



Ministry for the
Environment
Manatū Mō Te Taiao

Guidance for Voluntary, Corporate Greenhouse Gas Reporting

Data and Methods for the 2009 Calendar Year

This report may be cited as:

Ministry for the Environment. 2011. *Guidance for Voluntary, Corporate Greenhouse Gas Reporting: Data and Methods for the 2009 Calendar Year*. Wellington: Ministry for the Environment.

Published in May 2011 by the
Ministry for the Environment
Manatū Mō Te Taiao
PO Box 10362, Wellington 6143, New Zealand

ISBN: 978-0-478-37219-9

Publication number: ME 1047

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www.mfe.govt.nz



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Environment
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This is the fourth version of an annual publication.

Each year the Ministry for the Environment will update this guide with the latest emission factors for the given calendar year.

Changes to data and methodology for the 2009 calendar year

Scope 1

Stationary combustion – emission factors for stationary combustion have been updated based on new figures for the 2009 calendar year.

Transport fuels – emission factors for transport fuels have been updated based on new figures for the 2009 calendar year, and emission factors for marine diesel, heavy fuel oil, and light fuel oil used in transport have been incorporated into the guidance.

Refrigerants – emission factors and methodologies for refrigerant emissions have been incorporated into Appendix B. The treatment of CFCs and HCFCs, including that of R22, has been clarified.

Scope 2

Purchased electricity – emission factors for purchased gas and electricity have been updated based on new figures for the 2009 calendar year.

Scope 3

Transmission and distribution losses – emission factors for transmission and distribution losses from purchased electricity and natural gas have been updated based on new figures for the 2009 calendar year.

Taxis/rental cars – emission factors for travel in taxis/rental cars have been updated based on new figures for the 2009 calendar year.

Air travel – emission factors for air travel have been updated based on the latest data.

Waste – emission factors for waste to landfill with methane capture have been updated based on the latest data on landfill gas collection rates for the 2009 calendar year.

Note that this guide is solely for use in voluntary greenhouse gas reporting, and should **not** be used for reporting under the New Zealand Emissions Trading Scheme.

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1 Guidance on reporting

1.1 Introduction

This guide has been prepared as guidance for voluntary, corporate greenhouse gas (GHG) reporting, including emission factors.

It encourages best practice in GHG monitoring and reporting and supports voluntary GHG reporting initiatives. It endorses the referenced reporting frameworks and provides information (emission factors and methods) to enable organisations to apply them.

This guide will be regularly updated to maintain consistency with international best practice and the New Zealand Government's national greenhouse gas inventory reporting.

1.2 Who is this guide intended for?

This guide is for organisations who wish to voluntarily monitor and report greenhouse gas emissions on an organisational basis (sometimes called 'corporate' or 'entity' level) for their New Zealand operations.

This guide is for voluntary GHG reporting and does not represent, or form part of, any mandatory reporting framework or scheme.

The emission factors and methods contained in this guide are provided for emission sources deemed common for commercial organisations; however, this guide also applies to industrial organisations who wish to voluntarily report on the same emission sources.

These emission factors and methods are not appropriate for a full life-cycle assessment or for the purposes of complying with the British Standards Institution PAS 2050 product carbon footprinting standard, or with the draft International Organization of Standardization (ISO) 14067 standard on the carbon footprint of products. These factors are not appropriate for life-cycle assessment as they only include direct emissions from activities, and do not include all sources of emissions required for a full life-cycle analysis. The United Kingdom Department for the Environment, Food and Rural Affairs (DEFRA) publish emission factors for a number of emission sources that take into account the life cycle of those activities. In addition, the GHG Protocol Initiative has published draft standards for the calculation of life-cycle emissions.¹

¹ www.ghgprotocol.org/standards/product-and-supply-chain-standard.

1.3 Why is this information not for use in an emissions trading scheme (ETS)?

The information in this guide is intended to help organisations who want to monitor and report their greenhouse gas emissions on a voluntary basis. Organisations that are required to participate in a mandatory emissions trading scheme will need to comply with the reporting requirements specific to that scheme. The rules and regulations of those schemes will determine which emission factors and methods must be used to calculate and report emissions.

Firms with obligations to report greenhouse gases under mandatory schemes (including emissions trading) or who choose to participate in voluntary greenhouse gas emission reporting schemes should check the rules and requirements of those schemes.

The information in this guide may, however, be useful to firms that have a reporting obligation under an emissions trading scheme for a particular activity within their business, but still wish to publish comprehensive emission reports for their organisation on a voluntary basis. Although this monitoring and reporting would not constitute compliance with an emissions trading scheme, it may help organisations prepare for, or understand how, an emissions trading scheme might impact on their business.

1.4 What rules should I follow to monitor and report emissions?

The Ministry for the Environment (the Ministry) recommends firms use the *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* (The GHG Protocol) or *ISO 14064-1:2006 Greenhouse gases – Part 1 Specification* with guidance at the organisation level for quantification and reporting of greenhouse gas emissions (ISO 14064-1).

The GHG Protocol is a standard developed jointly by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). It is available at www.ghgprotocol.org/standards.

The ISO 14064-1 standard is published by the International Standards Organisation. This standard is closely based on The GHG Protocol.

The Ministry for the Environment endorses both *The GHG Protocol* and *ISO 14064-1* for voluntary corporate GHG monitoring and reporting.

1.5 What do the GHG Protocol and ISO 14064-1 cover?

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

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

1.6 What is the difference between these standards?

ISO 14064-1 is a shorter, more direct document than *The GHG Protocol*, which is more descriptive and discusses, for example, motivational reasons for monitoring and reporting greenhouse gas emissions. *ISO 14064-1* refers users to *The GHG Protocol* for further detail on some issues.

In general, those choosing to report against the ISO standard would find the *The GHG Protocol* useful for providing context.

1.7 What information do I need?

To report emissions, organisations require a method of converting data they gather about activities (eg, vehicle travel) in their organisation into information about their emissions (measured in tonnes of CO₂ equivalent). These methods involve using what are sometimes called ‘emission factors’. An emission factor allows GHG emissions to be estimated from a unit of available activity data (eg, litres of fuel consumed).

Emission factors are available from a number of sources (including from the [Greenhouse Gas Protocol Initiative](#) website). However, there has been demand for the Ministry to publish a consistent list of emission factors and methods (how the emission factors should be applied) specifically for use in New Zealand, for common corporate emission sources.

This guide draws on technical information provided by New Zealand government agencies, and presents it in a form suitable for voluntary, corporate GHG reporting. It also uses some international data where New Zealand-specific information is not yet available.

This guide provides emission factors and methods for common emission sources, for the most recent calendar year. The Ministry will update the information on emission factors annually.

This guide also details how these emission factors were derived and assumptions surrounding their use.

1.8 Verification

1.8.1 Should I have my emissions inventory verified?

The term ‘verification’ is generally used to refer to scrutiny by a suitably qualified, independent body or person to confirm the extent to which an emissions inventory is a fair representation of the actual situation.

Verification provides you and your stakeholders with confidence about the accuracy of an emissions inventory. If an emissions inventory is intended for public release then the Ministry for the Environment recommends that firms obtain independent verification of the inventory to confirm that calculations are accurate, and the correct methodology has been followed.

1.8.2 Who should verify my inventory?

An accreditation framework has been developed by the Joint Accreditation System of Australia and New Zealand (JAS-ANZ) which accredits verifiers to the ISO 14065 standard. This confirms that these verifiers are suitably qualified and enables them to certify an inventory as being prepared in accordance with *ISO 14064-1*.²

The Ministry recommends that organisations use verifiers who:

- are independent
- are members of a suitable professional organisation
- can demonstrate they have experience with emissions inventories
- understand ISO 14064 and The GHG Protocol
- have effective internal peer review and quality control procedures.

² Accredited bodies under the JAS-ANZ Register may be found at: www.jas-anz.org/index.php?option=com_content&task=blogcategory&id=44&Itemid=1.

Firms that have achieved the status of designated operational entity (DOE) and/or accredited independent entity (AIE) under the Kyoto Protocol framework will have experience in verifying greenhouse gas emission reductions on a project basis.³ While verification of greenhouse gas emission reductions from projects is a different task than verification of organisation-level greenhouse gas emissions inventories, there are many similarities, and providers who have achieved DOE or AIE status will have many of the competencies required to verify emissions inventories.

Verification should be undertaken by independent organisations who can demonstrate they have experience with emissions inventories, *ISO 14064* and *The GHG Protocol*.

³ A list of DOEs can be found at <http://cdm.unfccc.int/DOE/list/index.html>.

2 Emission factors and methods – context

The emission factors reported in this guide are intended to be default factors (ie, to be used in the absence of better information). They are designed to be consistent with the reporting requirements of *ISO 14064-1* and *The GHG Protocol*. The emission factors are also designed to be aligned with the emission factors used for the Ministry's national greenhouse gas inventory reporting.

The purpose of providing these emission factors is to:

- collate an official set of annually updated emission factors for voluntary corporate reporting
- present emission factors in an easy to use form which will facilitate reporting by organisations
- provide guidance on a consistent approach to choosing emission factors for financial-year and calendar-year reporting.

As explained previously, these emission factors are largely derived from technical information published by New Zealand government agencies.⁴ The key source of information is the Ministry of Economic Development. Each section gives the particular source for each emission factor and how the factors are derived.

This guidance covers the six direct Kyoto gases (CO₂, CH₄, N₂O, HFCs, PFCs and SF₆) covered by *ISO 14064-1* and *The GHG Protocol*. This is also consistent with the reporting requirements for New Zealand's National Greenhouse Gas Inventory.

Greenhouse gases (GHGs) vary in their radiative activity and atmospheric residence time. This means that different GHGs have different global warming potentials (GWPs). To enable a meaningful comparison between gases, GHG emissions are commonly expressed as carbon dioxide equivalent or CO₂-e. The emission factors in this guide therefore convert activity data into the equivalent estimate of CO₂-e per unit of activity data (eg, kg CO₂-e/litre of petrol).

Under the reporting requirements of *ISO 14064-1* and *The GHG Protocol*, GHG emissions should be reported in tonnes CO₂-e. This guidance presents emission factors in kg CO₂-e per unit. Division by 1000 converts kg to tonnes (see example calculations on the following pages). Emission factors presented in CO₂-e use the global warming potentials for methane and nitrous oxide from the IPCC's Second Assessment Report, consistent with the Kyoto Protocol.⁵

In line with the reporting requirements of *ISO 14064-1*, the emission factors allow calculation of CO₂, CH₄ and N₂O separately, as well as the total CO₂ equivalent for Scope 1 emission sources (discussed in Section 2.2).

⁴ For instance, the energy emission factors are largely sourced from the *Energy Greenhouse Gas Emissions (2010)* publication, produced by the Ministry of Economic Development. References for specific emission factors are included on the following pages.

⁵ Global warming potential for methane = 21; global warming potential for nitrous oxide = 310.

CO₂ emission factors are based on the carbon and energy content of a fuel. CO₂ emissions therefore remain constant regardless of the way in which a fuel is combusted. However, CH₄ and N₂O (ie, non-CO₂) emissions depend on the manner in which the fuel is being combusted. The emission factors for CH₄ and N₂O therefore vary depending on the combustion process.⁶ Separate CO₂-e emission factors for commercial and industrial users are presented in Table 1 on page 8. The relevant Ministry of Economic Development publication describes assumptions made.

As well as providing common emission factors, the Ministry considers it useful to illustrate how these emission factors have been derived. Appendix 1 discusses and provides an example of how the emission factors have been calculated.

2.1 Timing of emission factors and annual reporting

Organisations can choose to report on a calendar or financial year basis.

Calendar year: If you are reporting on a calendar year basis, then the latest published emission factors should be used and the inventory may have to be recalculated when the most appropriate emission factors are published at a later date. Many emission factors will rely on a review of historical data, such as the proportion of renewable generation feeding into the electricity grid. The previous calendar year's emission factors will therefore be provided in this guide each year, following the release of the *Energy Greenhouse Gas Emissions, New Zealand Energy Data File* and *New Zealand's Greenhouse Gas Inventory* publications.

Financial year: If you are reporting on a financial year basis then you could either:

- choose to pro rata the emission factors according to the specific financial year used by your organisation, or
- use the emission factors from the latest inventory with an explanation that these are the latest available published emission factors.

2.2 The concept of 'scope'

The GHG Protocol categorises emission sources into Scope 1, Scope 2 and Scope 3 activities as follows:

- Scope 1: Direct GHG emissions occurring from sources that are owned or controlled by the company (ie, sources within the organisational boundary). For example, emissions from combustion of fuel in owned or controlled vehicles. *The GHG Protocol* and *ISO 14064-1* **require** Scope 1 emissions to be reported.
- Scope 2: Indirect GHG emissions occurring from the generation of purchased electricity consumed by the company. *The GHG Protocol* and *ISO 14064-1* **require** Scope 2 emissions to be reported.

⁶ For example, the CH₄ and N₂O emission factors for diesel used for industrial heating are different to the CH₄ and N₂O emission factors for diesel used in vehicles.

- Scope 3: Other indirect GHG emissions occurring as a consequence of the activities of the company, but generated from sources not owned or controlled by the company (eg, emissions from air travel). Under the reporting framework of *The GHG Protocol* and ISO 14064-1, Scope 3 is an **optional** reporting category that allows for the treatment of all other indirect emissions. The GHG Protocol states that Scope 3 emissions should be reported if they are 1) significant in the context of the whole inventory, 2) material to stakeholders, and 3) easy to reduce.

Section 3 of this guide presents emission factors according to each category of activity.

3 Emission factors and methods 2009

3.1 Scope 1: Direct emissions

3.1.1 Stationary combustion of fuels

Scope 1 emissions occur from the combustion of fuels from sources owned or controlled by the reporting organisation. Table 1 contains emission factors for common fuels used for stationary combustion.

In line with the reporting requirements of *ISO 14064-1* and *The GHG Protocol*, emission factors are provided to allow calculation of CO₂, CH₄ and N₂O separately.

Table 1: Fuel combustion emission factors (fuels used for stationary combustion) – 2009

Emission source	User	Unit	Emission factor total CO ₂ -e (kg CO ₂ -e/unit)	Emission factor CO ₂ (kg CO ₂ /unit)	Emission factor CH ₄ (kg CO ₂ -e/unit)	Emission factor N ₂ O (kg CO ₂ -e/unit)
Stationary combustion						
Distributed natural gas	Commercial	KWh	0.194	0.191	0.0000816	0.00231
		GJ	53.8	53.2	0.0227	0.642
Coal – bituminous	Commercial	Kg	2.61	2.59	0.00594	0.0123
Coal – sub-bituminous	Commercial	Kg	1.96	1.94	0.00434	0.00897
Coal – lignite	Commercial	Kg	1.43	1.43	0.00305	0.00630
Coal – default*	Commercial	Kg	1.96	1.94	0.00434	0.00897
Diesel	Commercial	Litre	2.65	2.64	0.000152	0.00448
LPG**	Commercial	Kg	3.00	2.99	0.00109	0.00875
Heavy fuel oil	Commercial	Litre	3.03	3.03	0.00245	0.00362
Light fuel oil	Commercial	Litre	2.96	2.96	0.00243	0.00359
Distributed natural gas	Industry	KWh	0.192	0.191	0.0000953	0.000100
		GJ	53.2	53.2	0.0265	0.0279
Coal – bituminous	Industry	Kg	2.61	2.59	0.000416	0.0140
Coal – sub-bituminous	Industry	Kg	1.96	1.94	0.000304	0.0103
Coal – lignite	Industry	Kg	1.43	1.43	0.000213	0.00720
Coal – default*	Industry	Kg	1.96	1.94	0.000304	0.0103
Diesel	Industry	Litre	2.65	2.64	0.000152	0.00448
LPG**	Industry	Kg	3.00	2.99	0.00109	0.00875
Heavy fuel oil	Industry	Litre	3.03	3.03	0.00245	0.00362
Light fuel oil	Industry	Litre	2.96	2.96	0.00243	0.00359
Wood	Industry***	Kg	0.0142	1.26	0.00288	0.0113
Wood	Fireplaces****	Kg	0.0865	1.26	0.0723	0.0142

- * The default coal emission factor should be used if it is not possible to identify the specific type of coal.
- ** LPG-use data in litres can be converted to kilograms by multiplying by the specific gravity of 0.536 kg/l.
- *** It is not expected that many commercial or industrial users will burn wood in fireplaces but this emission factor has been provided for completeness. It is the default residential emission factor.
- **** The total CO₂-e emission factor for wood only includes CH₄ and N₂O emissions. This is based on *ISO 14064-1* and *The GHG Protocol* reporting requirements for combustion of biomass as Scope 1 emissions. CO₂ emissions, from the combustion of biologically sequestered carbon are reported separately.

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

Assumptions

The kg CO₂-e per activity unit emission factors supplied in Table 1 are derived by the Ministry of Economic Development using calorific values. The calorific values used can be found in Appendix 1.

All emission factors include the effect of relevant oxidation factors. Oxidation factors allow for the small proportion of carbon that remains unoxidised due to incomplete combustion, and remains as soot and ash.

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

The default coal emission factor is assumed to be the same as the sub-bituminous coal emission factor on the basis that the majority of coal use is of sub-bituminous coal.⁷

The Automotive Gas Oil-10 ppm Sulphur emission factor (provided in the *Energy Greenhouse Gas Emissions (2010)* publication) has been used as the default emission factor for diesel.

Example calculation

A commercial organisation uses 1400 kg of LPG to heat one of its office buildings in 2008.

$$\begin{aligned}\text{CO}_2 \text{ emissions} &= 1400 * 2.99 = 4186 \text{ kg CO}_2 \\ \text{CH}_4 \text{ emissions} &= 1400 * 0.00109 = 1.526 \text{ kg CO}_2\text{-e} \\ \text{N}_2\text{O emissions} &= 1400 * 0.00875 = 12.25 \text{ kg CO}_2\text{-e} \\ \text{Total CO}_2\text{-e emissions} &= 1400 * 3.00 = 4200 \text{ kg CO}_2\text{-e}\end{aligned}$$

⁷ Approximately 92 per cent of the coal used by the commercial sector is sub-bituminous coal.

3.1.2 Transport fuels where fuel use data is available

Scope 1 emissions from transport occur from vehicles which are owned or controlled by the reporting organisation. The most accurate way to quantify the emissions associated with transport is by using information on the quantity of fuel used.

Emission factors for combustion of transport fuels are reported in Table 2. The emission factors are provided by the Ministry of Economic Development.

Table 2: Fuel combustion emission factors (transport fuels) – 2009

Fuel	Unit	Emission factor total CO ₂ -e* (kg CO ₂ -e/unit)	Emission factor CO ₂ (kg CO ₂ /unit)	Emission factor CH ₄ (kg CO ₂ -e/unit)	Emission factor N ₂ O (kg CO ₂ -e/unit)
Regular petrol	litre	2.36	2.33	0.0136	0.0154
Premium petrol	litre	2.39	2.36	0.0137	0.0156
Petrol – default*	litre	2.36	2.33	0.0136	0.0155
Diesel	litre	2.69	2.64	0.00303	0.0436
LPG	litre	1.62	1.60	0.0159	0.00469
Marine diesel	litre	2.74	2.71	0.00540	0.0228
Heavy fuel oil	litre	3.06	3.03	0.00573	0.0242
Light fuel oil	litre	2.99	2.96	0.00568	0.0239

* The default petrol emission factor should be used if it is not possible to distinguish between regular and premium petrol use.

Assumptions

The kg CO₂-e per activity unit emission factors supplied in Table 2 are derived by the Ministry of Economic Development using calorific values. All emission factors incorporate relevant oxidation factors which are sourced from *The IPCC Revised Guidelines for National Greenhouse Gas Inventories (1996)*.

The default petrol factor is a weighted average of regular and premium petrol based on 2009 sales volume data from the *New Zealand Energy Data File 2010*. It should be used when petrol use data does 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 Scope 3 emissions associated with the extraction, production and transport of the fuel.

Example calculation

An organisation has 15 petrol vehicles. They used 40,000 litres of regular petrol in 2009.

CO₂ emissions = 40,000 * 2.33 = 92,200 kg CO₂

CH₄ emissions = 40,000 * 0.0136 = 544 kg CO₂-e

N₂O emissions = 40,000 * 0.0154 = 616 kg CO₂-e

Total CO₂-e emissions = 40,000 * 2.36 = 94,400 kg CO₂-e

3.1.3 Transport where no fuel data is available (based on distance travelled)

If your records only provide information on kilometres travelled, and you do not have information on fuel use, the emission factors in Table 3 can be used to calculate emissions from transport. Note, however, that factors such as individual vehicle fuel efficiency and driving efficiency mean that kilometre-based estimates of CO₂-e emissions are less accurate than calculating emissions based on fuel-use data. The emission factors in Table 3 should therefore only be used if information on fuel use is not available.

Table 3: Transport emission factors (based on distance travelled) – 2009

Vehicle size class*	Unit	'Real world' petrol fuel use estimate (L/100km)	Emission factor total CO ₂ -e (kg CO ₂ -e/unit)	Emission factor CO ₂ (kg CO ₂ /unit)	Emission factor CH ₄ (kg CO ₂ -e/unit)	Emission factor N ₂ O (kg CO ₂ -e/unit)
Car – small (<1600 cc)	Km	7.47	0.177	0.174	0.00102	0.00116
Car – medium (1600–<2500 cc)	Km	9.90	0.234	0.231	0.00135	0.00153
Car – large (≥ 2500 cc)	Km	13.03	0.308	0.304	0.00177	0.00202
Car – default**	Km	9.90	0.234	0.231	0.00135	0.00153

* Example (representative) vehicle models for each of the size classes are: Small = Toyota Echo, Medium = Honda Accord, Large = Holden Commodore.

** The default emission factor should be used if vehicle size class can not be determined.

Assumptions

The above emission factors in Table 3 assume that all representative vehicles are petrol. The emission factors are derived by multiplying the default petrol emission factor from Table 2 by 'real world' fuel consumption rates⁸ for the petrol light vehicle fleet, based on information from New Zealand vehicle fleet Statistics for 2009 (Ministry of Transport). 'Real world' fuel consumption rates take into account 'real world' effects such as driver behaviour. Due to lack of data it is not currently possible to derive 'real world' fuel consumption rates for vehicles which use other fuels (eg, diesel, LPG). The above CO₂-e emission factors should therefore be applied to all vehicles (for which only kilometre travelled information is available), regardless of the type of fuel used.

The above emission factors are averages and therefore do not reflect the variability in fuel consumption rates between individual vehicles.

The default emission factor (for vehicles of unknown size) is the same as that for medium vehicles (1600–<2500 cc).⁹

⁸ They have been calculated by multiplying the average Euro emissions dyno test cycle fuel consumption rate, for each vehicle size class, by a 'real world' scale-up factor of 1.148. The figures are based on consumption rates for new vehicles sold in New Zealand between 2008 and 2010.

⁹ In 2007, 54.9 per cent of light petrol vehicles sold in New Zealand were in the medium vehicle size class, 25.6 per cent were small and 19.5 per cent were large. (Source: Motor Industry Association New Vehicle Sales Database 2007).

Example calculation

An organisation has three vehicles which it owns. They are all large vehicles and travelled a total of 37,800 km in 2009.

CO₂ emissions = 37,800 * 0.304 = 11,491 kg CO₂

CH₄ emissions = 37,800 * 0.00177 = 67 kg CO₂-e

N₂O emissions = 37,800 * 0.00202 = 76 kg CO₂-e

Total CO₂-e emissions = 37,800 * 0.308 = 11,642 kg CO₂-e

3.1.4 Refrigerants

Greenhouse gas emissions from hydrofluorocarbons (HFCs) are associated with unintentional leaks and spills from refrigeration units, air conditioners and heat pumps. While quantities of HFCs reported in a business emissions inventory may be small, HFCs have very high global warming potentials (commonly 1300 to 3300 times more potent than CO₂) and emissions from this source may therefore be material. In addition, emissions associated with this sector are growing significantly as they replace chlorofluorocarbons and hydrochlorofluorocarbons (CFCs and HCFCs).

Scope 1 emissions from refrigeration occur from refrigeration units which are owned or controlled by the reporting organisation. If the unit is leased, associated emissions should be reported under Scope 3 emissions.

Emissions of HFCs are not calculated using emission factors, rather they are determined by estimating leakage from refrigerant equipment. Maintenance engineers can be asked to provide the actual amounts that are used to top up equipment (ie, to replace what has leaked). The Ministry recommends three alternative methods for estimating leakage, depending on the equipment and available information. The 2008 guidance describes these methods in detail. These methods have not changed, and rather than repeat the text here, they are reproduced in Appendix B.

If you consider it likely your emissions from refrigerant equipment and leakage is a material proportion of your total emissions (ie, >5 per cent), then you should include them in your emissions inventory. You may need to carry out a preliminary screening test to determine materiality.

The 2008 version of the Guidance for Voluntary, Corporate Greenhouse Gas Reporting incorrectly states that CFCs and HCFCs (including R22) do not have global warming potentials. CFCs and HCFCs can have very high global warming potentials (up to 14,400 times as potent as CO₂ over 100 years), however they are not included in greenhouse gas inventories as they are already being phased out through the Montreal Protocol on Substances that Deplete the Ozone Layer. The GHG Protocol includes direct emissions of CFCs and HCFCs as optional reporting categories under scope 3 emissions. Global warming potentials for CFCs and HCFCs can be found on page 212 of the IPCC's publication, *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007*.¹⁰

¹⁰ Available at www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf.

3.2 Scope 2: Electricity indirect emissions

3.2.1 Purchased electricity

An emission factor for the consumption of purchased electricity (by end users) is calculated on a calendar year basis, and accounts for the emissions from fuel combustion at thermal power stations. It also includes a relatively small proportion of fugitive emissions from geothermal generation.

The emission factor for the consumption of purchased electricity and the emission factor for transmission and distribution line losses have been aligned with the definitions used in the *GHG Protocol*.

The electricity emission factor covers purchased electricity which has been bought from an electricity supplier who sources its electricity from the national grid.¹¹

Table 4: Emission factor for the consumption of purchased electricity – 2009

Emission source	Unit	Emission factor total CO ₂ -e (kg CO ₂ -e/unit)
Purchased electricity	kWh	0.159

Assumptions

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.

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. Under the reporting framework of *The GHG Protocol* the emissions associated with transmission and distribution line losses are Scope 3 emissions. Table 5 contains an emission factor for transmission and distribution line losses.

The emission factor in Table 4 is derived from the net electricity generation data (as opposed to consumption data) in the *New Zealand Energy Data File 2010*. This is explained in more detail in the section below covering transmission and distribution line losses.

Notes on the use of electricity emission factors

The emission factor provided in Table 4 is an average over the calendar year to which the emission factor relates and is used for reporting the annual emissions associated with the consumption of purchased electricity.

A grid-average emission factor best reflects the CO₂-e emissions associated with the generation of a unit of electricity, purchased from the national grid, in New Zealand in 2009.

¹¹ It does not cover on-site, self-generation of electricity.

Retailer-specific electricity factors for grid electricity may be considered in the future. At this stage, however, there is insufficient information to prepare such factors and no clear consensus on the advantages of this approach. It is suggested users contact the Ministry for the Environment for advice when assessing carbon neutrality claims by electricity retailers.

The grid-average emission factor cannot be used for calculating abatement by intervention or reducing the use of thermal generation (eg, for an offset project). A marginal emission factor is more appropriate in these circumstances, because it is designed to take into account the change in electricity generation at the margin. Users wanting more information on marginal electricity emission factors are advised to contact the Electricity Commission. A report on *Carbon Abatement Effects of Electricity Demand Reductions* is also now available on the Ministry for Economic Development's website.¹²

Example calculation

An organisation uses 800,000 kWh of electricity in 2009. Their Scope 2 emissions from electricity are:

$$\text{Total CO}_2\text{-e emissions} = 800,000 * 0.159 = 127,200 \text{ kg CO}_2\text{-e}$$

3.3 Scope 3: Other indirect emissions

3.3.1 Transmission and distribution line losses for purchased electricity

This emission factor accounts for emissions from the additional generation required to make up for electricity lost in the transmission and distribution network due to inefficiencies in the grid. Under *The GHG Protocol* reporting framework, emissions from the generation of electricity that is consumed in a transmission and distribution system should be reported as a Scope 3 emission by end users.

The emission factor for transmission and distribution line losses is the difference between the generation and consumption emission factors reported by the Ministry of Economic Development on their website.¹³

Table 5: Transmission and distribution line losses for purchased electricity – 2009

Emission source	Unit	Emission factor total CO ₂ -e (kg CO ₂ -e/unit)
Transmission and distribution line losses for purchased electricity	kWh	0.0155

¹² *Carbon Abatement Effects of Electricity Demand Reductions*.
www.med.govt.nz/templates/MultipageDocumentTOC____33805.aspx.

¹³ *Voluntary Greenhouse Gas Reporting Energy Emission Factors 2009*.
www.med.govt.nz/energy/voluntaryefs.

Assumptions

This emission factor covers grid purchased electricity, bought by an end user. It is an average figure and therefore makes no allowance for distance from off-take point, or other factors that may vary between individual consumers.¹⁴

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

Example calculation

An organisation uses 800,000 kWh of electricity in 2009. Their Scope 3 emissions from transmission and distribution line losses for purchased electricity are:

$$\text{Total CO}_2\text{-e emissions} = 800,000 * 0.0155 = 12,400 \text{ kg CO}_2\text{-e}$$

3.3.2 Transmission and distribution losses for distributed¹⁵ natural gas

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

These emission factors are derived from information in the *Energy Greenhouse Gas Emissions (2010)* and *New Zealand Energy Data File 2010* publications.

Table 6: Transmission and distribution losses for distributed natural gas – 2009

Emission source	Unit ¹⁶	Emission factor total CO ₂ -e (kg CO ₂ -e/unit)
Transmission and distribution losses for distributed natural gas	kWh	0.0100
	GJ	2.777

Assumptions

These emission factors represent an estimate of the average amount of CO₂-e emitted from losses associated with the delivery (transmission and distribution) of a unit of gas per unit of gas consumed through local distribution networks in 2009. They are average figures and therefore make no allowance for distance from off-take point, or other factors that may vary between individual consumers.

¹⁴ Major electricity users need to be aware that a losses allowance may already be included in their electricity invoices.

¹⁵ ‘Distributed’ refers to natural gas distributed via low pressure, local distribution networks.

¹⁶ Emission factors are presented based on gas used in both kWh and GJ. One should be used depending on which unit your natural gas data uses.

The figures assume that all losses are attributable to gas consumed via local distribution networks. A small amount (<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. These emission factors are therefore appropriate for use by customers who receive their gas through a local distribution network, and are not intended for customers who receive gas directly from the transmission system, or directly from a gas producer via high-pressure transmission lines.

These emission factors do not cover the emissions associated with the extraction and production of the gas.

Example calculation

An organisation uses 800 gigajoules of distributed natural gas in 2009. Their Scope 3 emissions from transmission and distribution losses are:

$$\text{Total CO}_2\text{-e emissions} = 800 \times 2.777 = 2222 \text{ kg CO}_2\text{-e}$$

3.3.3 Taxis and rental cars

Business travel in taxis and rental cars are likely to be a common source of Scope 3 emissions for most businesses. As with Scope 1 emissions from transport, the most accurate way to calculate emissions is based on fuel consumption data. However, this information may not be easily available, particularly for business travel in taxis. Table 7 provides emission factors for rental car and taxi travel, based on kilometres travelled, as well as an emission factor for taxi travel based on dollars spent.

Table 7: Emission factors for travel in taxis and rental cars (based on distance travelled) – 2009

Emission source	Unit	Emission factor total CO ₂ -e (kg CO ₂ -e/unit)
Rental car – small (<1600cc)	Km	0.177
Rental car – medium (1600 – <2500cc)	Km	0.234
Rental car – large (≥ 2500)	Km	0.308
Rental car – default*	Km	0.234
Taxi travel – distance travelled	Km	0.308
Taxi travel – dollars spent (GST inclusive)	\$	0.123

* The default emission factor should be used if the vehicle size class of rental cars cannot be determined.

Assumptions

The emission factors for taxis and rental cars are the same as those found in Table 3 (transport fuels emission factors) and the underlying assumptions are the same.

The default emission factor for rental cars is the same as that for medium vehicles (1600–<2500 cc). Data from the Motor Industry Association New Vehicle Sales database showed that for the period January 2002–July 2008, 60 per cent of rental vehicles purchased were in the medium vehicle size class.

The default emission factor for taxis is the same as that for large vehicles (≥ 2500 cc) from Table 3. Data from the Motor Industry Association New Vehicle Sales database showed that for the period January 2002–July 2008, 84.2 per cent of taxis purchased were in the large vehicle size class.

The dollars spent emission factor is based on a national average figure of \$2.50 per kilometre travelled. This figure is sourced from Taxicharge New Zealand and includes GST.

Example calculation

An organisation uses rental cars to travel 12,000 km in 2009. It also spends \$18,000 on taxi travel.

Total CO₂-e emissions from rental cars = $12,000 \times 0.234 = 2808$ kg CO₂-e

Total CO₂-e emissions from taxi travel = $\$18,000 \times 0.123 = 2214$ kg CO₂-e

3.3.4 Air travel

The emission factors provided in Table 8 are intended for use by organisations wishing to report their air travel emissions, based on the distance travelled per passenger. The emission factors provided follow those published by the UK Department for Environment Food and Rural Affairs (DEFRA) in their *2010 Guidelines to DEFRA / DECC's GHG Conversion Factors for Company Reporting*.¹⁷ These are deemed to be the most suitable emission factors currently available. The DEFRA publication discusses the emission factor methodology in more detail, including changes in the methodology over time.

Table 8: Emission factors for air travel (based on distance travelled) – 2009

Emission source	Unit	Emission factor total CO ₂ -e (kg CO ₂ -e/unit)
Domestic	pkm*	0.1733
Short haul international (<3700 km)	pkm	0.0980
Long haul international (>3700 km)	pkm	0.1143

* person kilometres

Assumptions

The emission factors contained in Table 8 are based on representative flight distances of: domestic 463 km, short haul 1108 km, and long haul 6482 km. The domestic emission factor should be applied to all domestic flights; the short haul emission factor to flights less than 3700 km; and the long haul emission factor should be applied to any flights greater in length than 3700 km.

¹⁷ www.defra.gov.uk/environment/business/reporting/conversion-factors.htm.

DEFRA endorses a nine per cent great circle distance uplift factor to take into account non-direct (ie, not along the straight-line/great-circle between destinations) routes and delays/circling. This figure comes from the IPCC's publication *Aviation and the Global Atmosphere* (section 8.2.2.3), and is based on studies on penalties to air traffic associated with the European ATS Route Network. This figure is likely to be overstated in New Zealand (initial estimates from Airways New Zealand is that this figure is likely to be less than five per cent). However in the absence of a New Zealand-specific figure it is recommended that those wishing to take a conservative approach apply the nine per cent uplift factor by multiplying the factors in Table 8 by 1.09.

The emission factors refer to aviation's direct carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) emissions only. There is currently uncertainty over the other non-CO₂ climate change effects of aviation (including water vapour, contrails, NO_x, etc) which have been estimated by the IPCC to be up to two to four times those of CO₂ alone. However, the science in this area is currently uncertain and a multiplier is not used for New Zealand's national greenhouse gas inventory reporting. As the emission factors contained in this guide are intended to be consistent with New Zealand's national greenhouse gas inventory reporting, it is not currently deemed appropriate to apply a multiplier to account for other aviation gases and effects.

Example calculation

An organisation makes a number of flights from Auckland to Sydney (2171 km each way). The total distance travelled was 217,100 km.

$$\text{Total CO}_2\text{-e emissions from air travel} = 217,100 * 0.0980 = 21,276 \text{ kg CO}_2\text{-e}$$

3.3.5 Waste to landfill

The emission factors and methodologies provided below will help organisations in estimating their emissions from waste disposed of at a landfill. Emission factors are based on figures from *New Zealand's Greenhouse Gas Inventory 1990–2008* and methodologies are derived from IPCC good practice guidance. The base methodology used is termed 'tier 1' under the IPCC Revised 1996 guidelines and allows all the potential emissions in a tonne of waste to be accounted for in the year of disposal.

Methodologies to determine emissions from wastewater treatment and solid waste incineration are not covered by this guide, as emissions are assumed to be negligible at the individual organisation level (with some exceptions for large industrial wastewater producers).

The anaerobic decomposition of organic waste in landfills generates methane (CH₄). Inventories should be adjusted to account for the landfill gas that is collected and destroyed.¹⁸ The methodologies outlined below provide for such adjustment depending on whether an organisation's waste is sent to a landfill with (or without) a landfill gas collection system.

¹⁸ Where CH₄ is recovered and flared or combusted for energy, the CO₂ emitted from the combustion process is regarded as part of the natural carbon cycle.

Methodologies

Two methodologies for determining a solid waste emission factor are provided. Choice of methodology depends on organisational knowledge of waste composition. It is preferable to know the composition of waste as it allows emissions to be more accurately quantified.¹⁹

Table 9 provides methodologies for four scenarios where composition of an organisation's waste is / is not known, and is sent to a landfill that has / does not have a landfill gas collection system.

If the organisation has data on individual waste streams, but doesn't know if the waste is going to a landfill with a gas collection system, then the default should be the factors for 'without landfill gas recovery' (ie, overestimate rather than potentially underestimate).

If the organisation does not know the composition of its waste but knows it is going to a landfill with a gas recovery system, then it should use the default 'mixed waste' emission factor found in Table 9 unless it is an office-based organisation. Note that this will be an inaccurate emission factor at the organisation level, as it assumes the organisation's waste matches the national average mixed municipal waste composition. If an organisation has an advanced diversion system (to recycling and composting) then this methodology will overestimate emissions. If an organisation has no diversion system, then it could underestimate emissions.

Default emission factors for 'office waste' are provided in Table 9. These should be used by office-based organisations that do not have information on the composition of their waste. The higher emission factors reflect the higher proportion of organic matter (eg, paper and food) found in office waste. The default office waste emission factors assume no diversion has occurred so if an organisation has an advanced diversion system then this methodology will overestimate emissions.

Table 9: Emission factors for waste to landfill – 2009

Emission source	Data input unit	Kgs CO ₂ e/unit
Landfilled waste of known composition (without landfill gas recovery)		
Paper and textiles	kg	2.520
Garden and food	kg	0.945
Wood	kg	1.890
Landfilled waste of known composition (with landfill gas recovery)		
Paper and textiles	kg	1.189
Garden and food	kg	0.446
Wood	kg	0.892
Landfilled waste – default values (without landfill gas recovery)		
Mixed waste (national average)	kg	1.167
Office waste	kg	1.547
Landfilled waste – default values (with landfill gas recovery)		
Mixed waste (national average)	kg	0.551
Office waste	kg	0.730

¹⁹ It also allows you to take into account reductions in emission from altering the composition of your waste (as opposed to just reducing your waste). For example, reducing the amount of paper going to landfill will result in a significantly lower emission factor for waste.

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

Assumptions

The emission factors for office waste represent 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. The derivations of all the emission factors in Table 9 are set out in Appendix C.

Example calculation

An organisation disposes of 30 tonnes of garden waste to a landfill with a gas recovery system in 2009.

Total CO₂-e emissions from waste to landfill = 30,000* 0.453 = 13,590 kg CO₂-e = 13.59 tonnes CO₂-e.

4 References

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Appendix A: Derivation of fuel emission factors

Importance of calorific value

Because the energy content of fuels may vary within and between fuel types, emission factors are commonly expressed in terms of energy units (eg, tonnes CO₂/TJ). This generally provides more accurate emissions estimates than if emission factors are expressed in terms of mass or volume. Converting to emission factors expressed in terms of mass or volume (eg, kg CO₂-e/litre) requires an assumption around which default calorific value should be used.

It is therefore useful to show how the per activity unit (eg, kg CO₂-e/litre) emission factors have been derived, and which calorific values have been used. It is important to note that if you are able to obtain fuel use information in energy units, or know the specific calorific value of the fuel which you are using, then you can calculate your emissions more accurately. All calorific values have been provided by the Ministry of Economic Development. Calorific values are provided in the *New Zealand Energy Data File 2010*, but some calorific values used here have been updated since that publication.

Note that gross calorific values have been used.

CH₄ and N₂O emission factors used in this guide

As stated above, although CO₂ emissions remain constant regardless of the way in which a fuel is combusted, CH₄ and N₂O emissions depend on the precise nature of the activity in which the fuel is being combusted. The emission factors for CH₄ and N₂O therefore vary depending on the combustion process. Table 10 shows the default CH₄ and N₂O emission factors (expressed in terms of energy units) which have been used in this guide. The calculations below show how these have been converted to per activity unit (eg, kg CO₂-e/kg) emission factors. All emission factors contained in Table 10 have been provided by the Ministry of Economic Development.

Note that gross emission factors have been used.

Oxidation factors used in this guide

All oxidation factors used are sourced from the *IPCC Revised Guidelines for National Greenhouse Gas Inventories*. Oxidation factors have been applied only to the CO₂ emission factors (and therefore by default to the CO₂-e emission factors) and have not been applied to the CH₄ and N₂O emission factors. This approach is consistent to that adopted by the National Greenhouse Gas Inventory.

Reference data

Table 10: Underlying data used to derive the per activity unit emission factors – 2009

Emission source	User	Unit	Calorific value (MJ/unit)	T CO ₂ /TJ (after oxidation)	T CH ₄ /TJ	T N ₂ O/TJ
Stationary combustion						
Distributed natural gas	Commercial	KWh	NA	53.2	0.00108	0.00207
		GJ	NA	53.2	0.00108	0.00207
Coal – bituminous	Commercial	Kg	29.16	88.9	0.00971	0.00136
Coal – sub-bituminous	Commercial	Kg	21.63	89.9	0.00956	0.00134
Coal – lignite	Commercial	Kg	15.28	93.3	0.00950	0.00133
Coal – default	Commercial	Kg	21.63	89.9	0.00956	0.00134
Diesel	Commercial	Litre	38.38	68.9	0.000188	0.000376
LPG	Commercial	Kg	49.51	60.4	0.00105	0.000570
Heavy fuel oil	Commercial	Litre	40.94	74.0	0.00285	0.000285
Light fuel oil	Commercial	Litre	40.58	72.9	0.00285	0.000285
Distributed natural gas	Industry	KWh	NA	53.2	0.00126	0.0000900
		GJ	NA	53.2	0.00126	0.0000900
Coal – bituminous	Industry	Kg	29.16	88.9	0.000679	0.00155
Coal – sub-bituminous	Industry	Kg	21.63	89.9	0.000669	0.00153
Coal – lignite	Industry	Kg	15.28	93.3	0.000665	0.00152
Coal – default	Industry	Kg	21.63	89.9	0.000669	0.00153
Diesel	Industry	Litre	38.38	68.9	0.000188	0.000376
LPG	Industry	Kg	49.51	60.4	0.00105	0.000570
Heavy fuel oil	Industry	Litre	40.94	74.0	0.00285	0.000285
Light fuel oil	Industry	Litre	40.58	72.9	0.00285	0.000285
Wood	Industry	Kg	9.63	130.7	0.0143	0.00380
Wood	Fireplaces*	Kg	12.08	104.2	0.285	0.00380
Transport fuels						
Regular petrol	Mobile use	Litre	35.05	66.38	0.0185	0.00142
Premium petrol	Mobile use	Litre	35.22	67.00	0.0186	0.00143
Diesel	Mobile use	Litre	38.38	68.85	0.00376	0.00367
LPG	Mobile use	Litre	26.54	60.43	0.0285	0.000570
Marine diesel	Mobile use	Litre	38.39	70.62	0.00669	0.00191
Heavy fuel oil	Mobile use	Litre	40.94	73.96	0.00666	0.00190
Light fuel oil	Mobile use	Litre	40.58	72.90	0.00666	0.00190

Table 11 contains the GWPs for CO₂, CH₄ and N₂O that have been used in converting to CO₂ equivalent emission factors, based on the IPCC's 1996 Second Assessment Report.

Table 11: Global warming potentials for CO₂, CH₄ and N₂O

	CO ₂	CH ₄	N ₂ O
Global warming potential	1	21	310

Example derivation of emission factors

The sub-bituminous coal emission factors for commercial use are derived as follows:²⁰

$$\begin{aligned}\text{CO}_2 \text{ emission factor (kg CO}_2\text{/kg)}^{21} &= (\text{Calorific value} \times \text{TCO}_2 \text{ per TJ emission factor}) / 1000 \\ &= (21.63 \times 89.9) / 1000 \\ &= 1.94 \text{ kg CO}_2\text{/kg coal} \\ \text{CH}_4 \text{ emission factor (kg CO}_2\text{-e/kg)} &= [(\text{Calorific value} \times \text{TCH}_4 \text{ per TJ emission factor}) \times \text{GWP of CH}_4] / 1000 \\ &= [(21.63 \times 0.00956) \times 21] / 1000 \\ &= 0.00434 \text{ kg CO}_2\text{-e/kg} \\ \text{N}_2\text{O emission factor (kg CO}_2\text{-e/kg)} &= [(\text{Calorific value} \times \text{TN}_2\text{O per TJ emission factor}) \times \text{GWP of N}_2\text{O}] / 1000 \\ &= [(21.63 \times 0.00134) \times 310] / 1000 \\ &= 0.00897 \text{ kg CO}_2\text{-e/kg} \\ \text{Total CO}_2\text{-e emission factor (kg CO}_2\text{-e/kg)} &= \text{Sum of CO}_2, \text{CH}_4 \text{ and N}_2\text{O emission factors} \\ &= 1.96 \text{ CO}_2\text{-e/kg}\end{aligned}$$

Note that if you knew that the calorific value of your coal was different to the default calorific value used in the above calculation, you could substitute your specific calorific value and obtain a more accurate (specific) emission factor.

²⁰ Note that some values may not multiply or add exactly as they have been rounded.

²¹ Tonnes CO₂/TJ = kg CO₂/GJ. Division by 1000 converts this to kg CO₂/MJ, consistent with the calorific value (MJ/unit of activity).

Appendix B: Methods for calculating emissions from refrigeration

Greenhouse gas emissions from hydrofluorocarbons (HFCs) are associated with unintentional leaks and spills from refrigeration units, air conditioners and heat pumps. While quantities of HFCs reported in a business emissions inventory may be small, HFCs have very high global warming potentials (commonly 1300 to 3300 times more potent than CO₂) and emissions from this source may therefore be material. In addition, emissions associated with this sector are growing significantly as they replace chlorofluorocarbons and hydrochlorofluorocarbons (CFCs and HCFCs).

Scope 1 emissions from refrigeration occur from refrigeration units which are owned or controlled by the reporting organisation. If the unit is leased, associated emissions should be reported under Scope 3 emissions.

Methodologies

Three approaches can be taken to assess HFC leakage from refrigeration equipment. The approach taken should be dependent upon the type of equipment you are performing the calculation for and the level of information available to you (see Choosing a Method below).

Method A – Life-cycle stage approach

$$E = (IE + S + DE) \times GWP$$

Where:

- E = emissions from the piece of equipment in kg CO₂-e (per year)
- IE = installation emissions (refrigerant used to charge new equipment less the total full charge²² of new equipment. This is omitted if the equipment has been pre-charged by the manufacturer)
- S = recorded quantity of refrigerant used to service equipment, also referred to as a ‘top-up’
- DE = disposal emissions (total full charge of retiring equipment less the refrigerant recovered from retiring equipment)
- GWP = the 100-year global warming potential of the refrigerant used in equipment (Table 13).

This approach is detailed in the *GHG Protocol HFC tool* (WRI/WBCSD 2005). This method requires service agents’ advice being sought for the following information on each piece of equipment, truck or bus operated by the organisation:

1. refrigerant type
2. full refrigerant charge
3. quantity used in installation of new equipment
4. quantity used in servicing
5. quantity recovered from retired equipment.

²² ‘Total full charge’ refers to the full, original charge of the equipment rather than to the actual charge, which may reflect leakage.

The equations for installation, operation and disposal emissions are explained in more detail in the *GHG Protocol HFC tool* guide.

Method B – Default annual leakage rate

$$E = (IE + OE + DE) \times GWP$$

Where:

- E = emissions from equipment in kg CO₂-e
- IE = installation emissions (as applicable – see above)
- OE = operation emissions
- DE = disposal emissions (as applicable – see above)
- GWP = the 100-year global warming potential of the refrigerant used in equipment (Table 13).

$$IE = C \times AEF$$

- C = original full refrigerant charge in equipment (kg)
- AEF = the default installation leakage for new equipment (%). This is omitted if the equipment has been pre-charged by the manufacturer

$$OE = C \times ALR$$

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

$$DE = (C \times (1 - (ALR \times S)) \times (1 - R) - D)$$

- C = original full refrigerant charge in equipment (kg)
- ALR = the default leakage for equipment (%)
- S = time since last recharge of equipment (years)
- R = amount of charge recycled from equipment (%)
- D = amount of refrigerant destroyed from equipment (kg)

Default leakage rates for calculation of installation (IE) and operating emissions (OE) are contained in Table 12. When calculating disposal emissions (DE), a value of zero (ie, no recycling or destruction) must be assumed if the amount of recycled (R) or destroyed (D) refrigerant is unknown.

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

Method C – Default annual leakage rate and default refrigerant charge

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

Where:

- E = emissions from equipment in kg CO₂-e
- IE = installation emissions (as per method B)
- C = default refrigerant charge in each piece of equipment (kg)
- ALR = default annual leakage emission factor for equipment (%)
- DE = disposal emissions (as per method B)
- GWP = the 100-year global warming potential of the refrigerant used in equipment (Table 13)

Method C is the same as Method B except that it allows default refrigerant quantities to be used as well as default leakage rates. Table 12 contains default refrigerant amounts for the New Zealand refrigeration and air conditioning equipment stock.

Choosing a method

The most accurate methodology is Method A – the life-cycle stage approach. The information required can be collected with the assistance of service agents, vehicle fleet managers or building managers. Currently however, these quantities are seldom recorded but it would be good practice to encourage service agents to record these amounts for future reporting. If an organisation determines that emissions from equipment are significant then it should endeavour to move to a Method A approach to estimate HFC emissions.

In some circumstances, gathering the information required for Method A may not be possible or due to the resource intensive nature of collecting detailed information for a particular type of equipment, may not be justifiable. If so, then Method B and C can be used in some circumstances (refer to guidance in Table 12) to measure leakage rates with the default factors also provided in Table 12. Method B and C are based on the ‘screening’ method approach contained in the *Greenhouse Gas Protocol HFC tool 2005*.

In some cases Method C is only suitable for investigating the approximate quantity of emissions when the refrigerant charge amount is unavailable. Screening provides a way of determining if the equipment should/should not be excluded based on significance of emissions from refrigerants. However, sometimes, depending on the equipment in question, Methods B and C would be so unreliable that they would be unacceptable even for a screening method.

Apart from office refrigerators, water coolers and car/van air conditioning, Method A should be considered the recommended method (see Table 12). For most equipment, Method B would be acceptable, especially for factory and office situations where refrigeration and air conditioning equipment is incidental rather than central to an organisation’s operations.

For supermarket refrigeration, commercial air conditioning (above 20kW), dairy farming, industrial, commercial and laboratory coolstores, the size ranges and configurations are so varied that there will be no meaningful default refrigerant charge amounts or emission factors. In these cases, there would be no reasonable alternative to Method A, relying on the leakage information available from service agents.

It is stressed that for all equipment for all methods, the type of refrigerant must be individually identified because the global warming potential of various refrigerant mixes are widely variable (see Table 13).

Organisations should also provide information on the approach used to quantify direct HFC emissions in their inventories to reflect the different levels of associated accuracy and uncertainty with each method.

Table 12: Default refrigerant charges and emission factors for refrigeration and air conditioning equipment

Refrigeration unit type	Default refrigerant charge (kg)	Default leakage rate (operating – ALR)	Default leakage rate (installation – AEF) ²³	Guidance on method choice		
				Method A	Method B	Method C
Small refrigerator or freezer (up to 150 litres ²⁴)	0.07	3%	Not applicable	Unnecessary	Recommended	Acceptable
Medium refrigerator or freezer (up to 300 litres)	0.11	3%	Not applicable	Unnecessary	Recommended	Acceptable
Large refrigerator or freezer (more than 300 litres)	0.15	3%	Not applicable	Unnecessary	Recommended	Acceptable
Small commercial stand-alone chiller (up to 300 litres)	0.25	8%	Not applicable	Recommended	Acceptable	Screening method only
Medium commercial stand-alone chiller (up to 500 litres)	0.45	8%	Not applicable	Recommended	Acceptable	Screening method only
Large commercial stand-alone chiller (more than 500 litres)	0.65	8%	Not applicable	Recommended	Acceptable	Screening method only
Small commercial stand-alone freezer (up to 300 litres)	0.2	8%	Not applicable	Recommended	Acceptable	Screening method only
Medium commercial stand-alone freezer (up to 500 litres)	0.3	8%	Not applicable	Recommended	Acceptable	Screening method only
Large commercial stand-alone freezer (more than 500 litres)	0.45	8%	Not applicable	Recommended	Acceptable	Screening method only
Water coolers	0.04	3%	Not applicable	Unnecessary	Recommended	Acceptable
Dehumidifiers	0.17	3%	Not applicable	Unnecessary	Recommended	Acceptable
Small self-contained air conditioners (window mounted or through-the-wall)	0.2kg per kW cooling capacity	1%	0.5%	Recommended	Acceptable	Screening method only
Non-ducted and ducted split commercial air conditioners (up to 20kW)	0.25kg per kW cooling capacity	3%	0.5%	Recommended	Acceptable	Screening method only
Commercial air conditioning (above 20kW)	wide range	Wide range	Wide range	Recommended	Unacceptable	Unacceptable
Cars/vans	0.7	10%	Not applicable	Unnecessary	Recommended	Acceptable
Trucks	1.2	10%	Not applicable	Recommended	Acceptable	Screening method only
Buses	2.5 (but up to 10)	10%	Not applicable	Recommended	Acceptable	Screening method only
Refrigerated truck trailer units	10	25%	0.5%	Recommended	Acceptable	Unacceptable
Self-powered or 'cab-over' refrigerated trucks	6	25%	0.5%	Recommended	Acceptable	Unacceptable
'Off-engine' or 'direct drive' refrigerated vans and trucks	2.5	25%	0.5%	Recommended	Acceptable	Unacceptable
Three-phase refrigerated containers	5.5	25%	0.5%	Recommended	Acceptable	Unacceptable

²³ 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.

²⁴ 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) ²³	Guidance on method choice		
				Method A	Method B	Method C
Single-phase refrigerated containers	3	25%	0.5%	Recommended	Acceptable	Unacceptable
Centralised commercial refrigeration eg, supermarkets	Wide range	Wide range	Wide range	Recommended	Unacceptable	Unacceptable
Industrial and commercial coolstores	Wide range	Wide range	Wide range	Recommended	Unacceptable	Unacceptable

Table 13: Detailed 100-year global warming potentials for various refrigerant mixtures²⁵

Refrigerant type (trade name)	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	PFC-218	Other*	Total GWP
GWP 100yr (IPCC, 1996)	11700	650	2800	1300	3800	140	7000	0	
R23	100%								11700
R134a				100%					1300
R403B: 5% R290, 56% R22, 39% R218							39%	61%	2730
R404A: 44% R125, 52% R143a, 4% R134a			44%	4%	52%				3260
R407C: 23% R32, 25% R125, 52% R134a		23%	25%	52%					1526
R408A: 7% R125, 46% 143a, 47% R22			7%		46%			47%	1944
R410A: 50% R32, 50% R125		50%	50%						1725
R413A: 9% R218, 88% R134a, 3% R600a				88%			9%	3%	1774
R416A: 59% R134a, 39.5% R124, 1.5% R600				59%				41%	767
R417A: 46.6% R125 50% R134a 3.4% R600			46.6%	50%				3.4%	1955
R422A: 85.1% R125, 11.5% R134a, 3.4% R600a			85.1%	11.5%				3.4%	2532
R507A: 50% R125, 50% R143a			50%		50%				3300

Assumptions

The default factors for installation, operation and disposal of refrigerant equipment supplied in Table 12 are derived from 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.

The greatest potential for significant emissions from refrigeration and air conditioning equipment is in the disposal stage of the life cycle. Recycling efficiency is likely to be high (around 90 per cent) for reputable service agents but in the absence of consistent information for New Zealand, the default assumption is 0 per cent recycling/destruction of the remaining charge in all sectors. It is assessed that there is no current justification for applying a lower default emission factor to any sector to reflect refrigerant gas collection for destruction. Refrigerants are often recycled within various sectors but the quantity currently shipped to Australia for destruction is relatively small.

²⁵ For consistency, until 2012, global warming potentials are set according to the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Intergovernmental Panel on Climate Change www.ipcc.ch.

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 be applicable (relevant) for many pre-charged units.

For simplicity, the default operating emission factor does not take account of the variability associated with equipment age.

Example calculations

A detailed example has been provided below.

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

- two office refrigerators
- one large commercial sized refrigerator
- one air conditioning unit (which is retired in the reporting year and replaced by a new model)
- two mobile air conditioning (MAC) units in the company owned car and delivery truck
- one delivery truck owned by the company
- two external delivery trucks operated by another company, but included in Scope 3 emissions.

To assess their emissions, the company takes the following approach for each type of equipment.

Two office refrigerators

Method B is the recommended approach and is relatively easy for newer equipment in this sector because compliance plates for refrigerators and freezers are nearly always accessible inside the fridge. (Alternatively, a Method C approach is acceptable, though less accurate, for refrigerant charges based on Table 1.)

Compliance plates inside the two large refrigerators confirm the refrigerant is R134A and the refrigerant amounts are 0.17 kg each.

Using Method B approach:

$$E = (IE + OE + DE) \times GWP$$

$$E = 2(0 + (0.17 \times 3/100) + 0) \times 1300$$

$$E = 2(0+0.0051+0) \times 1300$$

$$E = 13 \text{ kg CO}_2\text{-e}$$

One large commercial sized refrigerator

Method A is the recommended approach to capture the significant leakage rates for commercial sized refrigerators. The company's service agents have maintained refrigerant top-up records for each piece of equipment at the company's request.

The large commercial refrigerator unit uses R404A refrigerant and the compliance plates show the refrigerant amount is 1.7 kg. Maintenance records for the refrigeration unit show it has been topped up by the service agent during the year with 0.32 kg.

Using Method A:

$$E = (IE + S + DE) \times GWP$$

$$E = (0 + 0.32 + 0) \times 3260$$

$$E = 1043 \text{ kg CO}_2\text{-e}$$

One commercial air conditioning unit

Method A is recommended for all commercial air conditioning units with the cooperation of service agents. Method B would be acceptable for all systems up to 20 kW but above that rating, refrigerant amounts and leakage rates are so site specific that there is no acceptable alternative to a Method A approach. Method C could be used as a screening test (Table 1) where the HFC refrigerant amount is not specified and the cooling capacity (up to 20 kW) is known.

The old air conditioning system for the company's building (using R407C HFC refrigerant (GWP 1526)) was retired and replaced in August of the 2007 reporting (calendar) year. The service agent did the annual servicing in January 2007, topping up the old system with 1.1 kg R407C to return it to the full charge of 8.5 kg (a high annual leakage rate of 13 per cent). This represents the leakage for the current accounting year even though most of it would have occurred in the previous year. The service agent records show that 6.8 kg (80 per cent) of the original charge in the old equipment was collected for destruction (because its quality was too degraded for recycling).²⁶

The service agent records show that 7.1 kg of R410A was used to fill the new air conditioning system. The full charge of the system is 7.0 kg of R410A (GWP 1725). Therefore 0.1 kg of R401A was lost during installation. No top up was required in the reporting year for the new system. Any leakage from August to December would not be accounted for until the following year if it is not topped up until the following January.

Using Method A approach:

$$E = (IE + S + DE) \times GWP^{27}$$

Installation emissions (IE) = refrigerant used to charge new equipment – total full charge of new equipment

$$= (7.1 - 7.0) \times 1725$$

$$= 173 \text{ kg CO}_2\text{-e}$$

Servicing emissions (S) = quantity of refrigerant used to service old equipment

$$= 1.1 \times 1526$$

$$= 1679 \text{ kg CO}_2\text{-e}$$

²⁶ This example is unlikely to happen for a few years until the relatively recent R407C and R410A equipment are being retired. R22 is more likely to be the retired refrigerant currently and this is omitted from the accounting because it is not a HFC.

²⁷ As global warming potentials are different for the air conditioning units they are calculated separately here.

Disposal emissions (DE) = total full charge of retiring equipment – refrigerant recovered from retiring equipment

$$= (8.5 - 6.8) \times 1526$$

$$= 2594 \text{ kg CO}_2\text{-e}$$

$$E = 173 + 1679 + 2594$$

$$= \mathbf{4446 \text{ kg CO}_2\text{-e}}$$

Mobile air conditioning (MAC)

Method A is recommended for trucks and buses with the cooperation of service agents. Method B is recommended for cars and vans (and acceptable for trucks and buses) because information on refrigerant amounts should be relatively straightforward for service agents to gather during maintenance. Method C (see Table 1) is acceptable for cars and vans and can be used as a screening test for trucks and buses until a regular fleet monitoring scheme is established. This is the case for the company at this stage.

The company owns one delivery truck and one car that are fitted with MAC units. It uses R134A refrigerant (GWP 1300).

Using Method C:

$$\begin{aligned} \text{Operation emissions (truck)} &= (1.2 \times 10/100 \times 1300) = 156 \\ \text{(car)} &+ (0.7 \times 10/100 \times 1300) = 91 \\ &= \mathbf{247 \text{ kg CO}_2\text{-e}} \end{aligned}$$

Refrigerated transport

Method A is recommended due to the high potential for leakage from this sector. Where this is not practical (high turnover of a large number of refrigerated trucks or containers), a Method B approach is acceptable.

The company owns one refrigerated truck. It is a larger self-powered unit (6 litres) and the compliance plates show R404A refrigerant (GWP 3620). Service agents have topped up the refrigerant twice over the year to a total of 1.32 kg. The organisation also accounts for two large three-phase refrigerated containers it operates that are owned by a contractor – one uses R22 and one R404A. The R22 refrigerated container is not included in the inventory. They are not able to collect service data and therefore use Method B to estimate emissions.

Using Method A for Scope 1:

$$\begin{aligned} \text{Operation emissions} &= S \times \text{GWP} \\ &= 1.32 \times 3260 \\ &= \mathbf{4303 \text{ kg CO}_2\text{-e}} \end{aligned}$$

Using Method B for Scope 3:

$$\begin{aligned} \text{Operation emissions} &= (C \times \text{ALR}) \times \text{GWP} \\ &= (5.5 \times 25/100) \times 3260 \\ &= \mathbf{4483 \text{ kg CO}_2\text{-e}} \end{aligned}$$

Therefore, total emissions for the company for refrigeration are:

Scope 1	kg CO₂-e
Office refrigeration	13
Large commercial sized refrigerator	1043
Commercial air conditioning unit	4446
Mobile air conditioning (MAC)	247
Refrigerated transport	4303
SCOPE 1 TOTAL	10052
Scope 3	
Refrigerated transport	4483
SCOPE 3 TOTAL	4483

Appendix C: Derivation of emission factors for waste to landfill

Base equation

The base equation used in deriving the waste emission factors, as taken from the 1996 *IPCC Good Practice Guidelines*, is as follows:

$\text{CO}_2\text{-e emissions (kg)} = ((\text{MSW}_T \times \text{DOC} \times \text{DOC}_F \times F \times 16/12) \times (1 - R) \times (1 - \text{OX})) \times 21$
--

Where: MSWT = total Municipal Solid Waste (MSW) generated (kg); DOC = degradable organic carbon; DOCF = fraction of DOC dissimilated; F = fraction of CH₄ in landfill gas; R = fraction recovered CH₄; OX = oxidation factor; 21 = GWP of methane (CH₄).

MSW_T = Activity data
DOC = 0.4 for paper and textiles, 0.15 for garden and food waste, and 0.3 for wood
DOC_F = 0.5
F = 0.5
16/12 – convert carbon to CO₂
R = 0.528 where landfill gas systems are in place, 0 otherwise
OX = 0.1

Table 14 shows how this equation has been applied to derive the emission factors for waste deposited to landfill.

Table 14: Derivation of emission factors for waste deposited to landfill

Emission source	Data input unit	Kgs CO ₂ e/unit	Equation
Landfilled waste of known composition (without landfill gas recovery)			
Paper and textiles	kg	2.520	$(0.4 * 0.5 * 0.5 * 16/12) * (1-0.1) * 21$
Garden and food	kg	0.945	$(0.15 * 0.5 * 0.5 * 16/12) * (1-0.1) * 21$
Wood	kg	1.890	$(0.3 * 0.5 * 0.5 * 16/12) * (1-0.1) * 21$
Landfilled waste of known composition (with landfill gas recovery)			
Paper and textiles	kg	1.189	$(0.4 * 0.5 * 0.5 * 16/12) * (1-0.528) * (1-0.1) * 21$
Garden and food	kg	0.446	$(0.15 * 0.5 * 0.5 * 16/12) * (1-0.528) * (1-0.1) * 21$
Wood	kg	0.892	$(0.3 * 0.5 * 0.5 * 16/12) * (1-0.528) * (1-0.1) * 21$
Landfilled waste – default values (without landfill gas recovery)			
Mixed waste (national average) ²⁸	kg	1.167	$0.0618 * (1-0.1) * 21$
Office waste	kg	1.547	$((0.536 * 0.4) + (0.208 * 0.15) + (0 * 0.3)) * 0.5 * 0.5 * 16/12 * (1-0.1) * 21$
Landfilled waste – default values (with landfill gas recovery)			
Mixed waste (national average)	kg	0.551	$0.0618 * (1-0.528) * (1-0.1) * 21$
Office waste ²⁹	kg	0.730	$((0.536 * 0.4) + (0.208 * 0.15) + (0 * 0.3)) * 0.5 * 0.5 * (16/12) * (1-0.528) * (1-0.1) * 21$

²⁸ 0.0618 is published within the national greenhouse gas inventory supplementary table 6.1A as the methane generation potential of a Gg of solid waste.

²⁹ These figures represent 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.