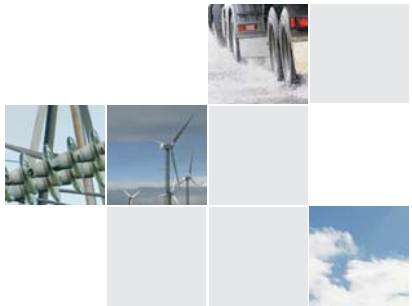
Ministry for the Environment
Manatū Mō Te Taiao



New Zealand's Greenhouse Gas Inventory 1990–2005

THE NATIONAL INVENTORY REPORT AND COMMON REPORTING FORMAT

JULY 2007

New Zealand Government

Acknowledgements

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Executive Summary

This annual inventory of emissions and removals of greenhouse gases forms part of New Zealand's obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The inventory is also a key element of the Ministry for the Environment's state of the environment reporting.

The inventory reports the emissions and removals of greenhouse gases not controlled by the Montreal Protocol. The gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) from six sectors: energy; industrial processes; solvents; agriculture; LULUCF (land use, land-use change and forestry); and waste. The indirect greenhouse gases carbon monoxide (CO), oxides of nitrogen (NO_x), sulphur dioxide (SO_2) and non-methane volatile organic compounds (NMVOCs) are also included in the inventory. Under the UNFCCC, only emissions and removals of the direct greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs and SF6) are reported in the national greenhouse gas total.

Only human-induced emissions and removals of greenhouse gases are included. A complete time-series of emissions and removals from 1990 through to 2005 (the current inventory year) are reported.

Climate change and the international response

Greenhouse gases trap the warmth from the sun and make life on Earth possible. Over the previous 50 to 100 years however, the concentration of the greenhouse gases carbon dioxide, methane and nitrous oxide in the atmosphere have been increasing. The increased concentration produces an "enhanced greenhouse effect" that causes the atmosphere to trap more heat and the climate to change. The climate changes ahead of us are expected to be much larger and happen more quickly than any recent natural changes.

The long-term objective of the United Nations Framework Convention on Climate Change is to "stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". All countries that ratify the UNFCCC are required to address climate change through national or regional programmes, preparing for adaptation to the impacts of climate change and monitoring emissions trends via greenhouse gas inventories. Developed countries agreed to non-binding targets to reduce greenhouse gas emissions to 1990 levels by the year 2000.

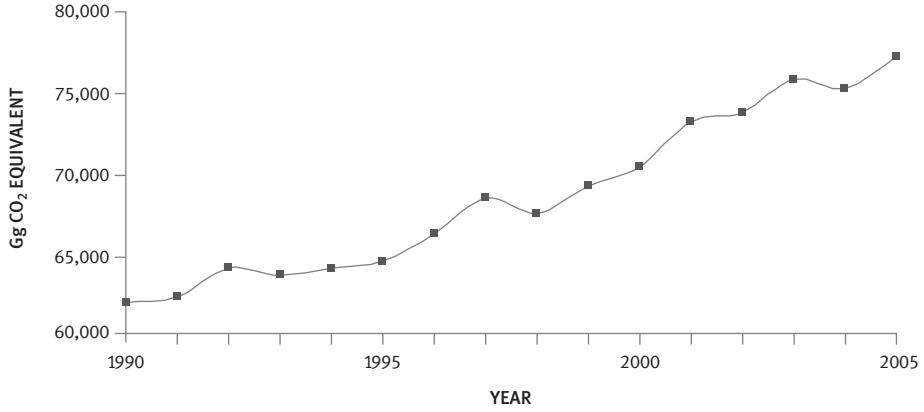
Only a few countries made appreciable progress towards achieving their targets. The international community recognised that the UNFCCC alone was not enough to ensure greenhouse gas levels would be reduced to safe levels, and that more urgent action was needed. In 1997 the Kyoto Protocol was adopted. The Kyoto Protocol commits Annex I Parties that ratify it to individual, legally-binding targets to limit or reduce their greenhouse gas emissions. New Zealand ratified the Kyoto Protocol on 19 December 2002 with a target of 100 per cent of the level of emissions in 1990. The Protocol came into force on 16 February 2005.

National trends in New Zealand's emissions and removals

In 1990, New Zealand's total greenhouse gas emissions were equal to 61,900.2 Gg CO_2 equivalent (CO_2-e). In 2005, total greenhouse gas emissions were 77,159.1 Gg CO_2-e equating to a 15,258.9 Gg (24.7 per cent) rise since 1990 (Figure 1.1). Net removals of CO_2 through forest sinks increased from 18,980.6 Gg CO_2 in 1990 to 24,500.8 Gg CO_2 in 2005.

FIGURE 1.1
New Zealand's total greenhouse gas emissions 1990–2005

There have been changes in the relative amounts of the different greenhouse gases emitted.



Whereas CH_4 and CO_2 contributed equally to New Zealand's emissions in 1990, CO_2 is now the major greenhouse gas in New Zealand's emissions profile (table 1.1). This is caused by increased growth in the energy sector compared to the agriculture sector.

TABLE 1.1
Emissions of greenhouse gases in 1990 and 2005

GREENHOUSE GAS EMISSIONS	Gg CO_2-EQUIVALENT		CHANGE FROM 1990 (Gg CO_2-EQUIVALENT)	CHANGE FROM 1990 (%)
	1990	2005		
CO_2 emissions (excluding LULUCF)	25,462.3	35,879.8	10,417.5	40.9
CH_4 (excluding LULUCF)	25,492.7	27,175.3	1,682.6	6.6
N_2O (excluding LULUCF)	10,417.2	13,259.9	2,842.7	27.3
HFCs	0.0	741.6	741.6	–
PFCs	515.6	80.7	–434.9	–84.3
SF^6	12.3	21.8	9.5	77.2

Source and sink category emission estimates and trends

New Zealand is unusual amongst developed nations in that 48.5 per cent of total emissions in 2005 were produced by the agriculture sector (Figure 1.2). By comparison, emissions from agriculture typically make up 12 per cent of total greenhouse gas emissions across Annex 1 Parties. New Zealand's agricultural emissions are predominantly CH_4 emissions from ruminant farm animals and N_2O emissions from animal excreta and nitrogenous fertiliser use. The current level of emissions from the agriculture sector is 4,948.2 Gg CO_2-e (15.2 per cent) above the 1990 level (table 1.2).

The energy sector is the other large component of New Zealand's emissions profile comprising 43.4 per cent of total emissions in 2005. Emissions from the energy sector are now 9,904.1 Gg CO_2-e (42.0 per cent) above the 1990 level (table 1.2). The growth in energy emissions since 1990 is primarily from "road transport" (an increase of 4,961.9 Gg CO_2-e or 64.7 per cent) and "electricity generation" (an increase of 4,697.2 Gg CO_2-e or 134.5 per cent). Emissions from thermal electricity generation vary from year to year depending on the water resources available for hydro generation. In "dry" years there is a greater reliance on thermal electricity generation.

Emissions from the industrial processes and waste sectors are a much smaller component of New Zealand's emissions profile, comprising 5.6 per cent and 2.4 per cent respectively of all greenhouse gas emissions in 2005. Emissions from the waste sector are now 25.9 per cent below the 1990 baseline with the majority of the reduction occurring from improvements in solid waste disposal. New Zealand's relatively small manufacturing base means that solvent use is small.

The land use, land-use change and forestry (LULUCF) sector represents a major sink for New Zealand removing 31.8 per cent of all greenhouse gas emissions in 2005. Net removals in 2005 were 29.1 per cent above net removals in 1990. Variations in planting rates and the impact of harvest regimes affect the size of this sink from year to year.

FIGURE 1.2
New Zealand's sectoral emissions in 2005 (all figures Gg CO_2-e)

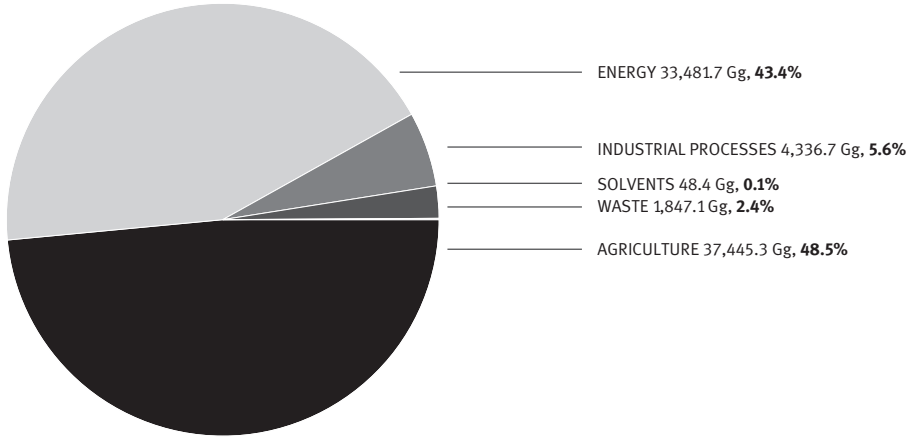


TABLE 1.2
Sectoral emissions of greenhouse gases in 1990 and 2005

SECTOR	Gg CO_2-EQUIVALENT		CHANGE FROM 1990 (Gg CO_2 – EQUIVALENT)	CHANGE FROM 1990 (%)
	1990	2005		
Energy	23,577.5	33,481.7	9,904.1	42.0
Industrial processes	3,291.2	4,336.7	1,045.5	31.8
Solvent and other product	41.5	48.4	6.9	16.6
Agriculture	32,497.1	37,445.3	4,948.2	15.2
Land-use change and forestry	–18,980.6	–24,500.8	–5,520.2	29.1
Waste	2,492.8	1,847.1	–645.7	–25.9

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CHAPTER 1: Introduction

1.1 Background

Greenhouse gases present in the Earth's atmosphere trap the warmth from the sun, keeping temperatures stable and preventing all the Earth's warmth from radiating away into space. Without these gases, Earth would be too cold to support life as we know it. We call these gases, primarily water vapour, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), greenhouse gases because they act like the glass in a greenhouse.

Until recently the greenhouse has existed in a state of natural balance, with the heat gained from the sun being matched by the heat lost by radiation back out to space. Although there have been climatic changes in the past, there have been no significant climatic changes since the start of human civilisation 10,000 years ago. Earlier changes have been either gradual, occurring over tens or hundreds of thousands of years, or when not gradual (when caused for example by major meteorite impacts) have extinguished much of the life on Earth.

In the past 50 to 100 years, human activity has changed markedly and rapidly. These changes have impacted significantly on the atmosphere. Worldwide there have been developments in transportation, agriculture and industry. These activities produce greenhouse gases, and as a consequence the concentration of these gases in Earth's atmosphere has increased. The greenhouse balance has been upset and more heat has been trapped. The Earth has begun to warm and the climate to change.

There is evidence of climate change effects, including raised temperatures and sea levels and the increased frequency of extreme weather events. The occurrence of these changes is projected to be more pronounced, and the rate of change more rapid.

1.1.1 The United Nations Framework Convention on Climate Change and the Kyoto Protocol

At a global level, the science of climate change is assessed by the **Intergovernmental Panel on Climate Change (IPCC)**. In 1990 the IPCC concluded that human-induced climate change was a threat to our future. In response, the United Nations General Assembly convened a series of meetings that culminated in the adoption of the **United Nations Framework Convention on Climate Change (UNFCCC)** at the Earth Summit in Rio de Janeiro in May 1992.

The UNFCCC took effect on 21 March 1994 and has been signed and ratified by 188 nations including New Zealand.

The main objective of the UNFCCC is to achieve "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (caused by humans) interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" (United Nations, 1992).

All countries that ratify the UNFCCC are required to address climate change through national or regional programmes. This includes preparing for adaptation to the impacts of climate change, protecting and enhancing carbon sinks (eg, forests), monitoring emissions trends via greenhouse gas inventories and, for developed countries, providing financial assistance to developing countries.

Developed countries party to the UNFCCC agreed to non-binding targets to reduce greenhouse gas emissions to 1990 levels by 2000.

Only a few countries made appreciable progress towards achieving their targets. The international community recognised that the UNFCCC alone was not enough to ensure greenhouse gas levels would be reduced to safe levels, and that more urgent action was needed. In response, Parties launched a new round of talks for stronger and more detailed commitments for developed countries. After two and a half years of negotiations, **the Kyoto Protocol** was adopted in Kyoto, Japan, on 11 December 1997. New Zealand ratified the Kyoto Protocol on 19 December 2002. The Protocol came into force on 16 February 2005.

The Kyoto Protocol shares the UNFCCC's objective, principles and institutions, but significantly strengthens the UNFCCC by committing Annex I Parties (OECD members and countries whose economies are in transition) to individual, legally-binding targets to limit or reduce their greenhouse gas emissions. Only Parties to the Convention that have also become Parties to the Protocol, by ratifying, accepting, approving, or acceding to it, are bound by the Protocol's commitments. Article 3 of the Kyoto Protocol states that the Annex I Parties ratifying the Protocol shall individually or jointly ensure that their aggregate anthropogenic greenhouse gas emissions do not exceed their "assigned amounts". The goal is to reduce aggregate emissions by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.

The "assigned amount" is the maximum amount of emissions (measured as the equivalent in carbon dioxide) that a Party may emit over the commitment period to comply with its emissions target. New Zealand's target is 100 per cent of the level in 1990. New Zealand's assigned amount over the commitment period is the gross emissions in 1990 multiplied by 5, ie, for the five years of the commitment period. Gross emissions do not include emissions and removals from the land use, land-use change and forestry sector (LULUCF) unless this sector was a source of emissions in 1990.

To achieve their targets, Annex I Parties must put in place domestic policies and measures to address emissions. This can be achieved in either of two ways: the quantity of greenhouse gases emitted can be reduced or carbon dioxide presently in the atmosphere can be removed using **carbon sinks** (eg, trees).

The Kyoto Protocol also defined three "flexibility mechanisms" to lower the overall costs of achieving its emissions targets:

- Clean Development Mechanism (CDM)
- Joint Implementation (JI)
- emissions trading.

These mechanisms enable Parties to access cost-effective opportunities to reduce emissions or to remove carbon from the atmosphere through action in other countries. While the cost of limiting emissions varies considerably from region to region, the benefit for the atmosphere is the same, wherever the action is taken. More information on these mechanisms can be obtained from the website of the UNFCCC (**www.unfccc.int**).

New Zealand greenhouse gas emissions profile

New Zealand's emissions have increased since 1990 as the economy has strengthened and grown. One half of New Zealand's emissions come from agriculture. This creates a unique greenhouse gas emission profile for New Zealand. The typical Annex 1 Party has the majority of emissions from industrial processes, electricity production and transportation activity.

Another consequence of this economic growth has been the increasing greenhouse gas emissions from the energy sector. In 2005, New Zealand's emissions from this sector accounted for 43.4 per cent of the total emissions, making it the second largest source after agriculture. Emissions from the energy sector have increased consistently since 1998 in response to increasing demands for energy from transport, electricity generation, manufacturing industries and construction. Renewable energy sources dominate New Zealand's electricity generation with hydroelectric power producing approximately 60 per cent of annual generation (depending on rainfall). Geothermal makes up approximately 7 per cent on an annual basis with smaller contributions from other renewable sources such as biogas, waste heat, wood, and wind.

1.1.2 A national greenhouse gas inventory

The development and publication of an annual inventory of all human-induced emissions and removals of greenhouse gases not controlled by the Montreal Protocol is part of New Zealand's obligations under the UNFCCC (Articles 4 and 12) and the Kyoto Protocol (Article 7). The inventory is the tool for measuring New Zealand's progress against these obligations.

The content and format of the inventory is prescribed by the Intergovernmental Panel on Climate Change (IPCC, 1996; 2000; 2003) and relevant decisions of the Conference of the Parties (COP) to the UNFCCC, the most recent being FCCC/SBSTA/2004/8. A complete inventory submission requires two components: the national inventory report (National Inventory Report) and emissions and removal data in the Common Reporting Format (CRF). Inventories are subject to an annual three-stage international review process administered by the UNFCCC secretariat.

The inventory reports emissions and removals of the gases carbon dioxide (CO_2) , methane (CH_4) , nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) from six sectors: energy; industrial processes; solvents; agriculture; land use, land-use change and forestry (LULUCF); and waste. The indirect greenhouse gases carbon monoxide (CO), oxides of nitrogen (NOX) and non-methane volatile organic compounds (NMVOCs) are also included in the inventory as is sulphur dioxide (SO_2) . Only emissions and removals of the direct greenhouse gases, CO_2, CH_4, N_2O, HFCs, PFCs and SF6 are reported in New Zealand's total emissions under the UNFCCC and are accounted for under the Kyoto Protocol.

Greenhouse gases vary in their radiative activity and in their atmospheric residence time. Emissions are converted into carbon dioxide equivalents (CO_2-e) to allow the integrated effect of emissions of the various gases to be compared. The national greenhouse gas inventory report presents emissions for each direct greenhouse gas as CO_2-e. This conversion is achieved through global warming potentials (GWPs). Global warming potentials represent the relative warming effect or cumulative radiative forcing, of a unit mass of the gas when compared with the same mass of CO_2 over a specific period. The UNFCCC reporting requirements (FCCC/SBSTA/2004/8) specify that the 100-year global warming potentials contained in the IPCC Second Assessment Report (IPCC, 1995) are used in national inventories (see section 1.9). The indirect effects of a number of gases (CO, NO_x, SO_2 and NMVOCs) cannot currently be quantified and consequently these gases do not have global warming potentials. In accordance with the UNFCCC reporting guidelines, gases that do not have global warming potentials are reported in the inventory but are not included in the inventory emissions total.

1.2 Institutional arrangements

The Climate Change Response Act 2002 (CCRA) came into force to enable New Zealand to meet its international obligations under the UNFCCC and the Kyoto Protocol. The CCRA names the person "who is for the time being the chief executive of the Ministry for the Environment" as New Zealand's inventory agency. The section "Part 2 Institutional Arrangements Sub part 3 – Inventory Agency of the CCRA" (2002) specifies the primary functions of the inventory agency, including:

- "to estimate annually New Zealand's human-induced emissions by sources and removals by sinks of greenhouse gases" (32.1(a))
- "to prepare New Zealand's annual inventory report under Article 7.1 of the Protocol and New Zealand's national communication (or periodic report) under Article 7.2 of the Protocol and Article 12 of the Convention" (32.1(b)(i) and (ii)).

The CCRA also specifies the responsibilities of the inventory agency in carrying out its functions, including record keeping and publication of the inventory. Part 3 of the CCRA provides for the authorisation of inspectors to collect information needed to estimate emissions or removals of greenhouse gases.

The Ministry for the Environment (MfE) is responsible for overall development, compilation and submission of the annual inventory to the UNFCCC. The Ministry also produces estimates of emissions for the agriculture and waste sectors and emissions and removals from the LULUCF sector (except for planted forests which is provided by the Ministry of Agriculture and Forestry).

The Ministry of Economic Development (MED) collects and processes all emissions from the energy sector and CO_2 emissions from the industrial processes sector. Emissions of the non-CO_2 gases from the industrial processes sector are obtained through industry survey by consultants, contracted to the Ministry for the Environment.

The Ministry of Agriculture and Forestry (MAF) provides many of the statistics for the agriculture sector and removals data from planted forests in the LULUCF sector. The inventory estimates are underpinned by the research and modelling of researchers at New Zealand's crown research institutes and universities.

New Zealand's national statistical agency, Statistics New Zealand, provides many of the official statistics for the agriculture sector through a regular agricultural census and provides statistics on oil consumption from the transport sector through the "Deliveries of Petroleum Fuels by Industry" survey.

1.3 Inventory preparation processes

The inventory contains data from the base year (1990) to two years before the current calendar year. Generation of the data in the Common Reporting Format and production of the National Inventory Report occurs over the period February to April as activity data statistics and emission data become available from the various participating institutions mentioned in section 1.2 "Institutional arrangements". The national inventory compilation occurs at the Ministry for the Environment using the UNFCCC "CRF Reporter" software. Ministry officials also undertake quality control checks on the data, calculate the inventory uncertainty, and undertake the key category assessment. The inventory and all required data for the submission to the UNFCCC are stored on the Ministry's central computer network in a controlled file system. Once the inventory has gone through the initial quality checks at the UNFCCC Secretariat it is ready for public release (both as hard copy and on the MfE and UNFCCC websites).

New Zealand is required to have a national system in place for its greenhouse gas inventory under Article 5.1 of the Kyoto Protocol. New Zealand provided a full description of the national system in the initial report for the Kyoto Protocol. Many of the arrangements detailed in the guidelines for national systems are also described in this report. For example, designation of the national inventory agency, and the assignment of responsibilities for the inventory preparation process.

1.4 Methodologies and data sources used

The guiding documents in inventory preparation are the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 1996), the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC, 2000), *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC, 2003) and the UNFCCC guidelines on reporting and review (FCCC/SBSTA/2004/8). The concepts contained in *Good Practice Guidance* are being implemented in stages, according to sector priorities and national circumstances.

Energy: Greenhouse gas emissions from the energy sector are calculated using an IPCC Tier 1 approach. Activity data (fuel consumed) are multiplied by the emission factors of specific fuels. Activity data comes from industry-supplied information via the Ministry of Economic Development and Statistics New Zealand (refer Chapter 3 and Annex 2). Carbon dioxide emission factors are usually New Zealand specific but applicable IPCC default factors are used for non-CO_2 emissions where New Zealand data are not available or are not well supported.

Industrial processes: Carbon dioxide emissions and activity data for the industrial processes sector are supplied directly to the Ministry of Economic Development by industry sources. IPCC Tier 2 approaches are used and emission factors are country-specific. Activity data for the non-CO_2 gases are collated through an industry survey through the Ministry for the Environment. Emissions of HFCs and PFCs are estimated using the IPCC Tier 2 approach and SF6 emissions from large users are assessed via the Tier 3a approach (IPCC, 2000).

Solvents: Very small amounts of nitrous oxide are emitted during use in medical applications. Estimates of NMVOC emissions are calculated using a consumption-based approach. Activity data are obtained through an industry survey.

Agriculture: Livestock population data are obtained from Statistics New Zealand, supplemented by estimates from the Ministry of Agriculture and Forestry. A Tier 2 (model) approach is used to estimate methane emissions from dairy cattle, non-dairy cattle, sheep and deer. The methodology uses animal productivity data to estimate dry matter intake. Methane production is determined from this intake. The same dry matter intake data are used to calculate nitrous oxide emissions from animal excreta. A Tier 1 approach is used for livestock species present in insignificant numbers.

Land use, land-use change and forestry: The LULUCF inventory is completed using a mix of IPCC Tier 2 and Tier 1 approaches. A Tier 2 approach is used for the "planted forest" subcategory of forest land. Changes in planted forest stocks are assessed from national forest survey data and computer modelling of the planted forest estate. A Tier 1 approach is used for the categories cropland, grassland, wetland, settlements and other land. Changes in land area for these categories are based on modified national land cover databases reclassified to the UNFCCC categories. The Land Cover Databases 1 and 2 were mapped in 1997 and 2002 (refer to Annex 3.3). Data for all other years are extrapolated from the changes observed between 1997 and 2002. At present, this is the best data available for reporting the LULUCF sector. The reporting will be improved significantly as a result of the Land Use and Carbon Analysis System (described in Annex 3.2).

Waste: Emissions from the waste sector are estimated using waste-survey data combined with population data. Calculation of emissions from solid-waste disposal uses an IPCC Tier 2 method with country-specific emission factors. Methane and nitrous oxide emissions from domestic and industrial wastewater handling are calculated using a refinement of the IPCC methodology (IPCC, 1996). There is no incineration of municipal waste in New Zealand. The only incineration is for small specific waste streams including medical, quarantine and hazardous wastes. For this inventory waste incineration emissions are reported to be negligible.

1.5 Key categories

The IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (GPG) (IPCC, 2000) identifies a key category as "one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both". Key categories are identified within the inventory so that the resources available for inventory preparation and improvement are prioritised.

The key categories in the New Zealand inventory have been assessed using the Good Practice Guide Tier 1 level and trend methodologies (IPCC, 2000/2003). The Good Practice Guide methodologies identify sources of emissions and removals that sum to 95 per cent of the total level of emissions or 95 per cent of the trend of the inventory in absolute terms.

Following *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (GPG-LULUCF) (IPCC, 2003) the key category analysis is performed once for the inventory excluding LULUCF categories and then repeated for the full inventory including the LULUCF categories. Non-LULUCF categories that are identified as key in the first analysis but that do not appear as key when the LULUCF categories are included are still to be considered as key categories.

The key categories identified in the 2005 inventory are summarised in table 1.5.1. The major contributions to the level analysis including LULUCF (table 1.5.2 a and b) are CO_2 from "forest land remaining forest land" (24.9 per cent) and CH_4 from enteric fermentation in domestic livestock (22.2 per cent).

The largest contribution to the trend analysis (table 1.5.3) is from CH_4 emissions from enteric fermentation in domestic livestock (17.6 per cent), CO_2 emissions from road transportation (16.5 per cent), and CO_2 emissions from stationary combustion of solid fuels (14.6 per cent). It is clear that these three categories have a major effect on the New Zealand inventory.

Although CO_2 emissions from the industrial processes of ammonia and urea manufacture (CRF category 2B5) did not appear in the top 95 per cent of categories for the quantitative level and trend analyses, the source is considered a qualitative key category because of the large increase in nitrogenous fertiliser use observed in the agriculture sector.

There were two modifications to the IPCC suggested source categories to reflect New Zealand's national circumstances. The category for fugitive emissions from geothermal operations was separated from the "fugitive emissions from fuels-oil and natural gas" category and CO_2 emissions from "ammonia production" were included in the analysis. More information on the calculation of the level and trend analysis is included in Annex 1.

TABLE 1.5.1
Summary of key categories in the 2005 inventory (including and excluding LULUCF activities)

QUANTITATIVE METHOD USED: TIER 1		
IPCC SOURCE CATEGORIES	GAS	CRITERIA FOR IDENTIFICATION
Energy sector		
CO_2 emissions from stationary combustion – solid	CO_2	level, trend
CO_2 emissions from stationary combustion – liquid	CO_2	level
CO_2 emissions from stationary combustion – gas	CO_2	level, trend
Mobile combustion – road vehicles	CO_2	level, trend
Mobile combustion – aviation	CO_2	level
Fugitive emissions from oil and gas operations	CO_2	level, trend
Industrial processes sector		
Emissions from cement production	CO_2	level
Emissions from the iron and steel industry	CO_2	level
PFC's from aluminium production	PFC	trend
Ammonia production	CO_2	qualitative
Emissions from substitutes for ozone depleting substances	HFCs	level, trend
Agricultural sector		
Emissions from enteric fermentation in domestic livestock	CH_4	level, trend
Emissions from manure management	CH_4	level
Direct emissions from agricultural soils	N_2O	level, trend
Emissions from agricultural soils – animal production	N_2O	level, trend
Indirect emissions from nitrogen used in agriculture	N_2O	level
LULUCF sector		
Forest land remaining forest land	CO_2	level, trend
Cropland remaining cropland	CO_2	level
Conversion to forest land	CO_2	level, trend
Other-emissions from liming	CO_2	level, trend
Conversion to grassland	CO_2	level, trend
Waste sector		
Emissions from solid waste disposal sites	CH_4	level, trend

TABLE 1.5.2 (A&B)
Key category analysis for the 2005 inventory – Tier 1 level assessment
including LULUCF (a) and excluding LULUCF (b)

(A) TIER 1 CATEGORY LEVEL ASSESSMENT – INCLUDING LULUCF

IPCC CATEGORIES	GAS	2005 ESTIMATE Gg	LEVEL ASSESSMENT	CUMULATIVE TOTAL
Forest land remaining forest land	CO_2	26,767.89	24.9	24.9
Emissions from enteric fermentation in domestic livestock	CH_4	23,919.80	22.2	47.1
Mobile combustion – road vehicles	CO_2	12,444.08	11.6	58.7
Emissions from stationary combustion – gas	CO_2	7,589.75	7.1	65.8
Emissions from agricultural soils – animal production	N_2O	7,559.46	7.0	72.8
Emissions from stationary combustion – solid	CO_2	6,727.23	6.3	79.1
Indirect emissions from nitrogen used in agriculture	N_2O	3,384.65	3.1	82.2
Emissions from stationary combustion – liquid	CO_2	3,128.98	2.9	85.1
Direct emissions from agricultural soils	N_2O	1,762.87	1.6	86.7
Emissions from the iron and steel industry	CO_2	1,662.00	1.5	88.3
Emissions from solid waste disposal sites	CH_4	1,460.70	1.4	89.7
Conversion to forest land	CO_2	1,254.72	1.2	90.8
Mobile combustion – aviation	CO_2	1,015.99	0.9	91.8
Emissions from substitutes for ozone depleting substances	HFCs	741.56	0.7	92.5
Emissions from manure management	CH_4	739.48	0.7	93.1
Other – emissions from liming	CO_2	714.21	0.7	93.8
Conversion to grassland	CO_2	706.91	0.7	94.5
Cropland remaining cropland	CO_2	671.12	0.6	95.1

(B) TIER 1 CATEGORY LEVEL ASSESSMENT – EXCLUDING LULUCF

IPCC CATEGORIES	GAS	2005 ESTIMATE Gg	LEVEL ASSESSMENT	CUMULATIVE TOTAL
Emissions from enteric fermentation in domestic livestock	CH_4	23,919.80	31.0	31.0
Mobile combustion – road vehicles	CO_2	12,444.08	16.1	47.2
Emissions from stationary combustion – gas	CO_2	7,589.75	9.8	57.0
Emissions from agricultural soils – animal production	N_2O	7,559.46	9.8	66.8
Emissions from stationary combustion – solid	CO_2	6,727.23	8.7	75.5
Indirect emissions from nitrogen used in agriculture	N_2O	3,384.65	4.4	79.9
Emissions from stationary combustion – liquid	CO_2	3,128.98	4.1	84.0
Direct emissions from agricultural soils	N_2O	1,762.87	2.3	86.3
Emissions from the iron and steel industry	CO_2	1,662.00	2.2	88.4
Emissions from solid waste disposal sites	CH_4	1,460.70	1.9	90.3
Mobile combustion – aviation	CO_2	1,015.99	1.3	91.7
Emissions from substitutes for ozone depleting substances	HFCs	741.56	1.0	92.6
Emissions from manure management	CH_4	739.48	1.0	93.6
Fugitive emissions from oil and gas operations	CO_2	650.24	0.8	94.4
Emissions from cement production	CO_2	568.68	0.7	95.2

TABLE 1.5.3
Key category analysis for the 2005 inventory – Tier 1 trend assessment
including LULUCF (a) and excluding LULUCF (b)

(A) TIER 1 CATEGORY TREND ASSESSMENT – INCLUDING LULUCF

IPCC CATEGORIES	GAS	BASE YEAR ESTIMATE Gg	2005 ESTIMATE Gg	TREND ASSESSMENT	CONTRIBUTION TO TREND	CUMULATIVE TOTAL
Emissions from enteric fermentation in domestic livestock	CH_4	21,806.54	23,919.80	0.034	17.6	17.6
Mobile combustion – road vehicles	CO_2	7,535.48	12,444.08	0.032	16.5	34.0
Emissions from stationary combustion – solid	CO_2	3,227.01	6,727.23	0.028	14.6	48.6
Emissions from stationary combustion – gas	CO_2	7,691.14	7,589.75	0.021	10.8	59.4
Emissions from solid waste disposal sites	CH_4	2,122.92	1,460.70	0.012	6.4	65.8
Direct emissions from agricultural soils	N_2O	475.16	1,762.87	0.012	6.3	72.1
Forest land remaining forest land	CO_2	20,624.90	26,767.89	0.011	5.7	77.8
Emissions from agricultural soils – animal production	N_2O	6,856.67	7,559.46	0.010	5.3	83.1
Emissions from substitutes for ozone depleting substances	HFCs	0.00	741.56	0.008	4.0	87.1
PFC's from aluminium production	PFC	515.60	80.70	0.006	3.0	90.2
Fugitive emissions from oil and gas operations	CO_2	263.48	650.24	0.003	1.7	91.9
Other – emissions from liming	CO_2	346.42	714.21	0.0029	1.52	93.4
Conversion to grassland	CO_2	706.91	706.91	0.0018	0.94	94.4
Conversion to forest land	CO_2	870.01	1,254.72	0.002	0.9	95.3

(B) TIER 1 CATEGORY TREND ASSESSMENT – EXCLUDING LULUCF

IPCC CATEGORIES	GAS	BASE YEAR ESTIMATE Gg	2005 ESTIMATE Gg	TREND ASSESSMENT	CONTRIBUTION TO TREND	CUMULATIVE TOTAL
Emissions from enteric fermentation in domestic livestock	CH_4	21,806.54	23,919.80	0.0339	19.4	19.4
Mobile combustion – road vehicles	CO_2	7,535.48	12,444.08	0.0317	18.2	37.6
Emissions from stationary combustion – solid	CO_2	3,227.01	6,727.23	0.0281	16.1	53.8
Emissions from stationary combustion – gas	CO_2	7,691.14	7,589.75	0.0208	11.9	65.7
Emissions from solid waste disposal sites	CH_4	2,122.92	1,460.70	0.0123	7.1	72.7
Direct emissions from agricultural soils	N_2O	475.16	1,762.87	0.0122	7.0	79.7
Emissions from agricultural soils – animal production	N_2O	6,856.67	7,559.46	0.0103	5.9	85.6
Emissions from substitutes for ozone depleting substances	HFCs	0.00	741.56	0.0077	4.4	90.0
PFC's from aluminium production	PFC	515.60	80.70	0.0058	3.4	93.4
Fugitive emissions from oil and gas operations	CO_2	263.48	650.24	0.0033	1.9	95.3

1.6 Quality assurance and quality control

Quality assurance (QA) and quality control (QC) are an integral part of preparing New Zealand's inventory. The Ministry for the Environment developed a QA/QC plan in 2004 as required by the UNFCCC guidelines (FCCC/CP/2004/8) to formalise, document and archive the procedures. The plan is regularly reviewed and updated in conjunction with New Zealand's inventory improvement plan.

1.6.1 Quality control

During the preparation of the 2005 inventory, the Ministry for the Environment continued to develop the Tier 1 QC checksheet first used in the preparation of the 2002 inventory. The quality checking was also expanded to include formal checks between the CRF tables and the National Inventory Report. The Tier 1 quality checks are based on the procedures suggested in *Good Practice Guidance* (IPCC, 2000). Further details (including examples of some of the checks carried out) are available in Annex 6. For the 2005 inventory, the Tier 1 QC checksheets were used on all key categories and a selection of non-key categories.

In addition to the formal quality control checks, data in the underpinning worksheets and entered into the UNFCCC secretariat's CRF Reporter database are checked visually for anomalies, errors and omissions. In the preparation of the 2005 inventory, the Ministry for the Environment used the quality control checking procedures included in the CRF Reporter database to ensure the data submitted to the UNFCCC secretariat were complete.

1.6.2 Quality assurance

Quality assurance reviews of individual sectors and categories are commissioned by the Ministry for the Environment. As part of the quality assurance procedures for the 2005 inventory, the energy sector underwent a review during 2006. A list of previous quality assurance reviews, their key conclusions and follow up is included in Annex 6. In addition, the methodologies used in the agricultural and LULUCF sectors have undergone scientific peer-review before inclusion in New Zealand's inventory.

A large part of the data in the energy and agriculture sectors are compiled using data collected in national surveys. These surveys are conducted and administered by Statistics New Zealand, which conducts its own rigorous quality assurance and quality control procedures on the data.

1.6.3 UNFCCC annual inventory review

New Zealand's greenhouse gas inventory was reviewed in 2001 and 2002 as part of a pilot study of the technical review process (UNFCCC, 2001a; 2001b; 2001c; 2003), where the inventory was subject to detailed in-country, centralised and desk review procedures. The inventories submitted for the years 2001/2003 were reviewed during a centralised review process. The 2004 inventory was reviewed as part of the Kyoto Protocol initial review. This was an in-country review held from 19 to 24 February 2007. In all instances, the reviews were conducted by a review team comprising of experts nominated by Parties to the UNFCCC. Review reports are available from the UNFCCC website (**www.unfccc.int**).

1.7 Inventory uncertainty

Uncertainty estimates are an essential element of a complete greenhouse gas emissions and removals inventory. The purpose of uncertainty information is not to dispute the validity of the inventory estimates, but to help prioritise efforts to improve the accuracy of inventories in the future and guide decisions on methodological choice (IPCC, 2000). Inventories prepared following the Good Practice Guidance methodologies (IPCC 2000; 2003) will typically contain a wide range of emission estimates, varying from carefully measured and demonstrably complete data on emissions to order-of-magnitude estimates of highly variable estimates such as N_2O fluxes from soils and waterways.

New Zealand has included a Tier 1 uncertainty analysis as required by the inventory guidelines (FCCC/SBSTA/2004/8) and Good Practice Guidance (IPCC 2000; 2003). Uncertainties in the categories are combined to provide uncertainty estimates for the entire inventory in any year and the uncertainty in the overall inventory trend over time. LULUCF categories have been included using the absolute value of any removals of CO_2 (table A7.1). Table A7.2 calculates the uncertainty only in emissions, ie, excluding LULUCF removals.

The calculated uncertainty for New Zealand's total inventory (emissions and removals) in 2005 is ± 16.9 per cent. The uncertainty in the overall trend from 1990 to 2005 is lower at ± 4.7 per cent. The uncertainty in total emissions (excluding removals) is ± 20.7 per cent with ± 5.5 per cent uncertainty in the trend of emissions. The trend is critical to the UNFCCC and Kyoto Protocol reporting where New Zealand's emissions are compared to the 1990 baseline.

The high uncertainty in a given year is dominated by emissions of CH_4 from enteric fermentation (Chapter 6, section 6.2) and N_2O emissions from agricultural soils (section 6.5). These categories comprise 12.1 per cent and 8.9 per cent respectively of the uncertainty as a percentage of New Zealand's total emissions and removals. The apparent high uncertainty in these categories reflects the inherent variability when estimating emissions from natural systems, eg, the uncertainty in cattle dry-matter intake and CH_4 emissions per unit of dry matter. With the agricultural sector comprising approximately half of New Zealand's emissions, high uncertainty in a given year is inevitable. Removals of CO_2 from forest land are also a major contribution to the uncertainty for 2005 at 6.2 per cent of New Zealand's total emissions and removals. In comparison, the uncertainty in CO_2 emissions from burning of fossil fuels is significantly lower at only 1.5 per cent of the total.

Uncertainty in the trend is dominated by CO_2 emissions from the energy sector, at 2.8 per cent of the trend. This is because of the size of the sector and because the uncertainty in energy activity data are greater than the uncertainty in energy emission factors. The other major contributors to trend uncertainty are removals of CO_2 by forest land (Chapter 7, section 7.2) and CH_4 from enteric fermentation in domestic livestock.

In most instances, the uncertainty values are determined by either expert judgement from sectoral or industry experts, by analysis of emission factors or activity data, or by referring to uncertainty ranges quoted in the IPCC documentation. A Monte Carlo simulation was used to determine uncertainty for CH_4 from enteric fermentation and N_2O from agricultural soils in the 2001/2002 inventory. The 95 per cent confidence intervals developed from the Monte Carlo simulation were extended to the 2005 inventory.

1.8 Inventory completeness

The New Zealand inventory for the 2005 year can be described as complete, with all IPCC source and sink categories reported that occur in New Zealand or that have emissions assessed to be above a negligible level. There are some small sources which remain "not estimated" (NE), eg, CH_4 emissions from waste incineration. Explanations on why these are reported as not estimated are found under the appropriate sector chapters. In accordance with Good Practice Guidance, New Zealand has focused its resources for inventory development on the key categories. Some categories considered to have negligible emissions are reported as "not estimated". Where this has occurred explanations have been provided in the National Inventory Report and in the CRF tables.

The LULUCF data are the best estimate possible using the data that are presently available. The Land Use and Carbon Analysis System (LUCAS) is being developed to improve the accuracy of these data. Estimates using this system will be included when available. Development of the LUCAS will also reduce uncertainty by using country-specific emission and removal factors and use spatial data mapped specifically for UNFCCC reporting. Details of the LUCAS development are included in Annex 3.2.

1.9 General notes

Units

Standard metric prefixes used in this inventory are:

kilo (k)	=	10^3 (thousand)
mega (M)	=	10^6 (million)
giga (G)	=	10^9
tera (T)	=	10^{12}
peta (P)	=	10^{15}

Emissions are generally expressed in gigagrams (Gg) in the inventory tables:

1 gigagram (Gg) = 1,000 tonnes = 1 kilotonne (kt)

1 megatonne (Mt) = 1,000,000 tonnes = 1,000 Gg

Gases

CO_2	carbon dioxide
CH_4	methane
N_2O	nitrous oxide
PFCs	perfluorocarbons
HFCs	hydrofluorocarbons
SF_6	sulphur hexafluoride
CO	carbon monoxide
NMVOC	non-methane volatile organic compounds
NO_X	oxides of nitrogen
SO_2	sulphur dioxide

Common Global Warming Potentials

CO_2 = 1	HFC–32 = 650
CH_4 = 21	HFC–125 = 2,800
N_2O = 310	HFC–134a = 1,300
CF_4 = 6,500	HFC–143a = 3,800
C_2F_6 = 9,200	HFC–227ea = 2,900
SF_6 = 23,900	

Conversion factors

From element basis to molecular mass	From molecular mass to element basis
C ⇢ CO_2: C x 44/12 (3.67)	CO_2 ⇢ C: CO_2 x 12/44 (0.27)
C ⇢ CH_4: C x 16/12 (1.33)	CH_4 ⇢ C: CO_2 x 12/16 (0.75)
N ⇢ N_2O: N x 44/28 (1.57)	N_2O ⇢ N: N_2O x 28/44 (0.64)

Indicators

In the common reporting format tables, the following standard indicators are used:

NO (not occurring) when the activity or process does not occur in New Zealand.

NA (not applicable) when the activity occurs in New Zealand but the nature of the process does not result in emissions or removals.

NE (not estimated) where it is known that the activity occurs in New Zealand but there are no data or methodology available to derive an estimate of emissions. Even if emissions are considered to be negligible, an emission estimated should be reported, if calculated, or the notation key "NE" used.

IE (included elsewhere) where emissions or removals are estimated but included elsewhere in the inventory (summary table 9 of the Common Reporting Format tables details the source category where these emissions or removals are reported).

C (confidential) where reporting at a disaggregated level could lead to the disclosure of confidential information.

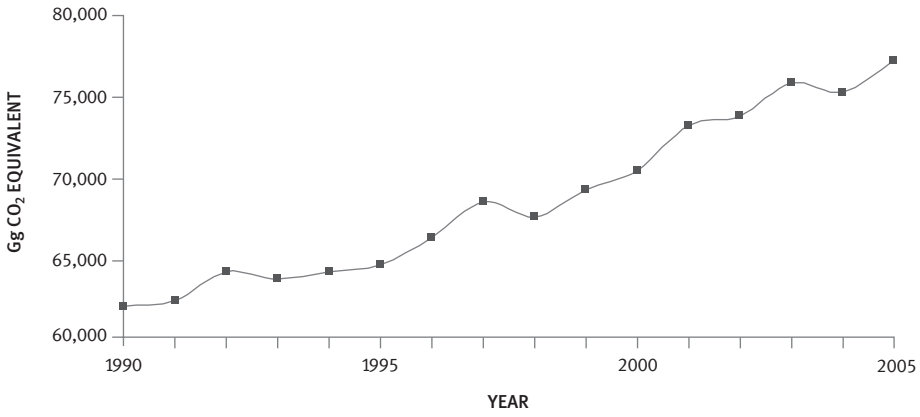
CHAPTER 2: Trends in greenhouse gas emissions

2.1 Emission trends for aggregated greenhouse gas emissions

In 1990, New Zealand's total greenhouse gas emissions were equivalent to 61,900.2 Gg CO_2 equivalent (CO_2-e). In 2005, total greenhouse gas emissions had increased by 15,258.9 Gg (24.7 per cent) to 77,159.1 Gg CO_2-e. (Figure 2.1.1). between 1990 and 2005, the average annual growth in overall emissions was 1.3 per cent.

Fluctuations in the trend are largely driven by emissions from the "public electricity and heat production" category. This category shows large year-to-year fluctuations because of the use of fossil fuels in thermal stations to supplement hydro-electric generation during dry years. Electricity generation in a year with hydro storage below average requires higher gas and coal use compared to a year with average rainfall and hydro storage. This is a different trend from the steady increase in emissions from coal and gas used in electricity generation found in many other countries.

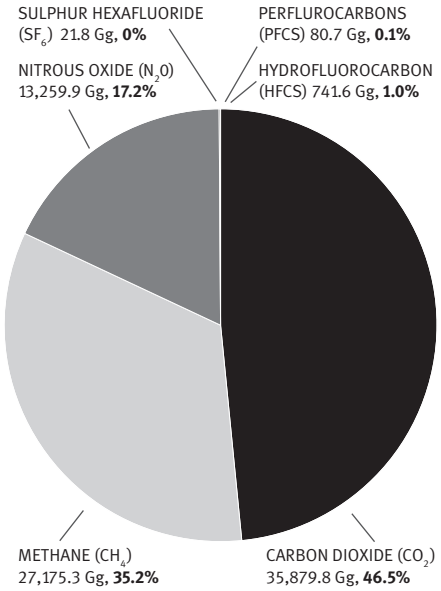
FIGURE 2.1.1
New Zealand's total greenhouse gas emissions 1990–2005



2.2 Emission trends by gas

Carbon dioxide and methane dominate New Zealand's increase in greenhouse gas emissions (Figures 2.2.1, 2.2.2 and table 2.2.1). In 2005, these gases comprised 81.7 per cent of total CO_2 equivalent emissions. In 1990 CH_4 and CO_2 made equally large contributions to New Zealand's total emissions. In 2005, CO_2 was the major greenhouse gas in New Zealand's emissions profile, followed by CH_4 and N_2O.

FIGURE 2.2.1
New Zealand's emissions by gas in 2005
(all figures Gg CO_2-e)



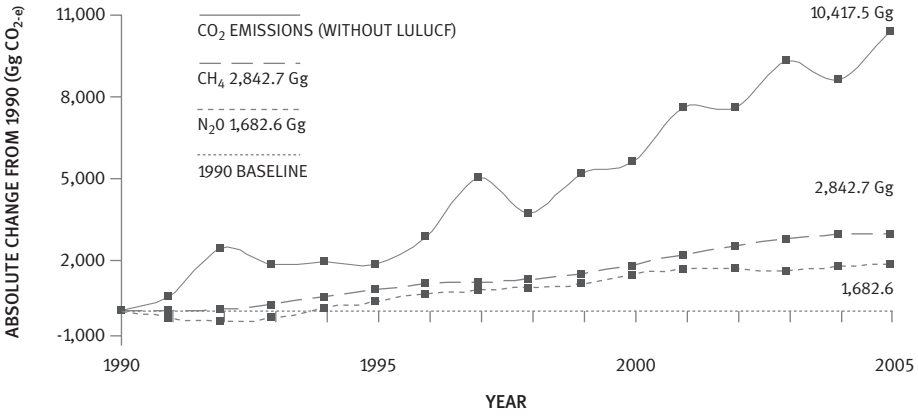
The growth in CO_2 represents the increased emissions from the energy sector. The growth in N_2O is from increased emissions from animal excreta and the increased use of nitrogenous fertilisers in agriculture eg, the amount of nitrogenous fertilisers used has increased six-fold since 1990.

Although the contribution of the other gases (HFCs, PFCs and SF6) in the inventory is around 1 per cent of the total emissions, these gases have also undergone relative changes between 1990 and 2005. Emissions of PFCs have decreased by 434.9 Gg due to improvements in the aluminium smelting process. HFC emissions have increased from 0 to 741.6 Gg because of the use of HFCs as a substitute for the chlorofluorocarbons (CFCs) phased out under the Montreal Protocol.

TABLE 2.2.1
Emissions of greenhouse gases 1990 and 2005

GREENHOUSE GAS EMISSIONS	Gg CO_2-EQUIVALENT		CHANGE FROM 1990 (Gg CO_2 / EQUIVALENT)	CHANGE FROM 1990 (%)
	1990	2005		
CO_2 emissions (without LULUCF)	25,462.3	35,879.8	10,417.5	40.9
CH_4	25,492.7	27,175.3	1,682.6	6.6
N_2O	10,417.2	13,259.9	2,842.7	27.3
HFCs	0.0	741.6	741.6	–
PFCs	515.6	80.7	–434.9	–84.3
SF_6	12.3	21.8	9.5	77.2

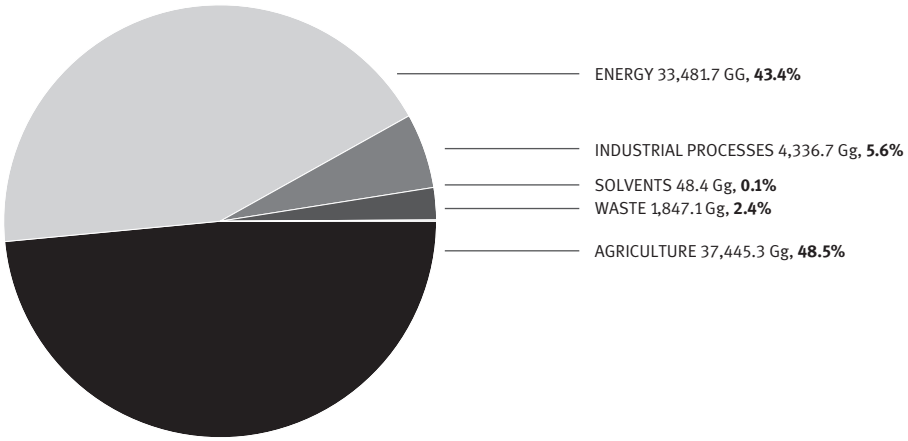
FIGURE 2.2.2
Change in New Zealand's emissions of CO_2, CH_4, and N_2O from 1990 to 2005



2.3 Emission trends by source

New Zealand is unusual amongst developed nations in the share of its total greenhouse gas emissions that come from agriculture (Figure 2.3.1 and table 2.3.1). In 2005, 48.5 per cent of New Zealand's total emissions were produced by the **agriculture sector**, predominantly CH_4 from ruminant farm animals, eg, dairy cows and sheep, and N_2O from animal excreta and nitrogenous fertiliser use. The current level of emissions from the agriculture sector is 15.2 per cent above the 1990 level (Figure 2.3.2). More detailed information on the agriculture sector is contained in Chapter 6.

FIGURE 2.3.1
New Zealand's sectoral greenhouse gas emissions in 2005
(all figures Gg CO_2-e, percentage of national total emissions in 2005)



The **energy sector** is the other large component of New Zealand's emissions profile comprising 43.4 per cent of total emissions (refer Chapter 3). Emissions from the energy sector in 2005 were 9,904.2 Gg CO_2-e (42.0 per cent) above the 1990 level and represent the highest sectoral growth in emissions. The growth in emissions from 1990 is primarily from road transport (increased by 4961.9 Gg CO_2-e or 64.7 per cent) and electricity generation (increased by 4,697.2 Gg CO_2-e or 134.5 per cent).

Emissions from the industrial processes and waste sectors are a much smaller component comprising 5.6 per cent and 2.4 per cent respectively of all greenhouse gas emissions in 2005. Emissions from the **industrial processes sector** have been increasing steadily and are now 1,045.5 Gg CO_2-e (31.8 per cent) above the 1990 baseline. This growth is primarily from increased CO_2 emissions from cement production (an increase of 127.0 Gg CO_2-e or 28.8 per cent over 1990), urea (nitrogenous fertiliser) manufacture (an increase of 71.66 Gg CO_2-e or 26.1 per cent over 1990), and HFC consumption (from 0 in 1990 to 741.6 Gg CO_2-e in 2005). The increase has been partially offset by PFC emissions from aluminium manufacture decreasing by 434.9 Gg CO_2-e (84.3 per cent) since 1990 as a result of improvements to the smelting process (refer to section 4.4.2).

Emissions from the **waste sector** are now 645.7 Gg CO_2-e (-25.9 per cent) below the 1990 baseline. The majority of the reduction has occurred in the solid waste disposal on land category, as a result of initiatives to improve solid waste management practices in New Zealand. This includes preparation of guidelines for the development and operation of landfills, closure and management of landfill sites, and consent conditions for landfills under New Zealand's Resource Management Act 1991.

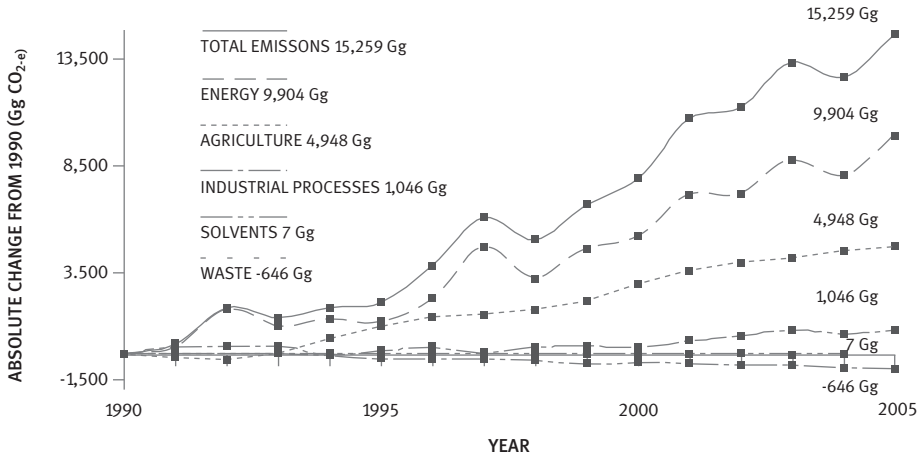
New Zealand's relatively small manufacturing base means emissions from the **solvent sector** are very small. In 2005, the solvent sector emitted 48.4 Gg of NMVOC.

The land use, land-use change and forestry (LULUCF) sector represents a major sink for New Zealand removing 31.8 per cent of all greenhouse gas emissions in 2005. Net removals in 2005 were 29.1 per cent above net removals in 1990. Variations in planting rates and the impact of harvest regimes affect the size of this sink from year-to-year.

TABLE 2.3.1
Sectoral emissions of greenhouse gases in 1990 and 2005

SECTOR	Gg CO_2-EQUIVALENT		CHANGE FROM 1990 (Gg CO_2-EQUIVALENT)	CHANGE FROM 1990 (%)
	1990	2005		
Energy	23,577.5	33,481.7	9,904.2	42.0
Industrial processes	3,291.2	4,336.7	1,045.5	31.8
Solvent and other product	41.5	48.4	6.9	16.6
Agriculture	32,497.1	37,445.3	4,948.2	15.2
Land-use change and forestry	–18,980.6	–24,500.8	–5,520.2	29.1
Waste	2,492.8	1,847.1	–645.7	–25.9

FIGURE 2.3.2
Change in sectoral greenhouse gas emissions from 1990 to 2005



2.4 Emission trends for indirect greenhouse gases and SO_2

The indirect greenhouse gases SO_2, CO, NO_X and NMVOC are also reported in the inventory. Emissions of these gases in 1990 and 2005 are shown in table 2.4.1. There have been marked increases in the emissions of all gases. Indirect greenhouse gases are not included in New Zealand's total greenhouse gas emissions.

TABLE 2.4.1
Emissions of indirect greenhouse gases and SO_2 in 1990 and 2005

GAS	Gg OF GAS(ES)		CHANGE FROM 1990 (Gg)	CHANGE FROM 1990 (%)
	1990	2005		
NO_X	104.1	163.4	59.3	57.0
CO	535.3	657.5	122.2	22.8
NMVOC	133.7	166.5	24.5	18.3
SO_2	54.3	83.8	29.5	54.3

Emissions of CO and NO_X come largely from the energy sector. The energy sector produced 85.8 per cent of total CO emissions in 2005. The largest single source was "road transportation". Similarly, the energy sector was the largest source of NO_X emissions (97.8 per cent), with "road transportation" again dominating. Other large sources of NO_X emissions are from "manufacturing industries and construction" and "energy industries".

The energy sector was also the largest producer of NMVOC's and SO_2. The energy sector produced 71.3 per cent of NMVOC emissions in 2005 with emissions from "road transportation" comprising 63.1 per cent of total NMVOC emissions. Other major sources of NMVOC's are in the solvent and other product use sector (20.3 per cent) and the industrial processes sector (8.4 per cent).

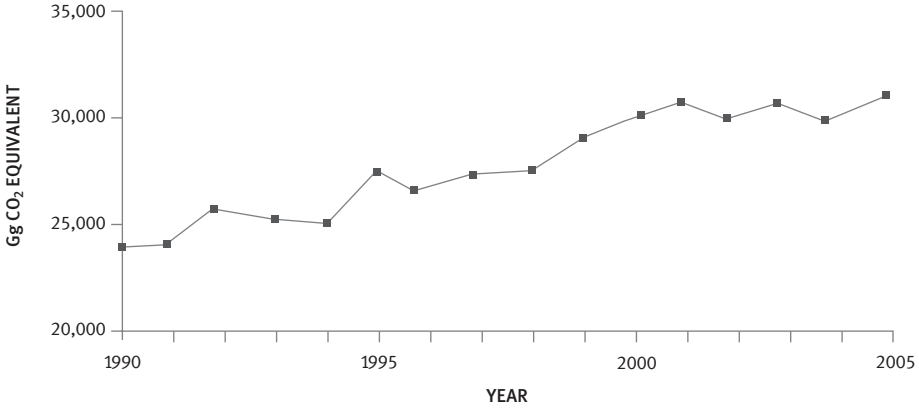
Emissions of SO_2 from the energy sector comprised 86.3 per cent of total SO_2 emissions. The "energy industries" category contributed 29.2 per cent, "manufacturing industries and construction" 24.5 per cent, and "transport" 16.0 per cent of total SO_2 emissions. The other source of SO_2 was from the industrial processes sector.

CHAPTER 3: Energy

3.1 Sector overview

The energy sector produced 33,481.7 Gg CO_2 equivalent (CO_2-e) in 2005, representing 43.4 per cent of New Zealand's total greenhouse gas emissions. Emissions from the energy sector are now 42.0 per cent above the 1990 value of 23,577.5 CO_2-e (Figure 3.1.1). The sources contributing most to this increase since 1990 are emissions from "public electricity and heat production" (an increase of 134.5 per cent) and "road transportation" (an increase of 64.7 per cent). Emissions from the "manufacture of solid fuels and other energy industries" subcategory have decreased by 1526.8 Gg CO_2-e (-86.0 per cent) from 1990. This is due to the cessation of synthetic petrol production in 1997.

FIGURE 3.1.1
Energy sector emissions 1990–2005

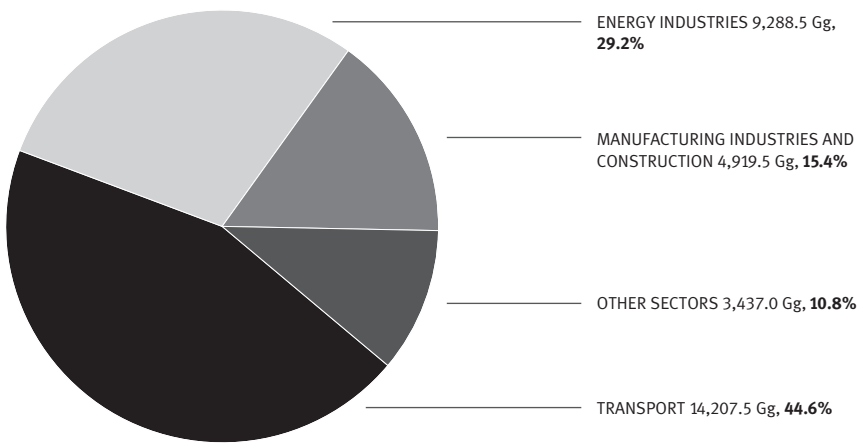


3.2 Fuel combustion (CRF 1A)

3.2.0.1 DESCRIPTION

The "fuel combustion" category reports all emissions from fuel combustion activities. This includes "energy industries", "manufacturing industries and construction", "transport" and "other sectors" (commercial, residential and agriculture/forestry/fisheries) (Figure 3.2.1). These subcategories use common activity data sources and emission factors. Details on the activity data and emission factors are included in Annex 2. Calculation worksheets used for the 2005 inventory are included in Annex 8. Information about methodologies, emission factors, uncertainty and quality assurance relevant to each of the subcategories are discussed on the following page.

FIGURE 3.2.1
Emissions from the energy sector: fuel combustion category in 2005
(all figures Gg CO_2-equivalent)



3.2.0.2 Methodological issues

Energy sector emissions for New Zealand's inventory are compiled from the Ministry of Economic Development's energy database along with relevant emission factors (Annex 2). Generally, greenhouse gas emissions are calculated by multiplying the emission factor of specific fuels by the activity data. There are only a few occasions where emission factors are unavailable due to confidentiality reasons and instances where natural gas was used as a feedstock.

The "fuel combustion" category is separated into two main divisions – stationary combustion and mobile combustion. Carbon dioxide emissions from the stationary combustion of gas, solid fuels, and liquid fuels are identified as key categories for New Zealand in the 2005 inventory. The relevant good practice decision tree (figure 2.1 in IPCC, 2000) identifies that to meet good practice, emissions should be estimated using data from sectors correcting for stored carbon and oxidation (a Tier 1 sectoral approach). New Zealand has data on fuel combustion detailed by sector but not by individual plants. The methodologies used for the energy sector are consistent with the Tier 1 sectoral approach. Good practice for methodological choice in the "mobile combustion" category is discussed in section 3.2.3.

Emission factors

New Zealand emission factors are based on Gross Calorific Value (GCV). Energy use in New Zealand is conventionally reported in gross terms with some minor exceptions (refer to Annex 2 for further details). New Zealand commissioned a review of all emission factors used in the energy sector in 2003 (Hale and Twomey Ltd, 2003). In accordance with good practice, New Zealand reverted to the IPCC default emission factors where country-specific values could not be supported (Annex 2). The new emission factors recommended by the review and agreed by a review panel were first used in the 2002 inventory, and have been used in all subsequent inventories. The exception is the use of IPCC default emission factors for CH_4 emissions in "road transport" which are being used for the first time in the 2005 inventory.

Before the 2002 inventory, the CO_2 emission factors used in inventories for the "transport" category were sourced from the *New Zealand Energy Information Handbook* (Baines, 1993). As a result of the Hale and Twomey Ltd. (2003) review the CO_2 emission factors are replaced with the individual liquid fuels emission factors derived from the New Zealand Refining Company data on carbon content and calorific values (Annex 2). When the fuel specifications of key liquid fuels are modified over time these will be noted and the emission factors altered according to the updated carbon content and the calorific values of the modified fuels.

3.2.0.3 Uncertainties and time-series consistency

Uncertainty in greenhouse gas emissions from fuel combustion varies depending on the gas (table 3.2.1). The uncertainty of CO_2 emissions is relatively low at 5 per cent and is primarily due to uncertainty in activity data rather than emission factors (IPCC, 2000). This is because of the direct relationship between fuels' carbon content and the corresponding CO_2 emissions during combustion. The low level of uncertainty in CO_2 emissions is important as CO_2 emissions comprise 96.8 per cent of emissions in the energy sector. Details of how uncertainty in CO_2 emissions is assessed are provided under each fuel type in Annex 2.

In comparison, emissions of the non-CO_2 gases are much less certain as emissions vary with combustion conditions. Many of the non-CO_2 emission factors used by New Zealand are the IPCC default values and the IPCC Guidelines (1996) often do not quantify the uncertainty in the default emission factors. The uncertainties proposed in table 3.2.1 are best estimates derived for New Zealand conditions (MED, 2006a).

TABLE 3.2.1
General uncertainty ranges for emission estimates from fuel combustion (MED, 2006a)

GAS	UNCERTAINTY
CO_2	± 5%
CH_4	± 50%
N_2O	± 50%
NO_x	± 33%
CO	± 50%
NMVOC	± 50%

3.2.1 Fuel combustion: Energy industries (CRF 1A1)

3.2.1.1 Description

This category comprises emissions from fossil fuels burnt in stationary combustion. It includes combustion for "public electricity and heat production", "petroleum refining", and the "manufacture of solid fuels" and "other energy industries".

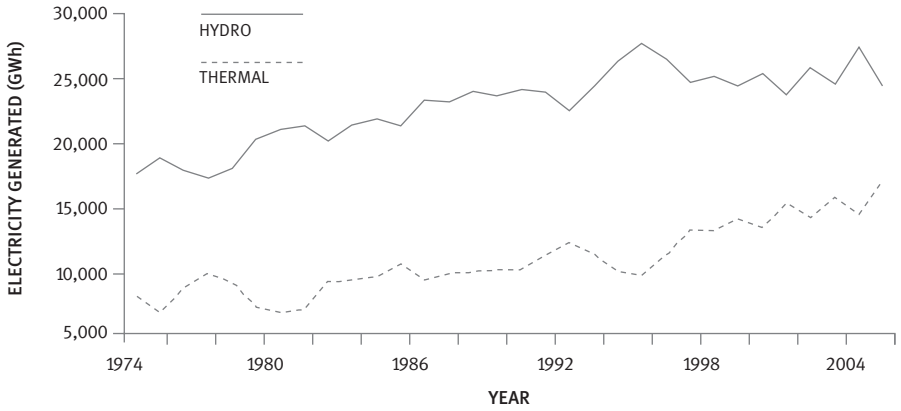
Emissions in the "energy industries" category totalled 9,288.5 Gg CO_2-e in 2005 and have increased 3,245.5 Gg CO_2-e (53.7 per cent) since 1990. The emissions profile in 2005 is dominated by emissions from "public electricity and heat production" which contributed 88.2 per cent of the CO_2-e emissions from the "energy industries" category.

New Zealand's electricity generation is dominated by hydro-electric generation. For the 2005 calendar year, hydro generation provided 56 per cent of New Zealand's electricity generation. A further 10 per cent came from other renewable sources (such as geothermal, wind and biomass) and waste heat sources. The remaining 34 per cent was provided by fossil fuel thermal generation plants using coal and gas (MED 2006a).

Greenhouse gas emissions from "public electricity and heat production" show large year-to-year fluctuations because use of thermal power generation stations complements the hydro-electric generation available. Generation in a 'normal' hydro year requires lower gas and coal use and in a "dry" hydro year requires higher gas and coal use. This is a different trend from the steady increase in emissions from coal and gas observed in electricity generation in many other countries.

Figure 3.2.2, which shows net electricity production by fuel type from 1974 to 2005, clearly illustrates that on an annual basis when the level of hydro-electric generation decreases, the level of fossil-fuel based thermal generation (gas, coal and oil) increases. Since 1998 there has been added thermal capacity of approximately 700 MW from new gas combined cycle plants, which is mainly responsible for the rise above 10,000 GWh.

FIGURE 3.2.2
Hydro-electric and thermal generation 1974–2005



3.2.1.2 Methodological issues

Public electricity and heat production

The CO_2 emissions from fossil-fuel based thermal electricity generation are derived from consumption figures provided by all the thermal electricity generators that use coal, oil and gas. The 155 MW oil-fired Whirinaki reserve generation plant was commissioned in June 2004. This additional generation helps to provide increased certainty of the electricity supply.

The data for liquid fuel use are from the "Delivery of Petroleum Fuels by Industry Survey" compiled by Statistics New Zealand (refer to Annex 2).

A large percentage of New Zealand's electricity is supplied by co-generation (otherwise known as combined heat and power). Most of the major co-generation plants are attached to large industrial facilities that consume most of the electricity and heat generated. In accordance with 1996 IPCC guidelines, where electricity and heat production is the primary activity of the enterprise operating the co-generation plant, emissions should be included in the "manufacturing industries" category. Where electricity generation is the primary activity the emissions should be included in the "electricity and heat production" category. According to this classification, there is only one plant determined to produce electricity as its primary purpose. The emissions from this plant are included under electricity and heat production whereas emissions from other co-generation plants are included under the "manufacturing industries and construction (other)" subcategory.

Petroleum refining

Energy use data for the "petroleum refining" subcategory are supplied to the Ministry of Economic Development by the New Zealand Refining Company Limited. For the refinery, a weighted-average CO_2 emissions factor is estimated based on the fuel used. The main liquid fuel used is fuel oil and the main gas is refinery gas. As there are no data available concerning non-CO_2 emissions from the refinery, IPCC default (IPCC, 1996) emission factors for industrial boilers are used.

Manufacturing of solid fuels and other energy industries

The low implied emission factors (IEFs) for "manufacturing of solid fuels and other energy industries" subcategory for gaseous fuels between 1990 and 1996 are caused by carbon sequestration in the process of producing synthetic petrol. Production of synthetic petrol stopped in New Zealand in 1997.

New Zealand has a gas field (Kapuni) with particularly high CO_2 content (refer to Annex 2). Most of the gas from this field is subsequently treated and the excess CO_2 is removed. The carbon content, and therefore the CO_2 emission factor, for this gas is lower for end users than when it is used by the gas field itself. Therefore the CO_2 implied emission factor for "manufacturing of solid fuels and other energy industries" subcategory is significantly higher than the CO_2 implied emission factor for typical gaseous fuels for other energy subcategories. The sequestration of carbon in synthetic petrol made up for this difference before 1997.

Emission factors

Carbon dioxide and non-CO_2 emission factors for fossil fuels are discussed in detail in Annex 2. Wood is also used for energy production. For wood consumption, the CO_2 emissions factor is 104.2 kt CO_2/PJ. This is calculated from the IPCC default emission factors, assuming the net calorific value (NCV) is 5 per cent less than the gross calorific value (GCV). In line with good practice (IPCC, 2000) CO_2 emissions from wood used for energy production are not included in the greenhouse gas emissions total.

The worksheets used for calculating emissions from the "energy industries" category are shown in Annex 8.

3.2.1.3 Uncertainties and time-series consistency

Uncertainties in emissions estimates for this category are relevant to the entire fuel combustion sector (refer to table 3.2.1 and Annex 2).

3.2.1.4 Source-specific QA/QC and verification

In preparation of this inventory, the "energy industries" category underwent Tier 1 quality checks.

3.2.1.5 Source-specific recalculations

The CO_2 emission factors for "stationary gas combustion" have been updated by the Ministry of Economic Development. In previous submissions the proportions of Maui and treated gas from the Kapuni gas field have been assumed to be 50 per cent each. The Energy Data File (MED, 2006b) reports annual production of the local gas fields for the period 1970 to 2005. For the 1990 to 2005 inventory, annual production of gas fields has been used to calculate weighted average annual CO_2 emission factors. This has resulted in recalculations of CO_2 emissions from gaseous fuels for 1990 to 2005.

There were also minor recalculations of CO_2, CH_4 and N_2O emissions in the "energy industries" category due to increased precision in data entry into the CRF Reporter.

3.2.2 Fuel combustion: manufacturing industries and construction (CRF 1A2)

3.2.2.1 Description

This category comprises emissions from fuels burnt in manufacturing industries and construction, including iron and steel, other non-ferrous metals, chemicals, pulp, paper and print, food processing, beverages and tobacco, and other uses.

Emissions in the "manufacturing industries and construction" category totalled 4,919.46 Gg CO_2-e in 2005. Emissions are 6.4 per cent above 1990 values. Between 2005 and 2004, emissions from this category decreased by 7.4 per cent. The main reason for this decrease is the reduction in methanol production following the shutdown of one of the methanol plants in November 2004.

The largest single source in 2005 is the "other" subcategory, which is a combination of manufacturing, food process, building and construction and other industrial activities.

3.2.2.2 Methodological issues

The energy data for the "other" subcategory is sourced from the "Delivery of Petroleum Fuels by Industry Survey" conducted by Statistics New Zealand (refer Annex 2.1). Methanol production produces the bulk of the emissions in the "chemical" subcategory. The energy data for methanol production is supplied directly to the Ministry of Economic Development by Methanex New Zealand Limited. Carbon dioxide emissions are calculated by comparing the amount of carbon in the gas purchased by the plants with the amount stored in methanol (refer Box 3.1). The data for gas use in "iron and steel" is also supplied direct to the Ministry for Economic Development. The data for other industry uses of gas are from the energy supply and demand balance tables in the Energy Data File (MED, 2006b).

BOX 3.1
Calculation of CO_2 emissions from methanol production (MED, 2006a)

ASSUMPTIONS
• Synthetic petrol is 85.8% carbon by weight.
• Methanol is 37.5% carbon by weight.
• CO_2 emissions factor for Maui gas is 52.0 kt/PJ (2005) (refer Annex 2).
• CO_2 emissions factor for Kapuni gas is 84.1kt/PJ.
• CO_2 emissions factor for mixed feed gas is 62.4 kt/PJ.
THE RESULTING CALCULATIONS ARE:
• Weight of carbon in gas to Methanex = [(PJ Maui) x 52.0 + (PJ Kapuni) x 84.1 + (PJ mixed feed) x 62.4] x 12/44 kilotonnes.
• Weight of carbon in petrol = [amount of petrol produced x 0.858] kilotonnes.
• Weight of carbon in methanol = [amount of methanol produced x 0.375] kilotonnes.
• Weight of carbon sequestered in the products = [weight of carbon in petrol + weight of carbon in methanol] kilotonnes.
• Total emissions of CO_2 = [(weight of carbon in gas to Methanex)-(weight of carbon sequestered)] x 44/12 kilotonnes.

Liquid fuel data are extracted from the "Deliveries of Petroleum Fuels by Industry Survey" conducted by Statistics New Zealand. Coal consumption data are determined from the "New Zealand Coal Sales Survey" also conducted by Statistics New Zealand (refer Annex 2). A considerable amount of coal is used in the production of steel, however virtually all the coal is used in a direct reduction process to remove oxygen from iron sand and not as a fuel. Emissions are therefore included in the industrial processes sector.

In the CRF tables, disaggregated activity data according to fuel types and corresponding CO_2 emissions have been provided for the "iron and steel" and "chemicals" subcategories only. This is because detailed energy-use statistics by industries (according to complete Australia New Zealand Standard Industrial Classification (ANZSIC) codes, similar to the International Standard Industrial Classification of All Economic Activities (ISIC) codes) are collected and reported in New Zealand for electricity consumption only. For the other energy/fuel types such as gas, liquid fuel and coal, data are collected and reported at a much more aggregated level. This is a reflection of the historical needs and practices of energy statistics collection in New Zealand. Gas use statistics by industries according to ANZSIC codes have been collected since 2001 and will be incorporated when they have been adequately verified. The subcategory "chemicals" relates to gas used by the methanol production company, Methanex New Zealand Limited.

The worksheets used for calculating emissions from the "manufacturing industries and construction" category are shown in the Excel spreadsheets in Annex 8.

3.2.2.3 Uncertainties and time-series consistency

Uncertainties in emission estimates are those relevant to the entire energy sector (refer table 3.2.1 and Annex 2).

3.2.2.4 Source-specific QA/QC and verification

In preparation of this inventory, the data for CO_2 emissions from stationary combustion (manufacturing industries and construction) underwent Tier 1 quality checks.

3.2.2.5 Source-specific recalculations

The CO_2 emission factors for "stationary gas combustion" have been updated by the Ministry of Economic Development (refer to section 3.2.1.5). This has resulted in recalculations of CO_2 emissions from gaseous fuels for 1990 to 2005.

There were also minor recalculations of CO_2 and CH_4 emissions in the "manufacturing industries and construction" category due to increased precision in data entry into the CRF Reporter.

3.2.3 Fuel combustion: transport (CRF 1A3)

3.2.3.1 Description

This category includes emissions from fuels combusted during transportation, such as civil aviation, road transport, rail transport and domestic marine transport. Emissions from international marine and aviation bunkers are reported but not included in the total emissions.

Emissions from the "transport" category totalled 14,207.5 Gg CO_2-e in 2005. Emissions have increased 5,429.4 Gg CO_2-e (61.9 per cent) from the 8,778.2 Gg CO_2-e emitted in 1990. The emissions profile in 2005 is dominated by emissions from the "road transportation" subcategory which accounted for 88.9 per cent of total transport emissions. Carbon dioxide emissions from the "road transportation" subcategory were identified as having a major influence on the trend in New Zealand's greenhouse gas emissions (table 1.5.3).

3.2.3.2 Methodological issues

Emissions from transport are compiled from the Ministry of Economic Ddevelopment's energy database. It is good practice to use a Tier 1 approach (total fuel consumed multiplied by an emission factor) for calculating CO_2 emissions as this provides the most reliable estimate of emissions using country-specific and IPCC default emission factors.

Activity data on the consumption of fuel by the transport sector are extracted from the "Deliveries of Petroleum Fuels by Industry Survey" conducted by Statistics New Zealand. Liquefied petroleum gas (LPG) and compressed natural gas (CNG) consumption figures are reported in the Energy Data File (MED, 2006b).

Road transport

The Tier 1 approach has been used to calculate CO_2 from road transport which is consistent with good practice (IPCC, 2000). Good practice encourages the use of a Tier 2 approach for calculating emissions of CH_4 and N_2O. Emissions from these gases are more complicated to estimate accurately because emission factors depend on vehicle technology, fuel and operating characteristics. New Zealand does not currently have all of the data to estimate non-CO_2 emissions from transport using a Tier 2 methodology. Therefore estimates of CH_4 and N_2O emissions from "road transportation" are currently calculated using a Tier 1 approach.

Before this inventory submission, New Zealand used country-specific emission factors for CH_4 emissions from "road transportation". Following the initial review in February 2007, New Zealand agreed to revert to the IPCC default CH_4 emission factor for gasoline and diesel oil until more work is done to substantiate the country-specific values. Emission factors of CO_2 and non-CO_2 gases for the various fuel types used in "road transportation" can be found in Annex 2.

Navigation (domestic marine transport)

Emissions from "navigation" in New Zealand are estimated using a Tier 1 approach with country-specific emission factors for estimating CO_2 emissions and IPCC default emission factors for CH_4 and N_2O. Before the 2002 inventory, New Zealand specific emission factors were used for CH_4 and N_2O emissions from fuel oil in domestic transport. The 2003 review of emission factors (Hale and Twomey Ltd, 2003) recommended reverting to the IPCC default factors.

Civil aviation

The New Zealand methodology for estimating emissions from "civil aviation" is a Tier 1 approach that does not use landing and take-off (LTO) cycles. There is no gain in inventory quality by moving from a Tier 1 to a Tier 2 approach using LTO cycles (IPCC, 2000). The distinction between domestic and international flights is based on refuelling at the domestic and international terminals of New Zealand airports. There is no basis for splitting the domestic and international components of fuel use for international flights with a domestic leg. This is because information on fuel use for "civil aviation" and "navigation" is available from the oil companies rather than from the individual airlines or shipping companies.

The worksheets used for calculating emissions from the "transport" category are shown in Annex 8.

3.2.3.3 Uncertainties and time-series consistency

Uncertainties in emission estimates from the "transport" category are relevant to the entire fuel combustion sector (refer table 3.2.1 and Annex 2).

3.2.3.4 Source-specific QA/QC and verification

Carbon dioxide emissions from "road transportation" (level and trend assessment) and "civil aviation" (level assessment) are identified as key categories for New Zealand in the 2005 inventory. In preparation of this inventory, the data for these emissions underwent Tier 1 quality checks.

3.2.3.5 Source-specific recalculations

The CH_4 emission factors for gasoline and diesel oil from "road transportation" have been revised. The country-specific emission factors used in previous inventory reports could not be substantiated during the Kyoto Protocol Initial Review (19 to 24 February 2007). New Zealand has adopted the IPCC default emission factors for the 1990 to2005 time-series and recalculated the data accordingly.

There were also minor recalculations of CO_2 and CH_4 emissions in the "transport" category due to increased precision in data entry into the CRF Reporter.

3.2.4 Fuel combustion: other sectors (CRF 1A4)

3.2.4.1 Description

This sector comprises emissions from fuels combusted in the "commercial/institutional", "residential" and "agriculture, forestry and fisheries" subcategories.

Emissions from fuel combustion of the "other sectors" category totalled 3,437.0 Gg CO_2-e in 2005 and are 507.1 Gg CO_2-e (17.3 per cent) above the 1990 value of 2,929.9 Gg CO_2-e. The emissions contribution in 2005 is divided between the "commercial and institutional" subcategory (42.9 per cent) and the "agriculture, forestry and fisheries" subcategory (38.9 per cent), with the "residential" subcategory comprising the remaining 18.2 per cent of emissions.

3.2.4.2 Methodological issues

The energy activity data are obtained from the same sources as other energy categories (Annex 2). Accurately partitioning energy use between the categories is difficult. Emissions from the "agriculture, forestry and fisheries" subcategory may be underestimated (MED, 2006a). This is because there are no separate estimates of fuel use by this group. The exception is liquid fuels and coal used in agriculture. However, these emissions have been included in other sectors such as industry and transport and are therefore included in New Zealand's total emissions.

The worksheets used for calculating emissions from the "other sectors" category are shown in Annex 8.

3.2.4.3 Uncertainties and time-series consistency

Uncertainties in emission estimates for data from other sectors is relevant to the entire energy sector (refer table 3.2.1 and Annex 2).

3.2.4.4 Source-specific QA/QC and verification

There were no specific Tier 1 quality checks undertaken for this category as it is not a key category. It was checked in the previous submission as part of a selection of non-key categories chosen for quality checking.

3.2.4.5 Source-specific recalculations

The CO_2 emission factors for "stationary gas combustion" have been updated by the Ministry of Economic Development (refer to section 3.2.1.5). This has resulted in recalculations of CO_2 emissions from gaseous fuels for 1990 to 2005.

There were also minor recalculations of CO_2 and CH_4 emissions in the "other sectors" category due to increased precision in data entry into the CRF Reporter.

3.3 Fugitive emissions from fuels (CRF 1B)

Fugitive emissions arise from the production, processing, transmission, storage and use of fossil fuels, and from non-productive combustion.

3.3.1 Fugitive emissions from fuels: solid fuels (CRF 1B1)

3.3.1.1 Description

Fugitive emissions from the "solid fuels" category produced 306.0 Gg CO_2-e in 2005. This is an increase of 33.9 Gg CO_2-e (12.4 per cent) from the 272.1 Gg CO_2-e reported in 1990. New Zealand's fugitive emissions from the "solid fuels" category are a product of coal mining operations.

Methane is created during coal formation. The amount of CH_4 released during coal mining is dependant on the coal rank and the depth of the coal seam. Surface mines are assumed to emit relatively little CH_4 compared with underground mines. In 2005, 75 per cent of the CH_4 from coal mining (including post-mining emissions) came from underground mining. There is no flaring of CH_4 at coal mines and CH_4 is rarely captured for industrial uses. Methane is also emitted during post-mining activities such as coal processing, transportation and use.

3.3.1.2 Methodological issues

Good practice in methodology choice for estimating fugitive emissions from coal mining is to focus on the sub-source category that dominates the emissions. New Zealand therefore focuses on estimating emissions from underground mining. The current New Zealand methodology is a Tier 1 approach using the top end of the IPCC default range in emission factors (table 3.3.1). New Zealand continues to use a New Zealand-specific emission factor for underground mining of sub-bituminous coal (Beamish and Vance, 1992). The calculation worksheets used for fugitive emissions are shown in Annex 8.

TABLE 3.3.1
Methane release factors for New Zealand coal

ACTIVITY	RELEASE FACTORS (T CH_4/KT COAL)	SOURCE OF RELEASE FACTORS
Surface mining	0.77	Mid-point IPCC default range (0.2–1.34 t/kt coal)
Underground: bituminous mining	16.75	Top end of IPCC default range (6.7–16.75 t/kt coal)
Underground: sub-bituminous mining	12.1	Beamish and Vance, 1992
Surface post-mining	0.067	Mid-point IPCC default range (0.0–0.134 t/kt coal)
Underground post-mining	1.6	Mid-point IPCC default range (0.6–2.7 t/kt coal)

Note: there is no release factor for lignite from underground mining as all lignite is taken from surface mining.

3.3.1.3 Uncertainties and time-series consistency

Uncertainties in fugitive emissions are relevant to the entire energy sector (refer table 3.2.1 and Annex 2).

3.3.1.4 Source-specific QA/QC and verification

There were no specific Tier 1 quality checks undertaken for this category as it is not a key category. It was checked in the previous submission as part of a selection of non-key categories chosen for quality checking.

3.3.1.5 Source-specific recalculations

There were no recalculations for the "fugitive emissions from fuels: solid fuels" subcategory.

3.3.2 Fugitive emissions from fuels: oil and natural gas (CRF 1B2)

3.3.2.1 Description

Fugitive emissions from the "oil and natural gas" category comprised 1,323.1 Gg CO_2-e in 2005. This is an increase of 391.1 Gg CO_2-e (35.7 per cent) from 932.0 Gg CO_2-e in 1990.

The main source of emissions from the production and processing of natural gas is the Kapuni gas treatment plant. The plant removes CO_2 from a portion of the Kapuni gas (a high CO_2 gas when untreated) before it enters the distribution network. Although emissions from the source are not technically due to flaring, they are included under this category because of confidentiality concerns. The large increase in CO_2 emissions for this source between 2003 and 2004 (from 367 to 601 Gg CO_2-e) and 2004 to 2005 (601 to 647 Gg CO_2-e) is related to a drop in methanol production. As discussed earlier, methanol production has dropped significantly since 2002. Carbon previously sequestered during this process is now being released as fugitive emissions from venting at the Kapuni Gas Treatment Plant.

Carbon dioxide is also produced when natural gas is flared at the wellheads of other fields. The combustion efficiency of flaring is 95-99 per cent (MED, 2006a), leaving some fugitive emissions as a result of incomplete combustion.

Fugitive emissions also occur in transmission and distribution of the natural gas although they are relatively minor in comparison with those from venting and flaring.

This sector also includes emissions from geothermal operations. Some of the energy from geothermal fields is transformed into electricity and the emissions are reported under the "fugitive emissions from fuels" category. This is because they are not the result of fuel combustion, unlike the emissions reported under the "energy industries" category. Sites with naturally occurring emissions where there is no use of geothermal steam for energy production are excluded from the inventory.

3.3.2.2 Methodological issues

The methodologies for natural gas are based on data from field operators or calculated from supplied energy data and country-specific emission factors. The major categories are discussed further in this section. The calculations used for fugitive emissions are shown in the Excel spreadsheets in Annex 8.

Venting and flaring from oil and gas production

Data on the amount of CO_2 released through flaring is either supplied directly by field operators or calculated from the supplied energy data using emission factors from Baines (1993). Vector Limited supplies estimates of CO_2 released during processing. These values are aggregated to derive annual emissions.

Gas transmission and distribution

Gas leakage occurs almost exclusively from low-pressure "distribution" pipelines rather than from high-pressure "transmission" pipelines. Estimates of annual leakage in 2005 from transmission pipelines, provided by Vector Limited, are less than 10 tonnes of CO_2 and approximately 130 tonnes of CH_4 (MED, 2006a). Therefore, the gas quantity shown in the Excel spreadsheets (Annex 8) excludes gas used in electricity generation and by others that take their gas directly from the transmission network. In consultation with the Gas Association of New Zealand, the Ministry for the Environment estimates that around 3.5 per cent of the gas entering the distribution system is unaccounted for and that around half of this (1.75 per cent) is actually lost through leakage, whereas the other half is unaccounted for due to metering errors and theft. The split between fugitive CO_2 and CH_4 emissions is based on gas composition data.

Oil transport, refining and storage

Fugitive emissions from the "oil-transport"and "oil-refining/storage" subcategories are calculated using an IPCC Tier 1 approach. For "oil-transport", the fuel activity data are the total New Zealand production of crude oil reported in the Energy Data File (MED, 2006b), and the CH_4 emission factor is the mid-point of the IPCC default value range (0.745 t CH_4/PJ). Emissions from "oil-refining/storage" are based on oil intake at New Zealand's single oil refinery. The CH_4 emission factor for refining is the same as that for transportation, whereas the emission factor for storage is 0.14 t CH_4/PJ (a New Zealand-specific emission factor). The combined emissions factor for "oil-refining/storage" is 0.885 t CH_4/PJ, derived by adding the emissions factors for refining and storage together.

Geothermal

Estimates of CO_2 and CH_4 for the "geothermal" subcategory are obtained directly from the geothermal field operators. Analyses of the gases emitted from the geothermal fields occur on a routine basis (at least once a year) and are carried out by a single independent laboratory.

No fuel is burnt in the geothermal operations as the process harnesses the energy in tapped geothermal fluid. High pressure steam (26 bar) is used to power the main electricity-producing back pressure turbines. In some plants, the low pressure exhaust steam is then used to drive secondary (binary) turbines. The gases CO_2 and CH_4 dissolved in the geothermal fluid are released along with steam.

3.3.2.3 Uncertainties and time-series consistency

The time-series of data from the various geothermal fields varies in completeness. Some fields were not commissioned until after 1990 and hence do not have records back to 1990.

3.3.2.4 Source-specific QA/QC and verification

No specific QA/QC activities are performed for this category.

3.3.2.5 Source-specific recalculations

There were also minor recalculations of CO_2 and CH_4 emissions in the "fugitive emissions from fuels: oil and natural gas" category due to increased precision in data entry into the CRF Reporter.

3.4 Other information

3.4.1 Comparison of sectoral approach with reference approach

The reference approach calculation identifies the apparent consumption of fuels in New Zealand from production, import and export data. This information is included as a check for combustion related emissions (IPCC, 2000). The check is performed for all years from 1990 to 2005.

The majority of the CO_2 emission factors for the reference approach are New Zealand specific (Annex 2: table A2.1). The natural gas emission factors used, which change from year to year are estimated based on a production-derived weighted average of emission factors for each of New Zealand's gas fields. This approach differs from previous inventories, where the emissions factors were estimated from the sectoral approach analysis by dividing aggregated CO_2 emissions (including carbon later stored) by aggregate energy use.

Comparison of the reference approach and sectoral approach in 2005 shows the sectoral total of CO_2 emissions is 0.38 per cent less than the reference total (table 3.4.1). This is mainly related to the differences in energy consumption.

The activity data for the reference approach are obtained from "calculated" energy use figures. These are derived as a residual figure from an energy-balance equation comprising production, imports, exports, stock change and international transport on the supply side (from which energy use for transformation activities is subtracted). The activity data used for the sectoral approach are referred to as "observed" energy-use figures. These are based on surveys and questionnaires administered by Statistics New Zealand on behalf of the Ministry for the Environment or by the Ministry for the Environment itself. The differences between "calculated" and "observed" figures are reported as statistical differences in the energy-balance tables contained in the Energy Data File (MED, 2006b).

The energy-use and calculated emissions for the major fuel categories are not directly comparable between the reference and sectoral approaches. First, the reference approach counts non-energy sector use of fuels such as gas in ammonia production, coal in steel production, and bitumen use, whereas the sectoral approach does not. However, the carbon embodied in fuels used for these purposes is included under stored carbon in the reference approach. Another difference is that combustion of refinery gas is included under gaseous fuels consumption in the sectoral approach but is not in the reference approach. This is because refinery gas is a by-product of the refining process derived from crude oil inputs. Consequently, emissions from the combustion of refinery gas are counted against crude oil in the reference approach.

TABLE 3.4.1
Percentage difference between the reference and sectoral approach for New Zealand's inventory and the International Energy Agency (IEA) reference and sectoral comparison

YEAR	DIFFERENCE BETWEEN NEW ZEALAND'S REFERENCE AND SECTORAL APPROACH (%)	DIFFERENCE BETWEEN THE IEA REFERENCE AND SECTORAL APPROACH (%)	DIFFERENCE BETWEEN CRF 2004 AND IEA SECTORAL APPROACHES (%)
1990	–4.98	4.80	–1.20
1991	–2.81		
1992	–6.39		
1993	–5.01		
1994	–7.40		
1995	–3.40	8.45	–8.08
1996	1.96		
1997	2.46		
1998	–0.21	7.09	–11.56
1999	2.69	1.05	–12.61
2000	–0.03	3.44	–13.23
2001	0.68	2.94	–12.64
2002	–0.90	–2.53	–14.26
2003	–0.40	1.30	–6.40
2004	1.46		
2005	0.38		

3.4.2 International bunker fuels

The data on fuel use by international transportation come from the Energy Data File (MED, 2006b). This uses information from oil company returns provided to the Ministry for Economic Development. Data on fuel use by domestic transport are sourced from the "Deliveries of Petroleum Fuels by Industry" survey undertaken by Statistics New Zealand.

3.4.3 Feedstock and non-energy use of fuels

The fuels supplied to industrial companies are used both as fuel and as feedstock. Emissions are calculated using the total fuel supplied to each company (this includes fuel used as feedstock) and by estimating the difference between the carbon content of the fuels used and the carbon sequestered in the final output (this is based on industry production and chemical composition of the products). This difference is assumed to be the amount of carbon emitted as CO_2. An example of the calculation for methanol is shown in Box 3.1 (section 3.2.2.2).
A considerable amount of coal is used in the production of steel, however virtually all of the coal is used in a direct reduction process to remove oxygen from ironsand and not as a fuel. The emissions from coal use in steel production are reported in the "industrial processes" sector.

3.4.4 CO_2 capture from flue gases and subsequent CO_2 storage

There is no CO_2 capture from flue gases and subsequent CO_2 storage occurring in New Zealand.

3.4.5 Country-specific issues

Energy sector reporting shows very few areas of divergence from the IPCC Good Practice Guidance methodologies (IPCC 1996;2000). The differences that exist are listed below:

- A detailed subdivision of the "manufacturing and construction" category as set out in the IPCC reporting tables is currently not available due to historical needs and practices of energy statistics collection in New Zealand.
- Some gas usage data from large industrial consumers in New Zealand and some emission factors for gas have been withheld for confidentiality reasons.
- Some of the coal production activity data in the reference approach is used in steel production. The CO_2 emissions from this coal are accounted for under the "industrial processes" sector and have been netted out of the energy reference approach using the "Estimating the carbon stored in products" table (Annex 8).
- The activity data shown in the CO_2 worksheets (Annex 8) under the sectoral approach exclude energy sources containing carbon that is later stored in manufactured products (rather than emitted during combustion), specifically methanol. This means that there is no subsequent downward adjustment required in carbon emissions. This is necessary to preserve the confidentiality of the gas usage data mentioned above.
- An additional worksheet is included to cover fugitive emissions of CO_2 and CH_4 from geothermal fields where electricity or heat generation plants are in operation.

3.4.6 Ozone precursors and SO_2 from oil refining

New Zealand's only oil refinery does not have a catalytic cracker. The emission factors used are the IPCC default values. The amounts of sulphur recovered at the refinery are provided by the New Zealand Refining Company. All storage tanks at the refinery are equipped with floating roofs and all but two have primary seals installed.

3.4.7 Energy balance

The "New Zealand Energy Data File" is an annual publication from the Ministry of Economic Development. It covers energy statistics including supply and demand by fuel types, energy balance tables, pricing information and international comparisons. An electronic copy of this report is available online at **www.med.govt.nz/energy/info**

A table providing an overview of the 2005 energy supply and demand balance for New Zealand is included in Annex 2 of this report.

CHAPTER 4: Industrial processes

4.1 Sector overview

New Zealand's industrial processes sector totalled 4336.7 Gg CO_2 equivalent (CO_2-e) in 2005 and represented 5.6 per cent of total greenhouse gas emissions. Emissions from industrial processes are now 1045.4 Gg CO_2-e (31.8 per cent) above the 1990 baseline of 3291.2 Gg CO_2-e (Figure 4.1.1). The sector is dominated by emissions from the metal production category (carbon dioxide (CO_2) and perfluorocarbons (PFCs)) at 53.0 per cent of sectoral emissions.

FIGURE 4.1.1
Industrial processes sector emissions 1990–2005

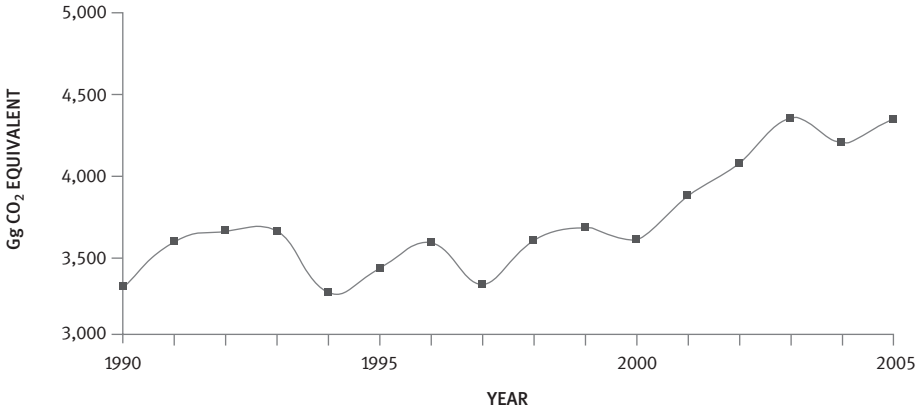
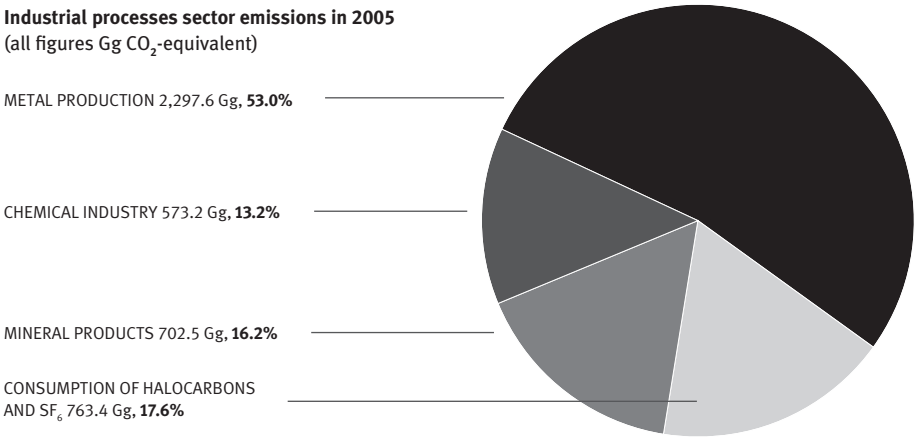


FIGURE 4.1.2
Industrial processes sector emissions in 2005
(all figures Gg CO_2-equivalent)



The emissions included in the industrial processes sector are from the chemical transformation of materials from one substance to another. Although fuel is also often combusted in the manufacturing process, emissions arising from combustion are included in the energy sector. Carbon dioxide emissions related to energy production, eg, refining crude oil and the production of synthetic petrol from natural gas, are also considered within the energy sector.

New Zealand has a relatively small number of plants emitting non-energy related greenhouse gases from industrial processes. However, there are six industrial processes in New Zealand that emit significant quantities of CO_2. These are the:

- reduction of ironsand in steel production
- oxidisation of anodes in aluminium production
- calcination of limestone for use in cement production
- calcination of limestone for lime
- production of ammonia and urea
- production of hydrogen.

The industrial processes categories use a few common data sources and emission factors. For this reason, general information about methodologies and uncertainties are included in this section as an overview.

4.1.1 Methodological issues

Emissions of CO_2 from industrial processes are compiled by the Ministry of Economic Development (MED) from information collected through industry surveys. The results are reported in *New Zealand Energy Greenhouse Gas Emissions 1990–2005* (MED, 2006).

Data on non-CO_2 emissions are gathered through a questionnaire distributed directly to industry by consultants contracted to the Ministry of Economic Development. The questionnaire requests information on greenhouse gas emissions and production, as well as on any relationship the companies have established between the two. This information is supplemented by further material from industry groups and other statistical sources. The IPCC default emission factors are applied to industry production data where no country-specific information is available. Full details of emission estimates and aggregate emission factors are included in the calculation worksheets in Annex 8.

4.1.2 Uncertainties

The number of companies in New Zealand producing CO_2 from industrial processes is small and the emissions of CO_2 supplied by the companies are considered to be accurate to ± 5 per cent (MED, 2006a). The uncertainty surrounding estimates of non-CO_2 emissions is greater than for CO_2 emissions and varies with the particular gas and category. Uncertainty of non-CO_2 emissions is discussed under each category.

4.2 Mineral products (CRF 2A)

4.2.1 Description

Emissions from the "mineral products" category comprised 702.5 CO_2-e in 2005. Overall, emissions in this category have grown by 173.5 Gg equivalent (32.8 per cent) from the 1990 level of 529.0 Gg CO_2-e. There are no emissions of CH_4 or N_2O from the mineral products category.

This category includes emissions produced from chemical transformations in the production of cement and lime, soda ash production and use, asphalt roofing, limestone and dolomite use, road paving with asphalt, and glass production. The emissions profile is dominated by production of cement (80.9 per cent) and lime (18.3 per cent). For both lime and cement production, only the emissions related to the calcination process are included in this category with the emissions from the combustion of coal reported in the energy sector.

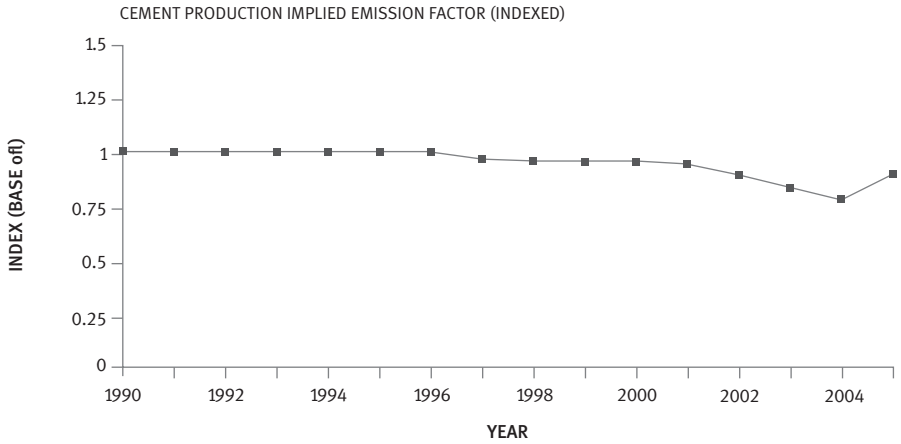
4.2.2 Methodological issues

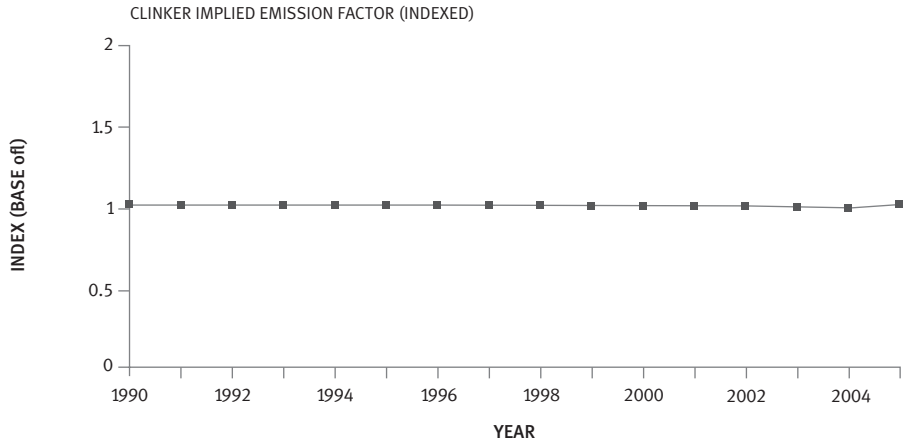
Cement production

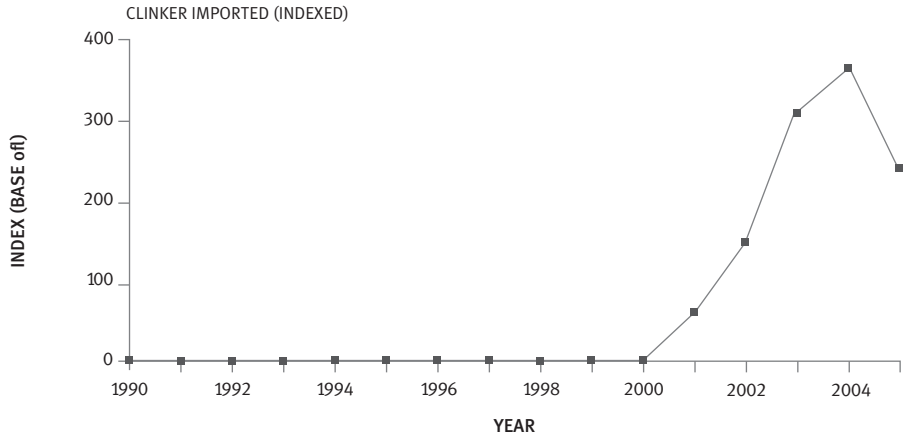
There are two cement production companies operating in New Zealand. Estimates of CO_2 emissions from cement production are calculated by both companies using the IPCC Tier 2 methodology (IPCC, 1996;2001). Because confidentiality of data is an issue, clinker data and the corresponding implied emission factors are not included in the CRF tables. Total process CO_2 emissions from cement production are reported. The amount of clinker produced by each plant is multiplied by a plant-specific emission factor for the clinker. The emission factors used are based on the calcium oxide (CaO) and magnesium oxide (MgO) content of the clinker produced. The inclusion of MgO results in the emission factors being slightly higher than the IPCC default of 0.50 t CO_2/t cement due to the chemical composition of clinker produced in New Zealand.

Figure 4.2.1 shows trends in New Zealand clinker production, imported clinker and the implied emission factors for cement and clinker. The information is indexed to respect the confidentiality of the data.

FIGURE 4.2.1
Indexed cement production data including clinker production, clinker imports and cement and clinker implied emission factors







A plant-specific clinker kiln dust correction factor is included in one company's CO_2 emissions calculation. The other company does not include a correction factor as it operates a "dry" process with no calcinated clinker kiln dust lost to the system.

Figure 4.2.1 shows clinker production activity data increasing over the time-series 1990 – 2005 while the implied CO_2 emission factor for cement production has been decreasing. The exception to this is from 2004 to 2005 when imports of clinker decreased. The cement companies have been importing increasing amounts of clinker in recent years to meet the high demand for cement in New Zealand. The decrease in the CO_2 implied emission factor can be explained by the greater increase in cement production in recent years compared to the CO_2 emissions, which have remained relatively steady. This has been due to the increase in imported clinker and a change in national standards for cement production in 1995 which permitted mineral additions to cement of up to 5 per cent by weight (CCANZ, 1995).

Sulphur dioxide is emitted in small quantities from the cement making process. The amount of SO_2 is determined by the sulphur content of the raw material (limestone). The IPCC guidelines (IPCC, 1996) report that 70 – 95 per cent of the SO_2 will be absorbed by the alkaline clinker product. New Zealand uses an SO_2 emission factor calculated using industry-specific information. This emission factor was updated during 2005 with improved information from industry. The emission factor was calculated using information from a sulphur mass balance study on one company's dry kiln process. This enabled the split between sulphur originating in the fuel and sulphur in the raw clinker material as sodium and potassium salts to be determined. The average emission factor is calculated as 0.64 kg SO_2/t clinker and is weighted to take into account the relative activity of the two cement companies.

Lime production

There are three companies in New Zealand which make up the burnt lime industry. Carbon dioxide emissions from lime production are supplied to the MED by industry. Emissions are calculated by multiplying the amount of lime produced by an emission factor. Before 2002, a single New Zealand-specific emission factor based on the typical levels of impurities in the lime produced in New Zealand was applied to all lime. This was the only information available for this source. Since 2002, plant-specific emission factors have been used. There has been little change in the implied emission factor which has varied from 0.72 t CO_2/t lime to 0.73 t CO_2 / t lime from 1990 to 2005.

The SO_2 emissions emitted during lime production vary depending on the processing technology and the input materials. An industrial processes survey undertaken in 2005 resulted in an updated value for the average SO_2 emission factor. The average emission factor is 0.48 kg SO_2/t lime and is weighted to take sulphur measurements at the various lime plants into account.

Limestone and dolomite use

Emissions arising from cement and burnt lime processes are reported under the cement and lime production categories as specified in the IPCC Guidelines (1996 section 2.5.1). The current exception to this is the use of limestone in the production of iron and steel by the major steel producer in New Zealand. In the iron production process coal is blended with limestone to achieve the required primary concentrate specifications. Currently all CO_2 process emissions from iron and steel production, including limestone use, are reported under the iron and steel category (2.C.1). New Zealand will aim to report emissions from limestone use in iron and steel production separately in future submissions.

Non-calcined uses of limestone for agricultural purposes (liming of soils) is reported in the Land use, land-use change and forestry sector.

Soda ash production and use

There is no soda ash production in New Zealand. A consultant who surveyed the industrial processes sector in 2005 was able to make preliminary estimates of CO_2 emissions resulting from the use of soda ash in glass production (CRL Energy Ltd, 2006a). The manufacturer was able to provide information on the amount of imported soda ash it used in 2005. It also provided approximate proportions of recycled glass over the past 10 years to enable back calculations because the soda ash amount is in fixed proportion to the production of new (rather than recycled) glass. Linear extrapolation of activity data from 1990 to 1995 was carried out in the absence of actual data. The IPCC default emission factor of 415 kg CO_2 per tonne of soda ash is applied to calculate the CO_2 emissions.

Asphalt roofing

There is only one company manufacturing asphalt roofing in New Zealand. Indirect emissions of NMVOCs and CO are calculated using the default IPCC emission factors (IPCC, 1996) and activity data supplied by the company. The industrial processes survey undertaken in 2005 revealed an updated estimation of activity data for this source. The data has been updated and back calculated for the entire time-series.

Road paving with asphalt

Data on bitumen production and emission rates are provided by the three main road paving companies operating in New Zealand. Estimates of national consumption of bitumen for road paving are confirmed by the New Zealand Bitumen Contractors Association. Solvents are rarely added to asphalt, so asphalt paving is not considered a significant source of emissions. New Zealand still uses a wet "cut-back" bitumen method rather than bitumen emulsions common in other countries.

The IPCC Guidelines (1996) make no reference to cut-back bitumen but do provide default emission factors for the low rates of SO_2, NO_x, CO and NMVOC emissions that arise from an asphalt plant. The IPCC recommended default road surface emissions factor of 320 kg of NMVOC per tonne of asphalt paved is not considered applicable to New Zealand. There is no possibility of this level of NMVOC emissions because the bitumen content of asphalt in New Zealand is only 6 per cent.

For the 2002 inventory, the New Zealand Bitumen Contractors Association provided the methodology shown in Box 4.1 for calculating the total NMVOC emissions from the use of solvents in the roading industry. The industrial processes survey undertaken in 2005 (CRL Energy Ltd, 2006a) showed that the fraction of weight of bitumen used to produce chip-seal has been changing over recent years as methods of laying bitumen have improved. From 1990 to 2001 the fraction by weight of bitumen used to produce chip-seal was 0.80. From 2002 to 2003 it was 0.65 and in 2004 the fraction was 0.60. The emissions of NMVOCs in the common reporting format have been updated for the time-series to reflect this changing fraction.

BOX 4.1
Calculation of NMVOC emissions from road paving asphalt

NMVOC EMITTED = A x B x C x D

where

A = The amount of bitumen used for road paving

B = The fraction by weight of bitumen used to produce chip-seal (0.80)

C = Solvent added to the bitumen as a fraction of the chip-seal (0.04)

D = The fraction of solvent emitted (0.75)

Glass production

There is one major glass manufacturer in New Zealand. The IPCC Guidelines (1996) report that NMVOC may be emitted from the manufacture of glass and provide a default emissions factor of 4.5 kg NMVOC per tonne of glass output. It has been assumed that the IPCC emissions factor for NMVOC is based on total glass production which includes recycled glass input. NO_x and CO emissions are assumed to be associated with fuel use so are not reported under industrial processes. The industrial processes survey undertaken in 2005 obtained estimates of CO_2 from soda ash use (see soda ash production and use section above) and SO_2 emissions from sodium sulphate decomposition.

4.2.3 Uncertainties and time-series consistency

Uncertainties in CO_2 emissions are assessed as ± 5 per cent as discussed in section 4.1.2. Uncertainties in non-CO_2 emissions are assessed by the contractor from the questionnaires and correspondence with industry sources (CRL Energy Ltd, 2006a).

TABLE 4.2.1
Uncertainty in non-CO_2 emissions from "mineral products"

PRODUCT	UNCERTAINTY IN ACTIVITY DATA	UNCERTAINTY IN EMISSION FACTORS
Cement	0%	± 40%
Lime	± 1%	± 80%
Asphalt roofing	± 30% (± 50% for 1990–2000)	± 40%
Road paving with asphalt	± 10%	± 15% (chip-seal fraction and solvent emission fraction) to ± 25% (solvent dilution).
Glass	0%	NMVOC: ± 50% SO_2: ± 10%

4.2.4 Source-specific QA/QC and verification

Carbon dioxide emissions from cement production is a key category (level assessment) for 1990 and 2005. In the preparation of this inventory, the data for these emissions underwent Tier 1 quality checks.

In the process of compiling non-CO_2 emissions, activity data are re-checked with industry experts where possible. The small number of companies in this category assists in achieving the complete coverage of the category.

4.2.5 Source-specific recalculations

During 2006 both cement companies were contacted and they provided complete time-series of CO_2 emissions from 1990 to 2005. These values were compared against the data archived at the Ministry for Economic Development. It was discovered there were small differences in some of the values from one company compared with the data available at the Ministry for Economic Development. As a result of discussions between the company, the Ministry for Economic Development and the Ministry for the Environment the data were revised. The data the company held were deemed to be the most accurate and consistent throughout the time-series. This has resulted in CO_2 emissions attributed to the mineral products category being recalculated for the entire time-series.

4.3 Chemical industry (CRF 2B)

4.3.1 Description

This category reports emissions from the production of ammonia, nitric and adipic acid, silicon and calcium carbide, and other chemicals. The major chemical processes occurring in New Zealand that fall into this category are the production of ammonia and urea, methanol, hydrogen, fertiliser (superphosphate) and formaldehyde. There is no production of nitric acid, adipic acid, carbide, carbon black, ethylene, dichloroethylene, styrene, coke or caprolactam in New Zealand.

Emissions from the chemical industry category comprised 573.2 Gg CO_2-e emissions in 2005 and have increased 126.2 Gg CO_2-e (28.2 per cent) from the 447.0 Gg CO_2-e estimated in 1990.

Carbon dioxide emissions from ammonia/urea production account for 60.4 per cent of emissions in this category.

Methane emissions from the chemical industry have decreased 31.3 Gg CO_2-e (68.5 per cent) between 2004 and 2005. There are two reasons for this. The first is the shut down of the Motunui methanol production plant in November 2004. This leaves only one methanol production plant at Waitara. The second is a decrease in ammonia production between 2004 and 2005 (production varies from year to year).

4.3.2 Methodological issues

Ammonia/urea

Ammonia is manufactured in New Zealand by the catalytic steam reforming of natural gas at New Zealand's sole ammonia/urea plant. The total amount of gas supplied to the plant is provided to the Ministry of Economic Development by the company operating the plant. In accordance with IPCC guidelines (IPCC, 1996) it is assumed that the carbon in urea is eventually released after it is applied to the land. Emissions of CO_2 are calculated by multiplying the quantities of gas (from different gas fields) used in ammonia production by their respective emission factors. Gas from three different fields is used in ammonia production in New Zealand. The emission factors vary from Kapuni (84.1 kt/PJ), Kaimiro (65.2 kt/PJ) to Maui (51.8 to 53.2 kt/PJ). The proportion of gas from each of these fields used in ammonia production changes on an annual basis and this explains the fluctuation in the CO_2 implied emission factor over the 1990 – 2005 time-series. Ammonia production decreased between 2004 and 2005. For more details on the gas emission factors refer to Annex 2.

Non-CO_2 emissions are considered by industry experts to arise from fuel combustion rather than from the process of making ammonia and are therefore covered in the energy sector.

Formaldehyde

Formaldehyde is produced at five plants in New Zealand. NMVOC emissions are calculated from company-supplied activity data and a country-specific emission factor of 1.5 kg NMVOC/t of product. Emissions of CO and CH_4 are not reported under this subcategory as these emissions are more appropriately included in the energy sector.

Methanol

Methanol is produced at two plants in New Zealand. Carbon dioxide emissions are reported in the energy sector. The process to calculate CO_2 emissions is shown in Box 3.1 (energy sector: manufacturing industries and construction).

The major non-fuel related emissions from the process are NMVOCs. Emissions are calculated from company-supplied activity data and emission factors. The NMVOC emissions factor was estimated in 2001 from American Petroleum Institute methods for calculating vapour emissions from storage tanks. NO_x and CO emission factors were measured in 1999. It is assumed the IPCC default factor for CH_4 (2g CH4/kg production) is appropriate for New Zealand (CRL Energy Ltd, 2006a).

Fertiliser

Superphosphate is produced by two companies (each with three plants) in New Zealand. Most of these plants produce sulphuric acid as a first step. One plant however now imports acid. Both companies have supplied activity data and emission factors for SO_2, which is the only indirect greenhouse gas emitted from the production of superphosphate fertiliser. The majority of these emissions are released during sulphuric acid production. No reference is made to superphosphate production in the IPCC Guidelines (1996). A default emissions factor of 17.5 kg SO_2 (range of 1 to 25) per tonne of sulphuric acid is recommended but it is assessed by New Zealand industry experts to be a factor of two to ten times too high for the New Zealand industry. Emission estimates are therefore based on industry supplied emission factors and activity levels. Checks were made with the supplied emission factors for superphosphate and one set was identified as an outlier. The SO_2 emission factor for the other company was assessed to be appropriate for both companies' superphosphate output.

Hydrogen

Emissions of CO_2 from hydrogen production are supplied directly to the Ministry of Economic Development by the two production companies involved. The majority of hydrogen produced in New Zealand is made by the New Zealand Refining Company as a feedstock at the Marsden Point refinery. Another company produces a small amount of hydrogen which is converted to hydrogen peroxide. The hydrogen is produced from CH_4 and steam. CO_2 is a by-product of the reaction and is vented to the atmosphere. The implied emission factor for hydrogen produced in New Zealand is 5.98 kt CO_2 per kt of hydrogen produced (MED, 2006a).

4.3.3 Uncertainties and time-series consistency

Uncertainties in CO_2 emissions are assessed as ± 5 per cent as discussed in section 4.1.2. Uncertainties in non-CO_2 emissions are assessed by the contractor from the questionnaires and correspondence with industry sources (CRL Energy Ltd, 2006a). These are documented in table 4.3.1.

TABLE 4.3.1
Uncertainty in non-CO_2 emissions from the "chemical industry"

PRODUCT	UNCERTAINTY IN ACTIVITY DATA	UNCERTAINTY IN EMISSION FACTORS
Ammonia /Urea	± 0%	± 30%
Formaldehyde	± 2%	± 50% (NMVOCs)
Methanol	0%	± 50% (NO_x and CO) ± 30% (NMVOCs) ± 80% (CH_4)
Fertiliser	± 10% sulphuric acid ± 10% superphosphate	± 15% sulphuric acid ± 25 to ± 60% superphosphate (varies per plant)

4.3.4 Source-specific QA/QC and verification

New Zealand specifies CO_2 from ammonia production as a qualitative key category because of the large increase in nitrogenous fertiliser use observed in the agriculture sector. The ammonia produced in New Zealand is used in the production of urea fertiliser. In the preparation of this inventory, the data for these emissions underwent Tier 1 quality checks.

4.3.5 Source-specific recalculations

The CO_2 emission factors for the gases used for ammonia production (from the Maui, Kapuni and Kaimiro gas fields) have been updated by the Ministry of Economic Development. In previous submissions, the proportions of Maui and treated gas from the Kapuni gas field have been assumed to be 50 per cent from each gas field. The Energy Data File (MED, 2006b) reports annual production of the local gas fields for 1970–2005. For the 1990–2005 inventory, annual production of the gas fields have been used to calculate weighted average annual CO_2 emission factors.

4.4 Metal production (CRF 2C)

4.4.1 Description

The "metal production" category reports emissions from the production of iron and steel, ferroalloys, aluminium and the SF_6 used in aluminium and magnesium foundries. The major metal production activities occurring in New Zealand are the production of iron, steel and aluminium. Carbon dioxide emissions from "iron and steel production" is a key category (level assessment) for 1990 and 2005. Carbon dioxide emissions from "aluminium production" is a key category in 1990 but not for 2005 (table 1.5.2) . Perfluorocarbon emissions from "aluminium production" is a key category in the trend analysis (table 1.5.3). New Zealand has no production of coke, sinter or ferroalloys.

Emissions from the "metal production" category were 2,297.6 Gg CO_2-e in 2005. Emissions from this category decreased 0.4 per cent from the 2,305.8 Gg CO_2-e recorded in 1990. Carbon dioxide emissions account for 96.5 per cent of emissions in this category with another 3.5 per cent from PFCs. In 2005, the level of CO_2 emissions increased by 429.5 Gg CO_2-e (24.0 per cent) above the 1990 baseline. Perfluorocarbon emissions have decreased from the 515.6 Gg CO_2-e in 1990 to 80.7 Gg CO_2-e in 2005, a decrease of 434.9 Gg CO_2-e (84.3 per cent).

The decrease in PFC emissions is because the sole aluminium smelter in New Zealand now has low anode effect duration by world standards. Anode effects are caused by depletion of alumina. The technology now in use introduces alumina into the pot quickly and extinguishes the anode effect. The smelter processes alumina in relatively large quantities by modern standards (50 kg per "feed" compared to 2 kg per "feed").

4.4.2 Methodological issues

Iron and steel

There are two steel producers in New Zealand. One produces iron using the "alternative iron-making" process from titanomagnetite ironsand. The iron is then processed into steel. The other company operates an electric arc furnace to process scrap metal into steel.

The company which produces steel from titanomagnetite ironsand produces the bulk of CO_2 emissions for this subcategory through the use of coal as a reducing agent and the quantities of other non-fuel carbon-bearing ingredients used in the process such as electrodes. The carbon content of the ironsand is negligible with iron (in the form of magnetite) the predominant chemical in the sand (Ure, 2000). Sub-bituminous coal and limestone in the multi-hearth furnaces are heated and dried together with the ironsand. This is then fed into the reduction kilns, where it is converted to 80 per cent metallic iron. Melters then convert this into molten iron. The iron, at around 1480°C, is transferred to the Vanadium Recovery Unit, where vanadium-rich slag is recovered for export and further processing into a steel-strengthening additive. The molten pig iron is then converted to steel in a KOBM oxygen steel-making furnace. Further refining occurs at the ladle treatment station, where ferroalloys are added to bring the steel composition up to its required specification. The molten steel from the ladle treatment station is then transferred to the continuous caster, where it is cast into slabs.

New Zealand uses a Tier 2 approach for calculating emissions from iron and steel production. New Zealand does not account for emissions from pig iron and steel production separately as all of the pig iron is transformed into steel. The carbon in the ironsand is negligible (Ure, 2000) and therefore not accounted for. The emission factor applied to the sub-bituminous coal used as a reducing agent is 93.7 kt CO_2/PJ. This emission factor is calculated based on the specific characteristics of the coal used. Care has been taken not to double-count coal use for iron and steel-making in the energy sector as well as the industrial processes sector. New Zealand energy statistics for coal are disaggregated into coal used in steel-making and coal used in other industries and sectors. The coal acts as both a reductant and an energy source in the iron-making process. Data does not exist to accurately split the amount of coal used in energy and industrial processes so it is all reported under industrial processes.

The second steel company melts approximately 250 kt of recycled steel annually in an electric arc furnace. Before being tapped from the furnace into a hot ladle, the molten steel is subsequently refined (fine tuning of temperature and chemistry) before continuous casting into billets. The process CO_2 emissions from the electric arc furnace arise from charge additions of carbon with the scrap and the oxidation of carbon electrodes. No meaningful CO_2 emissions data were available from the company before the year 2000. Emissions are calculated by multiplying steel production by an emission factor based on the average implied emission factor for the plant for the years 2000–2004 (approximately 0.1 t CO_2/t steel). The implied emission factor has been calculated using a mass balance approach. This calculation is based on the principle of the net difference between the amount of carbon contained in the raw materials and the amount of carbon sequestered in the finished product. From the mass balance approach analysis the emission factor for the years 2000–2004 lies within the range of 0.088 – 0.104 tCO_2/t steel, with an average of 0.0968 t CO_2/t steel.

The non-CO_2 emission factors for the indirect greenhouse gases (CO, SO_2 and NO_x) for both steel plants are based on measurements in conjunction with mass balance (for SO_2) and technical reviews (CRL Energy Ltd, 2006a).

Aluminium

Aluminium production activity data and associated CO_2 and PFC emissions are supplied by Rio Tinto Aluminium, New Zealand's sole aluminium smelter operator. The technology type used on site is Centre Worked Prebaked (CWPB). Carbon anode oxidisation is responsible for almost 90 per cent of the CO_2 emissions from aluminium production.

The carbon consumption is multiplied by 3.812 to convert carbon to CO_2 (as compared with 3.666 if the standard atomic weights ratio of 44/12 is used). This factor was determined by Rio Tinto Aluminium to account for additional carbon used in the carbon bake furnace process as well as the consumption of carbon in the reduction cell. The factor was developed based on average historic consumption of coke and pitch across Rio Tinto Aluminium's Australian and New Zealand smelters to calculate CO_2 emissions (Hamilton, 2007). Various fuels such as heavy fuel oil, LPG, petrol and diesel are used in the aluminium production process and associated emissions are included in the energy sector (MED, 2005; Bloor, 2006a).

Emissions of two PFCs (CF_4 and C_2F_6) from the production of aluminium are also supplied by the aluminium smelter. The PFC emissions from aluminium smelting are calculated using the IPCC Tier 2 method. This involves using the IPCC default coefficients for Centre Worked Prebaked technology in the slope equation together with smelter-specific operating parameters of anode effect frequency and duration. Anode effect frequency is multiplied by duration to get anode effect minutes per cell day.

EF (kg CF_4 or C_2F_6 per tonne of Al) = Slope x AE min/cell day

Slope = 1.698 x (p/CE)

AE min/cell day = AEF x AED

Where:

Slope = 0.14 for CF_4 and 0.018 for C_2F_6 kg_{PFC}/t_{Al}/AE – minutes/cell day

(CWPB default values from IPCC GPG)

AEF = Number of anode effects per cell day

AED = Anode effect duration in minutes

(Tier 2 and 3b equations, IPCC Good Practice Guidance)

The smelter captures every anode effect, both count and duration, through its process control software. All monitoring data are logged and stored electronically to give the anode effect minutes per cell day value. This is then multiplied by the tonnes of hot metal and the slope factor to provide an estimate of CF_4 and C_2F_6 emissions. The IPCC default slope coefficients of 0.14 and 0.018 for Centre Worked Prebaked technology are used. The smelter advises there are no plans to directly measure PFC emissions so a smelter-specific, long-term relationship between measured emissions and operating parameters is not likely to be established in the near future.

For estimates of indirect greenhouse gases, the IPCC default emission factor is used for NO_x emissions. Plant-specific emission factors are used for CO and SO_2. An industry supplied value of 110 kg CO per tonne (IPCC range 135–400 kg CO per tonne) is based on measurements and comparison with Australian CO emission factors. Sulphur dioxide emissions are calculated from the input sulphur levels and direct monitoring.

Other metal production

The only other metals produced in New Zealand are gold and silver. Companies operating in New Zealand confirm they do not emit indirect gases (NO_x, CO and SO_2) with one using the Cyanisorb recovery process to ensure everything is kept under negative pressure to ensure no gas escapes to the atmosphere. Gold and silver production processes are listed in IPCC (1996) as sources of non-CO_2 emissions. However, no details or emission factors are provided and no published information on emission factors has been identified. Consequently, no estimation of emissions from this source has been included in New Zealand's inventory for 2005.

4.4.3 Uncertainties and time-series consistency

Uncertainty in CO_2 emissions is assessed as ± 5 per cent as discussed in section 4.1.2. Uncertainties in non-CO_2 emissions are assessed by the contractor from the questionnaires and correspondence with industry sources (CRL Energy Ltd, 2006a). These are documented in table 4.4.1.

TABLE 4.4.1
Uncertainty in non-CO_2 emissions from "metal production"

PRODUCT	UNCERTAINTY IN ACTIVITY DATA	UNCERTAINTY IN EMISSION FACTORS
Iron and steel	0%	± 20–30% (CO)
		± 70% (NO_X)
Aluminium	0%	± 5% (SO_2)
		± 40% (CO)
		± 50% (NO_X)
		± 30% (PFCs)[1]

[1] There is no independent means of assessing the calculations of PFC emissions from the smelter. Given the broad range of possible emission factors indicated in the IPCC (2000) table 3.10, and in the absence of measurement data and precision measures, the total uncertainty is assessed to be ± 30% (CRL Energy Ltd, 2006a).

4.4.4 Source-specific QA/QC and verification

Carbon dioxide emissions from "iron and steel production" and "aluminium production" are key categories for 1990 (level assessment). In 2005, only iron and steel is a key category (level assessment).

In 2005, PFCs from aluminium production is a key category (trend assessment). In the preparation of this inventory, the data for these emissions underwent Tier 1 quality checks.

4.4.5 Source-specific recalculations

There were some minor recalculations of CO_2 emissions from the "iron and steel" category due to increased precision in data entry into the CRF Reporter.

4.5 Other production (CRF 2D)

4.5.1 Description

The "other production" category includes emissions from the production of pulp and paper, and food and drink. In 2005, emissions from this category totalled 7.1 Gg NMVOC. This was an increase of 1.2 Gg NMVOCs since 1990.

4.5.2 Methodological issues

Pulp and paper

There are a variety of pulping processes in New Zealand. These include:

- chemical (Kraft)
- chemical thermomechanical
- thermomechanical
- mechanical.

Mechanical pulp production in 2005 was responsible for 54 per cent of all pulp production, with chemical production responsible for 46 per cent (CRL Energy Ltd, 2006a). Estimates of emissions from the chemical pulping process are calculated from production figures obtained from the Ministry of Agriculture and Forestry. Emission estimates from all chemical pulping processes have been calculated from the industry-supplied emission factors for the Kraft process. In the absence of better information, the NMVOC emission factor applied to the chemical pulping processes is also applied to the thermomechanical pulp processes (CRL Energy Ltd, 2006a). Emissions of CO and NO_x from these processes are related to fuel combustion and not reported under industrial processes.

Food and drink

NMVOCs are produced during the fermentation of cereals and fruits in the manufacture of alcoholic beverages. They are also produced during all processes in the food chain which follow after the slaughtering of animals or harvesting of crops. Estimates of indirect greenhouse gas emissions have been calculated using New Zealand production figures from Statistics New Zealand and relevant industry groups with default IPCC emission factors (IPCC, 1996). No New Zealand-specific emission factors could be identified. In 2005, NMVOC emissions were estimated to be 6.3 Gg, an increase of 1.1 Gg since 1990.

4.5.3 Uncertainties and time-series consistency

Uncertainties in non-CO_2 emissions are assessed by the contractor from the questionnaires and correspondence with industry sources (CRL Energy Ltd, 2006a). These are documented in table 4.5.1.

TABLE 4.5.1
Uncertainty in non-CO_2 emissions from "other production"

PRODUCT	UNCERTAINTY IN ACTIVITY DATA	UNCERTAINTY IN EMISSION FACTORS
Pulp and paper	5%	± 50% (chemical pulp) ± 70% (thermal pulp)
Food – alcoholic beverages	± 5% (beer) ± 20% (wine) ± 40% (spirits)	± 80% (beer and wine) ± 40% (spirits)
Food – food production	± 5–20% (varies with food type)	± 80% (IPCC factors)

4.5.4 Source-specific QA/QC and verification

"Other production" is a non-key category and no specific QA/QC activities were performed. Where possible, activity data are cross-referenced between companies and industry associations to verify the data.

4.5.5 Source-specific recalculations

There are no source-specific recalculations performed for this category in this inventory submission.

4.6 Production of halocarbons and SF_6 (CRF 2E)

New Zealand does not manufacture halocarbons and SF_6. Emissions from consumption are reported under section 4.7

4.7 Consumption of halocarbons and SF_6 (CRF 2F)

4.7.1 Description

Emissions from hydrofluorocarbons (HFCs) totalled 741.6 Gg CO_2-e in 2005. There was no known use of HFCs in 1990. This large increase is due to the replacement of ozone-depleting CFCs and HCFCs with HFCs. HFC emissions are identified as a key category in the level and trend analysis of the 2005 inventory (tables 1.5.2 and 1.5.3).

SF_6 emissions have increased from 9.5 Gg CO_2-e in 1990 to 21.8 Gg CO_2-e in 2005, an increase of 130.9 per cent. The majority of SF_6 emissions are from the consumption and disposal of SF_6 associated with its use in electrical equipment.

HFCs and PFCs are used in a wide range of equipment and products from refrigeration systems to aerosols. No HFCs or PFCs are manufactured within New Zealand. Perfluorocarbons are produced from the aluminium smelting process (as discussed in section 4.4.2). The use of synthetic gases, especially HFCs, has increased since the mid 1990s when CFCs and HCFCs began to be phased out under the Montreal Protocol. In New Zealand, the Ozone Layer Protection Act (1996) sets out a programme for phasing out the use of ozone-depleting substances by 2015. According to the 1996 IPCC guidelines, emissions of HFCs and PFCs are separated into seven major source categories:

- aerosols
- solvents
- foam
- mobile air conditioning (MAC)
- stationary refrigeration and air conditioning
- fire protection
- "other".

The emissions inventory for SF_6 is broken down into two source categories: electrical equipment and other. In New Zealand, one electricity company accounts for 80–90 per cent of total SF_6 used in electrical equipment.

4.7.2 Methodological issues

HFCs/PFCs

Information on bulk imports of HFCs and PFCs each year is based on data supplied by the Ministry of Economic Development. This information is derived from an annual survey of all importers and distributors of these chemicals. This provides a basis for estimating potential emissions. To report actual emissions, further information is collected from importers and distributors to identify the end users and proportion of bulk chemical used in each sub-source category.

Several additional importers were identified for the latest survey (2005/06) compared with the previous survey carried out in 2004. The New Zealand methodology follows the IPCC Tier 2 approach which accounts for the time lag between consumption and emissions of the chemicals. A summary of calculation methods and emission factors for HFCs is included in table 4.7.1.

Potential emissions for HFCs and PFCs have been calculated using the Tier 1b approach. Due to a lack of disaggregated HFC and PFC data for "refrigeration and mobile air conditioning equipment", potential emissions from this category have been pro-rated. This has been done using the actual amounts of each HFC and PFC gas reported for refrigeration and mobile air conditioning.

TABLE 4.7.1
Halocarbon and SF_6 calculation methods and emission factors

HFC SOURCE	CALCULATION METHOD	EMISSION FACTOR
Aerosols	IPCC GPG 2000 Eqn 3.35	IPCC default factor of 50% of the initial charge per year
Foam	IPCC GPC 2000 table 3.17	IPCC default factor of 10% initial charge in first year and 4.5% annual loss of initial charge over an assumed 20-year lifetime
Mobile air conditioning	IPCC GPG 2000 Eqn 3.44	Top-down approach does not require emission factors
Stationary refrigeration/air conditioning	IPCC GPG 2000 Eqn 3.40	Top-down approach does not require emission factors
Fire protection	IPCC GPG 2000 Eqn 3.51	Bottom-up approach using emission rate of 0.015
SF_6 SOURCE	**CALCULATION METHOD**	**EMISSION FACTOR**
Electrical equipment	IPCC GPG 2000 Eqn 3.17	Tier 3 approach based on overall consumption and disposal with country-specific emission factor of 1% and this was supplemented by information from equipment manufacturers and servicing contractors using IPCC default emission factor of 2% (Tier 2b approach)
Other applications	IPCC GPG 2000 Eqn 3.22	No emission factor required as 100% is emitted within two years

Aerosols

Activity data on aerosol usage are provided by the only New Zealand aerosol manufacturer using HFCs and the Aerosol Association of Australia/New Zealand. The New Zealand manufacturer also provided activity data on annual HFC use, domestic and export sales and product loading emission rates. Data on the total number of doses contained in metered dose inhalers used from 1999 to 2005 are provided by the sole New Zealand supplier. The weighted average quantity of propellant per dose was calculated from information supplied by industry. There were no HFCs used in aerosols before 1996 and HFC–134a was not used in metered dose inhalers before 1995.

Solvents

A survey of distributors of solvent products and solvent recycling firms did not identify any use of HFCs or PFCs as solvents (CRL Energy Ltd, 2006b).

Foam

The survey revealed one New Zealand manufacturer importing HFCs for foam blowing and some of the products are exported overseas for use in refrigeration manufacture. There is insufficient data to estimate the proportion of HFC exported (CRL Energy Ltd, 2006b). The manufacturer started HFC usage in 2000. From 2000 to 2003, the HFC used was HFC–134a. From 2004, a mixture of HFC–245fa/365mfc has been imported for use. A global warming potential for this mixture has not been agreed to by the IPCC and UNFCCC, so on recommendation by the review team, New Zealand has reallocated these emissions to the section called “information on additional greenhouse gases” in the CRF tables.

Stationary refrigeration/air conditioning

New Zealand uses a top-down Tier 2 approach and country-specific data to obtain HFC emissions from stationary refrigeration and air conditioning (IPCC equation 3.40, IPCC, 2001):

Emissions = (annual sales of new refrigerant) – (total charge of new equipment)
+ (original total charge of retiring equipment) – (amount of intentional destruction)

To estimate the actual emissions of HFCs and PFCs, all refrigeration equipment has been split into two groups: factory-charged equipment and all other equipment which is charged with refrigerant on site. Information is available on the quantities of factory-charged imported refrigeration equipment and on the amount of bulk HFC refrigerant used in that equipment.

The amount of new refrigerant used to charge all other equipment (which is charged on site after assembly) is assumed to be the amount of HFC refrigerant sold each year minus that used to manufacture factory-charged equipment and that used to top up all non-factory charged equipment.

Factory-charged equipment consists of all equipment charged in factories (both in New Zealand and overseas), including all household refrigerators and freezers and all factory-charged, self-contained refrigerated equipment used in the retail food and beverage industry. All household air conditioners and most medium-sized commercial air conditioners are also factory charged although some extra refrigerant may be added by the installer for piping.

It is estimated there are about 2.2 refrigerators and freezers per household in New Zealand (Roke, 2006). Imported appliances account for around half of new sales each year, with the remainder manufactured locally. New Zealand also exports a significant number of factory-charged refrigerators and freezers.

Commercial refrigeration includes central rack systems used in supermarkets, chillers used for commercial building air conditioning and process cooling applications, rooftop air conditioners, and transport refrigeration systems. In most instances, these types of systems are assembled and charged on site, although some imported units may already be pre-charged. Self-contained commercial equipment includes frozen food display cases, reach-in refrigerators and freezers, beverage merchandisers, and vending machines.

Mobile air conditioning

The automotive industry has used HFC–134a as the refrigerant for mobile air conditioning in new vehicles since 1994. HFC–134a is imported into New Zealand for use in the mobile air conditioning industry through bulk chemical importers/distributors and within the air conditioning systems of imported vehicles. Industry sources report that air conditioning systems are retrofitted (with "aftermarket" units) to new trucks and buses and to secondhand cars.

New Zealand uses the Tier 2 top-down approach (IPCC equation 3.44, IPCC, 2001):

Annual emissions of HFC–134a = First fill emissions + Operation emissions
+ Disposal emissions – Intentional destruction

First-fill emissions are calculated from vehicle fleet numbers provided by the New Zealand Transport Registry Centre and assumptions made on the percentage MAC installations. Operation and disposal data are obtained from the industry survey and the New Zealand Transport Registry Centre.

Fire protection

HFCs and PFCs are used as substitutes to halons in portable (streaming) and fixed (flooding) fire protection (fire suppression) equipment. Halons have traditionally been used in areas that contain high-value equipment and where risks to personal safety are high. These include computer rooms, data centres and on aircraft.

HFC-based foams have only been used in fire protection systems in New Zealand since 1994. Within the New Zealand fire protection industry, the two main supply companies were identified as using relatively small amounts of HFC–227ea. The systems installed have very low leak rates with most emissions occurring during routine servicing and accidental discharges.

The bottom-up approach is used for estimating emissions from this sub-source category. For each year, an emission rate of 1.5 per cent is applied to the total amount of HFC installed to get annual HFC–227ea emissions.

SF_6

Actual and potential emissions of SF_6 result primarily from the use of SF_6 in electrical switchgear. For the 2005 inventory, emissions were calculated using the Tier 3a approach for the majority of electrical switchgear emissions and supplemented by information from equipment manufacturers and servicing contractors. One company, representing 80–90 per cent of the total SF_6 held in equipment, provided sufficient information for the Tier 3a approach. A Tier 2b approach was taken for the rest of the industry. SF_6 questionnaires were sent to the two importers of SF_6 and New Zealand's main users of SF_6, the electricity transmission, generation and distribution companies (CRL Energy Ltd, 2006b). Potential emissions of SF_6 were calculated and included in the 2005 inventory. In 2005, potential emissions were less than actual emissions because there was less SF_6 imported in 2005 compared with previous years.

4.7.3 Uncertainties and time-series consistency

The uncertainty in estimates of actual emissions from the use of HFCs and PFCs varies with each application and is described in table 4.7.2. For many sources there is no measure of uncertainty but a quantitative assessment is provided from expert opinion.

TABLE 4.7.2
Uncertainties in "consumption of halocarbons and SF_6" (CRL Energy Ltd. 2006a)

HFC SOURCE	UNCERTAINTY ESTIMATES
Aerosols	± 56% for aerosol imports, ± 60% in locally manufactured aerosols and ± 10% from emissions from MDIs
Solvents	Not occurring
Foam	± 50% in activity level and ± 50% in emission factors.
Stationary refrigeration/air conditioning	± 10% on total HFC/PFC imported and in locally charged equipment, ± 30% in factory-charged equipment ± 28% in total HFC/PFC proportion used for charging new commercial refrigeration units
Mobile air conditioning	Combined uncertainty ± 43%
Fire protection	Combined uncertainty ± 32%
SF_6 SOURCE	**UNCERTAINTY ESTIMATES**
Electrical equipment	Combined uncertainty ± 20%
Other applications	± 30% for tracer usage activity data ± 50% for medical use activity data

4.7.4 Source-specific QA/QC and verification

In the preparation of this inventory, the data for the consumption of halocarbons and SF_6 underwent Tier 1 quality checks. During data collection and calculation, activity data provided by industry are verified against national totals where possible and unreturned questionnaires and anomalous data are followed up and verified to ensure an accurate record of activity data.

4.7.5 Source-specific recalculations

Emissions from the mixture HFC–245fa/365mfc has been reallocated to the section called "information on additional greenhouse gases" in the CRF tables. A global warming potential for this mixture has not been agreed to by the IPCC and UNFCCC so cannot be included under the foam subcategory.

Potential emissions for HFCs and PFCs have been recalculated for the time-series 1990–2004. Potential emissions for the full time-series was included in the last inventory submission but because of a lack of disaggregated bulk chemical data for the "refrigeration and mobile air conditioning equipment" subcategory, potential emissions for the category were not estimated. This led to an underestimation of total potential emissions. The potential-to-actual HFC and PFC ratio was reported to be less than one. The estimates from "refrigeration and mobile air conditioning equipment" were pro-rated in this inventory submission to improve total potential emissions. This has been calculated using the actual amounts of each HFC and PFC gas reported for "refrigeration and mobile air conditioning equipment".

4.8 Other (CRF 2G)

4.8.1 Description

Panel products

Activity data are obtained from industry and supplemented with statistics from the Ministry of Agriculture and Forestry. The NMVOC emission factors for particleboard and medium-density fibreboard are derived from two major manufacturers. An assumption was made that the industry-supplied NMVOC emission factors are applicable to all particleboard and fibreboard production in New Zealand. There is no information in the IPCC guidelines (1996) for this category. NMVOC estimates for panel products in 2005 was 1.5 Gg. This is an increase of 0.7 Gg since 1990.

CHAPTER 5: Solvent and other product use

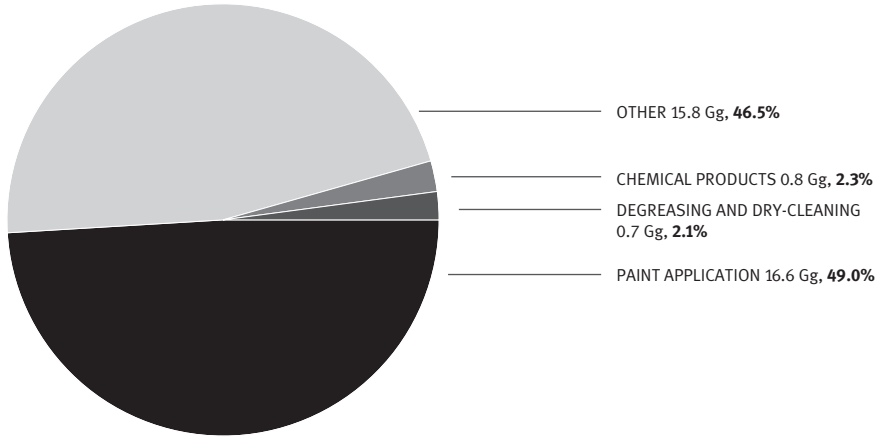
5.1 Sector overview (CRF 3)

This sector includes emissions from chemical cleaning substances used in dry-cleaning, printing, metal degreasing and a variety of industrial and household uses. Also included are emissions from paints, lacquers, thinners and related materials. Emissions arise from the evaporation of the volatile chemicals when solvent-based products are exposed to air.

Solvents and related compounds are a significant source of emissions of NMVOC. Some solvents have been banned under the Montreal Protocol and there is an international trend away from solvent use in paints towards water-based (acrylic) paints.

Emissions from the "solvent and other product use" sector in 2005 comprised 33.9 Gg of NMVOC. This is an increase of 6.2 Gg (18.2 per cent) from 27.7 Gg in 1990. The categories dominating the sector are NMVOC emissions from "paint application" and "other domestic and commercial use" (Figure 5.1.1).

FIGURE 5.1.1
Emissions of NMVOC from the solvent and other product use sector in 2005
(all figures Gg NMVOC)



In 2005, N_2O emissions from anaesthesia use totalled 0.2 Gg N_2O or 48.4 Gg CO_2-e. This is a small increase from 1990 when emissions from anaesthesia totalled 0.1 Gg N_2O.

5.1.1 Description

Ethanol and methanol are the only solvents produced in New Zealand and the majority of both products are exported. All other solvents are imported, including some ethanol and methanol (for quality and price reasons).

5.1.2 Methodological issues

Detailed methodologies for emissions from solvents and other product use are not provided in the IPCC revised guidelines (IPCC, 1996). Two basic approaches for estimating emissions – consumption and production-based estimates – are documented. The IPCC guidelines note that for many applications of solvents, the end uses are too small-scale, diverse and dispersed to be tracked directly. Therefore, emission estimates are generally based on total consumption and an assumption that once these products are sold to end users, they are applied and emissions produced relatively rapidly. For most surface coating and general solvent use, this approach is recommended. The New Zealand inventory estimates solvent emissions with a consumption-based approach. Information is obtained by an industry (CRL Energy Ltd, 2006a). Worksheets for the solvents and other products sector are included in Annex 8.

Emission factors are developed based on the likely final release of NMVOC to the atmosphere per unit of product consumed. The emission factors are applied to sales data for the specific solvent or paint products. The subcategories of solvents and other products specified in the common reporting format are detailed below.

Paint application

Consumption and emissions from paints and thinners are based on information from Nelson (Nelson, P, 1992) and the Auckland Regional Council (1997). Additional information for 1993 to 1996 was provided by the New Zealand Paint Manufacturers Association.

Degreasing and dry-cleaning

Most dry-cleaners in New Zealand use perchloroethylene and a small number use white spirits. Trichloroethylene has never been used in dry-cleaning but it is used in degreasing, for instance in the leather manufacturing industry. In general, solvent losses from the dry-cleaning industry have reduced substantially as closed circuit machines and refrigerated recovery units are increasingly used. Consumption of perchloroethylene and trichloroethylene are assumed to equal the volume of imports. Import information is supplied by Statistics New Zealand.

Chemical products (manufacturing and processing)

The solvents tetrabutyl urea and alkyl benzene are used in the production of hydrogen peroxide. Emissions of NMVOCs are provided by the sole producer of hydrogen peroxide in New Zealand. The hydrogen-peroxide plant has an on-line, continuous, activated-carbon solvent recovery system. Solvent losses are recorded annually as the difference between input solvent and solvent collected for incineration.

Losses of ethanol (and other minor components such as methanol, acetaldehyde and ethyl acetate) are monitored in the three ethanol plants in New Zealand. Using these values, an emission factor for NMVOC of 6 g/litre has been calculated. Ethanol used for alcoholic beverage production has been reported under food and drink production in the industrial processes sector.

Other – printing ink use

There is one major printing ink company in New Zealand with approximately 50 per cent of the solvent ink market share. The company provided a breakdown on the type of ink used. Approximately 50 per cent of inks used are oil inks (paste inks) which contain high boiling temperature oils. These are evaporated off during "heat setting" but it is understood that the volatiles are generally treated in a solvent burner that minimises emissions. The remaining 50 per cent of inks are liquid, of which 60 per cent are solvent inks (the remaining 40 per cent are water based).

Other – aerosols

Approximately 25 million aerosol units are sold in New Zealand each year. Based on the assumptions that the units are fully discharged within two years of purchase, the average propellant charge is 84 grams and 95 per cent are hydrocarbon-based, total NMVOC emissions in 2005 were 2.0 Gg.

Other – domestic and commercial use

This category includes NMVOC emissions from domestic and commercial solvent use in the following areas: household products, toiletries, rubbing compounds, windshield washing fluids, adhesives, polishes and waxes, space deodorants, and laundry detergents and treatments. Emissions for this category are based on a per capita emission factor. The emission factor used is 2.54 kg NMVOC/capita/yr (US EPA, 1985). It is assumed the emissions rate per capita derived by the United States Environmental Protection Agency (US EPA) is applicable to the average product use in New Zealand (CRL Energy Ltd, 2006a). Population figures are from the Statistics New Zealand website.

N_2O for anaesthesia

Activity data for 2005 were obtained from the sole importer of bulk N_2O into New Zealand. The importer supplies its competitor with its requirements so the figure represents full coverage of N_2O use in New Zealand. Most of the N_2O is used for anaesthesia and the production of Entonox (a half-and-half mixture of nitrous oxide and oxygen for pain relief). There is a very small amount used in motor sports and in scientific analysis.

5.1.3 Uncertainties and time-series consistency

Estimates of uncertainty are based on information provided by industry in the questionnaires and discussions with respondents (CRL Energy Ltd, 2006a). The overall uncertainties are assessed to be:

- paint application: ± 40 per cent
- degreasing/drycleaning: ± 30 per cent
- chemical product emissions: ± 20 per cent
- printing, aerosols and domestic/commercial use: ± 50 per cent, ± 20 per cent and ± 60 per cent respectively.
- N_2O for anaesthesia: ± 10 per cent for annual imports.

5.1.4 Source-specific QA/QC and verification

The consumption data from Auckland Regional Council (1997) and Nelson (Nelson, P, 1992) were compared to import data and discrepancies analysed and clarified by the consultant. There are considerable uncertainties and inconsistencies in applying the United States EPA per capita emission factors based on international experience. However, this is the best option at present as there is generally very little information available on the use of various products and their consequent NMVOC emissions in New Zealand.

5.1.5 Source-specific recalculations

Data in this sector for the 2005 inventory were derived using the same method used for previously reported data.

5.1.6 Source-specific planned improvements

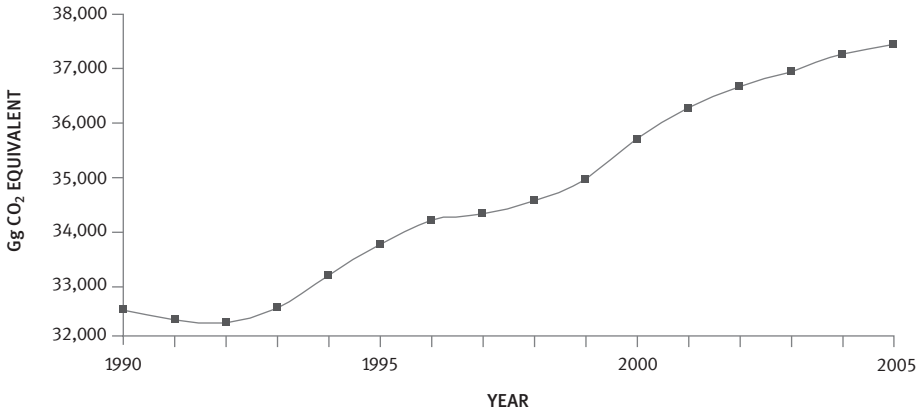
There are no planned improvements for this sector. There are large uncertainties, however the emission levels from the solvents and other products sector are negligible compared with other sectors. In accordance with good practice, New Zealand will continue to focus its inventory development on key source categories (IPCC, 2001).

CHAPTER 6: Agriculture

6.1 Sector overview

The agriculture sector emissions totalled 37,445.3 Gg CO_2 equivalent (Gg CO_2-e) and represented 48.5 per cent of all greenhouse gas emissions in 2005. Emissions in this sector are now 4,948.2 Gg CO_2-e (15.2 per cent) higher than the 1990 level of 32,497.1 Gg CO_2-e (Figure 6.1.1). The increase is primarily attributable to a 2,113.3 Gg CO_2-e (9.7 per cent) increase in CH_4 emissions from "enteric fermentation" and a 2,673.3 Gg CO_2-e (26.6 per cent) increase in N_2O emissions from the "agricultural soils" category.

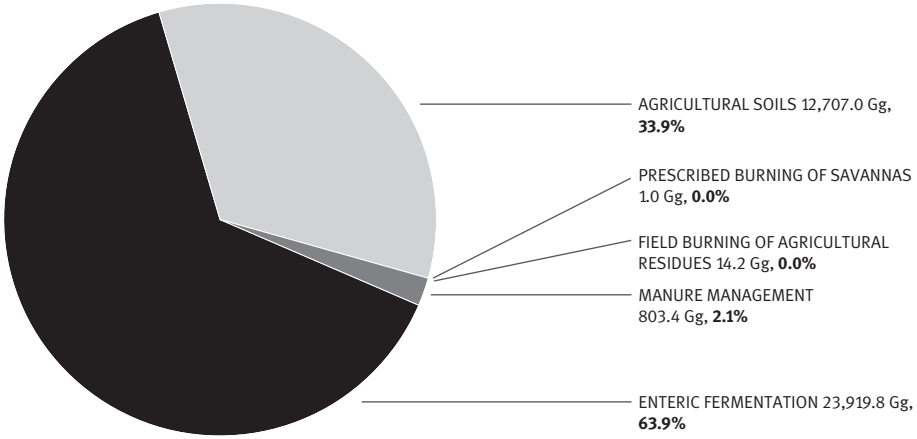
FIGURE 6.1.1
Agricultural sector emissions from 1990 to 2005



Emissions of CH_4 from "enteric fermentation" dominate, producing 63.9 per cent of CO_2-e emissions in the sector (Figure 6.1.2) and 31.0 per cent of New Zealand's total emissions. N_2O emissions from "agricultural soils" are the other major component of the sector comprising 33.9 per cent of agricultural CO_2-e emissions.

Agriculture is a major component of the New Zealand economy and agricultural products comprise over 50 per cent of total merchandise exports. This is because of the favourable temperate climate, the abundance of agricultural land and the unusual farming practices used in New Zealand. These practices include the extensive use of year-round grazing systems and a reliance on nitrogen fixation by legumes rather than nitrogen fertiliser.

FIGURE 6.1.2
Emissions from the agricultural sector in 2005
(all figures Gg CO_2-equivalent)



Since 1984, there have been changes in the proportions of the main livestock species farmed. There has been a trend for increased dairy and deer production because of high world demand and favourable prices. This has been counterbalanced by land coming out of sheep production and decreasing sheep numbers. Beef numbers have remained relatively static. There have also been productivity increases across all major animal species and classes. The land area used for horticulture has not changed significantly since 1990 although the types of produce grown have changed. There is now less grain grown, but more vegetables, fruit, and grapes (for wine production) than in 1990. There has also been an expansion of the land used for plantation forestry.

New Zealand uses a June year for all animal statistics as this reflects the natural biological cycle for animals in the southern hemisphere. The models developed to estimate emissions therefore work on a monthly timeframe beginning in July of one year and ending in June of the next year. To obtain emissions for single calendar years (January to December), emissions from the last six months of a July to June year are combined with the first six months' emissions of the next July to June year. All emissions in the inventory are reported on a rolling three-year average of the emissions calculated for single January–December years. To ensure consistency, a single livestock population characterisation and feed intake estimate is used when estimating CH_4 emissions from "enteric fermentation", CH_4 and N_2O emissions from "manure management", and N_2O emissions from "animal wastes deposited directly onto pasture". Information on livestock population census and survey procedures is included in Annex 3.1.

6.2 Enteric fermentation (CRF 4A)

6.2.1 Description

Methane is produced as a by-product of digestion in ruminants eg, cattle, and some non-ruminant animals such as swine and horses. Ruminants are the largest source of CH_4 as they are able to digest cellulose. The amount of CH_4 released depends on the type, age and weight of the animal, the quality and quantity of feed, and the energy expenditure of the animal.

Methane emissions from "enteric fermentation" have been identified as the largest key category for New Zealand in the level assessment. In accordance with Good Practice Guidance (IPCC, 2000), the methodology for estimating CH_4 emissions from "enteric fermentation" in domestic livestock was revised to a Tier 2 modelling approach for the 2001 inventory. All subsequent inventories have used this Tier 2 approach.

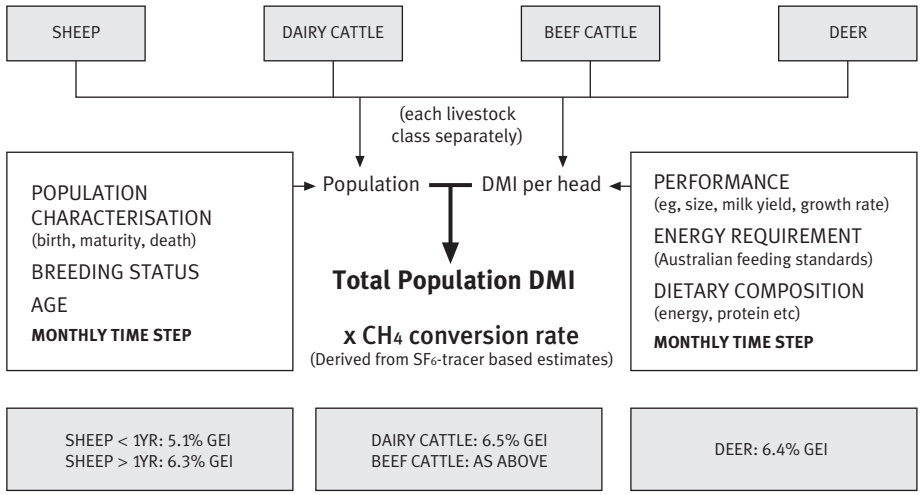
In 2005, emissions from enteric fermentation comprised 23,919.8 Gg CO_2-e. This represents 31.0 per cent of New Zealand's total CO_2-e emissions and is the largest single category of emissions in the New Zealand inventory. The category is dominated by emissions from cattle (both dairy and non-dairy). In 2005, cattle contributed 58.0 per cent of emissions from "enteric fermentation" and sheep contributed 38.5 per cent of emissions. The current level of emissions from "enteric fermentation" is 9.7 per cent above the 1990 level. Since 1990, there have been changes in the source of emissions within the "enteric fermentation" category. The largest increase has been in emissions from dairy cattle which have increased 70.5 per cent since 1990. This increase has been partially offset by decreases in emissions from sheep (–18.2 per cent) and minor livestock populations such as goats, horses and swine.

6.2.2 Methodological issues

New Zealand's methodology uses detailed livestock population characterisation and livestock productivity data to calculate feed intake for the four largest categories in the New Zealand ruminant population (dairy cattle, beef cattle, sheep and deer). The amount of CH_4 emitted is calculated using CH_4 emissions per unit of feed intake (Figure 6.2.1). The calculation process is explained in the full description of the Tier 2 approach in Annex 3.1 and Clark et al (2003). A Tier 1 approach is adopted for minor species such as goats, horses and swine using either IPCC (horses and swine) or New Zealand-derived default values (goats). These minor species comprised 0.3 per cent of total enteric methane emissions in 2005. Adopting a Tier 1 as opposed to a Tier 2 approach for these species has little effect on total estimated enteric methane emissions.

There has been a gradual increase in the implied emission factors for dairy cattle and beef cattle from 1990 to 2005. This is to be expected because the methodology uses animal performance data that reflects the increased levels of productivity achieved by New Zealand farmers since 1990. Increases in animal weight and animal performance (milk yield and liveweight gain) require increased feed intake by the animal to meet higher energy demands. Increased feed intake results in increased CH_4 emissions per animal. The increases in productivity are shown in the agricultural worksheets in Annex 8 and in the detailed description in Annex 3.1.

FIGURE 6.2.1
Schematic of New Zealand's enteric fermentation calculation methodology



6.2.3 Uncertainties and time-series consistency

Livestock numbers

Many of the calculations in this sector require livestock numbers. Both census methods and survey methods are used. Surveys occur each year between each census. Detailed information from Statistics New Zealand on the census and survey methods is included in Annex 3.1.2.

Methane emissions from enteric fermentation

In the 2001 inventory, the CH_4 emissions data from domestic livestock in 1990 and 2001 were subjected to Monte Carlo analysis using the software package @RISK to determine the uncertainty of the annual estimate (Clark et al, 2003; table 6.2.1). For the 2005 inventory, the uncertainty in the annual estimate was calculated using the 95 per cent confidence interval determined from the Monte Carlo simulation as a percentage of the mean value, ie, in 2001, the uncertainty in annual emissions was ± 53 per cent.

The overall inventory uncertainty analysis shown in Annex 7 (A.7.1) demonstrates that the uncertainty in annual emissions from enteric fermentation is 12.1 per cent of New Zealand's total emissions and removals for 2005, and is the largest single component affecting the national total. In the trend from 1990 to 2005 however, the uncertainty from enteric fermentation is only 2.4 per cent of the trend in emissions and removals. The uncertainty between years is assumed to be correlated, therefore the uncertainty in the trend is mostly in the emission factors rather than the activity data. Hence the uncertainty in the trend is much lower than uncertainty for an annual estimate.

TABLE 6.2.1
Uncertainty in the annual estimate of enteric fermentation emissions for 1990, 2001 and 2005 estimated using Monte Carlo simulation (1990, 2001) and the 95 per cent confidence interval (2005)

YEAR	ENTERIC CH_4 EMISSIONS (Gg/ANNUM)	95% CI MIN	95% CI MAX
1990	1,015.5	478.1	1,552.9
2001	1,099.4	517.6	1,681.2
2005	1,139.0	536.2	1,741.8

Note: The methane emissions used in the Monte Carlo analysis exclude those from swine and horses.

Uncertainty in the annual estimate is dominated by variance in the measurements used to determine the "CH_4 per unit of intake" factor. For the measurements made of this factor, the standard deviation divided by the mean is equal to 0.26. This uncertainty is thought to be mostly natural variation from one animal to the next. Uncertainties in the estimation of energy requirements, herbage quality and population data are thought to be much smaller (0.005–0.05), so these variables play a much smaller role.

6.2.4 Source-specific QA/QC and verification

Methane emission rates measured for 20 dairy cows scaled up to a herd have been corroborated using micrometeorological techniques. Laubach and Kelliher (2004) used the integrated horizontal flux technique and the flux gradient technique to measure CH_4 flux above a dairy herd. Both techniques are comparable, within estimated errors, to scaled-up animal emissions. The emissions from the cows measured by integrated horizontal flux and averaged over three campaigns are 329 (± 153) g CH_4/day/cow compared to 365 (± 61) g CH_4/day/cow for the scaled-up measurements reported by Waghorn et al (2002;2003). Methane emissions from lactating dairy cows have also been measured using the New Zealand SF_6 tracer method and open-circuit respiration chamber techniques (Grainger 2007). Total CH_4 emissions were similar, 322 and 331 g CH_4/day, when measured using chambers or the SF_6 tracer technique.

6.2.5 Source-specific recalculations

The provisional livestock population data for 2005 were updated to final population numbers, and the corresponding three-year average populations for 2004, 2005 and 2006 updated. There are minor revisions in data because of updated data precision and correcting of minor transcription errors.

6.2.6 Source-specific planned improvements

A national inter-institutional ruminant CH_4 expert group was formed to identify the key strategic directions for research into the CH_4 inventory and mitigation, and to develop a collaborative approach to improve the certainty of CH_4 emissions. This expert group is funded through the Ministry of Agriculture and Forestry. The Pastoral Greenhouse Gas Research Consortium has been established to carry out research, primarily into mitigation technologies and management practices but also on-farm inventory considerations. The consortium is funded by both public and private sectors. The implementation of the Tier 2 approach for CH_4 emissions from enteric fermentation and manure management is a consequence of the research conducted by the expert group.

6.3 Manure management (CRF 4B)

6.3.1 Description

Emissions from the "manure management" category comprised 803.4 Gg CO_2-e (2.1 per cent) of emissions from the agriculture sector.

Livestock manure is composed principally of organic material. When the manure decomposes in the absence of oxygen, methanogenic bacteria produce CH_4. The emissions of CH_4 are related to the amount of manure produced and the amount that decomposes anaerobically. Methane from "manure management" has been identified as a key category for New Zealand in both the 1990 and 2005 key category level assessments (table 1.5.2).

This category also includes emissions of N_2O related to manure handling before the manure is added to the soil. The amount of N_2O released depends on the system of waste management and the duration of storage. With New Zealand's extensive use of all-year-round grazing systems, this category is relatively small at 63.9 Gg CO_2-e in 2005. In comparison, agricultural soil emissions of N_2O totalled 12,707.0 Gg CO_2-e.

6.3.2 Methodological issues

Methane

Methane emissions from ruminant animal wastes in New Zealand have been calculated using an IPCC Tier 2 approach. The methodology adopted is based on the methods recommended by Saggar et al (2003) in a review commissioned by the Ministry of Agriculture and Forestry.

The approach is based on:

1. an estimation of the total quantity of faecal material produced
2. the partitioning of this faecal material between that deposited directly onto pastures and that stored in anaerobic lagoons
3. the development of specific New Zealand emission factors for the quantity of methane produced per unit of faecal dry matter deposited directly onto pastures and that stored in anaerobic lagoons.

The quantity of faecal dry matter produced is calculated by multiplying the feed intake by the dry matter digestibility of the feed. The feed intake estimates and monthly dry matter digestibility values are the same as in the current enteric fermentation and N_2O inventories.

In New Zealand, only dairy cows have a fraction (5 per cent) of the excreta stored in anaerobic lagoon waste systems. The remaining 95 per cent of excreta from dairy cattle is deposited directly on pasture. These fractions relate to the proportion of time dairy cows spend on pasture and compared to the time they spend in the milking shed. All other ruminant species (sheep, beef cattle, deer and goats) graze outdoors all year round and deposit all of their faecal material directly onto pastures. Values for the quantity of CH_4 produced per unit of faecal dry matter deposited on pastures for cattle are obtained from New Zealand research by Saggar et al (2003) and Sherlock et al (2003). The value for sheep comes from a New Zealand study by Carran et al (2003). So the average of cattle and sheep values is used. No values for deer are available.

Methane emissions from anaerobic lagoons are estimated assuming that faecal material deposited in lagoons is diluted with 90 litres of water per kilogram of dung dry matter (Heatley, 2001). This gives a total volume of effluent stored. A New Zealand study on emissions from anaerobic lagoons by McGrath and Mason (2002) quotes an emission rate for an effluent pond of 4.6 m depth. Using this depth figure as "typical" for the industry, it is then possible to arrive at a surface area of the faecal material produced by dairy cows stored in anaerobic lagoons. McGrath and Mason (2002) quote specific emissions values of 0.33–6.21 kg CH_4/m^2/year from anaerobic lagoons and the mean value of 3.27 CH_4/m^2/year of this range is assumed in the New Zealand Tier 2 calculations.

TABLE 6.3.1
Derivation of methane emissions from manure management

ANIMAL SPECIES	PROPORTION OF FAECAL MATERIAL DEPOSITED ON PASTURE	CH_4 FROM ANIMAL WASTE ON PASTURES (G CH_4/KG FAECAL DRY MATTER)	PROPORTION OF FAECAL MATERIAL STORED IN ANAEROBIC LAGOONS	WATER DILUTION RATE (LITRES WATER/KG FAECAL DRY MATTER)	AVERAGE DEPTH OF A LAGOON (METRES)	CH_4 FROM ANAEROBIC LAGOON (G CH_4/m^2/ YEAR)
Dairy cattle	0.95	0.98	0.05	90	4.6	3.27
Beef cattle	1.0	0.98	0.0	–	–	–
Sheep	1.0	0.69	0.0	–	–	–
Deer	1.0	0.92	0.0	–	–	–

New Zealand-specific emissions factors are not available for CH_4 emissions from manure management for swine, horses and poultry. These are minor livestock categories in New Zealand and emissions estimates for these species use IPCC default emission factors (refer to the agricultural worksheets in Annex 8.4).

Nitrous oxide

For the N_2O calculation, six alternative regimes for treating animal manure, known as animal waste management systems (AWMS), are identified in the IPCC guidelines (1996). New Zealand farming uses four AWMS:

1. anaerobic lagoons
2. pasture, range and paddock
3. solid storage and dry-lot
4. other systems (poultry without bedding and swine deep litter).

With the exception of dairy cattle, animals were allocated to the different AWMS according to the information provided in the IPCC guidelines (1996) for the Oceania region, as New Zealand scientists and Ministry of Agriculture and Forestry officials considered these were applicable to New Zealand farming practices. For dairy cattle, New Zealand-specific data from Ledgard and Brier (2004) were used.

The "pasture, range and paddock" AWMS is the predominant regime for animal waste in New Zealand. All sheep, goats, deer and non-dairy cattle excreta are allocated to the pasture, range and paddock AWMS. For dairy cattle, 95 per cent of excreta is allocated to pasture, range and paddock and 5 per cent is allocated to anaerobic lagoons (Ledgard and Brier, 2004). Emissions from the "pasture, range and paddock" AWMS are reported in the "agricultural soils" category.

The calculation for the quantity of nitrogen in each animal waste management system is shown in the agricultural worksheets in Annex 8. A time-series of nitrogen excreta (N_{ex}) values used for calculating animal production N_2O emissions is also shown in Annex 8. The (N_{ex}) values show an increase over time reflecting the increases in animal production.

N_{ex} is calculated from:

N_{ex} = N intake – N in products

where, N intake = Feed intake x N content of feed

and, N in products = Animal productivity x N content of products

Feed intake and animal productivity values are the same as used in the Tier 2 model for determining methane emissions (Clark et al, 2003). Nitrogen content of feed is estimated from a review of over 6,000 pasture samples of dairy and sheep and beef systems (Ledgard et al, 2003). Nitrogen contents of products are derived from the values used in the model OVERSEER® or from industry data. For lactating cattle the nitrogen content of milk is derived from the protein content of milk (Nitrogen = protein/6.25) published annually by the Livestock Improvement Corporation. The nitrogen content of sheep meat, beef and wool and the nitrogen retained in deer velvet are taken from OVERSEER®.

6.3.3 Uncertainties and time-series consistency

Emission factors from manure and manure management systems, the livestock population, nitrogen excretion rates and the usage of the various manure management systems are the main factors causing uncertainty in N_2O emissions from manure management (IPCC, 2000). New Zealand uses the IPCC default values for EF_3 (direct emissions from waste) for all AWMS except for $EF_{3(PR\&P)}$ (manure deposited on pasture, range and paddock). The value of $EF_{3(PR\&P)}$ which is a country-specific factor is 0.01 kg N_2O–N/kg N (further details in section 6.5.2). The IPCC default values have uncertainties of –50 per cent to +100 per cent (IPCC, 2000).

The overall inventory uncertainty analysis shown in Annex 7 (A.7.1) demonstrates the effect of uncertainty in annual emissions from manure management is relatively minor compared to the effect from CH_4 emissions from enteric fermentation and N_2O from agricultural soils.

6.3.4 Source-specific QA/QC and verification

Methane from manure management was identified as a key category (level assessment) for New Zealand in both the 1990 and 2005 inventories. In preparation for this inventory, the data for this category underwent Tier 1 quality checks.

6.3.5 Source-specific recalculations

There are minor revisions in data due to updated data precision and correcting minor transcription errors.

6.3.6 Source-specific planned improvements, if applicable

No source-specific improvements are planned.

6.4 Rice cultivation (CRF 4C)

6.4.1 Description

There is no rice cultivation in New Zealand. The "NO" notation is reported in the common reporting format.

6.5 Agricultural soils (CRF 4D)

6.5.1 Description

The "agricultural soils" category produces the majority of N_2O emissions in New Zealand comprising 12,707.0 Gg CO_2-e in 2005. Emissions are 2,673.3 Gg CO_2-e (26.6 per cent) above the level in 1990. The category comprises three subcategories:

- direct N_2O emissions from animal production (the pasture, range and paddock AWMS)
- indirect N_2O from nitrogen lost from the field as NO_3, NH_3 or NO_X
- direct N_2O emissions from agricultural soils as a result of adding nitrogen in the form of synthetic fertilisers, animal waste, biological fixation, inputs from crop residues and sewage sludge.

Each of these subcategories has been identified as key categories for New Zealand (tables 1.5.2 and 1.5.3). Direct soil emissions from animal production contributed 7,559.5 Gg CO_2-e, indirect N_2O from nitrogen used in agriculture contributed 3,384.6 Gg CO_2-e and direct N_2O emissions from agricultural soils contributed 1,762.9 Gg CO_2-e.

Carbon dioxide emissions from limed soils are reported in the LULUCF sector.

6.5.2 Methodological issues

Nitrous oxide emissions are determined using the IPCC (1996) approach where emission factors dictate the fraction of nitrogen deposited on the soils that is emitted into the atmosphere as N_2O. The two main inputs in New Zealand are from nitrogen fertiliser and the excreta deposited during animal grazing.

The worksheets for the agricultural sector document the emission factors and other parameters used in New Zealand's calculations. Three New Zealand-specific factors/parameters have been used: EF_1, $EF_{3(PR\&P)}$ and $Frac_{LEACH}$. The $EF_{3(PR\&P)}$ emission factor and $Frac_{LEACH}$ were extensively reviewed for the 2001 submission, and a new value for $Frac_{LEACH}$ was used from the 2001 inventory onwards and back-calculated to 1990. Data on EF_1 was reviewed during 2006 and the recommendation by Kelliher and de Klein (2006) to use a country-specific factor of 1 per cent has been adopted.

Animal production (N_2O)

Direct soil emissions from animal production refers to the N_2O produced from the pasture, range and paddock AWMS. This AWMS is the predominant regime for animal waste in New Zealand as 95 per cent of dairy cattle excreta and 100 per cent of sheep, deer and non-dairy cattle excreta are allocated to it. The emissions calculation is based on the livestock population multiplied by nitrogen excretion (N_{ex}) values and the percentage of the population on the pasture, range and paddock AWMS. The N_{ex} and allocation to AWMS are discussed in section 6.3.2. The N_{ex} values have been calculated based on the same animal intake and animal productivity values used for calculating CH_4 emissions for the different animal classes and species. This ensures the same base values are used for both CH_4 and N_2O emission calculations.

New Zealand uses a country-specific emission factor for $EF_{3(PR\&P)}$ of 0.01 (Carran et al, 1995; Muller et al, 1995; de Klein et al, 2003; Kelliher et al, 2003). Considerable research effort has gone into establishing a country-specific value for $EF_{3(PR\&P)}$. Field studies have been performed as part of a collaborative research effort called NzOnet. The parameter $EF_{3(PR\&P)}$ has been measured by NzOnet researchers in the Waikato (Hamilton), Canterbury (Lincoln) and Otago (Invermay) regions for pastoral soils of different drainage classes (de Klein et al, 2003). These regional data are comparable because the same measurement methods were used at the three locations. The percentage of applied nitrogen (as urine or dung) emitted as N_2O, and environmental variables, were measured in four separate trials that began in autumn 2000, summer 2002, spring 2002 and winter 2003. Measurements were carried out for up to 250 days or until urine-treated pasture measurements dropped back to background emission levels.

Kelliher et al (2003, 2005) assessed all available $EF_{3(PR\&P)}$ data and its distribution to pastoral soil drainage class, to determine an appropriate national annual mean value. The complete $EF_{3(PR\&P)}$ data set of NzOnet was synthesised using the national assessment of pastoral soils drainage classes. These studies recognise that: (1) environmental (climate) data are not used to estimate N_2O emissions using the IPCC (1996) methodology; (2) the N_2O emission rate can be strongly governed by soil water content; (3) soil water content depends on drainage that can moderate the effects of rainfall and drought; and (4) as a surrogate for soil water content, drainage classes of pastoral soils can be assessed nationally using a geographic information system. In New Zealand, earlier analysis showed the distribution of drainage classes for pasture land is highly skewed with 74 per cent well-drained, 17 per cent imperfectly drained and 9 per cent poorly drained (Sherlock et al, 2001).

The research and analysis to date indicates that if excreta is separated into urine and dung components, EF_3 for urine and dung could be set to 0.007 and 0.003, respectively. However, it is recognised that the dung EF_3 data are limited. Combining urine and dung EF_3 values, the dairy cattle total excreta EF_3 is 0.006. Conservatively rounding the total excreta EF_3 of 0.006 provides a country-specific value of 0.01 for $EF_{3(PR\&P)}$. The IPCC default value of $EF_{3(PR\&P)}$ is 0.02.

Indirect N_2O from nitrogen used in agriculture

The N_2O emitted indirectly from nitrogen lost from agricultural soils through leaching and run-off is shown in the agricultural worksheets in Annex 8. This nitrogen enters water systems and eventually the sea, with quantities of N_2O being emitted along the way. The amount of nitrogen that leaches is a fraction of that deposited or spread on land ($Frac_{LEACH}$).

Research studies and a literature review in New Zealand have shown lower rates of nitrogen leaching than are suggested in the IPCC guidelines. In inventories reported before 2003, a New Zealand parameter for $Frac_{LEACH}$ of 0.15 was used. However, using a $Frac_{LEACH}$ of 0.15, IPCC-based estimates for different farm systems were found on average to be 50 per cent higher than those estimated using the OVERSEER® (Wheeler et al, 2003) nutrient budgeting model. The model provides average estimates of the fate of nitrogen for a range of pastoral, arable and horticultural systems. In pastoral systems, nitrogen leaching is determined by the amount of nitrogen in fertiliser, dairy farm effluent and that excreted in urine and dung by grazing animals. The latter is calculated from the difference between nitrogen intake by grazing animals and nitrogen output in animal products, based on user inputs of stocking rate or production and an internal database with information on the nitrogen content of pasture and animal products.

The IPCC estimates were closer for farms using high rates of nitrogen fertiliser, indicating that the IPCC-based estimates for nitrogen leaching associated with animal excreta were too high. When the IPCC methodology was applied to field sites where nitrogen leaching was measured (four large-scale, multi-year animal grazing trials), it resulted in values that were double the measured values. This indicated that a value of 0.07 for $Frac_{LEACH}$ more closely followed actual field emissions (Thomas et al, 2005). This value was adopted and used for all years as it reflects New Zealand's national circumstances.

New Zealand uses the IPCC default EF_4 emission factor for indirect emissions from volatilisation of nitrogen in the form of NH_3 and NO_x.

Direct N_2O emissions from agricultural soils

The N_2O emissions from "direct N_2O emissions from agricultural soils" category arise from synthetic fertiliser use, spreading animal waste as fertiliser, nitrogen fixing in soils by crops, and decomposition of crop residues left on fields. All of the nitrogen inputs are collected together and an emissions factor applied to calculate total direct emissions from non-organic soils.

Nitrogen fertiliser use is determined by the Zealand Fertiliser Manufacturers' Research Association (FertResearch) from sales records for 1990 to 2005. A rolling three-year average is used to calculate inventory data. There has been a six-fold increase in elemental nitrogen applied through nitrogen-based fertiliser over the time-series, from 51,787 tonnes in 1990 to 308,406 tonnes in 2005. The calculation of N_2O that is emitted indirectly through synthetic fertiliser and animal waste being spread on agricultural soils is shown in the agricultural worksheets in Annex 8. Some of the nitrogen contained in these compounds is emitted into the atmosphere as ammonia (NH_3) and nitrogen oxides (NO_x) through volatilisation, which returns to the ground during rainfall and is then re-emitted as N_2O. This is shown as an indirect emission of N_2O.

The calculation for animal waste includes all manure that is spread on agricultural soils irrespective of which animal waste management system it was initially stored in. This includes all agricultural waste in New Zealand except for emissions from the pasture range and paddock animal waste management system. New Zealand uses a country-specific value for EF_1 of 0.01 kg N_2O–N/kg N (Kelliher and de Klein, 2006).

Direct N_2O emissions from organic soils are calculated by multiplying the area of cultivated organic soils by an emission factor. Recent analysis identified 202,181 hectares of organic soils, of which it is estimated that 5 per cent (ie, 10,109 ha) are cultivated on an annual basis (Kelliher et al, 2002). New Zealand uses the IPCC default emissions factor (EF_2 equal to 8 kg N_2O–N/kg N) for all years of the time-series.

Direct emissions from agricultural soils are calculated in the six tables shown in the worksheets in Annex 8.

6.5.3 Uncertainties and time-series consistency

Uncertainties in N_2O emissions from agricultural soils are assessed for the 1990, 2001 and 2002 inventory using a Monte Carlo simulation of 5,000 scenarios with the @RISK software (Kelliher et al, 2003) (table 6.5.1). The emissions distributions are strongly skewed, reflecting pastoral soil drainage whereby 74 per cent of soils are classified as well-drained, whereas only 9 per cent are classified as poorly drained. For the 2005 inventory, the uncertainty in the annual estimate was calculated using the 95 per cent confidence interval determined from the Monte Carlo simulation as a percentage of the mean value, ie, in 2002, the uncertainty in annual emissions was +74 per cent and –42 per cent.

TABLE 6.5.1
Uncertainties in N_2O emissions from agricultural soils for 1990, 2002 and 2005 estimated using Monte Carlo simulation (1990, 2002) and the 95 per cent CI (2005)

YEAR	N_2O EMISSIONS FROM AGRICULTURAL SOILS (Gg/ANNUM)	95% CI MIN	95% CI MAX
1990	31.9	17.2	58.2
2002	40.6	23.4	70.4
2005	41.0	23.6	71.1

The overall inventory uncertainty analysis shown in Annex 7 (Good Practice table 6.1) demonstrates the uncertainty in annual emissions from agricultural soils is a major contributor to uncertainty in the total estimate and trend from 1990. The uncertainty between years is assumed to be correlated, therefore the uncertainty is mostly in the emission factors and the uncertainty in the trend is much lower than uncertainty for an annual estimate. Uncertainty in the N_2O emissions from agricultural soils contributes 8.9 per cent of the uncertainty in New Zealand's total emissions and removals in 2005 and 1.1 per cent to the trend in emissions and removals from 1990 to 2005.

The Monte Carlo numerical assessment was also used to determine the effects of variability in the nine most influential parameters on uncertainty of the calculated N_2O emissions in 1990 and 2001. These parameters are shown in table 6.5.2 together with their percentage contributions to the uncertainty. There was no recalculation of the influence of parameters for the 2005 inventory. The Monte Carlo analysis confirmed that uncertainty in parameter $EF_{3(PR\&P)}$ has the most influence on total uncertainty, accounting for 91 per cent of the uncertainty in total N_2O emissions in 1990. This broad uncertainty reflects natural variance in EF_3 determined largely by the vagaries of the weather and soil type.

TABLE 6.5.2
percentage contribution of the nine most influential parameters on the uncertainty of total N_2O emissions inventories for 1990 and 2001

PARAMETER	1990 % CONTRIBUTION TO UNCERTAINTY	2001 % CONTRIBUTION TO UNCERTAINTY
$EF_{3(PR\&P)}$	90.8	88.0
EF_4	2.9	3.3
Sheep N_{ex}	2.5	1.8
EF_5	2.2	2.8
Dairy N_{ex}	0.5	0.7
$Frac_{GASM}$	0.5	0.5
EF_1	0.3	2.4
Beef N_{ex}	0.2	0.3
$Frac_{LEACH}$	0.1	0.2

6.5.4 Source-specific QA/QC and verification

Nitrous oxide emissions from "direct soil emissions" and "pasture, range and paddock manure" are key categories for both 1990 and 2005 (level and trend assessment). Nitrous oxide from "indirect emissions" is a key category for both 1990 and 2005 (level assessment). In preparation of this inventory, the data for these categories underwent Tier 1 quality checks.

The nitrogen fertiliser data obtained from FertResearch are corroborated by the Ministry of Agriculture and Forestry using nitrogen imports and exports, urea production figures and industrial applications (including resin manufacture for timber processing) data.

6.5.5 Source-specific recalculations

There are minor revisions in data due to updated data precision and correcting minor transcription errors.

6.5.6 Source-specific planned improvements

Research is continuing by New Zealand scientists to better quantify N_2O emission factors for New Zealand's pastoral soils.

6.6 Prescribed burning of savanna (CRF 4E)

6.6.1 Description

Prescribed burning of savanna is not a key category for New Zealand. The New Zealand inventory includes burning of tussock (Chionochloa) grassland in the South Island for pasture renewal and weed control. The amount of burning has been steadily decreasing since 1959 as a result of changes in lease tenure and a reduction in grazing pressure. In 2005, total emissions accounted for 1.0 $GgCO_2$-e, a 2.3 Gg CO_2-e (70.6 per cent) reduction from the 3.3 Gg CO_2-e reported in 1990.

The IPCC guidelines (1996) state that in agricultural burning, the CO_2 released is not considered to be a net emission as the biomass burned is generally replaced by regrowth over the subsequent year. Therefore the long-term net emissions of CO_2 are considered to be zero. However, the by-products of incomplete combustion, CH_4, CO, N_2O and NOx, are net transfers from the biosphere to the atmosphere.

6.6.2 Methodological issues

New Zealand has adopted a modified version of the IPCC methodology (IPCC, 1996). The same five equations are used to calculate emissions. Instead of using total grassland and a fraction burnt, New Zealand uses statistics of the total amount of tussock grassland that has been granted a consent (a legal right) under New Zealand's Resource Management Act (1991) for burning. Only those areas with a consent are legally allowed to be burned. Expert opinion obtained from land managers in local government is that approximately 20 per cent of the area allowed to be burnt is actually burnt in a given year.

Current practice in New Zealand is to burn in damp spring conditions which reduces the amount of biomass consumed in the fire. The composition and burning ratios used in calculations are from New Zealand-specific research (Payton and Pearce, 2001) and the IPCC reference manual (1996).

6.6.3 Uncertainties and time-series consistency

The same sources of data and emission factors are used for all years. This gives confidence in comparing emissions through the time-series from 1990 and 2005. The major sources of uncertainty are the percentage of consented area actually burnt in that season, extrapolation of biomass data from two study sites for all areas of tussock, and that many of the other parameters (ie, the carbon content of the live and dead components, the fraction of the live and dead material that oxidise and the nitrogen to carbon ratio for the tussocks) are the IPCC default values. Uncertainty in the New Zealand biomass data has been quantified at ± 6 per cent (Payton and Pearce, 2001), however many IPCC parameters vary by ± 50 per cent and some parameters lack uncertainty estimates.

6.6.4 Source-specific QA/QC and verification

There are minor revisions in data due to updated data precision and correcting minor transcription errors.

6.6.5 Source-specific recalculations

There were no recalculations for the 2005 inventory.

6.7 Field burning of agricultural residues (CRF 4F)

6.7.1 Description

Burning of agricultural residues produced 14.2 Gg CO_2-e in 2005. Emissions are currently 11.1 Gg CO_2-e lower (–43.9 per cent) than the level of 25.2 Gg CO_2-e in 1990. Burning of agricultural residues is not identified as a key category for New Zealand.

New Zealand reports emissions from burning barley, wheat and oats residue in this category. Maize residue is not burnt in New Zealand. New Zealand uses three-year averages of crop production in combination with the IPCC default emission ratios and residue statistics. Oats are included under the same emission factors as barley.

Burning of crop residues is not considered to be a net source of CO_2 because the CO_2 released into the atmosphere is reabsorbed during the next growing season. However, the burning is a source of emissions of CH_4, CO, N_2O and NO_X (IPCC, 1996). Burning of residues varies between years due to climatic conditions and is a declining source.

6.7.2 Methodological issues

The emissions from burning of agricultural residues are estimated in accordance with the IPCC guidelines (IPCC, 1996). The calculation uses crop production statistics, the ratio of residue to crop product, the dry matter content of the residue, the fraction of residue actually burned, the fraction of carbon oxidised and the carbon fraction of the residue. These figures are multiplied to calculate the carbon released. The emissions of CH_4, CO, N_2O and NO_X are calculated using the carbon released and an emissions ratio. N_2O and NO_X emissions calculations also use the nitrogen to carbon ratio.

Good Practice Guidance suggests an estimate of 10 per cent of residue burnt may be appropriate for developed countries but also notes that IPCC defaults "are very speculative and should be used with caution. The actual percentage burned varies substantially by country and crop type. This is an area where locally developed, country-specific data are highly desirable." (IPCC, 2000). For the years 1990 to 2003 it is estimated that 50 per cent of stubble was burnt. For the years 2004 and 2005, experts assessed this to have been 30 per cent. These figures were developed from opinions of the Ministry of Agriculture and Forestry officials working with the arable production sector.

6.7.3 Uncertainties and time-series consistency

No numerical estimates for uncertainty are available for these emissions. The fraction of agricultural residue burned in the field is considered to make the largest contribution to uncertainty in the estimated emissions.

6.7.4 Source-specific QA/QC and verification

There was no source-specific QA/QC for this category.

6.7.5 Source-specific recalculations

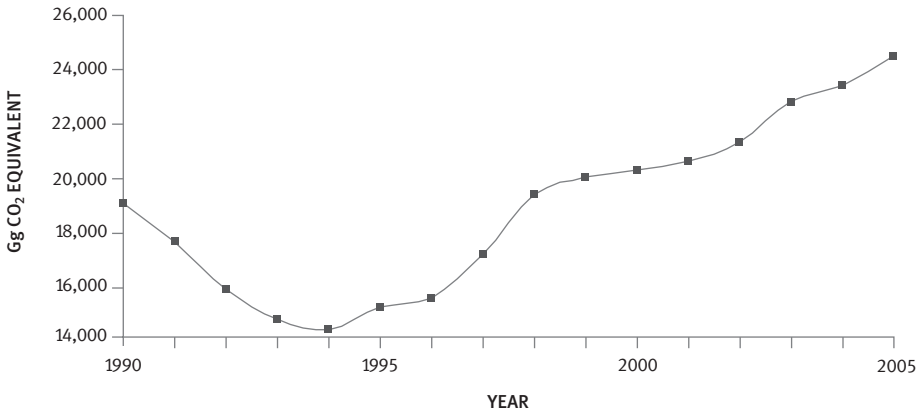
There are minor revisions in data due to updated data precision and correcting minor transcription errors.

CHAPTER 7: Land use, land-use change and forestry (LULUCF)

7.1 Sector overview

The land use, land-use change and forestry (LULUCF) sector represented the removal of approximately 31.8 per cent of all New Zealand's greenhouse gas emissions in 2005. Net removals from the sector in 2005 totalled 24,500.81 Gg CO_2 equivalent (CO_2-e) and are 29.0 per cent above net removals in 1990 (Figure 7.1.1).

FIGURE 7.1.1
LULUCF sector net removals from 1990 to 2005



7.1.1 Methodological issues for LULUCF in New Zealand

Six broad categories of land use are described in GPG-LULUCF. These categories are:

- Forest land – all land with woody vegetation consistent with defined national thresholds. It also includes areas of vegetation that currently fall below, but are expected to exceed the defined national thresholds.
- Cropland – arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds used for forest land.
- Grassland – rangelands and pasture land that are not considered as cropland. It also includes areas of vegetation that fall below but are not expected to exceed, without human intervention, the national threshold defined in the forest land category.
- Wetlands – land that is covered or saturated by water for all or part of the year (eg, peat land) and that does not fall into the forest land, cropland, grassland or settlements categories. Natural rivers and lakes are unmanaged subdivisions of wetlands.

- Settlements – all developed land, including transportation infrastructure and human settlements unless they are already included under other categories.
- Other land – bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories.

To improve transparency and accuracy of reporting in the LULUCF sector, and to meet the additional reporting requirements of the Kyoto Protocol, the Ministry for the Environment is developing the Land Use and Carbon Analysis System (LUCAS). The LUCAS project is described in detail in Annex 3.2.

7.1.1.1 Representation of land areas

To estimate land areas in each LULUCF land category for the current inventory, New Zealand has used an analysis of two existing land-cover maps of New Zealand – the Land Cover Databases 1 and 2 (LCDB1 and LCDB2, respectively) (Thompson et al, 2004). The LCDB1 and LCDB2 are an example of the wall-to-wall mapping of Approach 3 as described in GPG-LULUCF. The LCDBs were not specifically developed for use in UNFCCC reporting, however they are the only national land-cover/land-use spatial databases available that provide current information and can be reasonably mapped to the LULUCF land categories. The land categories to be mapped and monitored through LUCAS are designed specifically for reporting under the UNFCCC and the Kyoto Protocol, and will replace LCDB data in the inventory in the future.

The LCDB1 was completed in 2000 using SPOT satellite imagery acquired over the summer of 1996/97. LCDB2 was released in July 2004 and used Landsat 7 ETM+ satellite imagery acquired over the summer of 2001/02. During processing of LCDB2, the classifications in LCDB1 were checked, corrected and integrated into the LCDB2 database. The inventory uses the corrected LCDB1 data. There are 43 land-cover/land-use classes mapped in LCDB 1 and 2. The classes are mutually exclusive and additive to 100 per cent of the surface area of New Zealand. Additional information on the processing to generate LCDB 1 and 2 is included in Annex 3.3. To complete the UNFCCC inventory, the land-cover classes in the LCDB 1 and 2 were mapped to the applicable LULUCF categories (table A3C.1).

New Zealand does not presently have land-use data for 1990. In the 2005 inventory, the 1990 data has been estimated by linear extrapolation of the 1997 data. Until the mapping component of the LUCAS project is completed, which will provide 1990 data, this method provides the best data available for the inventory.

Table 7.1.1 shows a simplified land-use change matrix developed from LCDB1 and LCDB2 for the years 1997 and 2002. More details of the conversions between categories and subdivisions are included in each land-use category in the National Inventory Report. A land-use change matrix for 2002–2005 was generated by extrapolating previous annual trends.

TABLE 7.1.1
Land-use change matrix between LCDB1 (1997) and LCDB2 (2002)

	LAND AREA CATEGORIES FROM LCDB1 (1997) (KHA)						
LCDB2 (2002)	**FOREST LAND**	**CROPLAND**	**GRASSLAND**	**WETLANDS**	**SETTLEMENTS**	**OTHER LANDS**	**TOTAL**
FOREST LAND	10,097.57	0.02	130.88	0.00	0.06	0.06	10,228.59
CROPLAND	0.22	412.91	4.32	0.00	0.00	0.01	417.44
GRASSLAND	5.11	0.00	14,360.63	0.00	0.06	0.21	14,366.01
WETLANDS	0.00	0.00	0.67	531.24	0.04	0.01	531.96
SETTLEMENTS	0.56	0.02	5.03	0.00	214.84	0.00	220.46
OTHER LANDS	0.19	0.00	0.06	0.00	0.00	1,056.84	1,057.09
TOTAL	10,103.65	412.95	14,501.58	531.24	215.00	1,057.13	26,821.56
NET	124.94	4.49	-135.57	0.72	5.46	-0.03	0.00

7.1.1.2 Inventory carbon pools

Changes in carbon stocks for land-use categories involves estimation from five carbon pools – aboveground biomass, belowground biomass, dead wood, litter, and soil organic matter – as well as emissions of non-CO_2 gases from such pools. For UNFCCC inventory reporting purposes, the pools are grouped into living biomass (aboveground biomass and belowground biomass), dead organic matter (dead wood and litter), and soil organic matter.

7.1.1.3 Summary of methodological approaches used in LULUCF

New Zealand has calculated removal and emissions of CO_2 by planted forests using a modelling approach and country-specific data. For all other land-use categories a Tier 1 approach is used to estimate emissions and removals. The variables appear in the Tier 1 equations for all land-use categories. For transparency, these factors are tabulated in tables 7.1.3.1, 7.1.3.2 and 7.1.3.3.

The types of land use and management factors affecting soil carbon stocks are defined in GPG-LULUCF and include: (1) a land-use factor (F_{LU}) that reflects carbon stock changes associated with type of land use; (2) a management factor (F_{MG}) that for permanent cropland represents different types of tillage; and (3) an input factor (F_I) representing different levels of inputs to soil.

New Zealand is using a country-specific reference soil carbon stock value of 83 t C ha^{-1} for 0–30 cm depth. This value is within the range of the default IPCC values provided in table 3.2.4 of the Good Practice Guidance for LULUCF (IPCC, 2003) for warm temperate moist climates (a range of 34–88 t C ha^{-1}). The New Zealand value is calculated from the measured soil carbon in New Zealand grassland soils of 105 t C ha^{-1} (Tate et al, 2003), divided by the stock change factors for high producing grassland, ie, 105 t C ha^{-1} / 1 / 1.14 / 1.11 = 83 t C ha^{-1}. New Zealand has always applied the default inventory time period of 20 years in calculating the Tier 1 estimates.

TABLE 7.1.3.1
Land-use factors used across land-use categories

LAND USE	STOCK CHANGE FACTORS SELECTED FROM GPG-LULUCF (GPG-LULUCF TABLES 3.3.4 AND 3.4.5)		
	F_{LU}	F_{MG}	F_I
Planted forest	1	1	1
Natural forest	1	1	1
Annual cropland	0.71	1.0	1.11
Perennial cropland	0.82	1.16	0.91
High-producing grassland	1	1.14	1.11
Low-producing grassland	1	1.14	1
Other land	1	1	1

TABLE 7.1.3.2
Living biomass carbon stocks in land use before conversion

LAND USE	VALUE	SOURCE/REFERENCE
Natural forest	182 t C ha^{-1}	364 tonnes dm ha^{-1} (Hall et al, 1998); carbon fraction of dm (0.5)
Planted forest	223.2 t C ha^{-1}	1st rotation, 28 years old (Wakelin, 2007)
Annual cropland	0 t C ha^{-1}	Annual crop is harvested. GPG-LULUCF only considers perennial crops (table 3.4.8)
Perennial cropland	63 t C ha^{-1}	GPG-LULUCF table 3.3.2. Temperate (all moisture regimes)
High-producing grassland	1.35 t C ha^{-1}	2.7 tonnes dm ha^{-1} (GPG-LULUCF table 3.4.2, warm temperate – wet climate); carbon fraction of dm (0.5)
Low-producing grassland	0.8 t C ha^{-1} 63 t C ha^{-1}	1.6 tonnes dm ha^{-1} (GPG-LULUCF table 3.4.2, warm temperate – wet climate); carbon fraction of dm (0.5) 63 t C ha^{-1} assumed for grassland woody vegetation

Dm = dry matter

TABLE 7.1.3.3
Annual growth in living biomass for land converted to another land use

LAND USE	VALUE	SOURCE/REFERENCE
Natural forest	T1 = 0 t C ha^{-1}	New Zealand's natural forests are assumed to be approximately in steady-state (Tate et al, 2000)
	T1 = 4.3 t C ha^{-1}	Tier 1 – GPG-LULUCF 3A.1.5 and 3A.1.8 (Gw=3.5 tonnes dm ha^{-1} (an average of the conifer (3.0) and broadleaf (4.0) values), R = 0.24, C_{frac} = 0.5)
Planted forest	IE /	Tier 2 – included in C-Change modelling (Beets et al, 1999; Wakelin, 2007)
	T1 = 8.9 t C ha^{-1}	Tier 1 – GPG-LULUCF 3A.1.6 and 3A.1.8 (Gw = 14.5 tonnes dm ha^{-1} (pinus), R = 0.23, C_{frac} = 0.5)
Annual cropland	5 t C ha^{-1}	GPG-LULUCF table 3.3.8 (temperate all moisture regimes)
Perennial cropland	2.1 t C ha^{-1}	GPG-LULUCF table 3.3.8 (temperate all moisture regimes)
High-producing grassland	6.75 t C ha^{-1}	13.5 tonnes dm ha^{-1} (GPG-LULUCF table 3.4.9, warm temperate – wet climate), C_{frac} = 0.5
Low-producing grassland	3.05 t C ha^{-1}	6.1 tonnes dm ha^{-1} (GPG-LULUCF table 3.4.9, warm temperate – dry climate), C_{frac} = 0.5

Dm = dry matter

7.2 Forest land (CRF 5A)

7.2.1 A history of forestry in New Zealand

Before the first human settlement by Polynesians in about 1250 AD, an estimated 75 per cent of New Zealand's total land area was natural forest. The forest area had reduced to about 60 per cent by the mid-nineteenth century and was further reduced to the current 23 per cent estimated coverage by subsequent European settlement, the latter due largely to deforestation and clearance for pastoral grazing land. Deforestation (subsequent to human settlement) is estimated to have resulted in vegetation carbon losses of 3,400,000 Gg C (Scott et al, 2001). Establishment of pastures probably slightly increased mineral soil carbon, however some losses of carbon due to erosion are also possible (Tate et al, 2003b).

Government controls on forest clearance (deforestation) were first imposed in the late nineteenth century but the continuing demand for timber and agricultural land resulted in ongoing forest removal. By the 1970s, growing public concern led to stronger conservation measures by Government. Large-scale forest clearance for agricultural land ceased and New Zealand's domestic timber supply came largely from mature planted forests. Further Government administrative changes in 1987 resulted in reservation of about five million hectares (18 per cent of New Zealand's total land area) of publicly-owned natural forests. Currently, New Zealand has 6.4 million hectares of natural forest. Commercial timber harvest from private natural forest was restricted to that sourced under sustainable forest management plans and permits by a 1993 amendment to the Forests Act 1949. The amendment still exempted West Coast publicly-owned forests and forests on specific Māori-owned lands. Further government controls resulted in the cessation of logging of the West Coast publicly-owned forests in March 2002. Timber harvested from privately-owned natural forests and from forests on exempted Māori lands has continued at a low level since the 1993 controls were imposed. Current proposed legislative changes will continue to exempt the Māori lands although logging has further reduced in these forests.

New Zealand has a substantial estate of planted forests, mainly comprising *Pinus radiata*, created specifically for timber supply purposes and has well-established data on this estate's extent and characteristics. These forests have removed and stored more CO_2 over the period 1990 to 2005 than has been emitted through forest harvesting of both the combined planted and natural forests. The new planting rate (land reforested or afforested) over the last 30 years has been, on average, 43,000 hectares per year. From 1992 to 1998, new planting rates were high (averaging 69,000 hectares per year). Since 1998 the rate of new planting has declined and in 2005, 6,000 hectares of new forest was established. Between 1990 and 2005 it is estimated that 680,000 hectares of new forest has been established as a result of afforestation and reforestation activities.

Having a large planted forest resource enables New Zealand to sustainably manage its publicly and privately-owned natural forest. Less than 0.1 per cent of New Zealand's total forest production is now harvested from natural forests.

7.2.2 Description

In New Zealand's Initial Report under the Kyoto Protocol (MfE, 2006a), national forest definition parameters were specified as required by UNFCCC decision 16/CMP.1. These values are a minimum area of 1 hectare, a height of 5 metres and a minimum crown cover of 30 per cent. This definition will be used when forest is mapped by the LUCAS project and reported under the inventories submitted from 2009. To complete the 2005 inventory, the categories of forest land used in the LCDB1 and LCDB2 were applied (an area of 1 hectare and a width of 100 metres).

The LCDB1 and LCDB2 also include a shrubland vegetation cover category, which does not exist as a LULUCF category. Some shrubland classes were classified as forest land and others were classified as grassland, based on whether the species would usually grow to over 5 metres in height *insitu*. The classification is shown in table A3C, and will be further refined when the LUCAS project is operational.

New Zealand has adopted the definition of managed forest land as provided in the IPCC guidelines and GPG-LULUCF: "Forest management is the process of planning and implementing practices for stewardship and use of the forest aimed at fulfilling relevant ecological, economic and social functions of the forest". All of New Zealand's forests, both those planted for timber production and natural forests, are considered managed forests.

"Natural forest" is a term used to distinguish New Zealand's indigenous forests from planted production forests. Natural forests are managed for a range of conservation, biodiversity and recreation purposes. New Zealand's wood needs are almost exclusively met from planted production forests (99.9 per cent). No timber is harvested from New Zealand's publicly-owned natural forests. The natural forest harvest reported in the inventory refers to the harvest of forests on land granted to Māori (New Zealand's indigenous people) under the South Island Landless Natives Act (SILNA) 1906. These forests are currently exempt from the indigenous forestry provisions of the Forests Act that apply to all privately-owned indigenous forests and required a sustainable forest management plan or permit before any harvesting. Approximately 50,000 hectares are in the SILNA. There is no specific data to estimate growth in these forests. The LUCAS will provide data for similar forests in similar locations to the SILNA forests.

Removals of CO_2 in natural forest are calculated by a Tier 1 approach. Preliminary results are that New Zealand's natural forests are approximately in steady-state or a possible small sink of carbon, ie, changes in vegetation carbon stock lie between 0.3 to –2.5 Tg C yr^{-1} (Tate et al, 2000). For this reason, removals are set to emissions in the CRF tables. Results from analysis of the Carbon Monitoring System (CMS) data within natural forests will enable New Zealand to provide a better estimate (refer to Annex 3.2).

Forest land contributed net CO_2 removals of 25,461.31 Gg CO_2 in the 2005 inventory. This figure includes removals from the growth of planted forests, emissions from the conversion of land to planted forest, and emissions from the small amount of harvesting of natural forests.

7.2.3 Methodological issues

Forest land remaining forest land

Planted forest (Tier 2)

Approximately 90 per cent of the forest area is planted in *Pinus radiata*. These forests are usually composed of stands of trees of a single age class and all forests have relatively standard silviculture regimes applied. Compared to many forest ecosystems, total biomass in New Zealand's planted forests is relatively straightforward to estimate. The methodology applied for the inventory is:

- A survey of forest growers is undertaken annually to estimate the area of forest by age, species, silvicultural regime and location.
- Stem wood volume yield tables are compiled periodically for combinations of species, silvicultural regime and location.
- The C_change model (Beets et al, 1999) is used to derive forest biomass and carbon from stem volume yield tables. C_change was previously known as the CARBON/DRYMAT model.
- The Forestry Oriented Linear Programming Interpreter (FOLPI) (Garcia, 1984; Manley et al, 1991) is used to time-shift the estate forwards to forecast future forest growth and forest management, including harvesting.
- The FOLPI model also recalculates historic estimates of CO_2 removals and emissions by time-shifting the latest available data backwards.

Planted forest survey data

The results of the National Exotic Forest Description (NEFD) survey as at 1 April 2005 are used to calculate removals and emissions provided in the 2005 inventory. This latest information brings in new forest-area data along with data on new planting, restocking and harvesting for the 2005 year (MAF, 2006).

The NEFD survey provides estimates of the forest area and merchantable stem wood volume (via yield tables) by crop-type and age. A crop-type is an aggregate of forest stands that are similar species, silviculture and location. Each crop-type has a yield table that provides estimated volumes of stem wood per hectare by age. The total forest area after harvest for the year ending March 2005 is based on: (a) the latest area estimates provided by the 2005 NEFD; (b) an estimate of the area to be planted during the year; and (c) an estimate of the area harvested during the year. The total estate area for 2004 has been estimated through back-calculations using this latest NEFD area data combined with new planting and harvesting time-series information. The area of new land planting is based on the Ministry of Agriculture and Forestry statistics. These estimates are revised and recalculated annually as provisional estimates are replaced by confirmed actual areas.

Modelling

The C_change model estimates carbon stock per hectare, by vegetation component and annual age-class, from stem wood volume data (Box 7.1).

BOX 7.1
Process steps in the C_change model (Beets et al, 1999)

1.	Stem wood volume is converted to an oven-dry biomass weight.
2.	The dry weight of non-stem wood components (bark, branches, foliage, cones, stumps, roots, floor litter and understorey) is calculated from stem wood volume using allometric equations. These allometric equations take account of age, stocking and site fertility.
3.	Total forest biomass is converted to carbon weight. The carbon fraction of dry matter is 0.5 using the IPCC default (GPG p3.25).

For the 2005 inventory, C_change was used to create a corresponding carbon yield table for each wood volume yield table, based on wood density and management assumptions appropriate to the species, regime and region. The allometric equations used were based on data for *Pinus radiata* when around 10 per cent of the estate is made up of other species such as Douglas-fir (*Pseudotsuga menziesii*) (5 per cent), other exotic softwoods (2 per cent), and exotic hardwoods (3 per cent). It is uncertain what impact these other species may have on the accuracy of calculations of total biomass, but current research should enable the impact to be further assessed.

To simplify the subsequent modelling, all crop-types were then aggregated to form a single, national area-weighted crop-type and associated area-weighted national yield table.

The second of the two models, FOLPI, is a linear programming model used to optimise the management of forest estates over time. It simulates actual rates of planting and harvesting where time-series data exists. Carbon stock estimates are calculated for March years and are reported as three-year averages. The assumption is that the stem wood removed at harvest for both natural and planted forests is oxidised in the year of harvest. The FOLPI model uses the biomass and carbon stocks at one point in time to give total carbon stocks for each modelled year and changes in carbon stocks between those years. Among the outputs of the FOLPI model are the LULUCF inventory results for 1990 to 2005. These results include:

- stem wood volume harvested from the planted estate, hence CO_2 emitted in that harvest
- total stock of estate carbon after harvesting in each year (accounting also for the decay of non-stem wood carbon left after harvesting).

The removal of carbon (net of harvest) is calculated from the total stock values. The gross removal of carbon is then calculated by adding the harvested stem wood carbon back into the net carbon removal figures. This gives the change in carbon stock between last year's harvested forests and this year's unharvested forests.

Natural forest (Tier 1)

Removals of CO_2 in natural forest are calculated by a Tier 1 approach. Estimates of any harvesting from natural forests are provided by the Ministry of Agriculture and Forestry. Stem wood volumes are converted to oven-dry weight using a factor of 0.5 (accounting for wood moisture) and then expanded to include non-stem wood biomass using a factor of 2.04 (Wakelin, 2007). These country-specific factors are within the ranges given by GPG-LULUCF (2003 (tables 3A1.9–1 and 3A1.10)).

Land converted to forest land

Data on the amount of land clearance for new forest planting are sourced from the Ministry of Agriculture and Forestry. The information includes the proportion of new forest planting that occurs on grassland with woody vegetation that falls below and is not expected to exceed, without human intervention, the threshold used to define forest land. Data are available from 1993 to the present and based on these figures it is assumed that the proportion was 20 per cent before 1993. It is estimated that 25 per cent of the vegetation biomass is burnt on site under controlled burning conditions and that the remainder is left to decay.

The quantity of on-site biomass for both grassland woody vegetation and natural forest, used in the land conversion and biomass burning calculations (see Annex 8.5), is based on the provisional results of research (adapted from Hall et al, 1998). The values reported (136 t dm/ha for grassland with woody vegetation and 364 t dm/ha for mature natural forest) are based on a national area-weighted average for biomass per hectare for a range of species.

Controlled burning

It has been assumed the biomass fuel consumption rate in fires in both forest biomass and grassland with woody vegetation is 90 per cent. Work is underway to improve biomass burning assumptions in the inventory, however it is now thought that both the fuel consumption rate and the volume of dry matter per hectare for grassland with woody vegetation are overestimated, leading to overestimates of the resulting non-CO_2 emissions.

Wildfire burning

Only non-CO_2 emissions from wildfires are reported in the inventory (consistent with the IPCC default method). CO_2 emissions from wildfires in grasslands are assumed to be zero as they are balanced by subsequent growth. Emissions from wildfires are based on fire reports collected by the National Rural Fire Authority (NRFA). These reports show the area of forest and grassland with woody vegetation burnt. It is assumed that all forest burning occurs in natural forest. In planted forests, fires occur infrequently and fire-damaged trees are usually salvaged and appear in harvest statistics. Some of the areas reported in the NRFA statistics involve land clearing and it is not specified whether this is for agricultural or forestry purposes. This implies there may be double counting between these figures and those allocated to land clearing for new forest planting. However, the most common cause of wildfires is escapes from land clearance burns, and in New Zealand these are mostly in the high country. The Ministry of Agriculture and Forestry assesses the possibility of double counting as relatively minor.

7.2.4 Uncertainties and time-series consistency

Attempts have been made to quantify the uncertainties in the CO_2 removal estimates for planted forests but it is difficult to quantify the overall error due to the assumptions implicit in the models. Some uncertainties within the C_change (CARBON/ DRYMAT) model are well characterised (Hollinger et al, 1993). These include ± 3 per cent for wood density, ± 15 per cent for carbon allocation and ± 5 per cent for carbon content. Combining the uncertainties indicates that the proportional error in the carbon sequestration estimates is likely to be at least ± 16 per cent. The total national planted area is considered to be accurate to within ± 5 per cent (MAF, 2006) and the yield tables are assumed to be accurate to within ± 5 per cent.

A sensitivity analysis was conducted using the above accuracy ranges for total planted area and commercial yield, and a proportional uncertainty error of ± 16 per cent. The C_change (CARBON/ DRYMAT) model runs indicate the precision of the carbon stock estimates could be of the order of ± 25 per cent. As part of the LUCAS, research has been commissioned to better quantify uncertainty. No uncertainty estimates are currently available for emissions from harvesting of natural forests.

Removals from forest land are 6.2 per cent of New Zealand's total emissions and removals uncertainty in 2005 (Annex 7). Forest land introduces 2.2 per cent uncertainty into the trend in the national total from 1990 to 2005. This is the third largest impact on the trend after CO_2 emissions from the energy sector and CH_4 from enteric fermentation.

7.2.5 Source-specific QA/QC and verification

Forest removals and emissions calculated via a Tier 1 approach

The LCDB1 and LCDB2 analysis used to complete the LULUCF inventory allows calculating a coarse Tier 1 estimate for the categories "forest land remaining forest land" and "land converted to forest land". These estimates are reported in the National Inventory Report to support the modelling approach.

Living biomass

For the category "forest land remaining forest land", the calculation follows the Tier 1 procedure outlined in GPG-LULUCF equation 3.2.4 using parameters from tables 3A.1.5 for natural forest, 3A.1.6 for plantation forest and root-shoot ratios from table 3A.1.8. The values chosen for the carbon stocks and growth rates (Gw and R) are documented in table 7.1.3.2.

Dead organic matter

In the Tier 1 calculation, the average transfer rate into the dead wood pool equals the transfer rate out of the dead wood pool. The net change is zero (GPG-LULUCF 3.2.1.2).

Soil carbon

In the Tier 1 calculation, it is assumed that when forest remains forest, the carbon stock in soil organic matter does not change. For land converted to forest, New Zealand has followed the Tier 1 method outlined in GPG-LULUCF 3.2.2.3. For Tier 1, the initial soil carbon stock is determined from the same reference soil carbon stocks used for all land uses, together with stock change factors (F_{LU}, F_{MG}, F_I) appropriate for the previous land use. The stock change factors used by New Zealand's Tier 1 calculation are listed in table 7.1.3.1. New Zealand has used 83 tonnes C ha–1 for reference carbon stock in soils (Tate et al 2003a).

Decreases in the carbon stock of forest land from harvest were calculated according to GPG-LULUCF equation 3.2.9 – "annual other losses of carbon". This equation was used in preference to the equation for commercial felling (equation 3.2.7) to keep calculations consistent with the LCDB analysis used for other land categories ie, equation 3.2.7 is based on the extracted roundwood volume rather than the area of forest harvested or disturbed (equation 3.2.9). The annual area of deforestation was calculated from the total area of LCDB1 forest classes that had changed to "harvested forest" in LCDB2, divided by the five years. Carbon stocks in living biomass for planted and natural forest were those documented in table GPG-LULUCF 7.1.3.2. Under the Tier 1 methodology, it is assumed that all aboveground biomass is lost.

Decreases in living biomass carbon stocks associated with land converted to forest were also included in the Tier 1 calculation. For the Tier 1 estimate, it was assumed the land category "low producing grassland converted to planted forest" was equivalent in area to the clearance of grassland with woody vegetation for forest planting. The value of living biomass carbon stocks in perennial cropland before conversion provided in GPG-LULUCF table 3.3.2 (63 t C ha–1) was used as an approximation of the carbon stock in grassland woody vegetation biomass. This value is similar to the value used in the Tier 2 modelling of 68 t C ha–1 from Hall et al (1998) (136 t dm ha^{-1} x 0.5 (carbon fraction of dry matter)).

Table 7.2.5.1 compares the results from the modelled (Tier 2) and Tier 1 approaches for the 2003 inventory. This comparison has not been repeated for the current inventory as results are expected to be similar. The results for the living biomass stock are comparable (11.0 per cent different) but the different approaches mean the two estimates will always vary. The main reasons for this are the different methodologies used in assessing planted forest estate and planting rates ie, comparing the annual National Exotic Forest Description survey versus remote sensing and extrapolation of previous interpolated planting trends, the lack of forest age data from the LCDB analysis, mapping of LCDB classes to LULUCF categories and the selection of Good Practice Guidance defaults for annual biomass growth and root-shoot ratios compared to country-specific modelling data.

TABLE 7.2.5.1
Comparison of the Tier 2 and Tier 1 approaches for forest land in 2003

	AREA (KHA)			LIVING BIOMASS STOCK (Gg C)		
	Modelled/ actual (Tier 2)	Tier 1	Difference	Modelled/ actual (Tier 2)	Tier 1	Difference
Forest land remaining forest (planted)	1878	2046	8.9%	6977	7742	11.0%
Land converted to planted forest land	18	26	44%	–237	–291	22.8%

Other checks

The information presented in the National Inventory Report and the variables chosen for calculation were reviewed by officials of the Ministry for the Environment and the Ministry of Agriculture and Forestry. Calculated estimates were visually assessed for obvious errors in calculations. Land-use change matrices were used to ensure the allocation of land between categories produced a consistent national total area of land.

One of the primary input data sets used is the National Exotic Forest Description (NEFD). The NEFD is New Zealand's official source of statistics on planted production forests and, as such, is subject to formalised data checking procedures. Each NEFD report is reviewed by a technical NEFD committee before publication. Broad comparisons of forest areas reported in the NEFD reports are made with independent sources of information such as the Land Cover Database estimates and the annual results of Statistics New Zealand's Agricultural Production Survey. NEFD yield tables have been subject to review (eg, Jaakko Poyry Consulting, 2003; Manley, 2004) and are in the process of being revised.

The 2005 planted forests removals and emissions have been compared for consistency with the 2004 estimates (Wakelin, 2007).

7.2.6 Source-specific recalculations

New proportions of area by NEFD regime are used to weight the carbon yield in the 2005 inventory. Area data and carbon yields underlying the models in recent reports use 89 crop-type yield tables in the area-weighting procedure, rather than just four. This means the national yield table better reflects the diversity represented in the NEFD data. Regimes were modelled based on averages from permanent plot data, rather than as notional NEFD regimes. This had the effect of smoothing fluctuations during the period of silvicultural activity and also a minor effect on predicted root/shoot biomass ratios. In addition, dead fine roots were removed from the yield table to avoid double counting with soil carbon estimates from the soil carbon monitoring system (or other sources).

For the planted forest category, no back-casting or recalculation of 1990–2003 values has been included as for previous years. Information on historic areas and/or carbon pools is considered to be less accurate than that used for the current year. Only the 2004 year has been recalculated as it is affected by three-year averaging of available data.

7.2.7 Source-specific planned improvements

Development of the LUCAS will enable New Zealand to revise the time-series in the LULUCF inventory, and reduce uncertainty by using country-specific emission and removal factors and UNFCCC category-specific activity data. Details of the research are included in Annex 3.2.

Improvements in NEFD area capture are ongoing. Survey respondents are now being asked to specify whether or not stands are first rotation, which should provide a more useful breakdown.

Ongoing research is aiming to improve carbon modelling, including partitioning in species other than radiata pine, plantation understorey carbon, biomass decay rates, and biomass burning assumptions.

7.3 Cropland (CRF 5B)

7.3.1 Description

Cropland is a key category for New Zealand. In 2005, the net CO_2 removals were 639.14 Gg CO_2.

Cropland includes all annual and perennial crops as well as temporary fallow land. Annual crops include cereals, oil seeds, vegetables, root crops, and forages. Perennial crops include orchards, vineyards and plantations, except where these lands meet the criteria for forest land.

The amount of carbon stored in, and emitted or removed, from permanent cropland depends on crop type, management practices, and soil and climate variables. Annual crops are harvested each year, so there is no long-term storage of carbon in biomass. However, perennial woody vegetation in orchards and vineyards can store significant carbon in long-lived biomass, the amount depending on species type, density, growth rates, and harvesting and pruning practices.

7.3.2 Methodological issues

Emissions and removals have been calculated using IPCC Tier 1 emission and removal values and activity data from the LCDB analysis described in section 7.1 and Annex 3.3. To align with the methodologies provided in GPG-LULUCF, cropland was partitioned into annual and perennial cropland for the UNFCCC inventory.

Cropland remaining cropland

Living biomass

As per GPG-LULUCF (section 3.3.1.1.1), the change in biomass is only estimated for perennial woody crops. For annual crops, increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in that same year – thus there is no net accumulation of biomass carbon stocks.

Values for the biomass accumulation rate (2.1 t C ha^{-1} yr^{-1}) in perennial vegetation and biomass carbon loss (63 t C ha^{-1}) are from GPG-LULUCF table 3.3.2. New Zealand is using the values for a temperate climate (all moisture regimes) as this is the default regime most applicable to New Zealand. The LCDB analysis cannot provide information on areas of perennial vegetation temporarily destocked, therefore no losses in carbon stock can be calculated.

Dead organic matter

The GPG-LULUCF states there is not sufficient information to provide a basic approach with default parameters to estimate carbon stock changes in dead organic matter pools in cropland remaining cropland. The notation "NE" is used in the CRF tables.

Soil carbon

To provide a Tier 1 estimate, New Zealand uses the IPCC default method for mineral soils (equation 3.3.3 of GPG-LULUCF). Mineral soils comprise 99.93 per cent of New Zealand soils. This equation compares the soil organic carbon stock in the inventory year, with the soil organic carbon stock in "T" years before the inventory. New Zealand uses the IPCC default value of 20 years for "T". The soil organic carbon stock is calculated from a reference carbon stock multiplied by the three land-use and management factors shown in table 7.1.3.1.

Changes in soil carbon stock are caused by changes in the land-use and management factors (F_{LU}, F_{MG} and F_I). Within the cropland category, the LCDB does not provide sufficient information to determine whether there has been a change in land use and management in the 20 years before the inventory. Therefore for cropland remaining cropland, the values for F_{LU}, F_{MG} and F_I are considered to be constant and there is no net change in carbon stocks in soils eg, (83x0.82x1x1.16) – (83x0.82x1x1.16))x Area)/20 = 0. The values for F_{LU}, F_{MG} and F_I are from table 3.3.4 in GPG-LULUCF.

Land converted to cropland

Living biomass

The Tier 1 method is the same approach for all conversions and provided in equation 3.3.8 of GPG-LULUCF. The calculation is based on multiplying the annual area of land converted to cropland by the carbon stock change per area for that type of conversion, including changes in carbon stocks from one year of cropland growth.

At Tier 1, carbon stocks in biomass immediately after conversion are assumed to be zero, ie, the land is cleared of all vegetation before planting crops. To complete the Tier 1 analysis, New Zealand has selected from default parameter values provided in Good Practice Guidance and country-specific values where possible. These are shown in tables 7.1.3.2 and 7.1.3.3 .

Dead organic matter

GPG-LULUCF states there is not sufficient information to provide a basic approach with default parameters to estimate carbon stock change in dead organic matter pools in land converted to cropland. The notation "NE" is used in the CRF tables.

Soil carbon

New Zealand has followed the method outlined in GPG-LULUCF. For Tier 1, the initial soil carbon stock is determined from the same reference soil carbon stocks used for all land uses, together with stock change factors (F_{LU}, F_{MG}, F_I) appropriate for the previous land use (refer to section 7.1.2.3 in this inventory).

N_2O emissions

These emissions are from mineralisation of soil organic matter resulting from conversion of forest land, grassland, settlements or other land to cropland. New Zealand uses the method outlined in GPG-LULUCF equations 3.3.14 and 3.3.15. The input parameters to these equations are:

- change in carbon stocks in mineral soils in land converted to cropland: this value is calculated from the land converted to cropland soil carbon calculations
- EF_1: the emission factor for calculating emissions of N_2O from nitrogen in the soil. The global default value of 0.0125 kg N_2O – N/kg N is used
- C:N ratio: the default ratio of carbon to nitrogen in soil organic matter (15) is used.

7.3.3 Uncertainties and time-series consistency

Uncertainties can be analysed as uncertainty in activity data and uncertainty in variables such as emission factors, growth rates, and the effect of land management factors. It is the uncertainty in the IPCC default variables that dominates the overall uncertainty in the estimate provided by New Zealand. The combined effect of uncertainty in cropland is estimated at ± 75 per cent (95 per cent confidence interval).

TABLE 7.3.3.1
Uncertainty in emissions and removals from cropland

VARIABLE	UNCERTAINTY (95% CONFIDENCE INTERVAL)
Uncertainty in cropland remaining cropland	± 75%
LCDB1 (user accuracy 93.9%)	± 6%
LCDB2 (assumed to be equal to LCDB1)	± 6%
Uncertainty in biomass accumulation rates	± 75% (GPG-LULUCF table 3.3.2)
Uncertainty from land converted to cropland	± 75%
Carbon stocks in previous land use	± 75%
Estimated uncertainty in land management factors	± 12% (GPG-LULUCF table 3.3.4)

7.3.4 Category-specific QA/QC and verification

No specific QA/QC and verification was used for cropland. Sector-level procedures are described in section 7.2.4 forest land.

7.3.5 Category-specific recalculations

There are no recalculations for this category.

7.3.6 Category-specific planned improvements

No specific improvements are planned for cropland. Sector-level improvements resulting from the LUCAS are described in section 7.2.6 forest land.

7.4 Grassland (CRF 5C)

7.4.1 Description

Grasslands in New Zealand can vary greatly in their degree and intensity of management, ranging from the extensively managed rangelands of the South Island high country, to low producing grasslands with woody vegetation cover, to the intensively managed dairy pasture in the Waikato and Taranaki regions. Grasslands generally have vegetation dominated by perennial grasses, with grazing as the predominant land use, and are distinguished from "forest" land by having a woody vegetation cover of less than the threshold used in the forest definition. In 2005, the net emissions from grassland were 748.57 Gg CO_2-e . These emissions are from the subcategory "land converted to grassland".

7.4.2 Methodological issues

Grassland remaining grassland

Living biomass

In GPG-LULUCF (section 3.4.1.1.1.1), the Tier 1 assumption is no change in living biomass. The rationale is that in grassland where management practices are static, biomass carbon stocks will be in an approximate steady-state where carbon accumulation through plant growth is roughly balanced by losses. New Zealand has reported "NA" in the CRF tables because the activity occurs but there are no removals or emissions associated with it.

Dead organic matter

No estimate is calculated as GPG-LULUCF states that not enough information is available to develop default coefficients for estimating the dead organic matter pool. For Tier 1 and 2 methods, changes in dead organic matter and inorganic carbon stocks should be assumed to be zero.

Soil carbon

To provide a Tier 1 estimate, New Zealand uses the IPCC default method for mineral soils (equation 3.4.8 of GPG-LULUCF). As noted in previous sections, mineral soils cover 99.93 per cent of New Zealand (Tate et al, 2004). The LCDB analysis used in the 2005 inventory does not provide sufficient information to determine whether there has been a change in land use and management in grassland for the 20 years before the inventory. Therefore for areas of grassland remaining grassland, the values for F_{LU}, F_{MG} and F_I are considered to be constant and consequently the calculation shows there is no net change in carbon stocks in soils.

Liming of grassland

The calculation for CO_2 emissions from the liming of grassland soils is included in CRF worksheet 5.5. The calculation is based on the total amount of limestone sold (provided by Statistics New Zealand) and a carbon conversion factor from limestone to carbon. New Zealand uses the IPCC (1996) default value of 0.12 for carbon conversion.

Land converted to grassland

Living biomass

New Zealand has applied the GPG-LULUCF Tier 1 method where the amount of carbon removed is estimated by multiplying the area converted annually by the difference between average carbon stocks in biomass before and following conversion and accounting for carbon in biomass that replaces cleared vegetation. Pre-conversion stocks and annual growth figures are shown in tables 7.1.3.2 and 7.1.3.3. Carbon stocks in biomass immediately after conversion are assumed to be zero.

Dead organic matter

No Tier 1 methodology is provided in GPG-LULUCF.

Soil carbon

Land conversion to grassland can occur from all land uses. In New Zealand, the primary change into grassland is from forest land to grassland. New Zealand uses the methodology outlined in GPG-LULUCF (section 3.4.2.2.1.1). For Tier 1, the initial (pre-conversion) soil carbon stock is determined from a reference soil carbon stock together with stock change factors (F_{LU}, F_{MG}, F_I) appropriate for the previous land use as well as for grassland use. The stock change factors used by New Zealand are shown in table 7.1.3.1.

7.4.3 Uncertainties and time-series consistency

It is the uncertainty in the IPCC default variables that dominates the overall uncertainty in the estimate provided by New Zealand. The combined effect of uncertainty in grassland is estimated at ± 75 per cent (95 per cent confidence interval).

TABLE 7.4.3.1
Uncertainty in emissions and removals from grassland

VARIABLE	UNCERTAINTY (95% CI)
Uncertainty in grassland remaining grassland	± 75%
LCDB1 (user accuracy 93.9%)	± 6%
LCDB2 (assumed to be equal to LCDB1)	± 6%
Uncertainty in biomass accumulation rates	± 75% (GPG-LULUCF table 3.4.2)
Uncertainty from land converted to grassland	± 75%
Carbon stocks in previous land use	± 75%
Estimated uncertainty in land management factors	± 12% (GPG-LULUCF table 3.3.4)

7.4.4 Category-specific QA/QC and verification

No specific QA/QC and verification was used for grassland. Sector-level procedures are described in section 7.2.4.

7.4.5 Category-specific recalculations

There are minor recalculations for this category in 2004 due to revised activity data.

7.4.6 Category-specific planned improvements

No specific improvements are planned for grassland. Sector-level improvements resulting from the LUCAS are described in section 7.2.6.

7.5 Wetlands (CRF 5D)

7.5.1 Description

GPG-LULUCF 3.5 defines wetlands as "land that is covered or saturated by water for all or part of the year (eg, peat land) and that does not fall into the forest land, cropland, grassland or settlements categories. It includes reservoirs as a managed subdivision and natural rivers and lakes as unmanaged subdivisions". New Zealand has categorised LCDB land-cover classes for lakes, rivers and estuarine open water in the LCDB into the unmanaged wetlands category (Annex 3.3). Other LCDB classes eg, herbaceous freshwater vegetation, commonly associated as wetlands in New Zealand, have been categorised as grassland following the GPG-LULUCF definitions. In 2005, the net emissions were 0.72 Gg CO_2-e . These emissions are from the subcategory "land converted to wetlands". Wetlands are not a key category for New Zealand.

7.5.2 Methodological issues

Wetlands remaining wetlands

A methodology for this category is not covered in GPG-LULUCF but is addressed in appendix 3a.3 Wetlands Remaining Wetlands: Basis for future methodological development. The appendix covers emissions from flooded land and extraction from peat land. Data is not available for the amount of peat extracted from peat land in New Zealand, but it is considered that any activity would be negligible and emissions are not able to be calculated. Re-cultivation of peat land is included under the agriculture sector. The GPG-LULUCF defines flooded lands as "water bodies regulated by human activities for energy production, irrigation, navigation, recreation etc, and where substantial changes in water area due to water level regulation occur. Regulated lakes and rivers, where the main pre-flooded ecosystem was a natural lake or river, are not considered as flooded lands".

New Zealand has not reported emissions from flooded land because of a lack of data ie, the LCDB does not separate out regulated water bodies where substantial changes in water area occur, and because the majority of New Zealand's hydro-electric schemes are based on rivers and lakes where the main pre-flooded ecosystem was a natural lake or river. The CRF tables for LULUCF do not require Parties to prepare estimates for this category (footnote 3, CRF table 5).

Land converted to wetlands

New Zealand has applied the GPG-LULUCF Tier 1 methodology for estimating the carbon stock change due to land conversion to flooded land (GPG-LULUCF equation 3.5.6). This method assumes the carbon stock of land before conversion is lost in the first year following conversion. The carbon stock of the land before conversion is documented in table 7.1.3.2 . In Tier 1, it is assumed that the carbon stock after conversion is zero.

GPG-LULUCF does not provide guidance on carbon stock changes from soils due to land conversion to flooded land. Emissions of non-CO_2 gases from land converted to flooded land are covered in appendix 3a.3 of GPG-LULUCF but are not reported (note 3, CRF table 5).

7.5.3 Uncertainties and time-series consistency

Uncertainties are estimated as ± 75 per cent based on the uncertainty for Tier 1 grassland carbon stocks (GPG-LULUCF table 3.4.2) lost during conversion to wetlands.

7.5.4 Category-specific QA/QC and verification

No specific QA/QC and verification was used for wetlands. Sector-level procedures are described in section 7.2.4 forest land.

7.5.5 Category-specific recalculations

There are no recalculations for this category.

7.5.6 Category-specific planned improvements

No specific improvements are planned for wetlands. Sector-level improvements resulting from the LUCAS are described in section 7.2.6 forest land.

7.6 Settlements (CRF 5E)

7.6.1 Description

This land-use category is described in GPG-LULUCF 3.6 as including "all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other land-use categories". Settlements include trees grown along streets, in public and private gardens, and in different kinds of parks where the parks are associated with urban areas. In 2005, the net emissions from settlements were 97.16 Gg CO_2-e. These emissions are from the subcategory "land converted to settlements". Settlements is not a key category for New Zealand.

New Zealand has categorised the applicable LCDB land-cover classes into the settlements category (Annex 3.3). The LCDB analysis showed there was 214.84 kha of settlements remaining settlements from 1997 to 2002 with a net gain of 5.46 kha (table 7.1.1). The largest single category change in area was from high-producing grassland converted to settlements, averaging 1000 hectares per year.

7.6.2 Methodological issues

Settlements remaining settlements

A basic method for estimating CO_2 emissions and removals in settlements remaining settlements is provided in appendix 3a.4 of GPG-LULUCF. The methods and available default data for this land use are preliminary and based on an estimation of changes in carbon stocks per tree crown cover area or carbon stocks per number of trees as a removal factor. New Zealand does not have this level of activity data available. The CRF tables for LULUCF do not require Parties to prepare estimates for this category (note 3, CRF table 5.)

Land converted to settlements

The fundamental equation (3.6.1) for estimating change in carbon stocks associated with land-use conversions is the same as applied for other areas of land-use conversion eg, land converted to cropland and grassland. The carbon stock of the land before conversion is documented in table 7.1.3.2 . The default assumptions for a Tier 1 estimate are that all living biomass present before conversion to settlements will be lost in the same year as the conversion takes place, and that carbon stocks in living biomass following conversion are equal to zero.

7.6.3 Uncertainties and time-series consistency

Uncertainties are estimated as ± 75 per cent based on the uncertainty for Tier 1 grassland carbon stocks (GPG-LULUCF table 3.4.2).

7.6.4 Category-specific QA/QC and verification

No specific QA/QC and verification was used for settlements. Sector-level procedures are described in section 7.2.4 forest land.

7.6.5 Category-specific recalculations

There are no recalculations for this category.

7.6.6 Category-specific planned improvements

No specific improvements are planned for settlements. Sector-level improvements resulting from the LUCAS are described in section 7.2.6 forest land.

7.7 Other land (CRF 5F)

7.7.1 Description

"Other land" is defined in GPG-LULUCF 3.7 as including bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five land-use categories. "Other land" is included in New Zealand's land area for checking overall consistency of land area and tracking conversions to and from other land. In 2005, the net emissions from other land were 38.98 Gg CO_2 -e. These emissions are from the subcategory "land converted to other land". Other land is not a key category for New Zealand.

7.7.2 Methodological issues

Other land remaining other land

All of New Zealand's land area is classified as "managed". No guidance is provided in GPG-LULUCF for "Other land" that is managed.

Land converted to other land

Living biomass

The fundamental equation (3.7.1) for estimating change in carbon stocks associated with land-use conversions is the same as applied for other areas of land-use conversion eg, land converted to cropland and grassland. The carbon stock of the land before conversion is documented in table 7.1.3.2. The default assumptions for a Tier 1 estimate are that all living biomass present before conversion to other land will be lost in the same year as the conversion takes place, and that carbon stocks in living biomass following conversion are equal to zero.

Soil carbon

New Zealand uses the IPCC methodology outlined in GPP LULUCF (equation 3.7.3). For Tier 1, the initial (pre-conversion) soil carbon stock is determined from reference soil carbon stocks together with stock change factors (table 7.1.3.1) appropriate for the previous land use. New Zealand uses a reference soil carbon stock of 83 t C ha–1 (refer to section 7.1.1.3 above). Soil carbon stocks in the inventory year are zero for land converted to other land.

7.7.3 Uncertainties and time-series consistency

Uncertainties are estimated as ± 75 per cent based on the uncertainty in carbon stocks lost during the conversion to other land eg, GPG-LULUCF table 3.4.2.

7.7.4 Category-specific QA/QC and verification

No specific QA/QC and verification was used for other land. Sector-level procedures are described in section 7.2.4 forest land.

7.7.5 Category-specific recalculations

There are no recalculations for this category.

7.7.6 Category-specific planned improvements

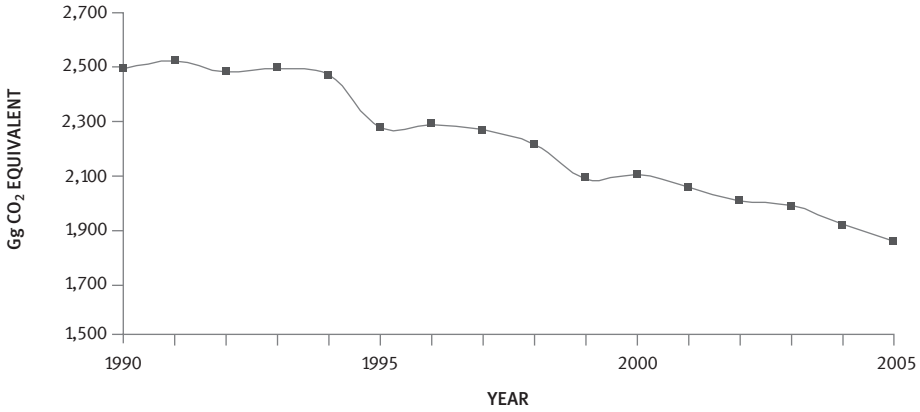
No specific improvements are planned for other land. Sector-level improvements resulting from the LUCAS are described in section 7.2.6 forest land.

CHAPTER 8: Waste

8.1 Sector overview

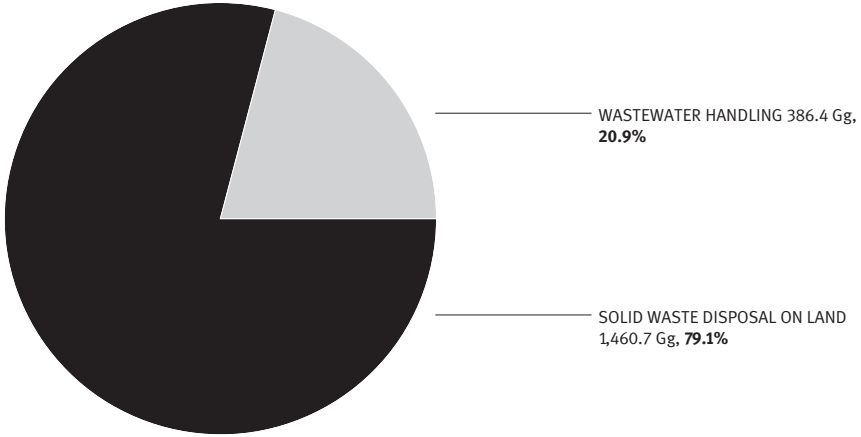
The waste sector totalled 1,847.1 Gg CO_2-e in 2005 and this represented 2.4 per cent of national greenhouse gas emissions. Emissions in 2005 are now 645.6 Gg CO_2-e (25.9 per cent) below the 1990 baseline value of 2,492.8 Gg CO_2-e (Figure 8.1.1). The reduction has occurred in the "solid waste disposal on land category" as a result of initiatives to improve solid waste management practices and increase landfill gas capture rates in New Zealand.

FIGURE 8.1.1
Waste sector emissions from 1990 to 2005



Emissions from the waste sector are calculated from solid waste disposal on land, wastewater handling (Figure 8.1.2) and waste incineration (not shown in Figure 8.1.2 as emissions are negligible). Methane from solid waste disposal was identified as a key category for New Zealand in 2005 (tables 1.5.2 and 1.5.3).

FIGURE 8.1.2
Waste sector emissions in 2005 (all figures Gg CO_2 equivalent)



Disposal and treatment of industrial and municipal waste can produce emissions of CO_2 and CH_4. The CO_2 is produced from the decomposition of organic material. These emissions are not included as a net emission because the CO_2 is considered to be reabsorbed in the following year. The most important gas is the CH_4 produced as a by-product of anaerobic decomposition.

8.2 Solid waste disposal on land (CRF 6A)

8.2.1 Description

Organic waste in solid waste disposal sites is broken down by bacterial action in a series of stages that result in the formation of CO_2 and CH_4. Carbon dioxide from aerobic decomposition is not reported in the inventory. The amount of CH_4 gas produced depends on a number of factors including the waste disposal practices (managed versus unmanaged landfills), the composition of the waste, and physical factors such as the moisture content and temperature of the solid waste disposal sites. The CH_4 produced can go directly into the atmosphere via venting or leakage, or it may be flared off and converted to CO_2.

In New Zealand, managing solid wastes has traditionally meant disposing of them in landfills. In 1995, a National Landfill Census showed there were 327 legally operating landfills or solid waste disposal sites in New Zealand that accepted approximately 3,180,000 tonnes of solid waste (MfE, 1997). Since that time there have been a number of initiatives to improve solid waste management practices in New Zealand. These have included preparing guidelines for the development and operation of landfills, closure and management of landfill sites, and consent conditions for landfills under New Zealand's Resource Management Act (1991). As a result of these initiatives, a number of poorly located and substandard landfills have been closed and communities rely increasingly on modern regional disposal facilities for disposal of their solid waste. The 2002 Landfill Review and Audit reported there were 115 legally operating landfills in New Zealand, a reduction of 65 per cent from 1995.

Recently, New Zealand's national focus has been towards waste minimisation and resource recovery. In March 2002, the Government announced its New Zealand Waste Strategy (MfE, 2002a). The strategy sets targets for a range of waste streams as well as improving landfill practices by the year 2010. As part of the implementation and monitoring of the strategy, the Government developed the Solid Waste Analysis Protocol (MfE, 2002b) that provided a classification system, sampling regimes and survey procedures to measure the composition of solid waste streams.

8.2.2 Methodological issues

New Zealand has used both the IPCC Tier 1 and Tier 2 approaches to calculate emissions from solid waste. The data reported in the inventory follow the IPCC Tier 2, first order decay approach (IPCC, 2000). New Zealand uses country-specific values for the degradable organic carbon factor, methane generation potential (L_0), and a methane generation rate constant (k) based on conditions at New Zealand landfills. The IPCC default oxidation correction factor of 0.1 is used (IPCC, 2000). Worksheets showing the waste sector calculations are included in Annex 8.

Data on municipal solid waste generation rates, waste composition, the fraction of degradable organic carbon (DOC) and the percentage of municipal solid waste disposed to solid waste disposal sites are obtained from the National Waste Data Report (MfE, 1997), the Landfill Review and Audit (MfE, 2002a), a report on Waste Composition and Construction Waste Data (MfE, 2006b), and the Solid Waste Analysis Protocol (SWAP) baseline results (MfE, 2003); surveys for 1995, 2002 and 2003. The proportion of waste for each type of solid waste disposal site is obtained from the 2003 solid waste disposal sites baseline results. It is estimated that in 1995, 90 per cent of New Zealand's waste was disposed to managed solid waste disposal sites and 10 per cent to uncategorised sites (MfE, 1997)[1]. The IPCC (1996) default values are used for the carbon content of the various components. Calculation of the methane generation potential is also based on the New Zealand SWAP baseline results.

Based on the 2002 Landfill Review and Audit, the 2006 report on Waste Composition and Construction Waste Data and using the SWAP classification system, it is estimated the quantity of solid waste going to landfills in New Zealand in 2005 was equivalent to 2.14 kg per person per day. This shows a reduction in waste generation from 2.35 kg per person per day in 1995.

There has been no new solid waste compositional data for 2004 and 2005, hence degradable organic content per Gg waste has remained constant. However, the methane correction factor has been increasing due to closure of unmanaged landfills and increasing volumes being disposed to larger modern landfills. These inputs have resulted in some increases to the methane generation potential of solid waste to landfills.

A methane generation rate constant of 0.06 is used for New Zealand's landfills. International measurements support a methane generation rate constant in the range of 0.03 to 0.2 (IPCC, 2000). The 0.03 represents a slow decay rate in dry sites and slowly degradable waste, whereas the 0.2 value represents high moisture conditions and highly degradable waste. The IPCC recommended value is 0.05 (IPCC, 2000). The relatively wet conditions in most regions of New Zealand mean that the methane generation rate constant is likely to be slightly above the 0.05 default value. This was confirmed by a comparison of CH_4 generation and recovery estimates to actual recovery rates at a limited number of solid waste disposal sites in New Zealand (SCS Wetherill Environmental, 2002).

The fraction of degradable organic carbon that actually degrades (0.5) and the methane oxidation factor (0.1) are drawn from the Topical Workshop on Carbon Conversion and Methane Oxidation in Solid Waste Disposal Sites, held by the IPCC Phase II Expert Group on Waste on 25 October 1996. The workshop was attended by 20 international experts with knowledge of the fraction of degradable organic carbon that is converted to CH_4 and/or the oxidation of CH_4 by microbes in the soil cover.

The recovered CH_4 rate per year was estimated based on information from a 2005 survey of solid waste disposal sites that serve populations of over 20,000 in New Zealand (WMNZ, 2005). There was no landfill gas collected in 1990 and 1991, with the first flaring system installed in 1992.

[1] The 10 per cent of solid waste not disposed to "managed" solid waste disposal sites, went to sites that fell outside the definition of "managed", yet insufficient information is held about the sites to classify them as deep or shallow unmanaged solid waste disposal sites, hence the "unclassified" status. The inventory assumes that by 2010 all solid waste will be disposed to "managed" solid waste disposal sites, which has lead to a linearly increasing Methane Correction Factor in L_0 calculations.

8.2.3 Uncertainties and time-series consistency

The overall estimated level of uncertainty is estimated at ± 20 per cent, which is the same uncertainty as the 2004 inventory, but an improvement on prior submissions. The improvement was due to the sampling and survey guidelines from the Solid Waste Analysis Protocol and the 2002 Landfill Audit and Review. Due to the unknown level of uncertainty associated with the accuracy of some of the input data it has not been possible to perform a statistical analysis to precisely determine uncertainty levels. Uncertainty in the data is primarily from uncertainty in waste statistics based on the 1997 National Waste Data Report (total solid waste disposed to landfills and the recovered methane rate).

The New Zealand waste composition categories from the Solid Waste Analysis Protocol do not exactly match the categories required for the IPCC degradable organic carbon calculation. The major difference is that in New Zealand's degradable organic carbon calculation, the putrescibles category includes food waste as well as garden waste. A separation into the IPCC categories was not feasible given the available data in the Solid Waste Analysis Protocol baseline report. The effect of this difference is managed by the use of IPCC default carbon contents which are similar for the non-food (17 per cent carbon content) and food categories (15 per cent carbon content).

8.2.4 Source-specific QA/QC and verification

The Tier 1 and Tier 2 approaches have been used for solid waste emission estimates and the gross CH_4 results compared, as recommended from the technical review of New Zealand's greenhouse gas inventory conducted in May 2001 (UNFCCC, 2001c). For the 2005 inventory, the Tier 2 value of gross annual methane generation is 127.6 Gg CH_4 and the Tier 1 value is 148.23 Gg CH_4. The assumptions used to calculate net CH_4 emissions from gross CH_4 are the same for both tiers.

CH_4 from solid waste disposal was identified as a key category for New Zealand in 1990 and 2005 (level and trend assessment). In preparation for this inventory, the data for this category underwent Tier 1 quality checks.

8.2.5 Source-specific recalculations

Municipal solid waste values for 2003 and 2004 were updated after obtaining new data on solid waste disposed to landfill in Auckland (New Zealand's largest urban area). The 2003 and 2004 inventory submissions assumed a constant fraction of municipal solid waste disposed at solid waste disposal sites in year x (MSWx), when the new data indicated that in the landfills measured, solid waste to landfill had increased faster than the population size. This new data has lead to increased total MSW tonnage figures in 2003 and 2004.

Textiles were added to the calculation of degradable organic carbon. Data on the proportion of solid waste volumes made up of textile waste was only available for 2003, and has been linearly applied for other years.

The waste generation rate increased for 2004 due to more accurate data becoming available for New Zealand's largest region which was published in a report on Waste Composition and Construction Waste Data (MfE, 2006).

Food and garden waste are combined in New Zealand's compositional analysis. This inventory submission revised the degradable organic carbon value associated with this combined category from 0.17 to 0.15GgC/Gg waste. This change was made following the recommendation of the UNFCCC expert review team to be conservative about reductions achieved relative to the 1990 base year.

Recalculations were performed back to 1990 and have resulted in a reduction of 2.7 Gg CH_4 in 1990 and an increase of 0.6 Gg CH_4 in 2004.

8.2.6 Source-specific planned improvements

There are no specific improvements planned for this category.

8.3 Wastewater handling (CRF 6B)

8.3.1 Description

Wastewater from virtually every town in New Zealand with a population over 1,000 people is collected and treated in community wastewater treatment plants. There are approximately 317 municipal wastewater treatment plants in New Zealand and approximately 50 government or privately-owned treatment plants serving more than 100 people.

Although most of the treatment processes are aerobic and therefore produce no CH_4, there are a significant number of plants that use partially anaerobic processes such as oxidation ponds or septic tanks. Small communities and individual rural dwellings are generally served by simple septic tanks followed by ground soakage trenches.

Large quantities of industrial wastewater are produced by New Zealand's primary industries. Most of the treatment is aerobic and any CH_4 from anaerobic treatment is flared. There are a number of anaerobic ponds that do not have CH_4 collection, particularly serving the meat-processing industry. These are the major sources of industrial wastewater CH_4 in New Zealand.

8.3.2 Methodological issues

Methane emissions from domestic wastewater treatment

CH_4 emissions from domestic wastewater handling have been calculated using a refinement of the IPCC methodology (IPCC, 1996). A population using each municipal treatment plant in New Zealand has been assessed. Where industrial wastewater flows to a municipal wastewater treatment plant, an equivalent population for that industry has been calculated based on a biological oxygen demand (BOD) loading of 70 g per person per day.

Populations not served by municipal wastewater treatment plants have been estimated and their type of wastewater treatment assessed. The plants have been assigned to one of nine typical treatment processes. A characteristic emissions factor for each treatment is calculated from the proportion of biological oxygen demand to the plant that is anaerobically degraded multiplied by the CH_4 conversion factor. The emissions calculations are shown in Annex 8.

It is good practice to use country-specific data for the maximum methane producing capacity factor (B_0). Where no data are available, the 1996 IPCC methodology recommends using B_0 of 0.25 CH_4/kg COD (chemical oxygen demand) or 0.6 kg CH_4/kg BOD. The IPCC biological oxygen demand value is based on a 2.5 scaling factor of chemical oxygen demand (IPCC, 2000). New Zealand has used these IPCC default factors in this inventory.

Methane emissions from industrial wastewater treatment

The IPCC default methodology is also used to calculate emissions from industrial wastewater treatment. For each industry, an estimate is made of the total industrial output in tonnes per year, the average chemical oxygen demand load going to the treatment plant and the proportion of waste degraded anaerobically (refer to Annex 8). CH_4 is only emitted from wastewater being treated by anaerobic processes. Industrial wastewater that is discharged into a sewer with no anaerobic pre-treatment is included in the domestic wastewater section of the inventory.

Methane emissions from sludge

The organic solids produced from wastewater treatment are known as sludge. In New Zealand, the sludge from wastewater treatment plants is typically sent to landfills. Any CH_4 emissions from landfilled sludge are reported under the solid waste disposal sites category. Other sources of emissions from sludge are discussed below.

In large treatment plants in New Zealand, sludge is handled anaerobically and the CH_4 is almost always flared or used[2]. Smaller plants generally use aerobic handling processes such as aerobic consolidation tanks, filter presses and drying beds.

Oxidation ponds accumulate sludge on the pond floor. In New Zealand, these are typically only desludged every 20 years. The sludge produced is well stabilised with an average age of approximately 10 years. It has a low biodegradable organic content and is considered unlikely to be a significant source of CH_4 (SCS Wetherill Environmental, 2002).

Sludge from septic tank clean-out, known as "septage", is often removed to the nearest municipal treatment plant. In those instances, it is included in the CH_4 emissions from domestic wastewater treatment. There are a small number of treatment lagoons specifically treating septage. These lagoons are likely to produce a small amount of CH_4 and their effect is included in the calculations.

Nitrous oxide emissions from domestic wastewater treatment

New Zealand's calculation uses a modification of the IPCC methodology (IPCC, 1996).

The IPCC method calculates nitrogen production based on the average per capita protein intake. However in New Zealand, raw sewage nitrogen data are available for many treatment plants. The raw sewage nitrogen data are used to calculate a per capita domestic nitrogen production of 13 g/day and a per capita wastewater nitrogen figure of 4.75 kg/person/year. The IPCC default method uses an emissions factor (EF_6) to calculate the proportion of raw sewage nitrogen converted to N_2O. New Zealand uses the IPCC default value of 0.01 kg N_2O–N /kg sewage N.

[2] An exception is the Christchurch sewage treatment plant that uses anaerobic lagoons for sludge treatment. Based on volatile solids reduction measurements in the lagoons they estimate CH_4 production of 0.46 Gg/year plus an additional 0.16 Gg/year from unburned CH_4 from the digester-gas fuelled engines.

Nitrous oxide emissions from industrial wastewater treatment

The IPCC does not offer a methodology for estimating N_2O emissions from industrial wastewater handling. Emissions are calculated using an emissions factor (kg N_2O–N/kg wastewater N) to give the proportion of total nitrogen in the wastewater converted to N_2O. The total nitrogen was calculated by adopting the chemical oxygen demand load from the CH_4 emission calculations and using a ratio of chemical oxygen demand to nitrogen in the wastewater for each industry.

8.3.3 Uncertainties and time-series consistency

Methane from domestic wastewater

It is not possible to perform rigorous statistical analyses to determine uncertainty levels because of biases in the collection methods (SCS Wetherill Environmental, 2002). The uncertainty reported for all wastewater figures is based on an assessment of the reliability of the data and the potential for important sources to have been missed from the data. It is estimated that domestic wastewater CH_4 emissions have an accuracy of – 40 per cent to + 60 per cent (SCS Wetherill Environmental, 2002).

Methane from industrial wastewater

The method used in estimating CH_4 emissions from industrial wastewater treatment limits the ability to undertake a statistical analysis of uncertainty.

Total CH_4 production from industrial wastewater has an estimated accuracy of ± 40 per cent based on assessed levels of uncertainty in the input data (SCS Wetherill Environmental, 2002).

Nitrous oxide from wastewater

There are very large uncertainties associated with N_2O emissions from wastewater treatment and no attempt has been made to quantify this uncertainty. The IPCC default emissions factor, EF_6, has an uncertainty of – 80 per cent to + 1,200 per cent (IPCC, 1996) meaning the estimates have only order of magnitude accuracy.

8.3.4 Source-specific QA/QC and verification

No specific quality checks were carried out for this category.

8.3.5 Source-specific recalculations

The scaling factor to convert chemical oxygen demand to biological oxygen demand was changed to 2.5 (from 1.5). This change was made following the recommendation from the UNFCCC expert review team. Wastewater volume data for 1997 and 2001 were used to extrapolate the data for the entire time-series. These changes resulted in recalculations in estimates of methane emissions from domestic and commercial wastewater treatment back to 1990. Emissions from domestic and commercial wastewater treatment have changed from 4.0 Gg CH_4 to 7.1 Gg CH_4 in 1990, and 4.0 Gg CH_4 to 6.6 Gg CH_4 in 2004.

8.3.6 Source-specific planned improvements

A comprehensive database of industrial/commercial and municipal wastewater treatment plants in use in New Zealand was developed during 2006. A subsequent project to update estimates of emissions from wastewater treatment will be performed through 2007. This project will include improvements such as using year-specific average per capita protein intake data and using the same industrial activity data, such as agricultural production, as used in the inventory.

8.4 Waste incineration (CRF 6C)

8.4.1 Description

New Zealand has not estimated emissions from waste incineration as they are considered to be negligible. There is no incineration of municipal waste in New Zealand. The only incineration is for small specific waste streams including medical, quarantine and hazardous wastes. Resource consents under New Zealand's Resource Management Act control non-greenhouse gas emissions from these incinerators. As the quantity of material being disposed through these incinerators is not required to be measured under resource consents, it is not possible to estimate the quantity of greenhouse gas emissions being released.

In 2004, New Zealand introduced national environmental standards for air quality. The standards effectively require all existing low temperature waste incinerators in schools and hospitals to obtain resource consent by 2006, irrespective of existing planning rules. Incinerators without consents will be prohibited.

8.4.2 Source-specific planned improvements

During 2007, the Ministry for the Environment will be contracting a project to estimate emissions from solid waste incineration. Data will be available for the 2008 inventory submission.

CHAPTER 9: Other (UNFCCC Sector 7)

New Zealand does not report any emissions under the UNFCCC category 7, "Other".

CHAPTER 10: Recalculations and improvements

This chapter summarises the recalculations and improvements made to the New Zealand greenhouse gas inventory following submission of the 2004 inventory. It summarises material that has already been described in greater detail in Chapters 3–8.

Each year the inventory is updated (existing activity data and/or emissions factors may be revised) and extended (the inventory includes a new inventory year). The inventory may also be expanded to include emissions from additional sources if a new source has been identified within the context of the IPCC revised guidelines and Good Practice Guidance. Recalculations may also occur if activity data and emission factors have become available for sources that were previously reported as "NE" (not estimated) due to a lack of data.

Updating the New Zealand inventory involves revision of last year's activity data for the agriculture sector and LULUCF category "forest land". This is because New Zealand uses three-year averages of activity data in these sectors. The updating process replaces the provisional numbers used in last year's average with actual numbers. For example, the 2005 inventory uses an average of 2004, 2005 and 2006. The livestock statistics and forestry data for the 2004 and 2005 years are finalised data, but only provisional data are available for the 2006 year. In the 2006 inventory, the provisional 2006 figures will be replaced by finalised data released by Statistics New Zealand and the Ministry of Agriculture and Forestry.

The use of revised methodologies and activity data in any sector will result in recalculation of the whole time-series from 1990 to the current inventory. This means estimates of emissions of a given year can differ from emissions reported in the previous inventory.

10.1 Explanations and justifications for recalculations

10.1.1 Energy sector

The CO_2 emission factors for "stationary gas combustion" have been updated by the Ministry of Economic Development. In previous submissions the proportions of Maui and treated gas from the Kapuni gas field have been assumed to be 50 per cent each. The Energy Data File (MED, 2006b) reports annual production of the local gas fields for the period 1970–2005. For the 1990–2005 inventory annual production of gas fields has been used to calculate weighted average annual CO_2 emission factors.

The CH_4 emission factors for gasoline and diesel oil from "road transport" have been revised. The country-specific emission factors used in previous inventory reports could not be substantiated during the Kyoto Protocol Initial Review (19–24 February 2007) so, on advice from the UNFCCC expert review team, New Zealand has adopted the IPCC default emission factors for the 1990–2005 time-series and recalculated the data accordingly.

There were also minor recalculations of CO_2, CH_4 and N_2O emissions in several categories in the energy sector due to increased precision in data entry into the CRF Reporter and data revision by the Ministry of Economic Development.

10.1.2 Industrial processes sector

Mineral products

The cement companies submitted complete time-series of CO_2 emissions from 1990–2005 to the Ministry for the Environment in early 2007. As explained in section 4.2.5, this has resulted in CO_2 emissions attributed to the "mineral products" category being recalculated for the 1990–2005 time-series.

Chemical industry

The CO_2 emission factors for the gases used in "ammonia production" have been updated to weighted emission factors based on annual production of the gas fields. Further explanations can be found in sections 4.3.5 and 10.1.1.

Metal production

There were some minor recalculations of CO_2 emissions from the "iron and steel" category due to increased precision in data entry into the CRF Reporter.

Consumption of halocarbons and SF_6

Emissions from the mixture HFC–245fa/365mfc have been reallocated to the section called "information on additional greenhouse gases" in the CRF tables.

Potential emissions from HFCs and PFCs have been recalculated for the time-series 1990–2005. As explained in section 4.7.5, potential emissions were recalculated to improve their accuracy in the "refrigeration" subcategory.

10.1.3 Solvents and other products

No recalculations were made for this sector.

10.1.4 Agriculture sector

Each year there is a recalculation in activity data for the previous year due to the use of the three-year averaging technique. The provisional livestock population data are updated with the finalised data from Statistics New Zealand.

10.1.5 LULUCF

Each year there is a recalculation in forest planting activity data for the previous year due to the use of the three-year averaging technique.

10.1.6 Waste

Several small changes have been made to the waste sector with resulting recalculations for the 1990–2005 time-series. As explained in section 8.2.5, methane emissions from solid waste disposal have been recalculated due to changes in L_0, degradable organic carbon and MSWx values. Domestic and commercial wastewater emissions were also recalculated back to 1990 due to correction of the scaling-up factor for chemical oxygen demand to biological oxygen demand and the addition of wastewater volume data for 1997 as well as the previously used 2001 data.

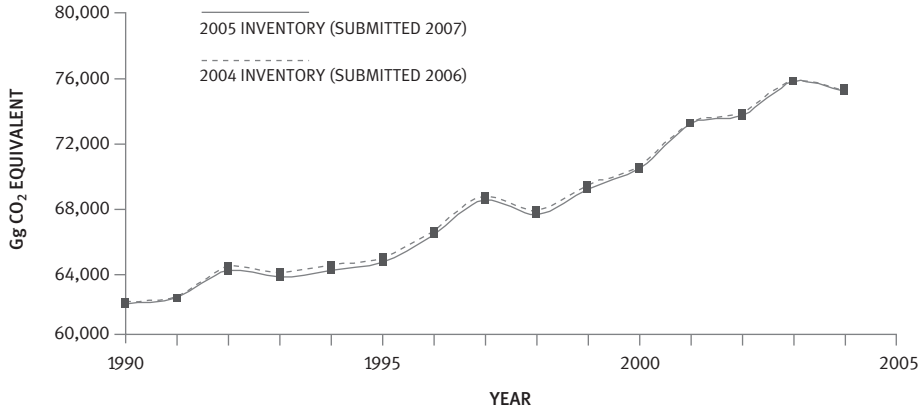
10.2 Implications for emission levels

The overall effect of all recalculations is shown in Figure 10.3.1. There is a 0.04 per cent increase in emissions for the 2004 year and a 0.01 per cent increase in emissions for the base year, 1990.

10.3 Implications for emission trends

In New Zealand's 2004 inventory, emissions were 21.3 per cent above the level reported in 1990. As a result of the recalculations, total emissions for 2004 were recalculated as being 21.4 per cent above 1990 (Figure 10.3.1). Changes in trends for individual sectors (excluding solvents) are discussed in the following sections. Solvents are not included because of the very low level of emissions throughout the time-series.

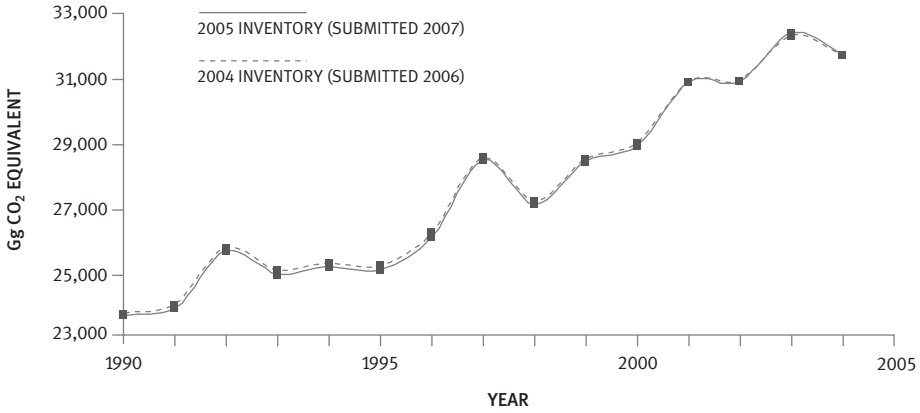
FIGURE 10.3.1
Effect of recalculation on total greenhouse gas emissions



Energy sector

The major recalculations for the energy sector were from updated CO_2 gas emission factors for stationary combustion and updated CH_4 emission factors for gasoline diesel oil in "road transportation". This increased the amount of CO_2 by 12.3 Gg CO_2-e but reduced the amount of CH_4 by 88.9 Gg CO_2-e in 1990. In 2004, the amount of CO_2 increased by 16.2 Gg CO_2-e.

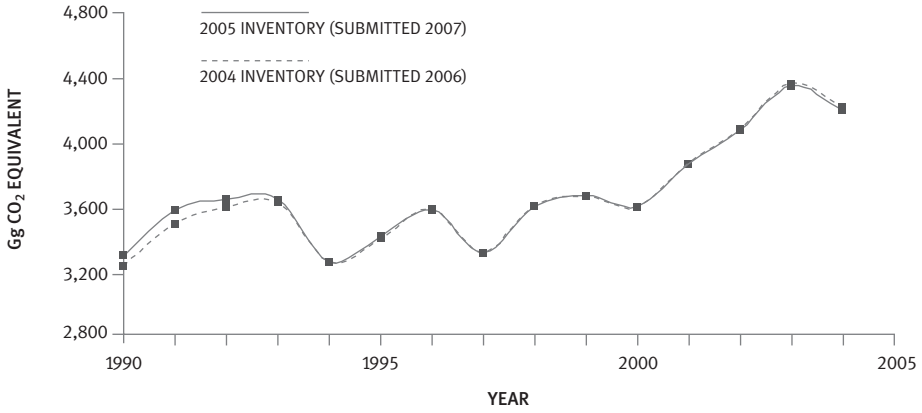
FIGURE 10.3.2
Effect of recalculation on the energy sector



Industrial processes

The major recalculation for industrial processes was from cement production. This increased the 1990 value by 75 Gg CO_2-e. In 2004, the difference was 5 Gg CO_2-e.

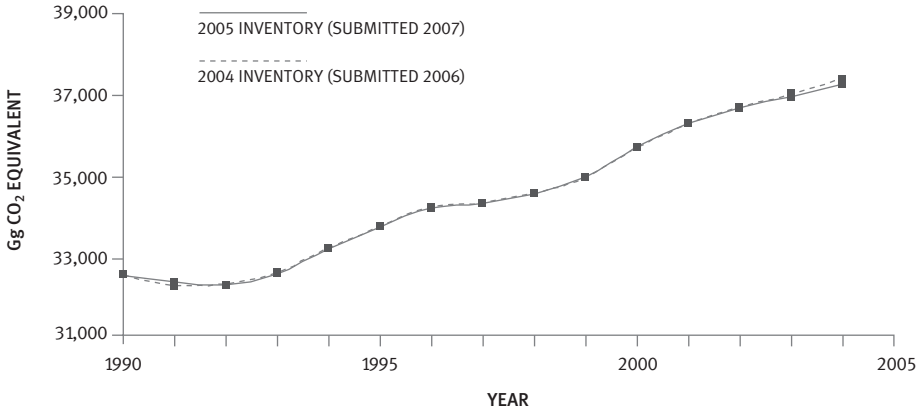
FIGURE 10.3.3
Effect of recalculation on the industrial processes sector



Agriculture

There were no major recalculations in the agriculture sector. Livestock population data for 2005 has been recalculated as explained in section 10.1.4. Some small corrections were made to some emissions estimates during quality checking of the data.

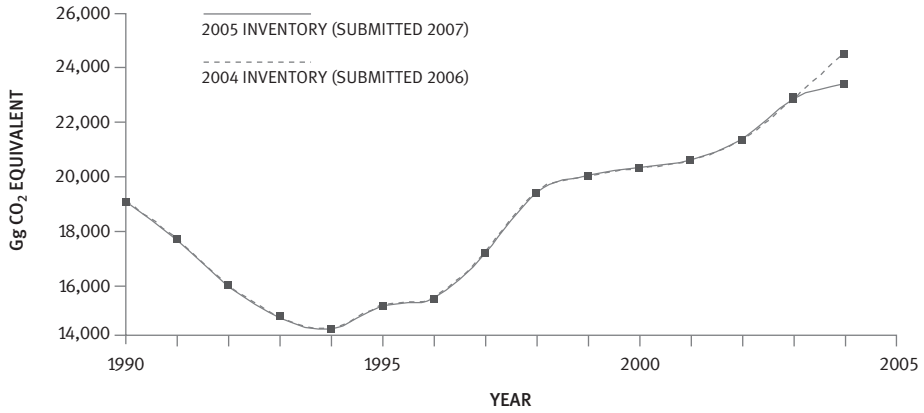
FIGURE 10.3.4
Effect of recalculation on the agriculture sector



LULUCF

Recalculations for forestry planting activity data are explained in section 10.1.5. The effect of this recalculation in 2004 was a decrease of 1,780.9 Gg CO_2-e.

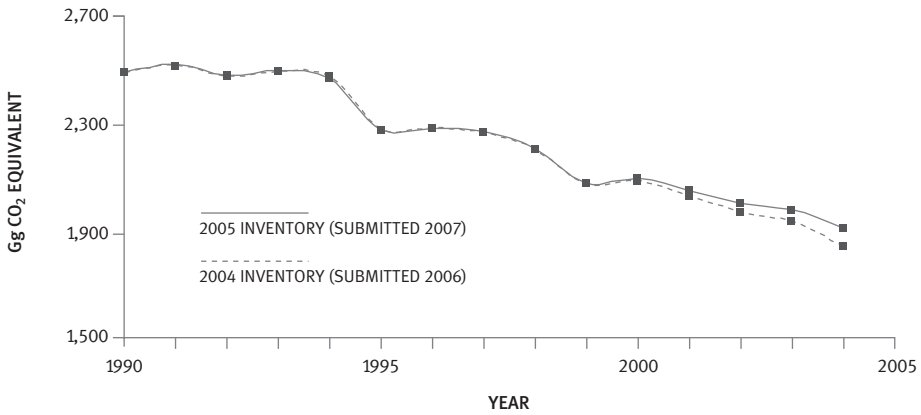
FIGURE 10.3.5
Effect of recalculation on LULUCF net removals



Waste

Methane emissions for 1990–2004 from solid waste were recalculated as a result of a number of small changes in solid waste and wastewater as explained in section 8.2.5. The results of these recalculations are shown in Figure 10.3.6. The recalculation resulted in an increase of 10.0 Gg CO_2-e in 1990 and 69.3 Gg CO_2-e in 2004.

FIGURE 10.3.6
Effect of recalculation on the waste sector



10.4 Recalculations in response to the review process and planned improvements

10.4.1 Response to the review process

The UNFCCC secretariat facilitated an in-country review of New Zealand's 2004 inventory submission as part of the Kyoto Protocol Initial Review process. This review took place in Wellington from 19–24 February 2007.

The review process is not expected to finish before July 2007 when the final review report is presented to the Kyoto Protocol Compliance Committee. New Zealand is implementing, where possible, recommendations the expert review team made on the last day of the in-country review. Allowing more time for final quality checking is one such recommendation New Zealand has started to implement with this inventory submission. Other recommendations of the review team in the finalised report will be incorporated into New Zealand's improvement plan and addressed as time and resources allow.

10.4.2 Planned improvements

Improvements to methodology/emission factors are discussed under each sector as appropriate.

Priorities for inventory development are guided by analysis of key categories (level and trend), uncertainty surrounding existing emission and removal estimates, and recommendations received from previous international reviews of New Zealand's inventory. The inventory improvement plan and the quality control and quality assurance plan are updated regularly to reflect current and future development.

10.5 Summary of recent improvements to the inventory

10.5.1 Improvements to the 2005 inventory

The focus for the 2005 inventory has been on improving the inventory national system. This has included improving quality control and assurance processes and improving the data analysis and reporting tool for the agriculture sector. Additional information was sought from various industries involved in the energy and industrial processes sectors to help improve transparency.

10.5.2 Improvements to the 2004 inventory

The focus for the 2004 inventory was on completeness, ensuring all estimates were calculated in accordance with Good Practice Guidance and increased transparency. The inclusion of data using a Tier 1 analysis for all LULUCF categories from 1990 is a significant improvement from the 2003 inventory (where data from 1997 were provided).

The other major improvements to the 2004 inventory include:

- upgrading the methodology for CH_4 from manure management to a Tier 2 approach
- changing the EF_1 emission factor for nitrous oxide emissions from direct nitrogen application to a country-specific emission factor of 1 per cent
- including estimates of CO_2 emissions from soda ash use
- including a national energy balance for 2004
- improving the coverage of data collection for halocarbons, especially HFCs from air conditioning units
- implementing a number of recommendations from the quality management review (see Annex 6). This has led to a more structured QA/QC plan and programme.

10.5.3 Improvements in the 2003 inventory

The overall focus for the 2003 inventory was an improvement in the accuracy of the inventory. This is shown in the number of recalculations that were applied across all sectors.

The major improvements to the 2003 inventory include:

- separating sectoral coal consumption into three key ranks of coal and using specific emission factors for each
- reporting emissions from a Tier 2 approach for mobile combustion from road transport. This was developed from a vehicle fleet model at the Ministry of Transport
- continuing development of the QA/QC system and extension of Tier 1 QC checks to include a selection of non-key sources and a Tier 2 QC check on the solid waste disposal key source category (refer to Annex 6)
- reporting CH_4 emissions from methanol production for the entire time-series due to activity data becoming available before 1997
- increasing explanatory text in the National Inventory Report to help understanding of the methodologies and address questions raised by UNFCCC expert review teams, especially in the energy, industrial processes and agricultural sectors
- revising the allocation of dairy excreta between lagoons and pasture
- including N_2O emissions from horse excreta
- adding emissions and removals for all LULUCF categories where activity data were available
- using the UNFCCC CRF Reporter tool to improve the quality of data entered into the common reporting format.

10.5.4 Improvements in the 2002 inventory

In the 2004 submission for the 2002 inventory, the focus was to provide a complete series of common reporting format tables for 1990–2002. Other improvements included:

- the development of a preliminary QA/QC plan and the trial of Tier 1 QC checksheets
- the trial of a Tier 3 questionnaire to calculate emissions of SF_6 from electrical equipment
- reporting N_2O use in anaesthesia for the solvent sector
- reporting CH_4 from methanol production back to 1997
- increasing explanatory text in the National Inventory Report to help understanding of the methodologies and address questions raised by the UNFCCC expert review teams, especially in the energy and industrial processes sector.

10.5.5 Improvements in the 2001 inventory

In the 2003 submission, the methodology used to estimate CH_4 emissions from ruminants was upgraded from Tier 1 to a Tier 2 approach consistent with good practice.

As part of the ongoing improvement to estimates of N_2O from agricultural sources, a complete recalculation of the time-series was carried out using revised emission factors from IPCC (2000), some revised country-specific emission factors, and new annual nitrogen excretion rates for the most significant animal classes.

10.5.6 Improvements in the 2000 inventory and prior inventories

In the 2002 submission for the year 2000, emissions from solid waste disposal were upgraded to Tier 2 and emissions from small sources previously unreported (lime and dolomite) were included. In the 2001 submission for the year 1999, estimates of emissions of the fluorinated gases (HFCs, PFCs and SF_6) were upgraded to Tier 2 methodology (IPCC, 2000).

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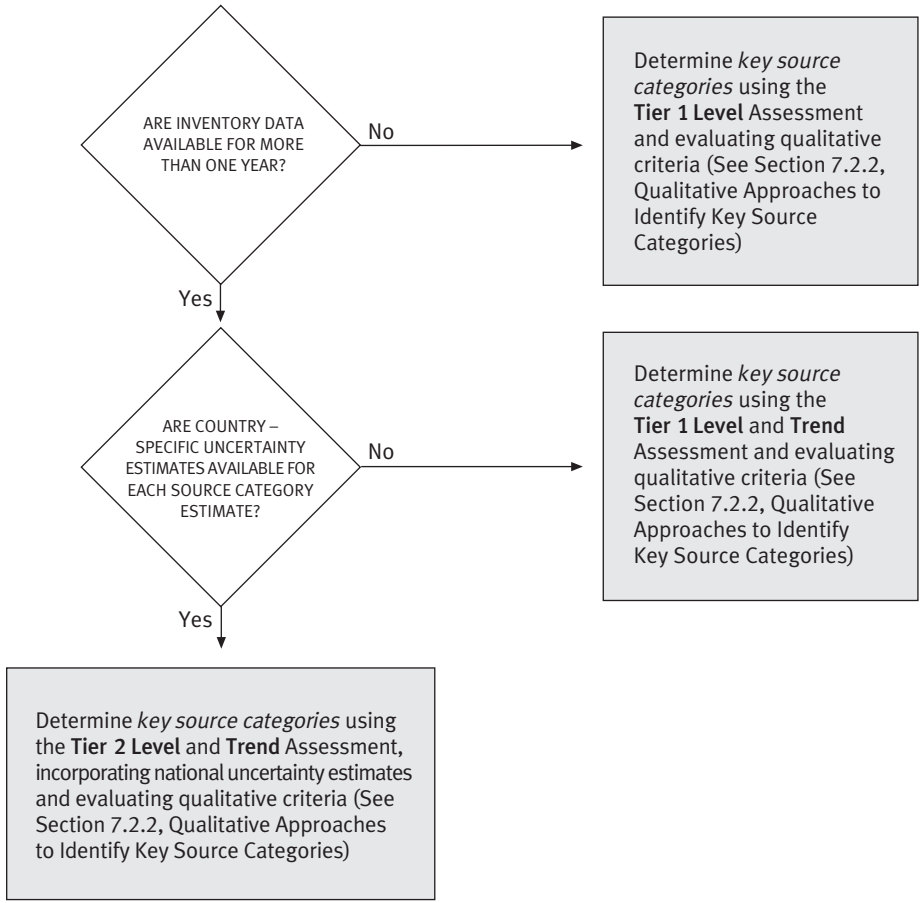
Annexes to New Zealand's National Inventory Report for 2005

ANNEX 1: Key categories

A1.1 Methodology used for identifying key categories

The key categories in the New Zealand inventory have been assessed according to the methodologies provided in Good Practice Guidance (IPCC, 2000). The methodology applied was determined using the decision tree shown in Figure A1.1.

FIGURE A1.1
Decision tree to identify key source categories (figure 7.1 from Good Practice Guidance)



For the 2005 inventory, the Tier 1 level and trend assessment were applied including the LULUCF sector and excluding the LULUCF sector (IPCC 2000, 2003). The "including LULUCF" level and trend assessments are calculated as per equations 5.4.1 and 5.4.2 of GPG-LULUCF. The "excluding LULUCF" level and trend assessments are calculated as per equations 7.1 and 7.2 of Good Practice Guidance (IPCC, 2000). Key categories are defined as those categories whose cumulative percentages, when summed in decreasing order of magnitude, contributed 95 per cent of the total level or trend.

A1.2 Disaggregation

The classification of categories follows the classification outlined in table 7.1 of Good Practice Guidance (IPCC, 2000). The category classification follows Good Practice Guidance by:

- identifying categories at the level of IPCC categories using CO_2 equivalent emissions and considering each greenhouse gas from each category separately
- aggregating categories that use the same emission factors
- including LULUCF categories at the level shown in GPG-LULUCF table 5.4.1.

There was one modification to the suggested categories to reflect New Zealand's national circumstances. The "fugitive emissions from fuels – oil and natural gas" category was divided into two categories: "fugitive emissions from oil and gas operations" and "fugitive emissions from geothermal operations". This is to reflect that New Zealand generates a significant amount of energy from geothermal sources that cannot be included as oil or gas operations.

A1.3 Tables 7.A1–7.A3 of the IPCC Good Practice Guidance

TABLE A1.1
(Table 7.A1 from Good Practice Guidance) showing results of the key category level analysis for 99 per cent of the total emissions and removals in 2005. Key categories are those that comprise 95 per cent of the total

(A) TIER 1 CATEGORY LEVEL ASSESSMENT – INCLUDING LULUCF

IPCC CATEGORIES	GAS	2005 ESTIMATE Gg	LEVEL ASSESSMENT	CUMULATIVE TOTAL
Forest land remaining forest land	CO_2	26,767.89	24.9	24.9
Emissions from enteric fermentation in domestic livestock	CH_4	23,919.80	22.2	47.1
Mobile combustion – road vehicles	CO_2	12,444.08	11.6	58.7
Emissions from stationary combustion – gas	CO_2	7,589.75	7.1	65.8
Emissions from agricultural soils – animal production	N_2O	7,559.46	7.0	72.8
Emissions from stationary combustion – solid	CO_2	6,727.23	6.3	79.1
Indirect emissions from nitrogen used in agriculture	N_2O	3,384.65	3.1	82.2
Emissions from stationary combustion – liquid	CO_2	3,128.98	2.9	85.1
Direct emissions from agricultural soils	N_2O	1,762.87	1.6	86.7
Emissions from the iron and steel industry	CO_2	1,662.00	1.5	88.3
Emissions from solid waste disposal sites	CH_4	1,460.70	1.4	89.7
Conversion to forest land	CO_2	1,254.72	1.2	90.8
Mobile combustion – aviation	CO_2	1,015.99	0.9	91.8
Emissions from substitutes for ozone depleting substances	HFCs	741.56	0.7	92.5

(A) TIER 1 CATEGORY LEVEL ASSESSMENT – INCLUDING LULUCF

IPCC CATEGORIES	GAS	2005 ESTIMATE Gg	LEVEL ASSESSMENT	CUMULATIVE TOTAL
Emissions from manure management	CH_4	739.48	0.7	93.1
Other – emissions from liming	CO_2	714.21	0.7	93.8
Conversion to grassland	CO_2	706.91	0.7	94.5
Cropland remaining cropland	CO_2	671.12	0.6	95.1
Fugitive emissions from oil and gas operations	CO_2	650.24	0.6	95.7
Emissions from cement production	CO_2	568.68	0.5	96.2
Emissions from aluminium production	CO_2	554.86	0.5	96.7
Mobile combustion – marine	CO_2	393.72	0.4	97.1
Emissions from ammonia/urea production	CO_2	346.19	0.3	97.4
Fugitive emissions from oil and gas operations	CH_4	320.85	0.3	97.7
Fugitive emissions from coal mining and handling	CH_4	305.99	0.3	98.0
Fugitive emissions from geothermal operations	CO_2	300.81	0.3	98.3
Emissions from wastewater handling	CH_4	222.87	0.2	98.5
Emissions from hydrogen production	CO_2	212.55	0.2	98.7
Emissions from wastewater handling	N_2O	163.56	0.2	98.8
Mobile combustion – rail	CO_2	150.85	0.1	99.0

TABLE A1.2
(Table 7.A1 from Good Practice Guidance) showing results of the key category level analysis for 99 per cent of the total emissions and removals in 1990. Key categories are those that comprise 95 per cent of the total

TIER 1 CATEGORY LEVEL ASSESSMENT – INCLUDING LULUCF

IPCC CATEGORIES	GAS	1990 ESTIMATE Gg	LEVEL ASSESSMENT	CUMULATIVE TOTAL
Emissions from enteric fermentation in domestic livestock	CH_4	21,806.54	25.6	25.6
Forest land remaining forest land	CO_2	20,624.90	24.2	49.8
Emissions from stationary combustion – gas	CO_2	7,691.14	9.0	58.8
Mobile combustion – road vehicles	CO_2	7,535.48	8.8	67.6
Emissions from agricultural soils – animal production	N_2O	6,856.67	8.0	75.7
Emissions from stationary combustion – solid	CO_2	3,227.01	3.8	79.5
Indirect emissions from nitrogen used in agriculture	N_2O	2,701.86	3.2	82.6
Emissions from stationary combustion – liquid	CO_2	2,546.55	3.0	85.6
Emissions from solid waste disposal sites	CH_4	2,122.92	2.5	88.1
Emissions from the iron and steel industry	CO_2	1,329.40	1.6	89.7
Conversion to forest land	CO_2	870.01	1.0	90.7
Mobile combustion – aviation	CO_2	772.83	0.9	91.6
Conversion to grassland	CO_2	706.91	0.8	92.4
Emissions from manure management	CH_4	590.47	0.7	93.1
Cropland remaining cropland	CO_2	538.67	0.6	93.8

TIER 1 CATEGORY LEVEL ASSESSMENT – INCLUDING LULUCF

IPCC CATEGORIES	GAS	1990 ESTIMATE Gg	LEVEL ASSESSMENT	CUMULATIVE TOTAL
PFC's from aluminium production	PFC	515.60	0.6	94.4
Direct emissions from agricultural soils	N_2O	475.16	0.6	94.9
Emissions from aluminium production	CO_2	457.92	0.5	95.5
Emissions from cement production	CO_2	441.67	0.5	96.0
Fugitive emissions from geothermal operations	CO_2	357.34	0.4	96.4
Other (including liming)	CO_2	346.42	0.4	96.8
Emissions from ammonia/urea production	CO_2	274.53	0.3	97.1
Fugitive emissions from coal mining and handling	CH_4	272.13	0.3	97.4
Fugitive emissions from oil and gas operations	CO_2	263.48	0.3	97.7
Fugitive emissions from oil and gas operations	CH_4	258.74	0.3	98.1
Mobile combustion – marine	CO_2	247.82	0.3	98.3
Emissions from wastewater handling	CH_4	222.93	0.3	98.6
Emissions from hydrogen production	CO_2	152.29	0.2	98.8
Emissions from wastewater handling	N_2O	146.92	0.2	99.0

TABLE A1.3
(Table 7.A2 from Good Practice Guidance) showing results of the key category trend analysis for 99 per cent of the total emissions and removals in 2005.
Key categories are those that comprise 95 per cent of the total

(A) TIER 1 CATEGORY TREND ASSESSMENT – INCLUDING LULUCF

IPCC CATEGORIES	GAS	BASE YEAR ESTIMATE Gg	2005 ESTIMATE Gg	TREND ASSESSMENT	CONTRIBUTION TO TREND	CUMULATIVE TOTAL
Emissions from enteric fermentation in domestic livestock	CH_4	21,806.54	23,919.80	0.034	17.6	17.6
Mobile combustion – road vehicles	CO_2	7,535.48	12,444.08	0.032	16.5	34.0
Emissions from stationary combustion – solid	CO_2	3,227.01	6,727.23	0.028	14.6	48.6
Emissions from stationary combustion – gas	CO_2	7,691.14	7,589.75	0.021	10.8	59.4
Emissions from solid waste disposal sites	CH_4	2,122.92	1,460.70	0.012	6.4	65.8
Direct emissions from agricultural soils	N_2O	475.16	1,762.87	0.012	6.3	72.1
Forest land remaining forest land	CO_2	20,624.90	26,767.89	0.011	5.7	77.8
Emissions from agricultural soils – animal production	N_2O	6,856.67	7,559.46	0.010	5.3	83.2
Emissions from substitutes for ozone depleting substances	HFCs	0.00	741.56	0.008	4.0	87.1
PFC's from aluminium production	PFC	515.60	80.70	0.006	3.0	90.2
Fugitive emissions from oil and gas operations	CO_2	263.48	650.24	0.003	1.7	91.9
Other – emissions from liming	CO_2	346.42	714.21	0.0029	1.52	93.4
Conversion to grassland	CO_2	706.91	706.91	0.0018	0.94	94.4
Conversion to forest land	CO_2	870.01	1,254.72	0.002	0.9	95.3
Fugitive emissions from geothermal operations	CO_2	357.34	300.81	0.002	0.8	96.1
Mobile combustion – marine	CO_2	247.82	393.72	0.001	0.5	96.5
Emissions from wastewater handling	CH_4	222.93	222.87	0.001	0.3	96.8
Mobile combustion – road vehicles	N_2O	64.41	134.94	0.001	0.3	97.1
Mobile combustion – rail	CO_2	77.50	150.85	0.001	0.3	97.4

(A) TIER 1 CATEGORY TREND ASSESSMENT – INCLUDING LULUCF						
IPCC CATEGORIES	GAS	BASE YEAR ESTIMATE Gg	2005 ESTIMATE Gg	TREND ASSESSMENT	CONTRIBUTION TO TREND	CUMULATIVE TOTAL
Mobile combustion – aviation	CO_2	772.83	1,015.99	0.001	0.3	97.7
Emissions from stationary combustion – liquid	CO_2	2,546.55	3,128.98	0.000	0.2	97.9
Mobile combustion – road vehicles	CH_4	69.00	51.76	0.000	0.2	98.1
Grassland remaining grassland	CH_4	57.36	37.82	0.000	0.2	98.3
Fugitive emissions from coal mining and handling	CH_4	272.13	305.99	0.0003	0.18	98.5
Non-CO_2 emissions from stationary combustion	N_2O	75.78	123.91	0.000	0.2	98.7
Emissions from lime production	CO_2	81.62	128.60	0.000	0.1	98.8
Conversion to settlement	CO_2	97.16	97.16	0.0002	0.13	98.9
Emissions from hydrogen production	CO_2	152.29	212.55	0.000	0.12	99.0

ANNEX 2: Methodology and data collection for estimating emissions from fossil fuel combustion

New Zealand emission factors are based on GCV (gross calorific value). Energy use in New Zealand is conventionally reported in gross terms, with some minor exceptions. The convention adopted by New Zealand to convert GCV to NCV (net calorific value) follows the Organisation for Economic Co-operation and Development (OECD) and International Energy Agency (IEA) assumptions (IEA, 2005):

- NCV = 0.95xGCV for coal and liquid fuels
- NCV = 0.90xGCV for gas.

A2.1 Emissions from liquid fuels

Activity data

Statistics New Zealand conducts the "Delivery of Petroleum Fuels by Industry Survey". This survey is run as a quarterly census. The purpose of the census is to provide data on the amount of fuel delivered by all oil companies to end-users and other distribution outlets. Each oil company in New Zealand supplies Statistics New Zealand with the volume of petroleum fuels delivered to resellers and industry groups. It is assumed there is a five per cent uncertainty associated with the sectoral energy allocation although the annual totals are likely to be more certain (MED, 2006a).

Because the "Delivery of Petroleum Fuels by Industry Survey" is run as a census there is no sampling error. The main sources of non-sample error are:

- respondent error: Statistics New Zealand makes every effort to confirm figures supplied by respondents, and given assurances of accuracy. Statistics New Zealand is bound to accept them. If a discrepancy is discovered at a later date, revised figures are supplied at the earliest possible opportunity
- processing error: there is always the possibility of error, however, Statistics New Zealand has thorough checking procedures to ensure that the risk of processing errors is minimised.

Emission factors

Carbon dioxide emission factors are described in table A2.1. The CO_2 emission factors for oil products are from the New Zealand Refining Company (NZRC) data, import data from industry and from Baines (1993[3]). The same values are used for each year of the inventory. There is a direct relationship between each fuel's carbon content and the corresponding CO_2 emissions during combustion. However, the carbon composition of oil products is not closely monitored and there will be variation over time, depending on the crude oil used in production. The New Zealand Refining Company estimates the uncertainty in emission factors to be within five per cent (MED, 2006a).

A review of New Zealand's energy emission factors (Hale and Twomey Ltd, 2003) identified a number of non-CO_2 emission factors (tables A2.2 and A2.3) where the supporting information (Bone et al, 1993; Waring et al, 1991) was assessed to be insufficient to retain the country-specific emission factors used in previous inventories. Where a country-specific value is not available, New Zealand uses either the IPCC value that best reflects New Zealand conditions or the mid-point value from the IPCC range. All emission factors from the IPCC guidelines are converted from NCV to GCV.

Following the initial review under the Kyoto Protocol in February 2007, New Zealand changed the CO_2 emission factor for gaseous fuels in "stationary combustion" and the CH_4 emission factor for gasoline and diesel oil in "road transportation". Explanations of these changes can be found in sections 3.2.1.5 and 3.2.3.5.

[3] The LPG CO_2 emissions factor was confirmed by checks of 2002 gas data.

TABLE A2.1
CO_2 emission factors used in the energy sector category

	EMISSION FACTOR (T CO_2/TJ)	EMISSION FACTOR (T C/TJ)
Gas		
Maui	51.7 (2005)	14.2 (2005)
Treated	52.3 (2005)	14.3 (2005)
Kapuni LTS	84.1	22.9
Weighted average of Maui and Kapuni treated	51.9 (2005)	14.1 (2005)
Methanol – mixed feed (1990–1994)	62.4	17.0
Methanol – LTS (1990–1994)	84.0	22.9
Kaimiro	65.2	17.8
Ngatoro	46.3	12.6
Rimu	53.7	14.6
Waihapa/Ngaere + Tariki/Ahuroa (1990)*	56.2	15.3
Waihapa/Ngaere + Tariki/Ahuroa (2002)	54.2	14.8
McKee	54.2	14.8
Mangahewa	52.3	14.3
Liquid fuels		
Regular petrol (all petrol 1990–1995)	66.2	18.1
Petrol – premium (1996 and onwards)	67.0	18.3
Diesel	69.5	19.0
Aviation fuels	68.1	18.6
Av gas	65.0	17.7
Other	72.9	19.9
Fugitive – flared	65.1	17.8
LPG	60.4	16.5
Heavy fuel oil	73.5	20.0
Light fuel oil	72.0	19.6
Averaged fuel oil	73.0	19.9
Bitumen (asphalt)	76.1	20.8
Biomass		
Biogas	101.0	27.5
Wood (industrial)	104.2	28.4
Wood (residential)	104.2	28.4
Coal		
All sectors (sub bit)	91.2	24.9
All sectors (bit)	88.8	24.2
All sectors (lignite)	95.2	26.0

* For the years 1991–2001, the emissions factors for these gas streams are interpolated between the 1990 and 2002 figures.

TABLE A2.2
CH_4 emission factors used in the energy sector category

	EMISSION FACTOR t CH_4/PJ	SOURCE
NATURAL GAS		
Electricity – boilers	2.745	IPCC Tier 2 (table 1–15) average for natural gas boilers and large gas-fired turbines >3 MW
Commercial	1.08	IPCC Tier 2 (table 1–19) natural gas boilers
Residential	0.9	IPCC Tier 2 (table 1–18) gas heaters
Domestic transport (CNG)	567	IPCC Tier 2 (table 1–43) passenger cars (uncontrolled)
Other stationary (mainly industrial)	1.26	IPCC Tier 2 (table 1–16) small natural gas boilers
LIQUID FUELS		
Stationary sources		
Electricity – residual oil	0.855	IPCC Tier 2 (table 1–15) residual oil boilers – normal firing
Electricity – distillate oil	0.855	IPCC Tier 2 (table 1–15) distillate oil boilers – normal firing
Industrial (including refining) – residual oil	2.85	IPCC Tier 2 (table 1–16) residual oil boilers
Industrial – distillate oil	0.19	IPCC Tier 2 (table 1–16) distillate oil boilers
Industrial – LPG	1.045	IPCC Tier 2 (table 1–18) propane/butane furnaces
Commercial – residual oil	1.33	IPCC Tier 2 (table 1–19) residual oil boilers
Commercial – distillate oil	0.665	IPCC Tier 2 (table 1–19) distillate oil boilers
Commercial – LPG	1.045	IPCC Tier 2 (table 1–18) propane/butane furnaces
Residential – distillate oil	0.665	IPCC Tier 2 (table 1–18) distillate oil furnaces
Residential – LPG	1.045	IPCC Tier 2 (table 1–18) propane/butane furnaces
Agriculture – stationary	3.8	IPCC Tier 2 (table 1–49) diesel engines (agriculture)
Mobile sources		
LPG	28.5	IPCC Tier 2 (table 1–44) passenger cars (uncontrolled)
Petrol – 1990 onwards	18.525	IPCC Tier 2 (table 1–27) passenger cars (uncontrolled – mid-point of average g/MJ)
Diesel – 1990 onwards	3.8	IPCC Tier 2 (table 1–32) passenger cars (uncontrolled – g/MJ)
Navigation (fuel oil and diesel)	6.65	IPCC Tier 2 (table 1–48) ocean-going ships
Aviation fuel/kerosene	1.9	IPCC Tier 2 (table 1–48) jet and turboprop aircraft
COAL		
Combustion		
Electricity generation	0.665	IPCC Tier 2 (table 1–15) pulverised bituminous combustion – dry bottom, wall fired
Cement	0.95	IPCC Tier 2 (table 1–17) cement, lime coal kilns
Lime	0.95	IPCC Tier 2 (table 1–17) cement, lime coal kilns
Industry	0.665	IPCC Tier 2 (table 1–16) dry bottom, wall fired coal boilers
Commercial	9.5	IPCC Tier 2 (table 1–19) coal boilers
Residential	285	IPCC Tier 1 (table 1–7) coal – residential
BIOMASS		
Wood stoker boilers	14.25	IPCC Tier 2 (table 1–16) wood stoker boilers
Wood – fireplaces	285	IPCC Tier 1 (table 1–7) wood – residential
Biogas	1.08	IPCC Tier 2 (table 1–19) gas boilers

TABLE A2.3
N_2O emission factors used in the energy sector category

	EMISSION FACTOR T N_2O/PJ	SOURCE
NATURAL GAS		
Electricity generation	0.09	IPCC Tier 1 (table 1–8) natural gas – all uses
Commercial	2.07	IPCC Tier 2 (table 1–19) natural gas boilers
Residential	0.09	IPCC Tier 1 (table 1–8) natural gas – all uses
Domestic transport (CNG)	0.09	IPCC Tier 1 (table 1–8) natural gas – all uses
Other stationary (mainly industrial)	0.09	IPCC Tier 1 (table 1–8) natural gas – all uses
LIQUID FUELS		
Stationary Sources		
Electricity – residual oil	0.285	IPCC Tier 2 (table 1–15) residual oil boilers – normal firing
Electricity – distillate oil	0.38	IPCC Tier 2 (table 1–15) distillate oil boilers – normal firing
Industrial (including refining) – residual oil	0.285	IPCC Tier 2 (table 1–16) residual oil boilers
Industrial – distillate oil	0.38	IPCC Tier 2 (table 1–16) distillate oil boilers
Commercial – residual oil	0.285	IPCC Tier 2 (table 1–19) residual oil boilers
Commercial – distillate oil	0.38	IPCC Tier 2 (table 1–19) distillate oil boilers
Residential (all oil)	0.19	IPCC Tier 2 (table 1–18) furnaces
LPG (all uses)	0.57	IPCC Tier 1 (table 1–8) oil – all sources except aviation
Agriculture – stationary	28.5	IPCC Tier 2 (table 1–49) diesel engines – agriculture
Mobile sources		
LPG	0.57	IPCC Tier 1 (table 1–8) oil – all sources except aviation
Petrol	1.425	IPCC Tier 2 (table 2.7 in GPG (IPCC, 2000)) US gasoline vehicles (uncontrolled)
Diesel	3.705	IPCC Tier 2 (table 2.7 in GPG (IPCC, 2000)) all US diesel vehicles
Fuel oil (ships)	1.9	IPCC Tier 2 (table 1–48) ocean going ships
Aviation fuel/kerosene	1.9	IPCC Tier 1 (table 1–8) oil – aviation
COAL		
Electricity generation	1.52	IPCC Tier 2 (table 1–15) pulverised bituminous combustion – dry bottom, wall fired
Cement	1.33	IPCC Tier 1 (table 1–8) coal – all uses
Lime	1.33	IPCC Tier 1 (table 1–8) coal – all uses
Industry	1.52	IPCC Tier 2 (table 1–16) dry bottom, wall fired coal boilers
Commercial	1.33	IPCC Tier 1 (table 1–8) coal – all uses
Residential	1.33	IPCC Tier 1 (table 1–8) coal – all uses
BIOMASS		
Wood (all uses)	3.8	IPCC Tier 1 (table 1–8) wood/wood waste – all uses
Biogas	2.07	IPCC Tier 2 (table 1–19) natural gas boilers

A2.2 Emissions from solid fuels

Activity data

The "New Zealand Coal Sales Survey" conducted by Statistics New Zealand is an ongoing quarterly survey which began on 1 March 1981. The purpose of this survey is to measure the amount of coal which is sold and available to users. The target population is all coal mines and major resellers of coal in New Zealand. Completion of the survey has been approved by the Minister of Statistics. Returning the completed and signed questionnaire is a requirement under the Statistics Act 1975.

The survey is a full coverage of the sector and therefore there are no sampling errors. Non-sampling errors in the survey data may result from errors in the sample frame (ie, units with the wrong New Zealand Standard Industrial Classification), respondent error (ie, wrong values supplied), mistakes made during processing survey results or non-response imputation. Statistics New Zealand adopts procedures to detect and minimise these potential errors.

The three ranks of coal measured are bituminous, sub-bituminous and lignite coal. From 1988 onwards, the coal sales questionnaire separated coal sales into seven end-use sectors, however these do not match the IPCC sectors. The sectoral shares of coal use that can be used for the UNFCCC inventory are based on Coal Research Limited's (CRL) survey of sectoral coal use for 1990 and 1995. Data is interpolated between 1990 and 1995 and extrapolated for all years beyond 1995. The exceptions are for the coal used for "iron and steel", "public electricity and heat production" and the "residential household" sector where the Ministry of Economic Development use data from the "New Zealand Coal Sales Survey". Sectoral shares are calculated by:

- summing the four calendar year quarters of coal sales data from the "New Zealand Coal Sales Survey"
- subtracting coal exports and coal used by the "residential" sector (from the "New Zealand Coal Sales Survey") and coal used for "iron and steel" and "public electricity and heat production" (both known accurately) dividing Coal Research Limited's annual coal tonnage for each sector by the total (excluding exports, steel, electricity and residential coal use) to give sectoral shares of coal use for 1990 and 1995
- interpolating sectoral shares between 1990 and 1995 and extrapolating for beyond 1995
- applying the sectoral share estimates to the "New Zealand Coal Sales Survey" total coal sold (excluding exports, electricity, steel and residential coal use).

The process of dividing coal use between different sectors will introduce uncertainty larger than the uncertainty in total coal sales. Uncertainty is also introduced from the assumption that coal used by sector is an average of the different ranks. These assumptions are thought to introduce an uncertainty of ± 5 per cent (MED, 2006a).

The sectoral partitioning used for coal was examined in 2003 by officials from the Ministry for the Environment. There was concern in extrapolating sectoral allocations from 1995 to 2002 given some probable changes in sectoral coal usage. However, coal industry experts (Hennessy, pers. Comm.) did not consider a survey could be justified because of the difficulty and expense in collating and verifying data from a number of sectors. Besides, the major categories of coal exports, coal used by the residential sector and coal used for steel and electricity, are all known accurately and are not affected by the sectoral partitioning.

Emission factors

The value for sub-bituminous coal (91.2 kt CO_2/PJ) is used to calculate New Zealand's emissions from coal burning (table A2.1). Using only the sub-bituminous value for all ranks of coal is a reasonable assumption for New Zealand as the bulk of the high-quality bituminous coal is exported and all coal used in public electricity generation is of sub-bituminous rank (MED, 2006a). The range in emission factors across all grades of coal is 5.5 per cent. Therefore the estimated uncertainty in coal emission factors is taken as ± 3 per cent (MED, 2006a). An uncertainty of ± 2 per cent is used for the sub-bituminous coal used in public electricity generation. All New Zealand values are within 2 per cent of the IPCC defaults (1996).
The non-CO_2 emission factors are shown in tables A2.2 and A2.3.

A2.3 Emissions from gaseous fuels

Activity data

Vector Limited has contracts with large users that allow metering errors of ± 2 per cent. Whenever the error between the meter reading and actual gas supplied exceeds 2 per cent, adjustments are made to the reported quantities of gas supplied. The uncertainty is therefore assumed to have an upper limit of ± 2 per cent (MED, 2006a).

Emission factors

The emission factors for natural gas used in distribution and sold to large users are shown in table A2.1. The values are calculated by averaging daily gas composition data supplied by industry. The composition, hence the emissions factor, varies slightly between daily measurements. Taking annual bounds, it is estimated that the uncertainty in the natural gas emission factors is less than 1.7 per cent (MED, 2006a).

As discussed in section 3.2.1.5, New Zealand now uses the information reported in the New Zealand Energy Data File (MED, 2006b) to support the calculation of the weighted average annual CO_2 emission factor for natural gas. This average emission factor is applied to a number of categories in the energy sector, such as the "manufacturing industries and construction category".

TABLE A2.4
Variation in CO_2 emission factors for natural gas

YEAR	MAUI (KT CO_2 / PJ)	TREATED (KT CO_2 / PJ)	AVERAGE (KT CO_2 / PJ)
1990	53.2	52.4	53.1
1991	52.9	52.8	52.9
1992	52.9	52.7	52.8
1993	52.6	52.5	52.6
1994	52.4	52.2	52.4
1995	52.1	52.9	52.2
1996	52.2	52.9	52.3
1997	52.3	52.4	52.1
1998	52.1	52.2	52.1
1999	51.8	52.4	51.9
2000	52.1	52.1	52.1
2001	51.9	52.6	52.0
2002	52.3	52.5	52.3
2003	52.0	52.6	52.1
2004	51.9	53.7	52.2
2005	52.0	52.6	52.1

A2.4 Energy balance for year ended December 2005

TABLE A2.5
New Zealand energy balance for year ended December 2005 (MED, 2006b)

ENERGY SUPPLY AND DEMAND BALANCE DECEMBER YEAR 2005

	CONVERTED INTO PETAJOULES USING GROSS CALORIFIC VALUES		COAL							OIL								GAS	RENEWABLES								ELECTRICITY	WASTE HEAT	TOTAL
			BITUMINOUS		SUB-BITUM.	BITUMINOUS & SUB-BITUM.	LIGNITE	PEAT/ COKE	TOTAL	CRUDES/ FEEDSTOCKS	LPG/NGL	MOTOR GASOLINE	DIESEL	FUEL OIL	AV. FUEL/ KERO	OTHERS	TOTAL	NATURAL GAS	HYDRO	GEO-THERMAL	SOLAR	WIND	BIOGAS	WOOD	TOTAL			
			COKING	OTHER																									
SUPPLY		Indigenous Production	77.07	2.915	5.59	135.57	3.98		**139.55**	38.89	8.74						**47.63**	**148.60**	84.49	80.96	0.23	2.22	1.44	42.71	**212.04**		1.13	**548.95**
	+	Imports		1.852	2.93	24.78	0.00	0.14	**24.92**	218.72	0.57	39.45	32.62	0.00	10.63	7.08	**309.07**											**333.99**
	−	Exports	73.45			73.45	0.00	0.05	**73.50**	28.11	0.65	0.57	0.15	6.75	0.00	0.00	**36.23**											**109.73**
	−	Stock Change				−6.46			**−6.46**	−5.01	0.23	1.82	−2.70	−1.73	−0.29	0.35	**−7.33**	**0.06**										**−13.72**
	−	International Transport										0.02	0.81	9.65	36.28	0.00	**46.77**											**46.77**
		TOTAL PRIMARY ENERGY	**3.61**	**4.76**	**78.52**	**93.35**	**3.98**	**0.09**	**97.42**	**234.51**	**8.43**	**37.04**	**34.35**	**−14.67**	**−25.36**	**6.73**	**281.03**	**148.54**	**84.49**	**80.96**	**0.23**	**2.22**	**1.44**	**42.71**	**212.04**		**1.13**	**740.16**
		ENERGY TRANSFORMATION				**−54.15**			**−54.15**	**−234.51**	**−0.80**	**78.25**	**73.03**	**27.14**	**40.91**	**5.29**	**−10.70**	**−83.19**	**−84.49**	**−71.28**		**−2.22**	**−1.32**	**−7.30**	**−166.61**	**135.63**	**−1.13**	**−180.15**
	of which	Electricity Generation				−53.17			**−53.17**									**−54.95**	−84.49	−64.64		−2.22	−0.99		**−152.34**	**142.73**		**−117.73**
	of which	Cogeneration				−0.88			**−0.88**									**−23.11**		−0.64			−0.33	−7.30	**−8.27**	**12.22**	−1.13	**−21.16**
		Oil Production								−234.51		77.69	74.88	25.93	40.75	13.43	**1.82**											**−1.82**
		Losses and Own Use				−0.10			**−0.10**		−0.80	0.55	−1.85	1.20	0.16	−8.14	**−8.88**	**−5.14**		−6.00					**−6.00**	**−19.32**		**−39.45**
		Non-energy Use				**−18.17**			**−18.17**							**−12.02**	**−12.02**	**−19.98**										**−50.17**
		CONSUMER ENERGY (calculated)		**4.76**	**78.52**	**21.03**	**3.98**	**0.09**	**25.10**		**7.63**	**115.29**	**107.38**	**12.47**	**15.55**	**0.00**	**258.31**	**45.36**		**9.67**	**0.23**	**0.00**	**0.12**	**35.42**	**45.44**	**135.63**	**0.00**	**509.84**
DEMAND		**Agriculture**				**1.21**	**0.013**		**1.22**			**1.15**	**10.78**	**1.09**	**0.23**		**13.25**	**1.78**								**4.86**		**21.11**
	of which	Agriculture and Hunting				1.21	0.013		**1.22**			1.12	6.82	0.01	0.22		**8.17**	**1.78**								**4.67**		**15.85**
	of which	Fishing										0.03	3.96	1.08	0.00		**5.07**									**0.18**		**5.26**
		Industrial				**11.98**	**3.51**		**15.49**		**2.71**	**0.47**	**12.03**	**0.96**	**0.20**		**16.35**	**29.51**		**5.71**				**27.27**	**32.99**	**52.09**		**146.44**
	of which	Other Primary Industry										0.01	2.87	0.25	0.01		**3.15**	**0.18**								**0.98**		**4.32**
	of which	Food Processing										0.00	0.06	0.10	0.00		**0.16**	**10.14**								**7.49**		**17.79**
		Textiles																								**0.55**		**0.55**
		Wood, Pulp, Paper and Printing																**8.18**								**12.46**		**20.64**
		Chemicals																**2.52**								**2.21**		**4.73**
		Non-metallic Minerals																**3.70**								**0.80**		**4.50**
		Basic Metals											0.00													**23.49**		**23.49**
		Mechanical/Electrical Equipment																								**1.19**		**1.19**
		Building and Construction										0.01	2.74	0.01	0.10		**2.87**	**0.08**								**0.85**		**3.80**
		Unallocated				11.98	3.51		**15.49**		2.71	0.44	6.35	0.59	0.08		**10.18**	**4.72**		5.71				27.27	**32.99**	**2.05**		**65.44**
		Commercial				**2.86**	**0.52**		**3.37**		**1.37**	**0.13**	**6.37**	**1.13**	**0.67**		**9.68**	**7.38**		**3.86**			**0.12**		**3.97**	**26.17**		**50.57**
		Residential				**0.47**	**0.41**		**0.89**		**2.25**	**0.00**	**0.00**	**0.00**	**0.00**		**2.26**	**6.49**		**0.10**	**0.23**			**8.15**	**8.48**	**46.54**		**64.65**
		Domestic Transport				**0.08**			**0.08**		**1.29**	**109.24**	**77.46**	**5.46**	**15.10**		**208.56**	**0.20**								**2.21**		**211.04**
		CONSUMER ENERGY (observed)				**16.61**	**4.45**	**0.00**	**21.06**		**7.63**	**110.99**	**106.65**	**8.64**	**16.19**	**0.00**	**250.09**	**45.36**		**9.67**	**0.23**		**0.12**	**35.42**	**45.44**	**131.86**	**0.00**	**493.80**
		Statistical Differences				4.43	−0.48	0.09	**4.04**		0.00	4.30	0.73	3.84	−0.65	0.00	**8.22**	**0.00**		0.00	0.00		0.00	0.00	**0.00**	**3.77**	0.00	**16.03**

ANNEX 3: Detailed methodological information for other sectors

A3.1 The agriculture sector

New Zealand's methodology uses a detailed livestock population characterisation and livestock productivity data to calculate feed intake for the four largest categories in the New Zealand ruminant population (dairy cattle, beef cattle, sheep and deer). The amount of CH_4 emitted is calculated using CH_4 emissions per unit of feed intake. A schematic overview of the model is presented in the agriculture sector. A full description of the data sources and assumptions used can be found in Clark et al (2003).

A3.1.1 Enteric methane emissions

Livestock populations

The New Zealand ruminant population can be separated into four main categories: dairy cattle, beef cattle, sheep and deer. For each livestock category, population models that further subdivided the principle categories were developed. The timing of births, timing of slaughter of growing animals, and the transfer of younger animals into the breeding population are reflected in these models in New Zealand farming systems.

Animal numbers are provided by Statistics New Zealand from census and survey data conducted in June each year. As shown in the agricultural worksheets in Annex 8, population numbers are reported as three-year rolling averages of the 30 June figure.

For sheep, dairy cattle, non-dairy cattle and deer the populations within a year are adjusted on a monthly basis to take account of births, deaths and transfers between age groups. This is necessary because the numbers present at one point in time may not accurately reflect the numbers present at other times of the year. For example, the majority of lambs are born and slaughtered between August and May and so do not appear in the June figures.

Emissions from goats, horses, pigs and poultry are reported but separate population models have not been developed and IPCC default emission values per head are used. For goats, a New Zealand-specific value per head based on 1990 sheep emissions, multiplied by total 30 June population numbers is used. This approach has been adopted because these species represent only a small proportion of the total animal population and data are not available to allow the development of detailed population models.

Livestock productivity data

For each livestock category, the best available data are used to compile the inventory. These data are from Statistics New Zealand and industry statistics. To ensure consistency, the same data sources are used each year. This ensures that the data provide a time-series that reflects changing farming practices, even if there is uncertainty surrounding the absolute values. A full description of the data sources and assumptions used can be found in Clark et al (2003).

Obtaining data on the productivity of ruminant livestock in New Zealand, and how it has changed over time, is a difficult task. Some of the information collected is robust ie, the slaughter weight of all livestock exported from New Zealand are collected by the Ministry of Agriculture and Forestry from all slaughter plants in New Zealand and this information is used as a surrogate for changes in animal liveweight over time. Other information, for instance liveweight of dairy cattle and liveweight of breeding bulls, is collected at irregular intervals from small survey populations, or is not available at all.

Livestock productivity and performance data are summarised in the time-series tables detailed in the worksheets in Annex 8. The data includes average liveweights, milk yields and milk composition of dairy cows, average liveweights of beef cattle (beef cows, heifers, bulls and steers), average liveweights of sheep (ewes and lambs), and average liveweights of deer (breeding and growing hinds and stags).

Dairy cattle: Data on milk production are provided by Livestock Improvement Corporation (2006) . These data include the amount of milk processed through New Zealand dairy factories plus an allowance for town milk supply. Annual milk yields per animal are obtained by dividing the total milk produced by the total number of milking dairy cows and heifers. Milk composition data are taken from the Livestock Improvement Corporation national statistics. For all years, lactation length was assumed to be 280 days.

Average liveweight data for dairy cows are obtained by taking into account the proportion of each breed in the national herd and its age structure based on data about breed and age structure from the Livestock Improvement Corporation. Dairy cow liveweights are only available from the Livestock Improvement Corporation from 1996 onwards. For earlier years in the time-series, liveweights are estimated using the trend in liveweights from 1996 to 2003 together with data on the breed composition of the national herd. Growing dairy replacements at birth are assumed to be 9 per cent of the weight of the average cow and 90 per cent of the weight of the average adult cow at calving. Growth between birth and calving (at two years of age) is divided into two periods: birth to weaning, and weaning to calving. Higher values apply between birth and weaning when animals receive milk as part of their diet. Within each period the same daily growth rate is applied for the entire length of the period.

No data are available on the liveweights and performance of breeding bulls and an assumption was made that their average weight was 500 kg and that they were growing at 0.5 kg per day. This was based on expert opinion from industry data. For example, dairy bulls range from small Jerseys through to larger-framed European beef breeds. The assumed weight of 500 kg and growth rate of 0.5 kg/day provide an average weight (at the mid-point of the year) of 592 kg. This is almost 25 per cent higher than the average weight of a breeding dairy cow but it is realistic given that some of the bulls will be of a heavier breed/strain (eg, Friesian and some beef breeds). Because these categories of animal make only small contributions to total emissions eg, breeding dairy bulls contribute 0.089 per cent of emissions from the dairy sector, total emissions are not highly sensitive to the assumed values.

Beef cattle: The principal source of information for estimating productivity was livestock slaughter statistics provided by the Ministry of Agriculture and Forestry. All growing beef animals are assumed to be slaughtered at two years of age and the average weight at slaughter for the three subcategories (heifers, steers and bulls) was estimated from the carcass weight at slaughter. Liveweights at birth are assumed to be 9 per cent of an adult cow weight for heifers and 10 per cent of the adult cow weight for steers and bulls. Growth rates of all growing animals are divided into two periods: birth to weaning, and weaning to slaughter, as higher growth rates apply before weaning when animals receive milk as part of their diet. Within each period the same daily growth rate is applied for the entire length of the period.

The carcass weights obtained from Ministry of Agriculture and Forestry slaughter statistics do not separate carcass weights of adult dairy cows and adult beef cows. Thus a number of assumptions[4] are made in order to estimate the liveweights of beef breeding cows. A total milk yield of 800 litres per breeding beef cow was assumed.

Sheep: Livestock slaughter statistics from the Ministry of Agriculture and Forestry are used to estimate the liveweight of adult sheep and lambs, assuming killing-out percentages of 43 per cent for ewes and 45 per cent for lambs. Lamb birth liveweights are assumed to be 9 per cent of the adult ewe weight with all lambs assumed to be born on 1 September. Growing breeding and non-breeding ewe hoggets are assumed to reach full adult size at the time of mating when aged 20 months. Adult wethers are assumed to be the same weight as adult breeding females. No within-year pattern of liveweight change was assumed for either adult wethers or adult ewes. All ewes rearing a lamb are assumed to have a total milk yield of 100 litres. Breeding rams are assumed to weigh 40 per cent more than adult ewes. Wool growth (greasy fleece growth) was assumed to be 5 kg/annum in mature sheep (ewes, rams and wethers) and 2.5 kg/annum in growing sheep and lambs.

[4] Number of beef breeding cows assumed to be 25 per cent of the total beef breeding cow herd; other adult cows slaughtered are assumed to be dairy cows. The carcass weight of dairy cattle slaughtered was estimated using the adult dairy cow liveweights and a killing-out percentage of 40 per cent. The total weight of dairy cattle slaughtered was calculated (carcass weight x number slaughtered) and then deducted from the national total carcass weight of slaughtered adult cows. This figure was then divided by the number of beef cows slaughtered to obtain an estimate of the carcass weight of adult beef cows; liveweights are then obtained assuming a killing-out percentage of 50 per cent.

Deer: Liveweights of growing hinds and stags are estimated from Ministry of Agriculture and Forestry slaughter statistics, assuming a killing-out percentage of 55 per cent. A fawn birthweight of 9 per cent of the adult female weight and a common birth date of mid-December are assumed. Liveweights of breeding stags and hinds are based on published data, changing the liveweights every year by the same percentage change recorded in the slaughter statistics for growing hinds and stags above the 1990 base. No within-year pattern of liveweight change was assumed. The total milk yield of lactating hinds was assumed to be 240 litres (Kay, 1995).

Goats: Enteric CH_4 from goats is not a key category. There are no published data on which to attempt a detailed categorisation of the performance characteristics as has been done for the major livestock categories. New Zealand uses a country-specific value of 9 kg CH_4/head/yr. This was calculated by assuming a default CH_4 emission value from goats for all years which is equal to the per head value of the average sheep in 1990 (ie, total sheep emissions/total sheep number). The goat value was not indexed to sheep over time because there are no data to support the kind of productivity increases that have been seen in sheep.

Horses and swine: Enteric CH_4 from these classes of livestock are not a key category and in the absence of data to develop New Zealand emission factors, IPCC default values are used.

Dry matter intake calculation

Dry matter intake (DMI) for the classes (dairy cattle, beef cattle, sheep and deer) and sub-classes of animals (breeding and growing) was estimated by calculating the energy required to meet the levels of performance assumed and dividing this by the energy concentration of the diet consumed. For dairy cattle, beef cattle and sheep, energy requirements are calculated using algorithms developed in Australia (CSIRO, 1990). These are chosen as they specifically include methods to estimate the energy requirements of grazing animals. The method estimates a maintenance requirement (a function of liveweight and the amount of energy expended on the grazing process) and a production energy requirement – influenced by the level of productivity (eg, milk yield and liveweight gain), physiological state (eg, pregnant or lactating) and the stage of maturity of the animal. All calculations are performed on a monthly basis.

For deer, an approach similar to that used for cattle was adopted using algorithms derived from New Zealand studies on red deer. The algorithms take into account animal liveweight and production requirements based on the rate of liveweight gain, sex, milk yield and physiological state.

Monthly energy concentrations

A single set of monthly energy concentrations of the diets consumed by beef cattle, dairy cattle, sheep and deer was used for all years in the time-series. This is because there are no comprehensive published data available that allow the estimation of a time-series dating back to 1990. The data used are derived from farm surveys on commercial cattle and sheep farms.

Methane emissions per unit of feed intake

There are a number of published algorithms and models[5] of ruminant digestion for estimating CH_4 emissions per unit of feed intake. The data requirements of the digestion models make them difficult to use in generalised national inventories and none of the methods have high predictive power when compared against experimental data. Additionally, the relationships in the models have been derived from animals fed indoors on diets unlike those consumed by New Zealand's grazing ruminants.

Since 1996, New Zealand scientists have been measuring CH_4 emissions from grazing cattle and sheep using the SF_6 tracer technique (Lassey et al, 1997; Ulyatt et al, 1999). New Zealand now has one of the largest data sets in the world of CH_4 emissions determined using the SF_6 technique on grazing ruminants. To obtain New Zealand-specific values, published and unpublished data on CH_4 emissions from New Zealand were collated and average values for CH_4 emissions from different categories of livestock were obtained. Sufficient data were available to obtain values for adult dairy cattle, sheep more than one year old and growing sheep (less than one year old). These data are presented in table A3.1.1 together with IPCC (2000) default values for per cent gross energy used to produce CH_4. The New Zealand values fall within the IPCC range and are adopted for use in this inventory calculation. Table A3.1.2 shows a time-series of CH_4 implied emission factors for dairy cattle, beef cattle, sheep and deer.

Not all classes of animals are covered in the New Zealand data set and assumptions had to be made for these additional classes. The adult dairy cattle value was assumed to apply to all dairy and beef cattle, irrespective of age, and the adult ewe value was applied to all sheep greater than one year old. An average of the adult cow and adult ewe value (21.25g CH_4/kg DMI) was assumed to apply to all deer. In very young animals receiving a milk diet, no CH_4 was assumed to arise from the milk proportion of the diet.

TABLE A3.1.1
Methane emissions from New Zealand measurements and IPCC defaults

	ADULT DAIRY CATTLE	ADULT SHEEP	ADULT SHEEP < 1 YEAR
New Zealand data (g CH_4/kg DMI)	21.6	20.9	16.8
New Zealand data (%GE)	6.5	6.3	5.1
IPCC (2000) defaults (%GE)	6 ± 0.5	6 ± 0.5	5 ± 0.5

[5] For example, Blaxter and Clapperton, 1995; Moe and Tyrrel, 1975; Baldwin et al, 1988; Djikstra et al, 1992; and Benchaar et al, 2001 – all cited in Clarke et al 2003.

TABLE A3.1.2
Time-series of implied emission factors for enteric fermentation (EF) (kg methane per animal per annum)

YEAR	DAIRY CATTLE	BEEF CATTLE	SHEEP	DEER
1990	70.1	51.2	9.2	19.2
1991	71.0	51.6	9.3	19.8
1992	72.5	52.6	9.4	20.3
1993	72.6	53.4	9.5	20.4
1994	72.4	53.7	9.5	20.5
1995	72.5	54.0	9.6	20.5
1996	73.5	54.2	9.8	20.8
1997	74.0	54.9	10.1	21.0
1998	74.6	54.8	10.2	21.3
1999	75.4	55.2	10.4	21.7
2000	76.9	55.9	10.5	21.9
2001	77.2	56.6	10.7	22.0
2002	78.1	56.4	10.7	22.0
2003	78.3	56.4	10.8	21.9
2004	79.2	56.8	10.9	22.0
2005	78.7	57.5	11.0	22.4
Previous fixed EF	76.8	67.5	15.1	30.6

A.3.1.2 Manure management emissions

Methane emissions from ruminant animal wastes in New Zealand were recalculated using an IPCC Tier 2 approach for the 2004 inventory. This Tier 2 approach is also used for the 2005 inventory and will be used in future inventory submissions. This replaces the Tier 1 approach used in previous national inventory submissions. The methodology adopted is based on the methods recommended by Saggar et al (2003) in a review commissioned by the Ministry of Agriculture and Forestry.

The general approach relies on (1) an estimation of the total quantity of faecal material produced; (2) the partitioning of this faecal material between that deposited directly onto pastures and that stored in anaerobic lagoons; and (3) the development of specific New Zealand emission factors for the quantity of methane produced per unit of faecal dry matter deposited directly onto pastures and that stored in anaerobic lagoons.

Dairy cattle

Faecal material deposited directly onto pastures

The quantity of faecal dry matter produced is obtained by multiplying the quantity of feed eaten by the dry matter digestibility of the feed, minus the feed retained in product. These feed intake estimates and dry matter digestibilities are those used in the current enteric methane and nitrous oxide inventories. In line with the current nitrous oxide inventory, 95 per cent of faecal material arising from dairy cows is assumed to be deposited directly onto pastures (Ledgard and Brier, 2004). The quantity of methane produced per unit of faecal dry matter is 0.98 g CH_4/kg. This value is obtained from New Zealand studies on dairy cows (Saggar et al 2003; Sherlock et al 2003).

Faecal material stored in anaerobic lagoons

In line with the current nitrous oxide inventory, 5 per cent of faecal (dung and urine) material arising from dairy cows is assumed to be stored in anaerobic lagoons. The method adopted here is to assume that all faeces deposited in lagoons are diluted with 90 litres of water per kilogram of dung dry matter (Heatley, 2001). This gives a total volume of effluent stored. Annual CH_4 emissions are estimated using the data of McGrath and Mason (2002) on the average depth of an anaerobic lagoon (4.6 m), which is used to calculate the surface area of anaerobic lagoons, and an average emission of 3.27 kg CH_4/m^2/year of surface area.

Beef cattle

Faecal material deposited directly onto pastures

The quantity of faecal dry matter produced is obtained by multiplying the quantity of feed eaten by the dry matter digestibility of the feed, minus the feed retained in product. These feed intake estimates and dry matter digestibilities are those used in the current enteric methane and nitrous oxide inventories. Beef cattle are not housed in New Zealand and all faecal material is deposited directly onto pastures. No specific studies have been conducted in New Zealand on CH_4 emissions from beef cattle faeces and values obtained from dairy cattle studies (0.98 g CH_4/kg) are used (Saggar et al, 2003; Sherlock et al, 2003).

Faecal material stored in anaerobic lagoons

Beef cattle are not housed in New Zealand and all faecal material is deposited directly onto pastures.

Sheep

Faecal material deposited directly onto pastures

The quantity of faecal dry matter produced is obtained by multiplying the quantity of feed eaten by the dry matter digestibility of the feed, minus the feed retained in product. These feed intake estimates and dry matter digestibilities are those used in the current enteric methane and nitrous oxide inventories. Sheep are not housed in New Zealand and all faecal material is deposited directly onto pastures. The quantity of methane produced per unit of faecal dry matter is 0.69g CH_4/kg. This value is obtained from New Zealand studies on sheep (Carran et al, 2003).

Faecal material stored in anaerobic lagoons

Sheep are not housed in New Zealand and all faecal material is deposited directly onto pastures.

Deer

Faecal material deposited directly onto pastures

The quantity of faecal dry matter produced is obtained by multiplying the quantity of feed eaten by the dry matter digestibility of the feed, minus the feed retained in product. These feed intake estimates and dry matter digestibilities are those used in the current enteric methane and nitrous oxide inventories. Deer are not housed in New Zealand and all faecal material is deposited directly onto pastures. There are no New Zealand studies on methane emissions from deer manure and values obtained from sheep and cattle are used. The quantity of methane produced per unit of faecal dry matter is assumed to be 0.92 g CH_4/kg. This value is the average value obtained from all New Zealand studies on sheep (Carran et al, 2003) and dairy cattle (Saggar et al, 2003; Sherlock et al, 2003).

Faecal material stored in anaerobic lagoons

Deer are not housed in New Zealand and all faecal material is deposited directly onto pastures.

A3.1.3 Uncertainty of animal population data

TABLE A3.1.3
Provisional sampling error and imputation levels for the 2003 Agricultural Production Survey

STATISTIC	SAMPLE ERRORS AT 95% CONFIDENCE INTERVAL (%)	PERCENTAGE OF TOTAL ESTIMATE IMPUTED
Ewe hoggets put to ram	4	12
Breeding ewes 2 tooth and over	2	12
Total number of sheep	2	11
Total lambs marked or tailed	2	11
Beef cows and heifers (in calf) 2 years and over	2	12
Beef cows and heifers (in calf) 1–2 years	5	11
Total number of beef cattle	2	12
Calves born alive to beef heifers/cows	3	12
Dairy cows and heifers, in milk or calf	2	14
Total number of dairy cattle	2	14
Calves born alive to dairy heifers/cows	3	13
Female deer mated	4	9
Total number of deer	4	9
Fawns or calves weaned on the farm	4	9
Area of potatoes harvested	1	12
Area of wheat harvested	4	11
Area of barley harvested	4	13

Details of the most recent surveys and census are included to provide an understanding of the livestock statistics process and uncertainty figures. The information documented is from Statistics New Zealand. Full details of the surveys are available from Statistics New Zealand's website **www.stats.govt.nz/datasets/primary-production/agriculture-production.htm**

Agricultural Production Surveys

The target population for the Agricultural Production Surveys is all businesses engaged in agricultural production activity (including livestock, cropping, horticulture and forestry) with the intention of selling that production and/or which owned land that was intended for agricultural activity during the year ended 30 June. The estimated proportion of eligible businesses responding to the Agricultural Production Survey is 80 to 85 per cent. Table A3.1.3 gives the sample errors based on a 95 per cent confidence level for the survey data collected in 2003.

TABLE A3.1.4
Agricultural sector sample errors based on 95 per cent confidence level

VARIABLE (TOTAL POPULATION)	SURVEY DESIGN ERROR (%)	ACHIEVED SAMPLE ERROR (%)
Dairy cattle	1	1.0
Beef cattle	1	0.9
Sheep	1	0.7
Goats	1	1.5
Deer	1	1.4
Pigs	1	0.9

2002 Agricultural Production Census

The target population for the 2002 Agricultural Production Census was all units that were engaged in agricultural production activity (including livestock, cropping, horticulture and forestry) with the intention of selling that production and/or which owned land that was intended for agricultural activity during the year ended 30 June 2002. The target population also includes businesses and persons commonly referred to as "lifestylers" engaged in agricultural production activity. The response rate was 81 per cent. Statistics New Zealand imputes using a random "hot deck" procedure for values for farmers and growers who did not return a completed questionnaire.

The 1999 livestock survey

The frame for the 1999 Agricultural Production Survey was based on a national database of farms called AgriBase which is maintained by AgriQuality New Zealand Ltd (formerly Ministry of Agriculture and Forestry Quality Management). A sample survey was conducted to obtain estimates of livestock on farms and area sown in grain and arable crops for the 30 June 1999 year. Questionnaires were sent to approximately 35,000 farms. The overall response rate for the survey was 85.7 per cent. The remaining units were given imputed values based on either previous data or on the mean value of similar farms.

A3.2 Additional information for the LULUCF sector: the Land Use and Carbon Analysis System (LUCAS)

Background

The aim of the Land Use and Carbon Analysis System (LUCAS) project is to develop a robust and comprehensive reporting and analysis system which is consistent with Good Practice Guidance (GPG) and designed to:

- be appropriate for UNFCCC LULUCF sector reporting
- enable reporting under Article 3.3 of the Kyoto Protocol in the first commitment period
- support and underpin New Zealand climate change policy development through to 2012 and beyond.

Methods

A major component of the LUCAS is the development of a database to store and manipulate all data used to calculate carbon stock changes in the LULUCF sector. The database will achieve the following objectives:

- establish an infrastructure to manage all data types
- develop data manipulation and analysis procedures
- provide consistent and controlled storage and manipulation of all point and spatial data.

The methodology is further separated into three components: forest related, soil related, and land-use mapping. Techniques are being developed to up-scale collected forest, soil and land-use data to derive carbon stock values.

"Forest land remaining as forest land" is an important sink category for New Zealand. A planted forest carbon inventory and country-specific parameters are being developed for New Zealand to increase the accuracy of reported values. Carbon stocks for the biomass carbon pools will then be modelled from these established values and separated into their individual pools using the C_change carbon allocation model.

Natural forests

The LUCAS system will establish the change in carbon stocks in New Zealand's natural forests. Forest trees and shrubs are measured within plots established in both indigenous forest and scrubland. These form "Carbon Monitoring System" (CMS) plots. Collection of these plot data began in summer 2002. Following collection and analysis of the plot data, additional analysis will be undertaken to improve allometric equations and wood density models used to calculate biomass. Results will be reported for each of the four non-soil carbon pools and the measurement process may be repeated at a later stage.

Planted forests

Planted forests can contain either native or exotic species, or both. Most – around 90 per cent – of the planted forests in New Zealand are exotic. If planted on non-forest land since 1990, they are classified by New Zealand as "Kyoto forests".

Kyoto forests

Change in carbon stocks in New Zealand's planted Kyoto forests is to be achieved by measurement of trees within plots to be established. For the carbon inventory of these forests airborne LiDAR (Light Detecting and Ranging) will be used. LiDAR can provide a three-dimensional map of forest plots. This map can then be used to provide inputs to proven models used by the forestry industry to calculate carbon volumes. The results of LiDAR imaging will be calibrated against some "on the ground" plot measurements. The C_change model will be used to distribute the total carbon amount into the four non-soil carbon pools required for reporting purposes. The measurement process will be repeated at the end of the first commitment period, based on the same set of plots.

Non-Kyoto forests

The LUCAS system will establish the change in carbon stocks in New Zealand's planted non-Kyoto forests (where the trees were planted before 1990). Trees are measured within plots to be established, with results reported per plot for each of the four non-soil carbon pools. It is anticipated that only one plot measurement will be made, with reliance on modelling to extend results to other years in the commitment period.

Soils

Soil carbon changes very slowly in response to land-use changes. The New Zealand-specific soil carbon model will be used within LUCAS. Soil data for the model have been collected to a depth of 30 cm and allow estimates of soil carbon for different soil types, climate and land-cover/land-use variables in New Zealand. The soils data will be analysed to identify gaps in its coverage across the country. Where significant gaps exist in important land-use areas, further samples and analysis will be performed.

Mapping

The LUCAS system has been designed to achieve the following land-use mapping objectives:

- determining changes in land use since 1990 by providing a New Zealand-wide electronic map of land use at 1990 and at 2008
- providing a New Zealand-wide electronic map of land use at 2012 to identify national changes in land use since 2008
- mapping the land-use categories forest land, cropland, grassland, wetlands, settlements and other land.

For 1990, Landsat satellite imagery provides almost complete coverage of New Zealand's land area. Capture of national data for 2008, via SPOT satellite imagery has begun.

Work in each of the three components (forest, soil and land-use mapping) has begun, and is due for completion by December 2012. The forest and soil work began in the mid-1990s and the mapping work in 2004. The results of investigations and method development for each of the components will be peer-reviewed to provide transparency and to ensure that the LUCAS is widely understood.

Statistical design and uncertainty

Statistical methods and assumptions are being used by New Zealand in developing and implementing data collection systems in the LUCAS. These methods and assumptions are being independently reviewed to ensure they are consistent with best practice in statistical design. Opportunities are also sought for ongoing improvement of data collection systems, while considering the cost-effectiveness of alternatives.

Uncertainty in estimated carbon values will be determined as data collection, land-use mapping and analysis techniques are developed. Once the design of the overall data collection and mapping system has been determined, a sensitivity and uncertainty analysis of the whole system will be completed. This analysis should identify where uncertainties occur, their size and influence on the national carbon estimate for each carbon pool, and the cost to reduce these uncertainties.

A3.3 Additional methodology for the LULUCF sector: the Land-cover Databases

Mapping process

The land-cover classes used for the Land-cover Databases 1 and 2 (LCDB1 and 2) are hierarchical. The first order classes are based on the physiognomy of the land cover (ie, grassland, shrubland, forest), with following divisions based on other characteristics such as phenology (evergreen/deciduous) and floristic composition (broadleaved/needle leaved). A 1-ha minimum mapping unit (MMU) was used for both Land-cover Databases.

LCDB2 was developed from image processing supplemented by ancillary data such as vegetation surveys, plot data and aerial photography. The database was also subjected to intensive field checking to:

- determine whether the land-cover types identified in the draft vectors are present on the ground
- determine whether land-cover types observed on the ground are captured and correctly labelled in the draft map
- identify land-cover classes with unknown or questionable spectral signatures

- identify characteristic signatures of the target land-cover classes to be used to train the classification in areas that cannot be field checked. Extrapolation of ground data was restricted to one New Zealand 260 map sheet (30 km x 40 km), as the spectral signatures of target classes can vary across a Landsat 7 ETM+ scene (185 km wide).

In assigning land cover to a specific class, the dominant cover rule was used. For example, a shrubland polygon with three or more main species (where further subdivision of the patch based on the 1-ha minimum mapping unit is not possible), is classified according to the dominant species in the matrix. This procedure was maintained throughout the LCDB2 mapping project.

Accuracy

For LCDB1, overall classification accuracy was assessed at 93.9 per cent. Accuracy has not been established for LCDB2, but class accuracies were assessed as: bare ground (81 per cent), natural forest (95 per cent), mangrove (97 per cent), planted forest (90 per cent), horticultural (95 per cent), pastoral (98 per cent), scrubland (89 per cent), tussock (95 per cent), and wetlands (87 per cent).

TABLE A3.3.1
Mapping of LCDB classification to the IPCC land-use categories

IPCC CATEGORY	LCDB CLASS
Cropland	
CM (perennial)	Orchard and other perennial crops, vineyard
CM (annual)	Short-rotation cropland
Forest land	
FM (planted)	Afforestation (imaged, post LCDB1), afforestation (not imaged), deciduous hardwoods, forest harvested, other exotic forest, pine forest – closed canopy, pine forest – open canopy
FM (natural)	Natural forest, broadleaved natural hardwoods, manuka and/or kanuka
Grassland	
GM (low prod)	Alpine grass/herbfield, depleted tussock grassland, fernland, gorse and broom, grey scrub, low producing grassland, major shelterbelts, matagouri, mixed exotic shrubland, subalpine shrubland, tall tussock grassland, flaxland, herbaceous freshwater vegetation, herbaceous saline vegetation, mangrove
GM (high prod)	High-producing exotic grassland
Other land	
O	Alpine, gravel and rock, coastal sand, gravel landslide, permanent snow and ice, river and lakeshore gravel and rock
Settlements	
S	Built-up area, dump, surface mine, transport infrastructure, urban parkland/open space
Wetlands	
W (unmanaged)	Estuarine open water, lake and pond, river

ANNEX 4: CO_2 reference approach and comparison with sectoral approach and relevant information on the national energy balance

Information on the CO_2 reference approach and a comparison with sectoral approach is provided in section 3.4.1. The section also includes a comparison with the International Energy Agency reference and sectoral approach for New Zealand.

ANNEX 5: Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded

An assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded is included in section 1.8.

ANNEX 6: Quality assurance and quality control

During preparation of the 2005 inventory, work continued on the implementation of the "New Zealand National Greenhouse Gas Inventory Quality Control and Quality Assurance Plan". Specific checks have been completed as time and resources have allowed.

A6.1 QC procedures implemented in preparation of the 2005 inventory

Tier 1 quality control (QC) checks for key sources (as identified in the level and trend analysis of the 2004 inventory) and a selection of non-key sources were completed on the 2005 data. One of the checklists is included as an example in this Annex (A.6.5). The checks incorporated in the CRF Reporter (time-series consistency, recalculation and completeness checks) were undertaken to identify any outliers and inconsistencies in the trends from 1990 to 2005. Additional cross-inventory checks between the CRF tables and the National Inventory Report for all sectors were incorporated into this inventory submission.

Some specific findings of the 2005 quality control process included:

- finding and correcting small transcription errors in the agricultural data. These corrections were made during some intensive checking of the sector following the implementation of new data analysis spreadsheets
- correcting small transcription errors in the waste data spreadsheets
- adding explanations in the industrial process sector in the common reporting format after a small number were found to be missing.

A6.2 QA procedures implemented

A checklist of recent reviews of specific sectors (including emission factors) undertaken as part of the quality assurance of the New Zealand national inventory is included in this Annex (A.6.6).

In 2006, a quality assurance review of the energy sector was undertaken by an independent consultant. The objective of the review was to ensure the energy sector of the greenhouse gas inventory has assumptions, methods and resulting estimates that are reasonable and an accurate reflection of New Zealand's energy emissions. Recommendations resulting from this review include developing a top-down energy inventory for verification purposes and having an audit of the energy data file report.

A6.3 Methods of QA/QC used by external agencies

To minimise error, all questionnaires at Statistics New Zealand are carefully designed and tested to make them easy for respondents to understand and complete correctly. During the processing of statistics, checks are carried out to ensure the data appears consistent. Checks are also undertaken to ensure responses have been recorded correctly.

Statistics New Zealand aims to ensure all farms and forests are represented in the agriculture surveys. The survey frame is updated with feedback from survey/census respondents. Statistics New Zealand provides an enquiry service for respondents who need help completing questionnaires and they follow up respondents to ensure high response rates are achieved. Statistical methodology (sample design, estimation techniques) follows international best practice. Data editing and consistency checks are carried out on all data.

A6.4 Future development of the QA/QC system

New Zealand will continue to develop the QA/QC system during 2007. This includes:

- redesigning the inventory compilation schedule to allow more time for individual sector and cross-inventory quality checks
- documenting a plan for Tier 2 quality checks
- investigating methods for performing verification of emissions data.

TIER 1 QC ACTIVITY & PROCEDURES						
QC ACTIVITY	**PROCEDURES**	**PROCEDURES ADOPTED FOR 2007 NIR (2005 DATA)**	**ORGANISATION/ PERSON RESPONSIBLE FOR QUALITY CHECK**	**BRIEF DESCRIPTION OF CHECK APPLIED (INCLUDE DATE/PERSON & REFERENCE IF REQUIRED)**	**RESULTS OF CHECK (INCLUDE REFERENCE IF REQUIRED)**	**CORRECTIVE ACTIONS TAKEN**
DATA GATHERING, INPUT, AND HANDLING ACTIVITIES: QUALITY CHECKS						
Check for transcription errors in data input and reference.	Cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors.	1. Cross-check activity data from NIR worksheets with that in the CRF for transcription errors. 2. Check activity data (population) with model output sheets.	MfE-SP	S.Petrie (27/4/07): 1. Compared EF emissions in NIR table builder with CRF for dairy, non-dairy, sheep, deer for 1990 and 2005. 2. Compared population data for dairy, non-dairy, sheep and deer between model output sheets, NIR table builder and CRF for 1990 and 2005.	1. The same 2. Dairy, non-dairy and sheep all the same. Difference found for deer in 2005: NIR and CRF the same (1,686,529) but model spreadsheet has 1,722,363.	1. None 2. Followed up with SW – value should have been 1,722,363 (as in model spreadsheet). Fixed in CFR.
DATA DOCUMENTATION: QUALITY CHECKS						
Check that assumptions and criteria for the selection of activity data and emission factors are documented.	Check descriptions of activity data and emission factors and ensure these are properly recorded and archived.	1. Check activity data and emission factors are described in the NIR report and any changes from previous years are adequately documented.	MfE-CC and LB	See results from CRF and NIR checksheets (doc IDs: 275741 and 275543).	N/A	N/A
Check for transcription errors in data input and reference.	Confirm that bibliographical data references are properly cited in the internal documentation.	Check all references cited in the appropriate source sector chapter in the NIR report and make sure they are correctly referenced at the end of the chapter.	MfE-SP and KL	See results from CRF and NIR checksheets (doc IDs: 275741 and 275543).	N/A	N/A
Undertake review of internal documentation.	Check there is detailed internal documentation to support the estimates and enable duplication of the emission and uncertainty estimates.	Review internal documentation – ensure there is adequate documentation to support the emissions estimates and uncertainty analysis.	MfE-SP	AgResearch-HC and CdK: reviewed agriculture chapter to ensure enough detail in NIR to explain emissions calculations.	OK	None
	Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review.	1. Check to ensure copies of reports of sector reviews and methodologies are archived. 2. Check inventory data is archived in S1.	MfE-SP	S.Petrie (27/4/07): 1. All supporting references are in the Silent One documentation system or in Sonia's tambour. 2. Inventory spreadsheets and supporting data is archieved in Silent One (doc ID:273954).	OK	None
CALCULATING EMISSIONS AND CHECKING CALCULATIONS						
Check that emissions are calculated correctly.	Reproduce a representative sample of emissions calculations.	Using the figures in the NIR worksheets, calculate emissions manually and compare to emissions figure from the CRF Reporter.	N/A	N/A	N/A	N/A
	Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.	Use Tier 1 approach to calculate a sub source of data (eg, CH_4 emissions from dairy cattle) to judge relative accuracy.	MfE-SP	S.Petrie (27/4/07): using IPCC default EF for oceania for dairy calculated dairy emissions for 2005.	T1 calculation was 350Gg compared with T2 calculation of 405 Gg. Relative accuracy OK.	None

TIER 1 QC ACTIVITY & PROCEDURES						
QC ACTIVITY	**PROCEDURES**	**PROCEDURES ADOPTED FOR 2007 NIR (2005 DATA)**	**ORGANISATION/ PERSON RESPONSIBLE FOR QUALITY CHECK**	**BRIEF DESCRIPTION OF CHECK APPLIED (INCLUDE DATE/PERSON & REFERENCE IF REQUIRED)**	**RESULTS OF CHECK (INCLUDE REFERENCE IF REQUIRED)**	**CORRECTIVE ACTIONS TAKEN**
CALCULATING EMISSIONS AND CHECKING CALCULATIONS						
Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used.	Check that units are properly labelled in calculation sheets.	Check the units are correctly labelled in the NIR worksheets.	MfE-SP	S.Petrie (27/4/07): check units used in consolidate page and ag data page on NIR ag builder.	all units OK	None
	Check that units are correctly carried through from beginning to end of calculations.	Check correct units are used in calculations.	MfE-SP	S.Petrie (27/4/07): sub sample checked (dairy-enteric fermentation).	correct SI units used consistently	None
	Check that conversion factors are correct.	Check that the correct conversion factors have been used to calculate the emissions in the NIR worksheets – particularly conversion from tonnes to Gg and from C to CH_4.	MfE-SP	S.Petrie (27/4/07): sub sample checked (dairy-enteric fermentation).	conversion of units correct (t to Gg)	None
Check the integrity of database and/or spreadsheet files.	Ensure that data fields are properly labelled and have the correct design specifications.	1. Check labels on NIR worksheets are consistent with previous year's NIR. 2. Ensure the addition or deletion of data lines are adequately explained.	MfE-SP	S.Petrie (27/4/07): check redesigned spreadsheets have consistent headings.	headings (years, category headings) are consistent	None
	Ensure that adequate documentation of database and model structure and operation are archived.	Ensure adequate documentation of spreadsheet structure and how the emissions are calculated.	MfE-SP	S.Petrie (27/4/07): check spreadsheets well laid out and easy to follow and documentation on how estimates are arrived at is archived.	spreadsheet easy to follow and calculation explanations in doc: 143440	None
Check for consistency in data between source categories.	Identify parameters (eg, activity data, constants) that are common to multiple source categories and confirm that there is consistency in the values used for these parameters in the emissions calculations.	Check for consistency in livestock number dataset.	MfE-SP	S.Petrie (27/4/07): visual check of time series of population for 4 main livestock categories.	OK	None
Check that the movement of inventory data among processing steps is correct.	Check that emissions data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries.	1. Manually sum CH_4 emissions from dairy cattle and non dairy cattle sources for enteric fermentation and compare with values in cattle node in CRF Reporter.	MfE-SP	S.Petrie (27/4/07): sum dairy cattle and non-dairy cattle EF emissions and compare with summary node in CRF.	result of 660.27 Gg for both – OK	None
	Check that qualifications, assumptions and expert judgements are recorded. Check that calculated uncertainties are complete and calculated correctly.	Check there is a documentation record of assumptions and expert judgements for uncertainty estimates.	MfE-SP	S.Petrie (27/4/07): check 1S has ag uncertainty docs archived.	files archived	None
Check methodological and data changes resulting in recalculations.	Check for temporal consistency in time-series input data for each source category.	Visual check of overall ag emissions in CRF Reporter.	MfE-SP	S.Petrie (27/4/07): visual check of ag emissions consistency over time-series.	visual check OK	None
	Check for consistency in the algorithm/ method used for calculations throughout the time-series.	Confirm the method used for estimating CH_4 from enteric fermentation is consistent throughout the time-series.	MfE-SP	S.Petrie (27/4/07): check model spreadsheet uses consistent method for all years.	consistent method used	None
	Check that known data gaps that result in incomplete source category emissions estimates are documented.	CRF – completeness check.	MfE-SP	S.Petrie (27/4/07): run CRF Reporter.	all complete for agriculture	None
Compare estimates to previous estimates.	For each source category, current inventory estimates should be compared to previous estimates. If there are significant changes or departures from expected trends, recheck estimates and explain any difference.	Check 2004 value in CRF Reporter – if figures in black are consistent with previous estimates; if in blue ensure recalculation has been explained.	MfE-SP	S.Petrie (27/4/07): check for recalculations in CRF Reporter.	revised activity data for 2004 (explanation included)	None

A6.6 QA summary worksheet

QUALITY ASSURANCE CHECKLIST INCLUDES ALL REVIEWS UP TO AND INCLUDING THE 2005 INVENTORY REPORT:

QA ACTIVITY & PROCEDURES

QA ACTIVITY	DESCRIPTION OF QA PROCEDURE	DATE OF REVIEW	REVIEWER	EXPERT QUALIFICATIONS ASSESSED	BRIEF DESCRIPTION OF REVIEW SCOPE (INCLUDE A REFERENCE TO THE REVIEW CONTRACT)	MAJOR CONCLUSIONS FROM THE REVIEW (INCLUDE A REFERENCE TO THE REVIEW)	ACTION TAKEN	PLACE WHERE IT IS FILED
Expert review of Energy Sector	QA review by S. Goldthorpe on the energy sector (concentrating on activity data).	Nov 06	S. Goldthorpe	Suitability assessed by MED officials.	The objective of the quality assurance review is to ensure the energy section of NZ's greenhouse gas (GHG) inventory has assumptions, methods and resulting estimates that are reasonable and an accurate reflection of NZ's energy emissions. The scope of the review is to consider the completeness, accuracy, transparency and consistency of the energy section of the GHG inventory focusing on activity data.	For 2005 inventory (submitted 2007): 1. The fugitive CO_2 emissions time series is revised to account fully for the CO_2 associated with Kapuni LTS gas. 2. The historical CO_2 inventory number for 2003 is adjusted to account fully for CO_2 from imported coal for power generation. 3. Material discrepancies between the DPFI data for liquid fuels delivered and the EDF data for apparent liquid fuel consumption are reconciled. 4. An audit of the greenhouse gas assessment for 2005 is carried out based on carbon balances for coal, oil and gas to ensure that there are no other material differences between the net fossil carbon entering the NZ energy systems, as defined in EDF, and the net fossil carbon accounted for in the GHG inventory. 5. An audit is carried out of the non-CO_2 and geothermal contribution to the energy section of the 2005 GHG inventory. For intermediate action (2006 inventory and beyond): 1. That a top-down model of NZ's energy system time series is developed focusing principally on complete determination of CO_2 emissions from fossil fuels, with secondary consideration to allocation of those emissions between sectors. 2. That an audit of the Energy Data File is undertaken to ensure that this foundation for the GHG inventory meets criteria of completeness, accuracy, transparency and consistency. 3. That the basis of energy assessments in EDF, the GHG model and the SADEM model should be consistent; either gross CV or net CV. 4. That a training course specific to the NZ energy situation is established for staff working on the GHG inventory, to compliment generic training in IPCC methodologies.	MED are working through the recommendations as time and resources allow.	Doc ID 243025 in Silent One.
	Review by T.S Clarkson of NIWA on the Energy Sector GHG emission reporting prior to submitting the 2002 NIR (2000 inventory).	April 2002	T.S Clarkson of NIWA	NIWA report internally reviewed by K.R.Lassey.	Peer review of energy sector as a quality control check, identify errors, make comments on GP, provide recommendations, and comment on uptake of recommendations provided in 2001. NIWA Report WLG2002/30.	1. The inventory is generally well presented and complete. 2. The CRF appears more robust than 2001 with fewer errors and inconsistencies. 3. There is still a need to ensure a QA/QC plan is developed and adhered to when preparing the inventory. 4. Provide more evidence of QA/QC in NIR. 5. Bring documentation up to that mentioned in GP, QA/QC. 6. Optimise T1 methods and bring in GP (including uncertainity estimates). 7. Note in NIR where GP applied. 8. Develop longer plan for adopting a T2 or bottom up approach. 9. Need a review of all emission factors to ensure they are up to date. 10. More work on diferences between reference and sectoral approaches.	3. QA/QC plan developed and regularly reviewed. 4. This is to be addressed in 2004 NIR. 5. Additional documentation has been added to NIR to increase transparency (meeting good practice). 6. Addressed. 7. This is addressed in inventory reports since 2003. 8. T2 approach is being developed as time and resources allow (work by Steve Goldthorpe end of 2006 has brought some emphasis to this work). 9. Major EFs reviewed by Hale and Twoomey. 10. Is being addressed by MED as resources allows	Hard copy kept in Sonia's tambour.
	Review by T.S Clarkson of NIWA on the Energy Sector GHG emissions on the NIR/CRF submitted in 2001 (1999 inventory).	Aug 2001	T.S Clarkson of NIWA	NIWA report internally reviewed by K.R.Lassey.	Peer review of energy sector as a quality control check, identify errors, make comments on GP and provide recommendations. NIWA Report WLG2001/50.	1. The inventory is generally well presented and complete. 2. A QA/QC plan should be developed and adhered to when preparing the inventory to remove inconsistencies in CRF tables. 3. Need a review of all emission factors to ensure they are up to date. 4. The documentation is insufficiently reported – statistics need explanation, and include supplementary documentation.	2. QA/QC plan is being continually updated. It was implemented in the 2004 inventory report and formal QC checks have been implemented for all subsequent inventories. The energy sector has a number of quality checks applied to various sources during the inventory compliation process. 3. Review of emission factors occurred in 2003. 4. Addressed in 2004 inventory report.	Doc ID 61671 in Silent One.

QUALITY ASSURANCE CHECKLIST INCLUDES ALL REVIEWS UP TO AND INCLUDING THE 2005 INVENTORY REPORT:

QA ACTIVITY & PROCEDURES

QA ACTIVITY	DESCRIPTION OF QA PROCEDURE	DATE OF REVIEW	REVIEWER	EXPERT QUALIFICATIONS ASSESSED	BRIEF DESCRIPTION OF REVIEW SCOPE (INCLUDE A REFERENCE TO THE REVIEW CONTRACT)	MAJOR CONCLUSIONS FROM THE REVIEW (INCLUDE A REFERENCE TO THE REVIEW)	ACTION TAKEN	PLACE WHERE IT IS FILED
Expert review of Energy Sector	Review of Energy Sector Greenhouse Gas Emissions Factors. A report to the Energy Modelling and Statistics Unit of the Ministry of Economic Development. (as a response to the previous reviews by T.S. Clarkson).	March 2003	Hale & Twomey Limited Level 4, Gleneagles Building 69-71The Terrace PO Box 10 444 Wellington New Zealand	Not documented (prior to QA procedures developed).	To undertake a review of the energy sector emissions factors used in NZ's GHG inventory and to recommend what emissions factors should be used for each GHG and what further work the Ministry should arrange.	1. Changes recommended for the vast majority of emissions factors, including reverting to IPCC recommended factor. 2. Methodology could also be improved eg by splitting petrol to premium and regular. 3. Further work includes – review of coal CO_2 emissions factors, review of coal CH_4 fugitive emissions, routine updating of gas emissions moving to tier 3 calculation for Transport (MOT's Vehicle Fleet emissions model). 4. NZ standardise on kt/PJ as standard unit. 5. Show emission factors to sufficient significant digits to indicate where grossing down has occurred.	1. Addressed new recommended factors used in inventory reports from 2004 onwards. 2. Addressed-this has been implemented from the 2004 inventory onwards. 3. MEd will update where appliciable and have the resources to do so. 4. Consensus has not been reached on this issue-to discuss with MED. 5. This is addressed in inventory reports from 2004 onwards.	Hard copy kept in Sonia's tambour and draft report kept on the MfE network.
Expert review of Industrial Processes Sector	Review of synthetic greenhouse gases in industrial processes sector.	August 2004	Iain McClinchy contractor to Ministry for the Environment.			1. NZCCO to establish formal relationship with Customs to ensure provision of data on a more regular basis. 2. NZCCO consider development of regulations under the Climate Change Reponse Act to clarify its powers to request data from importers and end users. 3. NZCCO work with Customs and the MED to develop a more useful set of tariff codes. 4. That potential emissions data be calculated and presented for future inventories in accordance with IPCC guidelines.	Emissions from Industrial Processes make up ~5% of New Zealand's total GHG. MfE is working with MED and external consultants to try and get the most accurate synthetic GHG data possible according to national circumstances.	Doc ID 61986 in SilentOne.
	Review of Industrial Processes Sector of National Greenhouse Gases Inventory submitted on 15 April 2003.	June 2003	Dr Doug Sheppard Geochemical Solutions PO Box 33 224 Petone New Zealand	Not documented (prior to QA procedures developed).	To review the industrial processes sector with an aim to identify gaps in reporting. Coverage does not include emissions of PFC's, HFC's and SF_6.	1. Clarify differences between tables, worksheets, the CRF and consultant reports. 2. Review why CO_2 from methanol production is not reported. 3. Check confusion over quantities of bitumen, ethanol and ammonia. 4. Check production quantities of wooden panel products. 5. Provide more explanation and documentation of underlying assumptions. 6. Review and restucture content of questionaire used to gather information from industry.	1. Consistency between tables and reports has improved over the past couple of years. 2. This information is in the energy sector. 3. Has been cleared up through CRL report (2004). 4. Very small part of inventory-not considered high priority at this stage. 5. Additional information has been provided in the NIR from 2004 onwards. 6. A new consultant has been found for this section of work who is more quality conscious.	Doc ID 61978 in Silent One.
Expert review of Solvent Sector	No review under taken for this sector as it is very small and does not contain any key categories.							
Expert review of Agriculture Sector	Review of Agricultural sector GHG programme to ascertain whether programme is meeting objectives.	2004	Marc Ullyatt		The research projects contracted by MAF over the period 2001–2004 to improve the methane inventory are reviewed within a framework that allows consideration of first the progress in developing an overall inventory model and second research into the components of the model.	The reviewer recommended the following areas need to be addressed, in the following order: 1. Evaluation of the soil sink for methane under plantation forests. 2. Continuation of the work determining enteric methane emission factors. 3. Determination of the proportion of methane emitted via the flatus. 4. Continued evaluation of satellite imagery in determining nutritive value on a national scale. 5. An independent evaluation of the methodology used in uncertainty analysis. 6. Measurements to determine an emission factor for waste management via anaerobic lagoons. 7. Annual upgrading of the model (this should probably be listed as an overhead outside research priorities because of the UNFCCC requirement for annual inventory reporting).		Doc ID 61522 in Silent One.

QA ACTIVITY	DESCRIPTION OF QA PROCEDURE	DATE OF REVIEW	REVIEWER	EXPERT QUALIFICATIONS ASSESSED	BRIEF DESCRIPTION OF REVIEW SCOPE (INCLUDE A REFERENCE TO THE REVIEW CONTRACT)	MAJOR CONCLUSIONS FROM THE REVIEW (INCLUDE A REFERENCE TO THE REVIEW)	ACTION TAKEN	PLACE WHERE IT IS FILED
Expert review of Agriculture Sector	Review of NZ Official 1990 Animal Statistics.	2004	Meat and Wool New Economic Service Rob Davison.	Organised by MAF	Review sheep livestock numbers and provide an assessment for base livestock from 1989–1991.	1. Sheep numbers from the 1991 census are probably to low and should be revised in the inventory. They would likely increase by 2% from 55,162 to 56,300. Lambs tailed would increase 7% from 38,716 to 41,398.	Follow up with MAF to ensure consistency.	Doc ID 61511 in Silent One.
	Report to MAF: Revised nitrous oxide emissions from New Zealand agricultural soils 1990–2001.	2003	FM Kelliher, SF Ledgard, H. Clark, AS Walcroft, M Buchan and RR Sherlock.		Revision of nitrous oxide emissions from agricultural soils 1990–2001 – including recommendations for inventory improvement.	1. N_2O emissions from grazing animal's urine & dung excreta should be estimated using separate emission factors (these to be determined from available & future measurements of NzOnet). 2. Grazing animal feed intake should be determined by the model by Clark et al to connect N_2O and CH_4 emissions inventories. 3. Nitrogen excretion by grazing animals should be determined using model OVERSEER. 4. Sales records should be used to determine N fertiliser use.	1. Not able to be done at present – explanation in NIR. Research ongoing. 2. Has been addressed – model used. 3. Has been addressed – model used. 4. Has been addressed – sales records now used.	Doc ID 61504 in Silent One.
	Peer review of nitrous oxide work through scientific papers: de Klein CAM, Barton L, Sherlock RR, Li Z, Littlejohn RP (2003). Estimating a Nitrous Oxide Emission Factor for Animal Urine from Some New Zealand Pastoral Soils. Australian Journal of Soil Research. 41(3): 381-399.	2003						
	Review of "Enteric methane emissions from New Zealand ruminants 1990–2001 calculated using an IPCC Tier 2 approach by Harry Clark, Ian Brookes and Adrian Walcroft."		KR Lassey of NIWA.					Report kept in Ag sector filemaster box in Sonia's tambour.
Expert review of Land use change and forestry Sector								
Expert review of Waste Sector								

QUALITY ASSURANCE CHECKLIST INCLUDES ALL REVIEWS UP TO AND INCLUDING THE 2005 INVENTORY REPORT:								
QA ACTIVITY & PROCEDURES								
QA ACTIVITY	DESCRIPTION OF QA PROCEDURE	DATE OF REVIEW	REVIEWER	EXPERT QUALIFICATIONS ASSESSED	BRIEF DESCRIPTION OF REVIEW SCOPE (INCLUDE A REFERENCE TO THE REVIEW CONTRACT)	MAJOR CONCLUSIONS FROM THE REVIEW (INCLUDE A REFERENCE TO THE REVIEW)	ACTION TAKEN	PLACE WHERE IT IS FILED
Review of QA/QC procedures and plan	Review of current QA/QC procedures and plans in the national inventory.	2004	Mr Wayne Gillies Claws Consulting Ltd.	CV assessed and in records.	Report detailing how the current Quality Assurance and Quality Control (QA/QC) procedures and plan used in the Inventory compare to the QA/QC guidance in GPG. Provide a prioritised list of recommendations to be implemented for the New Zealand inventory QA/QC system to be consistent with GPG.	Key short-term recommendation is to document a plan to achieve consistency with GPG by 30/9/06 and ensure this plan is understood and agreed with all necessary parties.	Many of the recommendations in this report have been addressed during 2005 calender year with the remaining to be addressed during 2006.	Doc ID 60650 in Silent One.

ANNEX 7: Uncertainty analysis (Table 6.1 of the IPCC Good Practice Guidance)

Uncertainty estimates are an essential element of a complete emissions inventory. The purpose of uncertainty information is not to dispute the validity of the inventory estimates, but to help prioritise efforts to improve the accuracy of inventories in the future and guide decisions on methodological choice (IPCC, 2000). Good Practice Guidance also notes that inventories prepared following the IPCC Guidelines and Good Practice Guidance will typically contain a wide range of emission estimates, varying from carefully measured and demonstrably complete data on emissions to order-of-magnitude estimates of highly variable N_2O fluxes from soils and waterways (IPCC, 2000).

New Zealand has included a Tier 1 uncertainty analysis as required by the inventory guidelines (FCCC/SBSTA/2004/8) and Good Practice Guidance (IPCC, 2000). Uncertainties in the categories are combined to provide uncertainty estimates for the entire inventory in any year and the uncertainty in the overall inventory trend over time. The New Zealand methodology follows the Tier 1 calculation procedure as specified in Good Practice Guidance (IPCC, 2000). LULUCF categories have been included using the absolute value of any removals of CO_2 (table A7.1). Table A7.2 calculates the uncertainty only in emissions, ie, excluding LULUCF removals.

A7.1 Tier 1 uncertainty calculation

The uncertainty in activity data and emission/removal factors shown in table A7.1 and A7.2 are equal to half the 95 per cent confidence interval divided by the mean and expressed as a percentage. The reason for halving the 95 per cent confidence interval is that the value corresponds to the familiar plus or minus value when uncertainties are loosely quoted as "plus or minus x per cent". Where uncertainty is highly asymmetrical, the larger percentage difference between the mean and the confidence limit is entered. Where only the total uncertainty is known for a category then:

- if uncertainty is correlated across years, the uncertainty is entered as emission or removal factor uncertainty and 0 in activity data uncertainty
- if uncertainty is not correlated across years, the uncertainty is entered as uncertainty in activity data and 0 in emission or removal factor uncertainty.

In tables A7.1 and A7.2, the figure labelled "uncertainty in the year" is an estimate of the percentage uncertainty in total national emissions and removals in the current year. This figure is calculated from the entries for individual categories combined by summing the squares of all the entries in the column "combined uncertainty as a % of the national total in year t" and taking the square root.

In the Tier 1 methodology, uncertainties in the trend are estimated using two sensitivities:

- Type A sensitivity: the change in the difference in the national total between the base year and the current year, expressed as a percentage, resulting from a 1 per cent increase in emissions of a given source category and gas in both the base year and the current year.
- Type B sensitivity: the change in the difference in overall emissions between the base year and the current year, expressed as a percentage, resulting from a 1 per cent increase in emissions of a given source category and gas in the current year only.

Uncertainties that are fully correlated between years will be associated with Type A sensitivities, and uncertainties that are not correlated between years will be associated with Type B sensitivities.

In tables A7.1 and A7.2, the figure labelled “uncertainty in the trend” is an estimate of the total uncertainty in the trend, calculated from the entries above by summing the squares of all the entries and taking the square root. The values for the individual categories are an estimate of the uncertainty introduced into the trend by the category in question.

TABLE A7.1
Uncertainty calculation for the New Zealand Greenhouse Gas Inventory 1990–2005 including LULUCF removals (following IPCC Tier 1)

IPCC SOURCE CATEGORY	GAS	BASE YEAR EMISSIONS OR ABSOLUTE VALUE OF REMOVALS	YEAR t EMISSIONS OR ABSOLUTE VALUE OF REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION OR REMOVAL FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	COMBINED UNCERTAINTY AS A % OF THE NATIONAL TOTAL IN YEAR t	TYPE A SENSITIVITY	TYPE B SENSITVITY	UNCERTAINTY IN THE TREND IN NATIONAL TOTALS INTRODUCED BY EMISSION OR REMOVAL FACTOR UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL TOTAL INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN THE NATIONAL TOTAL	EMISSION / REMOVAL FACTOR QUALITY INDICATOR	ACTIVITY DATA QUALITY INDICATOR
Energy sector	CO_2	2,2719.15	32,401.65	5	0	5	1.54	0.0457	0.3885	0.0000	2.7471	2.75	M	R
Industrial processes sector	CO_2	2,743.15	3,478.14	5	0	5	0.17	0.0003	0.0417	0.0000	0.2949	0.29	M	R
LULUCF sector – forest land	CO_2	19,754.89	25,513.17	5	25	25	6.20	0.0079	0.3059	0.1981	2.1631	2.17	M	R
LULUCF sector other land-use categories	CO_2	1,684.65	2197.12	15	184	185	3.87						M	R
Energy sector	CH_4	708.08	806.52	5	50	50	0.39	–0.0010	0.0097	–0.0505	0.0684	0.08	D	R
CRF2A – mineral products	CH_4	0.00	0.00											
CRF2B – chemical industry	CH_4	20.16	14.41	0	80	80	0.01	–0.0001	0.0002	–0.0105	0.0000	0.01	D	R
CRF4A – enteric fermentation	CH_4	21,806.54	23,919.80	2	53	53	12.09	–0.0420	0.2868	–2.2258	0.8112	2.37	M	M
CRF4B – manure management	CH_4	590.47	739.48	2	100	100	0.70	–0.0000	0.0089	–0.0040	0.0251	0.03	M	M
CRF4E – prescribed burning	CH_4	2.82	0.83	20	60	63	0.00	–0.0000	0.0000	–0.0020	0.0003	0.00	D	R
CRF4F – burning of residues	CH_4	18.78	10.68	50	40	64	0.01	–0.0002	0.0001	–0.0062	0.0091	0.01	D	R
LULUCF sector	CH_4	93.54	84.90	10	35	36	0.03	–0.0004	0.0010	–0.0138	0.0144	0.02		
CRF 6A – solid waste disposal	CH_4	2,122.92	1,460.70	0	20	20	0.28	–0.0145	0.0175	–0.2900	0.0000	0.29	M	R
CRF 6B – wastewater handling	CH_4	222.93	222.87	0	20	20	0.04	–0.0007	0.0027	–0.0138	0.0000	0.01	D	R
Energy sector	N_2O	150.28	273.48	5	50	50	0.13	0.0010	0.0033	0.0506	0.0232	0.06	D	R
CRF4D – agricultural soils	N_2O	10,033.69	12,706.97	5	73	73	8.86	0.0010	0.1524	0.0744	1.0773	1.08	M	M
CRF4B – manure management	N_2O	37.82	63.89	5	100	100	0.06	0.0002	0.0008	0.0196	0.0054	0.02		
CRF4E – prescribed burning	N_2O	0.51	0.15	20	60	63	0.00	–0.0000	0.0000	–0.0004	0.0001	0.00	D	R
CRF4F – burning of residues	N_2O	6.46	3.49	50	40	64	0.00	–0.0001	0.0000	–0.0022	0.0030	0.00	D	R
LULUCF sector	N_2O	9.49	8.62	10	35	36	0.00	–0.0000	0.0001	–0.0014	0.0015	0.00		
CRF6B – wastewater handling	N_2O	146.92	163.56	0	1,200	1,200	1.87	–0.0003	0.0020	–0.3059	0.0000	0.31	D	R
CRF2F	HFCs	0.00	741.56	120	50	130	0.92	0.0089	0.0089	0.4446	1.5089	1.57	D	R
CRF2C	PFCs	515.60	80.70	0	30	30	0.02	–0.0068	0.0010	–0.2043	0.0000	0.20	M	M
CRF2F	SF_6	12.33	21.84	5	20	21	0.00	0.0001	0.0003	0.0015	0.0019	0.00		
TOTAL EMISSIONS/REMOVALS		**83,401.19**	**104,914.52**	**UNCERTAINTY IN THE YEAR**			**16.9%**	**UNCERTAINTY IN THE TREND**				**4.7%**		

TABLE A7.2
Uncertainty calculation for the New Zealand Greenhouse Gas Inventory 1990–2005 excluding LULUCF removals (following IPCC Tier 1)

IPCC SOURCE CATEGORY	GAS	BASE YEAR EMISSIONS	YEAR t EMISSIONS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	COMBINED UNCERTAINTY AS A % OF THE TOTAL EMISSIONS IN YEAR t	TYPE A SENSITIVITY	TYPE B SENSITVITY	UNCERTAINTY IN THE TREND IN NATIONAL TOTALS INTRODUCED BY EMISSION FACTOR UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL TOTAL INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL EMISSIONS	EMISSION /REMOVAL FACTOR QUALITY INDICATOR	ACTIVITY DATA QUALITY INDICATOR
Energy sector	CO_2	22,719.15	32,401.65	5	0	5	2.10	0.0658	0.5229	0.0000	3.6977	3.70	M	R
Industrial processes sector	CO_2	2,743.15	3,478.14	5	0	5	0.23	0.0010	0.0561	0.0000	0.3969	0.40	M	R
Energy sector	CH_4	708.08	806.52	5	50	50	0.52	−0.0012	0.0130	−0.0611	0.0920	0.11	D	R
CRF2A – mineral products	CH_4	0.00	0.00											
CRF2B – chemical industry	CH_4	20.16	14.41	0	80	80	0.01	−0.0002	0.0002	−0.0138	0.0000	0.01	D	R
CRF4A – enteric fermentation	CH_4	21,806.54	23,919.80	2	53	53	16.43	−0.0523	0.3860	−2.7712	1.0919	2.98	M	M
CRF4B – manure management	CH_4	590.47	739.48	2	100	100	0.96	0.0001	0.0119	0.0061	0.0338	0.03	M	M
CRF4E – prescribed burning	CH_4	2.82	0.83	20	60	63	0.00	−0.0000	0.0000	−0.0026	0.0004	0.00	D	R
CRF4F – burning of residues	CH_4	18.78	10.68	50	40	64	0.01	−0.0002	0.0002	−0.0082	0.0122	0.01	D	R
LULUCF sector	CH_4	93.54	84.90	10	35	36	0.04	−0.0005	0.0014	−0.0179	0.0194	0.03		
CRF 6A – Solid waste disposal	CH_4	2,122.92	1,460.70	0	20	20	0.38	−0.0191	0.0236	−0.3822	0.0000	0.38	M	R
CRF 6B – wastewater handling	CH_4	222.93	222.87	0	20	20	0.06	−0.0009	0.0036	−0.0177	0.0000	0.02	D	R
Energy sector	N_2O	150.28	273.48	5	50	50	0.18	0.0014	0.0044	0.0696	0.0312	0.08	D	R
CRF4D – agricultural soils	N_2O	10,033.69	12,706.97	5	73	73	12.04	0.0033	0.2051	0.2411	1.4501	1.47	M	M
CRF4B – manure management	N_2O	37.82	63.89	5	100	100	0.08	0.0003	0.0010	0.0271	0.0073	0.03		
CRF4E – prescribed burning	N_2O	0.51	0.15	20	60	63	0.00	−0.0000	0.0000	−0.0005	0.0001	0.00	D	R
CRF4F – burning of residues	N_2O	6.46	3.49	50	40	64	0.00	−0.0001	0.0001	−0.0029	0.0040	0.00	D	R
LULUCF sector	N_2O	9.49	8.62	10	35	36	0.00	−0.0001	0.0001	−0.0018	0.0020	0.00		
CRF6B – wastewater handling	N_2O	146.92	163.56	0	1,200	1,200	2.54	−0.0003	0.0026	−0.3777	0.0000	0.38	D	R
CRF2F	HFCs	0.00	741.56	120	50	130	1.25	0.0120	0.0120	0.5984	2.0310	2.12	D	R
CRF2C	PFCs	515.60	80.70	0	30	30	0.03	−0.0091	0.0013	−0.2720	0.0000	0.27	M	M
CRF2F	SF_6	12.33	21.84	5	20	21	0.01	0.0001	0.0004	0.0021	0.0025	0.00		
TOTAL EMISSIONS/REMOVALS		**61,961.65**	**77,204.23**	**UNCERTAINTY IN THE YEAR**			**20.7%**		**UNCERTAINTY IN THE TREND**			**5.5%**		

ANNEX 8: Worksheets for all sectors

Worksheets with country-specific data for each sector can be found in MS Excel spreadsheets on the CD-Rom accompanying this inventory report.

ANNEX 9: Trend tables from the 2005 Common Reporting Format

The summary common reporting format tables for 1990–2005 can be found on the CD-Rom accompanying this inventory report.