Measuring Emissions: A Guide for Organisations

2020 DETAILED GUIDE

New Zealand Government

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Overview of changes since the previous update

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

There have been several updates since the tenth edition of the guidance in 2019

- New Chapters:
  - Indirect business related emission factors, including working from home emission factors and guidance on data centres.
- Some categories have been improved:
  - The refrigerant chapter now also includes medical gases.
  - The Purchased electricity, heat and steam emissions chapter now includes a time series for electricity and transmission and distribution losses.
  - The travel chapter now includes public transport emission factors for buses and rail services. Additional accommodation emission factors have been added.
  - The freight transport emissions chapter now includes additional truck freight emission factors for tonne-km data.
  - The materials and waste chapter now recommends a construction material data base and includes non-municipal solid waste emission factors and an anaerobic emission factor.
  - The water supply and wastewater chapter now includes additional emission factors for specific waste water treatment plants.
  - The agriculture, forestry and other land use chapter now includes emission factors for swine, goats, horses, alpaca, mules, asses and poultry.

Impacts of the Coronavirus disease (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 commenced measuring their emissions in 2020.

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

1 Introduction

1.1 Purpose of this guide

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

The guide aligns with and endorses the use of the *GHG Protocol Corporate Accounting and Reporting Standard* (referred to as the *GHG Protocol* throughout the rest of the document) and *ISO 14064-1:2018* (see section 1.5). It provides information about preparing a GHG inventory (section 0), emission factors (see sections 3–10, and the Emission Factors Workbook) and methods to apply them to activity data.

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

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

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

Measuring Emissions: A Guide for Organisations		
Quick Guide	The go-to document explaining changes since the last update, how to produce an inventory and what data you need to work out emissions from your activities	
Detailed Guide	For users who need to know the data sources, methodologies, uncertainties and assumptions behind the emission factors for each emission source	THIS DOCUMENT
Emission Factors Summary	Quick look up tables providing the main emission factors for each emission source	
Emission Factors Workbook	As above but in excel format across multiple tabs	
Emission Factors Flat File	Simple format for integration with software	
Interactive Workbook	Use this spreadsheet to input your activity data, in order to work out your organisation's emissions and produce an inventory	
Example GHG Inventory	Shows what a finished inventory might look like	
Example GHG Report	Shows what a finished report might look like	

Feedback

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

1.2 Important notes

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

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 Task Force on Climate-related Financial Disclosures (TCFD) framework. However, the complete TCFD recommendations go beyond the scope of this guidance. For further guidance on these please consult the TCFD website.[1]

> The Task Force on Climate-related Financial Disclosures (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.
>
> In September 2020, New Zealand announced plans to introduce mandatory climate risk reporting in line with the TCFD recommendations for all listed issuers and large banks, investment managers and insurers. This guide and the emission factors and methods align with the TCFD recommendations for disclosure of GHG emissions.

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

This guide, and the emission factors and methods, are not appropriate for a full life-cycle assessment or product carbon footprinting. 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 analysis. If you want to do a full life-cycle assessment, we recommend using UK BEIS emission factors, which account for the life-cycle of those activities for a number of emission sources, including well-to-tank for some categories. The GHG Protocol has also published standards for the calculation of life-cycle emissions.[2]

This information is not appropriate for use in an emissions trading scheme. Organisations required to participate in the New Zealand Emissions Trading Scheme (NZ ETS) need to comply with the scheme-specific reporting requirements. The NZ ETS regulations determine which emission factors and methods must be used to calculate and report emissions.

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

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

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

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

1.3 Gases included in the guide

This guide covers the following greenhouse gases (GHGs): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3) and other gases (eg, Montreal Protocol refrigerant gases or medical gases".[3]

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).[4] To enable a meaningful comparison between the seven gas types, GHG emissions are commonly expressed as carbon dioxide equivalent or CO_2-e. This is used throughout the guide.

To do this, we multiply the emissions for each gas by the GWP in a 100-year period – see table 1Table 1. The Intergovernmental Panel on Climate Change (IPCC) provides more information on how these factors are calculated.[5]

Throughout the guide, kilograms (kg) of methane and nitrous oxide are reported in kg CO_2-e by multiplying the actual methane emissions by the GWP of 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 GWPs in the IPCC Fourth Assessment Report (AR4) to align with the National Inventory approach. 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.

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

GHGs	Scientific Formula	GWP (AR4)
Nitrous Oxide	N_2O	298
Methane	CH_4	25
Carbon Dioxide	CO_2	1

1.5.1 Kyoto and Montreal protocols and Paris Agreement

The Kyoto Protocol,[6] 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: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3.

[3] The *GHG Protocol* added nitrogen trifluoride in 2013 as a requirement and *ISO 14064-1* included nitrogen trifluoride in 2018. This is consistent with the national inventory.

[4] We use the 2007 IPCC GWPs to ensure consistency with the national inventory. 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

[5] *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

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

The Montreal Protocol,[7] 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.

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

The 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 inventory reporting under the Paris Agreement will be using GWPs from IPCC AR5. The first such inventory will be submitted in 2023.

1.4 Uncertainties

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

- Disclose the data on the quantified uncertainty if known.
- Disclose the qualitative uncertainty if known based on expert judgement from those providing the data.
- Disclose the uncertainty ranges in the IPCC Guidelines if provided.
- Disclose that the uncertainty is unknown.

1.5 Standards to follow

We recommend following ISO 14064-1:2018 and the GHG Protocol Corporate Accounting and Reporting Standard. We wrote this guide to align with both.

- ISO 14064-1:2018[8] is shorter and more direct than the GHG Protocol. A PDF copy costs 158 Swiss francs.
- The GHG Protocol[9] gives more description and context around what to do to produce an inventory. It is free to download.

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

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

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7 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

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

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

1.5.1 How emission sources are categorised

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

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

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 guide continues to report direct (Scope 1), indirect (Scope 2) or indirect (Scope 3) emissions, as summarised in table 2.

Table 2: Emissions by scope, category and source category

Scope	Category	Direct/Indirect emissions and removals	Source	New for this guide?
Scope 1	Category 1	Direct GHG emissions and removals	Fuel	
			Refrigerant and medical gases*	Yes
			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	
			Staff commute	Yes
			Freight transport	
			Refrigerant use (from chilled transport or air conditioner)	
	Category 4	Indirect GHG emissions from products an organisation uses	Transmission and distribution losses	
			Working from home	Yes
			Water supply and wastewater treatment	
			Materials and waste	
	Category 5	Indirect GHG emissions (use of products from the organisation)	Outside the scope of this guide	
	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 140064-1:2018 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 (CO_2-e). Example calculations in this guide do so. See the 2019 Example GHG Report and 2019 Example GHG Inventory for further examples.

2 How to quantify and report GHG emissions

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

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

CALCULATION METHODOLOGY

E = Q × F

Where:

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

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

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

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

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

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

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

2.1 Step-by-step inventory preparation

To prepare an inventory:

1. Select the boundaries (organisational and reporting[10]) and measurement period (ie, calendar or financial year) you will report against for your organisation, based on the intended uses of the inventory.

[10] See Glossary for definitions.

2. Collect activity data on each emission source within the boundaries for that period.
3. Multiply the quantity used by the appropriate emission factor in a spreadsheet. See the 2019 Example GHG Inventory.
4. 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 commenced measuring their emissions in 2020.

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*[11] and may be excluded from the total inventory, provided that the total of excluded emissions does not exceed the materiality threshold. For example, if using a materiality threshold of 5 per cent, the total of all emission sources excluded as *de minimis* must not exceed 5 per cent of the inventory. Typically, an organisation estimates any emissions considered *de minimis* using simplified methods to justify the classification. It is important these are transparently documented and justified. You only need to re-estimate excluded emissions in subsequent years if the assumptions change.

2.2 Using the emission factors

Emission factors rely on historical data. This 2020 guide is based on New Zealand's Greenhouse Gas Inventory 1990–2018 as this was the latest complete set of data available. We intend to update these emissions factors every second year, 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.[12]

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 2019 calendar year, use this 2020 guide, which largely relies on 2018 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 2019/2020 financial year, use this 2020 guide. For a July to June reporting year, apply the more recent set of factors.

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[11] See Glossary for definition.

[12] 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.

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 1990-2018. 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 CO_2-e. However, many emission factors are too small to be reported meaningfully in tonnes, therefore this guide presents emission factors in kg CO_2-e per unit. Dividing by 1000 converts kg to tonnes (see example calculations on the following pages).

In line with the reporting requirements of ISO 14064-1:2018, the emission factors allow calculation of carbon dioxide, methane and nitrous oxide separately, as well as the total carbon dioxide equivalent for direct (Scope 1) emission sources.

Carbon dioxide emission factors are based on the carbon and energy content of a fuel. Therefore, the carbon dioxide emissions remain constant 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.[13] To reflect this variability, the guide provides uncertainty estimates for direct (Scope 1) emission factors. Table 3 presents separate carbon dioxide equivalent emission factors for residential, commercial and industrial users. It follows the IPCC guidelines for combustion and adopts the uncertainties.[14]

We 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.

2.3 Producing a GHG report

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

A GHG REPORT

To compile a full GHG report, organisations should include:

- a description of the organisation
- the person or entity responsible for the report
- a description of the inventory boundaries
  - organisational boundary
  - reporting boundary
  - measurement period

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

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

A GHG REPORT

- the chosen base year (initial measurement period for comparing annual results)
- emissions (and removals where appropriate)
- for all seven GHGs separately in metric tonnes CO_2-e
- emissions separated by scope
  - total Scope 1 and 2 emissions
  - specified Scope 3 emissions
- emissions from biologically sequestered carbon reported separately from the scopes
- a time series of emissions results from base year to present year
- significant emissions changes, including in the context of triggering any base year recalculations
- the 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.

2.4 Verification

Verification[15] 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.

2.4.1 Who should verify my inventory?

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

- are independent
- are members of a suitable professional organisation
- have experience with emissions inventories
- understand ISO 14064 and the GHG Protocol
- have effective internal peer review and quality control processes.

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

[15] See

Glossary for definition.

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.[16]

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

3 Fuel emission factors

Fuel can be categorised as stationary combustion or transport. This section also includes biofuels, and the transmission and distribution losses for reticulated natural gas.

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

3.1 Overview of changes since previous update

There has been no update to emission factors for stationary fuels, transport fuels, biofuels and biomass.

3.2 Stationary combustion fuel

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

Table 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 national inventory.

Table 3: Emission factors for the stationary combustion of fuels

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

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)	Uncertainties kg CO_2-e/unit
Industrial use						
Coal – default	kg	2.05	2.03	0.00529	0.00946	3.5%
Coal – bituminous	kg	2.66	2.64	0.00703	0.0126	3.5%
Coal – sub-bituminous	kg	2.01	1.99	0.00514	0.00919	3.5%
Coal – lignite	kg	1.43	1.42	0.00362	0.00648	3.5%
Diesel	litre	2.66	2.65	0.00272	0.00649	0.5%
LPG	kg	3.02	3.02	0.00119	0.00142	0.5%
Heavy fuel oil	litre	3.02	3.01	0.00291	0.00695	0.5%
Light fuel oil	litre	2.92	2.92	0.00287	0.00685	0.5%
Natural gas	kWh	0.194	0.194	0.0000810	0.0000966	2.4%
	GJ	54.0	54.0	0.0225	0.0268	2.4%

Notes

- These numbers are rounded to three significant figures.
- Commercial and industrial classifications are based on standard classification.[17]
- Use the default coal emission factor if it is not possible to identify the type of coal.
- Convert LPG-use data in litres to kilograms by multiplying by the specific gravity of 0.536 kg/litre.

3.2.1 GHG inventory development

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

Q = quantity of fuel used (unit)
F = appropriate emission factors from table 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_2O emissions	= 1,400 × 0.00142	= 1.99 kg CO_2-e
Total CO_2-e emissions	= 1,400 × 3.03	= 4,242 kg CO_2-e

Note: Numbers may not add due to rounding.

3.2.2 Emission factor derivation methodology

MBIE derived the kg CO_2-e per activity unit emission factors supplied in table 3 using calorific values[18] 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.

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

[18] See Appendix A: Derivation of fuel emission factors for more information.

The equation used is:

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

* t is tonnes

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

3.2.3 Assumptions, limitations and uncertainties

MBIE derived the kg CO_2-e per activity unit emission factors supplied in table 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.

3.3 Transport fuel

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

Table 4: Transport fuel emission factors

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

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.

3.3.1 GHG inventory development

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

Q = quantity of fuel used (unit)
F = appropriate emission factors from table 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_2O emissions	= 40,000 × 0.0797	= 3,186 kg CO_2-e
Total CO_2-e emissions	= 40,000 × 2.45	= 98,000 kg CO_2-e

Note: Numbers may not add due to rounding.

3.3.2 When no fuel data are available

If your records only provide information on kilometres (km) travelled, and you do not have information on fuel use, see section 0

Travel emission factors. Factors such as individual vehicle fuel efficiency and driving efficiency mean that kilometre-based estimates of carbon dioxide equivalent emissions are less accurate than calculating emissions based on fuel-use data. Therefore, only use the emission factors based on distance travelled if information on fuel use is not available.

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

3.3.3 Emission factor derivation methodology

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

3.3.4 Assumptions, limitations and uncertainties

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

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

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

3.4 Biofuels and biomass

This 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, the combustion of biofuels generates anthropogenic methane and nitrous oxide. Organisations should calculate and report these gases, as required by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories.*[19]

Table 5Table 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_2O/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%

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

Biodiesel	GJ	3.42	67.3	2.85	0.570	0.1%
	litre	0.000125	2.45	0.000104	0.0000208	0.1%
Wood – fireplaces	kg	0.0670	0.862	0.0578	0.00918	36.3%
Wood – industrial	kg	0.0150	0.862	0.00578	0.00918	43.7%

Notes

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

3.4.1 GHG inventory development

Note that although the direct (Scope 1) carbon dioxide emissions of biomass combustion are considered carbon neutral over the short term carbon cycle, organisations should still report the carbon dioxide released through biofuel and biomass combustion.[20]

Calculate the carbon dioxide emissions in the same way as the direct emissions. Then, instead of including them within the emissions total (where CH_4 and NO_2 gases are reported), list them as a separate line item called ‘biogenic emissions’.[21] This ensures the organisation is transparent regarding all potential sources of carbon dioxide from its activities.

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

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

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

The equation used is:

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

BIOFUELS AND BIOMASS: EXAMPLE CALCULATION

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

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

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

BIOFUELS AND BIOMASS: EXAMPLE CALCULATION

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_2O emissions	= 7,000 × 0.0000208	= 0.146 kg CO_2-e

Total CO_2-e emissions = 7,000 × 0.000125 = 0.875 kg CO_2-e (reported as Scope/Category 1)

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

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

Therefore, 10 per cent biodiesel blend conversion factor =

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

Note: Numbers may not add due to rounding.

3.4.2 Emission factor derivation methodology

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

3.4.3 Assumptions, limitations and uncertainties

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

3.5 Transmission and distribution losses for reticulated gases

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

Reticulated LPG is supplied in parts of Canterbury and Otago only (natural gas is not available in the South Island). The guide assumes there are no transmission and distribution losses from reticulated LPG due to the chemical composition of the gas. 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_2O/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.

3.5.1 GHG inventory development

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

Q = quantity of fuel used (unit)
F = appropriate emission factors from table 6Table 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_2O 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.

3.5.2 Emission factor derivation methodology

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

3.5.3 Assumptions, limitations and uncertainties

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.

4 Refrigerant and other gases use emission factors

4.1 Overview of changes since previous update

This guide includes the 100-year GWPs of the Kyoto and Montreal Protocol gases. This is consistent with the national inventory. We use the GWPs published in the IPCC Fourth Assessment Report (IPCC AR4*)*, in line with the UNFCCC, to which we submit *New Zealand's Greenhouse Gas Inventory*.

The eleventh version of the guide now includes selected medical anaesthetic gases. Where IPCC AR4 GWPs are available these are used; where they are not available IPCC AR5 GWPs are used instead.

4.2 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.

4.2.1 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 GWPs from the IPCC's Fourth Assessment Report[22] to ensure consistency with the national inventory.

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

Some refrigerants 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 GWP of various refrigerant mixtures, please see table B2 in Appendix B: Alternative methods of calculating emissions from refrigerants.

Table 7: GWPs of refrigerants

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

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

4.2.2 GHG inventory development

There are three approaches to estimate HFC leakage from refrigeration equipment, depending on 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.

4.2.3 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.

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

Where:

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

4.2.4 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.

4.2.5 Example calculations

We provide refrigerant emissions calculation examples below.

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

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

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

REFRIGERANT USE METHOD A: EXAMPLE CALCULATIONS

Method A: Top-up

Chiller unit: During the 2018 calendar year, a service technician confirmed a top-up of 6 kg of HFC-134a (GWP = 1430) in December 2018. The technician also confirmed that when last serviced at the end of December 2017, no top-ups were needed. So we assume all the 6 kg of gas was lost during calendar year 2018.

So, for the 2018 inventory:

6 kg HFC-134a × 1,430 = 8,580 kg CO_2-e

Air conditioning unit: During the 2018 calendar year, a service technician confirmed a top-up of 6 kg of HFC-143a (GWP = 4,470) in July 2018. The technician also confirmed that when last serviced at the end of July 2017, no top-ups were needed. So we assume all the gas was lost at an even rate during the 12 months between service visits, and six of those months sit in the 2018 measurement period.

6 kg /12 months = 0.5 kg per month

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

3 kg HFC-143a × 4,470 = 13,410 kg CO_2-e

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

REFRIGERANT USE METHOD B: EXAMPLE CALCULATIONS

Method B: Screening method with default annual leakage rate

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

So, for the 2018 calendar year,

12 kg HFC-134a × 8% × 1,430 = 1,372.8 kg CO_2-e

Air conditioning unit: A service technician confirms the refrigerant is HFC-143a (GWP = 4,470) and the volume held is 10 kg. For the size of the unit, the default leakage rate is 3%.

So, for the 2018 calendar year,

12 kg HFC-143a × 3% × 4,470 = 1,609.2 kg CO_2-e

Note: Numbers may not add due to rounding.

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

4.3 Medical gases use

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

4.3.1 Global warming potentials of medical gases

Table 9 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 National Inventory Report. 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 please 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[23]	AR5 GWPs in a 100-year period (kg CO_2-e) without climate change feedbacks[24]
HFE-347mmz1 (Sevoflurane)	$(CF_3)_2CHOCH_2F$	kg	Not available	216
HCFE-235da2 (Isoflurane)	$CHF_2OCHClCF_3$	kg	350	491
HFE-236ea2 (Desflurane)	$CHF_2OCHFCF_3$	kg	Not available	1790

4.3.2 GHG inventory development

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

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

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

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

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

MEDICAL GAS USE : EXAMPLE CALCULATION

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

5 bottles x 0.3 kg = 1.5 kg

Total CO_2-e emissions = 1.5 × 350 = 525 kg CO_2-e

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

5 bottles x 250 mL x 1.49/ 1000 = 1.86 kg

Total CO_2-e emissions = 1.86 × 350 = 651 kg CO_2-e

4.3.3 Assumptions

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

5 Purchased electricity, heat and steam emission factors

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

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

The guide provides information on reporting imported heat and steam and geothermal energy. It does not provide emission factors for these categories as they are unique to a specific site.

5.1 Overview of changes since previous update

In the eleventh version of the guide, we have included a time series of historic electricity emission factors. This 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.

5.2 Direct emissions from purchased electricity from New Zealand grid

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

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.

We calculate purchased electricity emission factors on a calendar-year basis, and based on the average grid mix of generation types for the 2018 year. 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 factor for purchased electricity from the New Zealand grid is in table 9.

Table 9: Emission factor for purchased grid-average electricity

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)
2018	kWh	0.101	0.097	0.0039	0.00014
2017	kWh	0.113	0.108	0.0044	0.00010
2016	kWh	0.098	0.093	0.0044	0.000086
2015	kWh	0.121	0.117	0.0044	0.00016
2014	kWh	0.127	0.122	0.0042	0.00018
2013	kWh	0.151	0.147	0.0039	0.00024
2012	kWh	0.180	0.176	0.0037	0.00036
2011	kWh	0.143	0.140	0.0035	0.00022
2010	kWh	0.155	0.151	0.0034	0.00020

Note: These numbers are rounded to three significant figures.

5.2.1 GHG inventory development

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

Q = quantity of electricity used (kWh)

F = emission factors from table 9

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

PURCHASED ELECTRICITY: EXAMPLE CALCULATION

An organisation uses 800,000 kWh of electricity in the 2019 reporting period. Its indirect (Scope 2) emissions from electricity are:

CO_2 emissions = 800,000 × 0.097 = 77,600 kg CO_2

CH_4 emissions = 800,000 × 0.0039 = 3,120 kg CO_2-e

N_2O emissions = 800,000 × 0.00014 = 112 kg CO_2-e

Total CO_2-e emissions = 800,000 × 0.101 = 80,800 kg CO_2-e

Note: Numbers may not add due to rounding.

5.2.2 Emission factor derivation methodology

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

Table 10: Information used to calculate the purchased electricity emission factor for 2010–2018

Calculation component	Public electricity consumed and emissions by gas and source								
	2018	2017	2016	2015	2014	2013	2012	2011	2010
Public electricity consumption (GWh)	39,916	39,373	39,788	40,477	39,983	39,496	39,880	40,342	40,690
Emissions of CO_2 from public electricity generation (kt)	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)	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)	0.05	0.06	0.05	0.06	0.07	0.08	0.09	0.08	0.09
Geothermal fugitive emissions of CH_4 (kt)	6.14	6.86	6.91	7.05	6.64	6.06	5.83	5.57	5.44
Emissions of N_2O from public electricity generation (kt)	0.02	0.01	0.01	0.02	0.02	0.03	0.05	0.03	0.03
Geothermal fugitive emissions of N_2O (kt)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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

$$public\ electricity\ consumption\ (GWh) \times 1{,}000{,}000 \\ = public\ electricity\ consumption\ (kWh)$$

Where:

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

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

Where:

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

5.2.3 Assumptions, limitations and uncertainties

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

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

We derived the emission factor in table 9 for purchased electricity from consumption data rather than generation data. This emission factor does not account for the emissions associated with the electricity lost in transmission and distribution on the way to the end user. Table 11 contains an emission factor for transmission and distribution line losses.

5.3 Transmission and distribution losses for electricity

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.[25]

The emission factor for transmission and distribution line losses is the difference between the generation and consumption emission factors. Table 11 shows the emission factors for transmission and distribution losses from the national grid.

Table 11: Transmission and distribution losses for electricity consumption

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	kg CH_4/unit (kg CO2-e)	kg N_2O/unit (kg CO2-e)
2018	kWh	0.0087	0.0084	0.0003	0.000012
2017	kWh	0.0082	0.0079	0.0003	0.000011
2016	kWh	0.0064	0.0062	0.0002	0.000009
2015	kWh	0.0070	0.0067	0.0003	0.00001
2014	kWh	0.0070	0.0068	0.0003	0.00001
2013	kWh	0.0085	0.0082	0.0003	0.00001
2012	kWh	0.0123	0.0118	0.0005	0.00002
2011	kWh	0.0090	0.0087	0.0003	0.00001
2010	kWh	0.0098	0.0094	0.0004	0.00001

Note: These numbers are rounded to three significant figures.

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

5.3.1 GHG inventory development

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

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

TRANSMISSION AND DISTRIBUTION LOSSES: EXAMPLE CALCULATION

An organisation uses 800,000 kWh of electricity in the 2019 reporting period. Its indirect (Scope 3) emissions from transmission and distribution losses for purchased electricity are:

CO_2 emissions	= 800,000 × 0.0084	= 6,720 kg CO_2
CH_4 emissions	= 800,000 × 0.000332	= 265.6 kg CO_2-e
N_2O emissions	= 800,000 × 0.000012	= 9.6 kg CO_2-e
Total CO_2-e emissions	= 800,000 × 0.0087	= 6,960 kg CO_2-e

Note: Numbers may not add due to rounding.

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

5.3.2 Emission factor derivation methodology

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 12: Calculating the ratio of each gas from electricity emissions

	kg CO_2-e	kg CO_2	CH_4 (kg CO_2-e)	N_2O (kg CO_2-e)
Electricity emission factor (per kWh)	0.0074			
Per cent breakdown by gas		96.04%	3.82%	0.14%
Calculation of component EF		= 0.9604 x 0.0074	= 0.038 x 0.0074	= 0.00149 x 0.0074
Breakdown by GHG		0.00711	0.00028	0.000010

Note: These numbers are rounded to three significant figures.

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

5.3.3 Assumptions, limitations and uncertainties

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

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

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

5.4 Imported heat and steam

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

5.5 Geothermal energy

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

6 Indirect business related emission factors

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

6.1 Emissions associated with employees working from home

This section provides a default emission factor, which incorporates typical emission sources associated with the activities of employees working from home. This emission factor can be used by employers to quantify the indirect (Scope 3) emissions associated with staff working from home. The emissions factor has been developed based on typical uses of the following emissions sources by staff members working from home:

- Computer/laptop plus monitors
- Heating and lighting, boiling a kettle
- Water, wastewater and waste

Alternatively 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.

Table 13: Working from home emission factor

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_2O/unit (kg CO_2-e)
Default	employee per day	0.908	0.679	0.207	0.022

6.1.1 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. Applying the equation in section 2, this means:

Q = number of employees working from home (days)
F = emission factor from table 6 above

WORKING FROM HOME EXAMPLE CALCULATION

An organisation has on average 15 employees working from home, 2 days per week, 46 weeks of the year, in the reporting period. Its indirect (Scope 3) emissions are:

15 employees x 2 days per week x 46 weeks per year = 1,380 days

CO_2 emissions = 1,380 × 0.679 = 937.0 kg CO_2
CH_4 emissions = 1,380 × 0.207 = 285.7 kg CO_2-e
N_2O emissions = 1,380 × 0.022 = 30.4 kg CO_2-e
Total CO_2-e emissions = 1,380 × 0.908 = 1,253 kg CO_2-e

Note: Numbers may not add due to rounding.

6.1.2 Emission factor derivation methodology

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

Electronic equipment electricity consumption was calculated based on guidance from the Energy Efficiency and Conservation Authority (EECA) and multiplied by the electricity emission factors in section 5.

Water and waste water was calculated from the per capita emission factors in section 9.

Waste to landfill was calculated from Auckland domestic kerbside per capita data published in the Auckland Council Waste Assessment 2017. The report stated per capita per year waste to landfill is 160 kg.

Table 14: Data used to calculate the default emission factor.

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_2O/unit (kg CO_2-e)	Assumptions
Monitor	Employee per day	0.020	0.019	0.001	0.000	8 hrs per day
Computer	employee per day	0.081	0.078	0.003	0.000	8 hrs per day
Laptop	employee per day	0.010	0.009	0.000	0.000	8 hrs per day
Kettle use	employee per day	0.012	0.011	0.0005	0.00002	2 boils of a kettle (2kW) filled 500ml
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	1 kW 8hrs per day half the year
Electric Heater	employee per day	0.815	0.779	0.035	0.001	2 kW 8hrs per day half the year
Waste to landfill	employee per day	0.163	-	0.163	-	21% of the year is a working year. general waste type (No-landfill gas recapture)
Waste water	employee per day	0.044	0.007	0.015	0.022	21% of the year is a working year
Water use	employee per day	0.004	0.003	0.000163	0.000003	

6.1.3 Assumptions, limitations and uncertainties

In the absence of accurate data for New Zealand a number of conservative assumptions have been made to establish one default working from home emission factor. It is assumed a working day is 8 hours and that all emission sources are used for the entire working day.

Heating, the biggest contributor to the emission factor, is assumed to be used half of the year. In addition it is assumed that fifty percent of staff use heaters while fifty percent use heat pumps. Likewise fifty percent of staff use desktops and fifty percent of staff use laptops. It is assumed all staff use a monitor, a 12W LED light, and boil two cups (500 mL) of water twice per day.

Based on working hours of 40 hours per week and 46 weeks of the year, waste water and water use are assumed to be 21 per cent of the per capita emission factor for waste water and water use. Furthermore, waste to landfill volume is assumed to be 21 per cent of Auckland domestic kerbside refuse per capita per year as general waste disposed in a landfill without gas recapture.

6.2 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 organization that operates with large third party IT infrastructure.

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

Therefore, organisations seeking to find out what the footprint is of the data centres where their “cloud” is stored should contact the providers of their data centre to request this information. 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.

7 Travel emission factors

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

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

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

7.1 Overview of changes since previous update

There has been one major change to travel emission factors since the previous version, which is the introduction of public transport passenger emissions factors for passenger travel on bus and rail. No data is currently available for ferries.

7.2 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 18. Table 19 lists default private car emission factors, and table 20 lists the rental car emission factors based on distance travelled. Table 21 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.[26] 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 15 details engine sizes and typical corresponding vehicles.

Table 15: Vehicle engine sizes and common car types

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

Table 16: 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_2O/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.

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

Table 17: 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_2O/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	0.009	0.009	0.0004	0.00001
	1350 - <1600 cc	km	0.010	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.011	0.011	0.0004	0.00002
	2000 - <3000 cc	km	0.012	0.012	0.0005	0.00002
	≥3000 cc	km	0.015	0.014	0.0006	0.00002
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	0.010	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

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_2O/unit (kg CO_2-e)
Electric vehicle	Very small	km	0.020	0.019	0.0008	0.00003
	Small	km	0.021	0.020	0.0008	0.00003
	Medium	km	0.023	0.022	0.0009	0.00003
	Large	km	0.026	0.025	0.0010	0.00004
	Very large	km	0.031	0.030	0.0012	0.00004
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 18: 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_2O/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	0.009	0.009	0.0003	0.00001
	1350 - <1600 cc	km	0.009	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_2O/unit (kg CO_2-e)
	2000 - <3000 cc	km	0.012	0.011	0.0004	0.00002
	≥3000 cc	km	0.014	0.014	0.0005	0.00002
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	0.0004	0.00001
	1350 - <1600 cc	km	0.010	0.009	0.0004	0.00001
	1600 - <2000 cc	km	0.010	0.010	0.0004	0.00001
	2000 - <3000 cc	km	0.012	0.011	0.0005	0.00002
	≥3000 cc	km	0.014	0.013	0.0005	0.00002
Electric vehicle	Very small	km	0.019	0.018	0.0007	0.00003
	Small	km	0.020	0.019	0.0008	0.00003
	Medium	km	0.022	0.021	0.0008	0.00003
	Large	km	0.025	0.024	0.0009	0.00003
	Very large	km	0.030	0.028	0.0011	0.00004
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 19: 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_2O/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 20: 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_2O/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 21: 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_2O (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.

7.2.1 GHG inventory development

Organisations should gather the activity data on passenger vehicle use with as much detail as possible, including age of the vehicle, engine size, fuel type and kilometres travelled. If information is not available, we provide conservative defaults to allow for 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 (table 21).

Applying the equation in section 2, this means:

- Q = distance travelled by vehicle type (km)
- F = emission factors for correlating vehicle type from table 16 to table 21

PASSENGER VEHICLES: EXAMPLE CALCULATION

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

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

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

CO_2 emissions	= 37,800 × 0.173	= 6539 kg CO_2
CH_4 emissions	= 37,800 × 0.002	= 76 kg CO_2-e
N_2O emissions	= 37,800 × 0.006	= 227 kg CO_2-e
Total CO_2-e emissions	= 37,800 × 0.181	= 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.

7.2.2 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 – see table 22.

- 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.[27]

Table 22 details the average fuel consumption rates for the vehicles.

[27] Motor Vehicle Register: https://opendata-nzta.opendata.arcgis.com/datasets/ce0ec40427b24e90b26bd5e0852cb76b_0

Table 22: 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
	≥3000 cc	kWh	15.618	14.354	13.763

Emission source		Units	Units of energy consumed per 100 km Pre-2010	2010–2015	Post-2015
Electric vehicle	<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
	≥3000 cc	kWh	33.017	30.346	29.097
Motorcycle	<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 EI report categorises the vehicles included for private, rental and taxi vehicles as light passenger vehicles.

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

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

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

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

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.[28] 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 23 shows this.

[28] New Zealand Transport Agency: https://nzta.govt.nz/resources/new-zealand-motor-vehicle-register-statistics/new-zealand-vehicle-fleet-open-data-sets/#data accessed 9/10/2020

Table 23: 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_2O/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:

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

Table 24: 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)[29] the average age of light passenger vehicles in 2018 was 14.4 years. This correlates to a 2004 year of manufacture. Also, according to MoT[30] 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 25: 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

29 Ministry of Transport: www.transport.govt.nz/mot-resources/transport-dashboard/2-road-transport/rd025-average-vehicle-fleet-age-years/

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

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.

7.2.3 Assumptions, limitations and uncertainties

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

The default emission factors (for vehicles of unknown engine size) are the same as those of a <3000 cc vehicle. Using the Motor Vehicle Register[31] 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 2018 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.

7.3 Public transport passenger

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

[31] New Zealand Transport Agency: https://nzta.govt.nz/resources/new-zealand-motor-vehicle-register-statistics/new-zealand-vehicle-fleet-open-data-sets/#data accessed 9/10/2020

Table 26: Emission factors for public transport

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit (kg CO2-e)	kg CH_4/unit (kg CO2-e)	kg N_2O/unit (kg CO2-e)
Bus	National Average for Bus	pkm	0.136	0.134	0.000	0.002
	Wellington Electric Bus	pkm	0.013	0.012	0.0005	0.00002
	Wellington Diesel Bus	pkm	0.111	0.109	0.0001	0.002
	Wellington Average Bus	pkm	0.108	0.107	0.0002	0.002
Rail	Electric (based on Wellington)	pkm	0.009	0.009	0.0004	0.00001
	Diesel (based on Wellington)	pkm	0.038	0.037	0.00005	0.001
	Average (based on Wellington)	pkm	0.014	0.014	0.0003	0.0001

7.3.1 GHG inventory development

To calculate public transport passenger emissions, collect data on the type of transport and distance travelled, and multiply this by the emission factors for each gas. Organisations could conduct a staff travel survey to quantify these emissions.[32]

Applying the equation in section 2, this means:

Q = distance travelled, by vehicle type (km)
F = emission factors for correlating vehicle type, from table 26

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 x 5 times = 94 pkm

CO_2 emissions = 94 x 0.012 = 1.128 kg CO_2
CH_4 emissions = 94 x 0.0005 = 0.047 kg CO_2-e
N_2O emissions = 94 x 0.00002 = 0.002 kg CO_2-e

Total CO_2-e emissions from passenger public travel = 0.013 x 94 = 1.2 kg CO_2-e

Note: Numbers may not add due to rounding.

7.3.2 Emission factor derivation methodology

National average bus

To calculate the emission factor for national average bus travel we used the NZTA passenger travel data[33] (table 27) to estimate the national average loading capacity of 8 people per bus.

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

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

Table 27: National bus pkm in 2018/19

Region	Mode	Breakdown	2017/18
NZ	Bus	pkm	870,108,991
NZ	Bus	Service km	107,550,467

The passenger loading per bus for the different regions for 2017/18 is shown in table 28.

Table 28: National bus passenger loading by region

Region	Unit	End Use
National	Passenger/bus	8
Auckland	Passenger/bus	9
Bay of Plenty	Passenger/bus	4
Canterbury	Passenger/bus	7
Gisborne	Passenger/bus	8
Hawkes Bay	Passenger/bus	7
Manawatu-Whanganui	Passenger/bus	8
Marlborough-Nelson-Tasman	Passenger/bus	6
Northland	Passenger/bus	10
Otago	Passenger/bus	4
Southland	Passenger/bus	1
Taranaki	Passenger/bus	9
Waikato	Passenger/bus	6
Wellington	Passenger/bus	11

We then divided the per km emission factor for diesel buses in table 29 by the national passenger/bus loading rate to give the emissions per gas.

Table 29: 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_2O/unit (kg CO_2-e)
Diesel bus	≥ 12000 kg	km	1.088	1.070	0.001	0.017

Wellington buses

To calculate the emissions from Wellington buses we used the most recent data available which was from the year 2019. This information was from Greater Wellington Regional Council. Data for electric buses is in table 30 and data for diesel buses is in table 31.

Table 30: GWRC data for electric buses

Wellington Electric Buses	Distance (km)	Electric bus avg power (kWh/km)	Electricity consumption	pkm
2019	395,000	1.3	**513,500**	4,162,900

Table 31: GWRC data for diesel buses

Wellington Diesel Buses	Fuel consumption (litres)	pkm
2019	5,923,000	143,526,200

The energy consumption was multiplied by its respective emission factors and divided by the pkm to provide the emission factor.

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

Wellington trains data

The information in table 32 for energy was provided by Kiwi Rail, this data comes from 2018 and the passenger data is from Transdev.

Table 32: Wellington train data

Metro Commuter Rail	Units	2018	pkm
Electric (Wellington)	kWh	24,783,206	269,506,640
Diesel (Wellington)	litres	811,253	57,925,242

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

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

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

7.3.3 Assumptions, limitations and uncertainties

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

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

7.4 Public transport vehicles

Public transport vehicle emissions include those from buses. 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 33Table 33 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 34 details the data provided to calculate the emission conversion factors.

Table 33: 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_2O/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 in section 2, this means:

Q = distance travelled, by vehicle type (km)
F = emission factors for correlating vehicle type, from table 33

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_2O 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 15 years (according to the Motor Vehicle Register). Therefore, we applied an average fuel consumption factor for a pre-2010 fleet to the bus fleet from the 2019 Vehicle Fleet Emissions Model.

Table 34: 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

Emission source		Unit	Pre-2010 units of energy per 100 km
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 34 and appropriate emission factor, the equation is:

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

Where:

- fuel/energy consumption = units of energy per 100 km travelled
- emission factor = the emission factor from table 4 or table 9.
- 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.

7.5 Air travel

This section does not include emission factors for helicopters. Organisations seeking to determine the emissions from helicopter use should contact the helicopter operator requesting the fuel consumption data for the services provided. The emissions can then be calculated using the guidance in section 3.3 and reported as indirect (Scope 3) emissions.

7.5.1 Domestic air travel

This section provides emission factors based on New Zealand data from 2016, which has not been updated for this publication. 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. 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 35 provides the emission factors without the radiative forcing multiplier applied. Table 36 provides emission factors with a radiative forcing multiplier of 1.9 applied.[34, 35]

Table 35: Domestic air travel emission factors 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_2O/unit (kg CO_2-e)
National average	pkm	0.130	0.125	0.0009	0.003
Jet aircraft	pkm	0.072	0.069	0.0005	0.002
Medium aircraft	pkm	0.114	0.110	0.0008	0.003
Small aircraft	pkm	0.353	0.341	0.0024	0.009

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

Table 36: Domestic aviation emission factors 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_2O/unit (kg CO_2-e)
National average	pkm	0.242	0.238	0.0009	0.003
Jet aircraft	pkm	0.134	0.132	0.0005	0.002
Medium aircraft	pkm	0.213	0.210	0.0008	0.003
Small aircraft	pkm	0.659	0.647	0.0024	0.009

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

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

7.5.2 GHG inventory development

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

Applying the equation in section 2, this means:

Q = passengers multiplied by distance flown (pkm)
F = emission factors from table 35 or table 36.

34 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

35 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/

DOMESTIC AIR TRAVEL: EXAMPLE CALCULATION

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

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

Note: Numbers may not add due to rounding.

7.5.3 Emission factor derivation methodology

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

Table 37 details the types of aircraft running domestic flights in 2016, and the data[36] used to calculate the emission factor. We assumed the average user is unaware of the type of aircraft they are flying on, and therefore an average factor would be the most applicable. Organisations that own aircraft could calculate emissions based on the fuel consumption data.

Table 37: Domestic aviation data

Aircraft type	Total seats per flight	Average distance per flight (km)	Total fuel used (kg)	Total flights
Airbus A320	173	666.15	158,788,876.47	49,699
Aerospatiale/Alenia ATR 72	68	399.11	39,631,695.18	51,267
British Aerospace Jetstream 32	19	167.78	94,556.00	324
Beechcraft Beech 1900D	19	250.73	2,152,521.40	6,277
Cessna Light Aircraft	6	95.87	1,199,632.30	9,791
De Havilland Canada DHC-8-300 Dash 8/8Q	50	313.25	61,505,087.49	71,122
Pilatus PC-12	9	300.72	847,901.49	4,315
Saab SF-340	34	479.70	407,373.70	668
FOKKER F50	53	631.55	12,890.19	11

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

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

Then calculate fuel per passenger:

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

[36] Data from The Transport Outlook Aircraft Movement and Greenhouse Gas (GHG) Emission Model www.transport.govt.nz/assets/Uploads/Research/Transport-Outlook/Documents/Aircraft-Movement-and-GHG-Emission-Model-Documentation-20171127.pdf

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

Using this, next calculate fuel per passenger per km:

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

The density of kerosene (the assumed aviation fuel) is 0.79 kg/l.[37]

See table 38 for the calculated figures.

Table 38: Calculating domestic air travel emissions

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

Emission factors for each aircraft were determined by multiplying the fuel (litres) per passenger per kilometre by the kerosene (aviation fuel) emission factor in table 4. A national average was then calculated using the share of total flights to weight the contributions of each aircraft, see table 39.

Table 39: Calculated emissions, without the radiative forcing multiplier, per aircraft type and the average used for the emission factors

Aircraft type	Share of total flights	Unit	kg CO_2-e/unit	kg CO_2/unit (kg CO_2-e)	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)
Airbus A320	25.69%	pkm	0.072	0.069	0.001	0.002
Aerospatiale/Alenia ATR 72	26.50%	pkm	0.074	0.072	0.001	0.002
British Aerospace Jetstream 32	0.17%	pkm	0.237	0.229	0.002	0.006
Beechcraft Beech 1900D	3.24%	pkm	0.186	0.180	0.002	0.005

[37] Z Energy: https://z.co.nz/assets/SDS/Kerosene_2.pdf

Aircraft type	Share of total flights	Unit	kg CO_2-e/unit	kg CO_2/unit (kg CO_2-e)	kg CH_4/unit (kg CO_2-e)	kg N_2O/unit (kg CO_2-e)
Cessna Light Aircraft	5.06%	pkm	0.552	0.534	0.004	0.014
De Havilland Canada DHC-8-300 Dash 8/8Q	36.76%	pkm	0.143	0.138	0.001	0.004
Pilatus PC-12	2.23%	pkm	0.188	0.182	0.002	0.005
Saab SF-340	0.35%	pkm	0.097	0.094	0.001	0.002
FOKKER F50	0.01%	pkm	0.091	0.088	0.001	0.002
Weighted average		pkm	0.130	0.125	0.001	0.003

Note: These numbers are rounded to three decimal places.

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

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

7.5.4 Assumptions, limitations and uncertainties

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

7.5.5 International air travel

Organisations wishing to report their international air travel emissions based on distance travelled per passenger should use the International Civil Aviation Organisation (ICAO) calculator.[38] 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 you prefer not to use the ICAO calculator, we recommend the emission factors provided in table 40 and table 41. These emission factors follow those published online by UK BEIS emission factors and include a distance uplift of 8 per cent.

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

Table 40: Emission factors for international air travel with radiative forcing

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_2O/unit (kg CO_2-e)
Short haul (<3700 km)	Average passenger	pkm	0.156	0.155	0.00001	0.001
	Economy	pkm	0.153	0.152	0.00001	0.001
	Business	pkm	0.229	0.228	0.00001	0.001
Long haul (>3700 km)	Average passenger	pkm	0.191	0.190	0.00001	0.001
	Economy	pkm	0.146	0.145	0.00001	0.001
	Premium economy	pkm	0.234	0.233	0.00001	0.001
	Business	pkm	0.424	0.422	0.00002	0.002
	First	pkm	0.585	0.582	0.00002	0.003

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

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

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_2O/unit (kg CO_2-e)
Short haul (<3700 km)	Average passenger	pkm	0.082	0.081	0.00001	0.001
	Economy	pkm	0.081	0.080	0.00001	0.001
	Business	pkm	0.121	0.120	0.00001	0.001
Long haul (>3700 km)	Average passenger	pkm	0.101	0.100	0.00001	0.001
	Economy	pkm	0.077	0.077	0.00001	0.001
	Premium economy	pkm	0.124	0.122	0.00001	0.001
	Business	pkm	0.224	0.222	0.00002	0.002
	First	pkm	0.309	0.306	0.00002	0.003

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

7.5.6 GHG inventory development

To calculate emissions for international air travel, use the ICAO calculator. Multiply the output by 1.09 to account for the distance uplift factor (see section 7.5.8).

Alternatively, gather the information on how far each passenger flew for each flight. Multiply this by the factors in table 40. Use the specified emission factors for different cabin classes if information is available. If unknown, use the average emission factors. Applying the equation in section 2, this means:

Q = passengers multiplied by distance flown (pkm)
F = appropriate emission factors from table 40 or table 41

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 × 0.146	= 5,458 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 × 0.191	= 10,711 kg CO_2-e

Total CO_2-e emissions from international air travel	= 5,458 + 10,711	= 16,169 kg CO_2-e
Total CO_2-e with distance uplift	= 16,169 × 1.09	= 17,624 kg CO_2-e

Note: Numbers may not add due to rounding.

7.5.7 Emission factor derivation methodology

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

7.5.8 Assumptions, limitations and uncertainties

The emission factors in table 40 and table 41 are based on UK and European data. The short-haul emission factor applies to international flights of less than 3,700 km. The long-haul factor applies to flights of more than 3,700 km.

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

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

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

7.6 Accommodation

Accommodation is an indirect (Scope 3) emissions source. We obtained the emission factors for accommodation, see table 42, directly from the Cornell Hotel Sustainability Benchmarking Index (CHSB) Tool.[39] The International Tourism Partnership (ITP) and Greenview produce the CHSB tool. The factors are in CO_2-e and are not available by gas type.

Table 42: Accommodation emission factors

Country	Unit	$kgCO_2$-e/unit
Argentina	Room per night	50.0
Australia	Room per night	43.0
Austria	Room per night	13.4
Belgium	Room per night	15.2
Brazil	Room per night	13.0
Canada	Room per night	17.4
Caribbean Region	Room per night	61.1
Chile	Room per night	37.6
China	Room per night	62.3
China (Hong Kong)	Room per night	70.6
Colombia	Room per night	16.7
Costa Rica	Room per night	11.5
Czech Republic	Room per night	35.2
Egypt	Room per night	60.6
Finland	Room per night	11.8
France	Room per night	7.3
French Polynesia	Room per night	73.0
Germany	Room per night	18.6
India	Room per night	75.6
Indonesia	Room per night	72.5
Ireland	Room per night	27.1
Italy	Room per night	22.9
Japan	Room per night	56.0
Jordan	Room per night	74.9
Malaysia	Room per night	69.3
Maldives	Room per night	161.6
Mexico	Room per night	25.3
Netherlands	Room per night	22.7
New Zealand	Room per night	12.8
Oman	Room per night	92.6
Panama	Room per night	27.2
Philippines	Room per night	65.7
Poland	Room per night	40.9

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

Country	Unit	$kgCO_2$-e/unit
Portugal	Room per night	30.1
Qatar	Room per night	117.9
Romania	Room per night	30.5
Russian Federation	Room per night	34.6
Saudi Arabia	Room per night	125.9
Singapore	Room per night	38.2
South Africa	Room per night	64.5
South Korea	Room per night	64.0
Spain	Room per night	20.6
Switzerland	Room per night	6.6
Taiwan	Room per night	86.8
Thailand	Room per night	55.6
Turkey	Room per night	37.3
United Arab Emirates	Room per night	98.7
United Kingdom	Room per night	15.7
United States	Room per night	21.7
Vietnam	Room per night	58.7

7.6.1 GHG inventory development

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

Q = rooms per night
F = emission factors for the country stayed in from table 42

EXAMPLE CALCULATION

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

6 people x 3 rooms x 4 nights = 72
Total CO_2-e emissions from the hotel stay = 72 x 43 kg CO_2-e/unit = 3,096 kg CO_2-e

7.6.2 Assumptions, limitations and uncertainties

The CHSB Guidance document[40] 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.

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

8 Freight transport emission factors

8.1 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). The emission factors include those for freighting goods for road, rail, domestic coastal shipping, international shipping and air freight. We provide freight vehicle emission factors (in km) for road light commercial and heavy goods vehicles.

8.2 Road freight

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

Included in road freight are light commercial vehicles (eg, vans) and heavy goods vehicles (eg, trucks). 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.

8.2.1 Light commercial vehicle emission factors

Table 43: 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_2O/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

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_2O/unit (kg CO_2-e)
	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 44: 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_2O/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
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) –	<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

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_2O/unit (kg CO_2-e)
electricity consumption	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 45: 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_2O/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

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_2O/unit (kg CO_2-e)
	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
	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 46: 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_2O/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.

8.2.2 Heavy goods vehicles emission factors

Table 47: 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_2O/unit (kg CO_2-e)
HGV diesel	<5,000 kg	km	0.421	0.414	0.001	0.007
	5,000 - <7,500 kg	km	0.480	0.472	0.001	0.008
	7,500 - <10,000 kg	km	0.661	0.649	0.001	0.010
	10,000 - <12,000 kg	km	0.753	0.740	0.001	0.012
	12,000 - <15,000 kg	km	0.895	0.879	0.001	0.014
	15,000 - <20,000 kg	km	1.014	0.997	0.001	0.016
	20,000 - <25,000 kg	km	1.292	1.270	0.002	0.020
	25,000 - <30,000 kg	km	1.413	1.389	0.002	0.022
	≥30,000 kg	km	1.534	1.508	0.002	0.024
HGV diesel hybrid	<5,000 kg	km	0.340	0.334	0.0004	0.005
	5,000 - <7,500 kg	km	0.387	0.380	0.0005	0.006
	7,500 - <10,000 kg	km	0.532	0.523	0.0007	0.008
	10,000 - <12,000 kg	km	0.607	0.596	0.0008	0.010
	12,000 - <15,000 kg	km	0.721	0.709	0.0009	0.011
	15,000 - <20,000 kg	km	0.922	0.906	0.0012	0.014
	20,000 - <25,000 kg	km	1.174	1.154	0.0015	0.018
	25,000 - <30,000 kg	km	1.328	1.306	0.0017	0.021
	≥30,000 kg	km	1.442	1.417	0.0019	0.023

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

Table 48: 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_2O/unit (kg CO_2-e)
HGV diesel	<5,000 kg	km	0.400	0.393	0.001	0.006
	5,000 - <7,500 kg	km	0.456	0.448	0.001	0.007
	7,500 - <10,000 kg	km	0.627	0.616	0.001	0.010
	10,000 - <12,000 kg	km	0.714	0.702	0.001	0.011
	12,000 - <15,000 kg	km	0.849	0.835	0.001	0.013
	15,000 - <20,000 kg	km	0.988	0.971	0.001	0.015
	20,000 - <25,000 kg	km	1.259	1.238	0.002	0.020
	25,000 - <30,000 kg	km	1.377	1.354	0.002	0.022
	≥30,000 kg	km	1.495	1.470	0.002	0.023
HGV diesel hybrid	<5,000 kg	km	0.322	0.316	0.0004	0.0050
	5,000 - <7,500 kg	km	0.367	0.361	0.0005	0.0057
	7,500 - <10,000 kg	km	0.505	0.496	0.0007	0.0079
	10,000 - <12,000 kg	km	0.575	0.565	0.0008	0.0090
	12,000 - <15,000 kg	km	0.683	0.672	0.0009	0.0107

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_2O/unit (kg CO_2-e)
	15,000 - <20,000 kg	km	0.898	0.883	0.0012	0.0141
	20,000 - <25,000 kg	km	1.144	1.125	0.0015	0.0179
	25,000 - <30,000 kg	km	1.295	1.273	0.0017	0.0203
	≥30,000 kg	km	1.405	1.382	0.0018	0.0220
HGV BEV (battery electric vehicle)	<5,000 kg	km	0.043	0.041	0.002	0.0001
	5,000 - <7,500 kg	km	0.048	0.047	0.002	0.0001
	7,500 - <10,000 kg	km	0.067	0.064	0.003	0.0001
	10,000 - <12,000 kg	km	0.076	0.073	0.003	0.0001
	12,000 - <15,000 kg	km	0.090	0.087	0.003	0.0001

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

Table 49: 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_2O/unit (kg CO_2-e)
HGV diesel	<5,000 kg	km	0.394	0.388	0.0005	0.0062
	5,000 - <7,500 kg	km	0.449	0.442	0.0006	0.0070
	7,500 - <10,000 kg	km	0.618	0.608	0.0008	0.0097
	10,000 - <12,000 kg	km	0.704	0.693	0.0009	0.0110
	12,000 - <15,000 kg	km	0.837	0.823	0.0011	0.0131
	15,000 - <20,000 kg	km	0.986	0.969	0.0013	0.0154
	20,000 - <25,000 kg	km	1.257	1.235	0.0017	0.0197
	25,000 - <30,000 kg	km	1.375	1.351	0.0018	0.0215
	≥30,000 kg	km	1.492	1.467	0.0020	0.0234
HGV diesel hybrid	<5,000 kg	km	0.315	0.309	0.0004	0.0049
	5,000 - <7,500 kg	km	0.359	0.353	0.0005	0.0056
	7,500 - <10,000 kg	km	0.493	0.485	0.0006	0.0077
	10,000 - <12,000 kg	km	0.562	0.553	0.0007	0.0088
	12,000 - <15,000 kg	km	0.668	0.657	0.0009	0.0105
	15,000 - <20,000 kg	km	0.896	0.881	0.0012	0.0140
	20,000 - <25,000 kg	km	1.142	1.123	0.0015	0.0179
	25,000 - <30,000 kg	km	1.292	1.270	0.0017	0.0202
	≥30,000 kg	km	1.403	1.379	0.0018	0.0220
HGV BEV	<5,000 kg	km	0.042	0.040	0.002	0.0001
	5,000 - <7,500 kg	km	0.047	0.046	0.002	0.0001
	7,500 - <10,000 kg	km	0.065	0.063	0.002	0.0001
	10,000 - <12,000 kg	km	0.074	0.071	0.003	0.0001
	12,000 - <15,000 kg	km	0.088	0.085	0.003	0.0001

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

Table 50 contains the default emission factors for heavy goods vehicles, based on a pre-2010 fleet and a gross vehicle mass of <7500 kg.

Table 50: 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_2O/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 51 contains emission factors for freighting goods.

Table 51: 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_2O/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.

8.2.3 GHG inventory development

If an organisation uses freight vehicles, they can calculate the emissions from the kilometres travelled. Multiply the distances by the emission factors in table 43 to table 50. Applying the equation in section 2, this means:

Q = km travelled by specific freight vehicle
F = appropriate emission factors from table 43 to table 50

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 51. Applying the equation in section 2, this means:

Q = tonne × kilometres travelled
F = appropriate emission factors from table 51

ROAD FREIGHT: EXAMPLE CALCULATION

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

For the 10 tonnes moved by truck:

CO_2 emissions	= 10 × 100 × 0.133	= 133 kg CO_2
CH_4 emissions	= 10 × 100 × 0.0002	= 0.2 kg CO_2-e
N_2O emissions	= 10 × 100 × 0.002	= 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 CO_2-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_2O 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.

8.2.4 Emission factor derivation methodology

The EI report[41] 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 52 and table 53.

Table 52: 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

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

Emission source		Units	Units of energy consumed per 100 km Pre-2010	2010–2015	Post-2015
Petrol PHEV – 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
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 53: 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	15.64	14.84	14.64
	5,000 - <7,500 kg	litres	17.82	16.91	16.68
	7,500 - <10,000 kg	litres	24.52	23.27	22.95
	10,000 - <12,000 kg	litres	27.94	26.51	26.15
	12,000 - <15,000 kg	litres	33.21	31.51	31.08
	15,000 - <20,000 kg	litres	37.64	36.68	36.61
	20,000 - <25,000 kg	litres	47.95	46.73	46.64
	25,000 - <30,000 kg	litres	52.46	51.13	51.03
	≥30,000 kg	litres	56.95	55.50	55.39

Emission source		Units	Units of energy consumed per 100 km Pre-2010	2010–2015	Post-2015
HGV diesel hybrid	<5,000 kg	litres	12.61	11.95	11.68
	5,000 - <7,500 kg	litres	14.36	13.62	13.31
	7,500 - <10,000 kg	litres	19.76	18.73	18.32
	10,000 - <12,000 kg	litres	22.52	21.34	20.87
	12,000 - <15,000 kg	litres	26.77	25.37	24.81
	15,000 - <20,000 kg	litres	34.21	33.34	33.28
	20,000 - <25,000 kg	litres	43.59	42.48	42.40
	25,000 - <30,000 kg	litres	49.31	48.06	47.96
	≥30,000 kg	litres	53.53	52.17	52.07
HGV BEV (battery electric vehicle)	<5,000 kg	kWh	44.21	41.91	41.09
	5,000 - <7,500 kg	kWh	50.38	47.76	46.82
	7,500 - <10,000 kg	kWh	69.31	65.71	64.41
	10,000 - <12,000 kg	kWh	78.97	74.87	73.40
	12,000 - <15,000 kg	kWh	93.87	89.00	87.24

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

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

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

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

The default emission factors for freighting vehicles include the following assumptions based on the MoT NZ Vehicle Fleet 2018:[42]

- Light commercial vehicles are on average 12 years old[43] and the most common engine size is 2000-3000 cc, therefore we used a pre-2010 fleet and a 2000-3000 cc engine size for the default values.
- Heavy trucks are on average 17 years old and the most common gross vehicle mass is <7500 km, therefore we selected a pre-2010 vehicle fleet with a gross vehicle mass of <7500 kg.

Emission factors for freighting goods (tkm) are from the MoT presentation 'Real-world fuel economy of heavy trucks'.[44]

42 Ministry of Transport: www.transport.govt.nz/assets/Uploads/Research/Documents/Fleet-reports/The-NZ-Vehicle-Fleet-2016-web.pdf

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

44 Ministry of Transport: www.transport.govt.nz/assets/Import/Uploads/Research/Documents/TKC2019/Wang-H_Real-world-fuel-economy-of-heavy-trucks_TKC2019-web.pdf

Table 54: 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 55 to calculate the ratio of carbon dioxide, methane and nitrous oxide.

Table 55: 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_2O (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 CO_2-e result by the calculated factor to provide emission factors broken down by gas type.

8.2.5 Assumptions, limitations and uncertainties

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

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

8.3 Rail freight

In New Zealand, KiwiRail owns the rail infrastructure and has provided the information to calculate the emission factor. The emission factor for freighting goods by rail is in table 56.

Table 56: 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_2O/unit (kg CO_2-e)
Rail freight	tkm	0.028	0.028	0.00005	0.0004

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

8.3.1 GHG inventory development

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

Applying the equation in section 2, this means:

Q = tonnes of freight × km travelled
F = emission factors in table 56

RAIL FREIGHT: EXAMPLE CALCULATION

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

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

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

CO_2 emissions	= 4,800 × 0.028	= 134.4 kg CO_2
CH_4 emissions	= 4,800 × 0.00005	= 0.24 kg CO_2-e
N_2O emissions	= 4,800 × 0.0004	= 1.92 kg CO_2-e
Total CO_2-e emissions	= 4,800 × 0.028	= 134.4 kg CO_2-e

Note: Numbers may not add due to rounding.

8.3.2 Emission factor derivation methodology

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

Table 57: Information provided by KiwiRail

Calculation component	Unit	Amount in 2016
Freight-only fuel	litres	43,390,603
Freight volumes (net)	NTKs (000s)	4,210,156
Electricity (net) North Island Main Trunk (NIMT)	kWh	10,269,015

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

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

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

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

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

To calculate emissions from transmission and distribution losses from the purchased electricity, multiply the kWh by the emission factors in table 16:

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

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

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

8.3.3 Assumptions, limitations and uncertainties

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

8.4 Air freight

In the absence of New Zealand data, we have adopted the air freight emission factors from the UK BEIS publication. We provide emission factors with and without radiative forcing. Please refer to section 7.5 for further guidance on radiative forcing to inform your choice of emission factor.

Table 58: 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_2O (kg CO_2-e)/unit
Domestic air freight	tkm	4.767	4.741	0.002	0.024
Short haul	tkm	2.209	2.198	0.000	0.011
Long haul	tkm	1.134	1.128	0.000	0.006

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

Table 59: 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_2O (kg CO_2-e)/unit
Domestic air freight	tkm	2.521	2.495	0.002	0.024
Short haul	tkm	1.168	1.157	0.000	0.011
Long haul	tkm	0.599	0.594	0.000	0.006

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

8.4.1 GHG inventory development

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

Applying the equation in section 2, this means:

Q = tonnes of freight × km travelled
F = appropriate emission factors in Table 58 or table 59

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 × 1.228	= 36,840 kg CO_2
CH_4 emissions	= 30,000 × 0.00004	= 1.2 kg CO_2-e
N_2O emissions	= 30,000 × 0.006	= 180 kg CO_2-e
Total CO_2-e emissions	= 30,000 × 1.134	= 34,020 kg CO_2-e

Note: Numbers may not add due to rounding.

8.4.2 Emission factor derivation methodology

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

8.4.3 Assumptions, limitations and uncertainties

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

We included the emission factors with radiative forcing to account for additional radiative forcing from emissions arising from aircraft transport at altitude (jet aircraft). The radiative forcing multiplier of 1.9 is based on current scientific evidence and research.[45, 46]

8.5 Coastal and international shipping freight

We calculated the domestic coastal shipping emission factor, table 60, based on the findings from the MoT presentation 'Real-world fuel economy of heavy trucks',[47] prepared for the 2019 Transport Knowledge Conference. We adopted the international shipping emission factors in table 61 from the UK BEIS emission factors.

Table 60: 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_2O/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.

45 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

46 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/

47 www.transport.govt.nz/assets/Import/Uploads/Research/Documents/TKC2019/Wang-H_Real-world-fuel-economy-of-heavy-trucks_TKC2019-web.pdf

Table 61: 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_2O/unit (kg CO_2-e)
Bulk carrier	200,000+ dwt	tkm	0.003	0.003	0.000001	0.00003
	100,000–199,999 dwt	tkm	0.003	0.003	0.000001	0.00004
	60,000–99,999 dwt	tkm	0.004	0.004	0.000001	0.00006
	35,000–59,999 dwt	tkm	0.006	0.006	0.000002	0.00008
	10,000–34,999 dwt	tkm	0.008	0.008	0.000002	0.00011
	0–9,999 dwt	tkm	0.030	0.029	0.000009	0.00040
	Average	tkm	0.006	0.006	0.000002	0.00008
General cargo	10,000+ dwt	tkm	0.012	0.012	0.000004	0.00016
	5,000–9,999 dwt	tkm	0.016	0.016	0.000005	0.00022
	0–4,999 dwt	tkm	0.014	0.014	0.000004	0.00019
	10,000+ dwt 100+ TEU	tkm	0.011	0.011	0.000003	0.00015
	5,000–9,999 dwt 100+ TEU	tkm	0.018	0.018	0.000005	0.00024
	0–4,999 dwt 100+ TEU	tkm	0.020	0.020	0.000006	0.00027
	Average	tkm	0.012	0.012	0.000004	0.00016
Container ship	8,000+ TEU	tkm	0.013	0.013	0.000004	0.00017
	5,000–7,999 TEU	tkm	0.017	0.017	0.000005	0.00023
	3,000–4,999 TEU	tkm	0.017	0.017	0.000005	0.00023
	2,000–2,999 TEU	tkm	0.020	0.020	0.000006	0.00027
	1,000–1,999 TEU	tkm	0.033	0.032	0.000010	0.00044
	0–999 TEU	tkm	0.037	0.036	0.000011	0.00050
	Average	tkm	0.020	0.020	0.000006	0.00027
Vehicle transport	4,000+ CEU	tkm	0.032	0.032	0.000010	0.00044
	0–3,999 CEU	tkm	0.058	0.058	0.000017	0.00079
	Average	tkm	0.039	0.038	0.000012	0.00052
RoRo (roll-on, roll-off) ferry	2,000+ LM	tkm	0.050	0.050	0.000015	0.00068
	0–1,999 LM	tkm	0.061	0.060	0.000018	0.00082
	Average	tkm	0.052	0.051	0.000015	0.00069
Refrigerated cargo	All dwt	tkm	0.013	0.013	0.000004	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.

8.5.1 GHG inventory development

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

Applying the equation in section 2, this means:

Q = tonnes of freight × km travelled
F = appropriate emission factors from table 60 or table 69

MULTIPLE FREIGHT MODES: EXAMPLE CALCULATION

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

Road freight emissions:

0.3 tonnes × 50 km = 15 tkm
15 tkm × 0.135 = 2.03 kg CO_2-e

Coastal shipping emissions:

0.3 tonnes × 500km = 150 tkm
150 tkm × 0.046 = 6.9 kg CO_2-e

Rail freight emissions:

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

Total freight emissions:

2.04 + 6.9 + 2.1 = 11.04kg CO_2-e

Note: Numbers may not add due to rounding.

8.5.2 Emission factor derivation methodology

We based the emission factors for coastal shipping on figures included in the MoT presentation 'Real world fuel economy of heavy trucks',[48] prepared for the 2019 Transport Knowledge Conference.

Table 62: Coastal shipping data

Mode	Typical gCO_2/tkm
Coastal shipping (oil products)	16
Coastal shipping (other bulk)	30
Coastal shipping (container freight)	46

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 55 contains the ratio.

For international shipping, we used the Freight Information Gathering System[49] 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)

48 Ministry of Transport: www.transport.govt.nz/assets/Import/Uploads/Research/Documents/TKC2019/Wang-H_Real-world-fuel-economy-of-heavy-trucks_TKC2019-web.pdf

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

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

We used MoT's Freight Information Gathering System (FIGS)[50] to find out the average sizes of ships visiting New Zealand. Ships are measured in deadweight tonnes (dwt), twenty-foot equivalent unit (TEU), car equivalent unit (CEU) or lanemetre (LM).

- Bulk carrier is 36,900 dwt and therefore in the 35,000–59,999 dwt category.
- General cargo is 15,800 dwt and therefore in the 10,000+ dwt category.
- Container ship is 2923 TEU and therefore in the 2000–2999 TEU category.
- Vehicle carrier (transport) is unknown and therefore the same as the UK average.
- RoRo ferry is unknown and therefore the same as the UK average.
- As there is only one emission factor for all refrigerated cargo an average was not necessary.

Emission factors for these have been adopted from the UK BEIS 2020 Guidance.[51] Please refer to that document for details on the methodology.

8.5.3 Assumptions, limitations and uncertainties

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

We carried over the assumptions for the international shipping emission factors from the UK BEIS 2020 emission factors.

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

[51] UK BEIS 2020 Guidance, accessed via: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

9 Water supply and wastewater treatment emission factors

Emissions result from energy use in water supply and wastewater treatment plants. Some treatment plants also generate emissions from the treatment of organic matter. We calculated the emission factors using data from Water NZ.

9.1 Overview of changes since previous update

In the 10th version of the guide the Septic tank emission factor incorrectly stated the per capita unit, when the data was expressed in cubic metres (m^3) of water supplied. This has now been corrected and the emissions factor is per capita. The wastewater section now also includes additional emission factors for specific types of wastewater treatment plants.

9.2 Water supply

Table 63 provides water supply emission factors. We calculated the factors using Water NZ data.

Table 63: Water supply emission factors

Emission source	Unit	kg CO_2-e/unit	kg CO_2/unit	CH_4 (kg CO_2-e)/unit	N_2O (kg CO_2-e)/unit
Water supply	m^3	0.031	0.030	0.0014	0.00003
	Per capita	3.951	3.770	0.178	0.0035

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

9.2.1 GHG inventory development

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

Applying the equation in section 2, this means:

Q = quantity of water used (m^3) or persons using water supply (per capita)
F = appropriate emission factors from table 63

WATER SUPPLY: EXAMPLE CALCULATION

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

CO_2 emissions	= 1,000 × 0.030	= 30 kg CO_2
CH_4 emissions	= 1,000 × 0.0014	= 1.4 kg CO_2-e
N_2O emissions	= 1,000 × 0.00003	= 0.03 kg CO_2-e
Total CO_2-e emissions	= 1,000 × 0.031	= 31 kg CO_2-e

Note: Numbers may not add due to rounding.

9.2.2 Emission factor derivation methodology

We adopted the Water NZ 2016/17 National Performance Review[52] methodology to calculate the water supply emission factors. The Water NZ review gathered data from participating water industry bodies, which represent approximately 86 per cent of New Zealand's population. Thirty participants in the survey provided reliable information on the energy use of their water systems, which was used to calculate national averages. In the 2016/17 period, the operation of water supply pumps used 579 TJ of energy to supply 501 million m^3 of water, and treatment plants used an estimated 1094 TJ of energy in the treatment of about 366 million m^3 of water. This equates to a median energy intensity of 1.2 MJ of energy per cubic metre of water supplied and 3.0 MJ of energy per cubic metre of water treated.

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

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

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

Where:

- energy use = the GJ of energy used by the water system that year
- water supply = m^3 of water supplied that year
- electricity emission factor = the relevant gas emission conversion factor (ie, CO_2, N_2O, CH_4)
- unit conversion factor = 277.778 (converting GJ to kWh).

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

If organisations don't know the volume of water used, they can estimate it based on a calculated per capita (per person) emission factor. To develop a per capita emission factor, we used an average of 130 m^3 of water per person per year, which is calculated from the following equations and information:

Equation 1:

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

Equation 2:

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

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

Where:

- m^3 of water supplied nationwide is 550,000,000[53]
- population served by WWTP is approximately 4.22 million.[54]

9.2.3 Assumptions, limitations and uncertainties

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

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

9.3 Wastewater treatment

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

We provide wastewater treatment emission factors in table 64 and table 65. Some industries produce wastewater that is particularly high in biological oxygen demand (BOD). For this reason, we developed industrial wastewater emission factors for the meat, poultry, pulp and paper, wine and dairy sectors. Manufacturing organisations in these sectors should use the specific industrial wastewater factors. All other organisations should use the domestic wastewater factors. Where the domestic waste water treatment type is unknown use the average for wastewater treatment plants in the table below.

Table 64: 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_2O/unit (kg CO_2-e)
Average for wastewater treatment plants	m^3 water supplied	0.457	0.077	0.154	0.2251
	per capita	48.056	8.155	16.203	23.698
Septic tanks	per capita	162.5	NA	162.5	NA
Anaerobic pond	m^3	0.079	NA	0.060	0.019
	per capita	8.301	NA	6.348	1.953
Imhoff tank	m^3	0.070	NA	0.051	0.019
	per capita	7.324	NA	5.371	1.953
Oxidation pond	m^3	0.037	NA	0.019	0.019
	per capita	3.906	NA	1.953	1.953
Facultative aerated pond	m^3	0.641	NA	0.623	0.019

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

[54] Ministry for the Environment's WWTP database

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_2O/unit (kg CO_2-e)
	per capita	67.48	NA	65.53	1.953
All other type*	m^3	0.019	NA	0.000	0.019
	per capita	1.953	NA	0.000	1.953

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

* All other types includes: Fully mixed aerated ponds; Activated sludge; Other aerobic plant; Maturation ponds; Milliscreening or no treatment; SBR; Trickling filters; BNR; Constructed wetlands; Aerated Lagoon; Aerobic (methane from sludge)

Table 65: 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_2O/unit (kg CO_2-e)
Meat (excluding poultry)	tonne of kills	47.528	NA	44.688	2.841
Poultry	tonne of kills	47.025	NA	42.969	4.057
Pulp and paper	tonne of product	10.530	NA	10.530	NA
Wine	tonne of crushed grapes	5.173	NA	5.173	NA
Dairy processing	m^3 of milk	0.115	NA	NA	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 m^3 of water sent to treatment. In the absence of this information, apply the per capita emission factor. Industrial organisations can calculate the emissions using appropriate activity data and the correlating emission factors.

Applying the equation in section 2, this means:

Q = quantity of water treated (m^3) or persons using water facilities (per capita)
F = appropriate emission factors from table 64 and table 65.

WASTEWATER: EXAMPLE CALCULATION

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

The office wastewater is domestic, therefore:

CO_2 emissions = 100 × 0.077 = 7.7 kg CO_2
CH_4 emissions = 100 × 0.154 = 15.4 kg CO_2-e
N_2O emissions = 100 × 0.225 = 22.5 kg CO_2-e
Total CO_2-e emissions = 100 × 0.457 = 45.7 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_2O emissions = n/a
Total CO_2-e emissions = 10 × 5.173 = 51.73 kg CO_2-e

The total wastewater emissions are:

= 45.7 + 51.73 = 97.43 kg CO_2-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.*[55] An updated methodology is available in the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*.[56] Using updated methodologies in the 2019 Refinement would be inconsistent with national inventory reporting at the time of publication of this guide. Use of the 2019 Refinement has not yet been addressed by the UNFCCC, and we have yet to explore any implications for New Zealand's GHG inventory.

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

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

Where:

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

Then calculate methane emissions per capita:

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

Where:

- MCF = 0.02414, the weighted-average methane correction factor (MCF) for wastewater treatment plants in 2016
- B_0 = 0.625, converts the BOD to maximum potential methane emissions
- TOW = the total organic product in wastewater from the equation above
- GWP = 25, converts methane into CO_2-e
- population served = the population served by all wastewater treatment plants.

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

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

To calculate methane emissions per water volume, divide methane emissions per capita by the average water volume (m^3) treated per capita (109 m^3).

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

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

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

Where:

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

Table 66: 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,[57] 99g/day
Fraction of N in protein	0.16		IPCC default
Fraction of non-consumption protein	1.4		IPCC default
Fraction of industrial and commercial co-discharged protein	1.25		IPCC default
N removed with sludge	0	Default is zero	IPCC default

Then:

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

Where:

- per capita nitrogen in effluent = from equation above
- effluent = emission factor of 0.005 kg N_2O-N/kg N (IPCC default)
- 44/28 ratio of N_2O to N_2
- GWP = 298 for N_2O (IPCC default AR4).

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

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

Industrial wastewater treatment

As with domestic wastewater, we derived the emission factors for industrial wastewater treatment from the total energy-use emissions in the wastewater treatment plants and the gases emitted during the treatment process.

For the purpose of this guide, it is assumed there are no direct carbon dioxide emissions from the treatment of wastewater, as all carbon dioxide emissions are biogenic. Therefore we have calculated only methane and nitrous oxide emissions.

The equation followed to calculate methane emissions is:

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

Where:

- mbCOD = the unit biodegradable chemical oxygen demand load in kg per tonne of material processed (specified by industry type in table 55: 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 (table 67 and table 68) detail the information used in the calculations to provide the industrial wastewater treatment emission factors.

Table 67: Industrial wastewater treatment methane emissions calculation information

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

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

The equation used to calculate nitrous oxide emissions is:

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

Where:

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

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

Table 68: Industrial wastewater treatment nitrous oxide emissions calculation information

Factor	Industry			Source
	Dairy product processing	Meat (excluding poultry)	Poultry	
Biodegradable chemical oxygen demand load (kg CODb/tonne)	2	50	50	Cardno (2015)
Total N:biodegradable COD ratio	0.044	0.09	0.09	Cardno (2015)
Nitrous oxide emission factor (kg N_2O/kg CODb)	0.00279	0.001348	0.001925	Cardno (2015)
GWP	298	298	298	IPCC default AR4

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

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 69 details the uncertainties with this source category.

Table 69: Uncertainties with wastewater treatment emission source category

	Uncertainty in activity data	Uncertainty in emission factors
Domestic and industrial CH_4	±10%	±40%
Domestic and industrial N_2O	±10%	±90%

10 Materials and waste emission factors

10.1 Overview of changes since previous update

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

- we added emission factors for non-municipal solid waste (class 2-5) landfills.
- we added anaerobic digestion and created the biological treatment of waste category which includes compost.
- we recommend 3rd party data for construction material emission factors not included in this guide.

10.2 Construction materials

We worked with Building Research Association of New Zealand (BRANZ),[58] who provided the emission conversion factors for the emission sources, to create this section of the guide. These emissions are indirect (Scope 3) if the organisation does not own or control the facilities making the materials.

This guide publishes emission conversion factors for three core construction materials: concrete, steel and aluminium. For users seeking information on a wider range of materials, especially any users from the construction industry, we recommend you use BRANZ CO_2NSTRUCT[59] which 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 and lifts.

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

Table 70: Construction materials emission factors

Emission source		Unit	kg CO_2-e/unit
Concrete	Default	kg	0.124
	17.5 megapascals (MPa)	kg	0.094
	20 MPa	kg	0.099
	25 MPa	kg	0.110
	30 MPa	kg	0.115
	35 MPa	kg	0.124
	40 MPa	kg	0.136

58 BRANZ Ltd, www.branz.co.nz

59 BRANZ CO_2NSTRUCT, https://www.branz.co.nz/environment-zero-carbon-research/framework/branz-co2nstruct/

Emission source		Unit	kg CO_2-e/unit
	45 MPa	kg	0.149
	50 MPa	kg	0.161
Average steel	Steel – structural, columns and beams	kg	2.85
Average aluminium	Default	kg	11.8

Note: These numbers are rounded to three significant figures.

10.2.1 GHG inventory development

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

Applying the equation in section 2, this means:

Q = quantity of materials used (kg)
F = appropriate emission factors from table 70

CONSTRUCTION MATERIALS: EXAMPLE CALCULATION

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

Total CO_2-e emissions = 300 kg of concrete × 0.124 = 37.2 kg CO_2-e

Note: Numbers may not add due to rounding.

10.2.2 Emission factor derivation methodology

Concrete

BRANZ calculated the emission factors for concrete from data published in the Firth EPD (2020)[60] for North Island on in-situ concrete made with Golden Bay Cement and Holcim cement for the North Island table 71 and South Island table 72. Density data for individual compressive strengths is from the Allied Concrete EPD (2020)[61] shown in table 73.

Concrete is categorised by its compressive strength, denoted by megapascals (MPa), which is one of its most important engineering properties. If you do not know which type of concrete was used, apply the default concrete value. The calculated default concrete value is based on an average of all categories of concrete strength and assumed proportions from the North and South Islands.

Table 71: North Island emission factors for concrete compressive strengths

	Compressive strength (MPa)							
North Island	17.5	20	25	30	35	40	45	50
kg CO_2-e/m³ (GBC)	208	223	248	263	283	307	345	365
kg CO_2-e/m³ (Holcim*)	237	253	283	303	332	367	396	425
kg CO_2-e/m³ (NI total)	223	238	265	283	308	337	370	395

*Estimated

60 www.firth.co.nz/assets/Uploads/TechnicalDocuments/Firth-EPD-Ready-mixed-concrete-Sep-20-WEB.pdf

61 https://gryphon4.environdec.com/system/data/files/6/16759/S-P-00555%20EPD%20Ready%20mixed%20concrete%20using%20Holcim%20supplied%20cement%202019.pdf

Table 72: South Island emission factors for concrete compressive strengths

South Island	Compressive strength (MPa) 17.5	20	25	30	35	40	45	50
kg CO_2-e/m^3 (GBC)	199	209	230	250	264	286	319	354
kg CO_2-e/m^3 (Holcim)	227	237	262	288	310	342	366	412
kg CO_2-e/m^3 (SI total)	213	223	246	269	287	314	343	383

Table 73: Concrete density for individual compressive strengths

Density	Compressive strength (MPa) 17.5	20	25	30	35	40	45	50
kg/m^3	2340	2350	2360	2410	2420	2420	2430	2430

Table 74: Calculated concrete emissions factors for the North and South Islands

	Compressive strength (MPa) 17.5	20	25	30	35	40	45	50
kg CO_2-e/kg (NI)	0.0951	0.1013	0.1124	0.1174	0.1271	0.1393	0.1524	0.1625
kg CO_2-e/kg (SI)	0.0910	0.0949	0.1042	0.1116	0.1186	0.1298	0.1409	0.1576
kg CO_2-e/kg (NZ)	0.0931	0.0981	0.1083	0.1145	0.1229	0.1346	0.1467	0.1601

Steel

All data are from structural steel because no New Zealand-specific data on different types of steel were available.

Table 75: Steel emission factors

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

Source: BlueScope Steel (2015)

Aluminium

BRANZ provided the data in table 76 for the aluminium emission factor. We decided to use an average for the New Zealand emission factor, based on these data from international sources.

Table 76: Aluminium data used for the emission source

Emission source	Unit	kg CO_2-e / unit
Aluminium (powder-coated finish, one side 0.08 mm), extruded glazing frame, 2.0mm BMT	kg	11.4
Aluminium (anodised finish, one side 0.02 mm), extruded glazing frame, 2.0mm BMT	kg	11.5
Aluminium (anodised, one side 0.02 mm), profile sheet metal, generic all profiles, 0.7mm BMT	kg	12.3
Aluminium (anodised, one side 0.02 mm), profile sheet metal, generic all profiles, 0.9mm BMT	kg	12.0
Aluminium (anodised finish, one side 0.02 mm), flat sheet, 0.7mm BMT	kg	12.3
Aluminium (anodised finish, one side 0.02 mm), flat sheet, 0.9mm BMT	kg	12.0
Aluminium (powder-coated finish, one side 0.08 mm), flat sheet, 0.7mm BMT	kg	12.3

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

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

10.2.3 Assumptions, limitations and uncertainties

The concrete emission factors are based on the assumption that all in-situ concrete producers in the North and South Islands have similar processes and therefore GHG impacts. The key variables are therefore the source of cement and location of manufacture (North or South Island). No data was available for Holcim cement in the North Island so it was estimated from South Island data. It is not known the what proportion of in-situ concrete is made with Golden Bay Cement or Holcim cement in either the North and South Islands so it is assumed to be fifty percent for all compressive strengths. The Firth EPD does not provide densities for individual compressive strengths, so it is assumed that Firth densities are the same as Allied Concretes. The proportion of in-situ concrete produced in the North Island and South Island by compressive strength is unknown so a ratio of two thirds North Island to one third South Island is assumed.

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

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

The uncertainties with these emission factors are unknown.

10.3 Waste disposal

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

The guide does not cover methodologies to determine emissions from solid waste incineration, as we assume emissions are negligible at the individual organisation level. This version now includes emission factors for non-municipal solid waste.

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

This update includes an emission factor for anaerobic digestion and this is grouped with composting as a form of biological treatment of waste.

The type of landfill influences the GHG conversion factor, based on whether there is a methane gas collection system.

Table 77: Description of landfill types

Landfill type	Description
Municipal (class 1) landfills With gas recovery	Municipal, well-managed Landfill where some of the CH_4 produced during the organic decomposition of waste is captured.
Municipal (class 1) landfills Without gas recovery	Municipal, well-managed Landfill where the CH_4 produced during organic decomposition of waste escapes into the atmosphere.
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 recycling materials, they could do so by independently accounting for the distance travelled by the waste to the recycling plant, using freight emission factors (see section 8).

We calculated the waste-to-landfill emission conversion factors based on the national inventory. table 78, table 79 and table 81 show the factors.

Table 78: Waste disposal to municipal (class 1) landfills with 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_2O/unit (kg CO_2-e)
Waste (known composition)	Food	kg	0.299	n/a	0.299	n/a
	Garden	kg	0.398	n/a	0.398	n/a
	Paper	kg	0.797	n/a	0.797	n/a
	Wood	kg	0.856	n/a	0.856	n/a
	Textile	kg	0.478	n/a	0.478	n/a
	Nappies	kg	0.478	n/a	0.478	n/a
	Other (inert)	kg	n/a	n/a	n/a	n/a
Waste (unknown composition)	General waste	kg	0.311	n/a	0.311	n/a
	Office waste	kg	0.489	n/a	0.489	n/a

Note: These numbers are rounded to three significant figures.

Table 79: 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_2O/unit (kg CO_2-e)
Waste (known composition)	Food	kg	1.125	n/a	1.125	n/a
	Garden	kg	1.500	n/a	1.500	n/a
	Paper	kg	3.000	n/a	3.000	n/a
	Wood	kg	3.225	n/a	3.225	n/a
	Textile	kg	1.800	n/a	1.800	n/a
	Nappies	kg	1.800	n/a	1.800	n/a
	Other (inert)	kg	n/a	n/a	n/a	n/a
Waste (unknown composition)	General waste	kg	1.170	n/a	1.170	n/a
	Office waste	kg	1.842	n/a	1.842	n/a

Note: These numbers are rounded to three significant figures.

Table 80: 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_2O/unit (kg CO_2-e)
Waste (known composition)	Biological	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	1.505	n/a	1.505	n/a
	Inert	kg	n/a	n/a	n/a	n/a
Average for non-municipal solid waste		kg	0.303	n/a	0.303	n/a

Table 81: 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_2O/unit (kg CO_2-e)
Composting	kg	0.172	n/a	0.10	0.072
Anaerobic digestion	kg	0.02	n/a	0.02	n/a

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

10.3.1 GHG inventory development

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

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

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

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

Applying the equation in section 2, this means:

Q = quantity of waste disposed (kg)
F = appropriate emission factors from table 78, table 79 or table 81

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 × 0.299	= 44.8 kg CO_2-e
General waste	= 50 × 0.311	= 15.6 kg CO_2-e
Garden waste	= 60 × 0.398	= 23.9 kg CO_2-e
Total waste emissions	= 44.8 + 15.6 + 23.9	= 84.3 kg CO_2-e

Note: Numbers may not add due to rounding

10.3.2 Emission factor derivation methodologies

We broke down data derived from the national inventory into seven categories. Table 82 identifies these alongside their proportion of the waste to municipal landfills in 2018.

Table 82: Composition of waste sent to NZ landfills in 2018

Waste category	Description	Estimated composition of waste to municipal landfills 2018	Estimated composition of waste to non-municipal landfills 1990–2018
Food	Food waste	16.8%	0.01%
Garden	Organic material	8.3%	11.0%
Paper	Paper and cardboard waste	10.7%	n/a
Wood	Wood waste	11.9%	10.9%
Textile	Fabrics and other textiles	5.6%	n/a
Nappies	Nappies and similar sanitary waste	3.0%	n/a
Inert	Waste that does not produce GHG emissions	43.8%	55.7%
Biological	Sludges from sewer/septic tanks and offal and meat based waste	n/a	3.9%
C & D	Construction and demolition waste	n/a	12.6%
Industrial	Where specific type of industrial is unknown	n/a	4.2%
Bulk waste	General domestic and farm waste	n/a	1.6%

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

We provide no methodology for nitrous oxide emissions from waste disposal because the IPCC[62] has found them to be insignificant.

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

10.3.3 When composition of waste is known

If the composition of waste is known, use the specific emission factors for each waste stream based on kilograms of waste produced.

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.

$$emission\ factor = DOC \times DOCf \times F \times MCF \times conversion \times (1 - oxidation) \times (1 - recovery) \times GWP$$

Where:

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

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

Table 83: Information on managed solid waste in 2018

Category	DOC	DOCF	F	MCF	Conversion	Ox	R
Food	0.15	0.5	0.5	1	16/12	0.1	0.7344
Garden	0.2	0.5	0.5	1	16/12	0.1	0.7344
Paper	0.4	0.5	0.5	1	16/12	0.1	0.7344
Wood	0.43	0.5	0.5	1	16/12	0.1	0.7344
Textiles	0.24	0.5	0.5	1	16/12	0.1	0.7344
Nappies	0.24	0.5	0.5	1	16/12	0.1	0.7344
Inert	0	0.5	0.5	1	16/12	0.1	0.7344
Source of information	IPCC defaults	IPCC default for managed landfills	IPCC default for managed landfills	IPCC default for managed landfills		IPCC default for managed landfills	MfE

Note: R only applies for landfills with gas recovery.

Table 84: Information on non-municipal solid waste in 2018

	DOC	DOCF	F	MCF	Conversion	Ox	R
Biological	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	0.43	0.5	0.5	0.42	16/12	0	0
Source of information	Tonkin & Taylor (2014)[63]	IPCC default for unmanaged landfills	IPCC default for unmanaged landfills	Tonkin & Taylor (2014)		IPCC default for unmanaged landfills	MfE

10.3.4 When composition of waste is unknown

If the composition is unknown, select a general waste or an office waste default emission factor.

We based the default emission factor for general waste on national average composition data from the national inventory, as in table 82 above.

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

Table 85: Composition of typical office waste

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

10.3.5 Composting and Anaerobic digestion

We calculated emission factors for composting and anaerobic digestion using IPCC default emission factors as shown in table 86.

Table 86: IPCC default data used to calculate composting and anaerobic digestion

Calculation component	CH_4	N_2O	Anaerobic digestion CH_4	Anaerobic digestion N_2O
EF (kg gas/kg)	0.004	0.00024	0.0008	Assumed negligible
GWP	25	298	25	298
EF (CO_2-e) (kg CO_2-e/ kg waste)	0.10	0.07152	0.020	0
Combined EF (kg CO_2-e/ kg waste)		0.172		0.020

63 www.mfe.govt.nz/publications/waste/new-zealand-non-municipal-landfill-database-report

10.3.6 Assumptions, limitations and uncertainties

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

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

The default emission factor for mixed waste is based on national average composition data from the national inventory. Only waste to municipal 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 wood 0 per cent) for office waste, based on waste data from government buildings. We separated garden and food waste in this version of the guide, and assume that food represents all waste previously allocated to that category. We assume the remaining 25.6 per cent is inert material.

11 Agriculture, forestry and other land use emission factors

This category covers emissions produced by land use, land-use change and forestry (LULUCF), livestock enteric fermentation, manure management and fertiliser use. Including these sources is in line with New Zealand's Greenhouse Gas Inventory 1990–2018.

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.

11.1 Overview of changes since previous update

This version of the guide includes additional emission factors for animal species including swine, goats, horses, alpaca, mules, asses and poultry. This guide uses data from the New Zealand Greenhouse Inventory which has revised methodologies and emissions factors from the previous edition. These are summarised as:

- use of new N_2O emission factors from animal excreta split by stock type and hill slope, applied using a new model to calculate the amount of livestock excreta deposited onto the different slopes: low (gradient between 0 degrees and 12 degrees), medium (between 12 degrees and 24 degrees) and steep (greater than 24 degrees gradient)
- use of revised activity data for the proportion of dairy goats in the overall farmed goat population
- minor improvements to the equations used to estimate energy efficiency for maintenance for beef cattle, sheep and deer, including the specification of a constant to more significant figures and reverting to the IPCC default value of 18.45 megajoules per kilogram of dry matter (MJ/kg DM) for the gross energy content of feed (from the previous values of 18.40 MJ/kg DM for cattle and deer, and 18.50 MJ/kg DM for sheep).

Please refer to section 5.1.5 (and other relevant sections) *New Zealand's Greenhouse Inventory* 1990–2018 for further details.[64]

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[64] www.mfe.govt.nz/sites/default/files/media/Climate%20Change/new-zealands-greenhouse-gas-inventory-1990-2018-vol-1.pdf

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

11.2.1 Overview of the sector

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

The LULUCF sector is responsible for both emitting GHG to the atmosphere (emissions ie, through harvesting and deforestation) and removing GHG from the atmosphere (removals ie, through vegetation growth and increasing organic carbon stored in soils). Most emissions reported in this sector are due to forestry activities such as harvest operations in production forests, and most removals are due to forest growth.

The basis for the methods given here is that the flux of carbon dioxide to and from the atmosphere is due to the changes in carbon stocks in vegetation and soils. When emissions exceed removals, LULUCF is a 'net source' and emissions are positive. When removals exceed emissions, LULUCF is a 'net sink' and emissions are negative.

The guide provides methods to estimate the carbon stock change (or flux) that occurs from forestry activities during the applicable measurement period. We do not provide methods here to estimate carbon stock changes in non-forest vegetation, soils, harvested wood products, or for the associated nitrous oxide and methane emissions. For more detail, see the national inventory.

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

> Organisations with LULUCF emissions should calculate and report these separately from direct and indirect (Scope 1, 2 and 3) emissions.

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

The emission factor for planted forest growth (shown in table 87) is based on the Land Use and Carbon Analysis System (LUCAS) national sample. It represents the average annual increment over 28 years. Note the emission factor accounts for both the gains from forest growth and losses from any forest management activities up until the point of harvest.

The emission factor for planted forest harvest and deforestation is in table 88.

Natural forests

The emission factors for natural forest growth (shown in table 87) are based on the LUCAS national sample. We provide separate emission factors if the forest is tall or regenerating after conversion from another land use, logging or other disturbance. If unable to distinguish regenerating from tall forest, organisations can apply the national average (16 per cent regenerating: 84 per cent tall) to the activity data.

The emission factor for natural forest deforestation (shown in table 88) is based on the average stock at the national level, calculated from the LUCAS national sample.

Table 87: LULUCF forest growth emission factors

Forest growth removal 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_2O/unit (kg CO_2-e)
Planted forests	All	ha	-33,807	-33,807	±30%[65]	n/a	n/a
Natural forest	Regenerating natural forest	ha	-2,273	-2273	±50%[66]	n/a	n/a
	Tall natural forest	ha	0	0	n/a	n/a	n/a

Source: New Zealand's LUCAS national forest inventory data November 2019

Table 88: 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_2O/unit (kg CO_2-e)
Planted forests	Harvest and deforestation	ha	946,605	946,605	±30%[67]	n/a	n/a
Natural forest	Harvest and deforestation	ha	828,667	828,667	±50%[68]	n/a	n/a

Source: New Zealand's LUCAS national forest inventory data November 2019

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.

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65 Uncertainty estimated across two yield tables to obtain a single EF.

66 Uncertainty estimated based on expert judgement as those reported in Paul TSH, Kimberley MO, Beets PN. Unpublished. Carbon Stocks and Change in New Zealand's Natural Forests: Estimates from the First Two Complete Inventory Cycles 2002–2007 and 2007–2014. Contract report prepared for the Ministry for the Environment by the New Zealand Forest Research Institute Ltd (trading as Scion) in 2019.

67 Uncertainty estimated based on expert judgement as data were averaged across two yield tables to obtain a single EF.

68 Uncertainty estimated based on expert judgement as those reported in Paul et al, 2019 are only valid at the national scale.

Forest types:

1. **Tall natural forest**: comprises mature indigenous forest, and may contain self-sown exotic trees, such as wilding pines.
2. **Regenerating natural forest**: comprises indigenous and naturally occurring vegetation, including broadleaved hardwood shrubland, mānuka–kānuka and other woody shrubland, with potential to reach forest under its current management.
3. **Planted forest**: plantations of forest species mainly used for forestry, including:
   - radiata pine (*Pinus radiata*)
   - Douglas fir (*Pseudotsuga menziesii*)
   - eucalypts (*Eucalyptus* spp)
   - other planted species (with potential to reach ≥ 5 metre height at maturity in situ).

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

1. Corporate or farm records for enterprises and organisations.
2. Geospatial analysis of the property or region.
3. The LUCAS Land Use Map[69] can provide area by vegetation type at 1990, 2008, 2012 and 2016. It requires geospatial expertise to analyse and extract the data by region. This is free to use and supports users in monitoring changes in their own land management practices.
4. The New Zealand Land Cover Database (LCDB)[70] provides multi-temporal land cover. It requires geospatial expertise to analyse and extract the data for sub-national analysis.

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

Q = area of land (ha)
F = appropriate emission factors (for land use) from table 87 and table 88

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

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

3 ha of planted forest were harvested, therefore:

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

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

CO_2 removals = 1 × -2,273 = -2,273 kg CO_2e

Therefore, total net CO_2-e emissions = 2,839,815 – 2,273 = 2,837,542 kg CO_2-e.

Note: Negative emissions are a carbon sink.

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

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

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:

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

Where:

- ΔC = carbon stock change in the pool, kg C yr^{-1}
- A = area of land, ha
- ij = corresponds to forest type, and whether harvested or deforested
- CI = rate of gain of carbon, kg C ha^{-1} yr^{-1}
- CL = rate of loss of carbon, kg C ha^{-1} yr^{-1}

The area refers to the area of each forest type and whether harvested or deforested in the year of the inventory. The general approach is to multiply the area data by an emission factor to provide the source or sink estimates.

Quantities of carbon can be expressed in different ways: carbon (C), CO_2 and CO_2-e.

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

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.

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

11.3 Agriculture

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

- Methane from enteric fermentation is a by-product of ruminant digestion. Cattle and sheep are the largest sources of methane in this sector.

- Storing and treating manure, including spreading it onto pasture, produces methane and nitrous oxide.
- Applying nitrogen (urea-sourced or synthetic) fertiliser onto land produces nitrous oxide and carbon dioxide emissions.
- Applying lime and dolomite fertilisers results in carbon dioxide emissions.

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

Note the livestock emissions you calculate using these emission factors are intended to be an approximate estimate of emissions only, and are based on the average per-animal biological emissions of New Zealand's main farmed livestock 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 farm based estimate of their agricultural emissions are encouraged to use tools such as Overseer.

11.3.1 Enteric fermentation

Enteric fermentation is the process by which ruminant animals produce methane through digesting feed. We provide emission factors for dairy cattle, non-dairy cattle, sheep and deer in in table 89.

Table 89: Enteric fermentation emission factors

Emission source		Unit	kg CO_2-e/unit	kg CO_2/unit	CH_4 (kg CO_2-e)/unit	N_2O (kg CO_2-e)/unit
Enteric fermentation	Dairy cattle	per head	2132	n/a	2,132	n/a
	Non-dairy cattle	per head	1452	n/a	1,452	n/a
	Sheep	per head	307	n/a	307	n/a
	Deer	per head	573	n/a	573	n/a
	Swine	per head	26.5	n/a	26.5	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

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 11.3.4) to calculate emissions from enteric fermentation.

Applying the equation in section 2, this means:

Q = number of animals (per head per livestock type)
F = appropriate emission factors from table 89

ENTERIC FERMENTATION: EXAMPLE CALCULATION

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

CO_2 emissions	= 0
CH_4 emissions	= (30 × 307) + (6 × 2,132) = 22,002 kg CO_2-e
N_2O emissions	= 0
Total CO_2-e emissions	= 22,002 kg CO_2-e

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

The national inventory publishes total emissions for enteric fermentation per livestock type, along with population numbers. The Ministry of Primary Industries (MPI) supplied these same data for the creation of emission factors. We used this information, shown in table 90, to calculate the emission factors based on the following equation:

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

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

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

Table 90: Enteric fermentation figures per livestock type

Animal	2018 population	Enteric fermentation emissions in 2018 (kt CH_4) (as GHG)
Dairy cattle	6,385,541	544.46
Non-dairy cattle	3,721,262	216.09
Sheep	27,295,749	335.6
Deer	851,424	19.5
Swine	279,049	7.39
Goats	88,785	19.89
Horses	40,370	18.17
Alpaca	8,769	1.75
Mules & asses	141	0.035
Poultry	17,949,985	n/a

Note: kt is kilotonne.

Source: Based on figures from the Agricultural Inventory Model used in *New Zealand's Greenhouse Gas Inventory 1990–2018.*

The emission conversion factors are in the Emission Factors Workbook.

Alternative methods and tools

There are alternative calculating tools, such as OVERSEER. 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 emission factors when comparing these to the factors from alternative tools.

Assumptions, limitations and uncertainties

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

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

11.3.2 Manure management emission factors

Manure management refers to the process of managing the excretion of livestock, particularly when they are not on paddocks. The storage and treatment of manure produces GHG emissions. We provide the manure management emission factors in table 91.

Table 91: 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_2O/unit (kg CO_2-e)
Manure management	Dairy cattle	per head	213	n/a	198	14.8
	Non-dairy cattle	per head	19.5	n/a	19.5	0.0
	Sheep	per head	3.21	n/a	3.2	0.0
	Deer	per head	6.95	n/a	7.0	0.0
	Swine	per head	149	n/a	149	58.3
	Goats	per head	5.0	n/a	5.0	0.0
	Horses	per head	58.5	n/a	58.5	0.0
	Alpaca	per head	2.37	n/a	2.4	0.0
	Mules and asses	per head	27.5	n/a	27.5	0.0
	Poultry	per head	0.77	n/a	0.8	0.7

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 11.3.4) to calculate emissions from manure management.

Applying the equation in section 2, this means:

Q = number of animals (per head per livestock type)
F = appropriate emission factors from table 91

MANURE MANAGEMENT: EXAMPLE CALCULATION

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

CO_2 emissions	= 0
CH_4 emissions	= (30 × 3.21) + (6 × 197.8) = 1283.1 kg CO_2-e
N_2O emissions	= (30 × 0) + (6 × 14.8) = 88.8 kg CO_2-e
Total CO_2-e emissions	= 1371.9 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 1990–2018. MPI provided these data, see table 92.

Table 92: Manure management source data

Animal	Population	Methane from manure management (kt CH_4)	Nitrous oxide from manure management (kt N_2O)
Dairy cattle	6,385,541	50.53	0.32
Non-dairy cattle	3,721,262	2.90	0.00
Sheep	27,295,749	3.50	0.00
Deer	851,424	0.24	0.00
Swine	279,049	41.44	16.27
Goats	88,785	0.44	0
Horses	40,370	2.36	0
Alpaca	8,769	0.021	0
Mules and asses	141	0.0039	0
Poultry	17,949,985	13.84	11.72

Note: kt is kilotonne.

Source: The Agricultural Inventory Model used in *New Zealand's Greenhouse Gas Inventory 1990–2018.*

We calculated the manure management emission factors for each type of livestock as follows:

1. Convert the units to kg of GHG.
2. Divide by population to generate kg of GHG per head (ie, per animal).
3. Calculate kg CO_2-e / animal by multiplying each GHG by the IPCC AR4 100 year GWP.

For example:

Animal	Population	Methane from manure management (kg CH_4)	Nitrous oxide from manure management (kg N_2O)
Dairy cattle	6,385,541	50,530,000	320,000

Methane emissions = 50,530,000 ÷ 6,385,541= 7.91 kg CH_4 per head

Nitrous oxide emissions = 320,000 ÷ 6,385,541= 0.05 kg N_2O per head

Total kg CO_2 equivalent = (7.91 x 25) + (0.05 x 298) = 213 kg CO_2-e per head.

Assumptions, limitations and uncertainties

The national inventory states that the major sources of uncertainty in emissions from manure management are the accuracy of emission factors for manure management system distribution, the activity data on the livestock population and the use of the various manure management systems.[71] Based on the IPCC methodologies, the uncertainty factor for methane emissions is ±20 per cent and for nitrous oxide emissions ±100 per cent. The national inventory details the assumptions and limitations of these data.

Alternative methods of calculation

See section 11.3.1: Alternative methods and tools.

11.3.3 Fertiliser use

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

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

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 93 lists the fertiliser use emission factors. Table 94 lists example products for the different fertiliser types.

Table 93: 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_2O/unit (kg CO_2-e)
Fertiliser use	Non-urea nitrogen fertiliser	kg	5.40	n/a	n/a	5.40
	Urea nitrogen fertiliser not coated with urease inhibitor	kg	5.07	1.59	n/a	3.48
	Urea nitrogen fertiliser coated with urease inhibitor	kg	4.86	1.59	n/a	3.27
	Limestone	kg	0.440	0.440	n/a	n/a
	Dolomite	kg	0.477	0.477	n/a	n/a

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

71 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

Table 94: Examples of different categories of fertilisers

Fertiliser type	Example product
Non-urea nitrogen	Diammonium Phosphate
Urea nitrogen not coated with urease inhibitor	Nrich Urea
Urea nitrogen coated with urease inhibitor	Agrotain, SustaiN

GHG inventory development

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

Q = type of fertiliser used (in kg)
F = appropriate emission factors from table 93

FERTILISER USE: EXAMPLE CALCULATION

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

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

Note: Numbers may not add due to rounding.

Emission factor derivation methodology

MPI provided data on the quantified direct and indirect GHG emissions produced per tonne of fertiliser (table 95 and table 96).

Table 95: Nitrogen fertiliser emission factors

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

Table 96: Quantified emissions factors from limestone and dolomite

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

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

1. Convert the data to kg (gas) per unit kg of fertiliser.
2. Sum emissions per component of the total emissions.
3. Calculate total carbon dioxide equivalent by multiplying the total kg gas/ kg of fertiliser by the IPCC AR4 100-year global warming potential of that gas.

For example:

Table 97: Emission factors for non-urea nitrogen fertilisers

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

Total emissions per gas:

- N_2O = 0.0008 + 0.0016 + 0.016 = 0.0184 kg N_2O/ kg fertiliser

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

Assumptions, limitations and uncertainties

MPI used the following parameters to calculate the emissions.

Table 98: Parameters for calculating emissions from fertilisers

Parameter	Value	Source
Direct emission factor non-urea-N	0.01	Based on Kelliher and de Klein, 2006
Direct emission urea-N	0.0059	Based on van der Weerden et al, 2016
FracGASnfert (UI)	0.055	Saggar, 2013
FracGASnfert (non-UI)	0.1	Sherlock et al, 2008
Volatilisation emission factor (EF4)	0.01	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, table 11.3
FracLeach	0.07	Thomas et al, 2005
Leaching emission factor (EF5)	0.0075	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, table 11.3
Urea emission factor (CO_2 component)	0.2	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, section 11.4.2
Emission factor for limestone	0.12	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, section 11.4.2
Emission factor for dolomite	0.13	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, section 11.4.2
N content of urea	46%	Agriculture inventory model
Molecular conversion CO_2	3.667	
Molecular conversion N_2O	1.571	
GWP100 N_2O	298	IPCC AR4

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

11.3.4 Agricultural soils

Agricultural soils emit nitrous oxide due to the addition of nitrogen to soils through manure, dung and urine. The guide provides emission factors for the impact of common agricultural livestock categories on soil in table 99.

Table 99: 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_2O/unit (kg CO_2-e)
Agricultural soils	Dairy cattle	per head	489	n/a	n/a	489
	Non-dairy cattle	per head	237	n/a	n/a	237
	Sheep	per head	32.2	n/a	n/a	32.2
	Deer	per head	78.1	n/a	n/a	78.1
	Swine	per head	47.0	n/a	n/a	47.0
	Goats	per head	68.7	n/a	n/a	68.7
	Horses	per head	325	n/a	n/a	325
	Alpaca	per head	70.0	n/a	n/a	70.0
	Mules & asses	per head	145	n/a	n/a	145
	Poultry	per head	1.72	n/a	n/a	1.72

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 in section 2, this means:

Q = number of animals (per head per type)
F = appropriate emission factors from table 99

AGRICULTURAL SOILS: EXAMPLE CALCULATION

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

CO_2 emissions = n/a
CH_4 emissions = n/a
N_2O emissions = (30 × 32.2) + (6 × 489) = 3,900.8 kg CO_2-e
Total CO_2-e emissions = 3,900.8 kg CO_2-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 1990–2018. These data are in table 100.

Table 100: Data used for agricultural soils emission factors

Animal	Population	Total agricultural soils (kt N_2O)
Dairy cattle	6,385,541	10.48
Non-dairy cattle	3,721,262	2.96
Sheep	27,295,749	2.95
Deer	851,424	0.22
Swine	279,050	0.04
Goats	88,785	0.02
Horses	40,370	0.04
Alpaca	8,769	0.00
Mules & asses	141	0.00
Poultry	17,949,985	0.10

Assumptions, limitations and uncertainties

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

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 CO_2-e/TJ) rather than mass or volume. This generally provides more accurate emissions estimates. Converting to emission factors expressed in terms of mass or volume (eg, kg CO_2-e/litre) requires an assumption around which default calorific value should be used.

It is therefore useful to show how we derived the per-activity unit (eg, kg CO_2-e/litre) emission factors, and which calorific values we used. It is important to note that if you can obtain fuel use information in energy units, or know the specific calorific value of the fuel you are using, you can calculate your emissions more accurately.

Note that we have used gross calorific values.

Methane and nitrous oxide emission factors used in this guide

Although carbon dioxide emissions remain constant regardless of how a fuel is combusted, methane and nitrous oxide emissions depend on the precise nature of the activity in which the fuel is being combusted. The emission factors for methane and nitrous oxide therefore vary depending on the combustion process. Table A1 shows the default methane and nitrous oxide emission factors (expressed in energy units) used in this guide. The calculation in section 3.2.2 shows how we converted these to a per activity unit (eg, kg CO_2-e/kg) emission factors. MBIE provided all emission factors in table 3.

Note that we have used gross emission factors.

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_2O / TJ
Stationary combustion						
Coal – bituminous	Residential	kg	29.59	89.13	0.285	0.001425
Coal – sub-bituminous	Residential	kg	21.64	91.99	0.285	0.001425
Coal – lignite	Residential	kg	15.26	93.11	0.285	0.001425

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

Note: It is not expected that many commercial or industrial users will burn wood in fireplaces, but this emission factor is included for completeness. It is the default residential emission factor. **Note[2]**: The total of each gas contribution are expressed in tonnes of gas (not CO_2-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.

B.1 Method B – Default annual leakage rate

$$E = OE \times GWP$$

Where:

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

$$OE = C \times ALR$$

Where:

- C = original full refrigerant charge in equipment (kg)
- ALR = the default annual leakage emission factor for equipment (%).

The type and quantity of HFC in the equipment will often be shown on the compliance plate. If not, this method requires service agents' advice for refrigerant type and full refrigerant charge of each piece of equipment.

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

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

Where:

- E = emissions from equipment in kg CO_2-e
- IE = installation emissions
- C = default refrigerant charge in each piece of equipment (kg)

- ALR = default annual leakage emission factor for equipment (%)
- DE = disposal emissions (as per method B)
- GWP = the 100-year global warming potential of the refrigerant used in equipment (table 7).

Table B1 contains default refrigerant charge amounts for the New Zealand refrigeration and air-conditioning equipment stock.

Table B1: Default refrigerant charges for refrigeration and air-conditioning equipment

Refrigeration unit type	Default refrigerant charge (kg)	Default leakage rate (operating – ALR)	Default leakage rate (installation – AEF)[72]	Method A	Method B
Small refrigerator or freezer (<150 litres[73])	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

72 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.

73 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)[72]	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 mixtures[74]

Refrigerant type (trade name)	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	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

74 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_2O	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	No
Eketahuna Landfill	Tararua District Council	No
Eves Valley Landfill	Tasman District Council	No
Fairfield Landfill (Dunedin)	Transpacific Industries Group (NZ) Ltd	Unknown
Franz Josef Refuse Station	Westland District Council	Closed
Green Island Landfill	Dunedin City Council	Yes
Haast Refuse Station	Westland District Council	No
Hampton Downs Landfill	EnviroWaste Services Ltd	Yes
Innovative waste Kaikoura	Innovative Waste Kaikoura Ltd	No
Karamea Refuse Tip	Buller District Council	No
Kate Valley (Amberley)	Canterbury Waste Services Ltd	Yes
Levin Landfill	Horowhenua District Council	Yes
Marlborough Regional Council (Bluegums)	Marlborough District Council	Yes
McLean's Pit Landfill	Grey District Council	No
Mount Cooee Landfill	Clutha District Council	No
Oamaru Landfill	Waitaki District Council	Closed
Omarunui Landfill	Hastings District Council	Yes
Palmerston Landfill	Waitaki District Council	No
Patearoa Landfill	Central Otago District Council	Closed
Pongaroa Landfill	Tararua District Council	No
Redruth Landfill	Timaru District Council	Yes
Redvale Landfill	Transpacific waste management	Yes
Rotorua District Sanitary Landfill	Rotorua District Council	No

Name	Operator	LFGR
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
CH_4	Methane
CFCs	Chlorofluorocarbons
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
COD	Chemical oxygen demand
CHSB	The Cornell Hotel Sustainability Benchmarking Index Tool
De minimis	An issue that is insignificant to a GHG inventory, usually <1% of an organisation's total inventory for an individual emissions source. Often there is a limit to the number of emission sources that can be excluded as *de minimis*
Deforestation	The clearing of forest land that is then converted to a non-forest land use
EECA	Energy Efficiency and Conservation Authority
Emission factor	A coefficient that quantifies the emissions or removals of a gas per unit activity
Enteric fermentation	The process by which ruminant animals digest feed and produce methane

Forest land	Land containing tree species that will reach a height of at least 5 meters, with a canopy cover of at least 30% and be of at least 1 hectare in size
Fugitive emissions	The emission of gases from pressurised equipment due to leaks or unintended releases of gases, usually from industrial activities
GHG	Greenhouse gas
GHG inventory	A quantification of an organisation's greenhouse gas sources, sinks, emissions and removals
GHG Protocol	The *Greenhouse Gas Protocol Accounting and Reporting Standard* provides guidance for organisations preparing a GHG inventory
GHG report	A standalone report to communicate an organisation's GHG-related information to intended users
GJ	Gigajoule (unit of measure, one billion joules)
Grazing off	Cattle feeding on paddock not owned by their farmer
GWP	Global warming potential, a factor describing the radiative forcing impact of one mass-based unit of a given GHG relative to an equivalent unit of carbon dioxide over a given period (typically 100 years)
GWRC	Greater Wellington Regional Council
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
National inventory	New Zealand's Greenhouse Gas Inventory
NDC	Nationally determined contributions under the Paris Agreement
NF_3	Nitrogen trifluoride
N_2O	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)
SF_6	Sulphur hexafluoride
Stationary combustion fuel	Fuel used in an unmoving engine eg, a power plant or boiler
TFCD	Task Force on Climate-related Financial Disclosures
tkm	Tonne-kilometre (unit of measure for freight)

Unique emission factor	A value given to an activity based on how emissions intensive it is. Experienced professionals must verify a unique emission factor. See Climate Change (Unique Emission Factors) Regulations 2009 for further information
Uplift factor	Applied to take into account the combined 'real-world' effects on fuel consumption (such as non-direct flight paths)
VFEM	The 2019 Vehicle Fleet Emissions Model supplied by the Ministry of Transport