



Measuring emissions: A guide for organisations

2022 detailed guide



Ministry for the
Environment
Manatū Mō Te Taiao



Te Kāwanatanga o Aotearoa
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Versions and updates

Updates to this document are as follows:

Date	Update
20 April 2022	Initial version published and circulated to stakeholders.
20 May 2022	<p>Version 2 contained updates to emission factors for:</p> <ul style="list-style-type: none">• purchased electricity and transmission & distribution losses• coal• public rail• hybrid electric vehicles. <p>Stakeholders were notified via email. The initial version of the document was removed from the website.</p>
16 August 2022	<p>Version 3 contained updates to emission factors for:</p> <ul style="list-style-type: none">• purchased electricity and transmission and distribution losses. <p>Accompanying technical information regarding the update was published on the Ministry's website.</p> <p>Stakeholders were notified via email. Version 2 of the document was removed from the website.</p>

Contents

Overview of changes since the previous update	10
Introduction	11
Purpose of this guide	11
Important notes	12
Gases included in the guide	14
Uncertainties	15
Standards to follow	15
How to quantify and report GHG emissions	18
Step-by-step inventory preparation	19
Using the emission factors	20
Producing a GHG report	21
Verification	22
Fuel emission factors	23
Overview of changes since previous update	23
Stationary combustion fuel	23
Transport fuel	25
Biofuels and biomass	27
Transmission and distribution losses for reticulated gases	29
Refrigerant and other gases use emission factors	31
Overview of changes since previous update	31
Refrigerant use	31
Medical gases use	37
Purchased electricity, heat and steam emission factors	39
Overview of changes since previous update	39
Indirect Scope 2 emissions from purchased electricity from the New Zealand grid	40
Transmission and distribution losses for electricity	43
Imported heat and steam	44
Geothermal energy	44
Indirect business-related emission factors	45
Overview of changes since previous update	45
Emissions associated with employees working from home	45
Guidance on the use of cloud-based data centres	48

Travel emission factors	49
Overview of changes since previous update	49
Passenger vehicles	49
Public transport passenger	59
Public transport vehicles	63
Air travel	64
7.6 Helicopters	74
7.7 Accommodation	75
Freight transport emission factors	78
Overview of changes since previous update	78
Road freight	78
Rail freight	89
Air freight	91
Coastal and international shipping freight	92
Water supply and wastewater treatment emission factors	96
Overview of changes since previous update	96
Water supply	96
Wastewater treatment	98
Materials and waste emission factors	105
Overview of changes since previous update	105
Construction materials	105
Waste disposal	105
Agriculture, forestry and other land use emission factors	112
Overview of changes since previous update	112
Land use, land-use change and forestry (LULUCF)	113
Agriculture	121
Appendix A: Derivation of fuel emission factors	131
Appendix B: Alternative methods of calculating emissions from refrigerants and medical gases	133
Appendix C: Landfills with and without landfill gas recovery	137
Glossary	139

Tables

Table 1:	Global warming potential (GWP) of GHGs based on 100-year period	14
Table 2:	Emissions by scope, category and source category	16
Table 3:	Emission factors for the stationary combustion of fuels	23
Table 4:	Transport fuel emission factors	25
Table 5:	Biofuels and biomass emission factors	27
Table 6:	Transmission and distribution loss emission factors for natural gas	29
Table 7:	GWPs of refrigerants	32
Table 8:	GWPs of medical gases	38
Table 9:	Emission factor for purchased grid-average electricity – annual average	40
Table 10:	Emission factor for purchased grid-average electricity – calendar quarters	41
Table 11:	Information used to calculate the purchased electricity emission factor for 2010–2020	42
Table 12:	Transmission and distribution losses for electricity consumption	43
Table 13:	Calculating the ratio of each gas from electricity emissions	44
Table 14:	Working from home emission factors	45
Table 15:	Data used to calculate the emission factors	47
Table 16:	Vehicle engine sizes and common car types	50
Table 17:	Pre-2010 vehicle fleet emission factors per km travelled	50
Table 18:	2010–2015 vehicle fleet emission factors per km travelled	51
Table 19:	Post-2015 vehicle fleet emissions per km travelled	52
Table 20:	Default private car emission factors per km travelled for default age of vehicle and <3000 cc engine size	53
Table 21:	Default rental car emission factors per km travelled	54
Table 22:	Emission factors for taxi travel	54
Table 23:	Fuel consumption in litres per 100 km	56
Table 24:	Data used for calculating the taxi emission factors	58
Table 25:	Data on the number of taxis purchased by fuel type	58
Table 26:	Energy consumption per 100 km for light passenger vehicles manufactured in 2004	58
Table 27:	Emission factors for public transport	60
Table 28:	National bus pkm in 2020/21	61
Table 29:	National bus passenger loading by region	61
Table 30:	Emission factor for diesel bus	61
Table 31:	Greater Wellington Regional Council 2020 data for electric buses	62
Table 32:	Greater Wellington Regional Council 2020 data for diesel buses	62

Table 33:	Train data	62
Table 34:	Bus emission factors per km travelled	63
Table 35:	Fuel/energy consumption per 100 km for pre-2010 fleet buses	64
Table 36:	Domestic air travel emission factors for 2019 without a radiative forcing multiplier	65
Table 37:	Domestic aviation emission factors for 2019 with a radiative forcing multiplier	65
Table 38:	Domestic air travel emission factors for 2020 without a radiative forcing multiplier	66
Table 39:	Domestic aviation emission factors for 2020 with a radiative forcing multiplier	66
Table 40:	Domestic aviation data (applicable to 2019)	67
Table 41:	Domestic aviation data (applicable to 2020)	67
Table 42:	Average fuel and passenger data for 2019	68
Table 43:	Average fuel and passenger data for 2020	68
Table 44:	Calculated emissions for 2019, without the radiative forcing multiplier, per aircraft type	69
Table 45:	Calculated emissions for 2019, with the radiative forcing multiplier, per aircraft type	69
Table 46:	Calculated emissions for 2020, without the radiative forcing multiplier, per aircraft type	70
Table 47:	Calculated emissions for 2020, with the radiative forcing multiplier, per aircraft type	70
Table 48:	Emission factors for international air travel with radiative forcing multiplier	71
Table 49:	Emission factors for international air travel without radiative forcing multiplier	72
Table 50:	Emission factors for helicopters	74
Table 51:	Accommodation emission factors	75
Table 52:	Emission factors for light commercial vehicles manufactured pre-2010	79
Table 53:	Emission factors for light commercial vehicles manufactured between 2010 and 2015	79
Table 54:	Emission factors for light commercial vehicles manufactured post-2015	81
Table 55:	Default light commercial vehicle values (based on pre-2010 fleet and a 2000–3000 cc engine size)	82
Table 56:	Emission factors for heavy goods vehicles manufactured pre-2010	82
Table 57:	Emission factors for heavy goods vehicles manufactured between 2010 and 2015	83
Table 58:	Emission factors for heavy goods vehicles manufactured post-2015	83
Table 59:	Default emission factors for heavy goods vehicles	84
Table 60:	Emission factors for freighting goods by road	84

Table 61:	Light commercial vehicles (energy consumption per 100 km)	86
Table 62:	Heavy goods vehicles (energy consumption per 100 km)	87
Table 63:	Data used to calculate the road freight (tkm) emission factor	88
Table 64:	Calculating the ratio of gases in diesel	89
Table 65:	Emission factors for rail freight	89
Table 66:	Information provided by KiwiRail	90
Table 67:	Air freight emission factors with radiative forcing multiplier	91
Table 68:	Air freight emissions without radiative forcing multiplier	91
Table 69:	Coastal shipping emission factors	93
Table 70:	International shipping emission factors	93
Table 71:	Coastal shipping data	94
Table 72:	Water supply emission factors	96
Table 73:	Domestic wastewater treatment emission factors	99
Table 74:	Industrial wastewater treatment emission factors	99
Table 75:	Domestic wastewater treatment emissions calculation components	101
Table 76:	Industrial wastewater treatment methane emissions calculation information	102
Table 77:	Industrial wastewater treatment nitrous oxide emissions calculation information	103
Table 78:	Uncertainties with wastewater treatment emission source category	103
Table 79:	Description of landfill types	106
Table 80:	Waste disposal to municipal (class 1) landfills with gas recovery	106
Table 81:	Waste disposal to municipal (class 1) landfills without gas recovery	107
Table 82:	Waste disposal to non-municipal (class 2-5) landfills	107
Table 83:	Biological treatment of waste emission factors	107
Table 84:	Composition of waste sent to NZ landfills in 2020	108
Table 85:	Information on managed solid waste in 2020	109
Table 86:	Information on non-municipal solid waste in 2020	110
Table 87:	Composition of typical office waste	110
Table 88:	IPCC default data used to calculate composting and anaerobic digestion	111
Table 89:	LULUCF forest growth emission factors	115
Table 90:	LULUCF land-use change emission factors	116
Table 91:	Enteric fermentation emission factors	121
Table 92:	Enteric fermentation figures per livestock type	122
Table 93:	Manure management emission factors	123
Table 94:	Manure management source data	124
Table 95:	Emissions from dairy cattle	125

Table 96:	Agricultural soils emission factors	125
Table 97:	Data used for agricultural soils emission factors	126
Table 98:	Fertiliser use emission factors	127
Table 99:	Examples of different categories of fertilisers	127
Table 100:	Nitrogen fertiliser emission factors	128
Table 101:	Quantified emissions factors from limestone and dolomite	128
Table 102:	Emission factors for non-urea nitrogen fertilisers	129
Table 103:	Parameters for calculating emissions from fertilisers	129
Table A1:	Underlying data used to calculate fuel emission factors	131
Table B1:	Default refrigerant charges for refrigeration and air-conditioning equipment	134
Table B2:	Detailed 100-year GWPs for various refrigerant mixtures	135
Table B3:	Detailed 100-year GWPs (IPCC, 2007) for medical gas blends	136
Table C1:	Landfills with and without landfill gas recovery	137

Figure

Figure 1:	Documents in measuring emissions: A guide for organisations	11
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Overview of changes since the previous update

This is the twelfth version of the publication originally titled *Guidance for Voluntary Greenhouse Gas Reporting*. Previous versions can be accessed on the Ministry's website [here](#).

There have been several updates since the last edition of the guidance in 2020

The emission factors in the fuel chapter have been updated to align with activity data from *New Zealand's Greenhouse Gas Inventory 1990–2020*.

The purchased electricity, heat and steam emissions chapter now includes a time series for electricity and transmission and distribution losses from 2019 and 2020.

The methodology in the indirect business emissions (working from home) chapter has been updated to align with international practices on emissions calculation methodologies.

The travel chapter includes updated emission factors for domestic air travel based on 2019 and 2020 data. Public transport emission factors for buses and rail services have been updated based on 2020 data. International air travel emission factors have been updated to align with the 2021 conversion factors from the United Kingdom Government Department for Business, Energy and Industrial Strategy (UK BEIS). Accommodation emission factors have been updated to align with the 2021 Cornell Hotel Sustainability Benchmarking Index.

The freight transport emissions chapter includes an update to heavy trucks and rail based on 2020 data, and an update to international shipping factors based on the 2021 conversion factors from the UK BEIS.

The materials and waste chapter now recommends users refer directly to the BRANZ CO₂NSTRUCT Report and the EPD Australasia database for up-to-date emission factors for construction materials. The wastewater and waste emission factors have been updated to align with *New Zealand's Greenhouse Gas Inventory 1990–2020*.

In the agriculture, forestry and other land use chapter the methodology and emission factors have been updated to align with *New Zealand's Greenhouse Gas Inventory 1990–2020*.

Impacts of the COVID-19 pandemic: Many organisations' emissions for 2020 have been significantly impacted by COVID-19, for example travel may have been reduced or levels of production reduced. ISO 14064-1:2018 allows a base year to be quantified using an average of several years. This may be an appropriate and representative approach for organisations that have begun measuring their emissions in 2020.

Introduction

Purpose of this guide

The Ministry for the Environment supports organisations taking climate action. 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. The majority of the source data which was used in the development of these emission factors is from 2020. This is done to align with *New Zealand’s Greenhouse Gas Inventory 1990-2020*. This contains data for the calendar years from 1990 to 2020 (inclusive). New Zealand’s Greenhouse Gas Inventory is published 15 months after the end of the period being reported on to allow time to collect and process the data and prepare its publication.

This detailed guide is part of a suite of documents that comprise *Measuring emissions: A guide for organisations*, listed in figure 1. The detailed guide explains how we derived these emission factors and sets out the assumptions surrounding their use.

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
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

THIS DOCUMENT

Feedback

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

Important notes

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

This guide recognises and supports the Government's ambition of a NetZero by 2050 target, and the many organisations that have already set, or are looking to set, ambitious emission reduction targets aligned with a science-based approach. The External Reporting Board guidance which is currently being developed will include the need for disclosure of GHG metrics and targets.

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.

The emission factors and methods in this guide are for sources common to many New Zealand organisations and supports the recommended disclosure of GHG emissions consistent with the Climate-related Disclosures framework and the Carbon Neutral Government Programme (CNGP).

Climate-related disclosures

In October 2021, New Zealand became the first country to legislate mandatory climate risk reporting on the Task Force on Climate-related Financial Disclosures (TCFD) recommendations for large listed issuers, banks, investment managers and insurers. By December 2022, the External Reporting Board expects to release climate standards based on the TCFD recommendations for these entities to disclose against. This will include the need for disclosure of GHG metrics.¹

The TCFD was set up by the Financial Stability Board to increase transparency, stability, and resilience in financial markets. The TCFD framework promotes consistent climate-related financial risk disclosures aligned with investors' needs and which supports organisations in understanding how to measure and report on their climate change risks and opportunities.

The complete TCFD recommendations go beyond the scope of this guidance. For further guidance on these consult the TCFD website.²

¹ External Reporting Board Climate-related Disclosures accessed via: <https://www.xrb.govt.nz/standards/climate-related-disclosures/>

² Task Force on Climate-related Financial Disclosures accessed via: www.fsb-tcfid.org/

Carbon Neutral Government Programme

The Carbon Neutral Government Programme (CNGP) was set up by the Government to accelerate the reduction of emissions within the public sector. The CNGP has published guidance for CNGP organisations on measuring and reporting their GHG emissions.³ It includes information on what sources of GHG emissions organisations need to collect, standards to follow, methods for calculating emissions, the required information to report, who to report to, and by when.

For further guidance on this consult the CNGP website⁴ or contact cngp@mfe.govt.nz.

This guide, and the emission factors and methods, are not appropriate for a full life-cycle assessment or product carbon foot printing. The factors presented in this guide only include direct emissions from activities, and do not include all sources of emissions required for a full life-cycle assessment. If you want to do a full life-cycle assessment, we recommend using life-cycle assessment databases and/or software tools. A list of relevant life-cycle inventory databases can be found on the [LCANZ website](#).⁵

Measuring your organisation's emissions is the first step in the journey to reducing your emissions. Developing and implementing a reduction plan is the next important step. The New Zealand Government's emissions reduction plan will be published in mid-2022. The emissions reduction plan is not intended to be guidance for how organisations should create their own emission reduction plans.

It is best practice to reduce emissions as much as possible before offsetting – see the Ministry's [Interim guidance for voluntary climate change mitigation](#).

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

If emission factors relevant to your organisation are not included in *Measuring emissions: A guide for organisations*, we suggest using alternatives such as those published by the UK government: <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021>.

When using emission factors from other sources, it is important to consider factors such as:

- the geographic context – ideally the data should reflect the country or region that the emissions calculation is associated with
- the time period it applies to – ideally the data should reflect the time period that the emissions calculation is associated with
- the age of emission factor – ideally emission factors should be based on methods and data published less than 5–10 years ago
- coverage – are the emission factors combustion based or life cycle
- global warming potential (GWP) values – are they based on the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report (AR4) or fifth assessment report (AR5)

³ <https://environment.govt.nz/publications/cngp-measuring-and-reporting-ghg-emissions/>

⁴ Carbon Neutral Government Programme accessed via: <https://environment.govt.nz/what-government-is-doing/key-initiatives/carbon-neutral-government-programme/>

⁵ <https://lcanz.org.nz/lca-guidance/lca-resources/#LCI>

- whether suitable supplier specific emissions factors are available rather than national average factors.

Gases included in the guide

This guide covers the following greenhouse gases (GHGs): carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆), nitrogen trifluoride (NF₃) and other gases (eg, Montreal Protocol refrigerant gases or medical gases).⁶

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).⁷ To enable a meaningful comparison between the seven gas types, GHG emissions are commonly expressed as carbon dioxide equivalent or CO₂-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 Intergovernmental Panel on Climate Change (IPCC) provides more information on how these factors are calculated.⁸

Throughout the guide, kilograms (kg) of methane and nitrous oxide are reported in kg CO₂-e by multiplying the actual methane emissions by the GWP of 25 and actual nitrous oxide emissions by the GWP of 298, as per table 1.

ISO 14064-1:2018 recommends using the latest IPCC GWPs. However, this guide uses the 100-year GWPs in the IPCC Fourth Assessment Report (AR4) to align with the approach used in *New Zealand's Greenhouse Gas Inventory 1990-2020*. There are a small number of 'other gases' that are included in the Fifth Assessment Report (AR5) but not AR4; in these cases the AR5 GWPs are used. These gases are clearly identified in this guidance.

The change from AR4 to AR5 GWPs may cause a significant change in some organisation's inventories, including those who use large quantities of refrigerants. For those that see reductions in their footprints, it would be misleading to interpret this as a true reduction, and the focus should remain on reducing the use of these refrigerants or switching to more climate-friendly alternatives. It may be necessary to restate previous inventories based on updated global warming potentials.

From 2023, the rest of this guidance will be updated to align with AR5 GWPs as we enter the reporting period for the Paris Agreement. Additional guidance will be provided at the next update about how to transition to the new global warming potentials.

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

GHGs	Scientific Formula	GWP (AR4)	GWP (AR5)
Nitrous Oxide	N ₂ O	298	265

⁶ The *GHG Protocol* added nitrogen trifluoride in 2013 as a requirement and ISO 14064-1 included nitrogen trifluoride in 2018. This is consistent with *New Zealand's Greenhouse Gas Inventory 1990-2020*.

⁷ We use the 2007 IPCC GWPs to ensure consistency with *New Zealand's Greenhouse Gas Inventory 1990-2020*. These can be found in the *IPCC AR4 Climate Change 2007: The physical science basis* accessed via: www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf

⁸ *IPCC AR4 Climate Change 2007: The physical science basis* accessed via: www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf

Methane	CH ₄	25	28
Carbon Dioxide	CO ₂	1	1

1.3.1 Kyoto and Montreal Protocols and Paris Agreement

The Kyoto Protocol,⁹ 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: CO₂, CH₄, N₂O, HFCs, PFCs, SF₆ and NF₃.

The Montreal Protocol,¹⁰ 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), hydrochlorofluorocarbons (HCFCs), hydrobromofluorocarbons (HBFCs), methyl bromide, carbon tetrachloride, methyl chloroform and halons. New Zealand prohibits imports of CFCs and HCFCs as part of our implementation of the protocol.

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

The 2015 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. New Zealand's Greenhouse Gas Inventory reporting under the Paris Agreement will be using 100-year GWPs from IPCC AR5. The first such Greenhouse Gas Inventory will be submitted in 2023.

Uncertainties

ISO 14064-1:2018 focuses on uncertainty, in particular, assessing and disclosing uncertainty associated with the organisation's GHG inventory.

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.

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. Depending on your intended final

⁹ UNFCCC, What is the Kyoto Protocol accessed via: https://unfccc.int/kyoto_protocol

¹⁰ UNDP, Montreal Protocol, accessed via: www.undp.org/content/undp/en/home/2030-agenda-for-sustainable-development/planet/environment-and-natural-capital/chemicals-and-waste-management/ozone.html

use and users, we recommend downloading the relevant following standards and using them in tandem with this guidance:

- [ISO 14064-1:2018](#)¹¹ is shorter and more direct than the GHG Protocol. A PDF copy can be purchased.
- The [GHG Protocol](#)¹² gives more description and context around what to do to produce an inventory. It is free to download. The [Corporate Value Chain \(Scope 3\) Accounting and Reporting Standards](#) are also available which allow companies to assess their entire value chain emissions impact and identify where to focus reduction activities.

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

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

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).

[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 terminology of ‘Categories’ is used in ISO 14064-1:2018, replacing the use of ‘Scopes’.

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

The guide reports emission factors for direct (Scope 1) and indirect (Scope 2) emissions and a limited set of indirect (Scope 3) emissions, as summarised in table 2.

Table 2: Emissions by scope, category and source category

Scopes used in the GHG Protocol	Categories used in ISO 14064-1:2018	Direct/Indirect emissions and removals	Source
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¹¹ Published by the International Organization for Standardization. This standard is closely based on the *GHG Protocol*.

¹² Developed jointly by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD).

Scope 1	Category 1	Direct GHG emissions and removals	Fuel
			Refrigerant and medical gases*
			Agriculture, forestry, and other land uses
Scope 2	Category 2	Indirect GHG emissions from imported energy	Purchased energy
Scope 3	Category 3	Indirect GHG emissions from transportation	Business travel
			Employee commute (travel)
			Freight transport
			Refrigerant use (from chilled transport or air conditioner)
			Working from home
	Category 4	Indirect GHG emissions from products an organisation uses	Transmission and distribution losses
			Water supply and wastewater treatment
			Materials and waste
	Category 5	Indirect GHG emissions (use of products from the organisation)	
	Category 6	Indirect GHG emissions (other sources)	

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

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

Currently for direct emissions, [ISO 14064-1:2018](#) requires that organisations report emissions by GHG as well as in carbon dioxide equivalents (CO₂-e). Example calculations in this guide do so. See the [2019 Example GHG Report](#) and [2019 Example GHG Inventory](#) for further examples.

How to quantify and report GHG emissions

To quantify and report GHG emissions, organisations need data about their activities (for example the quantity of fuel used). They can then convert this into information about their emissions (measured in tonnes of CO₂-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

$$E = Q \times F$$

Where:

E	=	emissions from the emissions source in kg CO ₂ -e per year
Q	=	activity data, eg, quantity of fuel used
F	=	emission factor for emissions source

This formula applies to the calculation of both CO₂-e emissions and individual carbon dioxide, methane and nitrous oxide emissions, with the appropriate emission factors applied for F.

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

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

A **GHG report** (see [section 2.3](#)) expands on the inventory with context about the organisation, 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 that wish to be in line with the [GHG Protocol](#) and [ISO 1406-1:2018](#) should be aware that it is best practice for organisations to understand their full scope 3 (value chain) emissions.

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.

Step-by-step inventory preparation

To prepare an inventory:

Select the boundaries (organisational and reporting¹³) and measurement period (ie, calendar or financial year) you will report against for your organisation, based on the intended uses of the inventory.

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

Multiply the quantity used by the appropriate emission factor in a spreadsheet. See the 2019 Example GHG Inventory.

Produce a GHG report, if applicable. See [section 2.3](#) and the [2019 Example GHG Report](#).

If this is the first year your organisation has produced an inventory, you can use it as a base year for measuring the change in emissions over time (as long as the scope and boundaries represent your usual operations, and that comparable reporting is used in future years). ISO 14064-1:2018 also allows a base year to be quantified using an average of several years. Due to COVID-19 this may be an appropriate and representative approach for organisations that have begun measuring their emissions in 2020 and 2021.

To ensure the representativeness of your base year GHG inventory, it is good practice to undertake a base year review and recalculation procedure to account for any significant changes that may have occurred since. Examples of such changes may result from:

- a structural change in your reporting or organisational boundary
- a change in calculation methodologies or emission factors, or
- the discovery of an error or cumulative errors in your activity data.

Any base year recalculations should be documented in subsequent inventories.

If the change to a factor is material and could result in a +/- 5% change in an organisations published GHG inventory then recalculation and re-publishing of the inventory is required. In the cases where historic emission factors have changed it is suggested these figures are provided in the document itself or made available elsewhere.

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*¹⁴ 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.

Note however, if the user is needing to report into a particular programme or satisfy an intended use or user, they may decide to include *de minimis* activities.

¹³ See Glossary for definitions.

¹⁴ See Glossary for definition.

Using the emission factors

Emission factors rely on historical data. This version of the guidance is based on [New Zealand's Greenhouse Gas Inventory 1990–2020](#) as this was the latest complete set of data available. We intend to update these emissions factors annually, where more recent data is available.

If you use the Interactive workbook, input your activity data and the emission factors will be applied automatically. If you do not use the Interactive workbook, simplified example calculations are provided throughout chapter 4 to demonstrate how to use the emission factors.¹⁵

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

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 2021 calendar year, use this 2022 guide, which largely relies on 2019 and 2020 data.

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 2020/21 financial year, use this 2022 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 1990–2020](#). This also means we use the GWPs from the AR4 to ensure consistency.

Under the reporting requirements of [ISO 14064-1:2018](#) and the [GHG Protocol](#), GHG emissions should be reported in tonnes CO₂-e. However, many emission factors are too small to be reported meaningfully in tonnes, therefore this guide presents emission factors in kg CO₂-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 irrespective of how a fuel is combusted.

Non-carbon dioxide emissions (ie, methane and nitrous oxide) and emission factors depend on the way the fuel is combusted.¹⁶ To reflect this variability, the guide provides uncertainty estimates for direct (Scope 1) emission factors. [Table 3](#) presents separate carbon dioxide

¹⁵ 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.

¹⁶ 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.

equivalent emission factors for residential, commercial and industrial users. It follows the IPCC guidelines for combustion and adopts the uncertainties.¹⁷

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.

Producing a GHG report

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

A GHG REPORT

To compile a full GHG report, organisations should include:

- a description of the organisation
- the person or entity responsible for the report
- a description of the inventory boundaries
- organisational boundary
- reporting boundary
- measurement period
- the chosen base year (initial measurement period for comparing annual results)
- emissions (and removals where appropriate)
- for all seven GHGs separately in metric tonnes CO₂-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 methodologies for calculating emissions, and references to key data sources
- impacts of uncertainty on the inventory
- any specific exclusions of sources, facilities or operations.

View an example reporting template on the [GHG Protocol Corporate Standard webpage](#).

¹⁷ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 2.

Verification

Verification¹⁸ 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 methodologies.

Who should verify my inventory?

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

- are independent
- hold accreditation or certification from a suitable professional organisation (for example, a professional recognition from NZICA, a carbon auditor certification from Carbon and Energy Professionals New Zealand, or organisations accredited to ISO 14065 standard)
- have experience with emissions inventories
- understand [ISO 14064](#), [ISAE \(NZ\) 3410](#), and the [GHG Protocol](#)
- have effective internal peer review and quality control processes.
- 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.¹⁹
- [ISAE \(NZ\) 3410](#) deals with assurance engagements to report on an entity's GHG statement. It is free to download.

¹⁸ See Glossary for definition.

¹⁹ View accredited bodies on the JAS-ANZ Register at www.jas-anz.org/accredited-bodies/all

Fuel emission factors

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

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

Overview of changes since previous update

The fuel emissions factors are based on data from the [New Zealand Greenhouse Gas Inventory 1990–2020](#). Updates were made to commercial diesel, heavy and light fuel oil, regular and premium petrol, and woody biomass.

Stationary combustion fuel

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

Table 3 contains emission factors for common fuels used for stationary combustion in New Zealand. The Ministry of Business, Innovation and Employment (MBIE) provided the emission factors and supporting data. The same data were used in the [New Zealand Greenhouse Gas Inventory 1990–2020](#).

Table 3: Emission factors for the stationary combustion of fuels

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	Uncertainties kg CO ₂ -e/unit
Residential use						
Coal – default	kg	2.10	1.94	0.150	0.00895	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	2.01	1.99	0.00517	0.00924	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	2.67	2.65	0.00907	0.0065	0.5%
LPG	kg	3.03	3.02	0.00594	0.0014	0.5%

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	Uncertainties kg CO ₂ -e/unit
Heavy fuel oil	litre	3.02	3.00	0.00971	0.0069	0.5%
Light fuel oil	litre	2.96	2.94	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	1.93	1.92	0.00496	0.0089	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.
- Commercial and industrial classifications are based on standard classification.²⁰
- 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.

GHG inventory development

To calculate stationary combustion fuel emissions, collect data on the quantity of fuel used in the unit expressed. Applying the equation $E=Q \times F$ (section 2), this means:

- E = emissions from the emissions source in kg CO₂-e per year
Q = quantity of fuel used (unit)
F = appropriate emission factors from table 3.

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 ₂ O 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.

²⁰ ANZSIC – Australian and New Zealand Standard Industrial Classification.

Emission factor derivation methodology

MBIE derived the kg CO₂-e per activity unit emission factors supplied in [table 3](#) using calorific values²¹ and emission factors for tonnes (t) of gas per terajoule (TJ). The calorific values are in [Appendix A: Derivation of fuel emission factors](#) alongside further information on the methodology.

Assumptions, limitations and uncertainties

MBIE derived the kg CO₂-e per activity unit emission factors supplied in [table 3](#) using calorific values, listed in [Appendix A: Derivation of fuel emission factors](#).

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

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

We calculated the default coal emission 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.

Transport fuel

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

Table 4: Transport fuel emission factors

Fuel type	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	Uncertainties kg CO ₂ -e/unit
Regular petrol (default)	litre	2.46	2.35	0.0276	0.0797	1.8%
Premium petrol	litre	2.48	2.37	0.0277	0.0801	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%

Notes:

These numbers are rounded to three significant figures.

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

These petrol emission factors are higher than the ones in ETS regulations so could be updated in future when the ETS emission factors are updated. The refinery closure will also affect them.²²

²¹ See [Appendix A: Derivation of fuel emission factors](#) for more information.

²² Climate Change (Liquid Fossil Fuels) Regulations 2008 (SR 2008/356) (as at 1 October 2018) Schedule Emissions factors for tonnes of carbon dioxide equivalent greenhouse gases per kilolitre – New Zealand Legislation.

GHG inventory development

To calculate transport fuel emissions, collect data on the quantity of fuel used in the unit expressed. Applying the equation $E = Q \times F$ (section 2), this means:

E	=	emissions from the emissions source in kg CO ₂ -e per year
Q	=	quantity of fuel used (unit)
F	=	appropriate emission factors from table 4

All 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 ₂ O emissions	= 40,000 × 0.0797	= 3,186 kg CO ₂ -e
Total CO ₂ -e emissions	= 40,000 × 2.46	= 98,400 kg CO ₂ -e

Note: Numbers may not add due to rounding.

When no fuel data are available

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

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

Emission factor derivation methodology

We applied the same methodology to the transport fuels that we used to calculate the stationary combustion fuels, using the raw data in table 4.

Assumptions, limitations and uncertainties

MBIE derived the kg CO₂-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 has not been updated since the last emissions factor publication and is a weighted average of regular and premium petrol based on 2021 sales volume data from *Energy in New Zealand 2021* (MBIE, 2021). 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.

Biofuels and biomass

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

The carbon dioxide emitted from the combustion of biofuels and biomass (including wood) is biogenic, meaning it equates to the carbon dioxide absorbed by the feedstock during its lifespan. This means we treat the carbon dioxide portion of the combustion emissions of biofuels as carbon neutral. However, these CO₂ emissions still need to be reported separately in the inventory, under biogenic emissions. This is why the kg CO₂-e/unit figures in table 5 are the sum of the CH₄ and N₂O.

The combustion of biofuels generates anthropogenic methane and nitrous oxide. Organisations should calculate and report these gases, as is done at the national level according to the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.²³

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

Table 5: Biofuels and biomass emission factors

Biofuel type	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	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 (100%)	GJ	3.42	67.3	2.85	0.570	0.1%
	litre	0.000125	2.45	0.000104	0.0000208	0.1%
Wood – residential	kg	0.06696	0.862	0.00578	0.00918	36.3%
Wood – industrial	kg	0.01496	0.862	0.05778	0.00918	43.7%

Notes

- These numbers are rounded to three significant figures.
- 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 CO₂-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.

²³ *2006 Guidelines for Greenhouse Gas Inventories*, Volume 2, Energy, accessed via: www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

GHG inventory development

Note that although the direct (Scope 1) carbon dioxide emissions of biomass combustion are considered carbon neutral over the short-term carbon cycle, organisations should still report the carbon dioxide released through biofuel and biomass combustion.²⁴

Calculate the carbon dioxide emissions in the same way as the direct emissions. Then, instead of including them within the emissions total (where CH₄ and NO₂ gases are reported), list them as a separate line item called 'biogenic emissions'.²⁵ 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 $E=Q \times F$ (section 2), this means:

E = emissions from the emissions source in kg CO₂-e per year
Q = quantity of fuel used (unit)
F = appropriate emission factors from table 5

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

The equation used is:

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

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 (reported separately)
CH ₄ emissions	= 7,000 × 0.000104	= 0.728 kg CO ₂ -e
N ₂ O 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 (reported as Scope/Category 1)

An organisation wants to report on its Scope 1 fuel emissions (in kg CO₂-e/litre) from a specific biodiesel blend of 10 per cent. It is known that:

mineral diesel emission factor = 2.69 kg CO₂-e/litre
biodiesel emission factor = 0.000125 kg CO₂-e/litre

Therefore, 10 per cent biodiesel blend emission factor =

$$(10\% \times 0.000125) + [(1-10\%) \times 2.69] = 2.42 \text{ kg CO}_2\text{-e/litre biofuel blend}$$

Note: Numbers may not add due to rounding.

²⁴ The GHG Protocol guidance on this is accessed via: https://ghgprotocol.org/sites/default/files/Stationary_Combustion_Guidance_final_1.pdf

²⁵ The GHG Protocol guidance on this is accessed via: https://ghgprotocol.org/sites/default/files/Stationary_Combustion_Guidance_final_1.pdf

Emission factor derivation methodology

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

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.

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).

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

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

Reticulated LPG is supplied in parts of Canterbury and Otago only (natural gas is not available in the South Island). The guide assumes there are no transmission and distribution losses from reticulated LPG due to the chemical composition of the gas. As 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 6 details the emission factors for the transmission and distribution losses for reticulated natural gas. These represent an estimate of the average amount of carbon dioxide equivalents emitted from losses associated with the delivery (transmission and distribution) of each unit of gas consumed through local distribution networks in 2018. They are average figures and therefore make no allowance for distance from off-take point, or other factors that may vary between individual consumers.

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

Transmission and distribution losses source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Natural gas used	kWh	0.012	n/a	0.012	n/a
	GJ	3.212	n/a	3.212	n/a

Note: These numbers are rounded to three significant figures.

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 $E = Q \times F$ (section 2), this means:

E	=	emissions from the emissions source in kg CO ₂ -e per year
Q	=	quantity of fuel used (unit)
F	=	appropriate emission factors from table 6

TRANSMISSION AND DISTRIBUTION LOSSES: EXAMPLE CALCULATION

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

CO ₂ emissions	= 800 × 0.00	= 0 kg CO ₂
CH ₄ emissions	= 800 × 3.212	= 2569.6 kg CO ₂ -e
N ₂ O emissions	= 800 × 0.00	= 0 kg CO ₂ -e
Total CO ₂ -e emissions	= 800 × 3.212	= 2569.6 kg CO ₂ -e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

MBIE provided the transmission and distribution losses emission factor in kg CO₂-e. We assume that natural gas is predominantly methane, so all leakage is methane.

Assumptions, limitations and uncertainties

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

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.

Refrigerant and other gases use emission factors

Overview of changes since previous update

This guide includes the 100-year global warming potentials (GWPs) of gases reported under the Kyoto Protocol and Paris Agreement and those gases reported under the Montreal Protocol. This is consistent with *New Zealand's Greenhouse Gas Inventory 1990-2020*. We use the GWPs published in the [IPCC Fourth Assessment Report \(IPCC AR4\)](#) and the [IPCC Fifth Assessment Report \(IPCC AR5\)](#), in line with the UNFCCC, to which we submit *New Zealand's Greenhouse Gas Inventory*.

Where IPCC AR4 GWPs are available these are used; where they are not available IPCC AR5 GWPs are used instead. In the next version of this guidance, GWP values from only IPCC AR5 will be included. This is to reflect the transition from the Kyoto Protocol to the Paris Agreement reporting periods.

Refrigerant use

GHG emissions from 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 so emissions from this source may be material. Also, emissions associated with this sector have grown significantly as they replace ozone depleting chemical such as CFCs and 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.

Global warming potentials (GWPs) of refrigerants

Table 7 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 100-year GWPs from the IPCC's Fourth Assessment Report²⁶ to ensure consistency with the *New Zealand Greenhouse Gas Inventory 1990–2020*.

Some refrigerants are 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 AR4 GWP of various refrigerant mixtures, see table B2 in Appendix B: *Alternative methods of calculating emissions from refrigerants*. For the AR5 GWP values, refer to Appendix 8.A in Chapter 8: *Anthropogenic and Natural Radiative Forcing* of the Fifth IPCC Assessment Report.

Table 7: GWPs of refrigerants

Industrial designation/ common name	Chemical formula	Unit	AR4 GWP ₁₀₀	AR5 GWP ₁₀₀
Substances controlled by the Montreal Protocol				
CFC-11	CCl ₃ F	kg	4750	4,660
CFC-12	CCl ₂ F ₂	kg	10,900	10,200
CFC-13	CCIF ₃	kg	14,400	13,900
CFC-113	CCl ₂ FCCIF ₂	kg	6,130	5,820
CFC-114	CCIF ₂ CCIF ₂	kg	10,000	8,590
CFC-115	CCIF ₂ CF ₃	kg	7,370	7,670
Halon-1301	CBrF ₃	kg	7,140	6,290
Halon-1211	CBrClF ₂	kg	1,890	1,750
Halon-2402	CBrF ₂ CBrF ₂	kg	1,640	1,470
Carbon tetrachloride	CCl ₄	kg	1,400	1,750
Methyl bromide	CH ₃ Br	kg	5	2
Methyl chloroform	CH ₃ CCl ₃	kg	146	160
HCFC-21	CHCl ₂ F	kg	n/a	148
HCFC-22	CHClF ₂	kg	1,810	1,760
HCFC-123	CHCl ₂ CF ₃	kg	77	79
HCFC-124	CHClFCF ₃	kg	609	527
HCFC-141b	CH ₃ CCl ₂ F	kg	725	782
HCFC-142b	CH ₃ CCIF ₂	kg	2,310	1,980
HCFC-225ca	CHCl ₂ CF ₂ CF ₃	kg	122	127
HCFC-225cb	CHClFCF ₂ CCIF ₂	kg	595	525
Hydrofluorocarbons				
HFC-23	CHF ₃	kg	14,800	12,400
HFC-32	CH ₂ F ₂	kg	675	677
HFC-41	CH ₃ F ₂	kg	n/a	116
HFC-125	CHF ₂ CF ₃	kg	3,500	3,170
HFC-134	CHF ₂ CHF ₂	kg	n/a	1,120

²⁶ 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

Industrial designation/ common name	Chemical formula	Unit	AR4 GWP ₁₀₀	AR5 GWP ₁₀₀
HFC-134a	CH ₂ FCF ₃	kg	1,430	1,300
HFC-143	CH ₂ FCHF ₂	kg	n/a	328
HFC-143a	CH ₃ CF ₃	kg	4,470	4,800
HFC-152	CH ₂ FCH ₂ F	kg	n/a	16
HFC-152a	CH ₃ CHF ₂	kg	124	138
HFC-161	CH ₃ CH ₂ F	kg	n/a	4
HFC-227ea	CF ₃ CHFCF ₃	kg	3,220	3,350
HFC-236cb	CH ₂ FCF ₂ CF ₃	kg	n/a	1,210
HFC-236ea	CHF ₂ CHFCF ₃	kg	n/a	1,330
HFC-236fa	CF ₃ CH ₂ CF ₃	kg	9,810	8,060
HFC-245ca	CH ₂ FCF ₂ CHF ₂	kg	n/a	716
HFC-245fa	CHF ₂ CH ₂ CF ₃	kg	1030	858
HFC-365mfc	CH ₃ CF ₂ CH ₂ CF ₃	kg	794	804
HFC-43-10mee	CF ₃ CHFCF ₂ CF ₃	kg	1,640	1,650
Perfluorinated compounds				
Sulphur hexafluoride	SF ₆	kg	22,800	23,500
Nitrogen trifluoride	NF ₃	kg	17,200	16,100
PFC-14	CF ₄	kg	7,390	6,630
PFC-116	C ₂ F ₆	kg	12,200	11,100
PFC-218	C ₃ F ₈	kg	8,830	8,900
PFC-318	c-C ₄ F ₈	kg	10,300	9,540
PFC-3-1-10	C ₄ F ₁₀	kg	8,860	9,200
PFC-4-1-12	C ₅ F ₁₂	kg	9,160	8,550
PFC-5-1-14	C ₆ F ₁₄	kg	9,300	7,910
PFC-9-1-18	C ₁₀ F ₁₈	kg	7,500	7,190
Trifluoromethyl sulphur pentafluoride	SF ₅ CF ₃	kg	17,700	17,400
Perfluorocyclopropane	c-C ₃ F ₆	kg	n/a	9,200
Fluorinated ethers				
HFE-125	CHF ₂ OCF ₃	kg	14,900	12,400
HFE-134	CHF ₂ OCHF ₂	kg	6,320	5,560
HFE-143a	CH ₃ OCF ₃	kg	756	523
HFE-227ea	CF ₃ CHFOCF ₃	kg	n/a	6,450
HCFE-235da2	CHF ₂ OCHClCF ₃	kg	350	491
HFE-236ea2	CHF ₂ OCHF ₂ CF ₃	kg	n/a	1,790
HFE-236fa	CF ₃ CH ₂ OCF ₃	kg	n/a	979
HFE-245cb2	CH ₃ OCF ₂ CF ₃	kg	708	654
HFE-245fa1	CHF ₂ CH ₂ OCF ₃	kg	n/a	828
HFE-245fa2	CHF ₂ OCH ₂ CF ₃	kg	659	812
HFE-245fb2	CF ₃ CH ₂ OCH ₃	kg	n/a	1
HFE-254cb2	CH ₃ OCF ₂ CHF ₂	kg	359	359
HFE-329mcc2	CHF ₂ CF ₂ OCF ₂ CF ₃	kg	n/a	3,070
HFE-338mcf2	CF ₃ CH ₂ OCF ₂ CF ₃	kg	n/a	929

Industrial designation/ common name	Chemical formula	Unit	AR4 GWP ₁₀₀	AR5 GWP ₁₀₀
HFE-347mcc3	CH ₃ OCF ₂ CF ₂ CF ₃	kg	575	530
HFE-347mcf2	CHF ₂ CH ₂ OCF ₂ CF ₃	kg	n/a	854
HFE-347pcf2	CHF ₂ CF ₂ OCH ₂ CF ₃	kg	580	889
HFE-356mec3	CH ₃ OCF ₂ CHF ₂ CF ₃	kg	n/a	387
HFE-356pcc3HFE-356pcc3	CHF ₂ OCF ₂ CF ₂ OCHF ₂ CH ₃ OCF ₂ CF ₂ CHF ₂	kg	110	413
HFE-356pcf2	CHF ₂ CH ₂ OCF ₂ CHF ₂	kg	n/a	719
HFE-356pcf3	CHF ₂ OCH ₂ CF ₂ CHF ₂	kg	n/a	446
HFE-365mcf3	CF ₃ CF ₂ CH ₂ OCH ₃	kg	n/a	<1
HFE-374pc2	CHF ₂ CF ₂ OCH ₂ CH ₃	kg	n/a	627
HFE-449sl (HFE-7100)	C ₄ F ₉ OCH ₃	kg	297	421
HFE-569sf2 (HFE-7200)	C ₄ F ₉ OC ₂ H ₅	kg	59	57
HFE-43-10pccc124 (H-Galden 1040x)	CHF ₂ OCF ₂ OC ₂ F ₄ OCHF ₂	kg	1,870	2,820
HFE-236ca12 (HG-10)	CHF ₂ OCF ₂ OCHF ₂	kg	2,800	5,350
HFE-338pcc13 (HG-01)	CHF ₂ OCF ₂ CF ₂ OCHF ₂	kg	1,500	2,910
Perfluoropolyethers				
PFPME	CF ₃ OCF(CF ₃)CF ₂ OCF ₂ OCF ₃	kg	10,300	9,710
Hydrocarbons and other compounds – direct effects				
Chloroform	CHCl ₃	kg	n/a	16
Dimethylether	CH ₃ OCH ₃	kg	1	1
Halon-1201	CHBrF ₂	kg	n/a	376
Methylene chloride	CH ₂ Cl ₂	kg	8.7	9
Methyl chloride	CH ₃ Cl	kg	13	12
Refrigerant blends – Zeotropes				
404A	R-125/143a/134a (44.0/52.0/4.0)	kg	3,921.6	3,922
406A	R-22/600a/142b (55.0/4.0/41.0)	kg	1,942.72	1,943
,407C	R-32/125/134a (23.0/25.0/52.0)	kg	1,773.85	1,774
407F	R-32/125/134a (30.0/30.0/40.0)	kg	1,825.50	1,825
408A	R-125/143a/22 (7.0/46.0/47.0)	kg	1,375.84	3,152
409A	R-22/124/142b (60.0/25.0/15.0)	kg	1,584.75	1,585
409B	R-22/124/142b (65.0/25.0/10.0)	kg	1,559.75	n/a
410A	R-32/125 (50.0/50.0)	kg	2,087.50	2,088
436A	R-290/600a (56.0/44.0)	kg	3.15	n/a
436B	R-290/600a (52.0/48.0)	kg	3.156	n/a
Refrigerant blends - Zeotropes				
507A	R-125/143a (50.0/50.0)	kg	3,985.0	3,985

Industrial designation/ common name	Chemical formula	Unit	AR4 GWP ₁₀₀	AR5 GWP ₁₀₀
Medical gases				
HFE-347mmz1 (Sevoflurane)*	(CF ₃) ₂ CHOCH ₂ F	kg	216	216
HCFE-235da2 (Isoflurane)	CHF ₂ OCHClCF ₃	kg	350	491
HFE-236ea2 (Desflurane)*	CHF ₂ OCHF ₂ CF ₃	kg	1,790	1,790
Medical gas blends				
Entonox	N ₂ O/O ₂ (50.0/50.0)	kg	173	173

GHG inventory development

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

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

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

Method A: Top-up

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

$$\text{Gas used (kg)} \times \text{GWP} = \text{Emissions (kg CO}_2\text{-e)}$$

Where:

- E = emissions from equipment in kg CO₂-e
- GWP = the 100-year global warming potential of the refrigerant used in equipment (table 7).

Methods B and C: Screening

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

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

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

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

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

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 2020 calendar year, a service technician confirmed a top-up of 6 kg of HFC-134a (AR4 GWP = 1430) in December 2020. The technician also confirmed that when last serviced at the end of December 2019, no top-ups were needed. So, we assume all the 6 kg of gas was lost during calendar year 2020.

So, for the 2020 inventory:

$$6 \text{ kg HFC-134a} \times 1,430 = 8,580 \text{ kg CO}_2\text{-e}$$

Air conditioning unit: During the 2020 calendar year, a service technician confirmed a top-up of 6 kg of HFC-143a (AR4 GWP = 4,470) in July 2020. The technician also confirmed that when last serviced at the end of July 2019, 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 2020 measurement period.

$$6 \text{ kg} / 12 \text{ months} = 0.5 \text{ kg per month}$$

So, for the 2020 calendar year inventory, $0.5 \times 6 \text{ months} = 3 \text{ kg}$. Emissions calculate as:

$$3 \text{ kg HFC-143a} \times 4,470 = 13,410 \text{ kg CO}_2\text{-e}$$

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

REFRIGERANT USE METHOD B: EXAMPLE CALCULATIONS

Method B: Screening method with default annual leakage rate

Chiller unit: Compliance plates on the equipment confirm the refrigerant is HFC-134a (AR4 GWP = 1,430) and the volume held is 12 kg. For the chiller unit size, the default leakage rate is 8%.

So, for the 2020 calendar year,

$$12 \text{ kg HFC-134a} \times 8\% \times 1,430 = 1,372.8 \text{ kg CO}_2\text{-e}$$

Air conditioning unit: A service technician confirms the refrigerant is HFC-143a (AR4 GWP = 4,470) and the volume held is 12 kg. For the size of the unit, the default leakage rate is 3%.

So, for the 2020 calendar year,

$$12 \text{ kg HFC-143a} \times 3\% \times 4,470 = 1,609.2 \text{ kg CO}_2\text{-e}$$

Note: Numbers may not add due to rounding.

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

Medical gases use

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

Global warming potentials of medical gases

Table 8 details the GWPs of the medical gases included in this chapter. The GWP is effectively the emission factor for each unit of medical gas lost to the atmosphere. The guide uses IPCC AR4 GWPs where available for consistency with the *New Zealand Greenhouse Gas Inventory 1990–2020*. For gases not reported in AR4, IPCC AR5 GWPs are used. It may be preferable for organisations wanting to compare potency of these gases to use only IPCC AR5.

Some medical gases consist of a mixture (or blend) of gases. If you know the blend composition, you can calculate the GWP based on the percentage of each gas. Alternatively, for the GWP of some commonly used medical blends refer to [table B3](#).

Table 8: GWPs of medical gases

Industrial designation/ common name	Chemical formula	Unit	AR4 GWPs in a 100-year period (kg CO ₂ -e) without climate change feedbacks ²⁷	AR5 GWPs in a 100-year period (kg CO ₂ -e) without climate change feedbacks ²⁸
HFE-347mmz1 (Sevoflurane)	(CF ₃) ₂ CHOCH ₂ F	kg	Not available	216
HCFE-235da2 (Isoflurane)	CHF ₂ OCHClCF ₃	kg	350	491
HFE-236ea2 (Desflurane)	CHF ₂ OCHF ₂ CF ₃	kg	Not available	1790

GHG inventory development

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

$$\text{Gas used (kg)} \times \text{GWP} = \text{Emissions (kg CO}_2\text{-e)}$$

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

MEDICAL GAS USE: EXAMPLE CALCULATION

An organisation uses 5 bottles of Isoflurane (HCFE-235da2, AR4 GWP = 350) in the reporting period. Each bottle holds 0.3 kg of Isoflurane. Its direct (Scope 1) emissions are:

$$\begin{aligned} 5 \text{ bottles} \times 0.3 \text{ kg} &= 1.5 \text{ kg} \\ \text{Total CO}_2\text{-e emissions} &= 1.5 \times 350 = 525 \text{ kg CO}_2\text{-e} \end{aligned}$$

An organisation uses 5 bottles 250mL bottles of Isoflurane (HCFE-235da2, AR4 GWP = 350) in the reporting period. The density of Isoflurane is 1.49 g/mL. Its direct (Scope 1) emissions are:

$$\begin{aligned} 5 \text{ bottles} \times 250 \text{ mL} \times 1.49 / 1000 &= 1.86 \text{ kg} \\ \text{Total CO}_2\text{-e emissions} &= 1.86 \times 350 = 651 \text{ kg CO}_2\text{-e} \end{aligned}$$

Assumptions

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

²⁷ AR4 GWPs accessed via www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf

²⁸ AR5 GWPs accessed via www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

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. Hence users could liaise directly with their supplier of the importing heat, steam, or geothermal energy, for supplier specific emissions intensities suitable for calculating in the organisation inventory.

Overview of changes since previous update

In this guide, we have included a time series of historic electricity emission factors based on annual and quarterly periods. The quarterly time series extends back to 2019, and the annual time series extends back to 2010. There is also an equivalent time series for transmission and distribution losses.

There has been an update to the previous electricity emission factor as the data in the source table has changed.

CHANGE IN METHODOLOGY BETWEEN 2020 AND 2022 GUIDANCE

The methodology for calculating the indirect (scope 2) emission factors for purchased electricity has changed between the guidance that was published in 2020 and this current guidance published in 2022. This improvement has been made to align with international best practice more closely, such as the guidance provided in the GHG Protocol.

The previous methodology was based on electricity consumption data rather than electricity generation data. This resulted in a slight overlap between the scope 2 method and the scope 3 method which accounts for indirect emissions due to transmission and distribution losses. By changing the methodology to use generation data, users can measure their transmission and distribution loss emissions separately if required, as described in section 5.3.

The magnitude of change between the 2020 guidance and 2022 guidance emission factors for purchased electricity is around -8 per cent.

Organisations will need to recalculate their purchased electricity emissions using the current emission factors if the impact of this change is material to their inventory.

Indirect Scope 2 emissions from purchased electricity from the 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.

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 2020. We recommend the use of the emissions factors in [table 9](#) for all electricity purchased from the national grid, apart from when a market-based method is being used.

We calculate purchased electricity emission factors on a calendar-year basis and based on the average grid mix of generation types for calendar years. The emission factor accounts for the emissions from fuel combustion at thermal power stations and fugitive emissions from the generation of geothermal electricity. Thermal electricity is generated by burning fossil fuels.

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.

Detailed additional guidance on reporting electricity emissions is available in the [GHG Protocol Scope 2 Guidance](#).

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

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

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
2020	kWh	0.120	0.117	0.0028	0.0002
2019	kWh	0.110	0.107	0.0029	0.0002
2018	kWh	0.094	0.091	0.0029	0.0001
2017	kWh	0.099	0.096	0.0033	0.0001
2016	kWh	0.088	0.084	0.0036	0.0001
2015	kWh	0.112	0.108	0.0039	0.0002
2014	kWh	0.118	0.114	0.0037	0.0002
2013	kWh	0.141	0.137	0.0037	0.0002
2012	kWh	0.167	0.163	0.0034	0.0003
2011	kWh	0.134	0.131	0.0033	0.0002
2010	kWh	0.145	0.142	0.0032	0.0002

Note: These numbers are rounded to one or more significant figures.

The emission factors for the calendar quarters for 2019 and 2020 purchased electricity from the New Zealand grid are in table 10.

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

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
December 2020	kWh	0.103	0.100	0.0029	0.0002
September 2020	kWh	0.147	0.144	0.0023	0.0003
June 2020	kWh	0.111	0.108	0.0030	0.0002
March 2020	kWh	0.117	0.114	0.0029	0.0002
December 2019	kWh	0.095	0.092	0.0029	0.0002
September 2019	kWh	0.113	0.110	0.0028	0.0002
June 2019	kWh	0.101	0.098	0.0030	0.0002
March 2019	kWh	0.131	0.128	0.0030	0.0003

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 $E = Q \times F$ (section 2), this means:

E = emissions from the emissions source in kg CO₂-e per year

Q = quantity of electricity used (kWh)

F = emission factors from table 9 or table 10

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

PURCHASED ELECTRICITY: EXAMPLE CALCULATION

An organisation uses 800,000 kWh of electricity in the 2020 reporting period. Its indirect (Scope 2) emissions from electricity are:

CO ₂ emissions	= 800,000 × 0.117	= 93,600 kg CO ₂
CH ₄ emissions	= 800,000 × 0.0028	= 2,240 kg CO ₂ -e
N ₂ O emissions	= 800,000 × 0.0002	= 160 kg CO ₂ -e
Total CO ₂ -e emissions	= 93,600 + 2,240 + 160	= 96,000 kg CO ₂ -e

Note: Numbers may not add due to rounding.

5.2.2 Emission factor derivation methodology

Table 11 details the data provided by MBIE to calculate the emission factors. New Zealand's Greenhouse Gas Inventory also contains this information.

Table 11: Information used to calculate the purchased electricity emission factor for 2010–2020

Calculation component	Public electricity consumed and emissions by gas and source										
	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Public electricity generation (GWh)	43,182	43,820	43,421	43,311	42,919	43,333	42,652	42,359	43,150	43,269	43,570
Emissions of CO ₂ from public electricity generation (kt)	4,174.16	3,756.46	3,303.98	3610.68	3057.9	4038.57	4240.2	5195.85	6417.74	5014.71	5518.35
Geothermal fugitive emissions of CO ₂ (kt)	449.69	477.11	583.44	643.26	659.15	675.69	645.51	596.68	604.77	617.85	630.79
Emissions of CH ₄ from public electricity generation (kt)	0.06	0.05	0.05	0.06	0.05	0.06	0.07	0.08	0.09	0.08	0.09
Geothermal fugitive emissions of CH ₄ (kt)	4.73	5.01	6.14	6.86	6.91	7.05	6.64	6.06	5.83	5.57	5.44
Emissions of N ₂ O from public electricity generation (kt)	0.03	0.03	0.02	0.01	0.01	0.02	0.02	0.03	0.05	0.03	0.03
Geothermal fugitive emissions of N ₂ O (kt)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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

Transmission and distribution losses for electricity

The emission factor for transmission and distribution line losses accounts for the additional electricity generated to make up for electricity lost in the transmission and distribution network. Under the [GHG Protocol](#), end users should report emissions from electricity consumed from a transmission and distribution system as an indirect (Scope 3) emission source. Electricity distribution companies should however report these losses as indirect (Scope 2) emissions.²⁹

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

Table 12: Transmission and distribution losses for electricity consumption

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
2020	kWh	0.0110	0.0107	0.0003	0.000021
2019	kWh	0.0119	0.0115	0.0003	0.000022
2018	kWh	0.0092	0.0089	0.0003	0.000013
2017	kWh	0.0094	0.0091	0.0003	0.000009
2016	kWh	0.0075	0.0072	0.0003	0.000007
2015	kWh	0.0107	0.0103	0.0004	0.000015
2014	kWh	0.0092	0.0089	0.0003	0.000013
2013	kWh	0.0100	0.0097	0.0003	0.000016
2012	kWh	0.0152	0.0149	0.0003	0.000030
2011	kWh	0.0126	0.0123	0.0003	0.000019
2010	kWh	0.0148	0.0144	0.0003	0.000019

Note: These numbers are rounded to one or more significant figures.

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 $E = Q \times F$ (section 2), this means:

- E = emissions from the emissions source in kg CO₂-e per year
- Q = quantity of electricity used (kWh)
- F = emission factors from [table 12](#)

TRANSMISSION AND DISTRIBUTION LOSSES: EXAMPLE CALCULATION

An organisation uses 800,000 kWh of electricity in the 2020 reporting period. Its indirect (Scope 3) emissions from transmission and distribution losses for purchased electricity are:

CO ₂ emissions	= 800,000 × 0.0107	= 8,560 kg CO ₂
CH ₄ emissions	= 800,000 × 0.0003	= 240 kg CO ₂ -e

²⁹ GHG Protocol Scope 2 Guidance, accessed via: https://ghgprotocol.org/sites/default/files/standards/Scope%20%20Guidance_Final_Sept26.pdf

$$\begin{aligned} \text{N}_2\text{O emissions} &= 800,000 \times 0.000021 = 16.8 \text{ kg CO}_2\text{-e} \\ \text{Total CO}_2\text{-e emissions} &= 8,560 + 240 + 16.8 = 8,816.8 \text{ kg CO}_2\text{-e} \end{aligned}$$

Note: Numbers may not add due to rounding.

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

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.

Table 13: Calculating the ratio of each gas from electricity emissions

	kg CO ₂ -e	kg CO ₂	CH ₄ (kg CO ₂ -e)	N ₂ O (kg CO ₂ -e)
Transmission & Distribution emission factor for 2020 (per kWh) (electricity consumption – electricity generation)	0.0110			
Per cent breakdown by gas		97.2%	2.59%	0.210%
Calculation of component EF		= 0.972 x 0.0110	= 0.0259 x 0.0110	= 0.00210 x 0.0110
Breakdown by GHG		0.0107	0.0003	0.00002

Note: These numbers are rounded to one or more significant figures.

We then multiplied the transmission and distribution losses in kg CO₂-e by these factors to give the breakdown by gas type.

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.

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.

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.

Indirect business-related emission factors

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

Overview of changes since previous update

The methodology for calculation of working from home emissions have been updated since the previous guidance. This is to align with international practice.

Emissions associated with employees working from home

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

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

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

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

Another change made this year was to remove the use of kettles, waste, and wastewater, and to assume only laptops are used (previously it was split between desktop and laptop). This change was made to more closely align with subsequently developed working from home methodologies from the United Kingdom and the United States of America.

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

Table 14: Working from home emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Working from home – Default	employee per day	0.446	0.429	0.0170	0.00061

Working from home – Without heating	employee per day	0.0665	0.0638	0.0025	0.00009
Working from home – With heating	employee per day	0.9791	0.9403	0.0374	0.0013

6.2.1 GHG inventory development

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

- E = emissions from the emissions source in kg CO₂-e per year
- Q = number of employees working from home without heating (days)
- Q_h = number of employees working from home with heating (days)
- F = emission factor from the second row of table 14
- F_h = emission factor from the bottom row of table 14

WORKING FROM HOME EXAMPLE CALCULATION

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

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

With heating = 168 employee days

CO ₂ emissions	= 168 × 0.94	= 157.9 kg CO ₂
CH ₄ emissions	= 168 × 0.037	= 6.29 kg CO ₂ -e
N ₂ O emissions	= 168 × 0.0013	= 0.23 kg CO ₂ -e
Total CO ₂ -e emissions	= 1,380 × 0.979	= 164.50 kg CO ₂ -e

Without heating = 84 employee days

CO ₂ emissions	= 84 × 0.064	= 5.37 kg CO ₂
CH ₄ emissions	= 84 × 0.0025	= 0.21 kg CO ₂ -e
N ₂ O emissions	= 184 × 0.00009	= 0.008 kg CO ₂ -e
Total CO ₂ -e emissions	= 1,380 × 0.067	= 5.59 kg CO ₂ -e

Note: Numbers may not add due to rounding.

6.2.2 Emission factor derivation methodology

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

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

The with heating factor assumes 50 per cent of staff use electric portable heaters while 50 per cent use heat pumps. It is assumed that heating was used an average of 6 hours per working day.

Table 15: Data used to calculate the emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	Assumptions
Monitor	Employee per day	0.020	0.019	0.001	0.000	8 hrs per day
Laptop	employee per day	0.010	0.009	0.000	0.000	8 hrs per day
Light Use	employee per day	0.010	0.009	0.00037	0.00001	12 W 8 hrs per day
Heat pump use	employee per day	0.408	0.390	0.018	0.0004	4 kW 6hrs per day 50% of households
Electric Heater	employee per day	0.815	0.779	0.035	0.001	2 kW 6hrs per day 50% of households

6.2.3 Employee commuting

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

6.2.4 The carbon benefits of working from home

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

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

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

6.2.5 Assumptions, limitations and uncertainties

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

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

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

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

Guidance on the use of cloud-based data centres

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

Due to the diversity and country location of data centres used by organisations in New Zealand it is not possible to produce a single emission factor that would inform users of the kg CO₂-e each gigabyte of data produces.

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

Travel emission factors

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

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

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

Staff commuting emissions are indirect (Scope 3/Category 7 GHG Protocol).

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.

Overview of changes since previous update

The travel chapter now includes updated emission factors for domestic air travel based on 2019 and 2020 data. Public transport emission factors for buses and rail services have also been updated. International air travel emission factors have been updated to align with the 2021 conversion factors from the UK BEIS. No data is currently available for ferries.

Passenger vehicles

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

Travel in rental vehicles is a common source of direct (Scope 1) emissions for many organisations, while staff mileage and taxi travel are indirect (Scope 3) emissions. 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.

Fuel-use based emission factors are above in [section 3](#).

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 16 to table 19. Table 20 lists default private car emission factors, and table 21 lists the rental car emission factors based on distance travelled. Table 22 lists emission factors for taxi travel based on dollars spent and kilometres travelled.

The data used to prepare these factors come from a report by Emission Impossible (EI) Ltd.³⁰ The report includes a dataset of projected real-world fuel consumption rates from 1970 to 2019. For simplicity we divided the fleet into three categories depending on age: pre-2010, 2010–2015 and post-2015.

Table 16 details engine sizes and typical corresponding vehicles.

Table 16: Vehicle engine sizes and common car types

Engine size	Vehicle size	Example vehicles	Comparative electric vehicles
<1350 cc	Very small	Fiat 500	Peugeot iOn
1350 - <1600 cc	Small	Suzuki Swift	Renault Zoe
1600 - <2000 cc	Medium	Toyota Corolla	Nissan Leaf
2000 - <3000 cc	Large	Toyota RAV4	Hyundai Ioniq
>3000	Very large	Ford Ranger	Nissan Env200

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

Emission source category	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Petrol vehicle	<1350 cc	km	0.204	0.196	0.002	0.007
	1350 - <1600 cc	km	0.212	0.202	0.002	0.007
	1600 - <2000 cc	km	0.238	0.228	0.003	0.008
	2000 - <3000 cc	km	0.265	0.253	0.003	0.009
	≥3000 cc	km	0.317	0.303	0.004	0.010
Diesel vehicle	<1350 cc	km	0.215	0.212	0.0003	0.003
	1350 - <1600 cc	km	0.207	0.204	0.0003	0.003
	1600 - <2000 cc	km	0.220	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	0.156	0.149	0.002	0.005
	1350 - <1600 cc	km	0.161	0.154	0.002	0.005
	1600 - <2000 cc	km	0.181	0.173	0.002	0.006
	2000 - <3000 cc	km	0.201	0.193	0.002	0.007
	≥3000 cc	km	0.241	0.230	0.003	0.008
Diesel hybrid vehicle	<1350 cc	km	0.193	0.190	0.0003	0.003
	1350 - <1600 cc	km	0.186	0.183	0.0002	0.003
	1600 - <2000 cc	km	0.197	0.194	0.0003	0.003
	2000 - <3000 cc	km	0.242	0.238	0.0003	0.004
	≥3000 cc	km	0.269	0.264	0.0004	0.004
Motorcycle	<60cc, petrol	km	0.066	0.063	0.001	0.002
	≥60 cc, petrol	km	0.131	0.126	0.001	0.004

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

³⁰ Real world energy use projections for VFEM (Report prepared for MoT), Emission Impossible, 2016. Accessed via: <https://www.transport.govt.nz/assets/Uploads/Data/Transport-outlook-updated/Emission-Impossible-Real-World-Energy-Use-Projections-for-VFEM-20160905.pdf>

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

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Petrol vehicle	<1350 cc	km	0.181	0.173	0.002	0.006
	1350 - <1600 cc	km	0.187	0.179	0.002	0.006
	1600 - <2000 cc	km	0.211	0.201	0.002	0.007
	2000 - <3000 cc	km	0.234	0.224	0.003	0.008
	≥3000 cc	km	0.280	0.268	0.003	0.009
Diesel vehicle	<1350 cc	km	0.198	0.194	0.0003	0.003
	1350 - <1600 cc	km	0.190	0.187	0.0002	0.003
	1600 - <2000 cc	km	0.202	0.198	0.0003	0.003
	2000 - <3000 cc	km	0.248	0.244	0.0003	0.004
	≥3000 cc	km	0.275	0.270	0.0004	0.004
Petrol hybrid vehicle	<1350 cc	km	0.141	0.135	0.002	0.005
	1350 - <1600 cc	km	0.146	0.140	0.002	0.005
	1600 - <2000 cc	km	0.165	0.157	0.002	0.005
	2000 - <3000 cc	km	0.183	0.175	0.002	0.006
	≥3000 cc	km	0.219	0.209	0.002	0.007
Diesel hybrid vehicle	<1350 cc	km	0.176	0.173	0.0002	0.003
	1350 - <1600 cc	km	0.170	0.167	0.0002	0.003
	1600 - <2000 cc	km	0.180	0.177	0.0002	0.003
	2000 - <3000 cc	km	0.221	0.217	0.0003	0.003
	≥3000 cc	km	0.245	0.241	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	0.077	0.073	0.001	0.002
	1600 - <2000 cc	km	0.086	0.082	0.001	0.003
	2000 - <3000 cc	km	0.096	0.092	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	0.010	0.0003	0.00002
	1350 - <1600 cc	km	0.010	0.010	0.0003	0.00002
	1600 - <2000 cc	km	0.012	0.011	0.0003	0.00002
	2000 - <3000 cc	km	0.013	0.013	0.0003	0.00003
	≥3000 cc	km	0.015	0.015	0.0004	0.00003
Diesel plug-in hybrid electric vehicle (PHEV) – diesel consumption	<1350 cc	km	0.092	0.091	0.0001	0.001
	1350 - <1600 cc	km	0.089	0.087	0.0001	0.001
	1600 - <2000 cc	km	0.094	0.093	0.0001	0.001
	2000 - <3000 cc	km	0.116	0.114	0.0002	0.002
	≥3000 cc	km	0.128	0.126	0.0002	0.002
Diesel plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.011	0.011	0.0003	0.00002
	1350 - <1600 cc	km	0.010	0.010	0.0003	0.00002
	1600 - <2000 cc	km	0.011	0.011	0.0003	0.00002
	2000 - <3000 cc	km	0.013	0.013	0.0003	0.00003
	≥3000 cc	km	0.015	0.015	0.0004	0.00003
Electric vehicle	Very small	km	0.021	0.020	0.0005	0.00004
	Small	km	0.022	0.021	0.0006	0.00005
	Medium	km	0.024	0.024	0.0006	0.00005

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
	Large	km	0.027	0.026	0.0007	0.00006
	Very large	km	0.032	0.032	0.0008	0.00007
Motorcycle	<60 cc, petrol	km	0.060	0.058	0.001	0.002
	≥60 cc, petrol	km	0.121	0.115	0.001	0.004
	<60 cc, electricity	km	0.005	0.004	0.0002	0.00001
	≥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.

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

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Petrol vehicle	<1350 cc	km	0.170	0.162	0.002	0.006
	1350 - <1600 cc	km	0.176	0.168	0.002	0.006
	1600 - <2000 cc	km	0.198	0.189	0.002	0.006
	2000 - <3000 cc	km	0.220	0.210	0.002	0.007
	≥3000 cc	km	0.263	0.251	0.003	0.009
Diesel vehicle	<1350 cc	km	0.188	0.185	0.0002	0.003
	1350 - <1600 cc	km	0.181	0.178	0.0002	0.003
	1600 - <2000 cc	km	0.191	0.188	0.0003	0.003
	2000 - <3000 cc	km	0.235	0.231	0.0003	0.004
	≥3000 cc	km	0.261	0.257	0.0003	0.004
Petrol hybrid vehicle	<1350 cc	km	0.128	0.123	0.001	0.004
	1350 - <1600 cc	km	0.133	0.127	0.001	0.004
	1600 - <2000 cc	km	0.149	0.143	0.002	0.005
	2000 - <3000 cc	km	0.166	0.159	0.002	0.005
	≥3000 cc	km	0.198	0.190	0.002	0.006
Diesel hybrid vehicle	<1350 cc	km	0.164	0.161	0.0002	0.003
	1350 - <1600 cc	km	0.158	0.155	0.0002	0.002
	1600 - <2000 cc	km	0.167	0.164	0.0002	0.003
	2000 - <3000 cc	km	0.206	0.202	0.0003	0.003
	≥3000 cc	km	0.228	0.224	0.0003	0.004
Petrol plug-in hybrid electric vehicle (PHEV) – petrol consumption	<1350 cc	km	0.067	0.064	0.001	0.002
	1350 - <1600 cc	km	0.069	0.066	0.001	0.002
	1600 - <2000 cc	km	0.078	0.075	0.001	0.003
	2000 - <3000 cc	km	0.087	0.083	0.001	0.003
	≥3000 cc	km	0.104	0.099	0.001	0.003
Petrol plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.009	0.0002	0.00002
	1350 - <1600 cc	km	0.010	0.010	0.0003	0.00002
	1600 - <2000 cc	km	0.011	0.011	0.0003	0.00002
	2000 - <3000 cc	km	0.012	0.012	0.0003	0.00003
	≥3000 cc	km	0.015	0.014	0.0004	0.00003

Emission source		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Diesel plug-in hybrid electric vehicle (PHEV) – diesel consumption)	<1350 cc	km	0.086	0.084	0.0001	0.001
	1350 - <1600 cc	km	0.083	0.081	0.0001	0.001
	1600 - <2000 cc	km	0.088	0.086	0.0001	0.001
	2000 - <3000 cc	km	0.108	0.106	0.0001	0.002
	≥3000 cc	km	0.119	0.117	0.0002	0.002
Diesel plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.010	0.0003	0.00002
	1350 - <1600 cc	km	0.010	0.010	0.0003	0.00002
	1600 - <2000 cc	km	0.011	0.011	0.0003	0.00002
	2000 - <3000 cc	km	0.012	0.012	0.0003	0.00003
	≥3000 cc	km	0.015	0.014	0.0004	0.00003
Electric vehicle	Very small	km	0.020	0.020	0.0005	0.00004
	Small	km	0.021	0.020	0.0005	0.00004
	Medium	km	0.023	0.023	0.0006	0.00005
	Large	km	0.026	0.025	0.0007	0.00005
	Very large	km	0.031	0.030	0.0008	0.00006
Motorcycle	<60 cc, petrol	km	0.057	0.055	0.001	0.002
	≥60 cc, petrol	km	0.115	0.110	0.001	0.004
	<60 cc, electricity	km	0.005	0.004	0.0002	0.00001
	≥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.

Table 20: 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 CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Private car default	Petrol	km	0.265	0.253	0.003	0.009
	Diesel	km	0.270	0.266	0.0004	0.004
	Petrol hybrid	km	0.201	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	0.012	0.000	0.00002
	Diesel plug-in hybrid (diesel consumption)	km	0.116	0.114	0.0002	0.002
	Diesel plug-in hybrid (electricity consumption)	km	0.012	0.012	0.000	0.00002
	Electric	km	0.026	0.025	0.001	0.00004

Notes:

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

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

Table 21: Default rental car emission factors per km travelled

Emission source		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Rental car default	Petrol	km	0.211	0.201	0.002	0.007
	Diesel	km	0.202	0.198	0.0003	0.003
	Petrol hybrid	km	0.165	0.157	0.002	0.005
	Diesel hybrid	km	0.180	0.177	0.0002	0.003
	Petrol plug-in hybrid (petrol consumption)	km	0.086	0.082	0.001	0.003
	Petrol plug-in hybrid (electricity consumption)	km	0.021	0.011	0.010	0.0004
	Diesel plug-in hybrid (diesel consumption)	km	0.094	0.093	0.000	0.001
	Diesel plug-in hybrid (electricity consumption)	km	0.021	0.010	0.010	0.000
	Electric	km	0.023	0.022	0.001	0.00003

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

Table 22: Emission factors for taxi travel

Emission source		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	CH ₄ (kg CO ₂ -e)/unit	N ₂ O (kg CO ₂ -e)/unit
Taxi travel	Distance travelled	km	0.225	0.221	0.0003	0.004
	Dollars spent	\$	0.070	0.069	0.0001	0.001

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

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 22](#)). If this information is not available, use the taxi emission factors per dollars spent.

Applying the equation $E = Q \times F$ ([section 2](#)), this means:

- E = emissions from the emissions source in kg CO₂-e per year
- Q = distance travelled by vehicle type (km)
- F = emission factors for correlating vehicle type from [table 16](#) to [table 22](#)

PASSENGER VEHICLES: EXAMPLE CALCULATION

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

CO ₂ emissions	= 40,000 × 2.35	= 94,000 kg CO ₂
CH ₄ emissions	= 40,000 × 0.0276	= 1,104 kg CO ₂ -e
N ₂ O 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 × 0.173	= 6539 kg CO ₂
CH ₄ emissions	= 37,800 × 0.002	= 76 kg CO ₂ -e
N ₂ O emissions	= 37,800 × 0.006	= 227 kg CO ₂ -e
Total CO ₂ -e emissions	= 37,800 × 0.181	= 6,842 kg CO ₂ -e

An organisation uses petrol rental cars to travel 12,000 km in 2020. It also spends \$18,000 on taxi travel.

Total CO ₂ -e emissions from rental cars	= 12,000 × 0.211	= 2,532 kg CO ₂ -e
Total CO ₂ -e emissions from taxi travel	= \$18,000 × 0.07	= 1,260 kg CO ₂ -e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

The 2019 Vehicle Fleet Emissions Model 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.

- 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.³¹

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

³¹ Motor Vehicle Register: <https://www.nzta.govt.nz/vehicles/how-the-motor-vehicle-register-affects-you/motor-vehicle-registrations-dashboard-and-open-data/>

Table 23: Fuel consumption in litres per 100 km

Emission source	Units	Units of energy consumed per 100 km			
		Pre-2010	2010–2015	Post-2015	
Petrol vehicle	<1350 cc	litres	8.339	7.374	6.924
	1350 - <1600 cc	litres	8.631	7.632	7.166
	1600 - <2000 cc	litres	9.718	8.594	8.069
	2000 - <3000 cc	litres	10.794	9.545	8.962
	≥3000 cc	litres	12.912	11.418	10.721
Diesel vehicle	<1350 cc	litres	8.000	7.337	6.968
	1350 - <1600 cc	litres	7.698	7.060	6.705
	1600 - <2000 cc	litres	8.159	7.483	7.107
	2000 - <3000 cc	litres	10.031	9.199	8.732
	≥3000 cc	litres	11.127	10.204	9.687
Petrol hybrid vehicle	<1350 cc	litres	6.346	5.763	5.228
	1350 - <1600 cc	litres	6.567	5.964	5.411
	1600 - <2000 cc	litres	7.395	6.715	6.092
	2000 - <3000 cc	litres	8.214	7.459	6.767
	≥3000 cc	litres	9.826	8.923	8.095
Diesel hybrid vehicle	<1350 cc	litres	7.171	6.546	6.085
	1350 - <1600 cc	litres	6.901	6.300	5.856
	1600 - <2000 cc	litres	7.314	6.677	6.207
	2000 - <3000 cc	litres	8.992	8.208	7.630
	≥3000 cc	litres	9.974	9.105	8.464
Petrol plug-in hybrid electric vehicle (PHEV) – petrol consumption	<1350 cc	litres	3.321	3.016	2.736
	1350 - <1600 cc	litres	3.437	3.121	2.832
	1600 - <2000 cc	litres	3.870	3.514	3.188
	2000 - <3000 cc	litres	4.298	3.903	3.541
	≥3000 cc	litres	5.142	4.670	4.236
Petrol plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	kWh	10.164	9.342	8.957
	1350 - <1600 cc	kWh	10.520	9.668	9.270
	1600 - <2000 cc	kWh	11.845	10.886	10.438
	2000 - <3000 cc	kWh	13.156	12.092	11.594
	≥3000 cc	kWh	15.738	14.465	13.869
Diesel plug-in hybrid electric vehicle (PHEV) – diesel consumption	<1350 cc	litres	3.753	3.426	3.185
	1350 - <1600 cc	litres	3.611	3.297	3.065
	1600 - <2000 cc	litres	3.828	3.494	3.248
	2000 - <3000 cc	litres	4.706	4.296	3.993
	≥3000 cc	litres	5.220	4.765	4.430
Diesel plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	kWh	11.086	10.189	9.770
	1350 - <1600 cc	kWh	10.648	9.786	9.383
	1600 - <2000 cc	kWh	11.667	10.723	10.281
	2000 - <3000 cc	kWh	13.205	12.137	11.637

Emission source	Units	Units of energy consumed per 100 km			
		Pre-2010	2010–2015	Post-2015	
Electric vehicle	≥3000 cc	kWh	15.618	14.354	13.763
	<1350 cc	kWh	21.324	19.598	18.792
	1350 - <1600 cc	kWh	22.069	20.283	19.448
	1600 - <2000 cc	kWh	24.849	22.838	21.898
	2000 - <3000 cc	kWh	27.601	25.367	24.323
Motorcycle	≥3000 cc	kWh	33.017	30.346	29.097
	<60 cc, petrol	litres	2.680	2.459	2.340
	≥60 cc, petrol	litres	4.952	4.591	4.582
	<60 cc, electricity	kWh	5.360	4.918	4.679
	≥60 cc, electricity	kWh	9.903	9.183	9.164

Source: The Emission Impossible report and supporting data

The *El 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 GHG is:

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

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.

Multiply the values for fuel consumption by the emission conversion factors in [table 4](#).

According to the Motor Industry Association, the most common taxi vehicle uses diesel (see [table 24](#)). We based the default factor for taxis on the average of <2000 cc and <3000 cc diesel vehicles from [table 17](#)). Data from the NZTA new registration database shows that for the calendar-year period 2018 the majority of taxis purchased were in this class. NZTA vehicle registration data also shows the average year of manufacture for the taxi fleet is 2012 while for the rental fleet this is 2015.³² For consistency we assumed a 2010–2015 fleet for both taxis and rental cars.

Taxicharge advised that, the current average price per kilometre in a taxi is \$3.20. North Island's average rate = \$3.02, while South Island's average = \$3.52.

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 17](#). Table 24 shows this.

³² New Zealand Transport Agency: <https://www.transport.govt.nz/assets/Uploads/Data/NZVehicleFleet.xlsx>

Table 24: Data used for calculating the taxi emission factors

		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Diesel vehicle	1600 - <2000 cc	km	0.202	0.198	0.0003	0.003
	2000 - <3000 cc	km	0.248	0.244	0.0003	0.004
Taxi	Average	km	0.225	0.221	0.0003	0.004

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

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

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

Table 25: Data on the number of taxis purchased by fuel type

Taxi cars purchased by year		2017	2018	2019
Taxi commercial passenger (MIA NZTA – vehicle sales data)	Petrol	181	116	84
	Diesel	796	888	448
	Electric	8	14	9
	Petrol hybrid	44	66	63
	Petrol plug-in hybrid	1	1	2

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)³³ the average age of light passenger vehicles in 2018 was 14.4 years. This correlates to a 2004 year of manufacture. Also, according to MoT³⁴ 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 26: Energy consumption per 100 km for light passenger vehicles manufactured in 2004

Engine type	Unit	Units per 100 km for a 2000–3000cc engine in 2004
Petrol	litre	10.794
Diesel	litre	10.031
Petrol hybrid	litre	8.214
Diesel hybrid	litre	8.992
Petrol plug-in hybrid (petrol)*	litre	3.903
Petrol plug-in hybrid (electricity)*	litre	12.092

³³ Ministry of Transport: <https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/vehicle-age#element-413>

³⁴ Ministry of Transport: <https://www.transport.govt.nz/assets/Uploads/Data/NZVehicleFleet.xlsx>

Engine type	Unit	Units per 100 km for a 2000–3000cc engine in 2004
Diesel plug-in hybrid (diesel)*	litre	4.296
Diesel plug-in hybrid (electricity)*	litre	12.137
Electric*	kWh	25.367

Note: * Vehicle energy 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 2018 period, an average of 45 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.

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 Register³⁵ we calculated that the most common private passenger vehicle in 2018 had an engine size 2000–3000 cc. Therefore, this is the default engine size used. The average age of a private car is 14.4 years, so for the 2020 period we assume 2004 as the year of manufacture.

The 2019 Vehicle Fleet Emissions Model (VFEM) supplied by MoT provided all real-world fuel consumption rates. The data in this model is 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.

Public transport passenger

In this update it has been possible to update the emission factors for public transport for passenger travel on buses and trains. The unit used for these emission sources are passenger kilometres (pkm).

Data for this update was sourced from NZTA, Greater Wellington Regional Council, Kiwirail and Metlink for the 2020 calendar year.

³⁵ New Zealand Transport Agency: <https://www.transport.govt.nz/assets/Uploads/Data/NZVehicleFleet.xlsx>

Table 27: Emission factors for public transport

Emission source		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Bus	National Average for Bus	pkm	0.155	0.153	0.00013	0.002
	Electric Bus (based on Wellington)	pkm	0.012	0.012	0.00040	0.00002
	Diesel Bus (based on Wellington)	pkm	0.060	0.060	0.00005	0.001
	Average Bus (based on Wellington)	pkm	0.036	0.036	0.00013	0.0001
Rail	Electric (based on Wellington)	pkm	0.013	0.013	0.00001	0.0000001
	Diesel (based on Wellington)	pkm	0.046	0.045	0.00006	0.001
	Average (based on Wellington)	pkm	0.019	0.019	0.00002	0.0001

GHG inventory development

To calculate public transport passenger emissions, collect data on the type of transport and distance travelled, and multiply this by the emission factors for each gas. Organisations could conduct a staff travel survey to quantify these emissions.³⁶

Applying the equation $E = Q \times F$ (section 2), this means:

E = emissions from the emissions source in kg CO₂-e per year

Q = distance travelled, by vehicle type (km)

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

PASSENGER BUS: EXAMPLE CALCULATION

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

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

CO₂ emissions = 94 × 0.012 = 1.128 kg CO₂

CH₄ emissions = 94 × 0.0004 = 0.038 kg CO₂-e

N₂O emissions = 94 × 0.00002 = 0.002 kg CO₂-e

Total CO₂-e emissions from passenger public travel = 0.024 × 94 = 2.3 kg CO₂-e

Note: Numbers may not add due to rounding.

³⁶ GHG Protocol Technical Guidance for Calculating Scope 3 Emissions:
https://ghgprotocol.org/sites/default/files/standards_supporting/Chapter6.pdf

Emission factor derivation methodology

National average bus

To calculate the emission factor for national average bus travel we used the NZTA passenger travel data³⁷ (table 28) to estimate the national average loading capacity of seven people per bus.

Table 28: National bus pkm in 2020/21

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

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

Table 29: National bus passenger loading by region

Region	Unit	End Use
National average	Passenger/bus	7
Auckland	Passenger/bus	7
Bay of Plenty	Passenger/bus	3
Canterbury	Passenger/bus	<i>Missing data</i>
Gisborne	Passenger/bus	8
Hawkes Bay	Passenger/bus	1
Manawatū-Whanganui	Passenger/bus	5
Marlborough-Nelson-Tasman	Passenger/bus	6
Northland	Passenger/bus	8
Otago	Passenger/bus	<i>Missing data</i>
Southland	Passenger/bus	3
Taranaki	Passenger/bus	12
Waikato	Passenger/bus	4
Wellington	Passenger/bus	20

We then divided the per km emission factor for diesel buses in table 30 by the national passenger/bus loading rate to give the emissions per gas.

Table 30: Emission factor for diesel bus

Bus type	Size	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Diesel bus	≥ 12000 kg	km	1.088	1.070	0.001	0.017

³⁷ NZTA Passenger data, accessed September 2020, online at: www.nzta.govt.nz/assets/userfiles/transport-data/PTPerformance.xlsx

Wellington buses

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

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

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

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

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

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

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

Wellington trains data

To calculate the emissions from Wellington trains we used the most recent data available which was from the year 2020. The energy consumption data in table 33 is from KiwiRail and the passenger kilometres data is from Metlink.

Table 33: Train data

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

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

The energy consumption was multiplied by its respective emission factors (table 9 and table 4) and divided by the pkm to provide the emission factor. This was calculated using 2020 electricity data.

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

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

Assumptions, limitations and uncertainties

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

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

Public transport vehicles

Public transport vehicle emissions include those from buses. Air travel is in a separate section below. It is possible to calculate the emissions from the whole vehicle. This approach is appropriate for transport operators or if a bus is chartered. [Table 34](#) details these emission factors.

Buses: We calculated the emissions of different buses using MoT’s Vehicle Fleet Emissions Model data for fuel consumption in litres per 100 kilometres. The guide presents the data in emissions per kilometre.

[Table 35](#) details the data provided to calculate the emission conversion factors.

Table 34: Bus emission factors per km travelled

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Diesel bus	<7,500 kg	km	0.567	0.557	0.001	0.009
	<12,000 kg	km	0.785	0.772	0.001	0.012
	≥12,000 kg	km	1.088	1.070	0.001	0.017
Diesel hybrid bus	<7,500 kg	km	0.401	0.394	0.001	0.006
	<12,000 kg	km	0.556	0.546	0.001	0.009
	≥12,000 kg	km	0.770	0.757	0.001	0.012
Electric bus	<7,500 kg	km	0.055	0.053	0.002	0.0001
	<12,000 kg	km	0.076	0.073	0.003	0.0001
	≥12,000 kg	km	0.106	0.102	0.004	0.0001

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

7.4.1 GHG inventory development

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

- E = emissions from the emissions source in kg CO₂-e per year
- Q = distance travelled, by vehicle type (km)
- F = emission factors for correlating vehicle type, from table 34

DIESEL BUS: EXAMPLE CALCULATION

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

CO ₂ emissions	= 500 x 0.557	= 278.5 kg CO ₂
CH ₄ emissions	= 500 x 0.001	= 0.5 kg CO ₂ -e
N ₂ O emissions	= 500 x 0.009	= 4.5 kg CO ₂ -e
Total CO ₂ -e emissions from bus travel = 500 km x 0.567 = 283.5 kg CO ₂ -e		

This result is for the entire bus.

Note: Numbers may not add due to rounding.

7.4.2 Emission factor derivation methodology

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

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

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

Using the information in [table 35](#) and appropriate emission factor, the equation is:

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

Where:

- fuel/energy consumption = units of energy per 100 km travelled
- emission factor = the emission factor from [table 4](#) or [table 9](#)

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

7.4.3 Assumptions, limitations and uncertainties

The 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.

Air travel

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

Domestic air travel

This section provides emission factors from 2016, 2019 and 2020.³⁸ Domestic air travel is a common source of indirect (Scope 3) emissions for many New Zealand organisations.

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

In this guidance, emission factors with a radiative forcing multiplier refers to the indirect climate change effects (non-CO₂ emissions eg, water vapour, contrails, NO_x). Emission factors without a radiative forcing multiplier refers to the direct climate change effects (CO₂, CH₄ and N₂O). If multipliers are applied, organisations should disclose the specific factor used including its source and produce comparable reporting. Therefore, avoid reporting with air travel conversion factors in one year and without in another year, as this may skew the interpretation of your reporting.

Table 36 provides the emission factors without the radiative forcing multiplier applied. Table 37 provides emission factors with a radiative forcing multiplier of 1.9 applied.^{39, 40}

Table 36: Domestic air travel emission factors for 2019 without a radiative forcing multiplier

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
National average	pkm	0.163	0.158	0.001	0.004
Large aircraft	pkm	0.090	0.087	0.001	0.002
Medium aircraft	pkm	0.120	0.116	0.001	0.003
Small aircraft*	pkm	0.352	0.341	0.003	0.009

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

Note: *Calculated using data from 2016.

Table 37: Domestic aviation emission factors for 2019 with a radiative forcing multiplier

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
National average	pkm	0.306	0.300	0.001	0.004
Large aircraft	pkm	0.168	0.165	0.001	0.002
Medium aircraft	pkm	0.224	0.220	0.001	0.003
Small aircraft*	pkm	0.670	0.647	0.005	0.017

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

Note: *Calculated using data from 2016.

³⁸ Multiple airlines were engaged with to contribute to this version of the guidance but were unable to do so at that time. The intention is to continue working with these airlines to supplement data in the next update.

³⁹ 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>

⁴⁰ 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/

Table 38: Domestic air travel emission factors for 2020 without a radiative forcing multiplier

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
National average	pkm	0.164	0.158	0.001	0.004
Large aircraft	pkm	0.090	0.087	0.001	0.002
Medium aircraft	pkm	0.120	0.116	0.001	0.003
Small aircraft*	pkm	0.352	0.341	0.003	0.009

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

Note: *Calculated using data from 2016.

Table 39: Domestic aviation emission factors for 2020 with a radiative forcing multiplier

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
National average	pkm	0.306	0.300	0.001	0.004
Large aircraft	pkm	0.168	0.165	0.001	0.002
Medium aircraft	pkm	0.224	0.220	0.001	0.003
Small aircraft*	pkm	0.670	0.647	0.005	0.017

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

Note: *Calculated using data from 2016.

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

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 pkm.

Applying the equation $E = Q \times F$ (section 2), this means:

E = emissions from the emissions source in kg CO₂-e per year

Q = passengers multiplied by distance flown (pkm)

F = emission factors from table 35 to table 39.

DOMESTIC AIR TRAVEL: EXAMPLE CALCULATION

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

Passenger kilometres travelled = $(2 \times 304) \times 5 = 3,040$ pkm

Total CO₂-e emissions from domestic air travel = $0.306 \times 3,040 = 929.92$ kg CO₂-e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

We developed these emission factors with data supplied by Air New Zealand and the Ministry of Transport. We calculated an average emission factor for domestic air travel using data from the 2016, 2019 and 2020 calendar years.

Tables 40 and 41 detail the types of aircraft running domestic flights in 2019 and 2020 respectively, using Air New Zealand data and 2016 Ministry of Transport data to calculate the emission factors. An average emissions factor has also been provided where the aircraft type is unknown. Organisations that own aircraft could calculate emissions based on the fuel consumption data.

Table 40: Domestic aviation data (applicable to 2019)

Aircraft type	Total seats per flight	Average distance per flight (km)	Total fuel used (kg)	Total flights
Airbus A320*	181	652.83	66,972,183	21,356.25
Aerospatiale/Alenia ATR 72*	68	394.73	41,633,907.59	55,102
British Aerospace Jetstream 32	19	167.78	94,556.00	324
Beechcraft Beech 1900D	19	250.73	2,152,521.40	6,277
Cessna Light Aircraft	6	95.87	1,199,632.30	9,791
De Havilland Canada DHC-8-300 Dash 8/8Q, Q300*	50	299.4	45,892,622.75	64,580
Pilatus PC-12	9	300.72	847,901.49	4,315
Saab SF-340	34	479.70	407,373.70	668
FOKKER F50	53	631.55	12,890.19	11

Note: *Average calculated using data from 2016 and 2019.

Table 41: Domestic aviation data (applicable to 2020)

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

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

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

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

Then calculate fuel per passenger:

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

Using this, next calculate fuel per passenger per km:

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

The density of kerosene (the assumed aviation fuel) is 0.79 kg/l.⁴¹

Tables 42 and 43 provide the average fuel and passenger data from 2016, 2019 and 2020 used to calculate the emission factors.

Table 42: Average fuel and passenger data for 2019

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*	2,933.78	148.5	19.906	0.0305	0.0331
Aerospatiale/Alenia ATR 72*	756.72	55.4	13.67	0.0346	0.0326
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, Q300*	692.26	40.7	17.125	0.0566	0.0499
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

Note: *Average calculated using data from 2016 and 2019.

Table 43: Average fuel and passenger data for 2020

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*	2,909.74	143.2	20.45	0.0304	0.0329
Aerospatiale/Alenia ATR 72*	743.19	55.0	13.52	0.0347	0.0327
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

⁴¹ Z Energy: https://z.co.nz/assets/SDS/Kerosene_2.pdf

De Havilland Canada DHC-8-300 Dash 8/8Q, Q300*	708.64	40.6	17.515	0.0559	0.0490
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

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

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

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

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

- large aircraft: A320neo, A321neo, A320ceo Domestic
- medium aircraft: ATR 72, De Havilland Canada DHC-8-300 Dash 8/8Q, Q300, FOKKER F50
- small aircraft: British Aerospace Jetstream 32, Cessna Light Aircraft, Pilatus PC-12, Beechcraft Beech 1900D, Saab SF-340

Table 44: Calculated emissions for 2019, without the radiative forcing multiplier, per aircraft type

Aircraft type	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Airbus A320*	pkm	0.090	0.087	0.001	0.002
Aerospatiale/Alenia ATR 72*	pkm	0.093	0.090	0.001	0.003
British Aerospace Jetstream 32	pkm	0.237	0.229	0.002	0.006
Beechcraft Beech 1900D	pkm	0.186	0.180	0.002	0.005
Cessna Light Aircraft	pkm	0.552	0.534	0.004	0.014
De Havilland Canada DHC-8-300 Dash 8/8Q*	pkm	0.145	0.140	0.001	0.004
Pilatus PC-12	pkm	0.188	0.182	0.002	0.005
Saab SF-340	pkm	0.097	0.094	0.001	0.002
FOKKER F50	pkm	0.091	0.088	0.001	0.002

Note: These numbers are rounded to three decimal places unless the number is significantly small. *Average calculated using data from 2016 and 2019.

Table 45: Calculated emissions for 2019, with the radiative forcing multiplier, per aircraft type

Aircraft type	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Airbus A320*	pkm	0.168	0.165	0.001	0.002
Aerospatiale/Alenia ATR 72*	pkm	0.174	0.171	0.001	0.003

Aircraft type	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
British Aerospace Jetstream 32	pkm	0.450	0.435	0.004	0.011
Beechcraft Beech 1900D	pkm	0.353	0.342	0.004	0.010
Cessna Light Aircraft	pkm	1.049	1.015	0.008	0.027
De Havilland Canada DHC-8-300 Dash 8/8Q, Q300*	pkm	0.270	0.266	0.001	0.004
Pilatus PC-12	pkm	0.357	0.346	0.004	0.010
Saab SF-340	pkm	0.184	0.179	0.002	0.004
FOKKER F50	pkm	0.173	0.167	0.002	0.004

Note: These numbers are rounded to three decimal places unless the number is significantly small. *Average calculated using data from 2016 and 2019.

Table 46: Calculated emissions for 2020, without the radiative forcing multiplier, per aircraft type

Aircraft type	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Airbus A320*	pkm	0.090	0.087	0.001	0.002
Aerospatiale/Alenia ATR 72*	pkm	0.093	0.090	0.001	0.003
British Aerospace Jetstream 32	pkm	0.237	0.229	0.002	0.006
Beechcraft Beech 1900D	pkm	0.186	0.180	0.002	0.005
Cessna Light Aircraft	pkm	0.552	0.534	0.004	0.014
De Havilland Canada DHC-8-300 Dash 8/8Q*	pkm	0.145	0.140	0.001	0.004
Pilatus PC-12	pkm	0.188	0.182	0.002	0.005
Saab SF-340	pkm	0.097	0.094	0.001	0.002
FOKKER F50	pkm	0.091	0.088	0.001	0.002

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

Table 47: Calculated emissions for 2020, with the radiative forcing multiplier, per aircraft type

Aircraft type	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Airbus A320*	pkm	0.168	0.165	0.001	0.002
Aerospatiale/Alenia ATR 72*	pkm	0.174	0.171	0.001	0.003
British Aerospace Jetstream 32	pkm	0.450	0.435	0.004	0.011
Beechcraft Beech 1900D	pkm	0.353	0.342	0.004	0.010
Cessna Light Aircraft	pkm	1.049	1.015	0.008	0.027

Aircraft type	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
De Havilland Canada DHC-8-300 Dash 8/8Q, Q300*	pkm	0.270	0.266	0.001	0.003
Pilatus PC-12	pkm	0.357	0.346	0.004	0.010
Saab SF-340	pkm	0.184	0.179	0.002	0.004
FOKKER F50	pkm	0.173	0.167	0.002	0.004

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

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.

International air travel

Organisations wishing to report their international air travel emissions based on distance travelled per passenger could use the International Civil Aviation Organisation (ICAO) calculator.⁴² This calculator considers aircraft types and load factors for specific airline routes but does not apply the radiative forcing multiplier (accounting for the wider climate effect of emissions arising from aircraft transport at altitude) or distance uplift factor to account for delays/circling and non-direct routes (ie, not along the straight-line/great-circle between destinations). If using the [ICAO calculator](#) to calculate emissions for international air travel, multiply the output by 8 per cent to account for the distance uplift factor (see [section 7.5.8](#)), and a radiative forcing multiplier of 1.9.

If you prefer not to use the ICAO calculator, we recommend the emission factors provided in table 48 and table 49. These emission factors follow those published online by [UK BIES conversion factors](#) and include a distance uplift of 8 per cent, and a radiative forcing multiplier of 1.9.

Table 48: Emission factors for international air travel with radiative forcing multiplier

Emission source	Travel class	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Short haul (<3700 km)	Average passenger	pkm	0.154	0.153	0.00001	0.001
	Economy	pkm	0.151	0.150	0.00001	0.001
	Business	pkm	0.227	0.225	0.00001	0.001
Long haul (>3700 km)	Average passenger	pkm	0.193	0.192	0.00001	0.001
	Economy	pkm	0.148	0.147	0.00001	0.001

⁴² International Civil Aviation Organisation Calculator, accessed via: www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx

Emission source	Travel class	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
	Premium economy	pkm	0.237	0.235	0.00001	0.001
	Business	pkm	0.429	0.427	0.00002	0.002
	First	pkm	0.591	0.589	0.00002	0.003

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

Table 49: Emission factors for international air travel without radiative forcing multiplier

Emission source	Travel class	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Short haul (<3700 km)	Average passenger	pkm	0.081	0.080	0.00001	0.001
	Economy	pkm	0.080	0.079	0.00001	0.001
	Business	pkm	0.120	0.119	0.00001	0.001
Long haul (>3700 km)	Average passenger	pkm	0.102	0.101	0.00001	0.001
	Economy	pkm	0.078	0.077	0.00001	0.001
	Premium economy	pkm	0.125	0.124	0.00001	0.001
	Business	pkm	0.227	0.225	0.00002	0.002
	First	pkm	0.313	0.313	0.00002	0.003

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

The emission factors from the UK BEIS are calculated regarding the indirect and direct climate change effects. For continuity in this guidance, we have categorised the international air travel emission factors by whether a radiative forcing multiplier was applied, as outlined in [section 7.5.1](#). Further information can be found in paragraphs 8.37-8.41 in the UK BEIS 2021 Government Greenhouse Gas Conversion Factors for Company Reporting: Methodology Paper for Conversion factors Final Report.

GHG inventory development

To calculate emissions for international air travel, gather the information on how far each passenger flew for each flight. Multiply this by the factors in table 48. Use the specified emission factors for different cabin classes if information is available. If unknown, use the average emission factors. Applying the equation $E = Q \times F$ ([section 2](#)), this means:

- E = emissions from the emissions source in kg CO₂-e per year
- Q = passengers multiplied by distance flown (pkm)
- F = appropriate emission factors from table 48 or table 49

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:

Passenger kilometres travelled	= (2 × 9,346) × 2	= 37,384 pkm
Their CO ₂ -e emissions from air travel	= 37,384 × 0.148	= 5,532 kg CO ₂ -e
For the three people with unknown travel classes:		
Passenger kilometres travelled	= (3 × 9,346) × 2	= 56,076 pkm
Their CO ₂ -e emissions from air travel	= 56,076 × 0.193	= 10,822 kg CO ₂ -e
Total CO ₂ -e emissions from international air travel	= 5,532 + 10,822	= 16,354 kg CO ₂ -e
Total CO ₂ -e with distance uplift	= 16,354 × 1.09	= 17,825 kg CO ₂ -e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

The [UK BEIS emission factors](#) publication discusses the methodology in more detail, including changes over time.

Assumptions, limitations and uncertainties

The emission factors in table 48 and table 49 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 is currently uncertain and New Zealand's Greenhouse Gas 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 class travellers. If everyone flew business class, fewer people could fit on the flight and therefore emissions per person would be higher.

7.6 Helicopters

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

Table 50: Emission factors for helicopters

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Eurocopter AS 350B Squirrel	hours	480.185	463.998	3.2647	12.923
Eurocopter AS 350B3 Squirrel	hours	496.518	479.780	3.3758	13.362
Robinson R44	hours	191.016	184.357	1.3430	5.316
Robinson R22 Beta	hours	130.695	126.139	0.9189	3.637
Bell 206B	hours	329.923	318.801	2.2431	8.879

7.6.1 GHG inventory development

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

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

- E = emissions from the emissions source in kg CO₂-e per year
- Q = hours of operating time (hours)
- F = emission factors for correlating helicopter type, from table 50 above

HELICOPTER USE: EXAMPLE CALCULATION

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

CO ₂ emissions	= 10 × 463.998	= 4,639.98 kg CO ₂
CH ₄ emissions	= 10 × 3.2647	= 32.647 kg CO ₂ -e
N ₂ O emissions	= 10 × 12.923	= 129.23 kg CO ₂ -e
Total CO ₂ -e emissions	= 10 × 480.185	= 4,801.85 kg CO ₂ -e

Note: Numbers may not add due to rounding.

7.6.2 Emission factor derivation methodology

These emission factors were derived from the Swiss Federal Office of Civil Aviation's (FOCA) Guidance on the Determination of Helicopter Emissions.⁴³ This contains air emissions data (non-GHG) for one hour of flying time, including fuel consumption, for a range of helicopter models.

The fuel consumption (provided in kgs) was converted to litres using assumed densities of 0.804 kg per litre and 0.690 kg per litre, for Jet A1 and aviation gas respectively. Turbine engine

⁴³ www.bazl.admin.ch/bazl/en/home/specialists/regulations-and-guidelines/environment/pollutant-emissions/aircraft-engine-emissions/guidance-on-the-determination-of-helicopter-emissions.html

helicopters are assumed to use Jet A1 while piston helicopters are assumed to use aviation gas. We then applied the Jet A1 and aviation gas emission factors from Transport fuels section above to determine the emission factor for one hour of operation.

We used the aircraft register on the New Zealand Civil Aviation Authority (CAA) website⁴⁴ to identify the most commonly registered helicopter models in the country.

7.6.3 Assumptions, limitations and uncertainties

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

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

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

7.7 Accommodation

Accommodation is an indirect (Scope 3) emissions source. We obtained the emission factors for accommodation, see table 51, directly from the Hotel Footprinting Tool, produced by the International Tourism Partnership and Greenview, which have been derived from the Cornell Hotel Sustainability Benchmarking Index (CHSB) Index 2021: Carbon Energy, and Water.⁴⁵ The factors are in CO₂-e and are not available by gas type.

Table 51: Accommodation emission factors

Country	Unit	kgCO ₂ -e/unit
Argentina	Room per night	50.0
Australia	Room per night	38.9
Austria	Room per night	11.9
Belgium	Room per night	11.6
Brazil	Room per night	14.9
Canada	Room per night	17.1
Caribbean Region	Room per night	61.1
Chile	Room per night	30.8
China	Room per night	60.7
Colombia	Room per night	11.0
Costa Rica	Room per night	7.0
Czech Republic	Room per night	31.8
Egypt	Room per night	54.0
Fiji	Room per night	54.8

⁴⁴ www.aviation.govt.nz/aircraft/aircraft-registration/aircraft-register-search/

⁴⁵ The Hotel Footprinting Tool can be accessed via: <https://www.hotelfootprints.org/>

Country	Unit	kgCO ₂ -e/unit
Finland	Room per night	11.1
France	Room per night	7.5
French Polynesia	Room per night	73.0
Germany	Room per night	18.2
Greece	Room per night	42.8
Hong Kong	Room per night	66.2
Hungary	Room per night	22.0
India	Room per night	66.0
Indonesia	Room per night	88.2
Ireland	Room per night	23.9
Israel	Room per night	51.8
Italy	Room per night	23.9
Japan	Room per night	54.7
Jordan	Room per night	64.5
Kazakhstan	Room per night	105.7
Macau	Room per night	68.1
Malaysia	Room per night	80.3
Maldives	Room per night	176.5
Mexico	Room per night	27.0
Morocco	Room per night	104.0
Netherlands	Room per night	21.2
New Zealand	Room per night	9.4
Oman	Room per night	117.3
Panama	Room per night	23.7
Peru	Room per night	29.9
Philippines	Room per night	62.9
Poland	Room per night	35.8
Portugal	Room per night	27.2
Qatar	Room per night	104.9
Romania	Room per night	25.5
Russian Federation	Room per night	30.9
Saudi Arabia	Room per night	112.5
Singapore	Room per night	28.5
South Africa	Room per night	56.6
South Korea	Room per night	56.5
Spain	Room per night	16.3
Switzerland	Room per night	7.4
Taiwan	Room per night	86.8
Thailand	Room per night	55.9
Turkey	Room per night	38.0
United Arab Emirates	Room per night	95.9

Country	Unit	kgCO ₂ -e/unit
United Kingdom	Room per night	13.4
United States	Room per night	19.8
Vietnam	Room per night	49.2

GHG inventory development

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

- E = emissions from the emissions source in kg CO₂-e per year
 Q = rooms per night
 F = emission factors for the country stayed in from table 51.

EXAMPLE CALCULATION

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

$$3 \text{ rooms} \times 4 \text{ nights} = 12$$

$$\text{Total CO}_2\text{-e emissions from the hotel stay} = 12 \times 38.9 \text{ kg CO}_2\text{-e/unit} = 466.8 \text{ kg CO}_2\text{-e}$$

Assumptions, limitations and uncertainties

The CHSB Index document⁴⁶ outlines the limitations of the study and the dataset.

These include:

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

⁴⁶ Access the CHSB Index via: [Hotel Sustainability Benchmarking Index 2021: Carbon, Energy, and Water \(cornell.edu\)](https://www.cornell.edu/hotel-sustainability-benchmarking-index-2021).

Freight transport emission factors

Overview of changes since previous update

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

There has been an update to the previous road freight heavy goods vehicles emission factors as the source data from the Ministry of Transport was updated. There has also been an update to the previous air freight and international shipping freight emission factors as the source data from the UK BEIS was updated.

Additionally, rail freight emission factors have been updated to align with source data from KiwiRail.

Road freight

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

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

The 2019 Vehicle Fleet Emissions Model 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.

TONNES PER KILOMETRE

A tkm is the distance travelled multiplied by the weight of freight carried by the LCV or HGV.

For example, an HGV carrying 5 tonnes freight over 100 km has a tkm value of 500 tkm.

The CO₂ emissions are calculated from these factors by multiplying the number of tkm the user has for the distance and weight of the goods being moved by the CO₂ conversion factor in the 'Freight workbook 2022' worksheet of the 2022 Interactive workbook for the relevant LCV or HGV class.

Light commercial vehicle emission factors

Table 52: Emission factors for light commercial vehicles manufactured pre-2010

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Petrol	<1350 cc	km	0.207	0.198	0.002	0.007
	1350 - <1600 cc	km	0.222	0.212	0.002	0.007
	1600 - <2000 cc	km	0.299	0.286	0.003	0.010
	2000 - <3000 cc	km	0.317	0.303	0.004	0.010
	≥3000 cc	km	0.362	0.346	0.004	0.012
Diesel	<1350 cc	km	0.215	0.212	0.0003	0.0034
	1350 - <1600 cc	km	0.207	0.204	0.0003	0.0032
	1600 - <2000 cc	km	0.276	0.271	0.0004	0.0043
	2000 - <3000 cc	km	0.296	0.291	0.0004	0.0046
	≥3000 cc	km	0.300	0.295	0.0004	0.0047
Petrol hybrid	<1350 cc	km	0.163	0.156	0.002	0.005
	1350 - <1600 cc	km	0.175	0.168	0.002	0.006
	1600 - <2000 cc	km	0.236	0.226	0.003	0.008
	2000 - <3000 cc	km	0.250	0.239	0.003	0.008
	≥3000 cc	km	0.286	0.273	0.003	0.009
Diesel hybrid	<1350 cc	km	0.193	0.190	0.0003	0.003
	1350 - <1600 cc	km	0.186	0.183	0.0002	0.003
	1600 - <2000 cc	km	0.247	0.243	0.0003	0.004
	2000 - <3000 cc	km	0.265	0.261	0.0003	0.004
	≥3000 cc	km	0.269	0.264	0.0004	0.004

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

Table 53: Emission factors for light commercial vehicles manufactured between 2010 and 2015

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Petrol	<1350 cc	km	0.195	0.186	0.002	0.006
	1350 - <1600 cc	km	0.209	0.200	0.002	0.007
	1600 - <2000 cc	km	0.282	0.270	0.003	0.009
	2000 - <3000 cc	km	0.299	0.286	0.003	0.010
	≥3000 cc	km	0.341	0.326	0.004	0.011

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Diesel	<1350 cc	km	0.199	0.195	0.0003	0.003
	1350 - <1600 cc	km	0.191	0.188	0.0003	0.003
	1600 - <2000 cc	km	0.254	0.250	0.0003	0.004
	2000 - <3000 cc	km	0.273	0.268	0.0004	0.004
	≥3000 cc	km	0.276	0.272	0.0004	0.004
Petrol hybrid	<1350 cc	km	0.154	0.147	0.002	0.005
	1350 - <1600 cc	km	0.165	0.158	0.002	0.005
	1600 - <2000 cc	km	0.223	0.213	0.003	0.007
	2000 - <3000 cc	km	0.236	0.225	0.003	0.008
	≥3000 cc	km	0.269	0.257	0.003	0.009
Diesel hybrid	<1350 cc	km	0.178	0.175	0.0002	0.003
	1350 - <1600 cc	km	0.171	0.168	0.0002	0.003
	1600 - <2000 cc	km	0.228	0.224	0.0003	0.004
	2000 - <3000 cc	km	0.245	0.240	0.0003	0.004
	≥3000 cc	km	0.248	0.243	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	0.086	0.083	0.001	0.003
	1600 - <2000 cc	km	0.117	0.111	0.001	0.004
	2000 - <3000 cc	km	0.123	0.118	0.001	0.004
	≥3000 cc	km	0.141	0.135	0.002	0.005
Petrol plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.010	0.000	0.00001
	1350 - <1600 cc	km	0.011	0.011	0.000	0.00002
	1600 - <2000 cc	km	0.012	0.012	0.000	0.00002
	2000 - <3000 cc	km	0.015	0.015	0.001	0.00002
	≥3000 cc	km	0.018	0.017	0.001	0.00002
Diesel plug-in hybrid electric vehicle (PHEV) – diesel consumption	<1350 cc	km	0.093	0.092	0.0001	0.0015
	1350 - <1600 cc	km	0.090	0.088	0.0001	0.0014
	1600 - <2000 cc	km	0.119	0.117	0.0002	0.0019
	2000 - <3000 cc	km	0.128	0.126	0.0002	0.0020
	≥3000 cc	km	0.130	0.127	0.0002	0.0020
Diesel plug-in hybrid electric vehicle (PHEV) – electricity consumption	<1350 cc	km	0.010	0.010	0.0004	0.00001
	1350 - <1600 cc	km	0.010	0.010	0.0004	0.00001
	1600 - <2000 cc	km	0.011	0.010	0.0004	0.00001
	2000 - <3000 cc	km	0.012	0.012	0.0005	0.00002
	≥3000 cc	km	0.015	0.014	0.0006	0.00002
Electricity: BEV (battery electric vehicle)	Very small	km	0.021	0.021	0.001	0.00003
	Small	km	0.023	0.022	0.001	0.00003
	Medium	km	0.026	0.025	0.001	0.00004
	Large	km	0.032	0.031	0.001	0.00004
	Very large	km	0.038	0.036	0.001	0.00005

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

Table 54: Emission factors for light commercial vehicles manufactured post-2015

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Petrol	<1350 cc	km	0.184	0.175	0.002	0.007
	1350 - <1600 cc	km	0.198	0.188	0.002	0.007
	1600 - <2000 cc	km	0.267	0.254	0.003	0.010
	2000 - <3000 cc	km	0.282	0.269	0.003	0.010
	≥3000 cc	km	0.322	0.307	0.004	0.012
Diesel	<1350 cc	km	0.189	0.185	0.0002	0.0030
	1350 - <1600 cc	km	0.182	0.178	0.0002	0.0028
	1600 - <2000 cc	km	0.242	0.238	0.0003	0.0038
	2000 - <3000 cc	km	0.259	0.255	0.0003	0.0041
	≥3000 cc	km	0.262	0.258	0.0003	0.0041
Petrol hybrid	<1350 cc	km	0.144	0.138	0.002	0.005
	1350 - <1600 cc	km	0.155	0.148	0.002	0.005
	1600 - <2000 cc	km	0.208	0.199	0.002	0.007
	2000 - <3000 cc	km	0.221	0.211	0.002	0.007
	≥3000 cc	km	0.252	0.241	0.003	0.008
Diesel hybrid	<1350 cc	km	0.170	0.167	0.000	0.003
	1350 - <1600 cc	km	0.163	0.160	0.000	0.003
	1600 - <2000 cc	km	0.217	0.214	0.000	0.003
	2000 - <3000 cc	km	0.233	0.229	0.000	0.004
	≥3000 cc	km	0.236	0.232	0.000	0.004
Petrol PHEV	<1350 cc	km	0.075	0.072	0.001	0.002
	1350 - <1600 cc	km	0.081	0.077	0.001	0.003
	1600 - <2000 cc	km	0.109	0.104	0.001	0.004
	2000 - <3000 cc	km	0.115	0.110	0.001	0.004
	≥3000 cc	km	0.132	0.126	0.001	0.004
Electricity: petrol PHEV	<1350 cc	km	0.010	0.010	0.0004	0.00001
	1350 - <1600 cc	km	0.011	0.010	0.0004	0.00001
	1600 - <2000 cc	km	0.012	0.012	0.0005	0.00002
	2000 - <3000 cc	km	0.015	0.014	0.0006	0.00002
	≥3000 cc	km	0.017	0.017	0.0007	0.00002
Diesel PHEV	<1350 cc	km	0.089	0.087	0.0001	0.001
	1350 - <1600 cc	km	0.085	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	0.123	0.121	0.0002	0.002
Electricity: diesel PHEV	<1350 cc	km	0.010	0.010	0.0004	0.00001
	1350 - <1600 cc	km	0.010	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.011	0.010	0.0004	0.00001

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
	2000 - <3000 cc	km	0.012	0.011	0.0005	0.00002
	≥3000 cc	km	0.014	0.014	0.001	0.00002
Electricity: BEV	Very small	km	0.021	0.020	0.001	0.00003
	Small	km	0.022	0.021	0.001	0.00003
	Medium	km	0.025	0.024	0.001	0.00003
	Large	km	0.031	0.030	0.001	0.00004
	Very large	km	0.036	0.035	0.001	0.00005

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

Table 55: 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 CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Petrol	km	0.317	0.303	0.004	0.010
Diesel	km	0.296	0.291	0.0004	0.005
Petrol hybrid	km	0.250	0.239	0.003	0.008
Diesel hybrid	km	0.265	0.261	0.0003	0.004

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

Heavy goods vehicles emission factors

Table 56 contains the default emission factors for heavy goods vehicles, based on a pre-2010 fleet and a gross vehicle mass of <7500 kg.

Table 56: Emission factors for heavy goods vehicles manufactured pre-2010

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
HGV diesel	<5,000 kg	km	0.446	0.439	0.001	0.007
	5,000 - <7,500 kg	km	0.510	0.503	0.001	0.008
	7,500 - <10,000 kg	km	0.624	0.615	0.001	0.010
	10,000 - <12,000 kg	km	0.740	0.729	0.001	0.012
	12,000 - <15,000 kg	km	0.841	0.828	0.001	0.013
	15,000 - <20,000 kg	km	0.982	0.968	0.001	0.016
	20,000 - <25,000 kg	km	1.308	1.288	0.002	0.021
	25,000 - <30,000 kg	km	1.460	1.438	0.002	0.023
	≥30,000 kg	km	1.538	1.515	0.002	0.024
HGV diesel hybrid	<5,000 kg	km	0.359	0.354	0.0005	0.006
	5,000 - <7,500 kg	km	0.411	0.405	0.0005	0.006
	7,500 - <10,000 kg	km	0.503	0.496	0.0007	0.008
	10,000 - <12,000 kg	km	0.596	0.588	0.0008	0.009
	12,000 - <15,000 kg	km	0.678	0.668	0.0009	0.011
	15,000 - <20,000 kg	km	0.893	0.879	0.0012	0.014
	20,000 - <25,000 kg	km	1.188	1.171	0.0016	0.019

	25,000 - <30,000 kg	km	1.372	1.352	0.0018	0.022
	≥30,000 kg	km	1.446	1.424	0.0019	0.023

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

Table 57: Emission factors for heavy goods vehicles manufactured between 2010 and 2015

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
HGV diesel	<5,000 kg	km	0.423	0.416	0.001	0.007
	5,000 - <7,500 kg	km	0.484	0.477	0.001	0.008
	7,500 - <10,000 kg	km	0.592	0.583	0.001	0.009
	10,000 - <12,000 kg	km	0.702	0.692	0.001	0.011
	12,000 - <15,000 kg	km	0.798	0.786	0.001	0.013
	15,000 - <20,000 kg	km	0.957	0.943	0.001	0.015
	20,000 - <25,000 kg	km	1.274	1.255	0.002	0.020
	25,000 - <30,000 kg	km	1.423	1.402	0.002	0.022
	≥30,000 kg	km	1.499	1.477	0.002	0.024
HGV diesel hybrid	<5,000 kg	km	0.340	0.335	0.0004	0.0053
	5,000 - <7,500 kg	km	0.390	0.384	0.0005	0.0061
	7,500 - <10,000 kg	km	0.477	0.470	0.0006	0.0075
	10,000 - <12,000 kg	km	0.565	0.557	0.0007	0.0089
	12,000 - <15,000 kg	km	0.642	0.633	0.0008	0.0101
	15,000 - <20,000 kg	km	0.870	0.857	0.0011	0.0136
	20,000 - <25,000 kg	km	1.158	1.141	0.0015	0.0182
	25,000 - <30,000 kg	km	1.338	1.318	0.0018	0.0210
	≥30,000 kg	km	1.409	1.388	0.0019	0.0221
HGV BEV (battery electric vehicle)	<5,000 kg	km	0.045	0.043	0.002	0.0001
	5,000 - <7,500 kg	km	0.052	0.050	0.002	0.0001
	7,500 - <10,000 kg	km	0.063	0.061	0.003	0.0001
	10,000 - <12,000 kg	km	0.075	0.072	0.003	0.0001
	12,000 - <15,000 kg	km	0.085	0.082	0.003	0.0001

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

Table 58: Emission factors for heavy goods vehicles manufactured post-2015

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
HGV diesel	<5,000 kg	km	0.421	0.415	0.0006	0.0066
	5,000 - <7,500 kg	km	0.477	0.470	0.0006	0.0075
	7,500 - <10,000 kg	km	0.583	0.575	0.0008	0.0092
	10,000 - <12,000 kg	km	0.692	0.681	0.0009	0.0108
	12,000 - <15,000 kg	km	0.786	0.774	0.0010	0.0123
	15,000 - <20,000 kg	km	0.955	0.941	0.0013	0.0150
	20,000 - <25,000 kg	km	1.271	1.252	0.0017	0.0199

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
	25,000 - <30,000 kg	km	1.420	1.398	0.0019	0.0223
	≥30,000 kg	km	1.496	1.473	0.0020	0.0235
HGV diesel hybrid	<5,000 kg	km	0.332	0.327	0.0004	0.0052
	5,000 - <7,500 kg	km	0.380	0.375	0.0005	0.0060
	7,500 - <10,000 kg	km	0.465	0.458	0.0006	0.0073
	10,000 - <12,000 kg	km	0.551	0.543	0.0007	0.0087
	12,000 - <15,000 kg	km	0.627	0.617	0.0008	0.0098
	15,000 - <20,000 kg	km	0.868	0.855	0.0011	0.0136
	20,000 - <25,000 kg	km	1.156	1.138	0.0015	0.0181
	25,000 - <30,000 kg	km	1.334	1.314	0.0018	0.0209
	≥30,000 kg	km	1.406	1.385	0.0018	0.0221
HGV BEV	<5,000 kg	km	0.044	0.042	0.002	0.0001
	5,000 - <7,500 kg	km	0.050	0.048	0.002	0.0001
	7,500 - <10,000 kg	km	0.062	0.059	0.002	0.0001
	10,000 - <12,000 kg	km	0.083	0.080	0.003	0.0001
	12,000 - <15,000 kg	km	0.083	0.080	0.003	0.0001

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

Table 59 contains the default emission factors for heavy goods vehicles, based on a pre-2010 fleet and a gross vehicle mass of <7500 kg.

Table 59: Default emission factors for heavy goods vehicles

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
HGV diesel	km	0.480	0.472	0.001	0.008
HGV diesel hybrid	km	0.387	0.380	0.0005	0.006

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

Table 60 contains emission factors for freighting goods.

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

Table 60: Emission factors for freighting goods by road

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Long-haul heavy truck	tkm	0.105	0.103	0.0001	0.002
Urban delivery heavy truck	tkm	0.390	0.383	0.0005	0.006
All trucks	tkm	0.135	0.133	0.0002	0.002

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

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 52 to table 60. Applying the equation $E = Q \times F$ (section 2), this means:

E	=	emissions from the emissions source in kg CO ₂ -e per year
Q	=	km travelled by specific freight vehicle one way
F	=	appropriate emission factors from table 52 to table 60

For emissions from freighting goods, users need to know the weight in tonnes of the goods freighted as well as the kilometres travelled. These two numbers multiplied together is the tkm. Multiply the tkm by the emission factors in table 60. Applying the equation $E = Q \times F$ (section 2), this means:

E	=	emissions from the emissions source in kg CO ₂ -e per year
Q	=	tonne × kilometres travelled one way
F	=	appropriate emission factors from table 60

ROAD FREIGHT: EXAMPLE CALCULATION

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

For the 10 tonnes moved by truck:

CO ₂ emissions	= 10 × 100 × 0.133	= 133 kg CO ₂
CH ₄ emissions	= 10 × 100 × 0.0002	= 0.2 kg CO ₂ -e
N ₂ O emissions	= 10 × 100 × 0.002	= 2 kg CO ₂ -e
Total CO ₂ -e emissions	= 10 × 100 × 0.135	= 135 kg CO ₂ -e

For the hired van, use the emission factors for the 2010–2015 fleet, petrol 1600-2000 cc. (Note: if the quantity of fuel used is known, users can more accurately calculate emissions using the litres of fuel used rather than distance.) In this example the fuel usage is unknown, so the organisation applies the emission factors for km travelled to calculate the total CO₂-e emissions.

For the goods moved by van:

CO ₂ emissions	= 800 × 0.270	= 216 kg CO ₂
CH ₄ emissions	= 800 × 0.003	= 2.4 kg CO ₂ -e
N ₂ O emissions	= 800 × 0.009	= 7.2 kg CO ₂ -e
Total CO ₂ -e emissions	= 800 × 0.282	= 225.6 kg CO ₂ -e
Total CO ₂ -e emission from freighted goods = 135 + 225.6 = 360.6 kg CO ₂ -e		

Note: Numbers may not add due to rounding.

For vehicles that run on electricity, care should be taken not to double-count emissions from electricity use that is already captured from reporting of an organisations on-site electricity consumption.⁴⁷

⁴⁷ UK BEIS 2021 Guidance, accessed via: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1049346/2021-ghg-conversion-factors-methodology.pdf

Emission factor derivation methodology

The [EI report](#)⁴⁸ 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 61 and table 63.

Table 61: 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	0.08	0.08	0.07
	1350 - <1600 cc	litres	0.09	0.09	0.08
	1600 - <2000 cc	litres	0.12	0.12	0.11
	2000 - <3000 cc	litres	0.13	0.12	0.11
	≥3000 cc	litres	0.15	0.14	0.13
Diesel	<1350 cc	litres	0.08	0.07	0.07
	1350 - <1600 cc	litres	0.08	0.07	0.07
	1600 - <2000 cc	litres	0.10	0.09	0.09
	2000 - <3000 cc	litres	0.11	0.10	0.10
	≥3000 cc	litres	0.11	0.10	0.10
Petrol hybrid	<1350 cc	litres	0.07	0.06	0.06
	1350 - <1600 cc	litres	0.07	0.07	0.06
	1600 - <2000 cc	litres	0.10	0.09	0.09
	2000 - <3000 cc	litres	0.10	0.10	0.09
	≥3000 cc	litres	0.12	0.11	0.10
Diesel hybrid	<1350 cc	litres	0.07	0.07	0.06
	1350 - <1600 cc	litres	0.07	0.06	0.06
	1600 - <2000 cc	litres	0.09	0.08	0.08
	2000 - <3000 cc	litres	0.10	0.09	0.09
	≥3000 cc	litres	0.10	0.09	0.09
Petrol PHEV – petrol consumption	<1350 cc	litres	0.03	0.03	0.03
	1350 - <1600 cc	litres	0.04	0.04	0.03
	1600 - <2000 cc	litres	0.05	0.05	0.04
	2000 - <3000 cc	litres	0.05	0.05	0.05
	≥3000 cc	litres	0.06	0.06	0.05

⁴⁸ Emission: Impossible, Real-world energy use projections for VFEM (Report prepared for MoT), Emission Impossible, 2016. Accessed via: <https://www.transport.govt.nz/assets/Uploads/Data/Transport-outlook-updated/Emission-Impossible-Real-World-Energy-Use-Projections-for-VFEM-20160905.pdf>

Emission source		Units	Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
Petrol PHEV – electricity consumption	<1350 cc	kWh	0.11	0.10	0.10
	1350 - <1600 cc	kWh	0.11	0.11	0.10
	1600 - <2000 cc	kWh	0.13	0.12	0.12
	2000 - <3000 cc	kWh	0.16	0.15	0.15
	≥3000 cc	kWh	0.19	0.18	0.17
Diesel PHEV – diesel consumption	<1350 cc	litres	0.04	0.03	0.03
	1350 - <1600 cc	litres	0.04	0.03	0.03
	1600 - <2000 cc	litres	0.05	0.04	0.04
	2000 - <3000 cc	litres	0.05	0.05	0.05
	≥3000 cc	litres	0.05	0.05	0.05
Diesel PHEV – electricity consumption	<1350 cc	kWh	0.11	0.10	0.10
	1350 - <1600 cc	kWh	0.11	0.10	0.10
	1600 - <2000 cc	kWh	0.12	0.11	0.10
	2000 - <3000 cc	kWh	0.13	0.12	0.12
	≥3000 cc	kWh	0.16	0.14	0.14
BEV – electricity consumption	<1350 cc	kWh	0.22	0.21	0.20
	1350 - <1600 cc	kWh	0.24	0.23	0.22
	1600 - <2000 cc	kWh	0.27	0.26	0.25
	2000 - <3000 cc	kWh	0.33	0.32	0.31
	≥3000 cc	kWh	0.39	0.37	0.36

Table 62: Heavy goods vehicles (energy consumption per 100 km)

Emission source		Units	Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
HGV diesel	<5,000 kg	litres	16.56	15.72	15.66
	5,000 - <7,500 kg	litres	18.97	18.01	17.73
	7,500 - <10,000 kg	litres	23.20	22.01	21.68
	10,000 - <12,000 kg	litres	27.51	26.01	25.71
	12,000 - <15,000 kg	litres	31.26	29.66	29.22
	15,000 - <20,000 kg	litres	36.51	35.59	35.50
	20,000 - <25,000 kg	litres	48.61	47.37	47.26
	25,000 - <30,000 kg	litres	57.28	52.90	52.77
	≥30,000 kg	litres	57.28	55.73	55.60
HGV diesel hybrid	<5,000 kg	litres	13.35	12.65	12.34
	5,000 - <7,500 kg	litres	15.29	14.50	14.14
	7,500 - <10,000 kg	litres	18.70	17.72	17.29
	10,000 - <12,000 kg	litres	22.17	21.01	20.50
	12,000 - <15,000 kg	litres	25.19	23.88	23.30
	15,000 - <20,000 kg	litres	33.19	32.35	32.27
	20,000 - <25,000 kg	litres	44.18	43.06	42.96

Emission source		Units	Units of energy consumed per 100 km		
			Pre-2010	2010–2015	Post-2015
	25,000 - <30,000 kg	litres	51.02	49.72	49.60
	≥30,000 kg	litres	53.75	52.38	52.26
HGV BEV (battery electric vehicle)	<5,000 kg	kWh	46.81	44.38	43.42
	5,000 - <7,500 kg	kWh	53.63	50.85	49.74
	7,500 - <10,000 kg	kWh	65.57	62.17	60.82
	10,000 - <12,000 kg	kWh	77.75	73.72	81.94
	12,000 - <15,000 kg	kWh	88.35	83.77	91.94

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

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

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 4](#).

The default emission factors for freighting vehicles include the following assumptions based on the MoT NZ Vehicle Fleet 2020:⁴⁹

- Light commercial vehicles are on average around 12 years old⁵⁰ and the most common engine size is 2000-3000 cc, therefore we used a pre-2010 fleet and a 2000-3000 cc engine size for the default values.
- Heavy trucks are on average 18 years old and the most common gross vehicle mass is <7500 kg, therefore we selected a pre-2010 vehicle fleet with a gross vehicle mass of <7500 kg.

Emission factors for freighting goods (tkm) are from the MoT presentation 'Real-world fuel economy of heavy trucks'.⁵¹

Table 63: Data used to calculate the road freight (tkm) emission factor

Truck type	Typical gCO ₂ /tkm	Source
Long-haul heavy truck	105	MoT
Urban delivery heavy truck	390	MoT
All trucks	135	MoT

As most heavy goods vehicles are diesel, we used the information in [table 64](#) to calculate the ratio of carbon dioxide, methane and nitrous oxide.

⁴⁹ Ministry of Transport: <https://www.transport.govt.nz/assets/Uploads/Data/NZVehicleFleet.xlsx>

⁵⁰ MoT, RD025 Average vehicle fleet age, source: <https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/vehicle-age#element-413>

⁵¹ Ministry of Transport: <https://www.knowledgehub.transport.govt.nz/assets/TKH-Uploads/TKC-2019/Real-world-fuel-economy-of-heavy-trucks.pdf>

Table 64: Calculating the ratio of gases in diesel

Information	kg CO ₂ -e/litre	kg CO ₂ /litre	kg CH ₄ (kg CO ₂ -e) / litre	kg N ₂ O (kg CO ₂ -e) / litre
Diesel emission factors	2.6939	2.6482	0.0035	0.0422
% of gas type to calculate losses	–	98.3%	0.13%	1.57%

Note: These numbers are rounded to three significant figures.

We multiplied the 0.135 kg CO₂-e (Road Freight: Example Calculation box) result by the calculated factor to provide emission factors broken down by gas type.

Assumptions, limitations and uncertainties

The Vehicle Fleet Emissions Model (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.

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 65.

Table 65: Emission factors for rail freight

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Rail freight	tkm	0.027	0.027	0.00009	0.0001

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

GHG inventory development

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

Applying the equation $E = Q \times F$ (section 2), this means:

- E = emissions from the emissions source in kg CO₂-e per year
- Q = tonnes of freight × km travelled
- F = emission factors in table 65

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: $8 \times 150 \times 4 = 4,800$ tkm

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

CO ₂ emissions	= 4,800 × 0.027	= 129.6 kg CO ₂
CH ₄ emissions	= 4,800 × 0.00009	= 0.4 kg CO ₂ -e
N ₂ O emissions	= 4,800 × 0.0001	= 0.5 kg CO ₂ -e
Total CO ₂ -e emissions	= 4,800 × 0.027	= 129.6 kg CO ₂ -e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

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

Table 66: Information provided by KiwiRail

Calculation component	Unit	Amount in 2020
Freight-only fuel	litres	39,996,846
Freight volumes (net)	NTKs (000s)	3,961,904
Electricity (net) North Island Main Trunk (NIMT)	kWh	6,373,312

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

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

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

To calculate emissions from electricity, multiply the net kWh by the emission factors in [table 9](#) or [table 10](#):

$$\begin{aligned} \text{emissions from electricity} \\ = \text{electricity NIMT} \times \text{purchased electricity emission factors} \end{aligned}$$

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

$$\begin{aligned} \text{emissions from T\&D losses} \\ = \text{electricity NIMT} \times \text{T\&D losses for purchased electricity emission factors} \end{aligned}$$

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

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

Assumptions, limitations and uncertainties

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

Air freight

In the absence of New Zealand data, we have adopted the air freight emission factors from the [UK BEIS publication](#). These emission factors are Scope 3. Refer to [section 7.5](#) for further guidance on radiative forcing to inform your choice of emission factor. While the radiative forcing multiplier of 1.9 used in this guidance is based on current scientific evidence and research, this figure is subject to significant uncertainty.^{52, 53}

Emissions from aviation have both direct (CO₂, CH₄ and N₂O) and indirect (non-CO₂ emissions eg, water vapour, contrails, NOx) climate change effects. Two sets of emission factors for air freight are presented here; one that includes the indirect effects of non-CO₂ emissions and one that represents direct effects only.

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

Organisations should include the indirect effects of non-CO₂ emissions when reporting air freight emissions to capture the full climate impact of their travel. However, it should be noted that there is significant scientific uncertainty around the magnitude of the indirect effect of non-CO₂ aviation emissions and it is an active area of research. Further information can be found in paragraphs 8.37-8.41 in the [UK BEIS Methodology Paper](#).

Table 67: Air freight emission factors with radiative forcing multiplier

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	CH ₄ (kg CO ₂ -e)/unit	N ₂ O (kg CO ₂ -e)/unit
Domestic air freight	tkm	4.494	4.469	0.0019	0.022
Short haul	tkm	2.302	2.291	0.0001	0.011
Long haul	tkm	1.019	1.014	0.00004	0.005

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

Table 68: Air freight emissions without radiative forcing multiplier

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	CH ₄ (kg CO ₂ -e)/unit	N ₂ O (kg CO ₂ -e)/unit
Domestic air freight	tkm	2.377	2.352	0.0019	0.022
Short haul	tkm	1.217	1.206	0.0001	0.011
Long haul	tkm	0.539	0.534	0.00004	0.005

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

⁵² 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>

⁵³ 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/

GHG inventory development

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

Applying the equation $E = Q \times F$ (section 2), this means:

E	=	emissions from the emissions source in kg CO ₂ -e per year
Q	=	tonnes of freight × km travelled
F	=	appropriate emission factors in table 67 or table 68

AIR FREIGHT: EXAMPLE CALCULATION

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

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

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

CO ₂ emissions	=	30,000 × 1.014	=	30,420 kg CO ₂
CH ₄ emissions	=	30,000 × 0.00004	=	1.2 kg CO ₂ -e
N ₂ O emissions	=	30,000 × 0.005	=	150 kg CO ₂ -e
Total CO ₂ -e emissions	=	30,000 × 1.019	=	30,570 kg CO ₂ -e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

The methodology paper for the [UK BEIS emission factors](#) contains full details on the derivation of these emission factors.

Assumptions, limitations and uncertainties

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

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

Coastal and international shipping freight

We calculated the domestic coastal shipping emission factor, table 69 based on the findings from the MoT presentation 'Real-world fuel economy of heavy trucks',⁵⁴ prepared for the 2019 Transport Knowledge Conference. We adopted the international shipping emission factors from the [UK BEIS emission factors](#).

⁵⁴ <https://www.knowledgehub.transport.govt.nz/assets/TKH-Uploads/TKC-2019/Real-world-fuel-economy-of-heavy-trucks.pdf>

Table 69: Coastal shipping emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Oil products	tkm	0.016	0.016	0.00004	0.0001
Other bulk shipping	tkm	0.030	0.030	0.00007	0.0002
Container freight	tkm	0.046	0.046	0.0001	0.0004

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

Table 70: International shipping emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Bulk carrier	200,000+ dwt	tkm	0.003	0.003	0.000000	0.00003
	100,000–199,999 dwt	tkm	0.003	0.003	0.000000	0.00004
	60,000–99,999 dwt	tkm	0.004	0.004	0.000000	0.00006
	35,000–59,999 dwt	tkm	0.006	0.006	0.000000	0.00008
	10,000–34,999 dwt	tkm	0.008	0.008	0.000000	0.00011
	0–9,999 dwt	tkm	0.030	0.029	0.000010	0.00040
	Average	tkm	0.004	0.003	0.000000	0.00005
General cargo	10,000+ dwt	tkm	0.012	0.012	0.000000	0.00016
	5,000–9,999 dwt	tkm	0.016	0.016	0.000010	0.00022
	0–4,999 dwt	tkm	0.014	0.014	0.000000	0.00019
	10,000+ dwt 100+ TEU	tkm	0.011	0.011	0.000000	0.00015
	5,000–9,999 dwt 100+ TEU	tkm	0.018	0.018	0.000010	0.00024
	0–4,999 dwt 100+ TEU	tkm	0.020	0.020	0.000010	0.00027
	Average	tkm	0.012	0.013	0.000000	0.00018
Container ship	8,000+ TEU	tkm	0.013	0.013	0.000010	0.00017
	5,000–7,999 TEU	tkm	0.017	0.017	0.000010	0.00023
	3,000–4,999 TEU	tkm	0.017	0.017	0.000010	0.00023
	2,000–2,999 TEU	tkm	0.020	0.020	0.000010	0.00027
	1,000–1,999 TEU	tkm	0.033	0.032	0.000010	0.00044
	0–999 TEU	tkm	0.037	0.036	0.000010	0.00049
	Average	tkm	0.016	0.016	0.000010	0.00022
Vehicle transport	4,000+ CEU	tkm	0.032	0.032	0.000010	0.00044
	0–3,999 CEU	tkm	0.058	0.058	0.000020	0.00078
	Average	tkm	0.039	0.038	0.000010	0.00052
RoRo (roll-on, roll-off) ferry	2,000+ LM	tkm	0.050	0.050	0.000020	0.00067
	0–1,999 LM	tkm	0.061	0.060	0.000020	0.00082
	Average	tkm	0.052	0.051	0.000020	0.00069
	Large ROPax ferry	tkm	0.377	0.372	0.000110	0.00506
Refrigerated cargo	All dwt	tkm	0.013	0.013	0.000000	0.00018

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

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

GHG inventory development

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

Applying the equation $E = Q \times F$ (section 2), this means:

- E = emissions from the emissions source in kg CO₂-e per year
- Q = tonnes of freight × km travelled
- F = appropriate emission factors from table 69 or table 70

MULTIPLE FREIGHT MODES: EXAMPLE CALCULATION

A company sends 300 kg of its product to a customer. It travels by road freight (All trucks) 50 km to the port, then 500 km by coastal shipping (container freight) to another domestic port. It is then loaded onto rail to its destination 250 km from the port.

Road freight emissions:

$$\begin{aligned} 0.3 \text{ tonnes} \times 50 \text{ km} &= 15 \text{ tkm} \\ 15 \text{ tkm} \times 0.135 &= 2.03 \text{ kg CO}_2\text{-e} \end{aligned}$$

Coastal shipping emissions:

$$\begin{aligned} 0.3 \text{ tonnes} \times 500 \text{ km} &= 150 \text{ tkm} \\ 150 \text{ tkm} \times 0.046 &= 6.90 \text{ kg CO}_2\text{-e} \end{aligned}$$

Rail freight emissions:

$$\begin{aligned} 0.3 \text{ tonnes} \times 250 \text{ km} &= 75 \text{ tkm} \\ 75 \text{ tkm} \times 0.027 &= 2.03 \text{ kg CO}_2\text{-e} \end{aligned}$$

Total freight emissions:

$$2.03 + 6.9 + 2.3 = 10.96 \text{ kg CO}_2\text{-e}$$

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

We based the emission factors for coastal shipping on figures included in the MoT presentation 'Real world fuel economy of heavy trucks',⁵⁵ prepared for the 2019 Transport Knowledge Conference.

Table 71: Coastal shipping data

Mode	Typical kg CO ₂ /tkm
Coastal shipping (oil products)	0.016
Coastal shipping (other bulk)	0.030
Coastal shipping (container freight)	0.046

We assumed transport fuel for coastal shipping is heavy fuel oil, and therefore applied the ratio of carbon dioxide, methane and nitrous oxide to provide a breakdown by gas. Table 71 contains the ratio.

⁵⁵ Ministry of Transport: <https://www.knowledgehub.transport.govt.nz/assets/TKH-Uploads/TKC-2019/Real-world-fuel-economy-of-heavy-trucks.pdf>

For international shipping, we used the Freight Information Gathering System (FIGS)⁵⁶ 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 FIGS⁵⁷ 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 3194 TEU and therefore in the 3000–4999 TEU category.
- Vehicle carrier (transport) is unknown and therefore the same as the UK average.
- RoRo ferry is unknown and therefore the same as the UK average.
- As there is only one emission factor for all refrigerated cargo an average was not necessary.

Emission factors for these have been adopted from the [UK BEIS 2021 Guidance](#).⁵⁸ Refer to that document for details on the methodology.

Assumptions, limitations and uncertainties

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

We carried over the assumptions for the international shipping emission factors from the [2021 UK BEIS Methodology Paper emission factors](#).

⁵⁶ Freight Information Gathering System, accessed via: <https://www.transport.govt.nz/statistics-and-insights/freight-and-logistics/>

⁵⁷ Freight Information Gathering System, overseas ships, accessed via: <https://www.transport.govt.nz/statistics-and-insights/freight-and-logistics/>

⁵⁸ UK BEIS 2020 Guidance, accessed via: <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021>

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 and *New Zealand's Greenhouse Gas Inventory 1990–2020*.

Overview of changes since previous update

There are several changes to wastewater emission factors, notably due to the publication of *Carbon Accounting Guidelines for Wastewater Treatment: CH₄ and N₂O* (WaterNZ, 2021).⁵⁹ The emissions factor for septic tanks has been updated to align with these new guidelines. Additionally, the emissions factors for specific types of wastewater treatment plants have been removed from these guidelines, and we advise users seeking this information to use WaterNZ's guidelines instead for much better accuracy. Average factors remain in this guide for general use.

There are minor changes to water supply and domestic wastewater emission factors, due to the use of the latest population data.

Water supply

Table 72 provides water supply emission factors. We calculated the factors using Water NZ data.

Table 72: Water supply emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	CH ₄ (kg CO ₂ -e)/unit	N ₂ O (kg CO ₂ -e)/unit
Water supply	m ³	0.031	0.030	0.0014	0.00003
	Per capita	3.785	3.611	0.170	0.0033

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

GHG inventory development

Users should collect data on cubic metres (m³) of water used, if available. In the absence of this information, apply the per capita emission factor.

Applying the equation $E = Q \times F$ (section 2), this means:

- E = emissions from the emissions source in kg CO₂-e per year
- Q = quantity of water used (m³) or persons using water supply (per capita)
- F = appropriate emission factors from table 72

⁵⁹ Guidelines can be found at: https://www.waternz.org.nz/Article?Action=View&Article_id=2078

WATER SUPPLY: EXAMPLE CALCULATION

An organisation's assets have water meters. Throughout the reporting year they use 1000 m³ of water.

CO ₂ emissions	= 1,000 × 0.030	= 30 kg CO ₂
CH ₄ emissions	= 1,000 × 0.0014	= 1.4 kg CO ₂ -e
N ₂ O emissions	= 1,000 × 0.00003	= 0.03 kg CO ₂ -e
Total CO ₂ -e emissions	= 1,000 × 0.031	= 31 kg CO ₂ -e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

We adopted the Water NZ 2016/17 National Performance Review⁶⁰ 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 m³ of water, and treatment plants used an estimated 1094 TJ of energy in the treatment of about 366 million m³ 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:

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

Where:

- energy use = the GJ of energy used by the water system that year
- water supply = m³ of water supplied that year
- electricity emission factor = the relevant gas emission conversion factor (ie, CO₂, N₂O, CH₄)
- unit conversion factor = 277.778 (converting GJ to kWh).

This equation gives the emissions per m³ 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 m³ of water per person per year, which is calculated from the following equations and information:

⁶⁰ View the report at: www.waternz.org.nz/NationalPerformanceReview

Equation 1:

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

Equation 2:

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

Where:

- m³ of water supplied nationwide is 550,000,000⁶¹
- population served by WWTP is approximately 4.55 million.⁶²

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.

Wastewater treatment

The emissions factors for specific types of wastewater treatment plants have been removed from these guidelines, and we advise users seeking this information to use WaterNZ's guidelines instead for much better accuracy. Average factors remain in the measuring emissions guide for general use.

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

We provide wastewater treatment emission factors in table 73 and table 74. 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

⁶¹ WaterNZ report www.waternz.org.nz/Attachment?Action=Download&Attachment_id=3142

⁶² Ministry for the Environment's WWTP database

wastewater factors. Where the domestic wastewater treatment type is unknown use the average for wastewater treatment plants in the table below.

Table 73: Domestic wastewater treatment emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Average for wastewater treatment plants	m ³ water supplied	0.480	0.077	0.167	0.2350
	per capita	48.360	7.812	16.861	23.697
Septic tanks	per capita	175.2	n/a	149.9	25.3

Note: These numbers are rounded to three significant figures unless the number is significantly small.

Table 74: Industrial wastewater treatment emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Meat (excluding poultry)	tonne of kills	47.528	n/a	44.688	2.841
Poultry	tonne of kills	47.025	n/a	42.969	4.057
Pulp and paper	tonne of product	10.530	n/a	10.530	n/a
Wine	tonne of crushed grapes	5.173	n/a	5.173	n/a
Dairy processing	m ³ of milk	0.115	n/a	n/a	0.115

Note: These numbers are rounded to three significant figures unless the number is significantly small.

9.3.1 GHG inventory development

Domestic water users should collect data on m³ 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 $E = Q \times F$ (section 2), this means:

- E = emissions from the emissions source in kg CO₂-e per year
- Q = quantity of water treated (m³) or persons using water facilities (per capita)
- F = appropriate emission factors from table 73 and table 74.

WASTEWATER: EXAMPLE CALCULATION

During the reporting period an organisation uses 100 m³ 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 × 0.167	= 16.7 kg CO ₂ -e
N ₂ O emissions	= 100 × 0.235	= 23.5 kg CO ₂ -e
Total CO ₂ -e emissions	= 100 × 0.480	= 48.0 kg CO ₂ -e

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

CO ₂ emissions	= n/a	
CH ₄ emissions	= 10 × 5.173	= 51.73 kg CO ₂ -e
N ₂ O emissions	= n/a	
Total CO ₂ -e emissions	= 10 × 5.173	= 51.73 kg CO ₂ -e

The total wastewater emissions are:

$$= 48.0 + 51.73 = 99.73 \text{ kg CO}_2\text{-e}$$

Note: Numbers may not add due to rounding.

9.3.2 Emission factor derivation methodology

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.

Direct carbon dioxide emissions from wastewater treatment are biogenic, methodologies described here are only for methane and nitrous oxide. We calculated these using equations in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.⁶³ An updated methodology is available in the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*.⁶⁴ Using updated methodologies in the 2019 Refinement would be inconsistent with *New Zealand Greenhouse Gas Inventory 1990–2020* reporting at the time of publication of this guide. The use of the 2019 Refinement will be considered for future inventories, and the guide will be revised after the NIR has been updated. The example calculations are done using AR4 GWPs.

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

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

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:

$$\frac{MCF \times B_0 \times TOW \times GWP}{\text{population served}} = \text{methane emissions (kg CH}_4\text{ per capita)}$$

⁶³ www.ipcc-nggip.iges.or.jp/public/2006gl/

⁶⁴ www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

Where:

- MCF = 0.02495, the weighted-average methane correction factor (MCF) for wastewater treatment plants in 2020
- 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 (IPCC AR4), converts methane into CO₂-e
- population served = the population served by all wastewater treatment plants.

To calculate methane emissions per water volume, divide methane emissions per capita by the average water volume (m³) treated per capita (101 m³).

Use the same equation to calculate the methane emissions from septic tanks, except that the MCF for septic tanks is 0.4313. 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:

$$\begin{aligned} & \text{per capita nitrogen in effluent (kg N per year)} \\ & = \text{protein} \times F_{\text{NPR}} \times F_{\text{NON-COM}} \times F_{\text{IND-COM}} \end{aligned}$$

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 AR4)
- $F_{\text{NON-COM}}$ = factor for non-consumed protein added to the wastewater (1.4, IPCC AR4)
- $F_{\text{IND-COM}}$ = factor for industrial and commercial co-discharged protein into the sewer system (1.25, IPCC AR4).

Table 75: 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, ⁶⁵ 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:

⁶⁵ National Greenhouse Gas Inventory from Wastewater Treatment and Discharge, prepared for Ministry for the Environment by Beca Infrastructure Ltd, August 2007.

N₂O emissions (kg CO₂e per capita)

$$= \text{per capita nitrogen in effluent} \times EF_{\text{effluent}} \times \frac{44}{28} \times GWP$$

Where:

- per capita nitrogen in effluent = from equation above
- effluent = emission factor of 0.005 kg N₂O-N/kg N (IPCC AR4)
- 44/28 ratio of N₂O to N₂
- GWP = 298 (IPCC AR4).

Divide these emissions per capita by the average volume of water treated (101 m³) per person to give the emissions per m³.

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:

$$mbCOD \times EF \times GWP = \text{methane emission factor (kg/unit)}$$

Where:

- mbCOD = the unit biodegradable chemical oxygen demand load in kg per tonne of material processed (specified by industry type in table 64: Calculating the ratio of gases in diesel) (kg CODb)/t
- EF = emission factor in kg methane/kg COD
- GWP = global warming potential.

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

Table 76: 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 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:

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

Where:

- mbCOD = unit biodegradable COD load (kg CODb/t)
- N:COD = total nitrogen to biodegradable COD ratio
- EF = emission factor
- 44/28 = ratio of N₂O to N₂
- 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 m³.

Table 77: 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 ₂ O/kg CODb)	0.00279	0.001348	0.001925	Cardno (2015)
GWP	298	298	298	IPCC AR4

Based on the Cardno report⁶⁶ we assume that there are no nitrous oxide emissions from the methods used to process wastewater from the wine and pulp and paper industries.

9.3.3 Assumptions, limitations and uncertainties

We calculated these emission factors on the best available data using industry-wide sources and international default factors where appropriate. As the wastewater emissions include electricity emissions, the same electricity emissions uncertainties carry through. Table 78 details the uncertainties with this source category.

Table 78: Uncertainties with wastewater treatment emission source category

	Uncertainty in activity data	Uncertainty in emission factors
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⁶⁶ Cardno, (2015), Greenhouse Gas Emissions from Industrial Wastewater Treatment – Inventory Basis Review. Accessed via: <https://environment.govt.nz/publications/greenhouse-gas-emissions-from-industrial-wastewater-treatment-inventory-basis-review/>

Domestic and industrial CH ₄	±10%	±40%
Domestic and industrial N ₂ O	±10%	±90%

Materials and waste emission factors

Overview of changes since previous update

There have been several changes in this version of the guide:

- emission factors for municipal landfills have been updated with the latest data to align with New Zealand's Greenhouse Gas Inventory, both with and without landfill gas
- the wood and average emission factors for non-municipal landfills have been revised to account for wood processing waste which has lower emissions
- the emission factors for construction materials have been removed from this version of the guidance to instead refer users directly to the source data and tools developed by Building Research Association of New Zealand (BRANZ).

Construction materials

BRANZ⁶⁷ provide the emission conversion factors for the emission sources, in their 2021 CO₂NSTRUCT dataset.⁶⁸ These emissions are indirect (Scope 3) if the organisation does not own or control the facilities making the materials.

We recommend that users refer directly to the free CO₂NSTRUCT tool for emission factors for construction materials. The tool provides embodied carbon and energy values for building materials including concrete, glass, timber, and metals, as well as products such as bathroom and kitchen fittings.

Users should also check EPD Australasia⁶⁹ for any interim updates to emission factors.

The Ministry of Business, Innovation and Employment's [Building for Climate Change Programme](#) (BFCC) is set up to reduce emissions from constructing and operating buildings, and to make sure buildings are prepared for the future effects of climate change. The BFCC Programme are contributing to the development of New Zealand's Emissions Reduction Plan and National Adaptation Plan, which are due to be published in May 2022 and August 2022 respectively.

Users should note that in the [GHG Protocol Corporate Accounting and Reporting Standard](#), construction materials are classified as Scope 3 Category 1 (emissions from purchased goods and services). These can form a large proportion of an organisation's GHG inventory. The guidance in this chapter relates to Scope 3 emissions from waste disposal only.

Waste disposal

Waste disposal emissions account only for the GHG emitted from end-of-life waste disposal. Currently, this guide covers emissions from waste-to-landfill for municipal and non-municipal

⁶⁷ BRANZ Ltd, www.branz.co.nz

⁶⁸ BRANZ CO₂NSTRUCT, www.branz.co.nz/co2nstruct

⁶⁹ <https://epd-australasia.com/>

landfills, as well as biological treatment (composting and anaerobic digestion). If users are seeking whole-life assessment of 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 CO₂-e per kg of material. The anaerobic decomposition of organic waste in landfills generates methane. Organisations should adjust inventories to account for the landfills that collected and destroyed landfill gas. Where methane is collected and destroyed by flaring or combustion to generate energy, the carbon dioxide emitted from the combustion process is regarded as part of the natural carbon cycle. Biogenic carbon dioxide, 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 since it has no net effect on greenhouse gases.

Emission factors for anaerobic digestion and composting are reported as forms of biological treatment of waste.

The type, age, design, engineering, and management practices of the landfill influences the GHG conversion factor, based on whether there is a methane gas collection system. In 2020, 97 per cent of municipal waste was disposed to landfills with gas collection.

Table 79: Description of landfill types

Landfill type	Description
Municipal (class 1) landfills with gas recovery	Municipal, well-managed landfill where a landfill gas recovery system is installed. Some of the CH ₄ produced during the organic decomposition of waste is captured and destroyed.
Municipal (class 1) landfills without gas recovery	Municipal, well-managed landfill where all the CH ₄ produced during organic decomposition of waste escapes into the atmosphere, apart from that which is oxidised inside the landfill.
Non-municipal (class 2-4) landfills	Non-municipal landfills that accept a broader range of wastes where the CH ₄ produced during organic decomposition of waste escapes into the atmosphere.

[Appendix C: Landfills with and without landfill gas recovery](#) includes a list of class 1 landfills with gas recovery.

If organisations are interested in calculating the emissions from transporting waste materials, they could do so by independently accounting for the distance travelled, using freight emission factors (see [section 8](#)).

We calculated the waste-to-landfill emission conversion factors based on the *New Zealand Greenhouse Gas Inventory 1990-2020*. Table 80 to table 83 show the factors.

Table 80: Waste disposal to municipal (class 1) landfills with gas recovery

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	kg CH ₄ /unit	kg N ₂ O/unit	
			(kg CO ₂ -e)	(kg CO ₂ -e)	(kg CO ₂ -e)	
Waste (known composition)	Food	kg	0.602	n/a	0.602	n/a
	Garden	kg	0.492	n/a	0.492	n/a
	Paper	kg	0.876	n/a	0.876	n/a
	Wood	kg	0.339	n/a	0.339	n/a

	Textile	kg	0.438	n/a	0.438	n/a
	Nappies	kg	0.219	n/a	0.219	n/a
	Sludge	kg	0.137	n/a	0.137	n/a
	Other (inert)	kg	n/a	n/a	n/a	n/a
Waste (unknown composition)	General waste	kg	0.207	n/a	0.207	n/a
	Office waste	kg	0.594	n/a	0.594	n/a

Note: These numbers are rounded to three significant figures.

Table 81: Waste disposal to municipal (class 1) landfills without gas recovery

Emission source		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Waste (known composition)	Food	kg	1.881	n/a	1.881	n/a
	Garden	kg	1.539	n/a	1.539	n/a
	Paper	kg	2.736	n/a	2.736	n/a
	Wood	kg	1.060	n/a	1.060	n/a
	Textile	kg	1.368	n/a	1.368	n/a
	Nappies	kg	0.684	n/a	0.684	n/a
	Sludge	kg	0.428	n/a	0.428	n/a
	Other (inert)	kg	n/a	n/a	n/a	n/a
Waste (unknown composition)	General waste	kg	0.647	n/a	0.647	n/a
	Office waste	kg	1.858	n/a	1.858	n/a

Note: These numbers are rounded to three significant figures.

Table 82: Waste disposal to non-municipal (class 2-5) landfills

Emission source		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Waste (known composition)	Sludge	kg	0.175	n/a	0.175	n/a
	Construction & Demolition	kg	0.140	n/a	0.140	n/a
	Bulk Waste	kg	0.980	n/a	0.980	n/a
	Food	kg	0.525	n/a	0.525	n/a
	Garden	kg	0.700	n/a	0.700	n/a
	Industrial	kg	0.525	n/a	0.525	n/a
	Wood	kg	1.190	n/a	1.190	n/a
	Inert	kg	n/a	n/a	n/a	n/a
Average for non-municipal solid waste		kg	0.176	n/a	0.176	n/a

Table 83: Biological treatment of waste emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Composting	kg	0.172	n/a	0.100	0.072
Anaerobic digestion	kg	0.020	n/a	0.020	n/a

Note: These numbers are rounded to three significant figures unless the number is significantly small.

GHG inventory development

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

- Where composition of waste is known.
- Where composition of waste is unknown.

The choice of methodology depends on organisational knowledge of waste composition. It is preferable to know the composition of waste as it allows more accurate calculation of emissions. The example calculations are done using IPCC AR4 GWPs.

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

Applying the equation $E = Q \times F$ (section 2), this means:

- E = emissions from the emissions source in kg CO₂-e per year
 Q = quantity of waste disposed (kg)
 F = appropriate emission factors from table 80 to table 83

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 × 0.602	= 90.3 kg CO ₂ -e
General waste	= 50 × 0.207	= 10.3 kg CO ₂ -e
Garden waste	= 60 × 0.492	= 29.5 kg CO ₂ -e
Total waste emissions	= 90.3 + 10.3 + 29.5	= 130.2 kg CO ₂ -e

Note: Numbers may not add due to rounding

Emission factor derivation methodologies

We broke down data derived from the National Inventory Report into seven categories. Table 84 identifies these alongside their proportion of the waste to municipal landfills in 2020.

Table 84: Composition of waste sent to NZ landfills in 2020

Waste category	Description	Estimated composition of waste to municipal landfills	Estimated composition of waste to non-municipal landfills
Food	Food waste	9.0%	0.01%
Garden	Organic material	5.7%	11.0%
Paper	Paper and cardboard waste	5.9%	n/a
Wood	Wood waste	12.6%	6.1%
Textile	Fabrics and other textiles	5.0%	n/a
Nappies	Nappies and similar sanitary waste	2.5%	n/a
Sludge	Sludges from sewer/septic tanks and offal and meat-based waste	1.9%	5.0%
Inert	Waste that does not produce GHG emissions	57.3%	67.4%

C & D	Construction and demolition waste	n/a	9.9%
Industrial	Where specific type of industrial is unknown	n/a	0.7%
Bulk waste	General domestic and farm waste	n/a	0.1%

Note: The composition for municipal landfills was based on a survey of 2018 data, and the composition for non-municipal landfills is held constant since 2015. Columns may not total to 100% due to rounding.

Substances such as plastics, metals and glass are inert because their decomposition in landfill does not directly produce GHG emissions. Only waste that contains degradable organic carbon produces methane as it breaks down.

We provide no methodology for nitrous oxide emissions from waste disposal because the IPCC⁷⁰ has found them to be insignificant.

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.

We generated emission factors for each waste category, following a simplification of the IPCC First Order Decay model.

$$\begin{aligned} \text{emission factor} \\ = \text{DOC} \times \text{DOCf} \times F \times \text{MCF} \times \text{conversion} \times (1 - \text{oxidation}) \times (1 \\ - \text{recovery}) \times \text{GWP} \end{aligned}$$

Where:

- DOC = amount of degradable organic carbon in the material
- DOCf = fraction of DOC that degrades in landfill
- F = fraction of CH₄ in the gas that is generated inside the landfill
- MCF = methane correction factor (the extent that the landfill is anaerobic)
- conversion = conversion of carbon to methane (molecular weight ratio CH₄/C)
- recovery = fraction of methane recovered where landfill gas systems are in place, 0 otherwise
- oxidation = oxidation factor of methane that degrades before being emitted
- GWP = global warming potential of methane.

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

Table 85: Information on managed solid waste in 2020

Category	DOC	DOCf	F	MCF	Conversion	Ox	R
Food	0.157	0.70	0.57	1	16/12	0.1	0.68

⁷⁰ www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf

Garden	0.161	0.56	0.57	1	16/12	0.1	0.68
Paper	0.32	0.5	0.57	1	16/12	0.1	0.68
Wood	0.43	0.14	0.57	1	16/12	0.1	0.68
Textiles	0.16	0.5	0.57	1	16/12	0.1	0.68
Nappies	0.08	0.5	0.57	1	16/12	0.1	0.68
Sludge	0.05	0.5	0.57	1	16/12	0.1	0.68
Inert	0	0.5	0.57	1	16/12	0.1	0.68
Source of information	Eunomia (unpublished)	Eunomia (unpublished) except 0.5 is IPCC default for managed landfills	Eunomia (unpublished)	IPCC default for managed landfills		IPCC default for managed landfills	Eunomia (unpublished)

Note: R only applies for landfills with gas recovery.

Table 86: Information on non-municipal solid waste in 2020

	DOC	DOCf	F	MCF	Conversion	Ox	R
Sludge	0.05	0.5	0.5	0.42	16/12	0	0
C&D	0.04	0.5	0.5	0.42	16/12	0	0
Bulk waste	0.28	0.5	0.5	0.42	16/12	0	0
Food	0.15	0.5	0.5	0.42	16/12	0	0
Garden	0.2	0.5	0.5	0.42	16/12	0	0
Industrial	0.15	0.5	0.5	0.42	16/12	0	0
Wood	0.34	0.5	0.5	0.42	16/12	0	0
Source of information	Tonkin & Taylor (unpublished) based on IPCC 2006 vol. 5, table 3.1 ⁷¹	IPCC default for unmanaged landfills	IPCC default for unmanaged landfills	Tonkin & Taylor (unpublished)		IPCC default for unmanaged landfills	MfE

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 *New Zealand Greenhouse Gas Inventory 1990-2020*, as in table 86 above.

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

Table 87: Composition of typical office waste

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

⁷¹ IPCC 2006, vol.5, table 3.1 www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf

Composting and Anaerobic digestion

We calculated emission factors for composting and anaerobic digestion using IPCC default emission factors as shown in table 88.

Table 88: IPCC default data used to calculate composting and anaerobic digestion

Calculation component	CH ₄	N ₂ O	Anaerobic digestion CH ₄	Anaerobic digestion N ₂ O
EF (kg gas/kg)	0.004	0.00024	0.0008	Assumed negligible
GWP (IPCC AR4)	25	298	25	298
EF (CO ₂ -e) (kg CO ₂ -e/ kg waste)	0.10	0.07152	0.020	0
Combined EF (kg CO₂-e/ kg waste)	0.172		0.020	

Assumptions, limitations and uncertainties

The uncertainties for emission factors used in methane emissions from managed municipal landfills is ± 40 per cent. This is consistent with the estimates in the IPCC Guidelines (IPCC, 2006a). New Zealand’s Greenhouse Gas Inventory states that “the emission factor uncertainty is set at this level, while better-quality parameters are used in this category, most of the parameters are based on international data and are not site specific”.

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

The default emission factor for average waste is based on national average composition data from *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Only waste to municipal and non-municipal landfills are 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 0 per cent for other waste types) 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.

Agriculture, forestry and other land use emission factors

This category covers emissions produced by land use, land-use change and forestry (LULUCF), livestock enteric fermentation, manure management and fertiliser use. Including these sources is in line with [New Zealand's Greenhouse Gas Inventory 1990-2020](#).

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

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

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

Users also have the option of estimating farm biological emissions and sequestration with the Ministry's [Agricultural Emissions Calculator](#) which uses the same methods and emissions factors as the guidance.

Overview of changes since previous update

This version of the guide includes additional emission factors for animal species including swine, goats, horses, alpaca and llama, mules, asses and poultry. This guide uses data from New Zealand's Greenhouse Inventory which has revised methodologies and emissions factors from the previous edition. The changes relevant to the updated emission factors included in this version are summarised as:

- use of new pasture quality values of metabolisable energy, organic matter digestibility, and nitrogen content for dairy cattle, non-dairy cattle, sheep and deer livestock categories in the Tier 2 methodology
- minor correction to the sheep nitrogen excretion calculations
- adoption of a new FracLEACH value for nitrogen applied to cropland (arable and vegetable). All other operations (eg, pastoral and permanent horticulture) use the Grasslands FracLEACH.
- an updated assumption to the purity of agricultural lime (previously assumed to be 100 per cent)
- the addition of the option to use Approach One- Stock Change Accounting or *Approach Two- Averaging Accounting*. This allows users who do not have access to harvest data to estimate emissions and removals. It also supports users who are aligning with New Zealand's International emissions reduction targets.

Please refer to section 5.1.5 (and other relevant sections) *New Zealand's Greenhouse Gas Inventory 1990–2020*. for further details.

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

11.2.1 Overview of the sector

GHG emissions from vegetation and soils due to human activities are reported in the land use, land-use change and forestry (LULUCF) sector. This guide provides emission factors related to forest growth, forest harvest and deforestation only. The term LULUCF is used for consistency with *New Zealand's Greenhouse Gas Inventory 1990–2020*.

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 *New Zealand Greenhouse Gas Inventory 1990-2020*.

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.

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

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

11.2.2 LULUCF emission factors

Planted forests

Two approaches are provided to calculate emissions and removals from planted forests. Only one approach can be used, a mixture of approaches is not permitted.

Approach one – Carbon stock change accounting

This approach estimates the net emissions and removals from forest growth and harvesting each year. The emission factors are based on the Land Use and Carbon Analysis System (LUCAS) national sample.

Annual removals from forest growth (table 89) are estimated as an average annual increment over the average duration of their harvesting cycle. Emission factors are provided for three species groups (*Pinus radiata*, other softwoods, and all hardwoods) and an 'all planted forest category' (this represents an average emission factor for New Zealand's planted forest estate, regardless of species). If a species breakdown is not available, then the 'all planted forest' category can be used. The emission factors for forest harvesting and deforestation are provided as the entire loss of carbon on the clearing of planted forest at the average harvest (table 90).

Note, if species-specific emission factors for forest growth are used, the corresponding species-specific values must be used to account for land-use change emissions. Likewise, if the 'all planted forest' emission factor is used for forest growth, then it must also be used to account for land-use change emissions.

Approach two – Averaging accounting

The *averaging* approach estimates carbon dioxide removals from the planting of new forests (afforestation) up to the age when they reach their average long-term carbon stock. The long-term average carbon stock represents the average carbon that is estimated to be stored over successive rotations.

Once carbon dioxide removals have been measured up to the long-term average carbon stock, there are assumed to be no further emissions or removals (ie, no additional removals from growth nor emissions from harvest). The averaging approach requires information on forest plant date, so the age can be determined, and for the forest to be in its first rotation.

The age that the long-term average carbon stock is reached varies depending on species (*Pinus radiata* = 22 years, other softwoods = 28 years, and all hardwoods = 13 years, or for all planted forest = 22 years). Any forest that is over the age of the long-term average carbon stock is considered to have an emission factor of zero. If a species breakdown is not available then the 'all planted forest' category can be used (this represents an average emission factor for New Zealand's planted forest estate, regardless of species).

This approach aligns with the approach that New Zealand will take to account for emissions and removals in first rotation post-1989 planted forest under the Paris Agreement. The averaging approach can be appropriate for participants who can identify the plant date of their forests (and if it is in its first rotation), or do not have data available on harvesting activity.

Deforestation emissions are still accounted in full, as in approach one (table 90). If species-specific emission factors for forest growth are used, the corresponding species-specific values must be used to account for land-use change emissions. Likewise, if the ‘all planted forest’ emission factor is used for forest growth, then it must also be used to account for land-use change emissions.

HARVESTING AND DEFORESTATION

Deforestation occurs when forest land is cleared for another land use.

Harvesting refers to the harvest of planted production forests for timber, which are then replanted.

Natural forests

The emission factors for natural forest growth (shown in table 89) are based on the LUCAS national sample. We provide separate emission factors if the forest is pre-1990 or post-1989. Post-1989 regenerating natural forest is regenerating natural forest that was established from 1 January 1990 onwards. Pre-1990 natural forest is natural forest that was established before 1 January 1990. Within pre-1990 natural forest we provide separate emission factors if the forest is tall or regenerating ie, recovering from conversion from another land use, logging, or other anthropogenic disturbance.

The emission factor for natural forest deforestation (shown in table 90) is based on the average stock at the national level, calculated from the LUCAS national sample.

Table 89: LULUCF forest growth emission factors

Forest growth removal source	Unit	kg CO ₂ -e/unit	Uncertainty (95% CI)	kg CH ₄ /unit (kg CO ₂ e)	kg N ₂ O/unit (kg CO ₂ e)
Planted forests: Approach one – Stock change accounting⁷²					
All planted forests	ha	-35,561	±13.3%	n/a	n/a
<i>Pinus radiata</i>	ha	-36,689	±13.2%	n/a	n/a
Other softwoods	ha	-29,453	±22.6%	n/a	n/a
All hardwoods	ha	-15,957	±65.2%	n/a	n/a
Planted forests: Approach two – Averaging accounting⁷³					
All planted forests – First rotation (Age 23 years and under)	ha	-35,561	±13.3%	n/a	n/a
<i>Pinus radiata</i> – First rotation (Age 22 years and under)	ha	-36,689	±13.2%	n/a	n/a

⁷² Uncertainty and emission factors derived from yield tables in Paul THS, Wakelin SJ, Dodunski, C. Unpublished. The NFI 2016-2020 analysis: Yield tables and carbon stocks in planted forests in New Zealand based on a five-year inventory cycle. Contract report prepared for the Ministry for the Environment by New Zealand Forest Research Institute Ltd (trading as Scion) in 2021.

⁷³ Long-term averages taken from Wakelin SJ, Paul THS, Dowling, LJ. Unpublished. Reporting New Zealand’s Nationally Determined Contribution under the Paris Agreement using Averaging Accounting for Post-1989 forests. Contract report prepared for the Ministry for the Environment by New Zealand Forest Research Institute Ltd (trading as Scion) in 2021. Long-term averages incorporate Harvested Wood Products and losses from soil carbon. This is in-line with the approach that New Zealand will take to account for emissions and removals in first rotation post-1989 planted forest under the Paris Agreement.

Forest growth removal source	Unit	kg CO ₂ -e/unit	Uncertainty (95% CI)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Other softwoods – First rotation (Age 28 years and under)	ha	-29,453	±22.6%	n/a	n/a
All hardwoods – First rotation (Age 13 years and under)	ha	-15,957	±65.2%	n/a	n/a
All planted forest above the long-term average age	ha	0	n/a	n/a	n/a
Natural forests					
Post-1989 Regenerating Natural Forest ⁷⁴	ha	-7,973	±44.8%	n/a	n/a
Pre-1990 Regenerating Natural Forest ⁷⁵	ha	-1,567	±119.6%	n/a	n/a
Pre-1990 Tall Natural Forest ⁷⁶	ha	0	n/a	n/a	n/a

Source: New Zealand's LUCAS national forest inventory data April 2022

Table 90: LULUCF land-use change emission factors

Land-use change emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	Uncertainty (95% CI)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Planted forests: Approach one – Stock change accounting⁷⁷							
All planted forests	Harvest or deforestation	ha	995,700	995,700	±21.9%	n/a	n/a
<i>Pinus radiata</i>	Harvest or deforestation	ha	1,027,286	1,027,286	±21.8%	n/a	n/a
Other softwoods	Harvest or deforestation	ha	1,178,113	1,178,113	±28.5%	n/a	n/a
All hardwoods	Harvest or deforestation	ha	239,354	239,354	±67.4%	n/a	n/a
Planted Forests: Approach two – Averaging accounting							
All planted forests	Harvest	n/a	n/a	n/a	n/a	n/a	n/a
All planted forests	Deforestation	ha	995,700	995,700	±21.9%	n/a	n/a
<i>Pinus radiata</i>	Harvest	n/a	n/a	n/a	n/a	n/a	n/a
<i>Pinus radiata</i>	Deforestation	ha	1,027,286	1,027,286	±21.8%	n/a	n/a
Other softwoods	Harvest	n/a	n/a	n/a	n/a	n/a	n/a
Other softwoods	Deforestation	ha	1,178,113	1,178,113	±28.5%	n/a	n/a
All hardwoods	Harvest	n/a	n/a	n/a	n/a	n/a	n/a

⁷⁴ Uncertainty and emission factors derived from Paul TSH, Beets PN, Kimberley MO. Unpublished. Carbon stocks in New Zealand's Post-1989 Natural Forest – Analysis of the 2018/2019 forest inventory data. Contract report prepared for the Ministry for the Environment by the New Zealand Forest Research Institute Ltd (trading as Scion) in 2020. Emission factor incorporates losses from soil carbon.

⁷⁵ Uncertainty and emission factors derived from Paul TSH, Kimberley MO, Beets PN. 2021. Natural Forests in New Zealand – a large terrestrial carbon pool in a national state of equilibrium. *Forest Ecosystems* 8(1): 1–21.

⁷⁶ Uncertainty and emission factors derived from Paul TSH, Kimberley MO, Beets PN. 2021. Natural Forests in New Zealand – a large terrestrial carbon pool in a national state of equilibrium. *Forest Ecosystems* 8(1): 1–21.

⁷⁷ Uncertainty and emission factors derived from yield tables in Paul THS, Wakelin SJ, Dodunski, C. Unpublished. The NFI 2016-2020 analysis: Yield tables and carbon stocks in planted forests in New Zealand based on a five-year inventory cycle. Contract report prepared for the Ministry for the Environment by New Zealand Forest Research Institute Ltd (trading as Scion) in 2021.

Land-use change emission source		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	Uncertainty (95% CI)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
All hardwoods	Deforestation	ha	239,354	239,354	±67.4%	n/a	n/a
Natural Forests							
Post-1989 Regenerating natural forest ⁷⁸	Deforestation	ha	141,350	141,350	27.0%	n/a	n/a
Tall pre-1990 Natural forest ⁷⁹	Deforestation	ha	898,704	898,704	20.9%	n/a	n/a
Regenerating pre-1990 Natural forest	Deforestation	ha	275,595	275,595	27.3%	n/a	n/a

Source: New Zealand's LUCAS national forest inventory data April 2022

11.2.3 GHG inventory development

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

First determine the type of forest and the area it covers. The New Zealand parameters to define a forest are a minimum area of 1 hectare, the potential to reach a minimum height of 5 metres and a minimum crown cover of 30 per cent.

Forest types:

- **Pre-1990 Tall natural forest:** areas, that on 1 January 1990, were and presently comprise of mature indigenous forest.
- **Pre-1990 Regenerating natural forest:** areas, that on 1 January 1990, were and presently comprise of indigenous and naturally occurring vegetation, including broadleaved hardwood shrubland, mānuka–kānuka and other woody shrubland, with potential to reach forest definition under its current management. This category represents mid-successional regenerating forest.
- **Post-1989 Regenerating natural forest:** areas of forest established from 1 January 1990 onwards that comprise of indigenous tree species arising from natural regeneration. This category represents early successional regenerating forest.

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

- The LUCAS Land Use Map⁸⁰ can provide area by vegetation type (pre-1990 and post-1989 natural forest) at 1990, 2008, 2012 and 2016. It requires geospatial expertise to analyse

⁷⁸ Uncertainty and emission factors derived from Paul TSH, Beets PN, Kimberley MO. Unpublished. Carbon stocks in New Zealand's Post-1989 Natural Forest – Analysis of the 2018/2019 forest inventory data. Contract report prepared for the Ministry for the Environment by the New Zealand Forest Research Institute Ltd (trading as Scion) in 2020.

⁷⁹ Uncertainty and emission factors derived from Paul TSH, Kimberley MO, Beets PN. 2021. Natural Forests in New Zealand – a large terrestrial carbon pool in a national state of equilibrium. *Forest Ecosystems* 8(1): 1–21.

⁸⁰ LUCAS Land Use Map ([MfE Data Service](#))

and extract the data by region. This is free to use and supports users in monitoring changes in their own land management practices.

- The New Zealand Land Cover Database (LCDB)⁸¹ provides multi-temporal land cover. This can be used to differentiate between tall and regenerating pre-1990 natural forest. Two LCDB classes are classified as tall forest; indigenous forest and broadleaved indigenous hardwoods. All other categories are classified as regenerating forest. It requires geospatial expertise to analyse and extract the data for sub-national analysis.

Alternatively, if the age of the forest is known or can be estimated, this can be used to determine forest type:

- Age 0 – 30 years: post-1989 regenerating natural forest
- Age 30 – 100 years: pre-1990 regenerating natural forest
- Age 100 years and over: pre-1990 tall natural forest

Planted forest: plantations of forest species mainly used for forestry, including:

- radiata pine (*Pinus radiata*)
- softwoods, such as douglas fir (*Pseudotsuga menziesii*)
- hardwoods, such as eucalypts (*Eucalyptus* spp)
- other planted species (with potential to reach ≥ 5 metre height at maturity in situ).

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

- Corporate or farm records for enterprises and organisations.
- Geospatial analysis of the property or region.
- The LUCAS Land Use Map⁷⁵
- The New Zealand Land Cover Database (LCDB)⁷⁶
- If Approach two (averaging) is used, the planting date (to calculate the age of the forest) will be required as well as evidence that the forest is in its first rotation.

Using the sources detailed above to gather information on the land use, forest type and size, organisations can apply the equation $E = Q \times F$ (section 2):

E	=	emissions from the emissions source in kg CO ₂ -e per year
Q	=	area of land (ha)
F	=	appropriate emission factors (for land use) from table 89 and table 90

⁸¹ The New Zealand Land Cover Database. LCDB v4.1 (Deprecated) - Land Cover Database version 4.1, Mainland New Zealand - Informatics Team | New Zealand | Environment and Land GIS | LRIS Portal (scinfo.org.nz)

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

Example one (using Approach one for planted forest):

An organisation owns 4 ha of land: 3 ha are planted forest (*Pinus radiata*) and 1 ha is pre-1990 regenerating natural forest. During the reporting year the organisation harvested the planted forest for timber.

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

$$\text{CO}_2 \text{ emissions} = 3 \times 1,027,286 = 3,081,858 \text{ kg CO}_2\text{-e}$$

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

$$\text{CO}_2 \text{ removals} = 1 \times -1,567 = -1,567 \text{ kg CO}_2\text{e}$$

Therefore, total net CO₂-e emissions = 3,081,858 – 1,567 = 3,080,291 kg CO₂-e.

Note: Negative emissions are a carbon sink.

Example two (using Approach two for planted forest):

An organisation owns 40 ha of land: 10 ha are planted forest (Other softwoods) below the long-term average age (< 28 years since time of planting), 20 ha are planted forest (*Pinus radiata*) above the long-term average age (> 22 years since time of planting) and a further 10 ha of planted forest (*Pinus radiata*) were deforested during the reporting year.

The removals (expressed as negative) for the 10 ha of planted forest (Other softwoods) below the long-term average age (< 28 years) are:

$$\text{CO}_2 \text{ removals} = 10 \times -29,453 = -294,530 \text{ kg CO}_2\text{-e}$$

The removals (expressed as a negative) for the 20 ha of planted forest (*Pinus radiata*) above the long-term average (> 22 years):

$$\text{CO}_2 \text{ removals} = 20 \times 0 = 0 \text{ kg CO}_2\text{e}$$

The emissions for the 10 ha of planted forest (*Pinus radiata*) that were deforested:

$$\text{CO}_2 \text{ emissions} = 10 \times 1,027,286 = 10,272,860 \text{ kg CO}_2\text{-e}$$

Therefore, total net CO₂-e emissions = 10,272,860 – 294,530 – 0 = 9,978,330 kg CO₂-e.

Activity data uncertainties

National mapping uncertainty for natural forest and pre-1990 planted forest land is ±5 per cent, and ±8 per cent for post-1989 forest land. As the guide combines planted forest types, we recommend applying the higher uncertainty of ±8 per cent.

11.2.4 Emission factor derivation methodology

The general approach to emissions estimation follows a simple equation (note that Approach two for planted forests follows a different approach:

$$\Delta C = \sum_{ij} [A_{ij} * (C_1 - C_L)_{ij}]$$

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), CO₂ and CO₂-e.

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

The approach to emissions estimation for Approach two (averaging) follows this equation:

$$\Delta C = \sum [A_a * (C_i) + A_b * 0]$$

Where:

- ΔC = carbon stock change in the pool, kg C yr⁻¹
- A_a = area of planted forest land that is yet to reach its long-term average, ha
- A_b = area of planted forest land that *has* reached its long-term average, ha
- CI = rate of gain of carbon, kg C ha⁻¹ yr⁻¹.

11.2.5 Assumptions, limitations and uncertainties

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

For natural forests, deforestation and harvest loss data are based on the national stock average, which come from the most recent carbon stock inventory for these forests.

The emission factors for planted forest (Approach one) and natural forest in this guide are based on *New Zealand's Greenhouse Gas Inventory 1990–2020*. The long-term average carbon stock for planted forest (Approach two) are based on Wakelin et al. (unpublished⁸²). These emission factors represent the most up-to-date forestry data available. ETS look-up tables are another source of emissions factors; however, these are not updated as frequently. The emission factors are based on national average data and the uncertainties will not necessarily reflect sub-national circumstances and will not be exactly the same as the ETS estimates of carbon sequestration which differentiate based on tree age, region and to a limited extent,

⁸² Wakelin SJ, Paul THS, Dowling, LJ. Unpublished. Reporting New Zealand's Nationally Determined Contribution under the Paris Agreement using Averaging Accounting for Post-1989 forests. Contract report prepared for the Ministry for the Environment by New Zealand Forest Research Institute Ltd (trading as Scion) in 2021.

the species. Selection of the most appropriate emission factor should be guided by the requirements of the intended use and by the user's inventory.

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.
- Losses from manure that is simply deposited in paddocks, which is distinct from losses from agricultural soils.
- Applying nitrogen (urea-sourced or synthetic) fertiliser onto land produces nitrous oxide and carbon dioxide (urea) emissions.
- Applying lime and dolomite fertilisers results in carbon dioxide emissions.

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

Note the livestock emissions you calculate using these emission factors are intended to be an approximate estimate of emissions only, and are based on the average per-animal biological emissions of New Zealand's main farmed livestock categories. 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 farm-based estimate of their agricultural emissions are encouraged to use alternative GHG calculator tools. An approved list of tools by the He Waka Eke Noa programme can be found here: [Know your number – Ag Matters](#).

Enteric fermentation

Enteric fermentation is the process by which ruminant animals produce methane through digesting feed. We provide emission factors for dairy cattle, non-dairy cattle, sheep and deer and other minor livestock categories in in table 91.

Table 91: Enteric fermentation emission factors

Emission source		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit	CH ₄ (kg CO ₂ -e)/unit	N ₂ O (kg CO ₂ -e)/unit
Enteric fermentation	Dairy cattle	per head	2,264	n/a	2,264	n/a
	Non-dairy cattle	per head	1,540	n/a	1,540	n/a
	Sheep	per head	318	n/a	318	n/a
	Deer	per head	597	n/a	597	n/a
	Swine	per head	27	n/a	27	n/a
	Goats	per head	224	n/a	224	n/a
	Horses	per head	450	n/a	450	n/a
	Alpaca	per head	200	n/a	200	n/a
	Mules & asses	per head	250	n/a	250	n/a

	Poultry	per head	0	n/a	0.0	n/a
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GHG inventory development

Organisations should collect data on the number and type of livestock as at 30 June during the measurement period (regardless of whether the period is a calendar or financial year; see [section 11.3.1](#)) to calculate emissions from enteric fermentation.

Applying the equation $E = Q \times F$ ([section 2](#)), this means:

- E = emissions from the emissions source in kg CO₂-e per year
- Q = number of animals (per head per livestock type)
- F = appropriate emission factors from table 91

ENTERIC FERMENTATION: EXAMPLE CALCULATION

An organisation owns 2400 sheep and 210 dairy cows on 30 June during the reporting period. They graze on land owned by the organisation.

CO ₂ emissions	= 0
CH ₄ emissions	= (2400 × 318) + (210 × 2,264) = 1,238,640 kg CO ₂ -e
N ₂ O emissions	= 0
Total CO ₂ -e emissions	= 1,238,640 kg CO ₂ -e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

The New Zealand Greenhouse Gas Inventory 1990–2020 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 to calculate the emission factors based on the following equation:

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

Note that the emission factors are based on data supplied for the *New Zealand Greenhouse Gas Inventory 1990–2020*. 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 92: Enteric fermentation figures per livestock type

Animal	2020 population	Enteric fermentation emissions in 2020 (kt CH ₄) (as GHG)
Dairy cattle	6,200,221	561.39
Non-dairy cattle	3,882,568	239.23
Sheep	26,028,935	330.85
Deer	833,258	19.91
Swine	234,533	0.25

Animal	2020 population	Enteric fermentation emissions in 2020 (kt CH ₄) (as GHG)
Goats	96,416	0.86
Horses	38,647	0.70
Alpaca and llama	9,366	0.07
Mules and asses	141	0.001
Poultry	18,822,291	n/a

Note: kt is kilotonne.

Source: Based on figures from the Agricultural Inventory Model used in *New Zealand's Greenhouse Gas Inventory 1990–2020*.

The emission conversion factors are in the Emission factors workbook.

Alternative methods and tools

There are alternative calculating tools, such as the Ministry's [Agricultural Emissions Calculator](#), [OverseerFM](#), or the [B+LNZ GHG calculator](#). The emission factors in this guide may differ from other tools because of the different in-built assumptions and limitations. It is up to the user to assess the appropriateness of alternative tools.

Assumptions, limitations and uncertainties

The *New Zealand Greenhouse Gas Inventory 1990–2020* 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.

Manure management emission factors

Manure management refers to the process of managing the excretion of livestock, particularly when they are not on paddocks, but also covers losses from manure that is simply deposited in paddocks, and it is distinct from losses from agricultural soils. The storage and treatment of manure produces GHG emissions. We provide the manure management emission factors in table 93.

Table 93: Manure management emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Manure management	Dairy cattle	per head	238	n/a	223	14.4
	Non-dairy cattle	per head	21.4	n/a	21.3	0.0
	Sheep	per head	3.53	n/a	3.53	0.0
	Deer	per head	7.57	n/a	7.57	0.0
	Swine	per head	206	n/a	149	57.7
	Goats	per head	5.00	n/a	5.00	0.0
	Horses	per head	58.5	n/a	58.5	0.0
	Alpaca	per head	2.57	n/a	2.57	0.0
	Mules and asses	per head	27.5	n/a	27.5	0.0

	Poultry	per head	1.44	n/a	0.78	0.65
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Note: These numbers are rounded to three significant figures unless the number is significantly small.

GHG inventory development

Organisations should collect data on the number and type of livestock as at 30 June during the measurement period (regardless of whether the period is a calendar or financial year, see [section 11.3.2](#)) to calculate emissions from manure management.

Applying the equation $E = Q \times F$ ([section 2](#)), this means:

E	=	emissions from the emissions source in kg CO ₂ -e per year
Q	=	number of animals (per head per livestock type)
F	=	appropriate emission factors from table 93

MANURE MANAGEMENT: EXAMPLE CALCULATION

An organisation owns 2400 sheep and 210 dairy cows on 30 June during the reporting period.

CO ₂ emissions	=	0
CH ₄ emissions	=	(2400 × 3.53) + (210 × 238) = 58,452 kg CO ₂ -e
N ₂ O emissions	=	(2400 × 0) + (210 × 14.4) = 3,204 kg CO ₂ -e
Total CO ₂ -e emissions	=	61,476 kg CO ₂ -e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

We calculated the emission factors from figures in the Agricultural Inventory Model, used in [New Zealand's Greenhouse Gas Inventory 1990–2020](#). MPI provided these data, see table 94.

Table 94: Manure management source data

Animal	Population	Methane from manure management (kt CH ₄)	Nitrous oxide from manure management (kt N ₂ O)
Dairy cattle	6,200,221	55.5	0.30
Non-dairy cattle	3,882,568	3.32	0.00
Sheep	26,028,935	3.68	0.00
Deer	833,258	0.25	0.00
Swine	234,533	1.39	0.05
Goats	96,416	0.02	0
Horses	38,647	0.09	0
Alpaca and llama	9,366	0.001	0
Mules and asses	141	0.0002	0
Poultry	18,822,291	0.59	0.04

Note: kt is kilotonne.

Source: The Agricultural Inventory Model used in [New Zealand Greenhouse Gas Inventory 1990–2020](#).

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 (i.e., per animal).
3. Calculate kg CO₂-e / animal by multiplying each GHG by the IPCC AR4 100-year GWP.

For example:

Table 95: Emissions from dairy cattle

Animal	Population	Methane from manure management (kg CH ₄)	Nitrous oxide from manure management (kg N ₂ O)
Dairy cattle	6,200,221	55,484,471	299,283

Methane emissions = 55,484,471 ÷ 6,200,221 = 8.95 kg CH₄ per head

Nitrous oxide emissions = 299,283 ÷ 6,200,221 = 0.05 kg N₂O per head

Total kg CO₂ equivalent = (8.95 x 25) + (0.05 x 298) = 238.1 kg CO₂-e per head.

Assumptions, limitations and uncertainties

The New Zealand Greenhouse Gas Inventory 1990–2020 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.⁸³ Based on the IPCC methodologies, the uncertainty factor for methane emissions is ±20 per cent and for nitrous oxide emissions ±100 per cent,⁸⁴ although different uncertainty values are reported in the New Zealand Inventory. The *New Zealand Greenhouse Gas Inventory 1990–2020* details the assumptions and limitations of these data.

Alternative methods of calculation

See section 11.3.1: [Alternative methods and tools](#).

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 categories on soil in table 96.

Table 96: Agricultural soils emission factors

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)	
Agricultural soils	Dairy cattle	per head	468	n/a	n/a	468
	Non-dairy cattle	per head	267	n/a	n/a	267
	Sheep	per head	36.3	n/a	n/a	36.3
	Deer	per head	83.8	n/a	n/a	83.8

⁸³ 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

⁸⁴ 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

Emission source	Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Swine	per head	5.40	n/a	n/a	5.40
Goats	per head	68.7	n/a	n/a	68.7
Horses	per head	325	n/a	n/a	325
Alpaca and llama	per head	75.9	n/a	n/a	75.9
Mules and asses	per head	145	n/a	n/a	145
Poultry	per head	0.11	n/a	n/a	0.11

Note: These numbers are rounded to three significant figures unless the number is significantly small.

GHG inventory development

Organisations should collect data on the number and type of livestock they had as at 30 June during the measurement period. Applying the equation $E = Q \times F$ (section 2), this means:

E = emissions from the emissions source in kg CO₂-e per year

Q = number of animals (per head per type)

F = appropriate emission factors from table 96

AGRICULTURAL SOILS: EXAMPLE CALCULATION

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

CO₂ emissions = n/a

CH₄ emissions = n/a

N₂O emissions = $(2,400 \times 36.3) + (210 \times 468) = 185,400$ kg CO₂-e

Total CO₂-e emissions = 185,400 kg CO₂-e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

We calculated the emission factors from the Agricultural Inventory Model, used in *New Zealand's Greenhouse Gas Inventory 1990–2020*. These data are in table 97.

Table 97: Data used for agricultural soils emission factors

Animal	Population	Total agricultural soils (kt N ₂ O)
Dairy cattle	6,200,221	9.75
Non-dairy cattle	3,882,568	3.48
Sheep	26,028,935	3.17
Deer	833,258	0.23
Swine	234,533	0.004
Goats	96,416	0.022
Horses	38,647	0.042
Alpaca and llama	9,366	0.002
Mules and asses	141	0.0001

Poultry	18,822,291	0.007
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Assumptions, limitations and uncertainties

The *New Zealand Greenhouse Gas Inventory 1990–2020* details the uncertainties associated with the activity data used to calculate the emission factors.

The level of uncertainty with N₂O emissions from agricultural soils was ±55 per cent for 2020.

Fertiliser use

The use of fertilisers produces GHG emissions. Nitrogen fertilisers break down to produce nitrous oxide and carbon dioxide (urea). Limestone and dolomite fertilisers break down to produce carbon dioxide. The *New Zealand Greenhouse Gas Inventory 1990-2020* reports the total emissions from fertiliser using New Zealand-specific emission factors. We used methodologies supplied by MPI to develop emission factors for:

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

In line with the reporting requirements of [ISO 14064-1:2018](#) and the [GHG Protocol](#), we provide emission factors to allow separate calculation of carbon dioxide, methane and nitrous oxide. Table 98 lists the fertiliser use emission factors. Table 99 lists example products for the different fertiliser types. For the nitrogen fertilisers listed in table 98, the input amounts are expressed in terms of the nitrogen component of fertiliser only.

Table 98: Fertiliser use emission factors

Emission source		Unit	kg CO ₂ -e/unit	kg CO ₂ /unit (kg CO ₂ -e)	kg CH ₄ /unit (kg CO ₂ -e)	kg N ₂ O/unit (kg CO ₂ -e)
Fertiliser use	Nitrogen content of non-urea nitrogen fertiliser*	kg N	5.40	n/a	n/a	5.40
	Nitrogen content of urea nitrogen fertiliser not coated with urease inhibitor	kg N	5.07	1.59	n/a	3.48
	Nitrogen content of urea nitrogen fertiliser coated with urease inhibitor	kg N	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.

* Noting that this is the mass of the nitrogen component of fertiliser only.

Table 99: Examples of different categories of fertilisers

Fertiliser type	Example product
Non-urea nitrogen	Diammonium phosphate
Urea nitrogen not coated with urease inhibitor	Nrich urea

Urea nitrogen coated with urease inhibitor	Agrotain, Sustain, N-Protect
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GHG inventory development

Organisations should collect data on quantity of nitrogen (in kg) of fertiliser used in the reporting period by type. Applying the equation $E = Q \times F$ (section 2), this means:

E	=	emissions from the emissions source in kg CO ₂ -e per year
Q	=	type of fertiliser used (in kg)
F	=	appropriate emission factors from table 98

FERTILISER USE: EXAMPLE CALCULATION

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

CO ₂ emissions	= (80 × 0.477) + (50 × 0)	= 38.2 kg CO ₂ -e
CH ₄ emissions	= (80 × 0) + (50 × 0)	= 0 kg CO ₂ -e
N ₂ O 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.

Emission factor derivation methodology

MPI provided data on the quantified direct and indirect GHG emissions produced per tonne of nitrogen in fertiliser (table 100 and table 101).

Table 100: Nitrogen fertiliser emission factors

Fertiliser type	Direct emissions of N ₂ O (kg N ₂ O/kg of N in fertiliser)	Indirect emissions- volatilisation (kg N ₂ O/kg of N in fertiliser)	Indirect emissions – leaching (kg N ₂ O/kg of N in fertiliser)	CO ₂ emissions from urea (kg CO ₂ /kg of N in fertiliser)
Non-urea nitrogen	0.0157	0.0016	0.0008	n/a
Urea nitrogen not coated with urease inhibitor	0.0093	0.0016	0.0008	1.594
Urea nitrogen coated with urease inhibitor	0.0093	0.0009	0.0008	1.594

Table 101: Quantified emissions factors from limestone and dolomite

Fertiliser type	Emissions (kg CO ₂ -e /kg fertiliser)
Limestone	0.440
Dolomite	0.477

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

- Convert the data to kg (gas) per unit kg of fertiliser.
- Sum emissions per component of the total emissions.
- Calculate total carbon dioxide equivalent by multiplying the total kg gas/ kg of fertiliser by the IPCC AR4 100-year global warming potential of that gas.

For limestone, the emission factors in table 101 assume that the lime applied to soils is 100 per cent pure calcium carbonate; MPI applies a correction factor of 82 per cent to the tonnage of agricultural lime applied to soil prior to determining estimated emissions. This accounts for the impurities of the lime, as well as its moisture content. No correction factor is required for dolomite.

For example:

Table 102: Emission factors for non-urea nitrogen fertilisers

Fertiliser type	Direct emissions of N ₂ O (kg N ₂ O/kg fertiliser)	Indirect emissions – volatilisation (kg N ₂ O/kg fertiliser)	Indirect emissions – leaching (kg N ₂ O/kg fertiliser)
Non-urea nitrogen	0.016	0.0016	0.0008

Total emissions per gas:

- N₂O = 0.0008 + 0.0016 + 0.016 = 0.0184 kg N₂O/ kg fertiliser

Total carbon dioxide equivalent = 0.018 × 298 = 5.4 kg CO₂-e/ kg fertiliser.

GHG inventory development

Organisations should collect data on quantity of lime (in kg) fertiliser used in the reporting period by type. Applying the equation E= Q x F (section 2), this means:

- E = emissions from the emissions source in kg CO₂-e per year
 Q = type of fertiliser used (in kg)
 F = appropriate emission factors from table 102

FERTILISER USE: EXAMPLE CALCULATION

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

CO ₂ emissions	= ((1,600 × 0.82) × 0.44)	= 577.3 kg CO ₂ -e
CH ₄ emissions	= (1,600 × 0)	= 0 kg CO ₂ -e
N ₂ O emissions	= (1,600 × 0)	= 0 kg CO ₂ -e
Total CO ₂ -e emissions	= 577.3 kg CO ₂ -e	

Note: Numbers may not add due to rounding.

Assumptions, limitations and uncertainties

MPI used the following parameters to calculate the emissions.

Table 103: 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
Fra _{C_{GASE}} (UI)	0.055	Saggar, 2013
Fra _{C_{GASE}} (non-UI)	0.1	Sherlock et al, 2008

Parameter	Value	Source
Volatilisation emission factor (EF4)	0.01	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, table 11.3
Fra _{C_{LEACH}} (Grassland)	0.07	Thomas et al, 2005
Fra _{C_{LEACH}} (Cropland)	0.10	Welten et al. 2021 Arable and vegetable crops.
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 ₂ O	1.571	
GWP100 N ₂ O	298	IPCC AR4

The *New Zealand Greenhouse Gas Inventory 1990–2020* uses the IPCC (2006) Tier 1 methodology when default emission factors are used, which assume conservatively that all carbon in the fertilisers is emitted as carbon dioxide into the atmosphere.

There is no country-specific methodology on carbon dioxide emissions from urea application for New Zealand. Emissions associated with the application of urea are estimated using a Tier 1 methodology (equation 11.13; IPCC, 2006), using the default emission factor for carbon conversion of 0.20.

Appendix A: Derivation of fuel emission factors

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 CO₂-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 CO₂-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 CO₂-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.

Methane and nitrous oxide emission factors used in this guide

Although carbon dioxide emissions remain constant regardless of how a fuel is combusted, methane and nitrous oxide emissions depend on the precise nature of the activity in which the fuel is being combusted. The emission factors for methane and nitrous oxide therefore vary depending on the combustion process. Table A1 shows the default methane and nitrous oxide emission factors (expressed in energy units) used in this guide. The calculation in [section 3.2.2](#) shows how we converted these to a per activity unit (eg, kg CO₂-e/kg) emission factors. MBIE provided all emission factors in [table 3](#).

Note that we have used gross emission factors.

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 have not been applied to the methane and nitrous oxide emission factors.

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 ₂ O / 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

Emission source	User	Unit	Calorific value			
			(MJ/unit)	‡ CO ₂ / TJ	‡ CH ₄ / TJ	‡ N ₂ O / TJ
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
Wood	Industry	kg	9.63	89.47	0.2	0.003
Wood	Residential	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. **Note²:** The total of each gas contribution are expressed in tonnes of gas (not CO₂-e as presented elsewhere in this guidance).

Source: MBIE.

Appendix B: Alternative methods of calculating emissions from refrigerants and medical gases

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. This appendix provides IPCC AR4 emission factors for medical gases and also provides alternative emission factors for medical gases from IPCC AR5.

Method B – Default annual leakage rate

$$E = OE \times GWP$$

Where:

- E = emissions from equipment in kg CO₂-e
- OE = operation emissions, kg by gas type
- GWP = the 100-year global warming potential of the refrigerant used in equipment (table 7).

$$OE = C \times ALR$$

Where:

- C = original full refrigerant charge in equipment (kg)
- ALR = the default annual leakage emission factor for equipment (%).

The type and quantity of HFC in the equipment will often be shown on the compliance plate. If not, this method requires service agents' advice for refrigerant type and full refrigerant charge of each piece of equipment.

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

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

Where:

- E = emissions from equipment in kg CO₂-e
- IE = installation emissions
- C = default refrigerant charge in each piece of equipment (kg)

- ALR = default annual leakage emission factor for equipment (%)
- DE = disposal emissions (as per method B)
- GWP = the 100-year global warming potential of the refrigerant used in equipment (table 7).

Table B1 contains default refrigerant charge amounts for the New Zealand refrigeration and air-conditioning equipment stock.

Table B1: Default refrigerant charges for refrigeration and air-conditioning equipment

Refrigeration unit type	Default refrigerant charge (kg)	Default leakage rate (operating – ALR)	Default leakage rate (installation – AEF) ⁸⁵	Method A	Method B
Small refrigerator or freezer (<150 litres ⁸⁶)	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

⁸⁵ 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.

⁸⁶ 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) ⁸⁵	Method A	Method B
Non-ducted and ducted split commercial air conditioners (<20 kW)	0.25 kg per kW cooling capacity	3%	0.5%	Acceptable	Screening method only
Commercial air conditioning (>20kW)	Wide range	Wide range	Wide range	Unacceptable	Unacceptable
Cars/vans	0.7	10%	n/a	Recommended	Acceptable
Trucks	1.2	10%	n/a	Acceptable	Screening method only
Buses	2.5 (but up to 10)	10%	n/a	Acceptable	Screening method only
Refrigerated truck trailer units	10	25%	0.5%	Acceptable	Unacceptable
Self-powered or ‘cab-over’ refrigerated trucks	6	25%	0.5%	Acceptable	Unacceptable
‘Off-engine’ or ‘direct drive’ refrigerated vans and trucks	2.5	25%	0.5%	Acceptable	Unacceptable
Three-phase refrigerated containers	5.5	25%	0.5%	Acceptable	Unacceptable
Single-phase refrigerated containers	3	25%	0.5%	Acceptable	Unacceptable
Centralised commercial refrigeration eg, supermarkets	Wide range	Wide range	Wide range	Unacceptable	Unacceptable
Industrial and commercial cool stores	Wide range	Wide range	Wide range	Unacceptable	Unacceptable

Table B2: Detailed 100-year GWPs for various refrigerant mixtures⁸⁷

Refrigerant type (trade name)	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-218	PFC-218	Other*	Total GWP
GWP100 (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

⁸⁷ Global warming potentials are set according to the UNFCCC guidelines. <https://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf>, which resolved that Parties would use the 100-year GWPs from the IPCC AR4. (IPCC, 2007).

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

B.2.1 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.

B.3 Medical gas blends

Table B3: Detailed 100-year GWPs (IPCC, 2007) for medical gas blends

Trade name	N ₂ O	O ₂	GWP ₁₀₀
Entonox	50% v/v	50% v/v	173

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). This table was last updated in 2013.

Table C1: Landfills with and without landfill gas recovery

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	Closed
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 Cooe 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

Name	Operator	LFGR
Rotorua District Sanitary Landfill	Rotorua District Council	Closed
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

AR4	The IPCC Fourth Assessment Report
AR5	The IPCC Fifth Assessment Report
Activity data	Data on the magnitude of human activity resulting in emissions or removals taking place during a given period
Base year	The first year in the reporting series
BEV	Battery electric vehicle
Biodiesel	A type of biofuel similar to diesel that is made from natural elements such as plants, vegetables and reusable materials
Bioethanol	A type of biofuel similar to ethanol that is made from natural elements such as plants, vegetables and reusable materials
Biofuels	Any fuel derived from biomass
Biologically sequestered carbon	The removal of carbon dioxide from the atmosphere and captured by plants and micro-organisms
BOD	Biological oxygen demand, the amount of dissolved oxygen needed by micro-organisms to break down biological organic matter in water
BRANZ	Building Research Association of New Zealand
Carbon sink	A natural or artificial process that removes carbon from the atmosphere
CH₄	Methane
CFCs	Chlorofluorocarbons
CO₂	Carbon dioxide
CO₂-e	Carbon dioxide equivalent
COD	Chemical oxygen demand
CHSB	The Cornell Hotel Sustainability Benchmarking Index Tool
<i>De minimis</i>	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 <i>de minimis</i>
Deforestation	The clearing of forest land that is then converted to a non-forest land use
EECA	Energy Efficiency and Conservation Authority
Emission factor	A coefficient that quantifies the emissions or removals of a gas per unit activity
Enteric fermentation	The process by which ruminant animals digest feed and produce methane
Forest land	Land containing tree species that will reach a height of at least 5 meters, with a canopy cover of at least 30% and be of at least 1 hectare in size

Fugitive emissions	The emission of gases from pressurised equipment due to leaks or unintended releases of gases, usually from industrial activities
GHG	Greenhouse gas
GHG inventory	A quantification of an organisation’s greenhouse gas sources, sinks, emissions and removals
GHG Protocol	The <i>Greenhouse Gas Protocol Accounting and Reporting Standard</i> provides guidance for organisations preparing a GHG inventory
GHG report	A standalone report to communicate an organisation’s GHG-related information to intended users
GJ	Gigajoule (unit of measure, one billion joules)
Grazing off	Cattle feeding on paddock not owned by their farmer
GWP	Global warming potential, a factor describing the radiative forcing impact of one mass-based unit of a given GHG relative to an equivalent unit of carbon dioxide over a given period (typically 100 years)
HBFCs	Hydrobromofluorocarbons
HCFCs	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbon, an alternative refrigerant gas that minimises damage to the ozone hole
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
Inert	Chemically inactive (eg, plastic waste)
IPCC	Intergovernmental Panel on Climate Change
ISO 14064-1:2018	International Organization for Standardisation standard on greenhouse gases – Part 1: Specification with guidance at the organisation level for quantification and reporting greenhouse gas emissions and removals
ITP	International Tourism Partnership
JAS-ANZ	Joint Accreditation System of Australia and New Zealand
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
NDC	Nationally determined contributions under the Paris Agreement

NF₃	Nitrogen trifluoride
N₂O	Nitrous oxide
NZ ETS	New Zealand Emissions Trading Scheme
NZTA	Waka Kotahi New Zealand Transport Agency
ODS	Ozone-depleting substances
Organisational boundary	The boundary of the organisation as it applies to measurement of GHG emissions. This typically aligns with legal and/or organisational structure; a financial boundary must be drawn within this too
OVERSEER	A New Zealand software platform that enables farmers and growers to estimate and improve nutrient use on farms
PFC	Perfluorocarbon
PHEV	Plug-in hybrid electric vehicle
pkm	Passenger-kilometre (unit of measure for transport)
Radiative forcing	The difference between solar energy absorbed by the Earth and that radiated back to space. Human activity has impacts which alter radiative forcing
Refrigerants	A substance or mixture used in a heat pump and refrigeration cycle
Removals	Withdrawal of a GHG from the atmosphere by GHG sinks
Reporting boundary	The emission sources included within an organisation's operations, including direct and indirect emission sources. It includes choosing which indirect emission sources to report
Reticulated gas	A piped gas system to deliver a gas such as LPG or natural gas to a consumer
Scope	Emission sources are categorised by Scope to manage risks and impacts of double counting. There are three scopes in greenhouse gas reporting: Scope 1 (direct emissions), Scope 2 (energy indirect emissions) and Scope 3 (other indirect emissions)
SF₆	Sulphur hexafluoride
Stationary combustion fuel	Fuel used in an unmoving engine eg, a power plant or boiler
TFCF	Task Force on Climate-related Financial Disclosures
tkm	Tonne-kilometre (unit of measure for freight)
Unique emission factor	A value given to an activity based on how emissions intensive it is. Experienced professionals must verify a unique emission factor. See Climate Change (Unique Emission Factors) Regulations 2009 for further information
Uplift factor	Applied to take into account the combined 'real-world' effects on fuel consumption (such as non-direct flight paths)
VFEM	The 2019 Vehicle Fleet Emissions Model supplied by the Ministry of Transport