	0.001	0.011
	12,000 - <15,000 kg	km	0.873	0.859	0.001	0.014
	15,000 - <20,000 kg	km	0.944	0.928	0.001	0.015
	20,000 - <25,000 kg	km	1.253	1.232	0.002	0.020
	25,000 - <30,000 kg	km	1.384	1.360	0.002	0.022
	≥30,000 kg	km	1.435	1.411	0.002	0.022
HGV diesel hybrid	<5,000 kg	km	0.382	0.358	0.002	0.022
	5,000 - <7,500 kg	km	0.367	0.360	0.0005	0.006
	7,500 - <10,000 kg	km	0.508	0.499	0.001	0.008
	10,000 - <12,000 kg	km	0.569	0.559	0.001	0.009
	12,000 - <15,000 kg	km	0.704	0.692	0.001	0.011
	15,000 - <20,000 kg	km	0.858	0.843	0.001	0.013
	20,000 - <25,000 kg	km	1.139	1.120	0.001	0.018
	25,000 - <30,000 kg	km	1.301	1.278	0.002	0.020
	≥30,000 kg	km	1.349	1.326	0.002	0.021

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 39: Emission factors for heavy goods vehicles manufactured between 2010 and 2015

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
HGV diesel	<5,000 kg	km	0.428	0.420	0.001	0.007
	5,000 - <7,500 kg	km	0.431	0.424	0.001	0.007
	7,500 - <10,000 kg	km	0.597	0.587	0.001	0.009
	10,000 - <12,000 kg	km	0.669	0.657	0.001	0.010
	12,000 - <15,000 kg	km	0.828	0.814	0.001	0.013
	15,000 - <20,000 kg	km	0.897	0.882	0.001	0.014
	20,000 - <25,000 kg	km	1.191	1.171	0.002	0.019
	25,000 - <30,000 kg	km	1.315	1.293	0.002	0.021
	≥30,000 kg	km	1.366	1.342	0.002	0.021
HGV diesel hybrid	<5,000 kg	km	0.346	0.340	0.001	0.005
	5,000 - <7,500 kg	km	0.349	0.343	0.001	0.005
	7,500 - <10,000 kg	km	0.483	0.475	0.001	0.008
	10,000 - <12,000 kg	km	0.541	0.532	0.001	0.008
	12,000 - <15,000 kg	km	0.670	0.658	0.001	0.010
	15,000 - <20,000 kg	km	0.816	0.802	0.001	0.013
	20,000 - <25,000 kg	km	1.084	1.066	0.001	0.017
	25,000 - <30,000 kg	km	1.238	1.217	0.002	0.019
	≥30,000 kg	km	1.284	1.262	0.002	0.020
HGV BEV (battery electric vehicle)	<5,000 kg	km	0.044	0.042	0.002	0.00004
	5,000 - <7,500 kg	km	0.044	0.042	0.002	0.00004
	7,500 - <10,000 kg	km	0.061	0.058	0.003	0.0001
	10,000 - <12,000 kg	km	0.068	0.065	0.003	0.0001
	12,000 - <15,000 kg	km	0.085	0.081	0.004	0.0001

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 40: Emission factors for heavy goods vehicles manufactured post-2015

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
HGV diesel	<5,000 kg	km	0.423	0.416	0.001	0.007
	5,000 - <7,500 kg	km	0.426	0.419	0.001	0.007
	7,500 - <10,000 kg	km	0.591	0.580	0.001	0.009
	10,000 - <12,000 kg	km	0.661	0.650	0.001	0.010
	12,000 - <15,000 kg	km	0.818	0.805	0.001	0.013
	15,000 - <20,000 kg	km	0.897	0.882	0.001	0.014
	20,000 - <25,000 kg	km	1.191	1.171	0.002	0.019
	25,000 - <30,000 kg	km	1.315	1.292	0.002	0.021
	≥30,000 kg	km	1.364	1.341	0.002	0.021
HGV diesel hybrid	<5,000 kg	km	0.346	0.340	0.0005	0.005
	5,000 - <7,500 kg	km	0.348	0.343	0.0005	0.005
	7,500 - <10,000 kg	km	0.483	0.474	0.001	0.008
	10,000 - <12,000 kg	km	0.541	0.531	0.001	0.008
	12,000 - <15,000 kg	km	0.669	0.658	0.001	0.010
	15,000 - <20,000 kg	km	0.815	0.801	0.001	0.013
	20,000 - <25,000 kg	km	1.082	1.064	0.001	0.017
	25,000 - <30,000 kg	km	1.236	1.215	0.002	0.019
	≥30,000 kg	km	1.282	1.260	0.002	0.020
HGV BEV	<5,000 kg	km	0.043	0.041	0.002	0.00004
	5,000 - <7,500 kg	km	0.043	0.041	0.002	0.00004
	7,500 - <10,000 kg	km	0.060	0.057	0.003	0.0001
	10,000 - <12,000 kg	km	0.067	0.064	0.003	0.0001
	12,000 - <15,000 kg	km	0.083	0.079	0.004	0.0001

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 41 contains the default emission factors for heavy goods vehicles, based on a pre-2010 fleet and a gross vehicle mass of <7500 kg.

Table 41: Default emission factors for heavy goods vehicles

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
HGV diesel	km	0.455	0.447	0.001	0.007
HGV diesel hybrid	km	0.367	0.360	0.0005	0.006

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 42 contains emission factors for freighting goods.

Table 42: Emission factors for freighting goods

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Road freight by truck	tkm	0.136	0.134	0.0002	0.002

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

7.2.3. GHG inventory development

If an organisation uses freight vehicles, they can calculate the emissions from the kilometres travelled. Multiply the distances by the emission factors in table 34 to table 41. Applying the equation in section 2, this means:

Q = km travelled by specific freight vehicle
F = appropriate emission factors from table 34 to table 41

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 tonne-kilometre (tkm). Multiply the tkm by the emission factors in table 42. Applying the equation in section 2, this means:

Q = tonne × kilometres travelled
F = appropriate emission factors from table 42

ROAD FREIGHT: EXAMPLE CALCULATION

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

For the 10 tonnes moved by truck:

CO_2 emissions	= 10 × 100 × 0.134	= 134 kg CO_2-e
CH_4 emissions	= 10 × 100 × 0.0002	= 0.2 kg CO_2-e
N_2O emissions	= 10 × 100 × 0.002	= 2 kg CO_2-e
Total CO_2-e emissions	= 10 × 100 × 0.136	= 136 kg CO_2-e

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

For the goods moved by van:

CO_2 emissions	= 800 × 0.235	= 188 kg CO_2-e
CH_4 emissions	= 800 × 0.003	= 2.4 kg CO_2-e
N_2O emissions	= 800 × 0.008	= 6.4 kg CO_2-e
Total CO_2-e emissions	= 800 × 0.246	= 197 kg CO_2-e

Total CO_2-e emission from freighted goods = 136 + 197 = 333 kg CO_2-e

Note: Numbers may not add due to rounding.

7.2.4. Emission factor derivation methodology

The *EI report*[36] supports a dataset of projected real-world fuel consumption rates in MoT's Vehicle Fleet Emission Model. The EI report categorises freight as light commercial and heavy goods vehicles. The litres of fuel (or kWh of electricity) consumed per 100 km are provided in table 43 and table 44.

Table 43: Light commercial vehicles (energy consumption per 100 km)

Emission source		Units	Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
Petrol	<1350 cc	litres	8.75	8.00	7.59
	1350 - <1600 cc	litres	8.41	7.68	7.29
	1600 - <2000 cc	litres	10.98	10.03	9.53
	2000 - <3000 cc	litres	10.68	9.75	9.26
	≥3000 cc	litres	12.34	11.27	10.70
Diesel	<1350 cc	litres	7.99	7.31	7.01
	1350 - <1600 cc	litres	7.69	7.04	6.74
	1600 - <2000 cc	litres	10.23	9.37	8.98
	2000 - <3000 cc	litres	10.97	10.05	9.63
	≥3000 cc	litres	11.11	10.17	9.75
Petrol hybrid	<1350 cc	litres	6.91	6.30	5.96
	1350 - <1600 cc	litres	6.64	6.05	5.72
	1600 - <2000 cc	litres	8.67	7.91	7.48
	2000 - <3000 cc	litres	8.43	7.69	7.27
	≥3000 cc	litres	9.74	8.89	8.40
Diesel hybrid	<1350 cc	litres	7.16	6.56	6.31
	1350 - <1600 cc	litres	6.89	6.32	6.07
	1600 - <2000 cc	litres	9.17	8.41	8.08
	2000 - <3000 cc	litres	9.83	9.01	8.66
	≥3000 cc	litres	9.96	9.13	8.77
Petrol PHEV – petrol consumption	<1350 cc	litres	3.62	3.30	3.12
	1350 - <1600 cc	litres	3.47	3.17	3.00
	1600 - <2000 cc	litres	4.54	4.14	3.91
	2000 - <3000 cc	litres	4.41	4.02	3.80
	≥3000 cc	litres	5.10	4.65	4.40

[36] Real-world energy use projections for VFEM (Report prepared for MoT), Emission Impossible, 2016

Emission source		Units	Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
Petrol PHEV – electricity consumption	<1350 cc	kWh	11.07	10.18	9.90
	1350 - <1600 cc	kWh	10.63	9.78	9.51
	1600 - <2000 cc	kWh	11.65	10.72	10.42
	2000 - <3000 cc	kWh	13.18	12.13	11.79
	≥3000 cc	kWh	15.59	14.34	13.95
Diesel PHEV – diesel consumption	<1350 cc	litres	3.75	3.43	3.30
	1350 - <1600 cc	litres	3.61	3.31	3.18
	1600 - <2000 cc	litres	4.80	4.40	4.23
	2000 - <3000 cc	litres	5.15	4.72	4.53
	≥3000 cc	litres	5.21	4.78	4.59
Diesel PHEV – electricity consumption	<1350 cc	kWh	11.07	10.18	9.90
	1350 - <1600 cc	kWh	10.63	9.78	9.51
	1600 - <2000 cc	kWh	11.65	10.72	10.42
	2000 - <3000 cc	kWh	13.18	12.13	11.79
	≥3000 cc	kWh	15.59	14.34	13.95
BEV – electricity consumption	<1350 cc	kWh	23.22	21.36	20.77
	1350 - <1600 cc	kWh	22.30	20.52	19.95
	1600 - <2000 cc	kWh	24.44	22.48	21.86
	2000 - <3000 cc	kWh	27.66	25.44	24.74
	≥3000 cc	kWh	32.71	30.09	29.26

Table 44: 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	16.75	15.87	15.70
	5,000 - <7,500 kg	litres	16.89	16.00	15.83
	7,500 - <10,000 kg	litres	23.39	22.17	21.92
	10,000 - <12,000 kg	litres	26.20	24.82	24.55
	12,000 - <15,000 kg	litres	32.42	30.72	30.38
	15,000 - <20,000 kg	litres	35.03	33.30	33.29
	20,000 - <25,000 kg	litres	46.52	44.23	44.21
	25,000 - <30,000 kg	litres	51.36	48.83	48.80
	≥30,000 kg	litres	53.27	50.65	50.62
HGV diesel hybrid	<5,000 kg	litres	13.50	12.84	12.83
	5,000 - <7,500 kg	litres	13.61	12.94	12.93
	7,500 - <10,000 kg	litres	18.85	17.92	17.92
	10,000 - <12,000 kg	litres	21.12	20.07	20.06
	12,000 - <15,000 kg	litres	26.13	24.84	24.83
	15,000 - <20,000 kg	litres	31.84	30.27	30.26
	20,000 - <25,000 kg	litres	42.29	40.20	40.18
	25,000 - <30,000 kg	litres	48.28	45.90	45.87
	≥30,000 kg	litres	50.08	47.61	47.58
HGV BEV (battery electric vehicle)	<5,000 kg	kWh	6.96	6.59	6.52
	5,000 - <7,500 kg	kWh	7.01	6.65	6.57
	7,500 - <10,000 kg	kWh	9.72	9.20	9.10
	10,000 - <12,000 kg	kWh	10.88	10.31	10.19
	12,000 - <15,000 kg	kWh	13.46	12.76	12.61

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

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

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 5.

The default emission factors for freighting vehicles include the following assumptions based on the MoT NZ Vehicle Fleet 2016:[37]

- Light commercial vehicles are on average 12.8 years old[38] and the most common engine size is 2000-3000 cc, therefore we used a pre-2010 fleet and a 2000-3000 cc engine size for the default values.
- Heavy trucks are on average 17.7 years old and the most common gross vehicle mass is <7500 km, therefore we selected a pre-2010 vehicle fleet with a gross vehicle mass of <7500 kg.

Emission factors for freighting goods (tkm) are from 'What We Know and Don't Know About Freight Emissions by Mode',[39] an unpublished report by Ralph Samuelson (MoT).

> Based on the New Zealand Ministry of Transport's Vehicle Fleet Emission Model (VFEM), emissions in calendar year 2016[40] (the last year for which historical data on both emissions and tonne-kms are available) for heavy trucks (>10,000 kg gross vehicle mass[41]) were 2.759 billion kg CO_2-e, while emissions for 'medium trucks' (>3500 kg gross vehicle mass) were 0.443 billion kg CO_2-e, for total medium and heavy truck emissions of 3.201 billion kg CO_2-e. Based on estimates developed from truck road user charge (RUC) returns and the NZTA's truck weigh-in-motion statistics,[42] net tonne-kilometres in the same year were 23,577 million. Dividing the two gives 136 g CO_2-e/tonne km.

Table 45: Data used to calculate the road freight (tkm) emission factor

Calculation components	Value	Source
For heavy trucks (>10,000 kg gross vehicle mass)	2.543 billion kg CO_2-e	MoT's Vehicle Fleet Emission Model (VFEM)
Medium trucks (>3500 kg gross vehicle mass)	0.437 billion kg CO_2-e	MoT's Vehicle Fleet Emission Model (VFEM)
Annual net tkm	23,577 million	2017 New Zealand Vehicle Fleet Annual spreadsheet

As most heavy goods vehicles are diesel, we used the information in table 46 to calculate the ratio of carbon dioxide, methane and nitrous oxide.

---

37 *www.transport.govt.nz/assets/Uploads/Research/Documents/Fleet-reports/The-NZ-Vehicle-Fleet-2016-web.pdf*

38 MoT, RD025 Average vehicle fleet age, source: *www.transport.govt.nz/resources/transport-dashboard/2-road-transport/rd025-average-vehicle-fleet-age-years/*

39 What We Know and Don't Know About Freight Emissions by Mode, Ralph D Samuelson, 14 June 2018

40 This model version of the model has not yet been published, but may be obtained upon request from the author.

41 See table 1 of the *Transport Outlook Vehicle Fleet Emissions Model* documentation available at *www.transport.govt.nz/assets/Uploads/Research/Transport-Outlook/Documents/Vehicle-Fleet-Emissions-Model-Documentation-20180125.pdf*, which defines "medium trucks" as <10,000 kg gross vehicle mass.

42 These estimates are in the 2017 New Zealand Vehicle Fleet Annual spreadsheet, tab 11.1,11.2, at *www.transport.govt.nz/resources/vehicle-fleet-statistics/*

Table 46: Calculating the ratio of gases in diesel

Information	kg CO_2-e	kg CO_2	kg CH_4	kg N_2O
Diesel emission factors (litres)	2.6939	2.6482	0.0035	0.0422
Calculation to get ratio of gases		= kg CO_2/kg CO_2-e	= kg CH_4/kg CO_2-e	= kg N_2O/kg CO_2-e
Multiplier factor to calculate losses		0.9830	0.0013	0.0157

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

We multiplied the 0.136 kg CO_2-e result by the calculated factor to provide emission factors broken down by gas type.

7.2.5. Assumptions, limitations and uncertainties

The VFEM 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 road user charge (RUC) returns and the NZTA's 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.

7.3. 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 47.

Table 47: Emission factors for rail freight

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Rail freight	tkm	0.028	0.027	0.00004	0.0004

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

7.3.1. 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 in section 2, this means:

Q = tonnes of freight × km travelled
F = emission factors in table 47

RAIL FREIGHT: EXAMPLE CALCULATION

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

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

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

CO_2 emissions	= 4,800 × 0.027	= 129.6 kg CO_2-e
CH_4 emissions	= 4,800 × 0.00004	= 0.2 kg CO_2-e
N_2O emissions	= 4,800 × 0.0004	= 1.9 kg CO_2-e
Total CO_2-e emissions	= 4,800 × 0.028	= 134 kg CO_2-e

Note: Numbers may not add due to rounding.

7.3.2. Emission factor derivation methodology

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

Table 48: Information provided by KiwiRail

Calculation component	Unit	Amount in 2016
Freight-only fuel	litres	45,726,454
Freight volumes (net)	NTKs (000s)	4,428,930
Electricity (net) North Island Main Trunk (NIMT)	kWh	22,251,462

Note: NTK is (net tonnes + third-party container tare weight) × rail distance

To calculate emissions from freight-only fuel, multiply the litres by the diesel emission factor in table 5:

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

To calculate emissions from electricity, multiply the net kWh by the emission factors in table 12:

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

To calculate emissions from transmission and distribution losses from the purchased electricity, multiply the kWh by the emission factors in table 14:

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

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

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

7.3.3. 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 travel by road. Therefore, these figures reflect the actual freight (including the weight of empty and loaded containers) that KiwiRail moved.

7.4. Air freight

In the absence of New Zealand data, we have adopted the air freight emission factors from the *UK BEIS publication*. We provide emission factors with and without radiative forcing. Please refer to section 6.4 for further guidance on radiative forcing to inform your choice of emission factor.

Table 49: Air freight emission factors with radiative forcing multiplier

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Domestic air freight	tkm	5.833	5.802	0.002	0.029
Short haul	tkm	1.947	1.937	0.0001	0.010
Long haul	tkm	1.232	1.226	0.00004	0.006

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 50: Air freight emissions without radiative forcing multiplier

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Domestic air freight	tkm	3.085	3.054	0.002	0.029
Short haul	tkm	1.029	1.020	0.0001	0.010
Long haul	tkm	0.651	0.645	0.00004	0.006

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

7.4.1. 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 in section 2, this means:

Q = tonnes of freight × km travelled
F = appropriate emission factors in table 49 or table 50

AIR FREIGHT: EXAMPLE CALCULATION

During the reporting period, an organisation air freights 0.5 tonnes of materials 10,000 km. This occurs six times in the reporting year. The organisation decides to use emission factors with the radiative forcing multiplier applied.

To calculate tkm: 0.5 × 10,000 × 6 = 30,000 tkm

Use long-haul emission factors because the journey is more than 3,700 km:

CO_2 emissions	= 30,000 × 1.226	= 36,780 kg CO_2-e
CH_4 emissions	= 30,000 × 0.00004	= 1.2 kg CO_2-e
N_2O emissions	= 30,000 × 0.006	= 180 kg CO_2-e
Total CO_2-e emissions	= 30,000 × 1.232	= 36,960 kg CO_2-e

Note: Numbers may not add due to rounding.

7.4.2. Emission factor derivation methodology

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

7.4.3. Assumptions, limitations and uncertainties

As we adopted these emission factors from the UK BEIS emissions for air freight to and from the UK, we assume the same factors apply to New Zealand. We have not considered the difference in the size of aircraft transporting domestic air freight – this limits the accuracy of these emission factors to truly reflect New Zealand domestic air freight.

We included the emission factors with radiative forcing to account for the global warming potential (GWP) of emissions arising from aircraft transport at altitude (jet aircraft). The radiative forcing multiplier of 1.9 is based on current scientific evidence and research.[43,44]

---

43 R Sausen et al (2005). Aviation radiative forcing in 2000: An update on IPCC (1999) Meteorologische Zeitschrift 14: 555-561, available at: *http://elib.dlr.de/19906/1/s13.pdf*

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

7.5. Coastal and international shipping freight

We calculated the domestic coastal shipping emission factor, table 51, based on the findings from the Samuelson paper.[45] We adopted the international shipping emission factors in table 52 from the *UK BEIS emission factors*.

Table 51: Coastal shipping emission factors

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Container freight	tkm	0.045	0.045	0.0001	0.0003
Oil products	tkm	0.016	0.016	0.00004	0.0001
Other bulk coastal shipping	tkm	0.030	0.030	0.0001	0.0002

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 52: International shipping emission factors

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Bulk carrier	200,000+ dwt	tkm	0.003	0.003	0.000001	0.00003
	100,000–199,999 dwt	tkm	0.003	0.003	0.000001	0.00004
	60,000–99,999 dwt	tkm	0.004	0.004	0.000001	0.0001
	35,000–59,999 dwt	tkm	0.006	0.006	0.000002	0.0001
	10,000–34,999 dwt	tkm	0.008	0.008	0.000003	0.0001
	0–9,999 dwt	tkm	0.030	0.029	0.00001	0.0004
	Average	tkm	0.006	0.006	0.000002	0.0001
General cargo	10,000+ dwt	tkm	0.012	0.012	0.000004	0.0002
	5,000–9,999 dwt	tkm	0.016	0.016	0.00001	0.0002
	0–4,999 dwt	tkm	0.014	0.014	0.00001	0.0002
	10,000+ dwt 100+ TEU	tkm	0.011	0.011	0.000004	0.0002
	5,000–9,999 dwt 100+ TEU	tkm	0.018	0.018	0.00001	0.0002
	0–4,999 dwt 100+ TEU	tkm	0.020	0.020	0.00001	0.0003
	Average	tkm	0.012	0.012	0.000004	0.0002
Container ship	8,000+ TEU	tkm	0.013	0.013	0.000004	0.0002
	5,000–7,999 TEU	tkm	0.017	0.017	0.00001	0.0002
	3,000–4,999 TEU	tkm	0.017	0.017	0.00001	0.0002
	2,000–2,999 TEU	tkm	0.020	0.020	0.00001	0.0003
	1,000–1,999 TEU	tkm	0.033	0.032	0.00001	0.0004
	0–999 TEU	tkm	0.037	0.036	0.00001	0.0005
	Average	tkm	0.020	0.020	0.00001	0.0003
	4,000+ CEU	tkm	0.032	0.032	0.00001	0.0004

[45] What We Know and Don't Know About Freight Emissions by Mode, Ralph D Samuelson, 20 November 2018

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Vehicle transport	0–3,999 CEU	tkm	0.058	0.058	0.00002	0.001
	Average	tkm	0.039	0.038	0.00001	0.001
RoRo (roll-on, roll-off) ferry	2,000+ LM	tkm	0.050	0.050	0.00002	0.001
	0–1,999 LM	tkm	0.061	0.060	0.00002	0.001
	Average	tkm	0.052	0.051	0.00002	0.001
Refrigerated cargo	All dwt	tkm	0.013	0.013	0.000004	0.0002

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.
dwt = deadweight tonnes. TEU = twenty-foot equivalent unit. CEU = car equivalent unit. LM = lanemetre.

7.5.1. 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 in section 2, this means:

Q = tonnes of freight × km travelled
F = appropriate emission factors from table 51 or table 52

MULTIPLE FREIGHT MODES: EXAMPLE CALCULATION

A company sends 300 kg of its product to a customer. It travels by road freight 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 × 0.136 = 2.04 kg CO_2-e

Coastal shipping emissions:

0.3 tonnes × 500km = 150 tkm
150 tkm × 0.045 = 6.75 kg CO_2-e

Rail freight emissions:

0.3 tonnes × 250km = 75 tkm
75 tkm × 0.028 = 2.1 kg CO_2-e

Total freight emissions:

2.04 + 6.75 + 2.1 = 10.89 kg CO_2-e

Note: Numbers may not add due to rounding.

7.5.2. Emission factor derivation methodology

We based the emission factors for coastal shipping on research and reviews of international comparisons for shipping in the Samuelson paper.[46] Samuelson indicates the following emission factors as a starting point for estimating freight emissions by mode:

- coastal shipping (container freight): 45 g CO_2-e/tkm
- coastal shipping (oil products): 16 g CO_2-e/tkm
- coastal shipping (other bulk): 30 g CO_2-e/tkm.

We assumed transport fuel for coastal shipping is heavy fuel oil, and therefore applied the ratio of carbon dioxide, methane and nitrous oxide to provide a breakdown by gas. Table 46 contains the ratio.

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

We identified the following shipping types as visiting New Zealand:

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

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

- Bulk carrier is 36,900 dwt and therefore in the 35,000–59,999 dwt category.
- General cargo is 15,800 dwt and therefore in the 10,000+ dwt category.
- Container ship is 2923 TEU and therefore in the 2000–2999 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.

---

[46] What We Know and Don't Know About Freight Emissions by Mode, Ralph D Samuelson, 20 November 2018

[47] Freight Information Gathering System, accessed via: *www.transport.govt.nz/resources/freight-resources/figs/containers/figs-new-zealand-trends/*

[48] Freight Information Gathering System, overseas ships, accessed via: *www.transport.govt.nz/resources/freight-resources/figs/overseas-ship-visits/*

Emission factors for these have been adopted from the UK BEIS 2018 Guidance.[49] Please refer to that document for details on the methodology.

7.5.3. Assumptions, limitations and uncertainties

We assumed the New Zealand coastal shipping fleet is similar to that in the *STREAM Freight Handbook*. These figures are highly uncertain as there is no New Zealand-specific data on either coastal shipping fuel or coastal shipping tkm.

We carried over the assumptions for the international shipping emission factors from the UK BEIS 2018 emission factors. As they are based on international data, there is a low level of uncertainty with these emission factors.

[49] UK BEIS 2018 Guidance, accessed via: *www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018*

8. 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 NZ.

8.1. Overview of changes since previous update

This is a new emission factor category for this version of the guide. Emissions result from energy use in water supply and wastewater treatment plants. Some plants also generate emissions when treating organic matter. We have developed emission factors for water supply and domestic and industrial wastewater treatment. We provide industrial wastewater treatment factors for five industries. Emissions from the supply of water and wastewater treatment are indirect (Scope 3) if the organisation does not own or control the facilities.

8.2. Water supply

Table 53 provides water supply emission factors. We calculated the factors using Water NZ data.

Table 53: Water supply emission factors

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Water supply	m^3	0.0313	0.0299	0.0014	0.00003
	Per capita	4.07	3.89	0.183	0.0036

Note: These numbers are rounded to three significant figures unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

8.2.1. GHG inventory development

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

Applying the equation in section 2, this means:

Q = quantity of water used (m^3) or persons using water supply (per capita)
F = appropriate emission factors from table 53

WATER SUPPLY: EXAMPLE CALCULATION

An organisation's assets have water meters. Throughout the reporting year they use 1000 m^3 of water.

CO_2 emissions	= 1,000 × 0.0299	= 29.9 kg CO_2
CH_4 emissions	= 1,000 × 0.0014	= 1.4 kg CO_2-e
N_2O emissions	= 1,000 × 0.00003	= 0.03 kg CO_2-e
Total CO_2-e emissions	= 1,000 × 0.0313	= 31.3 kg CO_2-e

Note: Numbers may not add due to rounding.

8.2.2. Emission factor derivation methodology

We adopted the Water NZ 2016/17 National Performance Review[50] methodology to calculate the water supply emission factors. The Water NZ review gathered data from participating water industry bodies, which represent approximately 86 per cent of New Zealand's population. Thirty participants in the survey provided reliable information on the energy use of their water systems, which was used to calculate national averages. In the 2016/17 period, the operation of water supply pumps used 579 TJ of energy to supply 501 million m^3 of water, and treatment plants used an estimated 1094 TJ of energy in the treatment of about 366 million m^3 of water. This equates to a median energy intensity of 1.2 MJ of energy per cubic metre of water supplied and 3.0 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:

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

Where:

- energy use = the 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).

This equation gives the emissions per m^3 of water supplied.

If organisations don't 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 130 m^3 of water per person per year, which is calculated from the following equations and information:

[50] View the report at: *www.waternz.org.nz/NationalPerformanceReview*

Equation 1:

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

Equation 2:

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

Where:

- m^3 of water supplied nationwide is 550,000,000[51]
- population served by WWTP is approximately 4.22 million.[52]

8.2.3. Assumptions, limitations and uncertainties

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

The assumptions used for water supply per person are inherently uncertain and organisations should only use them in the absence of water volume data. They do not account for factors such as seasonal use of water, water-intensive activities such as gardening, lifestyle choices and geography, and therefore per person water supply reflects only an average. Furthermore, the figure is based on a national average of water usage throughout the year and will overestimate emissions from office use per capita. This is because employees do not spend 100 per cent of their time in the office, and it is likely that most of their water usage will be outside working hours.

8.3. Wastewater treatment

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 54 and table 55. Some industries produce wastewater that is particularly high in biological oxygen demand (BOD). For this reason, we developed industrial wastewater emission factors for the meat, poultry, pulp and paper, wine and dairy sectors. Manufacturing organisations in these sectors should use the specific industrial wastewater factors. All other organisations should use the domestic wastewater factor.

---

[51] WaterNZ report *www.waternz.org.nz/Attachment?Action=Download&Attachment_id=3142*

[52] Ministry for the Environment's WWTP database

Table 54: Domestic wastewater treatment emission factors

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Wastewater treatment plants	m^3 water supplied	0.447	0.077	0.151	0.218
	per capita	48.5	8.4	16.4	23.7
Septic tanks	per capita	0.202	n/a	0.202	n/a

Note: These numbers are rounded to three significant figures unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 55: Industrial wastewater treatment emission factors

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Meat (excluding poultry)	tonne of kills	47.5	n/a	44.7	2.8
Poultry	tonne of kills	47.0	n/a	43.0	4.1
Pulp and paper	tonne of product	10.5	n/a	10.5	n/a
Wine	tonne of crushed grapes	5.17	n/a	5.17	n/a
Dairy processing	m^3 of milk	0.119	n/a	n/a	0.119

Note: These numbers are rounded to three significant figures unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

8.3.1. GHG inventory development

Domestic water users should collect data on m^3 of water sent to treatment. In the absence of this information, apply the per capita emission factor. Industrial organisations can calculate the emissions using appropriate activity data and the correlating emission factors.

Applying the equation in section 2, this means:

Q = quantity of water treated (m^3) or persons using water facilities (per capita)
F = appropriate emission factors from table 54 and table 55

WASTEWATER: EXAMPLE CALCULATION

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

The office wastewater is domestic, therefore:

CO_2 emissions = 100 × 0.077 = 7.7 kg CO_2
CH_4 emissions = 100 × 0.151 = 15.1 kg CO_2-e
N_2O emissions = 100 × 0.218 = 21.8 kg CO_2-e
Total CO_2-e emissions = 100 × 0.447 = 44.7 kg CO_2-e

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

CO_2 emissions = n/a
CH_4 emissions = 10 × 5.17 = 51.7 kg CO_2-e
N_2O emissions = n/a
Total CO_2-e emissions = 10 × 5.17 = 51.7 kg CO_2-e

The total wastewater emissions are:

$44.7 + 51.7 \quad = 96.4$ kg CO_2-e

Note: Numbers may not add due to rounding.

8.3.2. Emission factor derivation methodology

8.3.2.1. 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.

There are no direct carbon dioxide emissions from wastewater treatment, only methane and nitrous oxide. We calculated these using equations in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories.*[53]

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:

- 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:

- MCF = 0.02425, the weighted-average methane correction factor (MCF) for wastewater treatment plants in 2016
- B_0 = 0.625, converts the BOD to maximum potential methane emissions
- TOW = the total organic product in wastewater from the equation above
- GWP = 25, converts methane into CO_2-e

53 *www.ipcc-nggip.iges.or.jp/public/2006gl/*

- 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 (109 m^3).

Use the same equation to calculate the methane emissions from septic tanks, except that the MCF for septic tanks is 0.4. There are no nitrous oxide emissions from septic tanks due to the treatment process, if managed properly.

To calculate nitrous oxide emissions from wastewater treatment plants we used the following equations:

$$per\ capita\ nitrogen\ in\ effluent\ (kg\ N\ per\ year) = protein\ \times F_{NPR} \times F_{NON-CON} \times F_{IND-COM}$$

Where:

- protein = annual per capita protein consumption (36.135 kg per year from Beca, 2007)
- F_{NPR} = fraction of nitrogen in protein (0.16, IPCC default)
- $F_{NON\text{-}CON}$ = factor for non-consumed protein added to the wastewater (1.4, IPCC default)
- $F_{IND\text{-}COM}$ = factor for industrial and commercial co-discharged protein into the sewer system (1.25, IPCC default).

Table 56: 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,[54] 99g/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:

$$N_2O\ emissions\ (kg\ CO_2\ e\ per\ capita) = per\ capita\ nitrogen\ in\ effluent\ \times EF_{effluent} \times \frac{44}{28} \times GWP$$

Where:

- per capita nitrogen in effluent = from equation above
- effluent = emission factor of 0.005 kg N_2O-N/kg N (IPCC default)

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

- 44/28 ratio of N_2O to N_2
- GWP = 298 for N_2O (IPCC default AR4).

Divide these emissions per capita by the average volume of water treated (109 m^3) per person to give the emissions per m^3.

8.3.2.2. 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 production (kg CODb)/t
- EF = emission factor in kg methane/kg COD
- GWP = global warming potential.

The following tables (table 57 and table 58) detail the information used in the calculations to provide the industrial wastewater treatment emission factors.

Table 57: Industrial wastewater treatment methane emissions calculation information

Factor	Industry				Source
	Pulp and paper	Meat (excluding poultry)	Poultry	Wine	
Biodegradable chemical oxygen demand load (kg CODb/tonne)	36	50	50	12.42	Cardno (2015)
CH_4 emission factor (kg CH_4/kg CODb)	0.0117	0.03575	0.034375	0.016661	Cardno (2015)
GWP	25	25	25	25	IPCC default AR4

It is assumed that the methods used to treat wastewater from dairy processing do not result in methane emissions.

The equation used to calculate nitrous oxide emissions is:

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

Where:

- mbCOD = unit biodegradable COD load (kg CODb/t)
- N:COD = total nitrogen to biodegradable COD ratio
- EF = emission factor
- 44/28 = ratio of N_2O to N_2
- GWP = global warming potential.

The following table details the information used in the calculations to provide the industrial wastewater treatment emission factors. Note that for dairy processing, users should first convert the quantity of milk to tonnes using a density factor of 1.031 tonnes per m^3.

Table 58: Industrial wastewater treatment nitrous oxide emissions calculation information

Factor	Industry			Source
	Dairy product processing	Meat (excluding poultry)	Poultry	
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	298	298	298	IPCC default AR4

Based on the Cardno 2015 report we assume that there are no nitrous oxide emissions from the methods used to process wastewater from the wine and pulp and paper industries.

8.3.3. 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 59 details the uncertainties with this source category.

Table 59: 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%

9. Materials and waste emission factors

9.1. Overview of changes since previous update

There have been several major changes in the tenth version of the guide:

- we added emission factors for commonly used construction materials
- we separated the emission factors for food and garden waste, and paper and textiles.

Since the previous guide, we have aligned the categories more closely to the national inventory.

9.2. Construction materials

We worked with BRANZ,[55] who provided the emission conversion factors for the emission sources, to create this new section of the guide. These emissions are indirect (Scope 3) if the organisation does not own or control the facilities making the materials.

Due to the limited availability of New Zealand-specific data, we decided to publish emission conversion factors for three core construction materials: concrete, steel and aluminium. In the future, as data become available, there may be an opportunity to reflect the embodied GHG emissions for a broader spectrum of construction materials in New Zealand.

The emission conversion factors do not allow for the breakdown of individual Kyoto Protocol gases. Therefore, the conversion factors are for carbon dioxide equivalents only. Users should also note the emission factors are for embodied emissions only and do not include the GHG benefit of recycling at end-of-life. Users should calculate emissions from construction taking place in the reporting year.

Table 60: Construction materials emission factors

Emission source		Unit	kg CO_2-e/unit
Concrete	Default	kg	0.148
	17.5 megapascals (MPa)	kg	0.109
	20 MPa	kg	0.113
	25 MPa	kg	0.123
	30 MPa	kg	0.133
	35 MPa	kg	0.149
	40 MPa	kg	0.172
	45 MPa	kg	0.181
	50 MPa	kg	0.203
Average steel	Steel – structural, columns and beams	kg	2.85
Average aluminium	Default	kg	11.8

Note: These numbers are rounded to three significant figures.

55 BRANZ Ltd, *www.branz.co.nz*

9.2.1. GHG inventory development

Users should collect data on quantity (kg) of materials used.

Applying the equation in section 2, this means:

Q = quantity of materials used (kg)
F = appropriate emission factors from table 60

CONSTRUCTION MATERIALS: EXAMPLE CALCULATION

An organisation builds a shelter with concrete foundations during the reporting period. They use 300 kg of concrete and do not know its tensile strength, so apply the default value.

Total CO_2-e emissions = 300 × 0.148 = 44.4 kg CO_2-e

Note: Numbers may not add due to rounding.

9.2.2. Emission factor derivation methodology

9.2.2.1. Concrete

We calculated the emission factors for concrete from data on in-situ, ordinary Portland cement with no reinforcement. Concrete is categorised by its compressive strength, denoted by megapascals (MPa), which is one of its most important engineering properties. If you do not know which type of concrete was used, apply the default concrete value. We calculated the default concrete value based on an average of all categories of concrete strength.

9.2.2.2. Steel

All data are from structural steel because no New Zealand-specific data on different types of steel were available. BRANZ will be publishing a full suite of construction material emission factors in the coming year, which we can add to the next guide.

Table 61: Steel emission factors

Emission source	Unit	kg CO_2-e /unit
Steel – structural, columns and beams	kg	2.85

Source: BlueScope Steel (2015)

9.2.2.3. Aluminium

BRANZ provided the data in table 62 for the aluminium emission factor. We decided to use an average for the New Zealand emission factor, based on these data from international sources.

Table 62: Aluminium data used for the emission source

Emission source	Unit	kg CO_2-e / unit
Aluminium (powder-coated finish, one side 0.08 mm), extruded glazing frame, 2.0mm BMT	kg	11.4
Aluminium (anodised finish, one side 0.02 mm), extruded glazing frame, 2.0mm BMT	kg	11.5
Aluminium (anodised, one side 0.02 mm), profile sheet metal, generic all profiles, 0.7mm BMT	kg	12.3
Aluminium (anodised, one side 0.02 mm), profile sheet metal, generic all profiles, 0.9mm BMT	kg	12.0
Aluminium (anodised finish, one side 0.02 mm), flat sheet, 0.7mm BMT	kg	12.3
Aluminium (anodised finish, one side 0.02 mm), flat sheet, 0.9mm BMT	kg	12.0
Aluminium (powder-coated finish, one side 0.08 mm), flat sheet, 0.7mm BMT	kg	12.3
Aluminium (powder-coated finish, one side 0.08 mm), flat sheet, 0.9mm BMT	kg	12.0
Aluminium (no finish), profile sheet metal, 0.7 mm BMT	kg	10.8
Aluminium (anodised finish, one side 0.02 mm), louvre blades, 2.0mm BMT	kg	11.4

Due to a lack of New Zealand-specific data on other construction materials, there are no other emission conversion factors produced in this guide.

9.2.3. Assumptions, limitations and uncertainties

The concrete emission factors are based on ordinary Portland cement.

The average steel emission factor is based on data from structural steel and profile products reported by BlueScope Steel. This does not directly reflect the uniqueness of the NZ Steel process, which uses iron sands.

The aluminium data provided by BRANZ account for the New Zealand grid electricity and assume the aluminium ingot is sourced from Tiwai Point. Some aluminium may be made from aluminium ingot made overseas, or from recycled products. The GHG emissions for ingot made overseas will be considerable higher, as their electricity is most likely to come from a larger proportion of fossil fuels. Emissions associated with recycled aluminium are likely to be lower than virgin product.

The uncertainties with these emission factors are unknown.

9.3. Waste disposal

Waste disposal emissions account only for the GHG emitted from waste processing. Currently, waste-to-landfill is the only stream with emissions. If users are seeking whole-life assessment of other waste streams, we direct them to the *UK BEIS emission factors* for company reporting.

The guide does not cover methodologies to determine emissions from solid waste incineration, as we assume emissions are negligible at the individual organisation level.

The units of emissions are kg CO_2-e per kg of material. The anaerobic decomposition of organic waste in landfills generates methane. Organisations should adjust inventories to account for the collected and destroyed landfill gas. Where methane is recovered and flared or combusted for energy, the carbon dioxide emitted from the combustion process is regarded as part of the natural carbon cycle. Biogenic carbon dioxide, being part of the natural cycle, is absorbed by living organic matter and released at the end of its life, and is not included in these emission factors.

The type of landfill influences the GHG conversion factor, based on whether there is a methane gas collection system. Table 63 describes the two types of landfills.

Table 63: Description of landfill types

Landfill type	Description
With gas recovery	Landfill where some of the CH_4 produced during the organic decomposition of waste is captured.
Without gas recovery	Landfill where the CH_4 produced during organic decomposition of waste escapes into the atmosphere.

Appendix C includes a list of landfills with gas recovery.

If organisations are interested in calculating the emissions from recycling materials, they could do so by independently accounting for the distance travelled by the waste to the recycling plant, using freight emission factors (see section 7).

We calculated the waste-to-landfill emission conversion factors based on the national inventory. Table 64, table 65 and table 66 show the factors.

Table 64: Waste disposal with landfill gas recovery

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Waste (known composition)	Food	kg	0.233	n/a	0.233	n/a
	Garden	kg	0.310	n/a	0.310	n/a
	Paper	kg	0.620	n/a	0.620	n/a
	Wood	kg	0.667	n/a	0.667	n/a
	Textile	kg	0.372	n/a	0.372	n/a
	Nappies	kg	0.372	n/a	0.372	n/a
	Other (inert)	kg	n/a	n/a	n/a	n/a
Waste (unknown composition)	General waste	kg	0.242	n/a	0.242	n/a
	Office waste	kg	0.381	n/a	0.381	n/a

Note: These numbers are rounded to three significant figures. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 65: Waste emission factors without landfill gas recovery

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Waste (known composition)	Food	kg	1.13	n/a	1.13	n/a
	Garden	kg	1.50	n/a	1.50	n/a
	Paper	kg	3.00	n/a	3.00	n/a
	Wood	kg	3.23	n/a	3.23	n/a
	Textile	kg	1.80	n/a	1.80	n/a
	Nappies	kg	1.80	n/a	1.80	n/a
	Other (inert)	kg	n/a	n/a	n/a	n/a
Waste (unknown composition)	General waste	kg	1.17	n/a	1.17	n/a
	Office waste	kg	1.84	n/a	1.84	n/a

Note: These numbers are rounded to three significant figures. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 66: Composting emission factors

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Composting	kg	0.172	n/a	0.100	0.072

Note: These numbers are rounded to three significant figures unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

9.3.1. GHG inventory development

There are two methodologies that organisations can follow for calculating waste emissions.

1. Where composition of waste is known.
2. Where composition of waste is unknown.

The choice of methodology depends on organisational knowledge of waste composition. It is preferable to know the composition of waste as it allows more accurate calculation of emissions.

Users should collect data on the quantity (kg) and type of waste disposed.

Applying the equation in section 2, this means:

Q = quantity of waste disposed (kg)
F = appropriate emission factors from table 64, table 65 or table 66

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 × 0.233	= 34.9 kg CO_2-e
General waste	= 50 × 0.242	= 12.1 kg CO_2-e
Garden waste	= 60 × 0.310	= 18.6 kg CO_2-e
Total waste emissions	= 34.9 + 12.0 + 18.6	= 65.6 kg CO_2-e

Note: Numbers may not add due to rounding

9.3.2. Emission factor derivation methodologies

We broke down data derived from the national inventory into seven categories. Table 67 identifies these alongside their proportion of the waste to municipal landfills in 2016.

Table 67: Composition of waste sent to NZ municipal landfills in 2016

Waste category	Description	Estimated composition of waste to municipal landfills 2016
Food	Food waste	16.8%
Garden	Organic material	8.3%
Paper	Paper and cardboard waste	10.7%
Wood	Wood waste	11.9%
Textile	Fabrics and other textiles	5.6%
Nappies	Nappies and similar sanitary waste	3.0%
Inert	Waste that does not produce greenhouse gas emissions	43.8%

Emission factors for plastics, metals and glass are inert because their decomposition does not directly produce GHG emissions. Only organic waste produces methane as it breaks down.

We provide no methodology for nitrous oxide emissions from waste disposal because the IPCC[56] has found them to be insignificant.

9.3.3. 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.

If an organisation does not know what type of landfill they send waste to, they should use the emission factor for without gas recovery, which will give a more conservative estimate.

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

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 = degradable organic carbon
- DOCF = fraction of DOC dissimilated
- F = fraction of CH_4 in landfill gas
- MCF = methane correction factor
- conversion = conversion of carbon to methane (molecular weight ratio CH_4/C)
- recovery = fraction of methane recovered where landfill gas systems are in place, 0 otherwise
- oxidation = oxidation factor
- GWP = global warming potential of methane.

We used the waste information from the national inventory to develop solid waste emission factors for voluntary reporting.

Table 68: Information on managed solid waste in 2016

Category	DOC	DOCF	F	MCF	Conversion	Ox	R
Food	0.15	0.5	0.5	1	16/12	0.1	0.7932
Garden	0.2	0.5	0.5	1	16/12	0.1	0.7932
Paper	0.4	0.5	0.5	1	16/12	0.1	0.7932
Wood	0.43	0.5	0.5	1	16/12	0.1	0.7932
Textiles	0.24	0.5	0.5	1	16/12	0.1	0.7932
Nappies	0.24	0.5	0.5	1	16/12	0.1	0.7932
Inert	0	0.5	0.5	1	16/12	0.1	0.7932
Source of information	IPCC defaults	IPCC default for managed landfills	IPCC default for managed landfills	IPCC default for managed landfills		IPCC default for managed landfills	MfE

Note: R only applies for landfills with gas recovery.

9.3.4. 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 the national inventory, as in table 67 above.

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

Table 69: Composition of typical office waste

Composition of office waste	
Paper	53.6%
Food	20.8%
Inert	25.6%

9.3.5. Composting

We calculated emission factors for composting using IPCC default emission factors as shown in table 70.

Table 70: IPCC default data used to calculate composting

Calculation component	CH_4	N_2O
EF (kg gas/kg)	0.004	0.00024
GWP	25	298
EF (CO_2-e) (kg CO_2-e/ kg waste)	0.10	0.07152
Combined EF (kg CO_2-e/ kg waste)		0.172

9.3.6. Assumptions, limitations and uncertainties

The uncertainties for emission factors used in methane emissions from managed municipal landfills is ±40 per cent. This is consistent with the estimates in the IPCC Guidelines (IPCC, 2006a). The national inventory states that "It is set at this level because some, but not all, of the estimates for methane recovery are based on metered gas-flow data".

If an organisation has an advanced diversion system (to recycling and composting) then using the 'mixed waste' category in the methodology will overestimate emissions. If an organisation has no diversion system, then it could underestimate emissions.

The default emission factor for mixed waste is based on national average composition data from the national inventory. Only waste to municipal landfills is considered.

Previously, the emission factors for office waste represented an assumed default composition (paper 53.6 per cent, garden and food 20.8 per cent and wood 0 per cent) for office waste, based on waste data from government buildings. We separated garden and food waste in this version of the guide, and assume that food represents all waste previously allocated to that category. We assume the remaining 25.6 per cent is inert material.

10. Agriculture, forestry and other land use emission factors

10.1. Overview of changes since previous update

This is a new category for this version of the guide, covering emissions produced by land use, land-use change and forestry (LULUCF), enteric fermentation of livestock, manure management and fertiliser use. Including these sources is in line with *New Zealand's Greenhouse Gas Inventory 1990-2016*.

We selected the emission factors below, based on appropriate available data and the professional opinions of the Ministry for Primary Industries (MPI) and the Ministry for the Environment.

- Land use, land-use change and forestry
  - forest growth
  - forest harvest and deforestation
- Agriculture
  - enteric fermentation
  - manure management
  - fertiliser use
  - agricultural soils.

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

10.2. Land use, land-use change and forestry (LULUCF)

10.2.1. Overview of the sector

GHG emissions from vegetation and soils due to human activities are reported in the land use, land-use change and forestry (LULUCF) sector. This guide provides emission factors related to forest growth, forest harvest and deforestation only. The term LULUCF is used for consistency with the national inventory.

The LULUCF sector is responsible for both emitting GHG to the atmosphere (emissions ie, through harvesting and deforestation) and removing GHG from the atmosphere (removals ie, through vegetation growth and increasing organic carbon stored in soils). 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 provide methods here 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 the *national inventory*.

In line with *ISO 14064-1:2018* and the *GHG Protocol*, organisations should consider LULUCF emissions if they have forest land within their measurement boundary, or own land that has been deforested during the measurement period.

Organisations with LULUCF emissions should calculate and report these separately from direct and indirect (Scope 1, 2 and 3) emissions. In the case that LULUCF is a net sink, however (ie, net emissions are negative), organisations should subtract the total from their other emissions – a practice known as offsetting.

The emission factors in this guide are New Zealand-specific, derived from national averages.

Although the main aim of this section of the guide is to estimate stock changes from forestry activities, it can also be used to estimate the total carbon stored for a given forest type in a given area. This can help organisations understand the potential impact of some forestry activities on emissions, and how to manage land use for carbon.

10.2.2. LULUCF emission factors

10.2.2.1. Planted forests

The emission factor for planted forest growth (shown in table 71) is based on the Land Use and Carbon Analysis System (LUCAS) national sample. It represents the average annual increment over 28 years. Note the emission factor accounts for both the gains from forest growth and losses from any forest management activities up until the point of harvest.

The emission factor for planted forest harvest and deforestation is in table 72.

10.2.2.2. Natural forests

The emission factors for natural forest growth (shown in table 71) are based on the LUCAS national sample. We provide separate emission factors if the forest is tall or regenerating after conversion from another land use, logging or other disturbance. If unable to distinguish regenerating from tall forest, organisations can apply the national average (16 per cent regenerating: 84 per cent tall) to the activity data.

The emission factor for natural forest deforestation (shown in table 72) is based on the average stock at the national level, calculated from the LUCAS national sample.

Table 71: LULUCF forest growth emission factors

Forest growth emission source		Unit	kg CO_2-e/unit	kg C/unit	Uncertainty (95% CI)	kg CH_4/unit	kg N_2O/unit
Planted forests	All	ha	-33,807	-9,220	±30%[57]	n/a	n/a
Natural forest	Regenerating natural forest	ha	-5,097	-1,390	±50%[58]	n/a	n/a
	Tall natural forest	ha	0	0	n/a	n/a	n/a

Source: *New Zealand's LUCAS national forest inventory data November 2018*

Table 72: LULUCF land-use change emission factors

Land-use change emission source		Unit	kg CO_2-e/unit	kg C/unit	Uncertainty (95% CI)	kg CH_4/unit	kg N_2O/unit
Planted forests	Harvest and deforestation	ha	946,605	258,165	±30%[59]	n/a	n/a
Natural forest	Harvest and deforestation	ha	848,650	231,450	±50%[60]	n/a	n/a

Source: *New Zealand's LUCAS national forest inventory data November 2018*

10.2.3. GHG inventory development

To calculate LULUCF emissions, organisations need activity data on each forest type, the area harvested and any changes to forested land within the organisational boundary for the measurement period. Different forest types have different emission factors, while deforestation and harvest rates change over time.

First determine the type of forest and the area it covers. Forest land comprises woody vegetation with a tree crown cover of more than 30 per cent in a given hectare (ha) area, in which the trees could reach a minimum height of 5 metres at maturity.

Forest types:

1. **Tall natural forest**: comprises mature indigenous forest, and may contain self-sown exotic trees, such as wilding pines.
2. **Regenerating natural forest**: comprises indigenous and naturally occurring vegetation, including broadleaved hardwood shrubland, mānuka–kānuka and other woody shrubland, with potential to reach forest under its current management.
3. **Planted forest**: plantations of forest species mainly used for forestry, including:
   – radiata pine (*Pinus radiata*)

[57] Uncertainty estimated across two yield tables to obtain a single EF

[58] Uncertainty estimated based on expert judgement as those reported in Holdaway et al, 2016 (*https://link.springer.com/article/10.1007/s10021-016-0084-x*) are only valid at the national scale

[59] Uncertainty estimated based on expert judgement as data were averaged across two yield tables to obtain a single EF

[60] Uncertainty estimated based on expert judgement as those reported in Holdaway et al, 2016 (*https://link.springer.com/article/10.1007/s10021-016-0084-x*) are only valid at the national scale

– Douglas fir (*Pseudotsuga menziesii*)

– eucalypts (*Eucalyptus* spp)

– other planted species (with potential to reach ≥ 5 metre height at maturity in situ).

Organisations will also need records of forest harvest and deforestation activities (including area in ha) to calculate the emissions from LULUCF. Sources of this information include:

1. Corporate or farm records for enterprises and organisations.
2. Geospatial analysis of the property or region.
3. The *LUCAS Land Use Map*[61] can provide area by vegetation type at 1990, 2008, 2012 and 2016. It requires geospatial expertise to analyse and extract the data by region. This is free to use and supports users in monitoring changes in their own land management practices.
4. The New Zealand Land Cover Database (*LCDB*)[62] provides multi-temporal land cover. It requires geospatial expertise to analyse and extract the data for sub-national analysis.

Using the sources detailed above to gather information on the land use, forest type and size, organisations can apply the equation in section 2:

Q = area of land (ha)
F = appropriate emission factors (for land use and age) from table 71 and table 72

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

An organisation owns 4 ha of land: 3 ha are planted forest and 1 ha is regenerating natural forest. During the reporting year the organisation harvested the planted forest for timber.

3 ha of planted forest were harvested, therefore:

CO_2 emissions = 3 × 946,605 = 2,839,815 kg CO_2

The emissions for the regenerating natural forest are:

CO_2 emissions = 1 × -5,097 = -5,097 kg CO_2

Therefore, total net CO_2-e emissions = 2,839,815 - 5,097 = 2,834,718 kg CO_2-e.

Note: Negative emissions are a carbon sink.

10.2.3.1. 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.

10.2.4. Emission factor derivation methodology

The general approach to emissions estimation follows a simple equation:

[61] Land Use Carbon Analysis System (LUCAS) Land Use Map available at *https://data.mfe.govt.nz/*

[62] LCDB available at *https://lris.scinfo.org.nz/layer/48423-lcdb-v41-land-cover-database-version-41-mainland-new-zealand/*

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

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), carbon dioxide (CO_2) and carbon dioxide equivalents (CO_2-e).

To convert carbon to carbon dioxide, multiply by $^{44}/_{12}$ (ie, the molecular conversion of carbon to carbon dioxide).

10.2.5. Assumptions, limitations and uncertainties

The emission factors are based on national average data and the uncertainties will not necessarily reflect sub-national circumstances.

Planted forest growth emission factors are based on the average annual increment over 28 years. Deforestation and harvest loss data are based on the stock maturity at 28 years for planted forests. For natural forests, deforestation and harvest loss data are based on the national stock average, which come from the most recent carbon stock inventory for these forests. If the forest is younger than this, the emissions from deforestation and harvest will be overestimated. If the forest is older, they will be underestimated.

10.3. Agriculture

Emissions from agriculture are produced in several ways. This section includes emissions from enteric fermentation, manure management and fertiliser use.

- 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.
- Applying nitrogen (urea-sourced or synthetic) fertiliser onto land produces nitrous oxide and carbon dioxide emissions.
- Applying lime and dolomite fertilisers results in carbon dioxide emissions.

If an organisation directly owns and manages livestock, agriculture emission sources are direct (Scope 1).

Note the livestock emissions you calculate using these 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 types in 2016. Actual animal emissions for an individual farm will differ depending on a number of factors, including live-weights, productivity, and feed quality. Organisations looking for a more accurate estimate of their agricultural emissions are encouraged to use tools such as Overseer.

10.3.1. 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 in in table 73.

Table 73: Enteric fermentation emission factors

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Enteric fermentation	Dairy cattle	per head	2,060	n/a	2,060	n/a
	Non-dairy cattle	per head	1,500	n/a	1,500	n/a
	Sheep	per head	300	n/a	300	n/a
	Deer	per head	560	n/a	560	n/a

Note: The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

10.3.1.1. GHG inventory development

Organisations should collect data on the number and type of livestock as at 30 June during the measurement period (regardless of whether the period is a calendar or financial year; see section 10.3.1.4) to calculate emissions from enteric fermentation.

Applying the equation in section 2, this means:

Q = number of animals (per head per livestock type)
F = appropriate emission factors from table 73

ENTERIC FERMENTATION: EXAMPLE CALCULATION

An organisation owns 30 sheep and six dairy cows on 30 June during the reporting period. They graze on land owned by the organisation.

CO_2 emissions = 0
CH_4 emissions = (30 × 300) + (6 × 2,060) = 21,360 kg CO_2-e
N_2O emissions = 0
Total CO_2-e emissions = 21,360 kg CO_2-e

Note: Numbers may not add due to rounding.

10.3.1.2. Emission factor derivation methodology

The national inventory publishes total emissions for enteric fermentation per livestock type, along with population numbers. The Ministry of Primary Industries (MPI) supplied these same data for the creation of emission factors. We used this information, shown in table 74, to calculate the emission factors based on the following equation:

$$emission\ factor\ per\ animal = \frac{enteric\ fermentation}{population}$$

Note that the emission factors are based on data supplied for the national inventory. To ensure consistency, organisations should report their population of livestock as at 30 June, regardless of the measurement period.

MPI defines non-dairy cattle as beef breeds of cattle, including dairy-beef, as well as any beef breeding stock.

Table 74: Enteric fermentation figures per livestock type

Animal	2016 population	Enteric fermentation emissions in 2016 (kt CH_4)
Dairy cattle	6,618,800	544.95
Non-dairy cattle	3,533,054	209.15
Sheep	27,583,673	336.5
Deer	834,608	18.6

Note: kt is kilotonne.

Source: Based on figures from the Agricultural Inventory Model used in *New Zealand's Greenhouse Gas Inventory 1990-2016.*

For information on goats, swine and horses, see volume 4 of *2006 IPCC guidelines for national greenhouse gas inventories*, and the *national inventory* for New Zealand-specific data on goats and swine.

The emission conversion factors are in the *Emission Factors Workbook*.

10.3.1.3. Alternative methods and tools

There are alternative calculating tools, such as OVERSEER. The emission factors in this guide will differ from tools because of the different inbuilt assumptions and limitations. It is up to the user to assess the appropriateness of emission factors when comparing these to the factors from alternative tools.

10.3.1.4. Assumptions, limitations and uncertainties

The national inventory details the uncertainties associated with the activity data used to calculate the emission factors.

The level of uncertainty with enteric fermentation emissions is ±16 per cent.

10.3.2. Manure management emission factors

Manure management refers to the process of managing the excretion of livestock, particularly when they are not on paddocks. The storage and treatment of manure produces GHG emissions. We provide the manure management emission factors in table 75.

Table 75: Manure management emission factors

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Manure management	Dairy cattle	per head	150	n/a	141	9.91
	Non-dairy cattle	per head	19.9	n/a	19.9	n/a
	Sheep	per head	3.15	n/a	3.15	n/a
	Deer	per head	6.59	n/a	6.59	n/a

Note: These numbers are rounded to three significant figures unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

10.3.2.1. GHG inventory development

Organisations should collect data on the number and type of livestock as at 30 June during the measurement period (regardless of whether the period is a calendar or financial year, see section 10.3.1.4) to calculate emissions from manure management.

Applying the equation in section 2, this means:

Q = number of animals (per head per livestock type)
F = appropriate emission factors from table 75

MANURE MANAGEMENT: EXAMPLE CALCULATION

An organisation owns 30 sheep and six dairy cows on 30 June during the reporting period.

CO_2 emissions	= 0	
CH_4 emissions	= (30 × 3.15) + (6 × 141)	= 940.5 kg CO_2-e
N_2O emissions	= (30 × 0) + (6 × 9.91)	= 59.5 kg CO_2-e
Total CO_2-e emissions	= 1000 kg CO_2-e	

Note: Numbers may not add due to rounding.

10.3.2.2. Emission factor derivation methodology

We calculated the emission factors from figures in the Agricultural Inventory Model, used in *New Zealand's Greenhouse Gas Inventory 1990-2016*. MPI provided these data, see table 76.

Table 76: Manure management source data

Animal	Population	Methane from manure management (kt CH_4)	Nitrous oxide from manure management (kt N_2O)
Dairy cattle	6,618,800	37.21	0.22
Non-dairy cattle	3,533,054	2.81	0.00
Sheep	27,583,673	3.48	0.00
Deer	834,608	0.22	0.00

Note: kt is kilotonne.

Source: The Agricultural Inventory Model used in *New Zealand's Greenhouse Gas Inventory 1990–2016.*

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 4AR 100 year GWP.

For example:

Animal	Population	Methane from manure management (kg CH_4)	Nitrous oxide from manure management (kg N_2O)
Dairy cattle	6,618,800	37,210,000	220,000

Methane emissions = 37,210,000 ÷ 6,618,800 = 5.622 kg CH_4 per head

Nitrous oxide emissions = 220,000 ÷ 6,618,800 = 0.033 kg N_2O per head

Total kg CO_2 equivalent = (5.622 x 25) + (0.033 x 298) = 150.451 kg CO_2-e per head.

10.3.2.3. Assumptions, limitations and uncertainties

The national inventory 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.[63] Based on the IPCC methodologies, the uncertainty factor for methane emissions is ±20 per cent and for nitrous oxide emissions ±100 per cent. The national inventory details the assumptions and limitations of these data.

10.3.2.4. Alternative methods of calculation

See section 10.3.1.3: Alternative methods and tools.

10.3.3. Fertiliser use

The use of fertilisers produces GHG emissions. Nitrogen fertilisers break down to produce nitrous oxide and carbon dioxide. Limestone and dolomite fertilisers break down to produce carbon dioxide. The national inventory reports the total emissions from fertiliser using New Zealand-specific emission factors. We used methodologies supplied by MPI to develop emission factors for the following fertilisers:

- non-urea nitrogen fertiliser
- urea nitrogen fertiliser not coated with urease inhibitor
- urea nitrogen fertiliser coated with urease inhibitor
- limestone
- dolomite.

63 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*

In line with the reporting requirements of *ISO 14064-1:2018* and the *GHG Protocol*, we provide emission factors to allow separate calculation of carbon dioxide, methane and nitrous oxide. Table 77 lists the fertiliser use emission factors. Table 78 lists example products for the different fertiliser types.

Table 77: Fertiliser use emission factors

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Fertiliser use	Non-urea nitrogen fertiliser	kg	5.40	n/a	n/a	5.40
	Urea nitrogen fertiliser not coated with urease inhibitor	kg	5.07	1.59	n/a	3.48
	Urea nitrogen fertiliser coated with urease inhibitor	kg	4.86	1.59	n/a	3.27
	Limestone	kg	0.440	0.440	n/a	n/a
	Dolomite	kg	0.477	0.477	n/a	n/a

Note: These numbers are rounded to three significant figures unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

Table 78: 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

10.3.3.1. GHG inventory development

Organisations should collect data on quantity (in kg) of fertiliser used in the reporting period by type. Applying the equation in section 2*,* this means:

Q = type of fertiliser used (in kg)
F = appropriate emission factors from table 77

FERTILISER USE: EXAMPLE CALCULATION

An organisation uses 80 kg of dolomite and 50 kg of non-urea nitrogen fertiliser in the reporting year.

CO_2 emissions = (80 × 0.477) + (50 × 0) = 38.2 kg CO_2-e
CH_4 emissions = (80 × 0) + (50 × 0) = 0 kg CO_2-e
N_2O emissions = (80 × 0) + (50 × 5.4) = 270 kg CO_2-e
Total CO_2-e emissions = 308.2 kg CO_2-e

Note: Numbers may not add due to rounding.

10.3.3.2. Emission factor derivation methodology

MPI provided data on the quantified direct and indirect GHG emissions produced per tonne of fertiliser (table 79 and table 80).

Table 79: Nitrogen fertiliser quantified emissions

Fertiliser type	Direct emissions of N_2O (t N_2O/tonne of N fertiliser)	Indirect emissions-volatilisation (t N_2O/tonne of N fertiliser)	Indirect emissions – leaching (t N_2O/tonne of N fertiliser)	CO_2 emissions from urea (t CO_2-e /tonne of N fertiliser)
Non-urea nitrogen	0.0157	0.0016	0.0008	n/a
Urea nitrogen not coated with urease inhibitor	0.0093	0.0016	0.0008	1.594
Urea nitrogen coated with urease inhibitor	0.0093	0.0009	0.0008	1.594

Table 80: Quantified emissions from limestone and dolomite

Fertiliser type	Emissions (t CO_2-e /tonne fertiliser)
Limestone	0.44
Dolomite	0.48

The methodology for calculating the emission factors for the fertiliser was as follows:

1. Convert the data to kg (gas) per unit kg of fertiliser.
2. Sum emissions per component of the total emissions.
3. Calculate total carbon dioxide equivalent by multiplying the total kg gas/ kg of fertiliser by the IPCC 4AR 100-year global warming potential of that gas.

For example:

Table 81: Non-urea nitrogen fertilisers

Fertiliser type	Direct emissions of N_2O (kg N_2O/kg fertiliser)	Indirect emissions – volatilisation (kg N_2O/kg fertiliser)	Indirect emissions – leaching (kg N_2O/kg fertiliser)	CO_2 emissions from urea (kg CO_2/kg fertiliser)
Non-urea nitrogen	0.016	0.0016	0.0008	n/a

Total emissions per gas:

- N_2O = 0.0008 + 0.0016 + 0.016 = 0.0184 kg N_2O/ Kg fertiliser
- CH_4 = 0
- CO_2 = 0

Total carbon dioxide equivalent = 0.018 × 298 = 5 kg CO_2-e/ kg fertiliser.

10.3.3.3. Assumptions, limitations and uncertainties

MPI used the following parameters to calculate the emissions.

Table 82: Parameters for calculating emissions from fertilisers

Parameter	Value	Source
Direct emission factor non-urea-N	0.01	Based on Kelliher and de Klein, 2006
Direct emission urea-N	0.0059	Based on van der Weerden et al, 2016
FracGASnfert (UI)	0.055	Saggar, 2013
FracGASnfert (non-UI)	0.1	Sherlock et al, 2008
Volatilisation emission factor (EF4)	0.01	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, table 11.3
FracLeach	0.07	Thomas et al, 2005
Leaching emission factor (EF5)	0.0075	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, table 11.3
Urea emission factor (CO_2 component)	0.2	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, section 11.4.2
Emission factor for limestone	0.12	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, section 11.4.2
Emission factor for dolomite	0.13	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, section 11.4.2
N content of urea	46%	Agriculture inventory model
Molecular conversion CO_2	3.667	
Molecular conversion N_2O	1.571	
GWP100 N_2O	298	IPCC 4AR

The national inventory uses the IPCC (2006) Tier 1 methodology when default emission factors are used, which assume conservatively that all carbon in the fertilisers are 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.

10.3.4. Agricultural soils

Agricultural soils emit nitrous oxide due to the addition of nitrogen to soils through manure, dung and urine. The guide provides emission factors for the impact of common agricultural livestock on soil in table 83.

Table 83: Agricultural soils emission factors

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit	kg N_2O/unit
Agricultural soils	Dairy cattle	per head	514	n/a	n/a	514
	Non-dairy cattle	per head	321	n/a	n/a	321
	Sheep	per head	71.5	n/a	n/a	71.5
	Deer	per head	128	n/a	n/a	128

Note: These numbers are rounded to three significant figures unless the number is significantly small. The kg CH_4 and kg N_2O figures are expressed in kg CO_2-e.

10.3.4.1. GHG inventory development

Organisations should collect data on the number and type of livestock they had as at 30 June during the measurement period. Applying the equation in section 2, this means:

Q = number of animals (per head per type)
F = appropriate emission factors from table 83

AGRICULTURAL SOILS: EXAMPLE CALCULATION

An organisation owns 30 sheep and six dairy cows on 30 June during the reporting period. They graze on land owned by the organisation.

CO_2 emissions = n/a
CH_4 emissions = n/a
N_2O emissions = (30 × 71.5) + (6 × 514) = 5,229 kg CO_2-e
Total CO_2-e emissions = 5,229 kg CO_2-e

Note: Numbers may not add due to rounding.

10.3.4.2. Emission factor derivation methodology

We calculated the emission factors from the Agricultural Inventory Model, used in *New Zealand's Greenhouse Gas Inventory 1990–2016*. These data are in table 84.

Table 84: Data used for agricultural soils emission factors

Animal	Population	Total agricultural soils (kt N_2O)
Dairy cattle	6,618,800	11.41
Non-dairy cattle	3,533,054	3.80
Sheep	27,583,673	6.62
Deer	834,608	0.36

10.3.4.3. Assumptions, limitations and uncertainties

The national inventory includes detailed assumptions and limitations of these data.

A. Appendix A: Derivation of fuel emission factors

A.1 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.

A.2 Methane and nitrous oxide emission factors used in this guide

Although carbon dioxide emissions remain constant regardless of how a fuel is combusted, methane and nitrous oxide emissions depend on the precise nature of the activity in which the fuel is being combusted. The emission factors for methane and nitrous oxide therefore vary depending on the combustion process. Table A1 shows the default methane and nitrous oxide emission factors (expressed in energy units) used in this guide. The calculation in section 3.2.2 shows how we converted these to per activity unit (eg, kg CO_2-e/kg) emission factors. MBIE provided all emission factors in table 4.

Note that we have used gross emission factors.

A.3 Oxidation factors used in this guide

We sourced all oxidation factors from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Oxidation factors have only been applied to the carbon dioxide emission factors (and therefore by default to the CO_2-e emission factors) and have not been applied to the methane and nitrous oxide emission factors.

A.4 Reference data

Table A1: 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	0.00000
		GJ	n/a	53.96	0.005	0.000
Coal – bituminous	Commercial	kg	29.59	89.13	0.0095	0.0014
Coal – sub-bituminous	Commercial	kg	21.64	91.99	0.0095	0.0014
Coal – lignite	Commercial	kg	15.26	93.11	0.0095	0.0014
Diesel	Commercial	litre	38.21	69.31	0.0095	0.0006
LPG	Commercial	g	50.00	60.43	0.005	0.0001
Heavy fuel oil	Commercial	litre	40.90	73.59	0.010	0.0006
Light fuel oil	Commercial	litre	40.32	72.30	0.010	0.0006
Distributed natural gas	Industry	kWh	n/a	0.19	0.000003	0.0000003
		GJ	n/a	53.96	0.001	0.00009
Coal – bituminous	Industry	kg	29.59	89.13	0.0095	0.001
Coal – sub-bituminous	Industry	g	21.64	91.99	0.0095	0.001
Coal – lignite	Industry	kg	15.26	93.11	0.0095	0.001
Diesel	Industry	litre	38.21	69.31	0.0029	0.0006
LPG	Industry	kg	50.00	60.43	0.001	0.0001
Heavy fuel oil	Industry	litre	40.90	73.59	0.003	0.0006
Light fuel oil	Industry	litre	40.32	72.30	0.003	0.0006
Transport fuels						
Regular petrol	Mobile use	litre	35.17	66.70	0.03	0.008
Premium petrol	Mobile use	litre	35.38	66.12	0.03	0.008
Diesel	Mobile use	litre	38.21	69.31	0.004	0.004
LPG	Mobile use	litre	26.54	60.43	0.06	0.0002
Heavy fuel oil	Mobile use	litre	40.90	73.59	0.007	0.002
Light fuel oil	Mobile use	litre	40.32	72.30	0.007	0.002
Jet kerosene / Jet A1	Mobile use	litre	46.29	68.22	0.48	1.9
Jet aviation gasoline	Mobile use	litre	47.3	65.89	0.48	1.9
Biofuels and biomass						
Biodiesel	All uses	litre	23.6	64.2	0.00285	0.00057
Bioethanol	All uses	litre	36.42	67.26	0.00285	0.00057

Emission source	User	Unit	Calorific value (MJ/unit)	t CO_2 / TJ	t CH_4 / TJ	t N_2O / TJ
Wood	Industry	kg	9.63	89.47	0.02	0.003
Wood	Fireplaces*	kg	9.63	89.47	0.2	0.003

Note: It is not expected that many commercial or industrial users will burn wood in fireplaces, but this emission factor is included for completeness. It is the default residential emission factor. Source: MBIE.

B. Appendix B: Alternative methods of calculating refrigerants

This appendix outlines two screening methods 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 8).

$$OE = C \times ALR$$

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

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

Where:

- E = emissions from equipment in kg CO_2-e
- IE = installation emissions (as per method B)
- 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 8).

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)[64]	Method A	Method B
Small refrigerator or freezer (<150 litres[65])	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

64 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.

65 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)[64]	Method A	Method B
Cars/vans	0.7	10%	n/a	Recommended	Acceptable
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 global warming potentials for various refrigerant mixtures[66]

Refrigerant type (trade name)	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	PFC-218	Other*	Total GWP
GWP 100yr (IPCC, 2007)	14,800	675	3,500	1,430	4,470	124	8,830	0	
R22 (HCFC-22)								100%	1,810
R23	100%								14,800
R134a				100%					1,430
R403B: 5% R290, 56% R22, 39% R218							39%	61%	3,444
R404A: 44% R125, 52% R143a, 4% R134a			44%	4%	52%				3,922
R407C: 23% R32, 25% R125, 52% R134a		23%	25%	52%					1,774
R408A: 7% R125, 46% 143a, 47% R22			7%		46%			47%	2,301
R410A: 50% R32, 50% R125		50%	50%						2,088
R413A: 9% R218, 88% R134a, 3% R600a				88%			9%	3%	2,053
R416A: 59% R134a, 39.5% R124,1.5% R600				59%				41%	844
R417A: 46.6% R125 50% R134a 3.4% R600			46.6%	50%				3.4%	2,346
R422A: 85.1% R125, 11.5% R134a, 3.4% R600a			85.1%	11.5%				3.4%	3,143
R507A: 50% R125, 50% R143a			50%		50%				3,985

66 Global warming potentials are set according to the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Intergovernmental Panel on Climate Change *www.ipcc.ch/*

C. Appendix C: Landfills with and without landfill gas recovery

Table C1, provided by Enviro-Mark Solutions Ltd, lists the landfills in New Zealand with and without landfill gas recovery (LFGR).

Table C1: Landfills with and without LFGR

Name	Operator	LFGR
AB Lime Ltd (Winton)	AB Lime Ltd	Yes
Ahipara Landfill	Far North District Council (Pukepoto Quarries)	No
Bonny Glenn (Rangitikei District)	Midwest Disposal Ltd	Yes
Broadlands Road Landfill	Taupo District Council	No
Burma Road Landfill	Whakatane District Council	No
Butlers Landfill	Westland District Council	No
Central Hawke's Bay District Landfill	Central Hawke's Bay District Council	No
Claris Landfill (Great Barrier Island)	Auckland City Council	No
Colson Road Regional Landfill	New Plymouth District Council	No
Eketahuna Landfill	Tararua District Council	No
Eves Valley Landfill	Tasman District Council	No
Fairfield Landfill (Dunedin)	Transpacific Industries Group (NZ) Ltd	Unknown
Franz Josef Refuse Station	Westland District Council	Closed
Green Island Landfill	Dunedin City Council	Yes
Haast Refuse Station	Westland District Council	No
Hampton Downs Landfill	EnviroWaste Services Ltd	Yes
Innovative waste Kaikoura	Innovative Waste Kaikoura Ltd	No
Karamea Refuse Tip	Buller District Council	No
Kate Valley (Amberley)	Canterbury Waste Services Ltd	Yes
Levin Landfill	Horowhenua District Council	Yes
Marlborough Regional Council (Bluegums)	Marlborough District Council	Yes
McLean's Pit Landfill	Grey District Council	No
Mount Cooee Landfill	Clutha District Council	No
Oamaru Landfill	Waitaki District Council	Closed
Omarunui Landfill	Hastings District Council	Yes
Palmerston Landfill	Waitaki District Council	No
Patearoa Landfill	Central Otago District Council	Closed
Pongaroa Landfill	Tararua District Council	No
Redruth Landfill	Timaru District Council	Yes

Redvale Landfill	Transpacific waste management	Yes
Rotorua District Sanitary Landfill	Rotorua District Council	No
Ruapehu District Landfill	Ruapehu District Council	No
Russell Landfill	Far North District Council (Transfield Services Ltd)	No
Silverstream Landfill	Hutt City Council	Yes
Southern Landfill	Wellington City Council	Yes
Spicer Landfill	Porirua City Council	Yes
Tarras Landfill	Central Otago District Council	Closed
Tirohia Landfill (Paeroa)	HG Leach & Co. Ltd	Yes
Tokoroa Landfill	South Waikato District Council	No
Victoria Flats Landfill (Queenstown/Cromwell)	Scope Resources Ltd	No
Waiapu Landfill	Gisborne District Council	No
Waikouaiti Landfill	Dunedin City Council	Closed
Waiouru Landfill	New Zealand Defence Force, Waiouru, owned by the NZ Defence Force and operated by Transfield Services Ltd	Unknown
Wairoa Landfill	Wairoa District Council	No
Waitomo District Landfill	Waitomo District Council	No
Whitford Landfill – Waste Disposal Services	Transpacific waste management	Yes
York Valley Landfill	Nelson City Council	Yes

Source: Enviro-Mark Solutions Ltd

Glossary

Activity data	Data on the magnitude of human activity resulting in emissions or removals taking place during a given period
Base year	The first year in the reporting series
BEV	Battery electric vehicle
Biodiesel	A type of biofuel similar to diesel that is made from natural elements such as plants, vegetables and reusable materials
Bioethanol	A type of biofuel similar to ethanol that is made from natural elements such as plants, vegetables and reusable materials
Biofuels	Any fuel derived from biomass
Biologically sequestered carbon	The removal of carbon dioxide from the atmosphere and captured by plants and micro-organisms
BOD	Biological oxygen demand, the amount of dissolved oxygen needed by micro-organisms to break down biological organic matter in water
Carbon sink	A natural or artificial environment that absorbs and stores carbon from the atmosphere
CO_2-e	Carbon dioxide equivalent
COD	Chemical oxygen demand
De minimis	An issue that is insignificant to a GHG inventory, usually <1% of an organisation's total inventory for an individual emissions source. Often there is a limit to the number of emission sources that can be excluded as *de minimis*
Deforestation	The clearing of forest land that is then converted to a non-forest land use
Emission factor	The average emission rate of a given GHG for a given source, relative to units of activity
Enteric fermentation	The process by which ruminant animals digest feed and produce methane
Fugitive emissions	The emission of gases from pressurised equipment due to leaks or unintended releases of gases, usually from industrial activities
GHG	Greenhouse gas
GHG inventory	A quantification of an organisation's greenhouse gas sources, sinks, emissions and removals
GHG Protocol	The *Greenhouse Gas Protocol Accounting and Reporting Standard* provides guidance for organisations preparing a GHG inventory
GHG report	A standalone report to communicate an organisation's GHG-related information to intended users
GJ	Gigajoule (unit of measure, one billion joules)
Grazing off	Cattle feeding on paddock not owned by their farmer
GWP	Global warming potential, a factor describing the radiative forcing impact of one mass-based unit of a given GHG relative to an equivalent unit of carbon dioxide over a given period (typically 100 years)
HFC	Hydroflurocarbon, an alternative refrigerant gas that minimises damage to the ozone hole
Inert	Chemically inactive (eg, plastic waste)

ISO 14064-1:2018	International Organization for Standardisation standard on greenhouse gases – Part 1: Specification with guidance at the organisation level for quantification and reporting greenhouse gas emissions and removals
kt	Kilotonne (unit of measure, one thousand tonnes)
LULUCF	Land use, land-use change and forestry
Materiality	To be considered as having significance to an organisation
Mature indigenous forest	A forest comprising predominantly native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed. The forest will contain large trees with multi-layered canopies and be considered a climax community
MBIE	Ministry of Business, Innovation and Employment
MfE	Ministry for the Environment
MoT	Ministry of Transport
MPI	Ministry of Primary Industries
Municipal landfill	Landfill that accepts household waste as well as other wastes
National inventory	*New Zealand's Greenhouse Gas Inventory 1990–2016*
Organisational boundary	The boundary of the organisation as it applies to measurement of GHG emissions. This typically aligns with legal and/or organisational structure; a financial boundary must be drawn within this too
OVERSEER	A New Zealand software platform that enables farmers and growers to estimate and improve nutrient use on farms
PHEV	Plug-in hybrid electric vehicle
pkm	Passenger-kilometre (unit of measure for transport)
Radiative forcing	The difference between solar energy absorbed by the Earth and that radiated back to space. Human activity has impacts which alter radiative forcing
Refrigerants	A substance or mixture used in a heat pump and refrigeration cycle
Removals	Withdrawal of a GHG from the atmosphere by GHG sinks
Reporting boundary	The emission sources included within an organisation's operations, including direct and indirect emission sources. It includes choosing which indirect emission sources to report
Reticulated gas	A piped gas system to deliver a gas such as LPG or natural gas to a consumer
Scope	Emission sources are categorised by Scope to manage risks and impacts of double counting. There are three scopes in greenhouse gas reporting: Scope 1 (direct emissions), Scope 2 (energy indirect emissions) and Scope 3 (other indirect emissions)
Stationary combustion fuel	Fuel used in an unmoving engine eg, a power plant or boiler
tkm	Tonne-kilometre (unit of measure for freight)
Unique emission factor	A value given to an activity based on how emissions intensive it is. Experienced professionals must verify a unique emission factor. See Climate Change (Unique Emission Factors) Regulations 2009 for further information
Uplift factor	Applied to take into account the combined 'real-world' effects on fuel consumption (such as non-direct flight paths)
Forest land	Land containing tree species that will reach a height of at least 5 meters, with a canopy cover of at least 30% and be of at least 1 hectare in size