Ministry for the Environment
Manatū Mō Te Taiao

Guidance for voluntary, corporate greenhouse gas reporting

Data and Methods for the 2007 Calendar Year

New Zealand Government

Published in September 2008 by the
Ministry for the Environment
Manatū Mō Te Taiao
PO Box 10362, Wellington, New Zealand

ISBN: 978-0-478-33132-5 (print)
978-0-478-33131-8 (electronic)

Publication number: ME 904

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

This is the second version of an annual publication.

Each year the Ministry for the Environment will update this guide with emission factors for the previous calendar year. It does not replace previous editions of this publication.

Changes to data and methodology for the 2007 calendar year

Scope 1

Stationary combustion – emission factors for stationary combustion have been updated based on new figures for the 2007 calendar year.

Transport fuels – emission factors for transport fuels have been updated based on new figures for the 2007 calendar year.

Refrigerants –refrigerant emission factors and methodologies to account for, and screen the materiality of, refrigerants are now included in the guidance publication.

Scope 2

Purchased electricity – emission factors for purchased gas and electricity have been updated based on new figures for the 2007 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 2007 calendar year.

Taxis/rental cars – emission factors for travel in taxis/rental cars have been updated based on new figures for the 2007 calendar year.

Air travel – emission factors for air travel have been updated due to changes to the methodology and data used for calculating emissions from air travel.

Waste – emission factors for waste to landfill with methane capture have been updated based on new projected methane capture data for the 2007 calendar year.

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1 Guidance on reporting

1.1 Introduction

This publication has been prepared to meet demand for guidance on voluntary corporate greenhouse gas (GHG) reporting, including emission factors to facilitate this.

It is intended to encourage best practice in GHG monitoring and reporting and to support voluntary GHG reporting initiatives. Its purpose is both to endorse the referenced reporting frameworks and to provide information (emission factors and methods) to enable organisations to apply them.

This guide will be regularly updated in order 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?

The information in this guide is intended to assist those who wish to voluntarily[1] monitor and report greenhouse gas emissions on an organisational (sometimes called "corporate" or "entity" level) basis for their New Zealand operations.

The emission factors and methods contained within this guide are provided for emission sources deemed common for commercial[2] organisations; however, this guide also applies to industrial organisations who wish to report on the same emission sources.

1.3 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 organization 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 http://www.ghgprotocol.org/standards.

1 Note that this guidance publication is solely intended for use in voluntary GHG reporting and does not represent, or form part of, a mandatory reporting framework or scheme.

2 The commercial sector includes non-manufacturing business establishments such as hotels, motels, restaurants, wholesale businesses, retail stores and health, social and educational facilities.

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.

Both documents are widely recognised and used. They provide comprehensive guidance on monitoring and reporting GHG emissions, and the Ministry believes there is no need to duplicate their content. Those wishing to monitor and report their corporate emissions on a voluntary basis should use these documents for New Zealand operations.

1.4 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.

1.5 What are the differences between these standards?

The approaches laid out in *ISO 14064-1* and *The GHG Protocol* are compatible as the ISO standard is closely based on *The GHG Protocol*.

ISO 14064-1 is a shorter, more direct document than *The GHG Protocol* which is more descriptive and (for example) discusses 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 usefully be informed by reading *The GHG Protocol* for context.

> It is worth noting that the infrastructure is being developed to enable users of *ISO 14064-1* to have their greenhouse gas inventories certified by an accredited verification body. Verification of inventories is discussed below.

1.6 What other information do I need?

This guide aims to provide information to help organisations using the above standards in a voluntary context. In order 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 (tonnes of CO_2-equivalent – see section two for a definition of this). These methods involve using what are sometimes called “emission factors”. An emission factor is a factor which 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 aims to meet this need by drawing on technical information provided by New Zealand government agencies, and presenting 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.

1.7 Is this information for use in an emissions trading scheme (ETS)?

No. 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.

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 be part of an emissions trading scheme, it may be useful to help organisations prepare for, or understand how, an emissions trading scheme might impact on their business.

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, not only are calculations free from material error but that, the approach in the *ISO 14064-1* standard or *The GHG Protocol* has been correctly applied.

1.8.2 Who should verify my inventory?

A framework for accrediting verifiers is being developed by the Joint Accreditation System of Australia and New Zealand (JAS-ANZ). This will involve accrediting 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*. The necessary infrastructure to apply ISO 14065 is still being developed.

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.

Firms that have achieved the status of Designated Operational Entity (DOE) and/or Accredited Independent Entity (AIE) will have experience in verifying greenhouse gas emission reductions on a project basis under the Kyoto Protocol.[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 emission factors for some emission sources which were not easily available (eg, waste to landfill, taxis) prior to publication of this guide
- provide guidance on a consistent approach to choosing emission factors for financial-year and calendar-year reporting.

As discussed previously, these emission factors are largely derived from technical information published by New Zealand government agencies.[4] The key source of the emission factors contained in this guide is the Ministry of Economic Development's *Energy Greenhouse Gas Emissions 1990–2007* (Ministry of Economic Development, 2008a). Information is also taken from the Ministry of Economic Development's *New Zealand Energy Data File* (Ministry of Economic Development, 2008b) and the Ministry for the Environment's *New Zealand's Greenhouse Gas Inventory* (Ministry for the Environment, 2008). Emission factors for refrigerants have been sourced from the *Assessment of HFC Emission Factors for GHG Reporting Guidelines* (CRL Energy Limited, 2008). The relevant sources for each emission factor and how the emission factors are derived are discussed in more detail below.

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 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 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). They have been converted to CO_2-e using GWPs sourced from the *Energy Greenhouse Gas Emissions* publication.[5]

4 For instance the energy emission factors are largely sourced from the *Energy Greenhouse Gas Emissions* publication. References for specific emission factors are included below.

5 Appendix 1 contains a table of the GWPs used in these conversions.

Under the reporting requirements of *ISO 14064-1* and *The GHG Protocol*, GHG emissions should be reported in tonnes CO_2-e. This guidance presents emission factors in kg CO_2-e per unit. Division by 1,000 converts kg to tonnes (see example calculations below).

In line with the reporting requirements of ISO 14064-1, the emission factors provided allow calculation of CO_2, CH_4 and N_2O separately (as well as the total CO_2-e equivalent) for Scope 1 (the concept of "scope" is discussed below in Section 2.2) emission sources. Emission factors for CH_4 and N_2O are expressed in kg CO_2-e.

CO_2 emission factors are derived based on the carbon content and energy content (ie, calorific value or heating value) of a fuel. CO_2 emissions (for a specific fuel) 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] Separate CO_2-e emission factors for commercial and industrial users are presented in Table 1 below. The *Energy Greenhouse Gas Emissions* publication discusses the source of the relevant emission factors in more detail. Any assumptions which are made in the underlying reports are also made for these emission factors.

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 should report on a calendar-year basis where possible.

Calendar year: If you are reporting on a calendar-year basis then you should wait until the emission factors for the reporting period become available in the following year (for example, the 2008 emission factors will be published in 2009). 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 should pro rata the emission factors according to the specific financial year used by your organisation. For example, if you wished to report on your 2007/2008 emissions then you would need to wait until the Ministry issued this publication in 2009, in order that the 2008 emission factors (as well as the 2007 emission factors) were available.

6 For example, the CH4 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.

Organisations could choose to extrapolate the calendar-year emission factors contained in the most recent report over the current financial year. This is likely to be less accurate than using data determined specifically for the reporting year, and is a less preferred approach,[7] although may be acceptable in instances where an organisation is reporting continuously from year to year.

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 occur 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: Electricity indirect GHG emissions occur from the generation of purchased electricity[8] consumed by the company. *The GHG Protocol* and *ISO 14064-1* require Scope 2 emissions to be reported
- Scope 3: Other indirect GHG emissions occur as a consequence of the activities of the company, but occur from sources not owned or controlled by the company, for example 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.

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

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[7] This will be particularly so in the case of emissions from purchased electricity, which vary significantly from year to year, depending on the proportion of generation from renewable sources.

[8] The term electricity is used by *The GHG Protocol* as shorthand for electricity, heat, or steam. Purchased heat and steam are also Scope 2 emissions.

3 Emission factors and methods 2007

3.1 Scope 1: Direct emissions

3.1.3 Stationary combustion of fuels

Scope 1 emissions from the stationary combustion of fuel 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.

These emission factors are sourced from the *Energy Greenhouse Gas Emissions 1990–2007* publication. The *Energy Greenhouse Gas Emissions* publication provides CO_2, CH_4 and N_2O emission factors for a range of fuels used by the energy sector.

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) – 2007

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)
Stationary Combustion						
Distributed Natural Gas	Commercial	KWh	0.194	0.192	0.0000816	0.00231
		GJ	54.0	53.3	0.0227	0.642
Coal – Bituminous	Commercial	Kg	2.53	2.51	0.00575	0.0119
Coal – Sub-bituminous	Commercial	Kg	2.01	2.00	0.00446	0.00921
Coal – Lignite	Commercial	Kg	1.49	1.48	0.00316	0.00653
Coal – Default**	Commercial	Kg	2.01	2.00	0.00446	0.00921
Diesel	Commercial	Litre	2.63	2.63	0.000538	0.00451
LPG***	Commercial	Kg	2.97	2.96	0.00109	0.00875
Heavy Fuel Oil	Commercial	Litre	2.99	2.98	0.00114	0.0037
Light Fuel Oil	Commercial	Litre	2.94	2.93	0.00114	0.0037
Distributed Natural Gas	Industry	KWh	0.192	0.192	0.0000953	0.000100
		GJ	53.3	53.3	0.0265	0.0279
Coal – Bituminous	Industry	Kg	2.52	2.51	0.000406	0.0136
Coal – Sub-bituminous	Industry	Kg	2.01	2.00	0.000314	0.0105
Coal – Lignite	Industry	Kg	1.49	1.48	0.000223	0.00747
Coal – Default**	Industry	Kg	2.01	2.00	0.000314	0.0105
Diesel	Industry	Litre	2.63	2.63	0.000153	0.00451

LPG***	Industry	Kg	2.97	2.96	0.00109	0.00875
Heavy Fuel Oil	Industry	Litre	2.99	2.98	0.00245	0.0037
Light Fuel Oil	Industry	Litre	2.94	2.93	0.00162	0.00479
Wood	Industry	Kg	0.0178*****	1.26	0.00361	0.0142
Wood	Fireplaces****	Kg	0.0865*****	1.26	0.0723	0.0142

* Use the total CO_2-e emission factor for calculating total CO_2-e emissions, rather than summing the totals for CO_2, CH_4 and N_2O.

** The default coal emission factor should be used if it is not possible to identify the specific type of coal.

*** Fuel-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) does not include the CO_2 emission factor. Under *ISO 14064-1* and *The GHG Protocol* reporting requirements, only CH_4 and N_2O emissions from the combustion of biomass are included as Scope 1 emissions. CO_2 emissions, from the combustion of biologically sequestered carbon, are reported separately from the scopes.

Changes in Methodology from 2006

The 2006 emission factors for stationary combustion of distributed natural gas (industrial and commercial) were generated using a weighted average of natural gas from Kapuni treated and Maui gas streams. The 2007 distributed natural gas emission factor is the weighted average of natural gas from all gas streams. This change in methodology is outlined in *Energy Greenhouse Gas Emissions 1990–2007*.

Assumptions

The kg CO_2-e per activity unit emission factors supplied in Table 1 are derived using calorific values sourced from the *New Zealand Energy Data File 2008*. The calorific values used can be found in Appendix 1.

All emission factors incorporate relevant oxidation factors which are sourced from *New Zealand's Greenhouse Gas Inventory 1990–2006*. Oxidation factors allow for the small proportion of carbon that remains unoxidised due to incomplete combustion, and remains as soot and ash. The oxidation factors used for each of the fuels can be found in Appendix 1.

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.[9]

The Automotive Gas Oil-50 ppm Sulphur emission factor (provided in the *Energy Greenhouse Gas Emissions 1990–2007* publication) has been used as the default emission factor for diesel.

9 Approximately 92 percent of the coal used by the commercial sector is sub-bituminous coal.

Example calculation

A commercial organisation uses 1,400 kg of LPG to heat one of its office buildings in 2007.

CO_2 emissions = 1,400 * 2.96 = 4,144 kg CO_2/1000 = 4.14 tonnes CO_2

CH_4 emissions = 1,400 * 0.00109 = 1.526 kg CO_2-e/1000 = 0.00153 tonnes CO_2-e

N_2O emissions = 1,400 * 0.00875 = 12.25 kg CO_2-e/1000 = 0.0123 tonnes CO_2-e

Total CO_2-e emissions = 1,400 * 2.97 = 4,158 kg CO_2-e/1000 = 4.16 tonnes 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 sourced from the *Energy Greenhouse Gas Emissions 1990–2007* publication.

Table 2: Fuel combustion emission factors (Transport fuels) – 2007

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)
Regular Petrol	litre	2.32	2.29	0.0136	0.0155
Premium Petrol	litre	2.36	2.33	0.0137	0.0156
Petrol – Default**	litre	2.33	2.30	0.0136	0.0155
Diesel	litre	2.68	2.63	0.00305	0.0440
LPG	litre	1.61	1.59	0.0159	0.00469

* Use the total CO_2-e emission factor for calculating total CO_2-e emissions, rather than summing the totals for CO_2, CH_4 and N_2O.

** 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 using calorific values sourced from the *New Zealand Energy Data File 2008*. All emission factors incorporate relevant oxidation factors which are sourced from *Energy Greenhouse Gas Emissions 1990–2007*.

The default petrol factor is a weighted average of regular and premium petrol based on 2007 sales volume data from the *New Zealand Energy Data File 2008*. 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 2007.

CO_2 emissions = 40,000 * 2.29 = 91,600 kg CO_2 = 91.6 tonnes CO_2

CH_4 emissions = 40,000 * 0.0136 = 544 kg CO_2-e = 0.544 tonnes CO_2-e

N_2O emissions = 40,000 * 0.0155 = 620 kg CO_2-e = 0.620 tonnes CO_2-e

Total CO_2-e emissions = 40,000 * 2.32 = 92,800 kg CO_2-e = 92.8 tonnes 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 in the following table can be used. 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 the below table should therefore only be used if information on fuel use is not available.

Table 3: Transport emission factors (based on distance travelled) – 2007

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_2O (kg CO_2-e/unit)
Car – Small (<1600 cc)	Km	7.53	0.175	0.173	0.00102	0.00117
Car – Medium (1600 – <2500 cc)	Km	10.4	0.241	0.238	0.00141	0.00160
Car – Large (>= 2500 cc)	Km	14.2	0.331	0.327	0.00194	0.00221
Car – Default***	Km	10.4	0.241	0.238	0.00141	0.00160

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

** Use the total CO_2-e emission factor for calculating total CO_2-e emissions, rather than summing the totals for CO_2, CH_4 and N_2O.

*** 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 vehicles are petrol. The emission factors are derived by multiplying the default petrol emission factor from Table 2 by 'real world' fuel consumption rates[10] for the petrol light vehicle fleet, based on information from *The New Zealand Light Vehicle Fleet: Light Fleet Statistics 2007* (Ministry of Transport, 2008). '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).[11] 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).[12]

Example calculation

An organisation has three vehicles which it owns. They are all large vehicles and travelled a total of 37,800 km in 2007.

CO_2 emissions = 37,800* 0.327 = 12,360.6 kg CO_2 = 12.4 tonnes CO_2

CH_4 emissions = 37,800* 0.00194= 73.332 kg CO_2-e = 0.0733 tonnes CO_2-e

N_2O emissions = 37,800* 0.00221 = 83.538 kg CO_2-e = 0.0835 tonnes CO_2-e

Total CO_2-e emissions = 37,800* 0.331 = 12,511 kg CO_2-e = 12.5 tonnes CO_2-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 1,300 to 3,300 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 hydrochlorofluorocarbons (HCFCs)[13] which are being phased out.

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[10] 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 1.207. The figures are based on consumption rates for new vehicles sold in New Zealand since 2005.

[11] For purpose of comparison in 2007, approximately 15.2 percent of the light vehicle fleet was made up of diesel vehicles.

[12] In 2007, 54.9 percent of light petrol vehicles sold in New Zealand were in the medium vehicle size class, 25.6 percent were small and 19.5 percent were large.

[13] Whilst HCFCs have no GWP; they are an ozone-depleting substance and being phased out through the Montreal Protocol on Substances That Deplete the Ozone Layer.

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 dependant 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 – Lifecycle stage approach

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

E	emissions from the piece of equipment in tonnes CO_2-e (per year)
IE	installation emissions (refrigerant used to charge new equipment less the total full charge[14] 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 5)
CF	kilograms to tonnes conversion factor = 1 tonne/1000 kg

This approach is detailed in the *GHG Protocol HFC tool* (WRI/WBCSD 2005). This method requires advice to be sought from service agents 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. the quantity recovered from retired equipment.

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

[14] 'Total full charge' refers to the full, original charge of the equipment rather than to the actual charge, which may reflect leakage.

Method B – default annual leakage rate

E = (IE + OE + DE) x GWP x CF

E emissions from equipment in t 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 5)

CF kilograms to tonnes conversion factor = 1 tonne/1000 kg

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 4. 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 the refrigerant type and full refrigerant charge of each piece of equipment that is operated by the organisation.

Method C – default annual leakage rate and default refrigerant charge

E = (IE +(C x ALR)+DE) x GWP x CF)

E emissions

IE installation emissions (as per method B)

C the default refrigerant charge in each piece of equipment (kg)

ALR the 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 5)

CF the tonnes from kilograms conversion factor = 1 tonne/1000 kg

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 4 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 any service agents, vehicle fleet or building manager. 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 may not be justifiable, due to the resource-intensive nature of collecting detailed information for a particular equipment type. If so, then Method B and C can be used in some circumstances (refer to guidance in Table 4) to measure leakage rates with the default factors also provided in Table 4. Method B and C are based on the "screening" method approach contained in the *Greenhouse Gas Protocol HFC tool 2005*[viii].

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 or 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 4). 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 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 and for all Methods, the type of refrigerant must be individually identified because the global warming potential (GWP) of various refrigerant mixes are widely variable (see Table 5). In addition, hydrocarbon and HCFC refrigerants (mainly R22) can be eliminated from the accounting as they have no GWP.

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 4: Default refrigerant charges and emission factors for refrigeration and air-conditioning equipment

Refrigeration Unit Type	Default Refrigerant Charge (kg)	Default (operating) Emissions	Default Installation Emissions[15]	Guidance on Method Choice		
				Method A	Method B	Method C
Small refrigerator or freezer (up to 150 litres[16])	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

15 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.

16 Internal dimensions up to 100 x 50 x 30cm for 150 litres, 150 x 50 x 40cm for 300 litres, 200 x 50 x 50cm for 500 litres.

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
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 5: Detailed 100-year Global Warming Potentials for various refrigerant mixtures[17]

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

* Hydrocarbons (such as R290 and R600a) and HCFCs (mainly R22) are not considered to have GWPs for GHG accounting purposes. Refrigerant compositions are from AIRAH (2003).

17 For consistency until 2012, GWPs are set according to IPCC (1996) *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 4 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 percent) for reputable service agents but in the absence of consistent information for New Zealand, the default assumption is zero percent 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.

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

E = (IE + OE + DE) x GWP x CF

E = 2(0 + (0.17 x 3/100) + 0) x 1300 x 1/1000

E = 2(0+0.0051+0) x 1300 x 0.001

E = **0.0133 tonnes 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) x GWP X CF

E= (0 + 0.32 + 0) x 3260 x1/1000

E= 1.04 tonnes 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 20kW 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 20kW) 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 percent). 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 6.8kg (80 percent) of the original charge in the old equipment was collected for destruction (because its quality was too degraded for recycling).[18]

The service agent records show that used 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 of the new system from August to December would not be accounted for until the following year if it is not topped-up until the following January.

[18] 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

E = (IE +S+DE) x GWP[19] X CF

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

= (7.1 – 7.0) x 1725 x 1/1000

= 0.173 tonne CO_2-e

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

= 1.1 x 1526 x 1/1000

= 1.68 tonnes CO_2-e

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

= (8.5 – 6.8) x 1526 x 1/1000

= 2.59 tonnes CO_2-e

E = 0.173 + 1.68 + 2.59

= 4.44 tonnes 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 x 1/1000) = 0.156
(car) + (0.7 x 10/100 x 1300 x 1/1000)	= 0.091
	= 0.247 tonnes 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 (six 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.

[19] As GWPs are different for the air-conditioning units they are calculated separately here.

Using Method A for Scope 1:

Operation Emissions = S x GWP x CF

= 1.32 x 3260 x 1/1000

= 4.78 tonnes CO_2-e

Using Method B for Scope 3:

Operation Emissions = (C x ALR) x GWP x CF

= (5.5 x 25/100) x 3260 x 1/1000)

= 4.48 tonnes CO_2-e

Therefore total emissions for the company for refrigeration are:

Scope 1	**Tonnes CO_2-e**
Office refrigeration	0.0133
Large commercial sized refrigerator	1.04
Commercial air-conditioning unit	4.44
Mobile air-conditioning (MAC)	0.247
Refrigerated transport	4.3078
SCOPE 1 TOTAL	**10.52**
Scope 3	
Refrigerated transport	4.48
SCOPE 3 TOTAL	**4.48**

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 provided in Table 6. The emission factor is calculated on a calendar-year basis and accounts for the emissions from fuel combustion at thermal power stations which are associated with the consumption of purchased electricity from the grid. It also includes a relatively small proportion of fugitive emissions from geothermal generation.

The emission factor for the consumption of purchased electricity, as well as the emission factor for transmission and distribution line losses (included below, in Table 7), have been aligned with the definitions used in the *GHG Protocol*.

This emission factor is sourced from the *Energy Greenhouse Gas Emissions 1990–2007* publication. This publication provides a historic record of (electricity) emission factors up to the previous calendar year.

The electricity emission factor covers purchased electricity which has been bought from an electricity supplier who sources its electricity from the national grid.[20]

[20] It does not cover on-site, self-generation of electricity.

Table 6: Emission factor for the consumption of purchased electricity – 2007

Emission Source	Unit	Emission factor Total CO_2-e (kg CO_2-e/unit)
Purchased electricity	kWh	0.165

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 T*he GHG Protocol* the emissions associated with transmission and distribution line losses are Scope 3 emissions. Table 7 contains an emission factor for transmission and distribution line losses.

The emission factor in Table 6 is derived from the tCO_2-e/MWh generation emission factor (as opposed to the consumption emission factor) in the *Energy Greenhouse Gas Emissions 1990–2007* publication. This is explained in more detail in the section below covering the transmission and distribution line losses emission factor.

Notes on the use of electricity emission factors

The emission factor provided in Table 6 is an average over the calendar year for 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.

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. In the meantime, use of a grid-average factor does not ignore or refute claims of carbon neutrality or similar by some electricity retailers. Rather, these claims should be accounted for separately. It is suggested users contact the Ministry for further advice on this issue.

This emission factor cannot be used for calculating abatement by intervention or reducing the use of thermal generation, for example 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.[21]

It is also possible that a different emission factor may be used for determining allocation under the New Zealand emissions trading scheme. An allocation factor has yet to be determined at this

[21] *Carbon Abatement Effects of Electricity Demand Reductions.* http://www.med.govt.nz/templates/MultipageDocumentTOC____33805.aspx

stage, but it may need to take into account a number of different issues that could produce a different value to that listed in Table 6.

Example calculation

An organisation uses 800,000 kWh of electricity in 2007. Their Scope 2 emissions from electricity are:

Total CO_2-e emissions = 800,000 * 0.165 = 132,000 kg CO_2-e = 132 tonnes CO_2-e

3.3 Scope 3: Other indirect emissions

3.3.1 Transmission and distribution line losses for purchased electricity

The transmission and distribution line losses emission factor accounts for emissions (from the generation) of the 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 in Table 4.8 of the *Energy Greenhouse Gas Emissions 1990–2007*.[22]

Table 7: Transmission and distribution line losses for purchased electricity – 2007

Emission Source	Unit	Emission factor Total CO_2-e (kg CO_2-e/unit)
Transmission and distribution line losses for purchased electricity	kWh	0.0142

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.[23]

This emission factor accounts for emissions from the generation of the electricity lost in the transmission and distribution network, during delivery to end users. It does not incorporate the emissions associated with the extraction, production and transport of the fuels burnt to produce the electricity.

22 The electricity figures reported in the *Energy Greenhouse Gas Emissions 1990–2007* are rounded figures. Calculations to derive the figure reported in Table 7 are sourced from unrounded figures available from the Ministry of Economic Development.

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

Example calculation

An organisation uses 800,000 kWh of electricity in 2006. Their Scope 3 emissions from transmission and distribution line losses for purchased electricity are:

Total CO_2-e emissions = 800,000 * 0.0142 = 11,360 kg CO_2-e = 11.4 tonnes CO_2-e

3.3.2 Transmission and distribution losses for distributed[24] 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.

This emission factor is derived based on information from the *Energy Greenhouse Gas Emissions 1990–2007* and *New Zealand Energy Data File 2008* publications.

Table 8: Transmission and distribution losses for distributed natural gas – 2007

Emission Source	Unit	Emission factor Total CO_2-e (kg CO_2-e/unit)
Transmission and distribution losses for distributed natural gas	kWh	0.0285
	GJ	7.91

Changes in methodology from 2007

The distributed natural gas emission factor for transmission and distribution losses is now based on a weighted average of all gas streams. In 2006, it was based on a weighted average of Maui and Kapuni treated natural gas only.

Assumptions

This figure represents an estimate of the average amount of CO_2-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 for 2007. 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.

This figure assumes that all losses are attributable to gas consumed via local distribution networks. A small amount (<1 percent) of emissions is attributable to losses occurring from delivery of gas to consumers who are directly connected to a high-pressure transmission pipeline.[25]

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24 "Distributed" refers to natural gas distributed via low pressure, local distribution networks.

25 See p 16 of the *Energy Greenhouse Gas Emissions 1990–2007* publication for more detail.

This emission factor is therefore appropriate for use by customers who receive their gas through a local distribution network, and is not intended for customers who receive gas directly from the transmission system, or directly from a gas producer via high-pressure transmission lines.

This emission factor covers the fugitive emissions which occur during the delivery of the gas to end users. It does not cover the emissions associated with the extraction and production of the gas.

Example calculation

An organisation uses 1,000 gigajoules of distributed natural gas in 2007. Their Scope 3 emissions from transmission and distribution losses are:

Total CO_2-e emissions = 1,000* 7.91 = 7,910 kg CO_2-e = 7.91 tonnes CO_2-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 9 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 9: Emission factors for travel in taxis and rental cars (based on distance travelled) – 2007

Emission Source	Unit	Emission factor Total CO_2-e (kg CO_2-e/unit)
Rental car – Small (<1600cc)	Km	0.175
Rental car – Medium (1600 – <2500cc)	Km	0.241
Rental car – Large (>= 2500)	Km	0.331
Rental car – Default*	Km	0.241
Taxi travel – Distance travelled	Km	0.331
Taxi travel – Dollars spent (GST inclusive)	$	0.133

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

Assumptions

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

The default emission factor for rental cars is the same as that for medium vehicles (1600 – <2500 cc) from Table 3. Data from the Motor Industry Association New Vehicle Sales database showed that for the period January 2002–July 2008, 60.0 percent 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 percent 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 2007. It also spends $18,000 on taxi travel.

Total CO_2-e emissions from rental cars = 12,000* 0.241 = 2,892 kg CO_2-e = 2.89 tonnes CO_2-e

Total CO_2-e emissions from taxi travel = $18,000*0.133 = 2,394 kg CO_2-e = 2.39 tonnes CO_2-e

3.3.4 Air travel

The emission factors provided in Table 10 are intended for use by organisations wishing to report their air travel emissions, based on the distance travelled per passenger. The emission factors provided below are based on emission factors published by the UK Department for Environment Food and Rural Affairs (DEFRA) in the *2008 Guidelines to DEFRA's GHG Conversion Factors: Methodology Paper for Transport Emission Factors* (DEFRA, 2008) These are deemed to be the most suitable emission factors currently available.[26] The DEFRA publication discusses the emission factor methodology in more detail.

Table 10: Emission factors for air travel (based on distance travelled) – 2007

Emission Source	Unit	Emission factor Total CO_2-e (kg CO_2-e/unit)
Domestic	pkm	0.1769
Short Haul International (<3700 km)	pkm	0.0992
Long Haul International (>3700 km)	pkm	0.1116

Changes in Methodology from 2006

DEFRA has recently published the *2008 guidelines to DEFRA's GHG Conversion Factors: Methodology Paper for Transport Emission Factors* which can be found at http://www.defra.gov.uk/environment/business/envrp/pdf/passenger-transport.pdf. The changes in methodology and assumptions have altered the emission factors from the 2006 version. These changes are explained in greater detail in the DEFRA guidelines.

26 The Greenhouse Gas Protocol Initiative provides air travel emission factors which are in the process of being updated. The suitability of the air travel emission factors contained in this guide will be reviewed once these become available.

In addition to changes in background assumptions and data, the emission factors now also include a 10 percent uplift to correct underestimation of emissions from climbing, cruising and descent. Note that this differs from the nine percent uplift for Great Circle distance (discussed below), which can be applied separately if an organisation decides to account for this in their inventory.

Assumptions

The underlying assumptions stated in the DEFRA publication are made here. Further discussion on the methodology used to derive the air travel emission factors can be found at http://www.defra.gov.uk/environment/business/envrp/pdf/passenger-transport.pdf.

The emission factors contained in Table 10 are based on representative flight distances of: domestic 463 km, short haul 1,108 km, and long haul 6,482 km. The domestic emission factor should be applied to all domestic flights; the short haul emission factor to flights less than 3,700 km; and the long haul emission factor should be applied to any flights greater in length than 3,700 km.

DEFRA endorses a nine percent Great Circle distance uplift factor to take into account non-direct (ie, not along the straight line between destinations) routes and delays/circling. This figure comes from the IPCC's *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 percent), however in the absence of a New Zealand-specific figure it is recommended that those wishing to take a conservative approach apply the nine percent uplift factor.

The DEFRA emission factors only take into account CO_2 emissions. In line with *ISO 14064-1* and *The GHG Protocol* reporting requirements, the emission factors provided in Table 10 are CO_2-e emission factors. They have been scaled-up based on the default CH_4 and N_2O emission factors (for aviation fuels) sourced from the *Energy Greenhouse Gas Emissions 1990–2007* publication. The percentage mark up (used to convert to CO_2-e) is 0.9194 percent. The mark up assumes that all fuel burnt is jet fuel.

The emission factors provided above do not include radiative forcing (ie, non-CO_2 climate change impacts). The total climate impacts of aviation due to radiative forcing 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 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 radiative forcing.

Example calculation

An organisation makes a number of flights from Auckland to Sydney (2,171 km each way). The total distance travelled was 217,100 km.

Total CO_2-e emissions from air travel = 217,000* 0.0983 = 21,331 kg CO_2-e = 21.3 tonnes CO_2-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 1990–2006* and methodologies are derived from IPCC good practice guidance. The (base equation) methodology provided below is termed "tier 1" under the IPCC 1996 guidelines and assumes all the potential emissions in a tonne of waste are released 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.[27] 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.[28]

Base equation

The base equation used in deriving the waste emission factors, as taken from the 1996 *IPCC Good Practice Guidelines*[x], 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)

27 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.

28 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.

Interpretation

Table 11 provides methodologies for four scenarios where composition of an organisation's waste is or is not known, and is sent to a landfill that has or 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 potential to 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 11 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 11. 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 (ie, 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 11: Emission factors for waste to landfill – 2007

Emission source	Data input unit	Kgs CO_2e/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	1.49	(0.4 * 0.5 * 0.5 * 16/12) * (1-0.408[29]) * (1-0.1) * 21
Garden and food	kg	0.559	(0.15 * 0.5 * 0.5 * 16/12) * (1-0.408) * (1-0.1) * 21
Wood	kg	1.11	(0.3 * 0.5 * 0.5 * 16/12) * (1-0.408) * 0.9 * 21
Landfilled waste – default values (without landfill gas recovery)			
Mixed waste (national average)	kg	0.947	0.0501[30] * (1-0.1) * 21
Office waste	kg	1.55	((0.536[31] * 0.4) + (0.208[33] * 0.15) + (0[33] * 0.3)) * 0.5 * 0.5 * 16/12) * (1-0.1) * 21

29 This figure can be found by dividing the recovered methane per year by gross emissions as found in the supplementary CD of the *New Zealand's Greenhouse Gas Inventory 1990–2006.*

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

31 These figures represent an assumed default composition (paper (53.6 percent), garden and food (20.8 percent) and wood (0 percent)) for office waste, based on waste data from government buildings.

Landfilled waste – default values (with landfill gas recovery)			
Mixed waste (national average)	kg	0.560	0.0501 * (1-0.408) * (1-0.1) * 21
Office waste	kg	0.915	$((0.536^{33} * 0.4) + (0.208^{33} * 0.15) + (0^{33} * 0.3)) * 0.5 * 0.5 * 16/12) * (1-0.408) * (1-0.1) * 21$

Assumptions

The emission factors provided in Table 11are based on 2006 data, however we recommend that they are used for the 2007 reporting period, as this is the most current data available.

Changes in methodology from 2006

The amount of greenhouse gas (methane) recovered from landfills is projected to increase more than gross emissions each year. Therefore, the emission factors for landfill waste with landfill gas recovery have decreased slightly.

Example calculation

An organisation disposes of 30 tonnes of garden waste to a landfill with a gas recovery system in 2007.

Total CO_2-e emissions from waste to landfill = 30,000* 0.559 = 16,770 kg CO_2-e = 16.77 tonnes CO_2-e

4 References

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Appendix: Derivation of fuel emission factors

A1. 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 are sourced from the *New Zealand Energy Data File 2008*.

Note that gross calorific values have been used.

A2. CH_4 and N_2O emission factors used in this guide

As stated above, 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 12 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 12 are sourced from the *Energy Greenhouse Gas Emissions* publication. This publication contains further CH_4 and N_2O emission factors for a range of other users (eg, residential).

Note that gross emission factors have been used.

A3. Oxidation factors used in this guide

All oxidation factors contained in Table 12 are sourced from *New Zealand's National Greenhouse Gas Inventory 1990–2006*. Oxidation factors have been applied only 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 the National Greenhouse Gas Inventory.

A4. Reference data

Table 12: Underlying data used to derive the per activity unit emission factors – 2007

Emission Source	User	Unit	Calorific Value	Oxidation Factor	T CO2/TJ (After Oxidation)	T CH4/TJ	T N2O/TJ
Stationary Combustion							
Distributed Natural Gas	Commercial	KWh	NA	0.995	53.3	0.00108	0.00207
		GJ	NA	0.995	53.3	0.00108	0.00207
Coal – Bituminous	Commercial	Kg	28.84	0.98	87.0	0.0095	0.00133
Coal – Sub-bituminous	Commercial	Kg	22.35	0.98	89.4	0.0095	0.00133
Coal – Lignite	Commercial	Kg	15.85	0.98	93.3	0.0095	0.00133
Coal – Default	Commercial	Kg	22.35	0.98	89.4	0.0095	0.00133
Diesel	Commercial	Litre	38.27	0.99	68.7	0.00067	0.00038
LPG	Commercial	Kg	49.51	0.99	59.8	0.00105	0.00057
Heavy Fuel Oil	Commercial	Litre	40.93	0.99	72.9	0.00133	0.000285
Light Fuel Oil	Commercial	Litre	40.65	0.99	72.1	0.00133	0.000285
Distributed Natural Gas	Industry	KWh	NA	0.995	53.3	0.00126	0.00009
		GJ	NA	0.995	53.3	0.00126	0.00009
Coal – Bituminous	Industry	Kg	28.84	0.98	87.0	0.000665	0.00152
Coal – Sub-bituminous	Industry	Kg	22.35	0.98	89.4	0.000665	0.00152
Coal – Lignite	Industry	Kg	15.85	0.98	93.3	0.000665	0.00152
Coal – Default	Industry	Kg	22.35	0.98	89.4	0.000665	0.00152
Diesel	Industry	Litre	38.27	0.99	68.7	0.00019	0.00038
LPG	Industry	Kg	49.51	0.99	59.8	0.00105	0.00057
Heavy Fuel Oil	Industry	Litre	40.93	0.99	72.9	0.00285	0.000285
Light Fuel Oil	Industry	Litre	40.65	0.99	72.1	0.0019	0.00038
Wood	Industry	Kg	12.08	1.00	104.2	0.0143	0.0038
Wood	Fireplaces*	Kg	12.08	1.00	104.2	0.285	0.0038
Transport Fuels							
Regular Petrol	Mobile use	Litre	34.87	0.99	65.69	0.0185	0.00143
Premium Petrol	Mobile use	Litre	35.24	0.99	66.11	0.0185	0.00143
Petrol – Default	Mobile use	Litre	34.94	0.99	65.77	0.0185	0.00143
Diesel	Mobile use	Litre	38.27	0.99	68.69	0.0038	0.00371
LPG	Mobile use	Litre	26.54	0.99	59.80	0.0285	0.00057

Table 13 contains the GWPs for CO_2, CH_4 and N_2O that have been used in converting to CO_2-equivalent emission factors.

Table 13: Global Warming Potentials for CO_2, CH_4 and N_2O

	CO_2	CH_4	N_2O
Global Warming Potential	1	21	310

A5. Example derivation of emission factors:

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

CO_2 emission factor (kg CO_2/kg) = [(Calorific value*TCO_2 per TJ emission factor)*
= (22.35*89.4)/1000
= 1.998 kg CO_2/kg

CH_4 emission factor (kg CO_2-e/kg) = [(Calorific value*TCH_4 per TJ emission factor)*GWP of CH_4]/1000
= [(22.35*0.0095)*21]/1000
= 0.00446 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
= [(22.35*0.00133)*310]/1000
= 0.00921 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
= 2.01 CO_2-e/kg

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.

* 2007 emission factors for CO_2 from the *New Zealand Energy Greenhouse Gas Emissions 1990–2007* are given as the value *after* oxidation. In 2006 this report gave CO_2 emission factors *before* oxidation, and therefore oxidation factors were applied to the 2006 values. This step was not required to calculate CO_2 emission factors (kg CO_2/kg) for 2007.