Ministry for the Environment
Manatū Mō Te Taiao

Guidance for Voluntary Corporate Greenhouse Gas Reporting

Data and Methods for the 2011 Calendar Year

New Zealand Government

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This is the sixth version of an annual publication.

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

Changes to data and methodology for the 2011 calendar year

Scope 1

Stationary combustion – emission factors for stationary combustion have been updated based on new figures for the 2011 calendar year.

Transport fuels – emission factors for transport fuels have been updated based on new figures for the 2011 calendar year.

No estimates are available for marine diesel for the 2011 calendar year 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.

Scope 2

Purchased electricity – the electricity emission factor has been updated based on new figures for the 2011 calendar year.

A time series of electricity emission factors are provided from 1990 to 2011 in the Microsoft Excel workbook.

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 2011 calendar year.

Taxis/rental cars – emission factors for travel in taxis/rental cars have been updated based on new figures for the 2011 calendar year.

Air travel – emission factors for air travel have been updated based on the latest data from the Department of Environment, Food and Rural Affairs (DEFRA) in the United Kingdom. Following feedback from users of this guidance, the emission factors for international flights are now broken down by cabin class.

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 2011 calendar year. The mixed waste factor has been updated based on national average composition data from *New Zealand's Greenhouse Gas Inventory 1990–2010* (MfE, 2012).

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 for voluntary corporate greenhouse gas (GHG) reporting, including emission factors.

The guide encourages best practice in GHG reporting and supports voluntary GHG reporting initiatives. It endorses the referenced reporting frameworks such as *The GHG Protocol* 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 GHG inventory reporting.

1.2 Who is this guide intended for?

This guide is for organisations who wish to voluntarily report GHG 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.[1] In addition, the GHG Protocol Initiative has published standards for the calculation of life-cycle emissions.[2]

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1 http://www.defra.gov.uk/publications/2012/05/30/pb13773-2012-ghg-conversion/.

2 http://www.ghgprotocol.org/product-life-cycle-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 report their GHG 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.

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

The information in this guide may, however, be useful to organisations that have a reporting obligation under an emissions trading scheme for a particular activity within their business, but that still wish to publish comprehensive emission reports for their organisation on a voluntary basis. Although this 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 standards should I follow to report emissions?

The Ministry for the Environment (the Ministry) recommends organisations 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 and removals* (*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 http://www.ghgprotocol.org/standards/corporate-standard.

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 reporting.

1.4.1 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.

1.4.2 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 reporting GHG 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 GHG Protocol* useful for providing context.

1.5 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 carbon dioxide (CO_2) 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 GHG 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 available.

> This guide provides emission factors and methods for common emission sources, for the 2011 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.

1.6 Verification

1.6.1 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 organisations obtain independent verification of the inventory to confirm that calculations are accurate, and the correct methodology has been followed.

1.6.2 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*.[3]

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.

Organisations 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 GHG emission reductions on a project basis.[4] While verification of GHG emission reductions from projects is a different task than verification of organisation-level GHG 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*.

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3 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.

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

2 Emission factors and methods – context

Following feedback from users of this guidance, all emission factors have also been included in a standalone pdf file and Microsoft Excel workbook.

The emission factors reported in this guide are intended to be default factors (ie, to be used in the absence of better company or industry-specific 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 GHG 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.

These emission factors are largely derived from technical information published by New Zealand government agencies. For example, the Ministry of Business, Innovation and Employment is the main source of information for the stationary combustion and electricity emission factors. Each section provides the source for each emission factor and how the factors are derived.

This guidance covers the six direct Kyoto gases (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) covered by *ISO 14064-1* and *The GHG Protocol.* This is also consistent with the reporting requirements for New Zealand's national GHG 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 CO_2-e. The emission factors in this guide therefore convert activity data into the equivalent estimate of CO_2-e per unit of activity data (eg, kg CO_2-e/litre of petrol).

Under the reporting requirements of *ISO 14064-1* 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 guidance presents emission factors in kg CO_2-e per unit. Division by 1000 converts kg to tonnes (see example calculations on the following pages). Emission factors presented in CO_2-e use the global warming potentials for methane and nitrous oxide from the IPCC's Second Assessment Report, consistent with the Kyoto Protocol.[5]

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

In line with the reporting requirements of *ISO 14064-1*, the emission factors allow calculation of CO_2, CH_4 and N_2O separately, as well as the total CO_2 equivalent for Scope 1 emission sources (discussed in Section 2.2).

Carbon dioxide emission factors are based on the carbon and energy content of a fuel. The CO_2 emissions therefore remain constant regardless of the way in which a fuel is combusted. However, CH_4 and N_2O (ie, non-CO_2) emissions depend on the manner in which the fuel is being combusted. The emission factors for CH_4 and N_2O therefore vary depending on the combustion process.[6] To reflect this variability, the guidance provides uncertainty estimates for Scope 1 emission factors. Separate CO_2-e emission factors for residential, commercial and industrial users are presented in table 1. The relevant Ministry of Business, Innovation and Employment 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. The accompanying Microsoft Excel workbook also provides further details on how the emission factors were 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 guidance with an explanation these are the latest available published emission factors.

The emission factors most likely to change from year to year are the electricity factors (scope 2 and 3). If emissions from electricity are the major source of a company's emissions you could pro rata the electricity emission factors for the appropriate years.

If updated emission factors are not available for the year you are reporting, a reasonable approach is to use the emission factors in the latest available voluntary GHG guidance and state they are provisional.

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[6] For example, the CH_4 and N_2O emission factors for diesel used for industrial heating are different to the CH_4 and N_2O emission factors for diesel used in vehicles.

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.
- 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 2011

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 CO_2, CH_4 and N_2O separately.

Table 1: Fuel combustion emission factors (fuels used for stationary combustion) – 2011

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_2O (kg CO_2-e/unit)	Uncertainty Total CO_2-e (%)
Stationary combustion							
Coal – bituminous	Residential		2.76	2.57	0.177	0.0122	4.8
Coal – sub-bituminous	Residential	Kg	2.08	1.94	0.130	0.00895	3.3
Coal – lignite	Residential	Kg	1.53	1.43	0.0916	0.00631	2.3
Coal – default*	Residential	Kg	1.86	1.74	0.115	0.00791	3.3
Distributed natural gas	Commercial	KWh	0.193	0.191	0.0000816	0.00231	2.4
		GJ	53.7	53.0	0.0227	0.642	2.4
Coal – bituminous	Commercial	Kg	2.59	2.57	0.00589	0.0122	3.5
Coal – sub-bituminous	Commercial	Kg	1.95	1.94	0.00433	0.00895	3.5
Coal – lignite	Commercial	Kg	1.44	1.43	0.00305	0.00631	3.5
Coal – default*	Commercial	Kg	1.69	1.68	0.00368	0.00761	3.5
Diesel	Commercial	Litre	2.66	2.65	0.000537	0.00453	0.5
LPG**	Commercial	Kg	2.89	2.88	0.00110	0.00884	0.5
Heavy fuel oil	Commercial	Litre	3.00	2.99	0.00114	0.00362	0.5
Light fuel oil	Commercial	Litre	2.94	2.93	0.00114	0.00359	0.5
Distributed natural gas	Industry	KWh	0.191	0.191	0.0000953	0.000100	2.4
		GJ	53.1	53.0	0.0265	0.0279	2.4
Coal – bituminous	Industry	Kg	2.59	2.57	0.000413	0.0139	3.5
Coal – sub-bituminous	Industry	Kg	1.95	1.94	0.000303	0.0102	3.5

Coal – lignite	Industry	Kg	1.44	1.43	0.000214	0.00721	3.5
Coal – default*	Industry	Kg	2.15	2.14	0.000338	0.0114	3.5
Diesel	Industry	Litre	2.66	2.65	0.000153	0.00453	0.5
LPG**	Industry	Kg	2.89	2.88	0.00110	0.00884	0.5
Heavy fuel oil	Industry	Litre	3.00	2.99	0.00245	0.00362	0.5
Light fuel oil	Industry	Litre	2.94	2.93	0.00244	0.00359	0.5
Wood	Industry***	Kg	0.0142	1.00	0.00288	0.0113	41.1
Wood	Fireplaces****	Kg	0.0690	1.00	0.0576	0.0113	42.6

Rounding is to 3 significant figures.

* The default coal emission factor should be used if it is not possible to identify the specific type of coal. Note, the default for industrial use of coal does not include coal used by the dairy industry as it is expected this sector would know the type of coal it consumes.

** 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 CO_2-e emission factor for wood only includes CH_4 and N_2O emissions. This is based on *ISO 14064-1* and *The GHG Protocol* reporting requirements for combustion of biomass as Scope 1 emissions. CO_2 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 they know the heating value of the coal they use.

Assumptions

The kg CO_2-e per activity unit emission factors supplied in table 1 are derived by the Ministry of Business, Innovation and Employment using calorific values. The calorific values used can be found in Appendix A.

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 calculated 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). Emission factors for residential coal have been included for completeness.

The Automotive Gas Oil-10 ppm Sulphur emission factor (provided in the *Energy Greenhouse Gas Emissions (2011)* 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 2011.

CO_2 emissions = 1400 * 2.88 = 4032 kg CO_2
CH_4 emissions = 1400 * 0.00110 = 1.54 kg CO_2-e
N_2O emissions = 1400 * 0.00884 = 12.376 kg CO_2-e
Total CO_2-e emissions = 1400 * 2.89 = 4046 kg CO_2-e

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 Business, Innovation and Employment.

Table 2: Fuel combustion emission factors (transport fuels) – 2011

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_2O (kg CO_2-e/unit)	Uncertainty Total CO_2-e (%)
Regular petrol	litre	2.34	2.31	0.0136	0.0155	0.7
Premium petrol	litre	2.36	2.33	0.0137	0.0156	0.7
Petrol – default*	litre	2.34	2.31	0.0137	0.0155	0.7
Diesel	litre	2.70	2.65	0.00307	0.0442	1.0
LPG	litre	1.55	1.53	0.0159	0.00469	0.7
Heavy fuel oil	litre	3.02	2.99	0.00572	0.0241	0.6
Light fuel oil	litre	2.96	2.93	0.00568	0.0240	0.6

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

Assumptions

The kg CO_2-e per activity unit emission factors supplied in table 2 are derived by the Ministry of Business, Innovation and Employment using calorific values. All emission factors incorporate relevant oxidation factors which are sourced from *The IPCC Revised Guidelines for National Greenhouse Gas Inventories* (IPCC, 1996).

The default petrol factor is a weighted average of regular and premium petrol based on 2011 sales volume data from the *New Zealand Energy Data File 2012* (MBIE, 2012). It should be used when petrol use data does not distinguish between regular and premium petrol.

No estimates have been included for marine diesel for the 2011 year 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 instead so the emission factor for light fuel oil should be used.

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 2011.

CO_2 emissions = 40,000 * 2.31 = 92,400 kg CO_2
CH_4 emissions = 40,000 * 0.0136 = 544 kg CO_2-e
N_2O emissions = 40,000 * 0.0155 = 620 kg CO_2-e
Total CO_2-e emissions = 40,000 * 2.34 = 93,600 kg CO_2-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 based on distance travelled shown 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 CO_2-e emissions are less accurate than calculating emissions based on fuel-use data. The emission factors in table 3, based on distance travelled, should therefore only be used if information on fuel use is not available.

Table 3: Transport emission factors (based on distance travelled) – 2011

Vehicle size class*	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_2O (kg CO_2-e/unit)
Car – small (<1600 cc)	Km	0.181	0.179	0.00106	0.00120
Car – medium (1600–<2500 cc)	Km	0.237	0.234	0.00138	0.00157
Car – large (≥ 2500 cc)	Km	0.308	0.305	0.00180	0.00204
Car – default**	Km	0.237	0.234	0.00138	0.00157

* 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 cannot 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 rates[7] for the petrol light vehicle fleet, based on vehicle fleet statistics from the 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 CO_2-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).[8]

Example calculation

An organisation has three vehicles which it owns. They are all large vehicles and travelled a total of 37,800 km in 2011.

CO_2 emissions = 37,800* 0.305 = 11,529 kg CO_2
CH_4 emissions = 37,800* 0.00180= 68.04 kg CO_2-e
N_2O emissions = 37,800* 0.00204 = 77.1 kg CO_2-e
Total CO_2-e emissions = 37,800* 0.308 = 11,642 kg CO_2-e

3.1.4 Refrigerants

GHG 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 CO_2) 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

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7 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 1.185. The figures are based on consumption rates for new vehicles sold in New Zealand between 2008 and 2010.

8 In 2010, 66 per cent of new light petrol vehicles sold in New Zealand were in the medium vehicle size class, 20 per cent were small and 15 per cent were large. (*Source*: Ministry of Transport 2010 NZ vehicle fleet annual statistics).

the equipment and available information. Details of these three methods are available 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.

CFCs and HCFCs can have very high global warming potentials (up to 14,400 times as potent as CO_2 over 100 years), however they are not included in GHG 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*.[9] HCFC R22 is the predominant HCFC used in New Zealand and its global warming potential is included in the tables in Appendix B for convenience.

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.[10]

Table 4: Emission factor for the consumption of purchased electricity – 2011

Emission source	Unit	Emission factor total CO_2-e (kg CO_2-e/unit)
Purchased electricity	kWh	0.129

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.

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

10 It does not cover on-site, self-generation of 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 for purchased electricity is derived from the net electricity generation data (as opposed to consumption data) in the *New Zealand Energy Data File 2012.* 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 for purchased electricity 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 CO_2-e emissions associated with the generation of a unit of electricity, purchased from the national grid, in New Zealand in 2011. Retailer specific electricity factors for grid electricity are out of scope for this guidance.

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.

Example calculation

An organisation uses 800,000 kWh of electricity in 2011. Its Scope 2 emissions from electricity are:

Total CO_2-e emissions = 800,000 * 0.129 = 103,200 kg CO_2-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. The emission factor for the 2011 calendar year is shown in table 5.

Table 5: Transmission and distribution line losses for purchased electricity – 2011

Emission source	Unit	Emission factor total CO_2-e (kg CO_2-e/unit)
Transmission and distribution losses for purchased electricity	kWh	0.0133

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.[11]

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 2011. Its Scope 3 emissions from transmission and distribution line losses for purchased electricity are:

Total CO_2-e emissions = 800,000 * 0.0133 = 10,640 kg CO_2-e

3.3.2 Transmission and distribution losses for distributed[12] 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.

The emission factor for transmission and distribution losses for distributed natural gas is derived from information from the Ministry of Business, Innovation, and Employment in the *Energy Greenhouse Gas Emissions 2012* and *New Zealand Energy Data File 2012* publications.

Table 6: Transmission and distribution losses for distributed natural gas – 2011

Emission source	Unit[13]	Emission factor total CO_2-e (kg CO_2-e/unit)
Transmission and distribution losses for distributed natural gas	kWh	0.0189
	GJ	5.25

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

12 'Distributed' refers to natural gas distributed via low pressure, local distribution networks.

13 Emission factors are presented based on gas used in both kWh and GJ. Use whichever one matches the unit used in your natural gas consumption data.

Assumptions

These emission factors represent an estimate of the average amount of CO_2-e emitted from losses associated with the delivery (transmission and distribution) of each unit of gas consumed through local distribution networks in 2011. They are average figures and therefore make no allowance for distance from off-take point, or other factors that may vary between individual consumers.

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 2011. Its Scope 3 emissions from transmission and distribution losses are:

Total CO_2-e emissions = 800* 5.25 = 4200 kg CO_2-e

3.3.3 Taxis and rental cars

Business travel in taxis and rental cars is 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 – 2011

Emission source	Unit	Emission factor total CO_2-e (kg CO_2-e/unit)
Rental car – small (<1600cc)	Km	0.181
Rental car – medium (1600 – <2500cc)	Km	0.237
Rental car – large (≥ 2500)	Km	0.308
Rental car – default*	Km	0.237
Taxi travel – distance travelled	Km	0.308
Taxi travel – dollars spent (GST inclusive)	$	0.114

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

Assumptions

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

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 calendar year period 2007–2010, an average of 71 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 calendar year period 2007–2010, an average of 53 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 $2.70 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 2011. It also spends $18,000 on taxi travel.

Total CO_2-e emissions from rental cars = 12,000* 0.237 = 2844 kg CO_2-e
Total CO_2-e emissions from taxi travel = $18,000*0.114 = 2052 kg CO_2-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 its May 2012 *Guidelines to DEFRA / DECC's GHG Conversion Factors for Company Reporting*.[14] 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) – 2011

Emission factors

Emission source	Cabin Class	Unit	Emission factor total CO_2-e (kg CO_2-e/unit)
Domestic	Average	pkm*	0.167
Short Haul International (<3700 km)	Average	pkm	0.0952
	Economy class	pkm	0.0907
	Business class	pkm	0.136
Long Haul International (>3700 km)	Average	pkm	0.109
	Economy class	pkm	0.0795
	Premium economy class	pkm	0.127
	Business class	pkm	0.231
	First class	pkm	0.318

14 http://www.defra.gov.uk/publications/2012/05/30/pb13773-2012-ghg-conversion/

* 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 international flights less than 3700 km; and the long haul emission factor should be applied to any flights greater in length than 3700 km.

The specified emission factors for different cabin classes should be used where information is available. The average emission factors can be applied where the cabin classes taken are unknown.

DEFRA endorses a 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. The value of nine per cent comes from an Intergovernmental Panel on Climate Change (IPCC) publication *Aviation and the Global Atmosphere* (refer to 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 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 (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions only. There is currently uncertainty over the other non-CO_2 climate change effects of aviation (including water vapour, contrails and NOx) which have been estimated by the IPCC to be up to two to four times those of CO_2 alone. However, the science in this area is currently uncertain and a multiplier is not used for New Zealand's national GHG inventory reporting. As the emission factors contained in this guide are intended to be consistent with New Zealand's national GHG 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 five flights from Auckland to Shanghai (9308 km each way). On the first occasion two people flew return to Shanghai on the same flight in economy class. On the second occasion three people flew return to Shanghai and the cabin classes were not recorded. The total person kilometres travelled was 93,080 km.

For the two people who travel economy class:
Person kilometres travelled = 2 × 9308 × 2 = 37,232 pkm

Their CO_2-e emissions from air travel = 37,232 * 0.0795 = 2960 kg CO_2-e

For the three people whose travel classes are unknown:
Person kilometres travelled = 3 × 9308 × 2 = 55,848 pkm

Their CO_2-e emissions from air travel = 55,848 * 0.109 = 6087 kg CO_2-e

Total CO_2-e emissions from air travel = 2960 + 6087 = 9,047 kg CO_2-e

3.3.5 Waste to landfill

The emission factors and methodologies provided in this section 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 1990–2010* (MfE, 2012) and methodologies are derived from the 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 (CH_4). Inventories should be adjusted to account for the landfill gas that is collected and destroyed.[15] 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.

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.[16]

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 emissions).

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.

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15 Where CH_4 is recovered and flared or combusted for energy, the CO_2 emitted from the combustion process is regarded as part of the natural carbon cycle.

16 It also allows you to take into account reductions in emissions 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.

Table 9: Emission factors for waste to landfill – 2011

Emission source	Unit	Emission factor total CO_2-e (Kg CO_2-e/unit)
Landfilled waste of known composition (without landfill gas recovery)		
Paper and textiles	kg	2.52
Garden and food	kg	0.945
Wood	kg	1.89
Landfilled waste of known composition (with landfill gas recovery)		
Paper and textiles	kg	1.06
Garden and food	kg	0.397
Wood	kg	0.794
Landfilled waste – default values (without landfill gas recovery)		
Mixed waste (national average)	kg	1.06
Office waste	kg	1.55
Landfilled waste – default values (with landfill gas recovery)		
Mixed waste (national average)	kg	0.444
Office waste	kg	0.650

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

Assumptions

The default emission factor for mixed waste is based on national average composition data from New Zealand's annual GHG inventory.

The emission factors for office waste represent an assumed default composition (paper 54 per cent; garden and food 21 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 2011.

> Total CO_2-e emissions from waste to landfill = 30,000* 0.397 = 11,910 kg CO_2-e = 11.91 tonnes CO_2-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 CO_2/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 CO_2-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 CO_2-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 Business, innovation, and employment. Calorific values are provided in the *New Zealand Energy Data File 2012*, but some calorific values used here have been updated since that publication.

Note that gross calorific values have been used.

CH_4 and N_2O emission factors used in this guide

Although CO_2 emissions remain constant regardless of the way in which a fuel is combusted, CH_4 and N_2O emissions depend on the precise nature of the activity in which the fuel is being combusted. The emission factors for CH_4 and N_2O therefore vary depending on the combustion process. Table 10 shows the default CH_4 and N_2O 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 CO_2-e/kg) emission factors. All emission factors contained in table 10 have been provided by the Ministry of Business, Innovation, and Employment.

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* (1996). Oxidation factors have only been applied to the CO_2 emission factors (and therefore by default to the CO_2-e emission factors) and have not been applied to the CH_4 and N_2O emission factors. This approach is consistent to that adopted by New Zealand's national GHG inventory.

Reference data

Table 10: Underlying data used to derive the fuel combustion emission factors – 2011

Emission source	User	Unit	Calorific value (MJ/unit)	T CO2/TJ (after oxidation)	T CH_4/TJ	T N_2O/TJ
Stationary combustion						
Coal – bituminous	Residential	Kg	29.5	87	0.285	0.00133
Coal – sub-bituminous	Residential	Kg	21.7	89.4	0.285	0.00133
Coal – lignite	Residential	Kg	15.3	93.3	0.285	0.00133
Distributed natural gas	Commercial	KWh	NA	0.191	0.00000389	0.00000745
		GJ	NA	53	0.00108	0.00207
Coal – bituminous	Commercial	Kg	29.5	87	0.0095	0.00133
Coal – sub-bituminous	Commercial	Kg	21.7	89.4	0.0095	0.00133
Coal – lignite	Commercial	Kg	15.3	93.3	0.0095	0.00133
Diesel	Commercial	Litre	38.4	68.9	0.000665	0.00038
LPG	Commercial	Kg	50	57.5	0.00105	0.00057
Heavy fuel oil	Commercial	Litre	41	73.1	0.00133	0.000285
Light fuel oil	Commercial	Litre	40.7	72.1	0.00133	0.000285
Distributed natural gas	Industry	KWh	NA	0.191	0.00000453	0.000000324
		GJ	NA	53	0.00126	0.00009
Coal – bituminous	Industry	Kg	29.5	87	0.000665	0.00152
Coal – sub-bituminous	Industry	Kg	21.7	89.4	0.000665	0.00152
Coal – lignite	Industry	Kg	15.3	93.3	0.000665	0.00152
Diesel	Industry	Litre	38.4	68.9	0.00019	0.00038
LPG	Industry	Kg	50	57.5	0.00105	0.00057
Heavy fuel oil	Industry	Litre	41	73.1	0.00285	0.000285
Light fuel oil	Industry	Litre	40.7	72.1	0.00285	0.000285
Wood	Industry	Kg	9.63	104	0.0143	0.0038
Wood	Fireplaces*	Kg	9.63	104	0.285	0.0038
Transport fuels						
Regular petrol	Mobile use	Litre	35.1	65.9	0.0185	0.00143
Premium petrol	Mobile use	Litre	35.2	66.1	0.0185	0.00143
Diesel	Mobile use	Litre	38.4	68.9	0.0038	0.00371
LPG	Mobile use	Litre	26.6	57.5	0.0285	0.00057
Marine diesel	Mobile use	Litre	-	-	-	-
Heavy fuel oil	Mobile use	Litre	41	73.1	0.00665	0.0019
Light fuel oil	Mobile use	Litre	40.7	72.1	0.00665	0.0019

Table 11 contains the GWPs for CO_2, CH_4 and N_2O that have been used in converting to CO_2 equivalent emission factors, based on the IPCC's Second Assessment Report (1995).

Table 11: Global warming potentials for CO_2, CH_4 and N_2O (100-year time horizon)

	CO_2	CH_4	N_2O
Global warming potential	1	21	310

Example derivation of emission factors

The sub-bituminous coal emission factors for commercial use are derived as follows:[17]

CO_2 emission factor (kg CO_2/kg)[18]	=	(Calorific value*TCO_2 per TJ emission factor)/1000
	=	(21.7*89.4)/1000
	=	1.94 kg CO_2/kg coal
CH_4 emission factor (kg CO_2-e/kg)	=	[(Calorific value*TCH_4 per TJ emission factor)*GWP of CH_4]/1000
	=	[(21.7*0.0095)*21]/1000
	=	0.00433 kg CO_2-e/kg
N_2O emission factor (kg CO_2-e/kg)	=	[(Calorific value*TN_2O per TJ emission factor)*GWP of N_2O]/1000
	=	[(21.7*0.00133)*310]/1000
	=	0.00895 kg CO_2-e/kg
Total CO_2-e emission factor (kg CO_2-e/kg)	=	Sum of CO_2, CH_4 and N_2O emission factors
	=	1.95 CO_2-e/kg

Note that if you know the calorific value of your coal, you could substitute your specific calorific value and obtain a more accurate (specific) emission factor.

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

18 Tonnes CO_2/TJ = kg CO_2/GJ. Division by 1000 converts this to kg CO_2/MJ, consistent with the calorific value (MJ/unit of activity).

Appendix B: Methods for calculating emissions from refrigeration

GHG 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 CO_2) 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 is dependent upon the type of equipment you are performing the calculation for and the level of information available to you (see the section "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 CO_2-e (per year)

IE = installation emissions (refrigerant used to charge new equipment less the total full charge[19] 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.

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19 '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 CO_2-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 x 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 x ALR
C = original full refrigerant charge in equipment (kg)
ALR = the default annual leakage emission factor for equipment (%).

DE = (C x (1 – (ALR x S)) x (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 CO_2-e
IE = installation emissions (as per method B)
C = default refrigerant charge in each piece of equipment (kg)
ALR = default annual leakage emission factor for equipment (%)
DE = disposal emissions (as per method B)
GWP = the 100-year global warming potential of the refrigerant used in equipment (table 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 help 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 GHG Protocol HFC tool* (WRI/WBCSD, 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 cool stores, the size ranges and configurations are so varied 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)[20]	Guidance on method choice		
				Method A	Method B	Method C
Small refrigerator or freezer (up to 150 litres[21])	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

20 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.

21 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)[20]	Guidance on method choice		
				Method A	Method B	Method C
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
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 cool stores	Wide range	Wide range	Wide range	Recommended	Unacceptable	Unacceptable

Table 13: Detailed 100-year global warming potentials for various refrigerant mixtures[22]

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	
R22 (HCFC-22)								100%	1810
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

[22] For consistency, 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.

Assumptions

The default factors for installation, operation and disposal of refrigerant equipment supplied in table 12 are derived from a report from CRL Energy Limited 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 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.

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 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.

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 its 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 kg CO_2-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 kg CO_2-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 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).[23]

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.

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23 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.

Using Method A approach:

E = (IE +S+DE) x GWP[24]

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

= (7.1 – 7.0) x 1725

= 173 kg CO_2-e

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

= 1.1 x 1526

= 1679 kg CO_2-e

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

= (8.5 – 6.8) x 1526

= 2594 kg CO_2-e

E = 173 + 1679 + 2594

= 4446 kg CO_2-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:

Operation emissions	(truck)	= (1.2 x 10/100 x 1300)	= 156
(car)		= 0.7 x 10/100 x 1300)	= 91
		156 +91	**= 247 kg CO_2-e**

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

[24] As global warming potentials are different for the air-conditioning units they are calculated separately here.

R22 and one R404A. The R22 refrigerated container is not included in the inventory. It is unable to collect service data and therefore uses Method B to estimate emissions.

Using Method A for Scope 1:

Operation emissions = S x GWP

= 1.32 x 3260

= 4303 kg CO_2-e

Using Method B for Scope 3:

Operation emissions = (C x ALR) x GWP

= (5.5 x 25/100) x 3260

= 4483 kg CO_2-e

Therefore, total emissions for the company for refrigeration are:

Scope 1	**kg CO_2-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 *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 1996), is as follows:

$$CO_2\text{-e emissions (kg)} = ((MSW_T \times DOC \times DOC_F \times F \times 16/12) \times (1 - R) \times (1 - OX)) \times 21$$

Where: MSW_T = total Municipal Solid Waste (MSW) generated (kg); DOC = degradable organic carbon; DOC_F = fraction of DOC dissimilated; F = fraction of CH_4 in landfill gas; R = fraction recovered CH_4; OX = oxidation factor; 21 = GWP of methane (CH_4).

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 CO_2
R	=	0.580 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	Unit	Emission factor total CO_2-e (Kg CO_2-e/unit)	Equation
Landfilled waste of known composition (without landfill gas recovery)			
Paper and textiles	kg	2.52	(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	1.89	(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	1.06	(0.4 * 0.5 * 0.5 * 16/12) * (1-0.580) * (1-0.1) * 21
Garden and food	kg	0.397	(0.15 * 0.5 * 0.5 * 16/12) * (1-0.580) * (1-0.1) * 21
Wood	kg	0.794	(0.3 * 0.5 * 0.5 * 16/12) * (1-0.580) *(1-0.1) * 21
Landfilled waste – default values (without landfill gas recovery)			
Mixed waste (national average)[25]	kg	1.06	0.0558 * (1-0.1) * 21
Office waste	kg	1.55	((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	0.444	0.0544 * (1-0.580) * (1-0.1) * 21
Office waste[26]	kg	0.650	((0.536 * 0.4) + (0.208 * 0.15) + (0 * 0.3)) * 0.5 * 0.5 * (16/12) * (1-0.580) * (1-0.1) * 21

25 0.0558 is published within the national greenhouse gas inventory supplementary table 6.A,C as the average methane generation potential of solid waste.

26 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.