Ministry for the
Environment
Manatū Mō Te Taiao

New Zealand's Greenhouse Gas Inventory 1990 – 2004

The National Inventory Report and Common Reporting Format

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Acknowledgements

Key contributors

Sonia Petrie (National Inventory Compiler) Simon Wear (Agriculture) Richard Nottage (LULUCF) Scott Gulliver (Waste) Toni Wilson (QA/QC)	Ministry for the Environment
Kennie Tsui and Darren Evans (Energy and Industrial Processes-CO_2)	Ministry of Economic Development

Technical contributors and contracted specialists

Industrial processes sector

Wayne Hennessy and Deborah Maxwell, CRL Energy Ltd
(non-CO_2 emissions, synthetic greenhouse gases and solvents)

Agriculture sector

Harry Clark, AgResearch; Gerald Rys and David Lillis,
Ministry of Agriculture and Forestry

Land use change and forestry sector

Steve Wakelin, Ensis; Paul Lane,
Ministry of Agriculture and Forestry

Waste sector

Tom Wetherill and Woody Xaio, Waste Management NZ

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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 (SF_6) from six sectors: energy, industrial processes, solvents, agriculture, 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 (NMVOC) are also included in the inventory. However, only emissions and removals of the direct greenhouse gases, CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 are reported in New Zealand's total emissions under the UNFCCC and are accounted for under the Kyoto Protocol.

Only human-induced emissions and removals of greenhouse gases are included. A complete time-series of emissions and removals from 1990 through to 2004 (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. However, over the previous 50 to 100 years, 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.

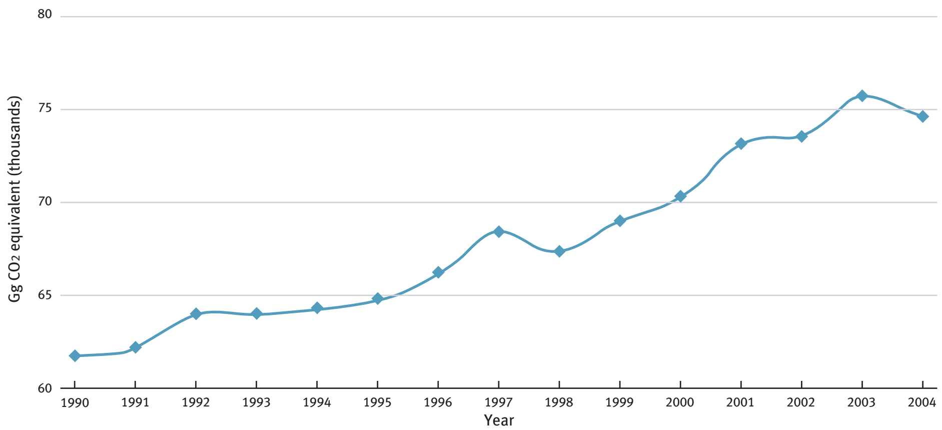
The long-term objective of the United Nations Framework Convention on Climate Change is to "stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". All countries that ratify the UNFCCC are required to address 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 the Protocol 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 percent 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 equivalent to 61,510.70 Gg of CO_2. In 2004, total greenhouse gas emissions were 74,605.22 Gg CO_2 equivalent equating to a 13,094.52 Gg (21.3 percent) rise since 1990 (Figure 1.1). Net removals of CO_2 through forest sinks increased from 18,977.92 Gg CO_2 in 1990 to 24,482.63 Gg CO_2 in 2004.

Figure 1.1 New Zealand's total greenhouse gas emissions 1990-2004



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 2004

Greenhouse Gas Emissions	Gg CO_2 equivalent 1990	Gg CO_2 equivalent 2004	Change from 1990 (Gg CO_2 equivalent)	Change from 1990 (%)
Net CO_2 emissions / removals	6,292.44	9,473.50	3,181.06	50.5
CO_2 emissions (without LULUCF)	25,373.39	34,038.90	8,665.51	34.1
CH_4	25,405.48	27,064.03	1,658.55	6.5
N_2O	10,306.92	12,878.75	2,571.83	25.0
HFCs	0.00	597.14	597.14	–
PFCs	515.60	87.70	-427.90	-83.0
SF_6	12.33	21.49	9.16	74.3
Total emissions without the LULUCF sector	**61,510.70**	**74,605.22**	**13,094.52**	**21.3**

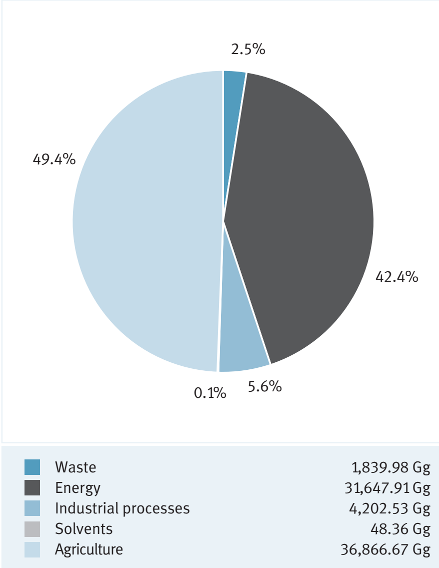
Source and sink category emission estimates and trends

New Zealand is unusual amongst developed nations in that 49.4 percent of total emissions in 2004 were produced by the agriculture sector (Figure 1.2). By comparison, emissions from agriculture typically make up 12 percent of total greenhouse gas emissions across Annex 1 Parties. The 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 4,750.08 Gg (14.8 percent) above the 1990 level (Table 1.2).

The energy sector is the other large component of New Zealand's emissions profile comprising 42.4 percent of total emissions in 2004. Emissions from the energy sector are now 7,992.76 Gg (33.8 percent) above the 1990 level (Table 1.2). The growth in energy emissions since 1990 is primarily from road transport (an increase of 4,855.03 Gg or 62.7 percent) and electricity generation (an increase of 2,572.46 Gg or 73.6 percent). 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 percent and 2.5 percent respectively of all greenhouse gas emissions in 2004. Emissions from the waste sector are now 25.9 percent 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 lower than in many other countries.

Figure 1.2 New Zealand's sectoral emissions in 2004 (all figures Gg CO_2 equivalent)



The land-use, land-use change and forestry (LULUCF) sector represents a major sink for New Zealand removing 32.8 percent of all greenhouse gas emissions in 2004. Net removals in 2004 were 29.0 percent 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 1.2 Sectoral emissions of greenhouse gases in 1990 and 2004

Sector	Gg CO_2 equivalent		Change from 1990 (Gg CO_2 equivalent)	Change from 1990 (%)
	1990	2004		
Energy	23,655.15	31,647.91	7,992.76	33.8
Industrial processes	3,214.61	4,202.53	987.92	30.7
Solvent and other product	41.54	48.36	6.82	16.4
Agriculture	32,116.58	36,866.67	4,750.09	14.8
Land-use change and forestry	-18,977.92	-24,482.63	-5504.71	29.0
Waste	2,482.81	1,839.98	-642.83	-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. While there have been climatic changes in the past, there have been no significant climatic changes since the start of human civilization 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 last 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 developing 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 at 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 percent 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 in order to comply with its emissions target. New Zealand's target is 100 percent 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 and 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. Much of New Zealand's economic growth is the result of developments in the agriculture sector. One half of New Zealand's emissions come from agriculture which contributes almost 7 percent of New Zealand's GDP. This creates a unique greenhouse gas emission profile for New Zealand with agriculture producing 49.4 percent of total emissions. 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 2004, New Zealand's emissions from this sector accounted for 42.4 percent 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 electricity generation, manufacturing industries, construction and transport. However, it should be noted that 75 percent of the energy currently consumed for electricity comes from renewable resources.

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 (NIR) 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 (SF_6) 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 (NO_X) and non-methane volatile organic compounds (NMVOC) are also included in the inventory as is sulphur dioxide (SO_2). However, only emissions and removals of the direct greenhouse gases, CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 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 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 carbon dioxide equivalents (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 GWPs 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 emission 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 via industry survey by consultants, contracted to the Ministry for the Environment.

The Ministry for 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 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

New Zealand submits its national inventory to the UNFCCC secretariat by 15 April of each year. The inventory contains data from the base year (1990) to two years prior to the current calendar year. Generation of the data in the Common Reporting Format (CRF) and production of the National Inventory Report (NIR) 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 Ministry for the Environment's website).

New Zealand is aware of the requirement under Article 5.1 of the Kyoto Protocol to have in place a national system for its greenhouse gas inventory. New Zealand will provide a formal 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 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). CO_2 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: CO_2 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 via industry survey through the Ministry for the Environment. Emissions of HFCs and PFCs are estimated using the IPCC Tier 2 approach and SF_6 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 via a survey of industry.

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, beef, sheep and deer animals. 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 non-significant animal species.

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 were mapped in 1997 and 2002. Data for all other years is extrapolated from the changes observed between 1997 and 2002. At present, the land-cover data is the best national data available for reporting the LULUCF sector. The reporting will be improved significantly as a result of the New Zealand Carbon Accounting System described in Annex 3.2.

Waste: Emissions from the waste sector are estimated using waste-survey data combined with population data. The 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). New Zealand has tried to ascertain emissions from waste incineration but there is very little incineration that occurs and data is difficult to obtain. For this inventory they are reported to be negligible. Most regional and territorial councils have banned the open burning of waste and there is no incineration of municipal waste in New Zealand.

1.5 Key categories

The IPCC Good practice guidance (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 are prioritised.

The key categories in the New Zealand inventory have been assessed using the good practice Tier 1 level and trend methodologies (IPCC, 2000; 2003). The good practice methodologies identify sources of emissions and removals that sum to 95 percent of the total emissions or 95 percent of the trend of the inventory in absolute terms.

Following 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 do not appear as key when the LULUCF categories are included are still to be considered as key.

The key categories identified in the 2004 inventory are summarised in Table 1.5.1. The major contribution to the level analysis (Table 1.5.2 a & b) are from the LULUCF category "forest land remaining forest land" and from CH_4 emissions from enteric fermentation in domestic livestock at 25.4 percent and 23.0 percent of the total respectively. CH_4 emissions from enteric fermentation in domestic livestock are the largest single source of emissions comprising 31.8 percent of total emissions (Table 1.5.2 (b)). The next largest contribution to emissions is CO_2 emissions from road transportation that comprised 16.6 percent of total emissions in 2004.

The largest contribution to the trend analysis is from CO_2 emissions from road transportation and CH_4 emissions from enteric fermentation in domestic livestock. It is clear that these three categories have a major effect on the New Zealand inventory.

While CO_2 emissions from the industrial processes of ammonia and urea manufacture (CRF category 2B5) did not appear in the top 95 percent 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 oil and gas" category and CO_2 emissions from ammonia and urea manufacture 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 2004 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, trend
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, trend
Fugitive emissions from oil and gas operations	CO_2	level, trend
Fugitive emissions from geothermal operations	CO_2	trend
Industrial processes sector		
Emissions from the iron and steel industry	CO_2	level
Emissions from aluminium production	CO_2	level
PFCs from aluminium production	PFC	trend
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 animal deposition on agricultural soils	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
Conversion to grassland	CO_2	level
Waste sector		
Emissions from solid waste disposal sites	CH_4	level, trend

Table 1.5.2 (a & b) Key category analysis for the 2004 inventory – Tier 1 level assessment including LULUCF (a) and excluding LULUCF (b)

(a) Tier 1 category level assessment – including LULUCF

IPCC categories	Gas	2004 estimate Gg	Level assessment	Cumulative total
Forest land remaining forest land	CO_2	26254.43	25.4	25.4
Emissions from enteric fermentation in domestic livestock	CH_4	23714.98	23.0	48.4
Mobile combustion – road vehicles	CO_2	12416.93	12.0	60.4
Emissions from agricultural soils – animal production	N_2O	7248.77	7.0	67.4
Emissions from stationary combustion – gas	CO_2	7031.32	6.8	74.2
Emissions from stationary combustion – solid	CO_2	5808.96	5.6	79.9
Indirect emissions from nitrogen used in agriculture	N_2O	3271.38	3.2	83.0
Emissions from stationary combustion – liquid	CO_2	2755.47	2.7	85.7
Direct emissions from agricultural soils	N_2O	1806.29	1.7	87.5
Emissions from the iron and steel industry	CO_2	1731.51	1.7	89.1
Emissions from solid waste disposal sites	CH_4	1509.12	1.5	90.6
Mobile combustion – aviation	CO_2	1192.23	1.2	91.7
Conversion to forest land	CO_2	747.94	0.7	92.5
Emissions from manure management	CH_4	745.88	0.7	93.2
Conversion to grassland	CO_2	666.44	0.6	93.8
Cropland remaining cropland	CO_2	662.29	0.6	94.5
Fugitive emissions from oil and gas operations	CO_2	602.86	0.6	95.1

(b) Tier 1 category level assessment – excluding LULUCF

IPCC categories	Gas	2004 estimate Gg	Level assessment	Cumulative total
Emissions from enteric fermentation in domestic livestock	CH_4	23714.98	31.8	31.8
Mobile combustion – road vehicles	CO_2	12416.93	16.6	48.4
Emissions from agricultural soils – animal production	N_2O	7248.77	9.7	58.1
Emissions from stationary combustion – gas	CO_2	7031.32	9.4	67.6
Emissions from stationary combustion – solid	CO_2	5808.96	7.8	75.4
Indirect emissions from nitrogen used in agriculture	N_2O	3271.38	4.4	79.7
Emissions from stationary combustion – liquid	CO_2	2755.47	3.7	83.4
Direct emissions from agricultural soils	N_2O	1806.29	2.4	85.9
Emissions from the iron and steel industry	CO_2	1731.51	2.3	88.2
Emissions from solid-waste disposal sites	CH_4	1509.12	2.0	90.2
Mobile combustion – aviation	CO_2	1192.23	1.6	91.8
Emissions from manure management	CH_4	745.88	1.0	92.8
Fugitive emissions from oil and gas operations	CO_2	602.86	0.8	93.6
Emissions from substitutes for ozone depleting substances	HFCs	597.36	0.8	94.4
Emissions from aluminium production	CO_2	552.29	0.7	95.1

Table 1.5.3 Key category analysis for the 2004 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	2004 estimate Gg	Trend assessment	Contribution to trend	Cumulative total
Mobile combustion – road vehicles	CO_2	7534.65	12416.93	0.036	18.5	18.5
Emissions from enteric fermentation in domestic livestock	CH_4	21553.97	23714.98	0.027	13.7	32.1
Emissions from stationary combustion – gas	CO_2	7679.40	7031.32	0.025	12.9	45.0
Emissions from stationary combustion – solid	CO_2	3227.01	5808.96	0.021	10.7	55.7
Direct emissions from agricultural soils	N_2O	476.05	1806.29	0.014	6.9	62.6
Emissions from solid waste disposal sites	CH_4	2179.23	1509.12	0.013	6.4	69.0
Forest land remaining forest land	CO_2	20624.90	26254.43	0.014	7.0	76.0
Emissions from agricultural soils – animal production	N_2O	6767.81	7248.77	0.011	5.4	81.4
Emissions from substitutes for ozone depleting substances	HFCs	0.00	597.36	0.007	3.4	84.8
PFCs from aluminium production	PFC	515.60	80.70	0.006	3.1	87.8
Emissions from stationary combustion – liquid	CO_2	2546.55	2755.47	0.004	1.9	89.7
Conversion to forest land	CO_2	870.01	747.94	0.003	1.7	91.4
Fugitive emissions from oil and gas operations	CO_2	263.75	602.86	0.003	1.6	93.0
Mobile combustion – aviation	CO_2	772.83	1192.23	0.003	1.4	94.5
Fugitive emissions from geothermal operations	CO_2	357.34	279.67	0.002	0.9	95.3

(b) Tier 1 category trend assessment – excluding LULUCF

IPCC categories	Gas	Base year estimate Gg	2004 estimate Gg	Trend assessment	Contribution to trend	Cumulative total
Mobile combustion – road vehicles	CO_2	7534.65	12416.93	0.0362	20.3	20.3
Emissions from enteric fermentation in domestic livestock	CH_4	21553.97	23714.98	0.0268	15.0	35.3
Emissions from stationary combustion – gas	CO_2	7679.40	7031.32	0.0252	14.1	49.4
Emissions from stationary combustion – solid	CO_2	3227.01	5808.96	0.0209	11.7	61.1
Direct emissions from agricultural soils	N_2O	476.05	1806.29	0.0136	7.6	68.7
Emissions from solid waste disposal sites	CH_4	2179.23	1509.12	0.0125	7.0	75.7
Emissions from agricultural soils – animal production	N_2O	6767.81	7248.77	0.0106	5.9	81.7
Emissions from substitutes for ozone depleting substances	HFCs	0.00	597.36	0.0066	3.7	85.4
PFCs from aluminium production	PFC	515.60	80.70	0.0060	3.4	88.7
Emissions from stationary combustion – liquid	CO_2	2546.55	2755.47	0.0037	2.1	90.8
Fugitive emissions from oil and gas operations	CO_2	263.75	602.86	0.0031	1.8	92.6
Mobile combustion – aviation	CO_2	772.83	1192.23	0.0028	1.6	94.1
Fugitive emissions from geothermal operations	CO_2	357.34	279.67	0.0017	1.0	95.1

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 QC and QA 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 2004 inventory, the Ministry for the Environment continued to develop the Tier 1 QC checksheet first used in the preparation of the 2002 inventory. The Tier 1 quality checks are based on the procedures suggested in the *Good Practice Guidance* (IPCC, 2000). Further details (including examples of some of the checks carried out) are available in Annex 6. For the 2004 inventory, the Tier 1 QC checksheets were used on all key categories and a selection of non-key categories.

In addition to the formal QC 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 2004 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 was 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 QA procedures for the 2004 inventory, the quality control and assurance plan was updated incorporating a number of recommendations from a quality management review undertaken in 2004. A history of reviews, their key conclusions and follow up is included as QA documentation 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, New Zealand's national statistics agency. Statistics New Zealand 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, 2002), where the inventory was subject to detailed in-country, centralised and desk review procedures. The inventories submitted for the years 2003-2005 were reviewed during a centralised review process. In all cases, the reviews were conducted by a review team comprised 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). Good practice also notes that inventories prepared following the methodologies in the IPCC 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 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. 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 2004 is ±17.0 percent. However the uncertainty in the overall trend from 1990-2004 is lower at only ±4.3 percent. The uncertainty in total emissions is ±21.2 percent with ±4.9 percent 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 12.2 percent and 9.1 percent 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 cow 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 2004 at 6.5 percent 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 percent of the total.

Uncertainty in the trend is dominated by CO_2 emissions from the energy sector, at 2.6 percent of the trend. This is because of the size of the sector and that the uncertainty in energy activity data is 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 cases, 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 percent confidence intervals developed from the Monte Carlo simulation were extended to the 2004 inventory.

1.8 Inventory completeness

The New Zealand inventory for the 2004 year can be described as complete with all IPCC source and sink categories that occur in New Zealand or that have emissions assessed to be above a negligible level reported. Improvements have been made with the inclusion of estimates for all LULUCF categories from the base year for all years (compared to 1997-2003 in the 2005 submission) and estimates of CO_2 from soda ash use in industrial processes. There are some small sources which remain "not estimated" (NE), eg, CH_4 emissions from waste incineration. Explanations on why these are reported as NE are found under the appropriate sector chapters.

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

Emissions of CO_2 and CH_4 from geothermal electricity generation are also a significant source in New Zealand. These emissions are reported as fugitive emissions in the energy sector. Sites with naturally occurring emissions where there is no electricity generation are excluded from the inventory.

In accordance with good practice, New Zealand has focused its resources for inventory development on the key source categories and some categories considered to have negligible emissions are reported as 'not estimated'. Where this has occurred explanations have been provided in the NIR and in the CRF tables.

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:

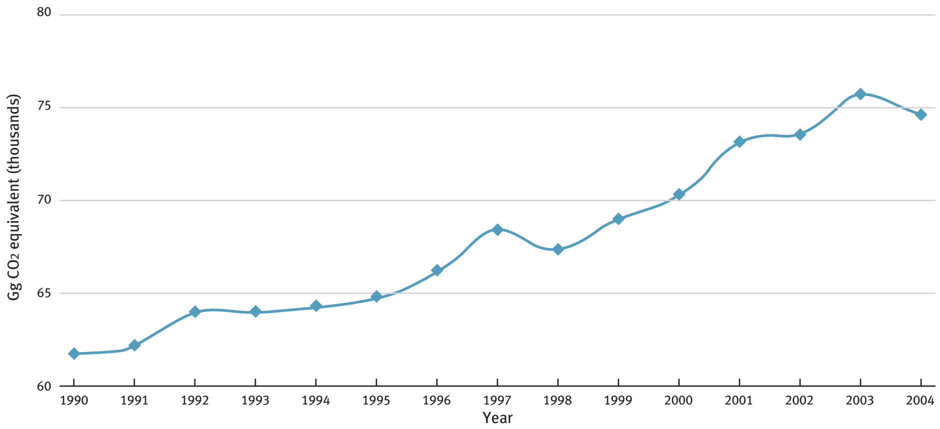
Trends in greenhouse gas emissions

2.1 Emission trends for aggregated greenhouse gas emissions

In 1990, New Zealand's total greenhouse gas emissions were equivalent to 61,510.70 Gg of CO_2. In 2004, total greenhouse gas emissions have increased by 13,094.52 Gg (21.3 percent) to 74,605.22 Gg CO_2 equivalent (Figure 2.1.1). Over the period 1990 to 2004, the average annual growth in overall emissions has been 1.5 percent per year.

Fluctuations in the trend are largely driven by emissions from public electricity generation. This category can show large year-to-year fluctuations because of the use of thermal stations to supplement the hydro-electric generation, during dry years. Generation in a year with normal rainfall requires lower gas and coal use and a year with less rainfall requires higher gas and coal use. This is a different trend from the steady increase in emissions from coal and gas used in electricity generation found in many other countries.

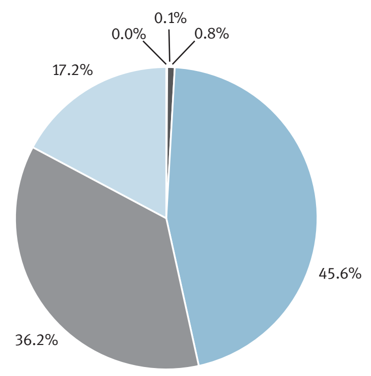
Figure 2.1.1 New Zealand's total greenhouse gas emissions 1990-2004



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 2004, these gases comprised 81.8 percent of total CO_2 equivalent emissions. Whereas CH_4 and CO_2 made equally large contributions to New Zealand's emissions in 1990, CO_2 is now the major greenhouse gas in New Zealand's emissions profile. The other major gas in New Zealand's emissions profile is N_2O.

Figure 2.2.1 New Zealand's emissions by gas in 2004 (all figures Gg CO_2 equivalent)



■	Perfluorocarbons (PFCs)	87.70 Gg
■	Hydrofluorocarbons (HFCs)	597.14 Gg
■	Carbon dioxide (CO_2) (without LULUCF)	34,038.90 Gg
■	Methane (CH_4)	27,064.03 Gg
■	Nitrous Oxide (N_2O)	12,878.75 Gg
■	Sulphur hexafluoride (SF_6)	21.49 Gg

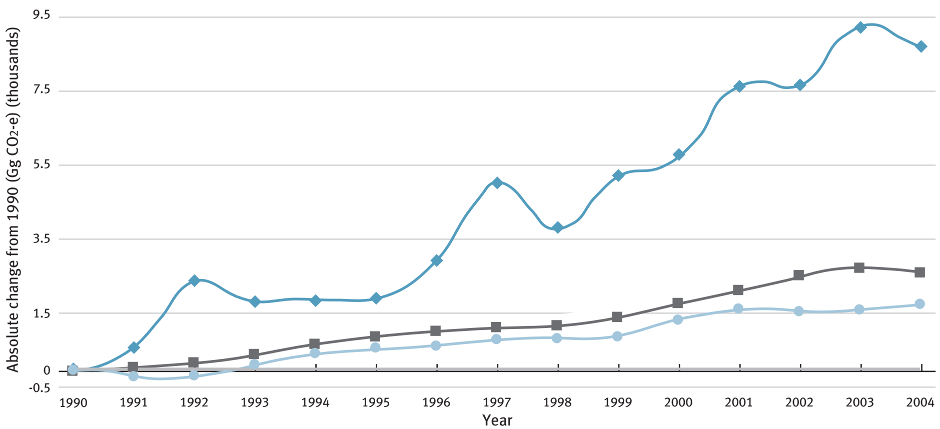
The growth in CO_2 represents the increased emissions from the energy sector. The growth in N_2O is from increased emissions from animal excreta and the increased use of nitrogenous fertilisers in agriculture, eg, the amount of nitrogenous fertilisers used has increased six-fold since 1990.

Although the contribution of the other gases in the inventory is less than 1 percent of the total emissions, these gases have also undergone relative changes between 1990 and 2004. Emissions of PFCs have decreased 427.90 Gg due to improvements in the aluminium smelting process, and HFC emissions have increased from 0 to 597.36 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 2004

Greenhouse gas emissions	Gg CO_2 equivalent		Change from 1990 (Gg CO_2 equivalent)	Change from 1990 (%)
	1990	2004		
CO_2 emissions (without LULUCF)	25,373.39	34,038.90	8,665.51	34.1
CH_4	25,405.48	27,064.03	1,658.55	6.5
N_2O	10,306.92	12,878.75	2,571.83	25.0
HFCs	0.00	597.14	597.14	–
PFCs	515.60	87.70	-427.90	-83.0
SF_6	12.33	21.49	9.16	74.3

Figure 2.2.2 Change in New Zealand's emissions of CO_2, CH_4, and N_2O from 1990-2004

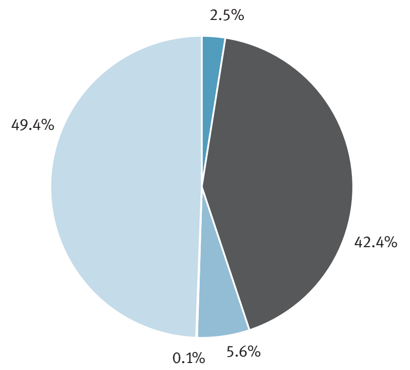


◆ CO_2 EMISSIONS (WITHOUT LULUCF)
■ CH_4
● N_2O
— 1990 baseline

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 2004, 49.4 percent of New Zealand's total emissions are 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 14.8 percent 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 2004 (all figures Gg CO2 equivalent, percentage of national total emissions in 2004)



The **energy sector** is the other large component of New Zealand's emissions profile comprising 42.4 percent of total emissions (refer Chapter 3). Emissions from the energy sector in 2004 are 7,992.76 Gg (33.8 percent) over the 1990 level and represent the highest sectoral growth in emissions. The growth in emissions from 1990 is primarily from road transport (increased by 4,855.03 Gg or 62.7 percent) and electricity generation (increased by 2,572.46 Gg or 73.6 percent).

Emissions from the industrial processes and waste sectors are a much smaller component comprising 5.6 percent and 2.5 percent respectively of all greenhouse gas emissions in 2004. Emissions from the **industrial processes sector** have been increasing steadily and are now 987.82 Gg (30.7 percent) over the 1990 baseline. This growth is primarily from increased CO_2 emissions from cement production (an increase of 118.11 Gg or 32.2 percent) over 1990), urea (nitrogenous fertiliser) manufacture (an increase of 105.35 Gg or 38.6 percent) over 1990) and HFC consumption (from 0 in 1990 to 597.36 Gg in 2004). The increase has been offset by PFC emissions from aluminium manufacture decreasing by 427.90 Gg (83.0 percent) since 1990 as a result of improvements to the smelting process (refer to section 4.4.2).

Emissions from the **waste sector** are now 642.83 Gg CO_2 equivalent (-25.9 percent) below the 1990 baseline. The majority of the reduction has occurred in the solid waste disposal on land category. This is a result of a number of initiatives to improve solid waste management practices in New Zealand, including 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.

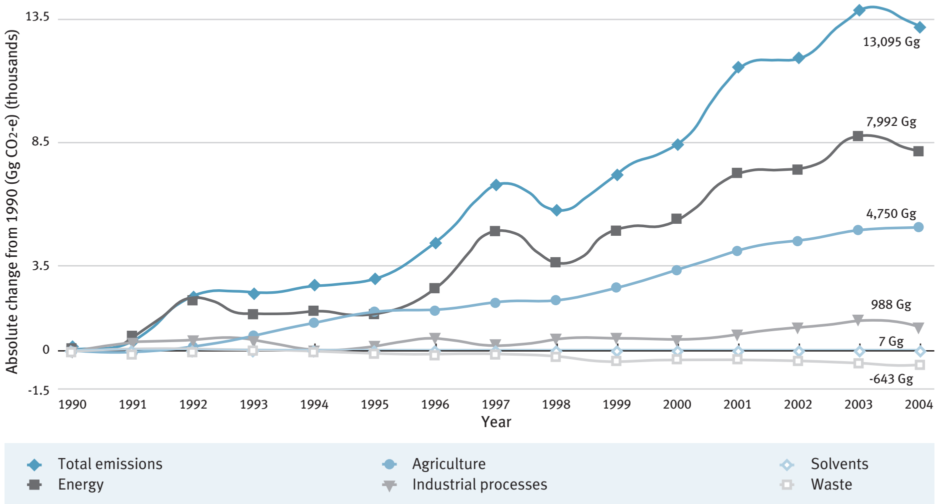
New Zealand's relatively small manufacturing base means that the **solvent sector** is much lower than in many other countries. In 2004, the solvent sector emitted 48.36 Gg of NMVOC.

The Land use, Land-use Change and Forestry (LULUCF) sector represents a major sink for New Zealand removing 32.8 percent of all greenhouse gas emissions in 2004. Net removals in 2004 were 29.0 percent 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 2004

Sector	Gg CO_2 equivalent 1990	Gg CO_2 equivalent 2004	Change from 1990 (Gg CO_2 equivalent)	Change from 1990 (%)
Energy	23,655.15	31,647.91	7,992.76	33.8
Industrial processes	3,214.61	4,202.53	987.92	30.7
Solvent and other product	41.54	48.36	6.82	16.4
Agriculture	32,116.58	36,866.67	4,750.08	14.8
Land-use change and forestry	-18,977.92	-24,482.63	-5504.71	29.0
Waste	2,482.81	1,839.98	-642.83	-25.9

Figure 2.3.2 Change in sectoral greenhouse gas emissions from 1990-2004



2.4 Emission trends for indirect greenhouse gases and SO_2

The indirect greenhouse gases CO, NO_x and NMVOC are also included in the inventory as is SO_2. Emissions of these gases in 1990 and 2004 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 2004

Gas	Gg of gas(es)		Change from 1990 (Gg)	Change from 1990 (%)
	1990	2004		
NO_x	135.34	157.45	22.11	16.3
CO	474.61	611.57	136.96	28.9
NMVOC	133.86	169.72	35.86	26.8
SO_2	54.28	75.51	21.23	39.1

Emissions of CO and NO_x come largely from the energy sector. The energy sector produced 93.6 percent of total CO emissions in 2004. The largest single source was road transportation. Similarly, the energy sector was the largest source of NO_x emissions (98.3 percent), 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 and SO_2. The energy sector produced 70.1 percent of NMVOC emissions in 2004 with emissions from road transportation comprising 62.7 percent of total NMVOC emissions. Other major sources of NMVOC are in the solvent and other product use sector (18.8 percent) and the industrial processes sector (10.4 percent).

Emissions of SO_2 from the energy sector comprised 85.2 percent of total SO_2 emissions. The manufacturing industries and construction and energy industries made up 54.0 percent of total SO_2 emissions. The other source of SO_2 was from the industrial processes sector.

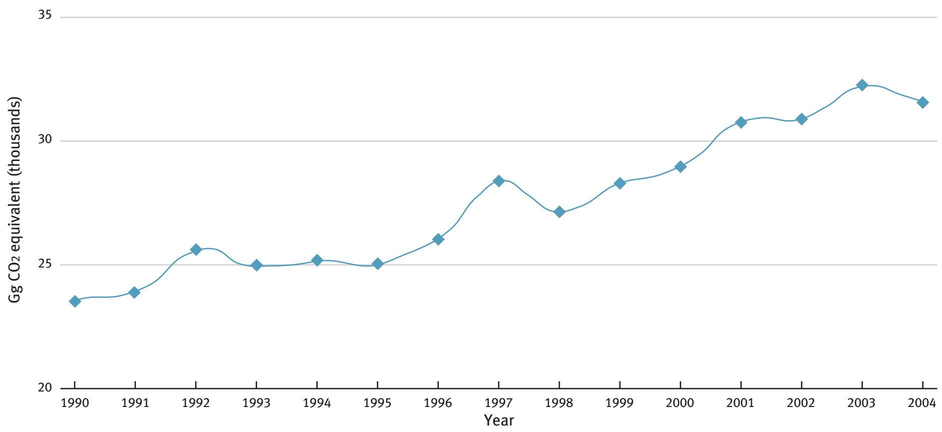
Chapter 3:

Energy

3.1 Sector overview

The energy sector produced 31,647.91 Gg CO_2 equivalent in 2004 and represented 42.4 percent of New Zealand's total greenhouse gas emissions. Emissions from the energy sector are now 33.8 percent above the 1990 baseline value of 23,655.15 Gg CO_2 equivalent (Figure 3.1.1). The sources contributing most to this increase since 1990 are emissions from "road transportation" (an increase of 62.7 percent) and public electricity and heat production (an increase of 73.6 percent) subcategories. Emissions from the "manufacture of solid fuels and other energy industries" subcategory have decreased by 1482.58 Gg CO_2 equivalent (83.4 percent) from 1990, mainly due to the ceasing of synthetic petrol production in 1997.

Figure 3.1.1 Energy sector emissions 1990 – 2004



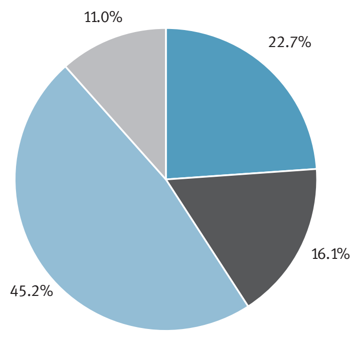
3.2 Fuel combustion (CRF 1.A)

3.2.0.1 Description

The "fuel combustion" category includes all emissions from fuel combustion activities, specifically: energy and transformation industries, manufacturing industries, transport and other subcategories – namely 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. Annex 8.1 shows the calculation worksheets used for the 2004 inventory. Information about methodologies, emission factors, uncertainty and quality assurance relevant to several subcategories are discussed below.

Figure 3.2.1 Emissions from the energy sector: fuel combustion category in 2004 (all figures Gg CO_2 equivalent)



Energy Industries	7,184.39 Gg
Manufacturing Industries and Construction	5,093.10 Gg
Transport	14,313.20 Gg
Other Sectors	3,475.47 Gg

3.2.0.2 Methodological issues

Energy sector emissions for New Zealand's inventory are compiled from the Ministry of Economic Development (MED)'s energy database along with the 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 sources of emissions – stationary combustion and mobile combustion. CO_2 emissions from the stationary combustion of gas, solid and liquid fuels are identified as key categories for New Zealand in the 2004 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 fuels combusted by sector but not by plant. The methodologies used for the energy sector are consistent with the Tier 1 sectoral approach. Good practice for methodological choice in the mobile combustion (transport) category is discussed in Section 3.2.3 – Fuel combustion: transport.

Emission factors

New Zealand emission factors are based on the GCV (Gross Calorific Value). This is because energy use in New Zealand is conventionally reported in gross terms with some minor exceptions (refer Annex 2). New Zealand did commission a review of all emission factors used in the energy sector in 2003 (Hale and Twomey, 2003). In accordance with good practice, where there was a significant difference between country-specific and IPCC default emission factors, and the country-specific factors could not be supported, New Zealand reverted to the IPCC default emission factors (refer to Annex 2). The new emission factors recommended by the review and agreed by a review panel were first used in the 2002 inventory. They have been used in all subsequent inventories.

Prior to 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). These are replaced with the emission factors for individual liquid fuels derived from the New Zealand Refining Company data on carbon content and calorific values (Annex 2) as a result of the 2003 review of energy sector emission factors. 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 percent and is primarily due to uncertainty in activity data rather than emission factors (IPCC, 2000). This is due to 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 99.6 percent 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 they vary with the 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 thought to be reasonably accurate but lack a rigorous foundation (MED, 2005).

Table 3.2.1 General uncertainty ranges for emission estimates from fuel combustion (MED, 2005)

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 fuels burnt in stationary combustion including combustion for "public electricity and heat production", "petroleum refining", and the "manufacture of solid fuels and other energy industries".

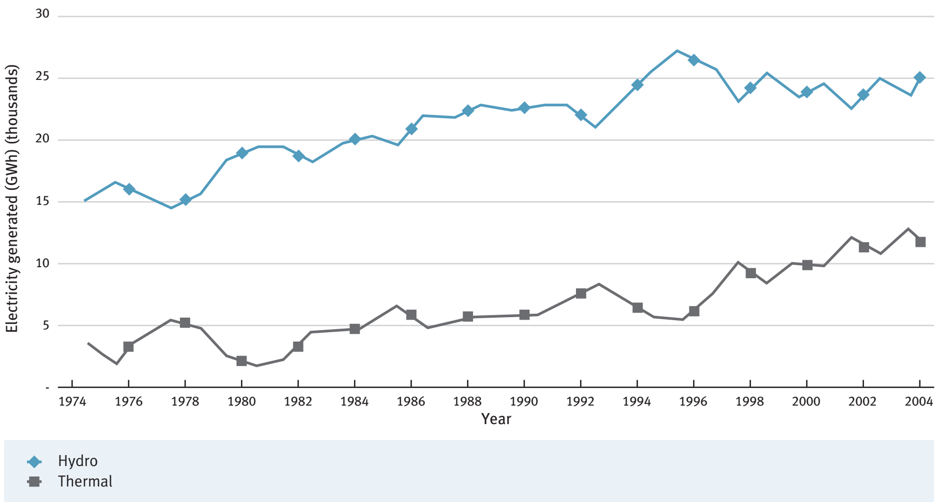
Emissions in the "energy industries" category totalled 7,184.39 Gg CO_2 equivalent in 2004 and have increased 1,139.42 Gg CO_2 equivalent (18.8 percent) since 1990. The emissions profile in 2004 is dominated by emissions from "public electricity and heat production" which contributed 84.4 percent of the CO_2 equivalent emissions from the "energy industries" category.

New Zealand's electricity generation is dominated by hydro-electric generation. On average, 67 percent of annual electricity needs are met by hydro-electric generation. Geothermal power contributes another 7 percent and there are also contributions from other renewable sources such as wind and co-generation using wood. The balance is provided by thermal generation using natural gas and coal.

Greenhouse gas emissions from public electricity generation show large year-to-year fluctuations because use of thermal stations complements the hydro-electric generation available. Generation in a 'normal' hydro year requires lower gas and coal use and 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 used in electricity generation found in many other countries.

Figure 3.2.2, which shows net electricity production by fuel type from 1974 to 2004, clearly illustrates that on an annual basis when the level of hydro-electric generation decreases, the level of thermal generation (gas, coal and oil) increases. It should be noted that 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 1974-2004



3.2.1.2 Methodological issues

Public electricity and heat generation

The CO_2 emissions from coal use in electricity generation are derived from coal use figures provided by the sole electricity generator that uses coal. 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. However, where electricity generation is the primary activity the emissions should be included in the "electricity and heat production" category.

For New Zealand's inventory the enterprise in question is taken to encompass both the industrial facility proper and the attached co-generation plant. 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" while emissions from other co-generation plants are included under the "manufacturing industries and construction (other)" subcategory.

Petroleum refining

Energy use data for "petroleum refining" subcategory are supplied to the MED 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 (IEF's) 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. In 1997, production of synthetic petrol in New Zealand ceased.

New Zealand has a gas field with particularly high CO_2 content (the Kapuni field– refer 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 sub-categories. The sequestration of carbon in synthetic petrol made up for this difference prior to 1997.

Emission factors

CO_2 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 NCV is 5 percent less than the GCV. In line with good practice (IPCC, 2000) carbon dioxide 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 8.1.

3.2.1.3 Uncertainties and time-series consistency

Uncertainties in emissions estimates are those 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

The review of energy sector emission factors (Hale and Twomey, 2003) encompassed the emission factors used in the "manufacturing industries and construction" subcategory. In preparation of the 2004 inventory, the data for electricity production and petroleum refining underwent a Tier 1 QC checklist.

3.2.1.5 Source-specific recalculations

Data revision by the MED has resulted in the minor recalculation of the "energy industries" category.

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 5,093.10 Gg CO_2 equivalent in 2004. The level of emissions in 2004 has reduced by 14.3 percent compared to 2003, and is 10.4 percent over the 1990 baseline. The largest single source in 2004 is the "chemicals" subcategory, made up entirely of emissions from natural gas consumption in the manufacture of methanol. Emissions from this subcategory have halved since 2002, largely due to a decline in the availability of low-priced natural gas. However, emissions still comprised 15.9 percent of emissions from "manufacturing industries and construction category".

3.2.2.2 Methodological issues

The energy data for methanol production is supplied directly to MED. CO_2 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-making is also supplied direct to MED. The data for other industry uses of gas are from the energy supply and demand balance tables in the Energy Data File (MED, 2005).

Box 3.1 Calculation of CO_2 emissions from methanol production (MED, 2005)

Assumptions

- Synthetic petrol is 85.8% carbon by weight.
- Methanol is 37.5% carbon by weight.
- CO_2 emissions factor for Maui gas is 52.8 kt / PJ (2002) (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)*52.8 + (PJ Kapuni)*84.1 + (PJ mixed feed)*62.4] *12/44 kilotonnes.
- Weight of carbon in petrol = [amount of petrol produced * 0.858] kilotonnes.
- Weight of carbon in methanol = [amount of methanol produced * 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)] * 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. These sources of activity data are further described in Annex 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 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 only the "iron and steel" and "chemicals" sub-categories. The reason for this is that 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 Methanex.

The worksheets used for calculating emissions from the "manufacturing industries and construction" category are shown in Annex 8.1.

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 the 2004 inventory, the data for CO_2 emissions from stationary combustion – manufacturing industries and construction underwent a Tier 1 QC checklist.

3.2.2.5 Source-specific recalculations

Data revision by the MED has resulted in the minor recalculation of the "manufacturing industries and construction" category.

3.2.3 Fuel combustion: transport (CRF 1A3)

3.2.3.1 Description

This category comprises emissions from fuels combusted in transportation, including civil aviation, road transport, rail transport and national navigation. Emissions from international marine and aviation bunkers are reported but not included in the total emissions.

Emissions from the "transport" category totalled 14,313.20 Gg CO_2 equivalent in 2004 and have increased 5,456.45 Gg CO_2 equivalent (61.6 percent) from the 8,856.75 Gg CO_2 equivalent emitted in 1990. The emissions profile in 2004 is dominated by emissions from the "road transportation" subcategory which accounted for 87.2 percent of total transport emissions. CO_2 emissions from the "road transportation" subcategory was identified as having a major influence on the trend in New Zealand's greenhouse gas emissions in the key category trend analysis (Table 1.5.3).

3.2.3.2 Methodological issues

Emissions from transportation are compiled from the MED'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 *Wholesale deliveries* census conducted by Statistics New Zealand. LPG and CNG consumption figures are reported in the Energy Data file (MED, 2005).

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. However emissions from these gases are more complicated to estimate accurately because emission factors depend on vehicle technology, fuel and operating characteristics. The Ministry of Transport (MoT) has been developing a vehicle fleet model which was used as a quality check for the CO_2 emissions from road transport in the 2003 inventory. This model however currently is unable to provide accurate emission factors for the non CO_2 gases. New Zealand therefore estimates CH_4 and N_2O emissions from road transport using a Tier 1 approach. Emission factors of CO_2 and non-CO_2 gases for various fuel types can be found in Annex 2.

Navigation

Good practice in methodology choice for navigation in New Zealand is to use 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 (IPCC 2000). The current New Zealand methodology meets good practice. Prior to 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 recommended reverting to the IPCC default factors (Hale and Twomey, 2003).

Aviation

The New Zealand methodology for estimating emissions from domestic 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 LTOs (IPCC, 2000). The distinction between domestic and international flights is based on refuelling at the domestic and international terminals of New Zealand airports respectively. There is no basis to split the domestic and international components of fuel use for international flights with a domestic leg. This is because aviation and marine fuel use information is available from the oil companies rather than from the airlines or the shipping companies.

The worksheets used for calculating emissions from the "transport" category are shown in Annex 8.1.

3.2.3.3 Uncertainties and time-series consistency

Uncertainties in emission estimates are those 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

CO_2 emissions from road transport and aviation are identified as key categories for New Zealand in the 2004 inventory. In preparation of the 2004 inventory, the data for these emissions underwent a Tier 1 QC checklist.

3.2.3.5 Source-specific recalculations

Data revision by the MED has resulted in the minor recalculation of the "transport" category.

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" subcategory, the "residential" subcategory and the "agriculture, forestry and fisheries" subcategory.

Emissions from fuel combustion of the "other sectors" category totalled 3,475.47 Gg CO_2 equivalent in 2004 and are 543.51 Gg CO_2 equivalent (18.5 percent) over the 1990 baseline value of 2,931.96 Gg CO_2 equivalent. The emissions contribution in 2004 is divided between the "commercial and institutional" subcategory (49.1 percent), and the "agriculture, forestry and fisheries" subcategory (33.7 percent), with the "residential" subcategory comprising the remaining 17.3 percent of emissions.

3.2.4.2 Methodological issues

The energy activity data are obtained from the same sources as other energy categories (Annex 2). However, in partitioning energy use between categories, emissions from the "agriculture, forestry and fisheries" subcategory are likely to be underestimated (MED, 2005). This is because there are no separate estimates of fuel use by this group, apart from 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 8.1.

3.2.4.3 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).

3.2.4.4 Source-specific QA/QC and verification

In preparation of the 2004 inventory, the data for the "other sectors" category underwent a Tier 1 QC checklist as part of a selection of non-key categories chosen for quality checking. As this category is a non-key source and was not on the list of non-key categories to undergo quality checks for 2004 it did not undergo a Tier 1 quality check for this inventory submission.

3.2.4.5 Source-specific recalculations

There were no recalculations for this category.

3.3 Fugitive emissions from fuels (CRF 1B)

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

3.3.1.1 Description

Fugitive emissions arise from the production, processing, transmission, storage and use of fuels, and from non-productive combustion. Fugitive emissions from the "solid fuels" category produced 311.88.Gg CO_2 equivalent in 2004. This is an increase of 39.75 Gg CO_2 equivalent (14.6 percent) from the 272.13 Gg CO_2 equivalent 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 to underground mines. In 2004, 75 percent 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 utilisation.

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). In 2004, coal production from underground mining by weight was 255 kt bituminous coal and 472 kt sub-bituminous coal. The calculation worksheets used for fugitive emissions are shown in Annex 8.1.

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 emissions are those relevant to the entire energy sector (refer Table 3.2.1 and Annex 2).

3.3.1.4 Source-specific QA/QC and verification

In preparation of the 2004 inventory, the data for the "solid fuels" category underwent a Tier 1 QC checklist as part of a selection of non-key categories chosen for quality checking. As this category is a non-key source, and was not on the list of non-key sources to undergo quality checks for 2004, it did not undergo a Tier 1 quality check for this inventory submission.

3.3.1.5 Source-specific recalculations

There were no recalculations for this category.

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 1,269.86 Gg CO_2 equivalent in 2004. This is an increase of 333.66 Gg CO_2 equivalent (35.7 percent) from 936.20 Gg CO_2 equivalent 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 source are not technically due to flaring, they are included under this category due to confidentiality concerns. CO_2 is also produced when natural gas is flared at the wellheads of other fields. The combustion efficiency of flaring is 95-99 percent (MED, 2005), leaving some fugitive emissions due to the incomplete combustion.

Fugitive emissions also occur in transmission and distribution of the natural gas. The large increase in CO_2 emissions for this source between 2003 and 2004 (from 367 to 601 Gg CO_2 equivalent) is related to the drop in methanol production. As discussed earlier, methanol production has dropped significantly since 2002. Carbon previously sequested during this process is now being released as fugitive emissions from venting at the Kapuni Gas Treatment Plant.

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 this category. This is because they are not the result of fuel combustion, unlike the emissions reported under 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 a data from field operators or calculated from supplied energy data and country-specific emission factors. This conforms to good practice in methodology choice (IPCC, 2000). The major categories are discussed further in this section. The calculation worksheets used for fugitive emissions are shown in Annex 8.1.

Venting and flaring from oil and gas production

The CO_2 released through flaring is either supplied directly by field operators or calculated from the supplied energy data using the emission factors from Baines (1993). The Natural Gas Corporation (NGC) 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. Approximate estimates of annual leakage in 2004 from transmission pipelines, provided by NGC, are less than 25 tonnes of CO_2 and approximately 183 tonnes of CH_4 (MED, 2005). Therefore, the gas quantity shown in the worksheets excludes the gas used in electricity generation and by others that take their gas directly from the transmission network. The NGC estimates that around 3.5 percent of the gas entering the distribution system is unaccounted for and that around half of this (1.75 percent) is actually lost through leakage, whilst 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 Oil Transport, Refining and Storage sub-categories are calculated using an IPCC Tier 1 approach with activity data and emission factors. For Oil Transport, the fuel activity data is the total New Zealand production of crude oil reported in the Energy Data File (MED, 2005), and the CH_4 emission factor is the midpoint of the IPCC default value range (0.745 t CH_4 / PJ). Emissions from refining and storage are both 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, while the emission factor for storage is 0.14 t CH_4 / PJ (a New Zealand specific emission factor). The combined emissions factor for refining and storage is 0.885 t CH_4 / PJ, derived by adding the emissions factors for refining and storage together.

Geothermal operations

Estimates of CO_2 and CH_4 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

Data revision by the MED has resulted in the minor recalculation of the "oil and natural gas" category.

3.4 Other information

3.4.1 Comparison of sectoral approach with reference approach

The calculation for the reference approach 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 2004.

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 differ from year to year are estimated based on a production derived weighted average of emission factors for each of New Zealand's gasfields. This 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 total in 2004 shows the reference total of CO_2 emissions is 1.46 percent less than the sectoral total (Table 3.4.1). This is mainly related to the differences in energy consumption, although, it is difficult to compare energy consumption in the reference approach with energy consumption in the sectoral approach.

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 MED or by the MED itself. The differences between 'calculated' and the 'observed' figures are reported as statistical differences in the energy balance tables contained in the Energy Data File (MED, 2005).

The energy use and calculated emissions for the major fuel categories are not directly comparable between the reference and sectoral approaches. Firstly the reference approach counts non-energy sector use of fuels such as gas in urea production, coal in steel production and bitumen use, while 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 in the sectoral approach, combustion of refinery gas is included under gaseous fuels consumption but this is not the case in the reference approach. This is because refinery gas is a by-product of the refining process derived from the crude oil inputs. Consequently, in the reference approach the emissions from the combustion of refinery gas are counted against crude oil.

The time-series comparison with the IEA data (IEA Statistics, 2005) shows that the differences between the sectoral and reference approach reported in CRF 2004 are generally less than those reported by the IEA. There are clear differences in the early part of the time-series and there is a clear trend narrowing the difference between the two sources that indicates stronger correlation in the reporting process developed over the annual inventory preparation process.

The percentage difference between the CRF 2004 and the IEA sectoral approaches is quite large. New Zealand will endeavour to investigate why there is such a large degree of disagreement between the two series.

Table 3.4.1 Percentage difference between the reference and sectoral approach for New Zealand's inventory and the 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		

3.4.2 International bunker fuels

The data on fuel use by international transportation come from the Energy Data File (MED, 2005). This sources information from oil company returns provided to the MED. 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 Feedstocks and non-energy use of fuels

The fuels supplied to industrial companies are used both as fuel and as feedstock. The emissions are calculated using the total fuel supplied to each company (this includes fuel used as feedstock) and estimating the difference between the carbon content of the fuels used and the carbon sequestered in the final output (this is based on the industry production and the 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 above. 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.

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 methodology. The differences that exist are listed below:

- A detailed subdivision of the manufacturing and construction source category as requested by 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 (refer to Worksheet 1.1, Annex 8).

- The activity data shown in the CO_2 worksheets (Worksheet 1.2, 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 and is necessary to preserve the confidentiality of the gas-use 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

A table showing the 2004 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 4202.53 Gg CO_2 equivalent in 2004 and represented 5.6 percent of total greenhouse gas emissions. Emissions from industrial processes are now 987.92 Gg CO_2 equivalent (30.7 percent) above the 1990 baseline of 3214.61 Gg CO_2 equivalent (Figure 4.1.1). The sector is dominated by emissions from the metal production category (carbon dioxide (CO_2) and perfluorocarbons (PFCs)) at 56.3 percent of sectoral emissions.

Figure 4.1.1 Industrial processes sector emissions 1990-2004

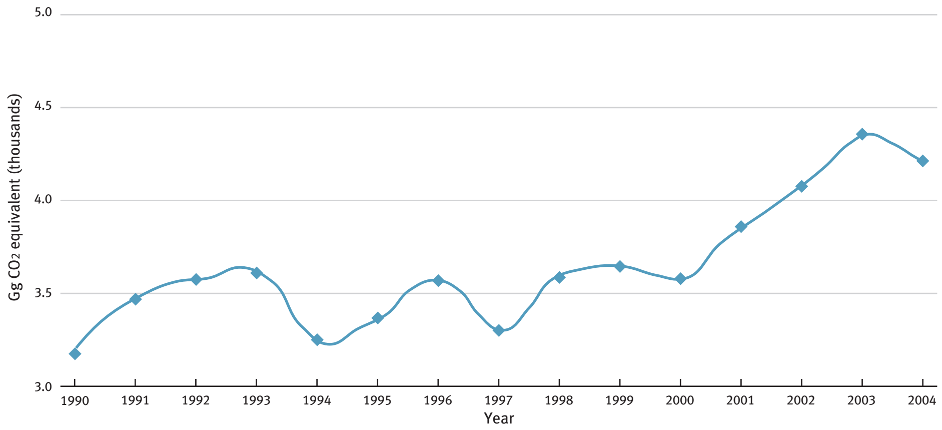
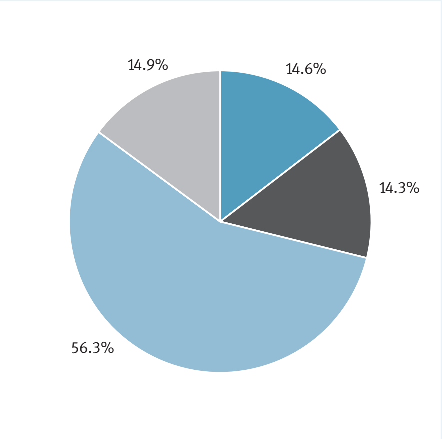


Figure 4.1.2 Industrial processes sector emissions in 2004 (all figures Gg CO_2 equivalent)



Mineral Products	612.79 Gg
Chemical Industry	599.39 Gg
Metal Production	2,364.50 Gg
Consumption of Halocarbons and SF_6	625.85 Gg

The emissions included in the industrial processes sector arise 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 (MED, 2005);

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

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 survey. The results are reported in the publication New Zealand Energy Greenhouse Gas Emissions 1990-2004 (MED, 2005).

Data on non-CO_2 emissions are gathered through a questionnaire distributed directly to industry via consultants contracted to the Ministry for the Environment. 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 information 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 worksheets for this sector (Annex 8.2).

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 percent (MED, 2005). 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 612.79 Gg CO_2 equivalent in 2004. Overall, emissions in the "mineral products" category have grown by 158.80 Gg equivalent (35.0 percent) from the 1990 level of 453.99 Gg CO_2 equivalent. 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 (79 percent) and lime (20 percent). 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

Since 1997, estimates of CO_2 emissions from cement production have been calculated by multiplying the amount of clinker produced by a plant-specific emission factor for clinker, in accordance with IPCC Tier 2 methodology (IPCC, 1996). The emission factors used are based on the CaO and MgO content of the clinker produced. Therefore, emissions from the decomposition of $MgCO_3$ into MgO and CO_2 are included along with emissions from the decomposition of $CaCO_3$. Two cement companies currently operating in New Zealand take account of CO_2 emissions from non-recycled cement kiln dust.

For the years 1990 to 1997, emissions are calculated using a Tier 1 approach. Total cement production is multiplied by a country-specific emission factor (0.51 t CO_2 / t cement). Clinker data, which is required for the Tier 2 approach, cannot be provided by the companies for the years 1990-1996. Clinker data was recorded by the companies from 1997-2004 so the Tier 2 approach has been able to be implemented for this time period. The use of both Tier 1 and Tier 2 approaches for this time series is unavoidable as this the only dataset on CO_2 emissions from cement production available in New Zealand.

The cement production activity data in the CRF reporter shows an increase from 1996-2004 however the CO_2 implied emission factor for cement production has decreased over the same period. After 1996 the demand for cement in New Zealand increased. The local cement companies had to import clinker to meet this demand. CO_2 emissions from cement production using the Tier 2 approach are only calculated from locally produced clinker (IPCC, 2000). The decrease in the CO_2 implied emission factor can be explained by the increase in cement production over the period 1997-2004 while the CO_2 emissions have remaining relatively steady due to the increase in imported clinker and a change in national standards for cement production (reducing the relative levels of clinker required to produce a given amount of cement).

SO_2 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 percent of the SO_2 will be absorbed by the alkaline clinker product. New Zealand uses a SO_2 emissions factor calculated using industry specific information. This emission factor has been updated with improved information from industry available during 2005. The emission factor was able to be calculated using information from a sulphur mass balance study on one company's dry kiln process. This was able to determine the split between sulphur originated in the fuel and sulphur in the raw clinker material as sodium and potassium salts. 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 lime industry. Carbon dioxide emissions from lime production are supplied to the Ministry of Economic Development by industry. Emissions are calculated by multiplying the amount of lime produced by an emission factor. Prior to 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 is the only available information available for this source for the years 1990-2001. From 2002, the emission factors used were plant-specific as the companies were able to supply this information for these more recent years. There has been little change to the implied emission factor – from 0.72 t CO_2 / t lime in 2001 to 0.73 t CO_2 / t lime from 2002 to 2004.

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

All limestone use in New Zealand is used for making lime or cement. Therefore emissions arising from these processes are reported under the cement and lime production categories as specified in the IPCC 1996 guidelines (section 2.5.1).

Soda ash production and use

There is no soda ash production in New Zealand. A survey of the industrial processes sector in 2005 was able to make some estimates of carbon dioxide emissions resulting from the use of soda ash in glass production after consultation with the sole glass manufacturer in New Zealand. The manufacturer was able to provide information on the amount of imported soda ash it utilised in 2005. It also provided approximate proportions of recycled glass over the last 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. Emissions are calculated using activity data supplied by the company. The industrial processes survey undertake 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. Emission factors for NMVOC and CO are from the IPCC Guidelines (IPCC, 1996).

Road paving with asphalt

Data on emission rates and bitumen production are provided by the three main road paving companies. Estimates of national consumption of bitumen for road paving are confirmed by the New Zealand Bitumen Contractors Association. In New Zealand, approximately 40 percent of the bitumen used for road paving is used for asphalt and 60 percent is for chip-seal resealing. Solvents are rarely added to asphalt, so asphalt paving is not considered a significant source of emissions. The main emissions from the road paving industry are from chip-seal resealing. New Zealand still uses a wet 'cut-back' bitumen method rather than bitumen emulsions common in other countries. The average solvent content in bitumen has been reducing in recent years as methods of laying bitumen have improved (CRL Energy Ltd, 2006).

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 from the 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. Since the bitumen content of asphalt in New Zealand is only 6 percent, there is no possibility of this level of NMVOC emissions. 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 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 NMVOC in the CRF 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 only 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. The industrial processes survey undertaken in 2005 was able to obtain estimates of CO_2 from soda ash use (see soda ash paragraph above) and SO_2 emissions from sodium sulphate decomposition. It has been assumed that the IPCC emissions factor is based on total glass production which includes recycled glass input. Activity data has been updated with estimates for years prior to 1995 extrapolated. NO_x and CO emissions are assumed to be associated with fuel use while NMVOC and SO_2 emissions are assumed to be associated with the industrial process because they are associated with the raw materials.

4.2.3 Uncertainties and time-series consistency

Uncertainties in CO_2 emissions are assessed as ± 5 percent 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, 2006).

Table 4.2.1. Uncertainty in non-CO_2 emissions from the mineral products industry

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

CO_2 emissions from cement production has, in past inventories, been identified as a key source category. In the 2004 inventory, CO_2 from cement production was not identified as a key source category (level assessment) but was in 1990. In preparation of this inventory, the data for these emissions underwent Tier 1 QC checks.

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

4.2.5 Source-specific recalculations

The inclusion of estimates of CO_2 arising from the use of soda ash in the glass production industry has been included for the first time in the 2004 inventory for all years from and including 1990. 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 in 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 599.39 Gg CO_2 equivalent emissions in 2004 and have increased 154.03 Gg CO_2 equivalent (34.6 percent) from the 445.37 Gg CO_2 equivalent estimated in 1990. CO_2 emissions from ammonia/urea production account for 68.3 percent of emissions in this category.

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 MED by the firm operating the plant. CO_2 emissions are calculated based on the assumption that all of the carbon in the gas used to produce the urea is eventually released. Emissions are calculated by multiplying the quantities of the different types of gas used by their respective emission factors (Annex 2.3). 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.

For the 2004 inventory emissions from urea production have been allocated to the "ammonia production" category. This was recommended in the review of New Zealand's 2003 inventory. In the 2003 inventory they were reported under a country-specific category "urea production".

Non-CO_2 emissions are considered by industry experts to all be arising from fuel combustion and are 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 were undetectable for at least two plants representing 60 percent of total formaldehyde production.

Methanol

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

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 CH_4/kg production) is appropriate for New Zealand (CRL Energy Ltd, 2006).

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 while one plant now imports acid. Both companies have supplied activity data and emission factors for sulphur dioxide (SO_2).

Sulphur dioxide 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 between 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 MED from the two companies involved. Most hydrogen produced in New Zealand is made by the New Zealand Refining Company as a feedstock at the Marsden Point refinery. Another firm produces a small amount 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 is 6.45 kt CO_2 per kt of hydrogen produced (MED, 2005).

4.3.3 Uncertainties and time-series consistency

Uncertainties in CO_2 emissions are assessed as ± 5 percent 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, 2006). 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% (NMVOC)
Methanol	0%	± 50% (NO_x and CO) ±30% (NMVOC) ±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

This category was checked in 2003 as part of quality control checks of non key categories so was not included in the schedule of non key categories to be checked in the 2004 inventory.

4.3.5 Source-specific recalculations

Ammonia was allocated from a country-specific category created during the 2003 inventory "urea production" to the "ammonia production" category as recommended by the international review team (UNFCCC, 2006).

Activity data has been estimated for all years for formaldehyde and EF for NMVOC changed from IPCC default to a country-specific one (1.5 kg NMVOC/tonne formaldehyde).

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. These sources are both key source categories for New Zealand (Table 1.5.2). PFC emissions from aluminium production are 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 rose 2.5 percent from the 2,305.79 Gg CO_2 equivalent recorded in 1990. CO_2 emissions account for 96.6 percent of emissions in this category with another 3.4 percent from PFCs. In 2004, the level of CO_2 emissions has increased by 496.48 Gg CO_2 equivalent (27.8 percent) over the 1990 baseline. However, the level of PFCs has decreased from the 515.60 Gg CO_2 equivalent in 1990 to 80.70 Gg CO_2 equivalent in 2004, a decrease of 434.90 Gg CO_2 equivalent (84.3 percent).

The decrease in PFC emissions is because the sole aluminium smelter in New Zealand now has a low anode effect duration by world standards. Anode effects are caused by depletion of alumina. The modern technology now in use introduces alumina into the pot quickly and extinguishes the anode effect. The smelter feeds 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

New Zealand calculates emissions from iron and steel manufacture based on the quantities of the reducing agents used and the quantities of other non-fuel carbon-bearing ingredients used in the process such as electrodes. An allowance is made for the carbon sequested in the steel.

There are two steel producers in New Zealand. The smaller plant, which produces approximately 200 kt of steel a year, operates an electric arc furnace, turning scrap metal into steel. As this plant does not perform the operation of turning iron-ore into iron, emissions from this plant are comparatively small – less than 25kt of CO_2 emissions per year. The other much larger steel plant produces steel from titanomagnetite ironsand and therefore produces the bulk of the emissions. A direct reduction process is used to smelt iron, where the primary reducing agent is sub-bituminous coal rather than coke, as in the traditional blast furnace method of smelting. 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 the plant uses. The molten pig-iron is converted to steel in a KOBM oxygen steel making furnace. Prior to 1998, the plant also melted over 100,000 t per year of scrap in an electric arc furnace.

New Zealand uses a modification of the Tier 2 approach for calculating emissions from iron and steel production. Firstly, New Zealand does not account for emissions from pig iron and steel production separately as all of the pig iron is transformed into steel. Secondly, the carbon in the ironsand, thought to be negligible, is not accounted for. Thirdly, due to lack of data, the carbon in the scrap metal consumed by the largest steel plant when it operated an electric arc furnace is not accounted for, although this omission should also have a negligible effect on emissions estimates. Finally, also due to a lack of data, for the years prior to 2000, emissions from the plant operating the electric arc furnace 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 (around 0.1 t CO_2 / t steel). The Ministry of Economic Development advises this should not have a large effect on total iron and steel emissions, given emissions from this plant are small.

Care has been taken not to double-count coal use for 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 non-CO_2 emission factors are based on measurements in conjunction with mass balance (for SO_2) and technical reviews (CRL Energy Ltd, 2006).

Aluminium

CO_2 emissions and production data are supplied by New Zealand's sole aluminium smelter. The technology type used on site is Centre Work Pre Bake (CWPB). Carbon anode oxidisation is responsible for almost 90 percent of the CO_2 emissions from aluminium production. The carbon consumption is multiplied by 3.812 to convert C to CO_2 (as compared with 3.666 if the standard atomic weights ratio of 44/12 is used). This number is specific to Comalco smelters to take into account some other process losses (Bloor, 2005). Other emissions come from fuel combustion (various fuels are used-heavy fuel oil, LPG, petrol and diesel) and are included in the energy sector (MED, 2005; Bloor, 2005).

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. SO_2 emissions are calculated from the input sulphur levels and direct monitoring.

Emissions of the two PFCs (CF_4 and C_2F_6) from the production of aluminium are supplied by the operator of New Zealand's sole aluminium smelter. The PFC emissions from aluminium smelting are calculated using a Tier 2 method. This involves using the IPCC default coefficients for Centre Worked Prebake technology in the slope equation together with smelter-specific operating parameters. Anode effect frequency is multiplied by duration. The smelter captures every anode effect both in terms of count and of duration through its process control software. All monitoring data are logged and stored electronically, with no data estimated, to give the value known as "anode effect minutes per cell day". This value is then multiplied by the hot metal tonnes 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 Pre Bake technology are used. The smelter advises that there are no plans by the smelter company to directly measure PFC emissions in the future so a smelter specific long term relationship between measured emissions and operating parameters is not likely to be established in the near future.

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 2004.

4.4.3 Uncertainties and time-series consistency

Uncertainty in CO_2 emissions is assessed as ± 5 percent 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, 2006). These are documented in Table 4.4.1.

Table 4.4.1 Uncertainty in non-CO_2 emissions from the metal industry

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, 2006).

4.4.4 Source-specific QA/QC and verification

CO_2 emissions from iron and steel production and aluminium production are key categories for New Zealand. These sources have undergone a Tier 1 QC check in preparation of the 2004 inventory.

4.4.5 Source-specific recalculations

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

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 2004, emissions from this category totalled 7.14 Gg NMVOC. This was an increase of 1.24 Gg NMVOC 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 2004 was responsible for 54 percent of all pulp production with chemical production responsible for 46 percent. 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 because using the IPCC default factors appears likely to significantly over-estimate emissions in the New Zealand context. In absence of better information the NMVOC emission factor applied to the chemical pulping processes is also applied to the thermomechanical pulp processes to estimate the emissions from that source (CRL Energy Ltd, 2006). Emissions of CO and NO_x from these processes are more likely to be fuel combustion related.

Food and drink

NMVOC 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 occur after the slaughtering of animals or harvesting of crops. Estimates of 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.

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, 2006). These are documented in Table 4.5.1.

Table 4.5.1 Uncertainty in non-CO_2 emissions from the other production category

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

No specific QA/QC activities are performed for this category. However, 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 625.85 Gg CO_2 equivalent in 2004. This is an increase of 462.84 Gg CO_2 equivalent (283.9 percent) from the 1995 level of 163.01 Gg CO_2 equivalent. This large increase is due to the replacement of CFCs and HCFCs with HFCs. HFC emissions are identified as a key category in the level and trend analysis of the 2004 inventory (Tables 1.5.2 and 1.5.3). SF_6 emissions have increased from 12.14 Gg CO_2 equivalent in 1995 to 21.49 Gg CO_2 equivalent in 2004, an increase of 77.0 percent.

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, however PFCs are produced from the aluminium smelting process (discussed in the metal production category). The use of HFCs/PFCs 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 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 percent of the charge of 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. In past surveys (up until 2001), the Ministry of Economic Development had compiled a detailed breakdown of bulk HFCs using information from import licences for a range of mixtures that included HFCs and PFCs. This analysis has not been carried out for four years. Consequently there is no longer an accurate independent check on the total imports reported by bulk chemical suppliers.

Activity data was collected directly from importers and distributors to identify the end users of imported bulk HFCs and PFCs. This information was used to determine the proportion of bulk chemical used in each sub-source category.

Several additional importers were identified for this survey compared to 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 data for refrigeration, potential emissions from refrigeration could not be calculated for each specific HFC chemical and as a result the total potential emissions for consumption of halocarbons are underestimated.

Table 4.7.1 Halocarbon and SF_6 calculation methods and emission factors

HFC source	Calculation method	Emission factor
Aerosols	IPCC GPG 2001 Eqn 3.35	IPCC default factor of 50%of the initial charge per year
Foam	IPCC GPC 2001 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 2001 Eqn 3.44	Top-down approach does not require emission factors
Stationary refrigeration/air conditioning	IPCC GPG 2001 Eqn 3.40	Top-down approach does not require emission factors
Fire protection	IPCC GPG 2001 Eqn 3.51	Bottom-up approach using emission rate of 0.015
SF_6 source	**Calculation method**	**Emission Factor**
Electrical equipment	IPCC GPG 2001 Eqn 3.17	Tier 3 approach based on overall consumption and disposal with country-specific EF of 1% and this was supplemented by information from equipment manufacturers and servicing contractors using IPCC default EF of 2% (Tier 2b approach).
Other applications	IPCC GPG 2001 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 (MDIs) used from 1999 to 2004 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 prior to 1996 and HFC-134a was not used in metered dose inhalers (MDIs) 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, 2006a).

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 emissions exported (CRL Energy 2006a). 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.

Stationary refrigeration/air conditioning

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 minus 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.

In terms of household refrigeration it is estimated that on average 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 cases 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.

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).

Mobile air conditioning (MAC)

The automotive industry has used HFC-134a as the refrigerant for mobile air conditioning (MAC) in new vehicles since 1994. HFC-134a is imported into New Zealand for use in the MAC 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). 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 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 during accidental discharges.

The method selected for estimating emissions from this sub-source category is the bottom-up approach. For each year, an emission rate of 1.5 percent 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 2004 inventory, emissions are calculated using the Tier 3c approach for the majority of electrical switchgear emissions and supplemented by information from equipment manufacturers and servicing contractors. One firm representing 80-90 percent of the total SF_6 held in equipment provided sufficient information for the Tier 3 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, 2006a). Potential emissions of SF_6 were calculated and included in the 2004 inventory.

4.7.3 Uncertainties and time-series consistency

The uncertainties surrounding 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 HFC/PFC calculations (from 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 preparation of the 2004 inventory, the data for consumption of halocarbons and SF_6 underwent a Tier 1 QC check. During the collection and calculation of data, 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

The 2005 survey for industrial processes was redesigned for HFCs from stationary refrigeration and air conditioning to capture more importers of HFCs and PFCs and to better identify the refrigerant associated with imported and exported factory charged refrigeration and air-conditioning units. This has resulted in HFC and PFC emissions higher (up to 3.6 times higher) than in previous inventory submissions. The approach used is assessed by industry experts to represent an upper limit for HFC/PFC emissions from commercial refrigeration and air conditioning but is the most accurate and complete data available. This survey has resulted in HFC and PFC emissions for this category being recalculated for the entire time series.

SF_6 data has been updated for the years 1991-1992 and 2000-2003.

4.8 Other (CRF 2G)

4.8.1 Description

Panel products

Activity data is obtained from industry and supplemented with statistics from the Ministry of Agriculture and Forestry website. 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.

Chapter 5:

Solvent and other product use

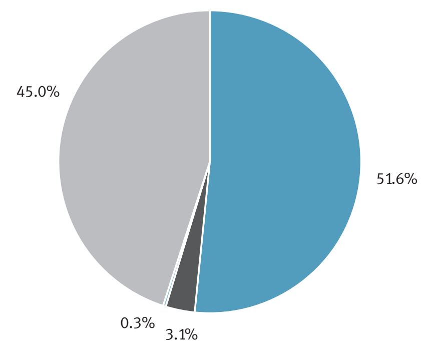
5.1 Sector overview (CRF 3)

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.

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.

Emissions from the solvents and other product use sector in 2004 comprised 31.94 Gg of NMVOC. This is an increase of 4.23 Gg (15.2 percent) from 27.71 Gg in 1990. The categories dominating the sector are NMVOC emissions from paint application and domestic and commercial use (Figure 5.1.1).

Figure 5.1.1 Emissions of NMVOC from the solvent and other product use sector in 2004 (all figures Gg NMVOC)



■	Paint application	16.48 Gg
■	Degreasing and drycleaning	0.99 Gg
■	Chemical products	0.09 Gg
■	Other	14.38 Gg

In 2004, N_2O emissions from anaesthesia use totalled 0.16 Gg N_2O or 48.36 Gg CO_2 equivalent. This is a small increase on 1990 emissions from anaesthesia which totalled 0.13 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 (due to quality and price reasons).

5.1.2 Methodological issues

The IPCC revised guidelines (IPCC, 1996) do not provide detailed methodologies for emissions from solvents and other product use. It does however document two basic approaches for estimating emissions: consumption and production-based estimates. 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 via a survey of industry and industry organisations (CRL Energy Ltd, 2006). Worksheets for the solvents and other products sector are included in Annex 8.3.

Emission factors are developed based on the likely ultimate 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 four categories of solvents and other products specified in the CRF are detailed below.

Paint application

Consumption and emissions from paints and thinners are based on information from Nelson (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 drycleaners in New Zealand use perchloroethylene and a few 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 drycleaning 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 figures, 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

One major printing ink company with approximately 50 percent of the solvent ink market share provided a breakdown on the type of ink used. Approximately 50 percent 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 percent of inks are liquid of which 60 percent are solvent inks (the remaining 40 percent 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 percent are hydrocarbon based, total NMVOC emissions in 2004 were 1.9 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 (USEPA, 1985). It is assumed that the emissions rate per capita derived by the United States Environmental Protection Agency (USEPA) is applicable to the average product use in New Zealand (CRL Energy Ltd, 2006). Population figures are from the Statistics New Zealand website.

N_2O for anaesthesia

Activity data for 2004 was 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 50/50 mix 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, 2006). The overall uncertainties are assessed to be:

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

5.1.4 Source-specific QA/QC and verification

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

5.1.5 Source-specific recalculations

Data in this sector for the 2004 inventory are derived using the same method used for previously reported data. No changes have been made to the methodology.

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 to other sectors. In accordance with Good Practice, New Zealand will continue to focus its inventory development on key source categories (IPCC, 2001).

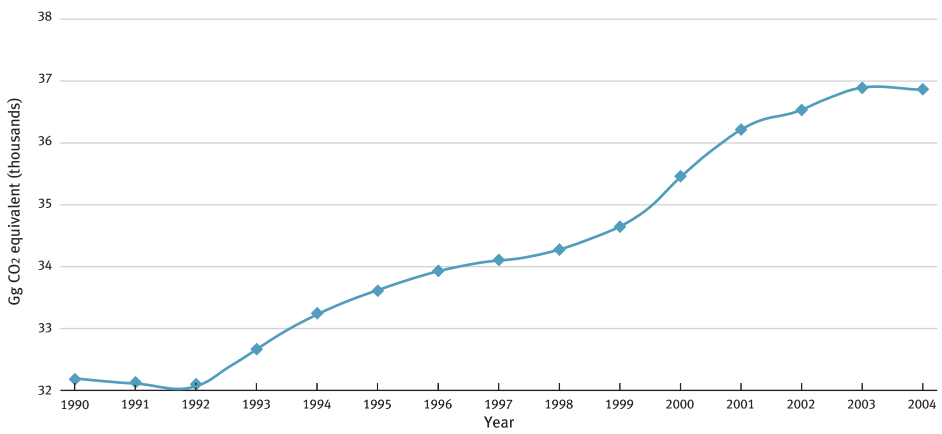
Chapter 6:

Agriculture

6.1 Sector overview

The agriculture sector emissions totalled 36,866.67 Gg CO_2 equivalent and represented 49.4 percent of all greenhouse gas emissions in 2004. Emissions in this sector are now 4,750.08 Gg CO_2 equivalent (14.8 percent) higher than the 1990 level of 32,116.58 Gg CO_2 equivalent (Figure 6.1.1). The increase is primarily attributable to a 2,161.00 Gg CO_2 equivalent (10.0 percent) increase in CH_4 emissions from enteric fermentation and a 2,413.64 Gg CO_2 equivalent (24.3 percent) increase in N_2O emissions from the agricultural soils category.

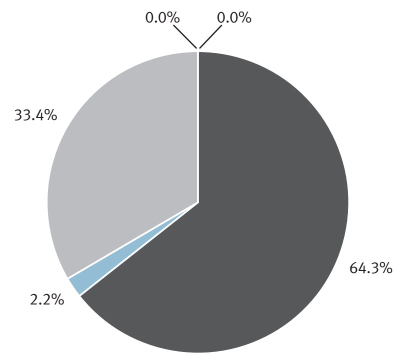
Figure 6.1.1 Agricultural sector emissions from 1990 to 2004



Emissions of CH_4 from enteric fermentation dominate the sector producing 64.3 percent of CO_2 equivalent emissions in the sector (Figure 6.1.2) and 31.8 percent of New Zealand's total emissions. N_2O emissions from agricultural soils are the other major component of the sector comprising 33.4 percent of agricultural CO_2 equivalent emissions.

Agriculture is the principal industry of New Zealand and agricultural products are the predominant component of exports. This is due to several factors: the favourable temperate climate, the abundance of agricultural land and the unique 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 2004 (all figures Gg CO_2 equivalent)



Field Burning of Agricultural Residues	15.04 Gg
Enteric Fermentation	23,714.98 Gg
Manure Management	809.38 Gg
Agricultural Soils	12,326.45 Gg
Prescribed Burning of Savannas	0.82 Gg

Since 1984, there have been changes in the balance of livestock species. There has been a trend for increased dairy and deer production due to prevailing good world prices. This has been counterbalanced by land coming out of sheep production and consequently decreased 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 with less grain but more vegetables, fruit and grapes for wine production. There has also been an expansion of the land used for plantation forestry.

New Zealand uses a June year for all animal statistics and reports a rolling three-year average in the inventory. The June year reflects the natural biological cycle for animals in the southern hemisphere. To maintain consistency, a single livestock population characterisation is used as the framework for estimating CH_4 emissions from enteric fermentation, CH_4 and N_2O emissions from manure management and N_2O emissions from animal production. A complete time-series of the agriculture data are shown in Annex 8.4 and information on livestock population census and survey procedures are included in Annex 3.1.

6.2 Enteric fermentation (CRF 4A)

6.2.1 Description

In 2004, emissions from enteric fermentation comprised 23,714.98 Gg CO_2 equivalent. This represents 31.8 percent of New Zealand's total CO_2 equivalent emissions and is the largest single category of emissions in the New Zealand inventory. The category is dominated by emissions from cattle (dairy and non-dairy) which represent 58.5 percent of emissions from enteric fermentation. The current level of emissions from enteric fermentation is 10.0 percent above the 1990 level, however there have been large changes within the category. The largest increase has been in emissions from dairy cattle which have increased 69.3 percent since 1990. This increase has been offset by decreases in emissions from sheep (-17.6 percent) and minor livestock populations such as goats horses and swine.

CH_4 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.

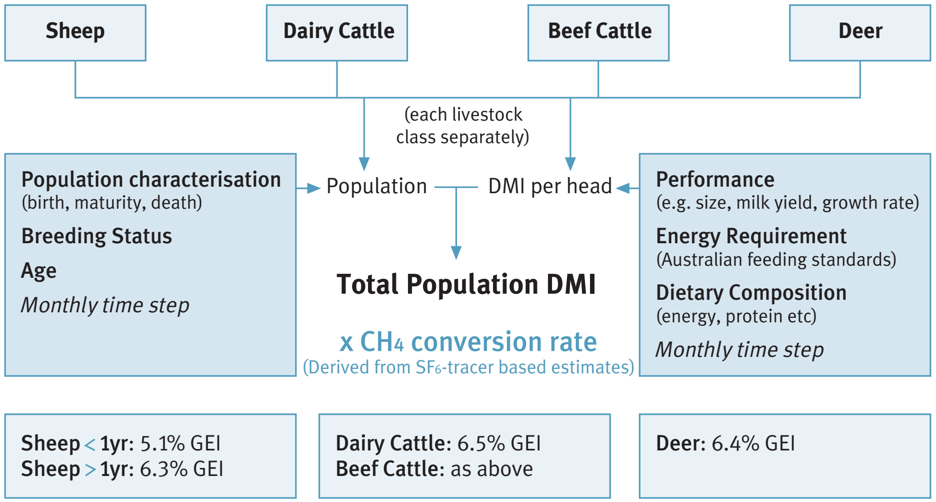
CH_4 emissions from enteric fermentation have been identified as the largest key category for New Zealand in the level assessment (excluding LULUCF). In accordance with good practice (IPCC, 2001), the methodology for estimating CH_4 emissions from enteric fermentation in domestic livestock was revised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

6.2.2 Methodological issues

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 (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).

There has been a gradual increase in the implied emission factors for dairy cattle and beef cattle from 1990 to 2004. This is to be expected because the methodology is able to use 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) require increased feed intake by the animal to meet energy demands. Increased feed intake produces increased CH_4 emissions per animal. The increases in productivity are shown in the agricultural worksheets in Annex 8.4 and in the detailed description in Annex 3.1.

Figure 6.2.1 Schematic of New Zealand's enteric methane calculation methodology



6.2.3 Uncertainties and time-series consistency

Animal numbers

Many of the calculations in this sector require livestock numbers. Both census and survey methods are used with surveys occurring in the intervening years 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 2004 inventory, the uncertainty in the annual estimate was calculated using the 95 percent 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 percent.

The overall inventory uncertainty analysis shown in Annex 7 (Good Practice Table 6.1) demonstrates that the uncertainty in annual emissions from enteric fermentation is 12.0 percent of New Zealand's total emissions and removals for 2004, and is the largest single component affecting the national total. However in the trend from 1990 to 2004, the uncertainty from enteric fermentation is only 1.9 percent of the trend in emissions and removals. 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.

Table 6.2.1 Uncertainty in the annual estimate of enteric methane emissions 1990, 2001 and 2004 and the 95 percent confidence interval (± 1.96 standard deviations from the mean) estimated using Monte Carlo simulation

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
2004	1,129.3	531.7	1,726.9

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

CH_4 emission rates measured for 20 selected dairy cows scaled up to a herd have been corroborated using micrometeorological techniques. *Laubach and Kelliher* (2005) used the integrated horizontal flux (IHF) 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 IHF 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) and Waghorn *et al*. (2003).

6.2.5 Source-specific recalculations

The provisional livestock population data for 2004 was updated to final population numbers, and the corresponding three-year average populations for 2002, 2003 and 2004 updated.

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 is funded through the Ministry of Agriculture and Forestry. A private sector funded 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 implementation of the Tier 3 approach for CH_4 emissions from enteric fermentation and manure management is a consequence of the research conducted by the expert group and continues to be improved. Validation of the SF_6 technique is also occurring through intercomparison with calorimeter estimates through collaborative research between Australian and New Zealand scientists.

6.3 Manure management (CRF 4B)

6.3.1 Description

Emissions from the manure management category comprised 809.38 Gg CO_2 equivalent (2.2 percent) 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. CH_4 from manure management has been identified as a key category for New Zealand in the 2004 level assessment (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 63.50 Gg CO_2 equivalent of N_2O in 2004. In comparison, agricultural soil emissions of N_2O totalled 12,326.45 Gg CO_2 equivalent.

6.3.2 Methodological issues

Methane

Methane emissions from ruminant animal wastes in New Zealand have been recalculated using an IPCC Tier 2 approach. This replaces the Tier 1 approach used in previous 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 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 and (3) the development of specific New Zealand emission factors for the quantity of methane produced per unit of faecal dry matter produced.

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 dry matter digestibility's are the same as in the current enteric methane and nitrous oxide inventories.

In New Zealand only dairy cows have a fraction (5 percent) of the excreta stored in an anaerobic lagoon waste system. The remaining 95 percent of excreta from dairy cattle is deposited directly on pasture. All other ruminant species (sheep, beef cattle, deer and goats) deposit all 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. The mean of cattle and sheep values is used for deer so no values for deer are available. Methane emissions from anaerobic lagoons are estimated using a water dilution rate (Heatley 2001), the average depth of a lagoon and the emissions data from lagoons (McGrath and Mason 2002).

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/M²/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 1996 IPCC Guidelines. New Zealand farming uses four AWMS; (1) anaerobic lagoons, (2) pasture, range and paddock, (3) solid storage and dry-lot, and (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 1996 guidelines for the Oceania region as Ministry of Agriculture and Forestry considered these were applicable to New Zealand farming practices. For dairy cattle, New Zealand specific data from Ledgard and Brier (2004) was 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 percent of excreta is allocated to pasture, range and paddock and 5 percent is allocated to anaerobic lagoons. Emissions from the "pasture, range and paddock" AWMS are reported in the "Agricultural soils" category.

The calculation for nitrogen in each animal waste management system is shown in the agricultural worksheets in Annex 8.4. A time series of nitrogen excreta (N_{ex}) values used for calculating animal production N_2O emissions is also shown in the worksheets in Annex 8.4. The N_{ex} values show an increase over time reflecting the increases in animal production. The nutrient input/output model OVERSEER® (Wheeler *et al*., 2003) is used to determine the annual quantities of nitrogen deposited in excreta by grazing animals. The OVERSEER® model uses the same animal populations and feed intake from the Tier 2 model used to determine methane emissions (Clark *et al*., 2003), and an assessment of feed nitrogen content modified by farm type.

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 $EF_{3(PRP)}$ (manure deposited on pasture, range and paddock). The value of $EF_{3(PRP)}$ which is a country-specific factor is 0.01 kg N_2O-N/kg N. The IPCC default values have uncertainties of -50 percent to +100 percent (IPCC, 2000).

The overall inventory uncertainty analysis shown in Annex 7 (Good Practice Table 6.1) demonstrates that 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 for New Zealand in the 2003 inventory. In preparation of the 2004 inventory, the data for this category underwent a Tier 1 quality check (refer Annex 6 for examples).

6.3.5 Source-specific recalculations

Methane from manure management is a key category. To ensure consistency with good practice, the methodology was upgraded to a Tier 2 approach for the 2004 inventory. The entire time series (1990-2004) has been recalculated.

6.3.6 Source-specific planned improvements, if applicable

No source specific improvements are planned during 2006.

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 CRF.

6.5 Agricultural soils (CRF 4D)

6.5.1 Description

The agricultural soils category is the category of the majority of N_2O emissions in New Zealand comprising 12,326.45 Gg CO_2 equivalent in 2004. Emissions are 2,413.64 Gg CO_2 equivalent (24.3 percent) over the level in 1990. The category comprises three sub-categories:

- direct N_2O emissions from animal production (the pasture, range and paddock AWMS)
- indirect N_2O from nitrogen lost from the field as NO_X or NH_3
- 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.

All of these sub-categories have been identified as key categories for New Zealand (Tables 1.5.2 and 1.5.3). Direct soil emissions from animal production is the third largest key category comprising 7,248.77 Gg CO_2 equivalent, indirect N_2O from nitrogen used in agriculture comprised 3,271.38 Gg CO_2 equivalent and direct N_2O emissions from agricultural soils comprised 1,806.29 Gg CO_2 equivalent.

CO_2 emissions from limed soils are reported in the LULUCF sector.

6.5.2 Methodological issues

N_2O 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 (Annex 8.4) document the emission factors and other parameters used in New Zealand's calculations. Three New Zealand specific factors/parameters have been used: EF_1, $EF_{3(PRP)}$ and $Frac_{LEACH}$. The $EF_{3(PRP)}$ 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 percent 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 percent of dairy cattle and 100 percent of sheep, deer and non-dairy cattle 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 nitrous oxide. The N_{ex} values have been calculated using the model OVERSEER® (Wheeler *et al*., 2003) based on the same animal intake values used for calculating CH_4 emissions for the different animal classes and species. This ensures that the same base values are used for both CH_4 and N_2O emission calculations.

New Zealand uses a country-specific emission factor for $EF_{3(PRP)}$ of 0.01 (Carran *et al*, 1995., Muller *et al*, 1995; de Klein *et al*, 2003 and Kelliher *et al*, 2003). Considerable research effort has gone into establishing a country-specific value for $EF_{3(PRP)}$. Field studies have been performed as part of a collaborative research effort called NzOnet. The parameter $EF_{3(PRP)}$ has been measured by NzOnet researchers in the Waikato (Hamilton), Canterbury (Lincoln) and Otago (Invermay) regions for pastoral soils of different drainage class (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 three separate trials that began in autumn 2000, summer 2002, and spring 2002. 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) assessed all available $EF_{3(PRP)}$ data, its distribution with respect to pastoral soil drainage class, to determine an appropriate national, annual mean value. The complete $EF_{3(PRP)}$ data set of NzOnet was synthesised using the national assessment of pastoral soils drainage classes. This study recognises 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 percent well-drained, 17 percent imperfectly drained and 9 percent 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. Research by NzOnet is continuing into the possibility of separate emission factors for dung and urine. 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 $EF_{3(PRP)}$. The IPCC default value of $EF_{3(PRP)}$ 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 8.4. 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 that is deposited or spread on land ($Frac_{LEACH}$).

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

When the IPCC methodology was applied to field sites where N 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) and this value was adopted and used for all years as it reflects New Zealand's national circumstances.

Direct N_2O emissions from agricultural soils

Direct emissions from agricultural soils are calculated in the five tables of worksheet 4.5.

The emissions 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 2004. A rolling three year average is used to calculate inventory data. There has been a six fold increase in nitrogen fertiliser use over the time series, from 51,787 tonnes in 1990 to 310,716 tonnes in 2004. 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 8.4. 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 AWMS it was initially stored in. This includes all waste in New Zealand except for emissions from the pasture range and paddock AWMS. 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 percent (ie, 10,109 ha) are cultivated on an annual basis (Kelliher *et al*, 2003). 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.

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 5000 scenarios with the @RISK software (Kelliher *et al*., 2003) (Table 6.5.1). The emissions distributions are strongly skewed reflecting that of pastoral soil drainage whereby 74 percent of soils are classified as well-drained, while only 9 percent are classified as poorly drained. For the 2004 inventory, the uncertainty in the annual estimate was calculated using the 95 percent 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 percent and -42 percent.

Table 6.5.1 Uncertainties in N_2O emissions from agricultural soils for 1990, 2002 and 2004 estimated using Monte Carlo simulation (1990, 2002) and the 95 percent CI (2004)

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
2003	39.8	22.9	69.0

The overall inventory uncertainty analysis shown in Annex 7 (Good Practice Table 6.1) demonstrates that 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 contributes 9.1 percent of the uncertainty in New Zealand's total emissions and removals in 2004 and 1.2 percent to the trend in emissions and removals from 1990-2004.

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 2004 inventory. The Monte Carlo analysis confirmed that uncertainty in parameter $EF_{3(PRP)}$ has the most influence on total uncertainty accounting for 91 percent 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
$EF_{3(PRP)}$	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

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

6.5.5 Source-specific recalculations

Nitrous oxide from agricultural soils is a key category. To ensure consistency with good practice, the EF_1 emission factor was changed to a country-specific emission factor of 1 percent. The agricultural soils category has therefore been recalculated for the entire time-series (1990-2004).

6.5.6 Source-specific planned improvements

The work of NzOnet will continue in order to better quantify N_2O emission factors for New Zealand's pastoral agriculture.

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 2004, total emissions accounted for 0.82 Gg CO_2 equivalent – a 2.51 Gg CO_2 equivalent (75.4 percent) reduction from the 3.33 Gg CO_2 equivalent 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 NO_X, 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 however 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 percent 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 2004. The major sources of uncertainty are the percentage of consented area actually burnt in that season, that biomass data from two study sites are extrapolated 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 N:C ratio for the tussocks) are the IPCC default values. Uncertainty in the New Zealand biomass data has been quantified at ±6 percent (Payton and Pearce, 2001), however many IPCC parameters vary by ±50 percent and some parameters lack uncertainty estimates.

6.6.4 Source-specific QA/QC and verification

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

6.6.5 Source-specific recalculations

There were no recalculations for the 2004 inventory.

6.7 Field burning of agricultural residues (CRF 4F)

6.7.1 Description

Burning of agricultural residues produced 15.04 Gg CO_2 equivalent in 2004. Emissions are currently 10.19 Gg CO_2 equivalent lower (-40.4 percent) than the level of 25.24 Gg CO_2 equivalent 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 becoming 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

(Annex 8.4). 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 suggests that an estimate of 10 percent of residue burnt may be appropriate for developed countries but also notes that the 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, 2001). For the years 1990 to 2003 it is estimated that 50 percent of stubble is burnt. For the year 2004 experts assessed this percentage dropped to 30 percent. These figures are developed from expert opinion 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 no recalculations for this category.

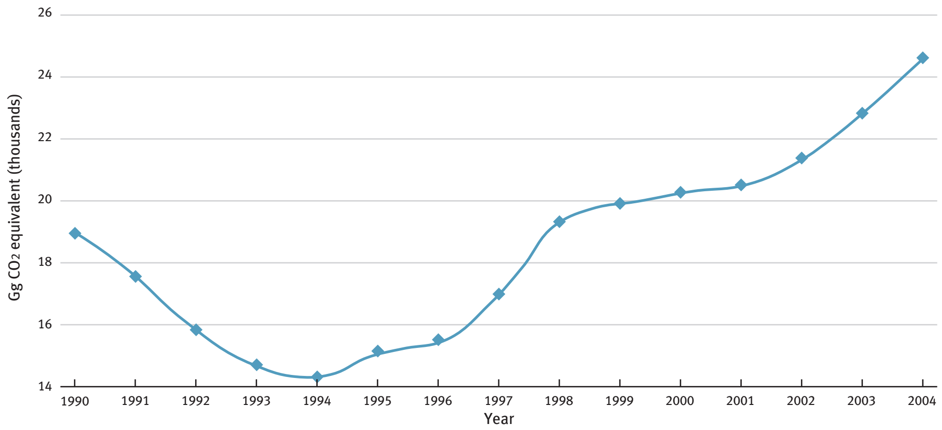
Chapter 7:

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 32.8 percent of all New Zealand's greenhouse gas emissions in 2004. Net removals from the LULUCF sector in 2004 totalled 24,482.63 Gg CO_2 equivalent and are 29.0 percent above net removals in 1990 (Figure 7.1.1).

Figure 7.1.1 LULUCF sector net removals from 1990 to 2004



7.1.1 A history of LULUCF in New Zealand

Prior to the first human settlement by Polynesians in about 1250 AD, approximately 75 percent of New Zealand's land area was estimated as natural forest. The forest area had reduced to about 60 percent by the mid-nineteenth century and was further reduced to the current approximate 23 percent 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 C losses of 3,400,000 Gg C (Scott *et al*., 2001). Establishment of pastures probably slightly increased mineral soil C, however some losses of C due to erosion are also possible (Tate *et al*., 2003a).

Government controls on forest clearance (deforestation) were first imposed in the late nineteenth century. However the continuing demand for timber and agricultural land resulted in ongoing forest removal. By the 1970s, growing public concern lead 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 5 million hectares (18 percent of New Zealand's total land area) of Crown-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 Crown–owned forests and forests on specific Maori-owned lands. However, further Government controls resulted in the cessation of logging of the West Coast Crown-owned forests in March 2002. Timber harvested from privately owned natural forests and from forests on exempted Maori lands has continued at a low level since the 1993 controls were imposed. Current proposed legislative changes will continue to exempt the Maori lands although logging has further reduced in these forests.

New Zealand has a substantial estate of planted forests, mainly comprised of *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 substantially more CO_2 over the period 1990 to 2004 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. In the period 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 2004, 10,600 hectares of new forest was established. Between 1990 and 2004 it is estimated that 671,000 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 Crown and privately owned natural forest. Less than 0.1 percent of New Zealand's total forest production is now harvested from natural forests.

7.1.2 Methodological issues for LULUCF in New Zealand

Six broad categories of land are described in GPG-LULUCF. The categories are consistent with the 1996 IPCC Guidelines and the requirements of Articles 3.3 and 3.4 of the Kyoto Protocol. The land categories are:

- Forest land – all land with woody vegetation consistent with national thresholds used to define forest land. It also includes systems with vegetation that currently fall below, but is expected to exceed, the threshold of the forest land category.
- Cropland – arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds used for the forest land category.
- Grassland – rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that falls below and is not expected to exceed, without human intervention, the threshold used 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.

A current lack of land use and land-use change data consistent with the IPCC land category classification, covering the period 1990 through to 2004, limits reporting in this sector. Research is being conducted on the carbon pools and fluxes in New Zealand's soils and natural forests through the Carbon Monitoring System (CMS) plots. The focus of the CMS activities is specifically to fulfil New Zealand's reporting requirements for the UNFCCC LULUCF inventory and the Kyoto Protocol. Details of the monitoring system are included in Annex 3.2.

7.1.2.1 Representation of land areas

To estimate land areas in each LULUCF land category, New Zealand has used an analysis of two existing land-cover maps of New Zealand – the Land Cover Databases 1 and 2 (respectively, LCDB1 and LCDB2) (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 have been used by New Zealand as 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 NZCAS will be 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, and these are mutually exclusive and additive to 100 percent 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. The 1990 data will be developed as part of the New Zealand Carbon Accounting System (NZCAS) described in Annex 3.2. In the 2004 inventory New Zealand has completed the 1990 LULUCF sector by linear extrapolation of the 1997 data. An analysis to complete 1990 using a 1985 map of New Zealand vegetative cover and classification system was initiated, however the differences in map scale between 1985 (1:1,000,000) and 1997 (1:50,000) meant the data was inconsistent between 1990 and 1997 and the remainder of the time series. To ensure consistency throughout the time series, New Zealand extrapolated backwards to 1990 from the 1997 data.

Table 7.1 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 NIR. Land-use change matrices including subdivisions of land categories and the annual changes interpolated for the periods 1997-1998, 1998-1999, 1999-2000, 2000-2001 and 2001-2002 are included in the worksheets accompanying the LULUCF sector. A land-use change matrix for 2002-2004 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)						
		F	C	G	W	S	O	Total
LCDB2 2002	F	10097.57	0.02	130.88	0.00	0.06	0.06	10228.59
	C	0.22	412.91	4.32	0.00	0.00	0.01	417.44
	G	5.11	0.00	14360.63	0.00	0.06	0.21	14366.01
	W	0.00	0.00	0.67	531.24	0.04	0.01	531.96
	S	0.56	0.02	5.03	0.00	214.84	0.00	220.46
	O	0.19	0.00	0.06	0.00	0.00	1056.84	1057.09
	Total	10103.65	412.95	14501.58	531.24	215.00	1057.13	26821.56
	Net	124.94	4.49	-135.57	0.72	5.46	-0.03	0.00

F= forest land, C=cropland, G=grassland, W= wetland, S=settlement and O=other lands.

7.1.2.2 Inventory carbon pools

Greenhouse gas inventory for land-use categories involves estimation of changes in carbon stock from five carbon pools, ie, 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 changes in living biomass (aboveground biomass and belowground biomass), changes in dead organic matter (dead wood and litter) and changes in soil organic matter.

7.1.2.3 Land-use factors and carbon stocks

Changes in carbon pools within a land-use category and between categories uses a number of variables of the stocks and growth in the living biomass, and the effect on land-use factors on soil carbon stocks. 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 C 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 C 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 is very similar to the default IPCC values provided in GPG-LULUCF for warm temperate moist climate in Table 3.2.4 (a range of 34-88 t C ha^{-1}). The New Zealand value is calculated from the measured soil C in New Zealand grassland soils of 105 t C ha^{-1} (Tate *et al*, 2003a), 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 prior to 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 dry matter (0.5)
Planted forest	223.2 t C ha^{-1}	1st rotation, 28 years old (Wakelin, 2006)
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 dry matter (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 dry matter (0.5) 63 t C ha^{-1} assumed for grassland woody vegetation.

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

Land use	Value	Source/Reference
Natural forest	NE / T1=4.3 t C ha^{-1}	New Zealand's natural forests are assumed to be approximately in steady-state (Tate *et al*., 2000) Tier 1 – GPG-LULUCF 3A.1.5 and 3A.1.8 (G_W=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 / T1=8.9 t C ha^{-1}	Tier 2 – Included in C_Change modelling (Beets *et al*, 1999, Wakelin, 2004) Tier 1 – GPG-LULUCF 3A.1.6 and 3A.1.8 (G_W=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

7.2 Forest land (CRF 5A)

New Zealand has not adopted a final national definition of forest to be used in reporting for the Kyoto Protocol. This definition requires New Zealand to state the minimum area, length (and thus width) of land areas categorised as forest land. This definition will be used when spatial information from the NZCAS is calculated and available for reporting. To enable New Zealand to complete the 2004 inventory and include information under the updated LULUCF guidance and CRF tables, the categories of forest land used in the LCDB1 and LCDB2 were applied. This is an area of one (1) hectare and a width of 100 metres. This definition of land mapped as forest land is not New Zealand's national definition to be applied under the Kyoto Protocol when the NZCAS is operational.

The LCDB1 and 2 also includes a shrubland vegetation cover category, which does not exist as a LULUCF category. Land-cover classes within the shrubland category were assigned to the grassland category as they do not meet the forest land criteria that New Zealand expects to formally adopt for the Kyoto Protocol (namely, 1 hectare, 30 percent canopy cover, 5 metres height and 100 metres width). The allocation of classes is shown in Table A3C.1.

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." New Zealand's natural forests are considered managed forests due to their primary management for ecological, biodiversity, and social functions.

7.2.1 Description

Forest land accounted for net CO_2 removals of 25,506.49 Gg CO_2 in the 2004 inventory. This figure includes removals from the growth of planted forests, emissions from the conversion of land to planted forest and from the very small amount of harvesting of natural 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, recreation, purposes. 99.9 percent of New Zealand's wood needs are met from planted forests and the Crown does not harvest any timber from New Zealand's natural forests. The natural forest harvest reported in the inventory refers to harvest of forests on land granted to Maori (New Zealand's indigenous people) under the South Island Landless Natives Act (SILNA) 1906. These 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 prior to any harvesting. Approximately 50,000 ha are in the SILNA. There is no specific data to estimate growth in these forests. The NZCAS will provide data for similar forests in similar locations to the SILNA forests.

Removals of CO_2 in natural forest are not calculated. This is because country-specific data are not available (refer the development of the CMS plots in Annex 3.2) and the growth rates provided for mixed broadleaf/coniferous forest in GPG-LULUCF are considered too high. 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). Results from the CMS monitoring will enable New Zealand to provide a better estimate.

7.2.2 Methodological issues

Forest land remaining forest land (Tier 2)

New Zealand has calculated the removal of CO_2 by planted forests and emissions from planted forests through harvesting using a modelling approach and country-specific data. Compared to many forest ecosystems, total biomass in New Zealand's planted forests is relatively straightforward to estimate. Approximately 90 percent of the forest area is planted in Pinus radiata, a forest is usually composed of stands of trees of a single age class and all forests have relatively standard silviculture regimes applied. The methodology applied for UNFCCC 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 the 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 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 2004 are used to calculate removals and emissions provided in the 2004 inventory. This latest information brings in new forest-area data along with data on new planting, restocking and harvesting for the 2004 year (MAF, 2005).

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, in respect to 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 2004 is based on (a) the latest area estimates provided by the 2004 NEFD, (b) an estimate of the area to be planted during the year, (c) an estimate of the area harvested during the year. The total estate area for the years before 2003 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 MAF 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 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. Carbon is taken as being 50% of biomass.

For the 2004 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 still based on data for *Pinus radiata*, when in fact around 10 percent of the estate is made up of other species such as Douglas-fir (5 percent) (*Pseudotsuga menziesii*), other exotic softwoods (2 percent), and exotic hardwoods (3 percent).

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. The model 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 as per the IPCC approach. The assumption is that the stem wood removed at harvest for both permanent 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 2004. 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.

Emissions from natural forest harvesting

Estimates of any harvesting from natural forests are provided by the MAF. 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 (Waklin, 2006). As for planted forest harvesting, emissions from harvesting natural forests are potential maximums rather than actual emissions as much of the carbon contained in the harvested stem wood ends up as wood products produced from the harvested timber rather than being oxidised at the time of harvest.

Land converted to forest land

Data on the amount of land clearance for new forest planting are sourced from the MAF. 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 it is assumed that prior to 1993, the proportion was 20 percent. It is assumed that 25 percent of the vegetation biomass is burnt on-site 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 now 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 the principal classes.

It has been assumed that the biomass fuel consumption rate in fires in both forest biomass and grassland with woody vegetation is 90 percent. This fuel consumption rate is double the IPCC default value and the resulting non-CO_2 emissions are likely to be over-estimated. Work is underway to improve biomass burning assumptions in the inventory.

Wildfire burning

Only non-CO_2 emissions from wildfires are reported in the inventory (consistent with the IPCC default method). Emissions from wildfires are based on fire reports collected by the National Rural Fire Authority. 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 Fire Authority statistics involve land clearing and it is not specified whether this is for agricultural or forestry purposes. This implies that 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.

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 NIR 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).

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 C stock is determined from the same reference soil C 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 C stock in soils (Tate *et al*, 2003).

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 5 years. Carbon stocks in living biomass for planted and natural forest were those documented in table 7.1.3.2. Under the Tier 1 methodology, it is assumed that all above ground biomass is lost.

Decreases in living biomass carbon stocks associated with land converted to forest was also included in the Tier 1 calculation. For the Tier 1 estimate, it was assumed that the land category of "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 crop land prior to conversion provided in GPG-LULUCF (63 t C ha^{-1}) was used as an approximation of the C stock in grassland woody vegetation biomass. This value is very 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} * 0.5 (carbon fraction of dry matter)).

Table 7.2.1 compares the results from the modelled and Tier 1 approaches for the 2003 inventory. The results for the living biomass stock are similar (11.0 percent different) however the different approaches mean that the two estimates will always differ. The primary reasons for this are the different methodologies used in assessing planted forest estate and planting rates, ie, comparing annual NEFD survey vs. 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 GPG defaults for Gw and R compared to country-specific modelling data.

Table 7.2.1 Comparison of the Tier 2 and Tier 1 approaches for forest land in 2003

	Area (kha)			Living biomass stock (Gg C)		
	modelled/ actual	tier 1	difference	modelled/ actual	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%

7.2.3 Uncertainties and time-series consistency

A process of using the models to time-shift the forest estate forwards to represent future forest growth and forest management, and backwards to improve historical estimates, is performed to minimise errors. As the estimation of carbon stocks is continuously being improved, both past and future years are recalculated.

Attempts have been made to quantify the uncertainties in the CO_2 removal estimates for planted forests. However, 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 percent for wood density, ±15 percent for carbon allocation and ±5 percent for carbon content. Combining the uncertainties indicates that the proportional error in the carbon sequestration estimates is likely to be at least ±16 percent. The total national planted area is considered to be accurate to within ±5 percent (MAF, 2005) and the yield tables are assumed to be accurate to within ±5 percent.

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

Including the forest land category in the overall inventory uncertainty analysis (Annex 7) shows that removals from forest land are 6.5 percent of New Zealand's total emissions and removals uncertainty in 2004. This is the third largest source of uncertainty in New Zealand's total for a given year. Forest land introduces 2.2 percent uncertainty into the trend in the national total from 1990 to 2004. This is the second largest impact on the trend after CO_2 emissions from the energy sector.

7.2.4 Source-specific QA/QC and verification

The information presented in the NIR and the variables chosen for calculation were reviewed by officials of the MfE and the MAF. Calculated estimates were visually assessed for obvious errors in calculations. For forest land, the Tier 2 modelled values were compared against a Tier 1 value. Land-use change matrices were used to ensure that the allocation of land between categories produced a consistent national total area of land.

One of the primary input datasets 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 prior to publication. In addition 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 2004 planted forests removals and emissions have been compared for consistency with the 2003 estimates (Wakelin S, *Carbon Inventory of NZ's Planted Forests [Calculations revised as at February 2006]*, Forest Research, Contract Report, February 2006).

7.2.5 Source-specific recalculations

New proportions of area by NEFD regime are used to weight the carbon yield in the 2004 inventory. Area data and carbon yields underlying the models in recent reports are similar to those used previously. The main changes in the national carbon yield table were due to the use of 89 croptype yield tables in the area-weighting procedure, rather than just four. This means that the national yield table better reflects the diversity represented in the NEFD data. Regimes were modelled based on averages from permanent soil 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 CMS (or other sources).

Back-casting and recalculation of 1990-2003 values has been included as in previous years. That is, previous estimates have been replaced with those from the current model. The process of using the forest models to time-shift the forest estate forwards to represent future forest growth and forest management, and backwards to improve historical estimates, is performed to minimise errors. As the estimation of carbon stocks is continuously being improved, both past and future years are recalculated.

Land previously reported as non-forest scrubland is classified as grassland as per GPG-LULUCF definitions.

7.2.6 Source-specific planned improvements

New Zealand's development of the CMS and the NZCAS will enable New Zealand to revise the time-series in the LULUCF inventory, and reduce the 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 accurate breakdown than the current approach.

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

The 2003 inventory was the first inventory where New Zealand has reported emissions and removals from cropland remaining cropland and from land converted to cropland. In 2004, the net CO_2 removals were 549.72 Gg CO_2. Cropland is a key category for New Zealand.

Cropland includes all annual and perennial crops as well as temporary fallow land. Annual crops include cereals, oils 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, 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 C stock can be calculated.

Dead organic matter

The GPG-LULUCF state that 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 percent 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 prior to 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 prior to 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, (83*0.82*1*1.16)-(83*0.82*1*1.16))*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 and 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 GPG 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 that 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 (3.3.2.2.1.1). For Tier 1, the initial soil C stock is determined from the same reference soil C 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 N 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 C to N 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, the effect of land management factors etc. 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 percent (95 percent CI).

Variable	Uncertainty (95% CI)
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 NZCAS 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 2004, the net emissions from grassland were 666.44 Gg CO_2. These emissions are from the subcategory "land converted to grassland".

7.4.2 Methodological issues

Grassland remaining grassland

Living biomass

In GPG-LULUCF, 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 state 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 percent of New Zealand (Tate *et al*., 2004). The LCDB analysis used in the 2004 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 prior to 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 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 prior to and following conversion and accounting for carbon in biomass that replaces cleared vegetation. Pre-conversion stocks and annual growth figures are tabulated 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 (3.4.2.2.1.1). For Tier 1, the initial (pre-conversion) soil C stock is determined from a reference soil C 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 tabulated in table 7.1.2.1.

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 percent (95 percent CI).

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 forest land.

7.4.5 Category-specific recalculations

There are no recalculations for this category.

7.4.6 Category-specific planned improvements

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

7.5 Wetland (CRF 5D)

7.5.1 Description

GPG-LULUCF 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 a wetland in New Zealand, have been categorised as grassland following the GPG-LULUCF definitions. In 2004, the net emissions were 0.72 Gg CO_2. These emissions are from the subcategory "land converted to wetland". Wetlands are not a key category for New Zealand.

7.5.2 Methodological issues

Wetland remaining wetland

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 peat land and flooded land. 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 wetland

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 that the carbon stock of land prior to conversion is lost in the first year following conversion. The carbon stock of the land prior to 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 percent based on the uncertainty for Tier 1 grassland carbon stocks (GPG-LULUCF table 3.4.2) lost during conversion to wetland.

7.5.4 Category-specific QA/QC and verification

No specific QA/QC and verification was used for wetland. 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 wetland. Sector-level improvements resulting from the NZCAS are described in section 7.2.6 forest land.

7.6 Settlement (CRF 5E)

7.6.1 Description

This land-use category is described in GPG-LULUCF as including "all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other land-use categories". Settlement includes trees grown along streets, in public and private gardens, and in different kinds of parks where the parks are associated to urban areas. In 2004, the net emissions from settlements were 97.16 Gg CO_2. These emissions are from the subcategory "land converted to settlement". Settlement is not a key category for New Zealand.

New Zealand has categorised the applicable LCDB land cover classes into the settlement category (Annex 3.3). The LCDB analysis showed that there was 214.84 kha of settlement remaining settlement 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 settlement, averaging 1000 hectares per year.

7.6.2 Methodological issues

Settlement remaining settlement

GPG-LULUCF provides a basic method for estimating CO_2 emissions and removals in settlements remaining settlements 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 settlement

The fundamental equation 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 prior to 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 percent 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 settlement. 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 settlement. Sector-level improvements resulting from the NZCAS 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 as including bare soil, rock, ice, and all unmanaged land areas that does 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 2004, the net emissions from other land were 38.16 Gg CO_2. 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

Change in carbon stocks and non-CO_2 emissions and removals in unmanaged "Other Land Remaining Other Land" do not need to be assessed under GPG-LULUCF. No guidance is provided in GPG-LULUCF for "Other Land" that is managed.

Land converted to other land

Living biomass

The fundamental equation 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 prior to 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 C stock is determined from reference soil C stocks together with stock change factors (Table 7.1.2.1) appropriate for the previous land use. New Zealand uses a reference soil C stock of 83 t C ha^{-1}. 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 percent 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 NZCAS are described in section 7.2.6 forest land.

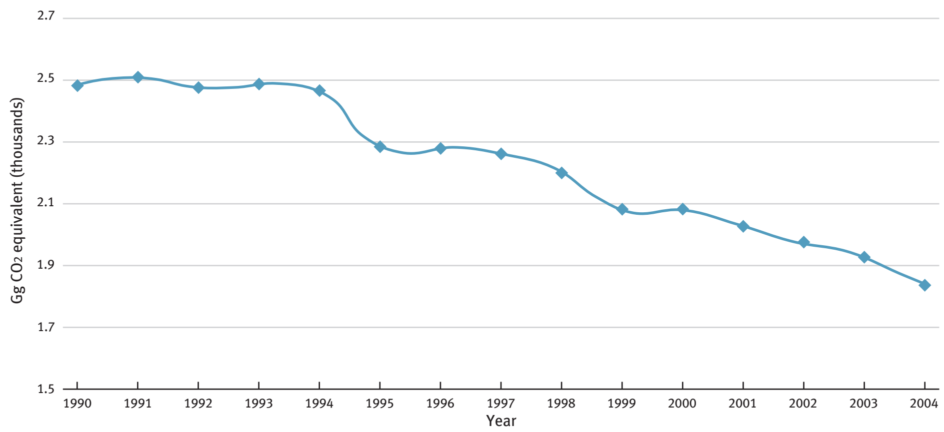
Chapter 8:

Waste

8.1 Sector overview

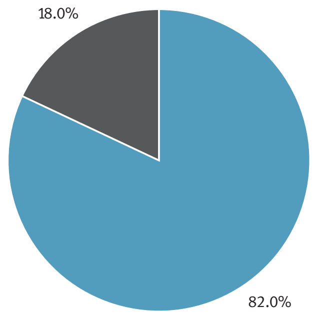
The waste sector totalled 1,839.98 Gg CO_2 equivalent in 2004 and this represented 2.5 percent of all greenhouse gas emissions. Emissions in 2004 are now 642.83 Gg CO_2 equivalent (25.9 percent) below the 1990 baseline value of 2,482.81 Gg CO_2 equivalent (Figure 8.1.1). The reduction has occurred in 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 2004



Emissions from the waste sector are calculated in three components (Figure 8.1.2): solid waste disposal on land, wastewater handling and waste incineration (not shown in figure as emissions are negligible). CH_4 from solid waste disposal was identified as a key category for New Zealand in 2004 (Tables 1.5.2 and 1.5.3).

Figure 8.1.2 Waste sector emissions in 2004 (all figures Gg CO_2 equivalent)



Solid Waste Disposal on Land	1,509.12 Gg
Wastewater Handling	330.87 Gg

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 however are not included as a net emission as 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 (SWDS) is broken down by bacterial action in a series of stages that result in the formation of CO_2 and CH_4. The amount of gas produced depends on a number of factors including the waste disposal practices (managed vs. unmanaged landfills), the composition of the waste, and physical factors such as the moisture content and temperature of the SWDS. 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 SWDS 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 that there were 115 legally operating landfills in New Zealand; a reduction of 65 percent from 1995.

Recently, New Zealand's national focus has been towards waste minimization and resource recovery. In March 2002, the Government announced its New Zealand Waste Strategy (MfE, 2002). 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, 2002a) 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 (DOC), 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 8.6.

Data on municipal solid waste (MSW) generation rates, waste composition, the fraction of degradable organic carbon (DOC) and the percentage of MSW disposed to SWDS are obtained from the National Waste Data Report (MfE, 1997), the Landfill Review and Audit (MfE, 2002) and the Solid Waste Analysis Protocol baseline results (SWAP; MfE, 2003) surveys for the periods 1995, 2002 and 2003. The proportion of waste for each type of SWDS is obtained from the 2003 SWAP baseline results. It is estimated that in 1995, 90 percent of New Zealand's waste is disposed to managed SWDS and 10 percent 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 Solid Waste Analysis Protocol baseline results.

[1] The 10% of solid waste not disposed to 'managed' SWDS, 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 SWDS, hence the 'unclassified' status. The inventory assumes that by 2010 all solid waste will be disposed to 'managed' SWDS, which has lead to a linearly increasing Methane Correction Factor in L_0 calculations.

Based on the 2002 Landfill Review and Audit and using the SWAP classification system, it is estimated that the quantity of solid waste landfilled in New Zealand in 2004 was equivalent to 2.09 kg per person per day. This shows a reduction in waste generation from 2.39 kg per person per day in 1995.

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 SWDS in New Zealand (SCS Wetherill Environmental, 2002).

The fraction of DOC 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 SWDS that serve populations of over 20,000 in New Zealand. (Waste Management New Zealand, 2005).

8.2.3 Uncertainties and time-series consistency

The overall estimated level of uncertainty is estimated at ±20 percent, which is the same uncertainty as the 2003 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 DOC calculation. The major difference is that in New Zealand's DOC 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. This effect of this difference is mediated by the use of IPCC default carbon contents which are similar for the non-food (17 percent carbon content) and food categories (15 percent 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 2004 inventory, the Tier 2 value of gross annual methane generation is 125.6 Gg CH_4 and the Tier 1 value is 129.8 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 2004. In preparation of the 2004 inventory, the data underwent Tier 1 QC procedures (refer Annex 6 for examples).

8.2.5 Source-specific recalculations

CH_4 recovery figures were updated due to a survey of operators in 2005. The analysis showed that recovery technology uptake happened at a much slower rate than anticipated in the mid-1990s. However the rate has increased and is now consistent with previous estimates (of landfills with capture systems in place).

Some minor corrections were made to the modelling (formula) attributes in the spreadsheet for the CH_4 emissions from managed solid waste disposal. This included the consistency of the half-life component. Accuracy of variables such as the CH_4 generation potential and CH_4 correction factors were improved by using data to five decimal places. Additionally, the annual MSW generation was recalculated by using 365.25 days instead of 365.

Recalculations were performed back to 1990 and have resulted in an additional 0.1Gg net CH_4 emissions being reported in 1990. Net CH_4 emissions for 2003 have increased 8.32 Gg. Of that increase, 98 percent is due to improved CH_4 recovery estimates.

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 all towns 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.

While 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.

Very large quantities of high-strength industrial wastewater are produced by New Zealand's primary industries. Most of the treatment uses aerobic treatment and any CH_4 from anaerobic treatment is flared. There are however 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 has been assessed for each municipal treatment plant in New Zealand. Where industrial wastewater flows to a municipal wastewater treatment plant, an equivalent population for that industry has been calculated based on a BOD (Biological Oxygen Demand) 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 BOD to the plant that is anaerobically degraded multiplied by the CH_4 conversion factor. The emissions calculations are shown in Annex 8.6.

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 BOD value is based on a 2.5 scaling factor of COD (IPCC, 2000). New Zealand uses a B_0 of 0.25 CH_4 / kg COD but calculates a country-specific value of 0.375 kg CH_4 / kg BOD, based on a scaling-up factor of 1.5*COD. The New Zealand scaling factor is based on information from New Zealand waste sector experts (SCS Wetherill Environmental, 2002) and research (Metcalf and Eddy, 1992).

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 COD load going to the treatment plant and the proportion of waste degraded anaerobically (refer to Annex 8.6). 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 landfilled. Any CH_4 emissions from landfilled sludge are reported under the SWDS 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 cases, it is included in the CH_4 emissions from domestic wastewater treatment. Where sludge is landfilled, the CH_4 production is included under solid waste disposal. 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 is 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 (EF6) 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 (Annex 8.6).

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 COD load from the CH_4 emission calculations and using a ratio of COD to nitrogen in the wastewater for each industry (Annex 8.6)

[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.

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 percent to +60 percent (SCS Wetherill Environmental, 2002).

Methane from industrial wastewater

The method used in estimating CH_4 emissions limits a statistical analysis of uncertainty.

Total CH_4 production from industrial wastewater has an estimated accuracy of ± 40 percent 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 and no attempt has been made to quantify this uncertainty. The IPCC default emissions factor, EF6, has an uncertainty of –80 percent to +1,200 percent (IPCC, 1996) meaning that the estimates have only an order of magnitude accuracy.

8.3.4 Source-specific QA/QC and verification

In preparation of the 2004 inventory, the data for the wastewater handling category (CH_4) underwent Tier 1 QC checks.

8.3.5 Source-specific recalculations

There have been no recalculations in the 2004 inventory.

The Ministry for the Environment is developing a comprehensive database of industrial/commercial and municipal wastewater treatment plants in use in New Zealand. It is anticipated data from this database (which is expected to be completed by July 2006) will help improve estimates from this source.

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 control certain 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 a resource consent (authorisation to operate) by 2006, irrespective of existing planning rules. Incinerators without consents will be prohibited.

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 GHG inventory since the submission of the 2003 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 or 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 2004 inventory uses an average of the 2003, 2004 and 2005 years numbers. The 2003 and 2004 years are actual data, but only provisional data is available for the 2005 year. In the 2005 inventory, the provisional 2005 figures will be replaced by actual figures and the 1990-2004 inventory will be recalculated.

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

No major recalculations have occurred between the 2003 and 2004 inventories. The Ministry of Economic Development advises the small differences that have occurred in the various categories are due to some minor rounding errors and updates to data in their energy greenhouse gas emissions report (MED, 2005).

10.1.2 Industrial processes sector

Mineral products

The inclusion of CO_2 from soda ash has been included for the first time in the 2004 inventory. Estimates have been included for all years from 1990 and this category has been recalculated for the entire time-series.

Chemical industry

Methane emissions from urea production have been removed from the industrial processes sector as industry experts consider all methane emissions from this process to be attributed to fuel combustion (CRL Energy Ltd, 2006). This has resulted in a slight reduction (1.5 Gg CO_2 equivalent) in methane emissions for the "chemical industry" category.

The 2004 inventory has reallocated CO_2 emissions from urea production from a previous country-specific "urea" category to the "ammonia" source category as recommended by the international review team in the 2005 review report (UNFCCC, 2006).

Consumption of halocarbons and SF_6

The 2005 survey for industrial processes was redesigned to capture more importers of HFCs and PFCs and to better identify the refrigerants associated with imported and exported factory charged refrigeration and air conditioning units. This has resulted in increased HFC and PFC emissions compared with the 2003 inventory.

10.1.3 Solvents and other products

No recalculations were made for this sector.

10.1.4 Agriculture sector

Animal statistics

Every year of inventory there is a recalculation for the previous year as the provisional animal population is updated with the actual population.

Manure management

The methodology for this source was upgraded to a Tier 2 approach. Emissions were recalculated for the entire time-series (further details can be found in section 6.3.5).

Agricultural soils

The EF_1 emission factor has been upgraded to a country-specific emission factor of 1 percent. This has resulted in a reduction in N_2O emissions from agricultural soils for the entire time-series (a 3.4 percent reduction for this category when compared to the 2003 inventory).

10.1.5 LULUCF

The carbon yield tables have been updated to better reflect the diversity represented in the National Exotic Forest Description (NEFD) data. Regimes were modelled based on averages from permanent soil 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. Further explanation on these recalculations can be found in section 7.2.5.

10.1.6 Waste

Methane emissions from solid waste disposal have been recalculated for the entire time-series. This was due to a survey completed in 2005 which showed methane recovery rates were not as high as initially calculated in the early to mid 1990s.

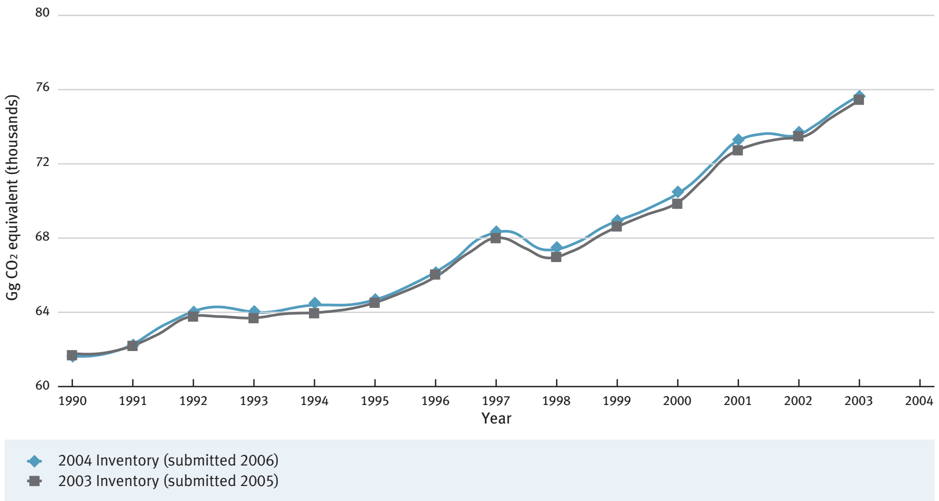
10.2 Implications for emission levels

The overall effect of all recalculations is shown in Figure 9.3.1. There is a 0.2 percent increase in emissions for the 2003 year and a 0.02 percent reduction in emissions for the base year, 1990.

10.3 Implications for emission trends

In New Zealand's 2003 inventory, emissions were 22.5 percent over the level reported in 1990. In the 2004 inventory, New Zealand's total emissions for 2004 are 21.2 percent over the level in 1990. As a result of the recalculations, total emissions for 2003 increased and emissions for 2003 were recalculated as being 22.7 percent over 1990 (Figure 9.3.1). Changes in trends for individual sectors are discussed in the following sections. Solvents are not included because of the very low level of emissions throughout the time-series.

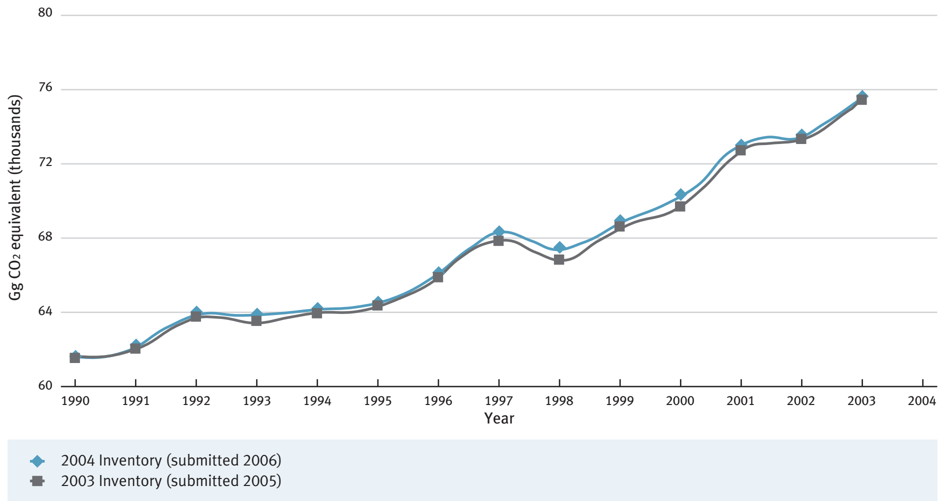
Figure 10.3.1 The effect of recalculation on total greenhouse gas emissions



Energy sector

The Ministry of Economic Development advises the small differences that have occurred in the various categories are due to some minor rounding errors and updates to data in their energy greenhouse gas emissions report (MED, 2005).

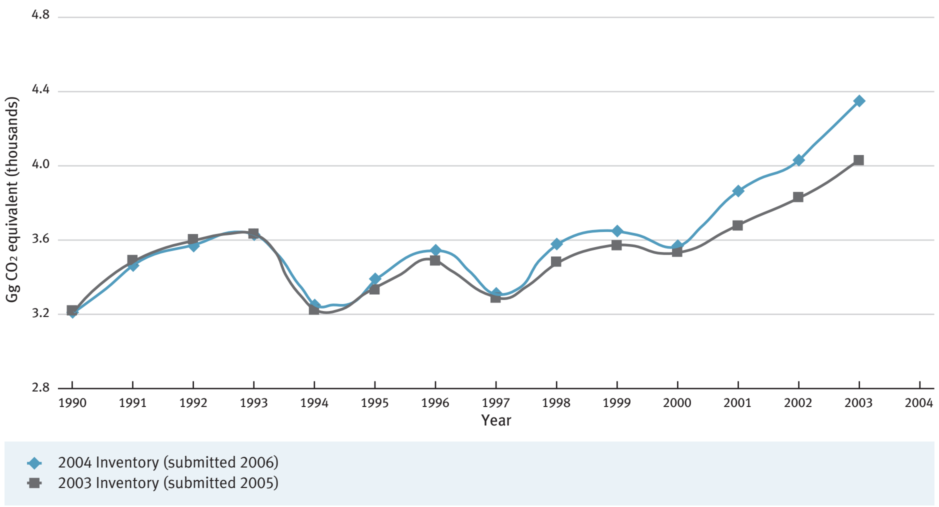
Figure 10.3.2 The effect of recalculation on the energy sector



Industrial processes

The largest recalculation for industrial processes was from the updated data on HFC and PFC use from the 2005 industrial processes survey (CRL Energy Ltd, 2006a). This resulted in an increase in emissions for the "consumption of halocarbons and SF_6" category of 324.67 Gg CO_2 equivalent in 2003. This increased total greenhouse gas emissions by 0.4 percent for 2003. This data represents an upper limit for HFC/PFC emissions from commercial refrigeration and air conditioning but is the most accurate and complete data currently available.

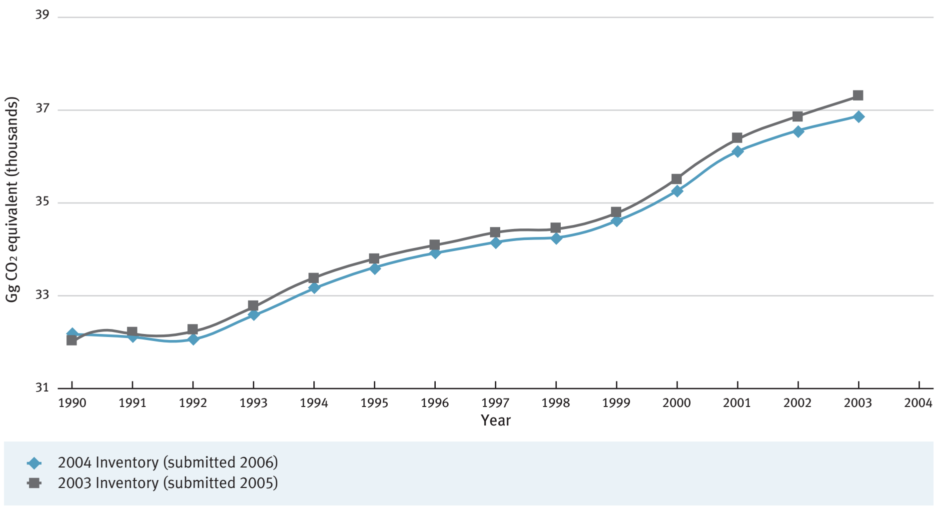
Figure 10.3.3 The effect of recalculation on the industrial processes sector



Agriculture

There are two prominent recalculations in the agriculture sector for the 2004 inventory. The first is the upgrade of manure management methodology from a Tier 1 to a Tier 2 approach. This resulted in an increase in emissions for the "manure management" category of 182.24 Gg CO_2 equivalent in 2003. This increased greenhouse gas emissions by 0.2 percent for 2003. The second recalculation resulted from a change in the EF_1 emission factor. This reduced emissions in the "agricultural soils" category by 439.23 Gg CO_2 equivalent in 2003. This reduced total greenhouse gas emissions by 0.6 percent for 2003.

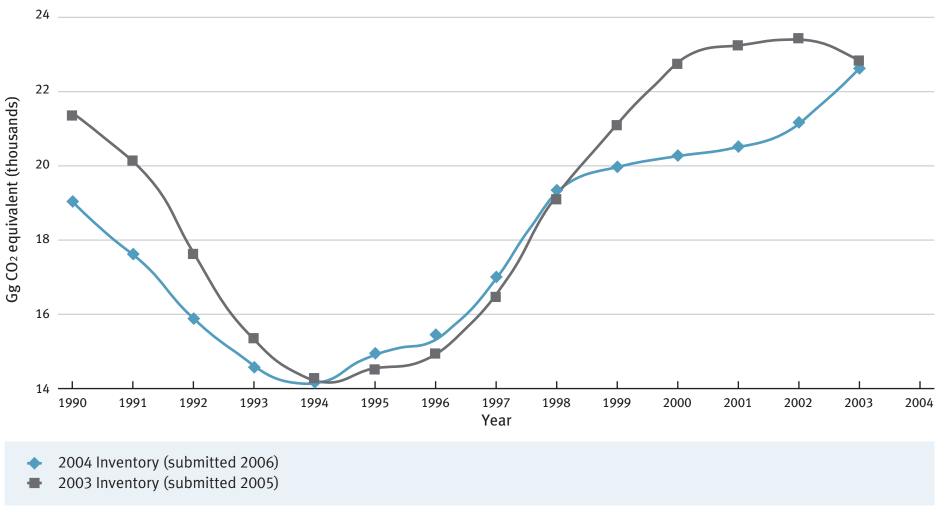
Figure 10.3.4 The effect of recalculation on the agriculture sector



LULUCF

Recalculations within the LULUCF sector are explained in section 9.1.5. Differences between the carbon yield tables are not constant across age classes, so there is an interaction with forest areas (which are also not constant across age classes) which explains the differences in net removals in the LULUCF sector between the 2003 and 2004 inventories (Figure 9.3.5).

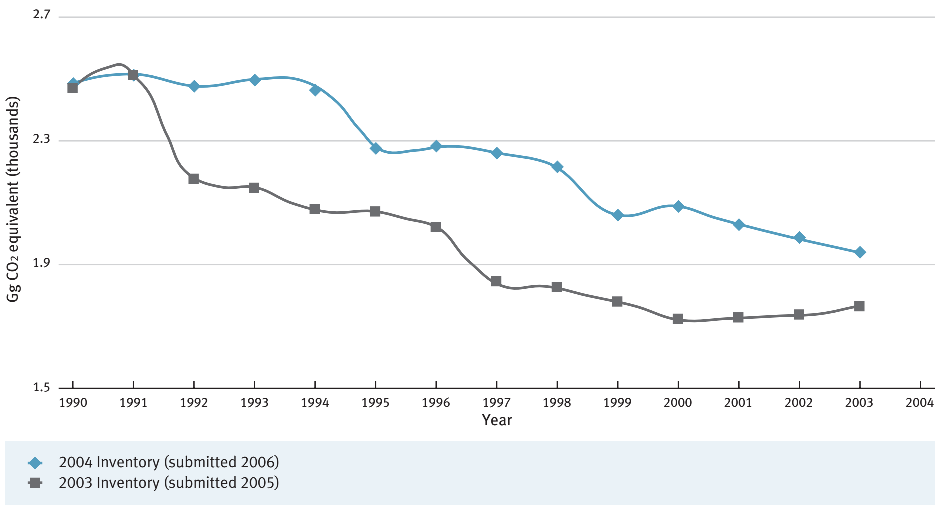
Figure 10.3.5 The effect of recalculation on LULUCF net removals



Waste

Methane emissions for 1990-2003 from solid waste were recalculated as a result of methane recovery data being updated due to commissioned work undertaken in 2005. This resulted in a slower recovery of methane than previously estimated as shown in Figure 9.2.6. The recalculation resulted in an increase of 174.64 Gg CO_2 equivalent in 2003. This increased total greenhouse gas emissions by 0.2 percent for 2003.

Figure 10.3.6 The 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 a centralised review of New Zealand's 2003 inventory submission (UNFCCC, 2006).

A number of recommendations have not yet been addressed due to the very short amount of time between the review report being published (end of March 2006) and the submission of this inventory (15 April 2006). During 2006 the recommendations of the review team 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.

For this inventory submission (2006) the emphasis has been on ensuring completeness and transparency across all source categories in line with good practice. Priorities for inventory development are guided by analysis of key sources (level and trend) and uncertainty surrounding existing emissions estimates and recommendations received from previous international reviews of New Zealand's inventory. The inventory improvement plan and the quality control and assurance plan are updated regularly to reflect current and future development. New Zealand will endeavour to undertake Tier 2 quality checks of key categories as resources permit.

The Ministry for the Environment will work towards the development of an inventory database system during 2006 to improve the inventory generation process.

10.5 Summary of recent improvements to the inventory

10.5.1 Improvements to the 2004 inventory

The focus of the 2004 inventory was on completeness, ensuring all estimates were calculated in accordance with good practice 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 was provided).

The other major improvements to the 2004 inventory include:

- Upgrading the methodology for CH_4 from manure management to a Tier 2 approach.
- Including estimates of CO_2 emissions from soda ash use.
- Including a national energy balance for 2004.
- Changing the EF_1 emission factor for nitrous oxide emissions from direct nitrogen application to a country-specific emission factor of 1 percent.
- 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.

10.5.2 Improvements in the 2003 inventory

The overall focus of 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 prior to 1997.
- Increasing explanatory text in the NIR 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 was available.
- Using the UNFCCC CRF reporter tool to improve the quality of data entered into the CRF.

10.5.3 Improvements in the 2002 inventory

In the 2004 submission for the 2002 inventory, the focus was provide a complete series of common reporting format tables for the period 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 NIR to help understanding of the methodologies and address questions raised by the UNFCCC expert review teams, especially in the energy and industrial processes sector.

10.5.4 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.

10.5.5 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) gases were upgraded to IPCC (2000) Tier 2 methodology.

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Annexes to New Zealand's National Inventory Report for 2004

Table of contents to the Annexes

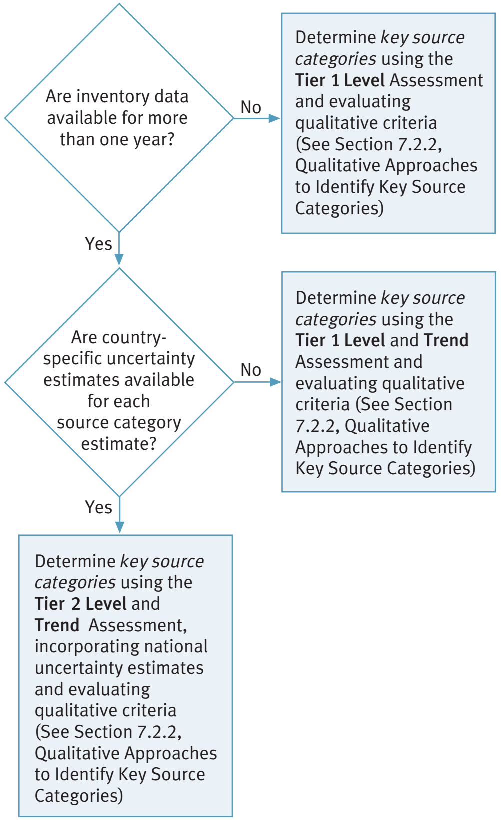
Annex 1:

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 (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)



For the 2004 inventory the Tier 1 Level and Trend assessment were applied including the LULUCF sector and excluding the LULUCF sector as per GPG LULUCF. 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 (IPCC, 2000). Key categories are defined as those categories whose cumulative percentages, when summed in decreasing order of magnitude, contributed 95 percent of the total level or trend. Categories occurring between 95 percent and 97 percent of the cumulative total were qualitatively assessed whether they are should be regarded as key categories.

A1.2 Disaggregation

The classification of categories follows the classification outlined in Table 7.1 of "Good Practice" (IPCC, 2000). The category classification follows good practice 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 oil and gas operations 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 of Good Practice) showing the results of the key category level analysis for 99 percent of the total emissions and removals in 2004. Key categories are those that comprise 95 percent of the total.

(a) Tier 1 category level assessment – including LULUCF

IPCC categories	Gas	2004 estimate Gg	Level assessment	Cumulative total
Forest land remaining forest land	CO_2	26254.43	25.4	25.4
Emissions from enteric fermentation in domestic livestock	CH_4	23714.98	23.0	48.4
Mobile combustion – road vehicles	CO_2	12416.93	12.0	60.4
Emissions from agricultural soils – animal production	N_2O	7248.77	7.0	67.4
Emissions from stationary combustion – gas	CO_2	7031.32	6.8	74.2
Emissions from stationary combustion – solid	CO_2	5808.96	5.6	79.9
Indirect emissions from nitrogen used in agriculture	N_2O	3271.38	3.2	83.0
Emissions from stationary combustion – liquid	CO_2	2755.47	2.7	85.7
Direct emissions from agricultural soils	N_2O	1806.29	1.7	87.5
Emissions from the iron and steel industry	CO_2	1731.51	1.7	89.1
Emissions from solid waste disposal sites	CH_4	1509.12	1.5	90.6
Mobile combustion – aviation	CO_2	1192.23	1.2	91.7
Conversion to forest land	CO_2	747.94	0.7	92.5
Emissions from manure management	CH_4	745.88	0.7	93.2
Conversion to grassland	CO_2	666.44	0.6	93.8
Cropland remaining cropland	CO_2	662.29	0.6	94.5
Fugitive emissions from oil and gas operations	CO_2	602.86	0.6	95.1
Emissions from substitutes for ozone depleting substances	HFCs	597.36	0.6	95.6
Emissions from aluminium production	CO_2	552.29	0.5	96.2
Emissions from cement production	CO2	484.77	0.5	96.6
Emissions from ammonia/urea production	CO_2	378.27	0.4	97.0
Fugitive emissions from oil and gas operations	CH_4	336.55	0.3	97.3
Mobile combustion – marine	CO_2	332.11	0.3	97.7
Fugitive emissions from coal mining and handling	CH_4	311.88	0.3	98.0
Fugitive emissions from geothermal operations	CO_2	279.67	0.3	98.2
Emissions from hydrogen production	CO_2	175.43	0.2	98.4
Mobile combustion – rail	CO_2	169.05	0.2	98.6
Emissions from wastewater handling	CH_4	166.95	0.2	98.7
Emissions from wastewater handling	N_2O	163.92	0.2	98.9
Mobile combustion – road vehicles	N_2O	133.42	0.1	99.0

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

Tier 1 category level assessment – including LULUCF				
IPCC categories	Gas	1990 estimate Gg	Level assessment	Cumulative total
Forest land remaining forest land	CO_2	20624.90	24.4	24.4
Emissions from enteric fermentation in domestic livestock	CH_4	21553.97	25.5	49.9
Emissions from stationary combustion – gas	CO_2	7679.40	9.1	59.0
Mobile combustion – road vehicles	CO_2	7534.65	8.9	67.9
Emissions from agricultural soils – animal production	N_2O	6767.81	8.0	75.9
Emissions from stationary combustion – solid	CO_2	3227.01	3.8	79.7
Indirect emissions from nitrogen used in agriculture	N_2O	2668.96	3.2	82.9
Emissions from stationary combustion – liquid	CO_2	2546.55	3.0	85.9
Emissions from solid waste disposal sites	CH_4	2179.23	2.6	88.5
Emissions from the iron and steel industry	CO_2	1329.40	1.6	90.1
Conversion to forest land	CO_2	870.01	1.0	91.1
Mobile combustion – aviation	CO_2	772.83	0.9	92.0
Conversion to grassland	CO_2	704.22	0.8	92.8
Direct emissions from agricultural soils	N_2O	476.05	0.6	93.4
Emissions from manure management	CH_4	583.30	0.7	94.1
Cropland remaining cropland	CO_2	538.67	0.6	94.7
PFCs from aluminium production	PFC	515.60	0.6	95.3
Emissions from aluminium production	CO_2	457.92	0.5	95.9
Emissions from cement production	CO_2	366.66	0.4	96.3
Fugitive emissions from geothermal operations	CO_2	357.34	0.4	96.7
Emissions from ammonia/urea production	CO_2	272.92	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	263.75	0.3	97.7
Fugitive emissions from oil and gas operations	CH_4	262.63	0.3	98.0
Mobile combustion – marine	CO_2	247.82	0.3	98.3
Emissions from wastewater handling	CH_4	156.66	0.2	98.5
Emissions from hydrogen production	CO_2	152.29	0.2	98.7
Mobile combustion – road vehicles	CH_4	148.20	0.2	98.8
Emissions from wastewater handling	N_2O	146.92	0.2	99.0

Table A1.3 (Table 7.A2 of Good Practice) showing the results of the key category trend analysis for 99 percent of the total emissions and removals in 2004. Key categories are those that comprise 95 percent of the total.

Tier 1 Category Trend Assessment - including LULUCF						
IPCC Categories	**Gas**	**Base year estimate Gg**	**2004 estimate Gg**	**trend assessment**	**Contribution to trend**	**Cumulative total**
Mobile combustion - Road vehicles	CO_2	7534.65	12416.93	0.036	18.5	18.5
Emissions from enteric fermentation in domestic livestock	CH_4	21553.97	23714.98	0.027	13.7	32.1
Emissions from Stationary combustion - gas	CO_2	7679.40	7031.32	0.025	12.9	45.0
Emissions from Stationary combustion - solid	CO_2	3227.01	5808.96	0.021	10.7	55.7
Direct emissions from Agricultural soils	N_2O	476.05	1806.29	0.014	6.9	62.6
Emissions from solid waste disposal sites	CH_4	2179.23	1509.12	0.013	6.4	69.0
Forest land remaining forest land	CO_2	20624.90	26254.43	0.014	7.0	76.0
Emissions from agricultural soils - animal production	N_2O	6767.81	7248.77	0.011	5.4	81.4
Emissions from substitutes for Ozone depleting substances	HFCs	0.00	597.36	0.007	3.4	84.8
PFC's from Aluminium production	PFC	515.60	80.70	0.006	3.1	87.8
Emissions from Stationary combustion - liquid	CO_2	2546.55	2755.47	0.004	1.9	89.7
Conversion to forest land	CO_2	870.01	747.94	0.003	1.7	91.4
Fugitive emissions from Oil and Gas operations	CO_2	263.75	602.86	0.003	1.6	93.0
Mobile combustion - Aviation	CO_2	772.83	1192.23	0.003	1.4	94.5
Fugitive emissions from Geothermal operations	CO_2	357.34	279.67	0.002	0.9	95.3
Mobile combustion - Road vehicles	CH_4	148.20	51.94	0.001	0.7	96.0
Emissions from the iron and steel industry	CO_2	1329.40	1731.51	0.001	0.7	96.7
Mobile combustion - Rail	CO_2	77.50	169.05	0.001	0.4	97.1
Mobile combustion - Road vehicles	N_2O	64.41	133.42	0.001	0.3	97.5
Emissions from ammonia/urea production	CO_2	272.92	378.27	0.001	0.3	97.7
Emissions from cement production	CO_2	366.66	484.77	0.000	0.2	97.9
Emissions from Manure Management	CH_4	583.30	745.88	0.000	0.2	98.2
Non-CO_2 emissions from Stationary combustion	CH_4	60.35	41.55	0.000	0.2	98.3
Mobile combustion - Marine	CO_2	247.82	332.11	0.000	0.2	98.5
Grassland remaining grassland	CH_4	57.36	43.66	0.000	0.1	98.7
Emissions from wastewater handling	CH_4	156.66	166.95	0.000	0.1	98.8
Emissions from lime production	CO_2	81.62	122.08	0.000	0.1	98.9
Non-CO_2 emissions from Stationary combustion	N_2O	76.75	115.66	0.000	0.1	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) since energy use in NZ is conventionally reported in gross terms, with some minor exceptions. The convention adopted by New Zealand to convert GCV to NCV (net calorific value) is to follow the OECD/IEA assumptions that:

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

A2.1 Emissions from Liquid Fuels

Activity data:

Statistics New Zealand conducts the *Delivery of Petroleum Fuels* collection and is New Zealand's national statistical office and administers the Statistics Act 1975.

The *Delivery of Petroleum Fuels* collection is 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 5 percent uncertainty associated with the sectoral energy allocation although the annual totals are likely to be more certain (MED, 2003).

This is a census which means 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 the respondents, and given assurances of accuracy, Statistics New Zealand are 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:

CO_2 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 a New Zealand source (Baines, 1993[1]). The same values are used for each year of inventory. There is a direct relationship between fuels' 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 NZRC estimates the uncertainty in emission factors to be within 5 percent (MED, 2003).

New Zealand's review of emission factors (Hale and Twomey, 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. The changes mainly affected the mobile combustion category. Where a country-specific value was not available, the emission factor used by New Zealand is either the IPCC value that was closest match to New Zealand's conditions or the mid-point value from the IPCC range.

Many of the sources in the stationary combustion category already used the IPCC (1996) emission factors, however there were minor changes to the 2002 inventory related to the re-interpretation of the IPCC tables resulting from the Hale and Twomey review. The changes were made to obtain the closest match to New Zealand conditions. The decision to change from the country-specific emission factors to IPCC values was confirmed by an expert review panel prior to including the emission factors in the inventory. There was no further review of emission factors for the subsequent inventory reports. All emission factors from the IPCC guidelines are converted from NCV to GCV.

[1] 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	51.8 (2004)	14.1 (2004)
Treated	53.7 (2004)	14.6 (2004)
Kapuni LTS	84.1	22.9
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 – 1990-1993*	60	Bone, Hunt and Spring (1993)
Petrol – 2003 onwards*	18.525	IPCC Tier 2 (table 1-27) passenger cars (uncontrolled – midpoint of average g/MJ)
Diesel – 1990-1993*	13	Bone, Hunt and Spring (1993)
Diesel – 2003 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

* For the years 1994-2002, emission factors are interpolated between the NZ specific emission factors (Bone, Hunt and Spring) and the IPCC defaults

Table A2.2 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 "Good practice…" (2000)) US gasoline vehicles (uncontrolled)
Diesel	3.705	IPCC Tier 2 (table 2.7 in "Good practice…" (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:

Statistics New Zealand "Coal Sales" survey is an ongoing quarterly survey which commenced 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 and returning the completed questionnaire, duly signed, is a compulsory 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 types of errors but they may still occur and they are not quantifiable.

The three ranks of coal measured are bituminous, sub-bituminous and lignite coal. From 1988 onwards the coal sales questionnaire broke 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 steel manufacture, electricity production and the residential household sector where the MED use figures from Statistics New Zealand's "Coal Sales" survey. Sectoral shares are calculated by:

- summing the four calendar year quarters of coal sales data from Statistics New Zealand's "Coal Sales" survey
- subtracting coal exports and coal used by the Residential sector (from Statistics New Zealand's "Coal Sales" survey) and coal used for steel and electricity (both known accurately) dividing CRL 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 "Coal Sales" survey's 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. An uncertainty of ± 5 percent is assumed to cover these issues (MED, 2003).

The sectoral partitioning used for coal was examined in 2003 by the Ministry for the Environment officials. There was concern in extrapolating sectoral allocations from 1995 to 2002 given some probable changes in sectoral coal usage. However, coal industry experts (Hennessy, *Personal Communication*) did not consider a survey could be justified because of the difficulty and expense in collating and verifying data from a number of sectors. Furthermore 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, 2003). The range in emission factors across all grades of coal is 5.5 percent. Therefore the estimated uncertainty in coal emission factors is taken as ± 3 percent (MED, 2003). An uncertainty of ± 2 percent is used for the sub-bituminous coal used in public electricity generation. All New Zealand values are within 2 percent 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:

The Natural Gas Corporation (NGC) has contracts with large users that allow metering errors of ± 2 percent. Whenever the error between the meter reading and actual gas supplied exceeds 2 percent, adjustments are made to the reported quantities of gas supplied. The uncertainty is therefore assumed to have an upper limit of ± 2 percent (MED, 2003).

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 percent (MED, 2003).

It has been assumed that half of the gas in the system is from the Maui gas field with an average CO_2 emissions factor of 51.9 kt CO_2/PJ for this 2004 inventory and the other half is treated gas (53.7 kt CO_2/PJ). The average value of 52.8 kt CO_2/PJ is used for this 2004 inventory (Table A2.4).

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	52.8
1991	52.9	52.8	52.8
1992	52.9	52.7	52.8
1993	52.6	52.5	52.5
1994	52.4	52.2	52.3
1995	52.1	52.9	52.5
1996	52.2	52.9	52.6
1997	52.3	52.4	52.4
1998	52.1	52.2	52.1
1999	51.8	52.4	52.1
2000	52.1	52.1	52.1
2001	51.9	52.6	52.3
2002	52.3	52.5	52.4
2003	52.0	52.6	52.3
2004	51.9	53.7	52.8

A2.4 Energy balance for year ended December 2004

Table A2.5 New Zealand energy balance for year ended December 2004

Energy Supply and Demand Balance December Year 2004

Converted into Petajoules using Gross Calorific Values	COAL							OIL								GAS	RENEWABLES								ELEC-TRICITY	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	Wastes	Wood	Total		
	Coking	Other																								
SUPPLY																										
Indigenous Production	77.58	1.75	48.89	128.22	3.79		**132.01**	42.53	9.20						**51.74**	**160.63**	97.28	84.95	0.20	1.288	1.47	17.17	35.00	**237.36**		**581.74**
+ Imports		1.61	18.43	20.04	0.00	0.21	**20.25**	217.01	0.39	41.03	36.22	0.00	13.80	7.30	**315.76**											**336.01**
- Exports	59.98			59.98	0.00	0.06	**60.04**	33.45	0.75	0.00	0.24	2.62	0.00	0.00	**37.06**											**97.10**
- Stock Change								-1.42	0.23	5.00	0.98	0.20	1.93	-0.34	**6.59**	**0.10**										**6.69**
- International Transport										0.00	1.53	8.80	38.04	0.00	**48.37**											**48.37**
TOTAL PRIMARY ENERGY	**17.59**	**3.36**	**67.33**	**88.28**	**3.79**	**0.15**	**92.22**	**227.51**	**8.62**	**36.02**	**33.47**	**-11.62**	**-26.18**	**7.64**	**275.47**	**160.53**	**97.28**	**84.95**	**0.20**	**1.288**	**1.47**	**17.17**	**35.00**	**237.36**		**765.59**
ENERGY TRANSFORMATION				**-45.37**			**-45.37**	**-227.51**	**-0.80**	**76.02**	**72.20**	**23.35**	**42.62**	**5.18**	**-8.95**	**-67.42**	**-97.28**	**-70.31**		**-1.288**	**-1.36**	**-16.80**	**-5.88**	**-192.93**	**142.57**	**-172.10**
of which Electricity Generation				-42.56			**-42.56**									**-39.80**	-97.28	-63.71		-1.288	-1.06			**-163.33**	**142.56**	**-103.13**
of which Cogeneration				-0.81			**-0.81**									**-20.59**		-0.61			-0.30	-16.80	-5.88	**-23.59**	**10.85**	**-34.15**
Oil Production								-227.51		76.47	74.90	21.30	43.26	12.28	**0.69**											**0.69**
Losses and Own Use				-2.00			**-2.00**		-0.80	-0.45	-2.70	2.05	-0.64	-7.10	**-9.64**	**-7.03**		-6.00						**-6.00**	**-10.84**	**-35.51**
Non-energy Use														***-12.82***	***-12.82***	***-50.59***										***-63.40***
CONSUMER ENERGY (calculated)		**3.36**	**67.33**	**42.90**	**3.79**	**0.15**	**46.85**		**7.82**	**112.04**	**105.67**	**11.73**	**16.44**	**0.00**	**253.71**	**42.53**		**14.64**	**0.20**	**0.000**	**0.11**	**0.37**	**29.12**	**44.43**	**142.57**	**530.09**
DEMAND																										
Agriculture				**0.52**	**0.01**		**0.53**			**1.18**	**9.74**	**1.48**	**0.20**		**12.60**										**5.61**	**18.74**
of which Agriculture and Hunting				0.52	0.01		**0.53**			1.15	6.27	0.01	0.19		**7.63**										**5.40**	**13.56**
of which Fishing										0.03	3.47	1.46	0.01		**4.97**										**0.21**	**5.18**
Industrial				**28.41**	**3.47**		**31.88**		**2.97**	**0.39**	**12.20**	**1.14**	**0.17**		**16.88**	**26.85**		**12.32**				**0.37**	**26.58**	**39.26**	**57.23**	**172.11**
of which Other Primary Industry										0.01	2.95	0.34	0.01		**3.31**										**1.20**	*
of which Food Processing										0.00	0.06	0.13	0.00		**0.19**										**7.85**	*
Textiles																									**0.61**	*
Wood, Pulp, Paper and Printing																									**14.96**	*
Chemicals																									**2.60**	*
Non-metallic Minerals																									**0.96**	*
Basic Metals				18.10			**18.10**				0.00														**24.36**	*
Mechanical/Electrical Equipment																									**1.32**	*
Building and Construction										0.01	2.60	0.01	0.10		**2.72**										**1.14**	*
Unallocated				10.32	3.47		**13.79**		2.97	0.36	6.60	0.66	0.06		**10.65**	**26.85**		12.32				0.37	26.58	**39.26**	**2.23**	*
Commercial				**5.97**	**0.60**		**6.57**		**1.40**	**0.47**	**3.41**	**0.63**	**0.66**		**6.57**	**8.75**					**0.11**			**0.11**	**26.61**	**48.61**
Residential				**0.45**	**0.40**		**0.86**		**2.23**	**0.00**	**0.00**	**0.00**	**0.00**		**2.23**	**6.71**		**2.32**	**0.20**				**2.54**	**5.06**	**47.68**	**62.54**
Domestic Transport				**0.08**			**0.08**		**1.22**	**110.96**	**75.76**	**4.61**	**17.71**		**210.25**	**0.22**									**2.14**	**212.69**
CONSUMER ENERGY (observed)				**35.44**	**4.49**	**0.00**	**39.93**		**7.82**	**113.00**	**101.11**	**7.85**	**18.75**	**0.00**	**248.52**	**42.53**		**14.64**	**0.20**		**0.11**	**0.37**	**29.12**	**44.43**	**139.28**	**514.69**
Statistical Differences				7.46	-0.70	0.15	**6.92**		0.00	-0.95	4.56	3.88	-2.30	0.00	**5.18**	**0.00**		0.00	0.00		0.00	0.00	0.00	**0.00**	**3.29**	**15.39**

* Unknown or confidential.
Electricity end use excludes electricity generated and consumed by cogeneration plants.

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.

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. These models reflect New Zealand farming systems with regard to the timing of births, timing of slaughter of growing animals and the transfer of younger animals into the breeding population.

Animal numbers are provided by Statistics New Zealand from census and survey data. As shown in the agricultural worksheets in Annex 8, three-year rolling averages are used throughout the agricultural sector for population numbers.

For sheep, dairy cattle, non-dairy cattle and deer the three-year average populations 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. Goats are also included in the analysis, but a separate model has not been developed, IPCC default values have been used. This is because goats represent only a very small proportion of the total animal population and numbers have dropped significantly in recent years.

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.

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 MAF on a census basis. This information is used as a surrogate for changes in animal liveweight. Other information is collected at irregular intervals or from small survey populations.

Livestock productivity and performance data are summarised in the time-series tables detailed in the Annex 8 worksheets. 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), average liveweights of deer (breeding and growing hinds and stags).

Dairy cattle: Data on milk production are provided by Livestock Improvement Corporation (2005). 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 (LIC) 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 LIC. Dairy cow liveweights are only available 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 percent of the weight of the average cow and 90 percent 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 are 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 592kg. This is almost 25 percent 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 percent of emissions from the dairy sector, total emissions are not highly sensitive to the assumed values.

Beef cattle: The principle source of information for estimating productivity was livestock slaughter statistics provided by the MAF. 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 percent of an adult cow weight for heifers and 10 percent of the adult cow weight for steers and bulls. Growth rates of all growing animals is divided into two periods as higher growth rates apply prior to 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.

Weights in slaughter statistics from the MAF do not separate carcass weights of adult dairy cows and adult beef cows. Thus a number of assumptions[2] 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 MAF are used to estimate the liveweight of adult sheep and lambs, assuming killing out percentages of 43 percent for ewes and 45 percent for lambs. Lamb birth liveweights are assumed to be 9 percent of the adult ewe weight with all lambs assumed to be born on 1st 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 percent more than adult ewes. Wool growth (greasy fleece growth) was assumed to be 5kg/annum in mature sheep (ewes, rams and wethers) and 2.5kg/annum in growing sheep and lambs.

2 Number of beef breeding cows assumed to be 25% of the total beef breeding cow herd; other adult cows slaughtered assumed to be dairy cows. Carcass weight of dairy cattle slaughtered was estimated using the adult dairy cow liveweights and a killing out percentage of 40. Total weight of dairy cattle slaughtered was 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 45.

Deer: Liveweights of growing hinds and stags are estimated from MAF slaughter statistics, assuming a killing out percentage of 55 percent. A fawn birthweight of 9 percent 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 is no published data on which to attempt a detailed categorisation of the performance characteristics in the same way as has been done for the major livestock categories. New Zealand uses the IPCC CH_4 emission factor for goats (9 kg CH_4/head/yr).

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 (Standard Australian Livestock Tables, 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 is no comprehensive published data available that allows the estimation of a time-series dating back to 1990.

Methane emissions per unit of feed intake

There are a number of published algorithms and models[3] 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 dissimilar to those consumed by New Zealand's grazed 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. A database has been constructed and is being systematically examined to obtain generalised relationships between feed and animal characteristics and CH_4 emissions. As an interim measure, 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 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 percent 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. A mean 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.

[3] 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 A3.1.1 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

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

Year	Dairy cattle	Beef cattle	Sheep	Deer
1990	70.8	51.0	8.9	21.0
1991	71.4	51.7	9.1	20.7
1992	73.3	52.7	9.2	20.6
1993	73.7	54.2	9.3	20.5
1994	73.9	53.6	9.4	20.6
1995	73.6	53.3	9.5	20.9
1996	74.4	52.6	9.6	21.3
1997	74.3	54.5	9.9	21.9
1998	75.1	54.5	10.0	22.2
1999	76.5	55.3	10.1	22.3
2000	78.7	55.1	10.2	22.4
2001	78.8	56.4	10.5	22.3
2002	79.0	56.1	10.5	22.3
2003	79.1	56.3	10.6	22.1
Previous fixed EF	76.8	67.5	15.1	30.6

A3.1.2 Manure management emissions

Methane emissions from ruminant animal wastes in New Zealand have been recalculated using an IPCC Tier 2 approach. This replaces the Tier 1 approach used in previous national communications. 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 produced.

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 percent of faecal material arising from dairy cows is assumed to be deposited directly onto pastures. The quantity of methane produced per unit of faecal dry matter is 0.98g CH_4/kg. This value is obtained from New Zealand studies on dairy cows (Saggar *et al*, 2003 and Sherlock *et al*, 2003).

Faecal material stored in anaerobic lagoons

In line with the current nitrous oxide inventory 5 percent of faecal (dung and urine) material arising from dairy cows is assumed to be deposited directly into lagoons. The method adopted here is to assume that all faeces deposited in lagoons are diluted with 90 litres of water per kg 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 and an average emission of 3.27 CH_4/M^2/year.

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 (0.98g 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. The quantity of methane produced per unit of faecal dry matter is 0.92g CH_4/kg. This value is obtained from 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

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.**

2003/4 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 2003 Agricultural Production Survey was 85 percent. These businesses contributed 87 percent of the total agricultural output. The sample error and percentage imputed for 2003 are shown in Table A3.2.1. For the 2004 survey, 30,715 forms were distributed. The survey response rate was 87 percent or 91 percent of the estimated value of production. Interim animal number results from the 2004 survey have been used for the 2005 submission. The 2003 animal numbers have been updated with final animal number estimates, as final numbers are not available until after submission of the inventory.

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 percent. Statistics New Zealand imputes using a random 'hot deck' procedure for values for farmers and growers who did not returned 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 MAF 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 percent. The remaining units were given imputed values based on either previous data or on the mean value of similar farms. Table A3.2.2 gives the sample errors based on a 95 percent confidence level for the survey data collected in 1999.

Table A3.2.1 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

Table A3.2.2 Agricultural sector sample errors based on 95 percent 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

A3.2 Additional information for the LULUCF sector: the Carbon Monitoring System plots and the New Zealand Carbon Accounting System.

Major ongoing work in the LULUCF sector includes research and implementing a monitoring system for the carbon stocks and fluxes in soils, shrublands and natural forests. This research was initiated by the MfE in 1996 and is being performed by two of New Zealand's Crown Research Institutes – Landcare Research and Forest Research. This five-year research project had the following objectives:

- the estimation of carbon storage in soils, shrublands and natural forests in 1990
- the development of a national system to determine soil carbon changes associated with land-use change
- the development of an effective information system to manage the above information.

Provisional results are available from the work under the first objective. Hall *et al*. (1998) have estimated that in 1990 carbon stored in natural forests was 933 MtC, while 527 Mt C was stored in shrublands and other woody mixed-vegetation. Forest floor litter carbon is estimated separately, based on Hall *et al*.(1998), as containing 570 Mt C for all natural vegetation (ie, both forest and scrub areas). These estimates are highly sensitive to both the accuracy of mapped areas and heterogeneity within mapped classes. Current (very provisional) estimates for soil carbon at soil depth intervals of 0-0.1, 0.1-0.3 and 0.3-1m are 1300±20, 1590±30 and 1750±70 Tg C respectively (Tate *et al*, 2003a). Some soil cells are still poorly represented in the database and additional field work is being undertaken. Further information on this project and initial estimates of carbon stocks at 1990 are found in Coomes *et al* (2002), Lawton and Barton (2002), Lawton and Calman (1999) and Hall *et al* (1998).

In 1999, the soil and vegetation carbon monitoring systems (CMS) developed during the first three years of the project were reviewed by an international panel of forestry and soil experts. The panel's report concluded that the systems being developed for New Zealand's natural forests are consistent with current forest inventory practices in other countries. Furthermore, the soils that the system represented are measured through a significantly advanced methodology compared with the IPCC default method (Theron *et al*, 1999). The international review of the system was held in time for the key recommendations of the review to be undertaken before the development phase was concluded.

The statistical design of the vegetation CMS provides for the establishment of 1400 permanent field plots on an 8x8 km grid across natural forest and shrublands for territorial New Zealand (Coomes *et al*, 2002). This includes the North and South Islands, Stewart Island, the Chatham Islands and other offshore islands. To provide continuity, and to build on previously collected data, about one-third of the plots are existing ones matched to nearby grid intersection points, and the rest are new plots established at unmatched grid intersections specifically for monitoring forest carbon pools. The plot measurements use the 20m by 20m quadrat method (Allen 1993) which has been used at various sites of interest in New Zealand but never on a statistically representative basis across all of the nation's natural forests and shrublands. Measurements are taken of above ground biomass, such as tree heights and diameters, understorey vegetation, litter, and coarse woody debris. These measurements will have utility for other international forestry reporting obligations such as those required under the Montreal Process, the FAO Global Forest Resource Assessment, and the Convention on Biological Diversity.

The soil CMS analyses soil samples to a depth of 0.3m for carbon content. One in every three of the vegetation plots is sampled for soils to reduce the uncertainty in some soil cells.

The CMS for soil and vegetation are currently moving from design to implementation. The first year's fieldwork for the operational vegetation CMS commenced in January 2002 and was completed in early 2003. The second year's fieldwork began in March 2003. Fieldwork over at least three more years will be required to install the complete network of field plots. Following this, another five-year round of sampling will be required to validate the implementation and begin monitoring of any changes. The current intention is then to repeat these measurements every ten years.

For the soil CMS, 40 soil-paired plots sites will be established to monitor key changes in soil carbon when land-use changes, ie, scrub to grassland, grassland to Kyoto forest and vice versa. The first four paired plots sites were established in 2003.

The New Zealand Carbon Accounting System (NZCAS) is being developed. This system will account for human-induced carbon sources and sinks from New Zealand's land use, land-use change and forestry (LULUCF) activities which (a) is appropriate for annual UNFCCC greenhouse gas emission LULUCF sector reporting; (b) enables accounting and reporting under the Kyoto Protocol; and (c) underpins scenario development and modelling capabilities that support New Zealand's Climate Change Policy development.

The most developed module of the NZCAS is for natural forests and shrublands (Coomes *et al*., 2002; Payton *et al*., 2004). This is based on the CMS plots. These unique natural forests cover 6.4 million hectares, and have been either too remote or inaccessible for timber extraction and are now largely protected, often as national parks. New Zealand has not, until now, needed to establish a national forest inventory to cover its protected forests. This is in sharp contrast to the advanced system used for monitoring and forecasting future wood supply from its 1.8 million hectares of plantation forests.

A monitoring and modelling module is currently being designed for those areas where afforestation and reforestation activities have occurred since 1990 – the so-called Kyoto forests. This will involve inventory measurements from permanent plots coupled with the use of existing allometric equations and/or forest volume and carbon models (Beets *et al*, 1999).

A3.3 Additional methodology for the LULUCF sector: the Land Cover Database

The Land Cover Database (LCDB1) was completed in 2000 using SPOT 2 and SPOT 3 satellite imagery acquired over the summer of 1996/97. A 1 ha minimum mapping unit (MMU) was used and this was retained for LCDB2. LCDB2 used the Landsat 7 ETM+ sensor, with the imagery pan-sharpened to a 15 m spatial resolution. All imagery for LCDB2 was acquired during summer 2001/02. Development of the final database involved several Government Crown Research Institutes, Ministries and companies. LCDB2 was released July 2004.

A description of the process to create LCDB2 is shown in figure A3c.1. A single set of polygon boundaries is used for both the attributes from LCDB1 and LCDB2. This removes the need for GIS overlay analysis to detect changes in land cover between databases. As part of the process of developing LCDB2, any errors identified in the LCDB1 were corrected and areas of apparent change confirmed.

The target classes used for LCDB1 and 2 are hierarchical (and derived from eight first order classes at the highest level, with an increasing number of more detailed classes at lower levels. The first order classes are based on the physiognomy of the land cover (ie, grassland, shrubland, forest etc). The following divisions are based on other characteristics, such as phenology (evergreen/deciduous) and floristic composition (broadleaved/needle leaved).

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 the following:

- whether the land-cover types identified in the draft vectors are present on the ground
- whether land-cover types observed on the ground are captured and correctly labeled 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 MMU is not possible), is classified according to the dominant species in the matrix. This procedure was maintained throughout the LCDB2 mapping project.

For LCDB1, overall user accuracy was assessed at 93.9 percent. A classification accuracy has not been established for LCDB2. The database was released to ensure that users have access to the updated national dataset for planning and monitoring purposes. However users can be confident that the accuracy of LCDB2 will be equal to or higher than the user accuracies for LCDB1, namely, bare ground (81 percent), natural forest (95 percent), mangrove (97 percent), planted forest (90 percent), horticultural (95 percent), pastoral (98 percent), scrubland (89 percent), tussock (95 percent), and wetlands (87 percent).

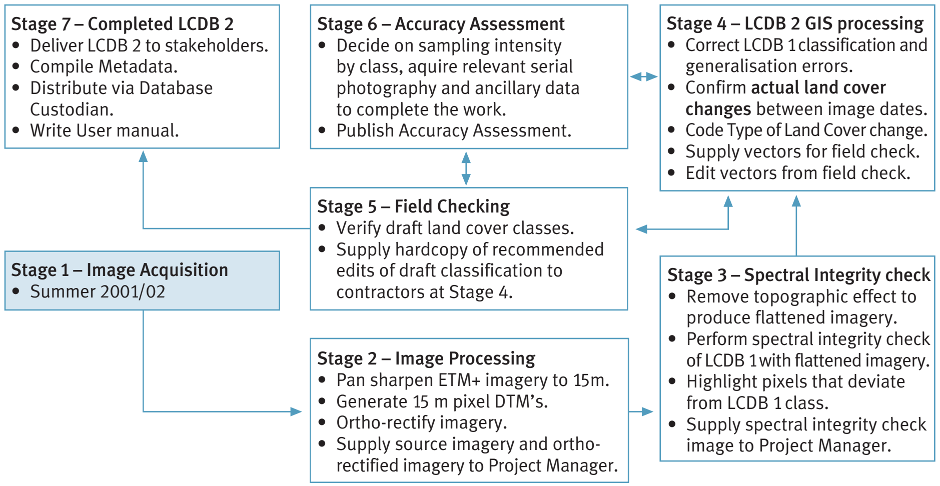


Table A3.3.1 Mapping of LCDB classification to the IPCC land-use categories.

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 LCDB 1), 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, sub-alpine 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 and gravel landslide permanent snow and ice river and lakeshore gravel and rock
SETTLEMENT	
S	Built-up area, dump, surface mine, transport infrastructure, urban parkland/ open space
WETLAND	
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 IEA 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 of Chapter 1.

Annex 6:

Quality assurance and quality control

During preparation of the New Zealand 2004 national greenhouse gas 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 2004 inventory

Tier 1 quality control (QC) checks for key sources (as identified in the level and trend analysis of the 2003 national inventory) and a selection of non key sources were completed on the 2004 data. Two of these checklists with the results are included as examples in this Annex. 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 1990-2004.

Some specific findings of the 2004 quality control process included:

- CO_2 emissions were found to be included for liquid fuels for iron and steel for this submission whereas the 2005 submission did not include emissions at this level. This error was corrected after consultation with the data providers Ministry of Economic Development
- LULUCF net removals data was found to be too high and on re-checking discovered the inclusion of soil carbon information in forest land was effectively causing double counting. This was corrected
- An error in activity data for road paving with asphalt was found for the years 2000-2003. Only activity data for cut-back was included in the CRF in the 2003 inventory. This has been corrected to include activity data for all bitumen use for roading in the 2004 inventory.

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.

During 2005 a number of recommendations from the quality management report produced in late 2004 were addressed.

- The improvement plan was updated with the objective of the greenhouse gas inventory to be consistent with IPCC Good Practice Guidance by September 2006
- A post-inventory evaluation will be undertaken after inventory submission on 15 April to review lessons learned and how to improve processes for the next inventory compilation. This is documented in the schedule of activities in the QA/QC plan
- The QA/QC coordinator and responsibilities for this position have been clearly defined in the QA/QC plan
- Objectives of the QA/QC programme have been formally documented in the QA/QC plan and performance against these objectives will be regularly reviewed
- The QA/QC plan now contains more specific information as cited in the IPCC Good Practice Guidance including a scheduled time frame that follows inventory preparation from its' initial development to final reporting in any given year. It also includes a schedule to review all source categories over a four year period.

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

Statistics New Zealand: To minimise error, all questionnaires 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. The questionnaire is designed with a view to making it easy for survey respondents to give the information which Statistics New Zealand requires. Questionnaires are tested prior to use in surveys. Statistics New Zealand provides an enquiry service for respondents who need to help completing questionnaires and they follow up respondents to ensure high response rates are achieved. Statistical methodology (sample design, estimation techniques etc) 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 address the recommendations from the quality management report during 2006. These include:

- documenting a plan for Tier 2 quality checks
- investigating ways of performing verification of emissions data
- continuing to plan and implement a document/records register to improve management of inventory documentation. (The new document management system implemented at the Ministry of the Environment during 2005 is assisting in achieving this improvement.)

A6.5 Example worksheets for QC procedures in 2004

TIER 1: INDIVIDUAL SOURCE CATEGORY CHECKLIST				Ver 1.0		
Inventory Checked:	2004					
Source Category:	4A Enteric fermentation-CH4			CH4		
Estimates prepared by:	Ministry of Agriculture and Forestry with data from Statistics New Zealand and Agresearch					
Working spreadsheet(s)						
Tier 1 QC Activity & Procedures						
QC Activity	**Procedures**	**Procedures adopted for 2006 NIR (2004 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**
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 that these are properly recorded and archived.	Check activity data and emission factors are described in the NIR report and any changes from previous years are adequately documented.	MfE-SP	S. Petrie : Checked description of activity data, emission factors and methodology in NIR	Well documented in chapter 6 and Annex 3a of the NIR	none
Check for transcription errors in data input and reference	Confirm that bibliographical data references are properly cited in the internal documentation.	1. Undertake visual checks of module names for consistency in NIR worksheets. 2. Check all references cited in the appropriate source sector chapter in the NIR report and make sure they are corrctly referenced at the end of the chapter.	MfE-TW	TW 5/4/06: 1. Checked module names in worksheets for consistency. 2. Check references cited in text are correctly referenced in the reference chapter.	1. 1990 module names incorrectly labelled as 2004 in worksheets; 1 submodule wrongly named. Need to streamline module names 2. Some references cited in text missing in reference chapter and several references no longer cited in main text	corrected to 1990; submodule name amended; module names updated
	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.	MfE-TW	TW 5/4/06: 1. visual check by comparing animal numbers for all classes for 1990 used in enteric fermentation figures from NIR worksheet with that in the CRF reporter	1. All livestock numbers in NIR worksheets are the same as those in the CRF reporter.	none
Check that emissions are calculated correctly.	Reproduce a representative sample of emissions calculations.	Using the figures in the NIR worksheets, calculate representative sample of emissions manually and compare to emissions value in CRF.	MfE-TW	TW 5/4/06: 1. Calculated dairy cattle CH4 enteric fermentation emissions using figures from worksheet 4.1 (1990) 2. calculate methane emissions using activity data-1990	1.Value calculated was 240.08Gg (NIR) compared with 240 Gg (CRF). Test passed. 2. Final emissions of methane: Value in NIR worksheet for 1990 is 1025.27Gg compared with 1026.38Gg in the CRF reporter. Within 1% -test passed.	none
	Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.	Use Tier 1 approach to calculate a sub source of data (eg CH4 emissions from dairy cattle) to judge relative accuracy.	MfE	limited time meant this check was not undertaken		
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-TW	TW 5/4/06: visual inspection of units labeled in agricultural worksheets	units correctly labelled	none
	Check that units are correctly carried through from beginning to end of calculations.	check appropriate units are used throughout calculations	MfE-TW	TW 5/4/06:checked units are appropriate	correct SI units are used in tables	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 CH4.	MfE-TW	TW 5/4/06: checked conversion from kg (as kg/head/yr) to Gg of CH4 for enteric fermentation and manure management occurred in NIR worksheet 4.1	conversion factors are correct and accounted for properly	none

Check the integrity of database and/or spreadsheet files.	Confirm that the appropriate data processing steps are correctly represented in the database.	confirm data processing steps within model for enteric fermentation are appropriate	MfE			
	Ensure that data fields are properly labelled and have the correct design specifications.	Ensure the addition or deletion of datalines are adequately explained	MfE-TW	TW 5/4/06: check worksheet tables for obvious gaps in the data-series	none found	none
	Ensure that adequate documentation of database and model structure and operation are archived.	Ensure there is adequate documentation of the model structure and that it is archived.	MfE	S. Petrie 13/04/05: check adequate documentation of enteric fermentation model	paper written by Clark et al (2003) describing the model is archived on the Mfe computer network and copies are also held at MAF	none
Check for consistency in data between source categories	Identify parameters (e.g. 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 animal number dataset.	MfE-TW	TW 6/4/06: Checked for consistency in animal numbers within CRF for dairy cattle and sheep in 1990 and 2004 (for enteric fermentation and manure management)	Dairy numbers consistent for dairy cattle in 1990 (3390.87) and 2004 (5118.8) and sheep in 1990 (57860.83) and 2004 (39572.43) across manure management and enteric fermentation	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 CH4 emissions from dairy cattle & non dairy cattle sources for enteric fermentation & compare with values in cattle node in CRF reporter.	MfE-TW	TW 5/4/06: 1. sum CH4 emissions from dairy cattle and non-dairy cattle and compare with total in CRF reporter	1. The summed value is 481.81 Gg from dairy and non-dairy cattle in 1990 compared with 474.62 Gg (total for cattle in CRF). Minor difference due to rounding.	none
	Check that emissions data are correctly transcribed between different intermediate products	QA/QC procedures used that show correct transcription between intermediate worksheets and final entry of data into CRF reporter	MfE	on-going and done informally by double checking all entries in model input sheets, output sheets and CRF excel sheetss		none
Check that uncertainties in emissions and removals are estimated or calculated correctly.	Check that qualifications of individuals providing expert judgement for uncertainty estimates are appropriate.					
	Check that qualifications, assumptions and expert judgements are recorded. Check that calculated uncertainties are complete and calculated correctly.	Check appropriate qualifications, assumptions and judgements for uncertainity analysis are recorded & archived. Check calculated uncertainties are completed and correct				
	If necessary, duplicate error calculations or a small sample of the probability distributions used by Monte Carlo analyses.					
Undertake review of internal documentation.	Check that 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 estimates and uncertainty analysis.	MfE-SP			
	Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review.	Check to ensure copies of reports of sector reviews and methodologies are archived.	MfE-SP	S.Petrie: Ensure spreadsheets and information on the enteric fermentation model are stored in an accessible and secure location	All data and methodologies associated with estimating enteric fermentation (and all agricultural emissions) are stored on the Mfe Silent One documentation system which is regularly backed up.	none
	Check integrity of any data archiving arrangements of outside organisations involved in inventory preparation.	N/A-data compliation done in house	MfE	N/A	N/A	
Check methodological and data changes resulting in recalculations.	Check for temporal consistency in time series input data for each source category.	record result from time series consistency check in CRF reporter software	MfE-SP	informal check by looking at all graphs	no inconsistencies in time-series notes	none
	Check for consistency in the algorithm/method used for calculations throughout the time series.	Confirm the method used for estimating CH4 from enteric fermentation is consistent throughout the time series	MfE-SP	S. Petrie : confirm consistent methodology	Methodology is consistent-reading model description and training on how the model runs confirms this	none
Undertake completeness checks.	Confirm that estimates are reported for all source categories and for all years from the appropriate base year to the period of the current inventory.	record result of completeness check in CRF reporter software	MfE-SP	S.Petrie : run completeness checks.	all passed	none
	Check that known data gaps that result in incomplete source category emissions estimates are documented.	ensure any known data gaps are documented	MfE-SP	N/A	N/A	N/A
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 1990 and 2003 value in CRF Reporter - If figures in black is consistent with previous estimates; if in blue explain differences	MfE-TW	TW 5/4/06: Check for inconsistencies with previous estimates for 1990 and 2003	Figures for 1990 and 2003 are different. These differences are due to updates in stock population numbers	none

A6.6 QA summary worksheet

QUALITY ASSURANCE CHECKLIST								
Includes all reviews up to and including the 2003 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 complete inventory	Not possible to do as an external review due to lack of time. Chapter 7 (LUCF) put out to review within MfE.							
Expert review of Energy Sector	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.	Document number 61671 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-see comment above. 4. This is to be addressed in 2004 NIR. 5. Is being addressed. 6. Addressed. 7. This is addressed in 2003 and 2004 inventory reports. 8. T2 approach is being developed as time and resources allow. 9. This has now been addressed (see report details below). 10.	Hard copy kept in Sonia's tambour
	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 69-71 The Terrace POBox 10444 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 inventury 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 CO2 emissions factors, review of coal CH4 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 being used in 2004 inventory report. 2. Addressed-this has been implemented in 2004 inventory report. 3. This will depend on the time and resources of MED... 4. Consensus has not been reached on this issue. 5. This is addressed in the 2004 inventory report.	Hard copy kept in Sonia's tambour and draft report kept on the MfE network.
Expert review of Industrial Processes Sector	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 SF6	1. Clarify differences between tables, worksheets, the CRF and consultant reports. 2. Review why CO2 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. Energy sector? 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. This is being addressed in the 2004 inventroy report. 6. A new consultant has been found for this section of work who is more quality conscious.	document number 61978 in Silent One
	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.		Doc number 61986 in SilentOne

Expert review of Solvent Sector								
Expert review of Agriculture Sector	Peer review of nitrous oxide work through scientific papers: de Klein C A M, Barton L, Sherlock R R, Li Z, Littlejohn R P (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		**Not documented (prior to QA procedures developed)**				
	Report to MAF: Revised nitrous oxide emissions from New Zealand agricultural soils 1990-2001	2003	F.M. Kelliher, S.F. Ledgard, H. Clark, A.S. Walcroft, M. Buchan & R.R. Sherlock	**Not documented (prior to QA procedures developed)**	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.	Document number 61504 in Silent One
	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"		K. R. Lassey of NIWA	**Not documented (prior to QA procedures developed)**				Report kept in Ag sector filemaster box in Sonia's tambour
	Review of Agricultural sector GHG program to ascertain whether program 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 no 61522 in Silent One
	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 no 61511 in Silent One
Expert review of Land use change and forestry Sector								
Expert review of Waste Sector								
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 & agreed with all necessary parties.	Many of the recommendations in this report have been addressed this during 2005 calender year with the remaining to be addressed during 2006.	Doc no 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 (GPG, 2000). Good practice 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 N2O 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. 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. 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 percent confidence interval divided by the mean and expressed as a percentage. The reason for halving the 95 percent confidence interval is that the value corresponds to the familiar plus or minus value when uncertainties are loosely quoted as 'plus or minus x percent'. 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 column H 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 percent 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 percent 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 A7.1and A7.2, the figure labeled “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 – 2004 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	22721.55	30590.19	5	0	5	1.49	0.0317	0.3654	0.0000	2.5836	2.58	M	R
Industrial processes sector	CO_2	2,666.52	3450.30	5	0	5	0.17	0.0021	0.0412	0.0000	0.2914	0.29	M	R
LULUCF sector - forest land	CO_2	20624.90	26254.43	5	25	25	6.50	0.0107	0.3136	0.2683	2.2174	2.23	M	R
LULUCF sector other land use categories	CO_2	1404.86	1577.33	15	184	185	2.83						M	R
Energy sector	CH_4	797.03	794.25	5	50	50	0.39	-0.0022	0.0095	-0.1108	0.0671	0.13	D	R
CRF2A - mineral products	CH_4	NO	NO											
CRF2B - chemical industry	CH_4	20.16	45.69	0	80	80	0.04	0.0002	0.0005	0.0200	0.0000	0.02	D	R
CRF4A - enteric fermentation	CH_4	21553.97	23714.98	2	53	53	12.22	-0.0331	0.2833	-1.7558	0.8012	1.93	M	M
CRF4B - manure management	CH_4	583.30	745.88	2	100	100	0.72	0.0003	0.0089	0.0345	0.0252	0.04	M	M
CRF4E- prescribed burning	CH_4	2.82	0.70	20	60	63	0.00	0.0000	0.0000	-0.0020	0.0002	0.00	D	R
CRF4F - burning of residues	CH_4	18.78	18.88	50	40	64	0.01	-0.0001	0.0002	-0.0020	0.0159	0.02	D	R
LULUCF sector	CH_4	93.54	75.15	10	35	36	0.03	-0.0005	0.0009	-0.0167	0.0127	0.02		
CRF 6A - Solid waste disposal	CH_4	2177.70	1507.49	0	20	20	0.29	-0.0140	0.0180	-0.2793	0.0000	0.28	M	R
CRF 6B - wastewater handling	CH_4	156.66	166.95	0	20	20	0.03	-0.0003	0.0020	-0.0061	0.0000	0.01	D	R
Energy sector	N_2O	151.26	265.05	5	50	50	0.13	0.0009	0.0032	0.0472	0.0224	0.05	D	R
CRF4D -Agricultural soils	N_2O	10021.98	12768.17	5	73	73	9.08	0.0053	0.1525	0.3905	1.0784	1.15	M	M
CRF4B - manure management	N_2O	37.93	63.50	5	100	100	0.06	0.0002	0.0008	0.0202	0.0054	0.02		
CRF4E- prescribed burning	N_2O	0.51	0.13	20	60	63	0.00	0.0000	0.0000	-0.0004	0.0000	0.00	D	R
CRF4F - burning of residues	N_2O	6.46	6.20	50	40	64	0.00	0.0000	0.0001	-0.0008	0.0052	0.01	D	R
LULUCF sector	N_2O	9.49	7.63	10	35	36	0.00	0.0000	0.0001	-0.0017	0.0013	0.00		
CRF6B - wastewater handling	N_2O	146.92	163.92	0	1200	1200	1.91	-0.0002	0.0020	-0.2392	0.0000	0.24	D	R
CRF2F	HFCs	0.00	597.36	120	50	130	0.75	0.0071	0.0071	0.3568	1.2109	1.26	D	R
CRF2C	PFCs	515.60	80.70	0	30	30	0.02	-0.0066	0.0010	-0.1982	0.0000	0.20	M	M
CRF2F	SF_6	9.46	21.49	5	20	21	0.00	0.0001	0.0003	0.0024	0.0018	0.00		
Total emissions/removals		**83721.40**	**102916.34**		**Uncertainty in the year**		**17.0%**		**Uncertainty in the trend**			**4.3%**		

assumptions as per IPCC GPG

1. where only total uncertainty is known for a source category then the following rules have been used.

a) if uncertainty is assumed to be correlated across years, then total uncertainty is entered as emission factor uncertainty

b) if uncertainty is assumed not to be correlated across years, then the total uncertainty is entered as activity data uncertainty

2. Column K: The same emission factor is used in both years and the emission factors are fully correlated.

3. Column L: The activity data in both years is assumed independent (not correlated).

Note that the total shown will not equal the gross or net totals reported in the CRF/NIR as not every source is specified in the uncertainty analysis

Table A7.2 Uncertainty calculation for the New Zealand Greenhouse Gas Inventory 1990 – 2004 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	22721.55	30590.19	5	0	5	2.04	0.0474	0.4959	0.0000	3.5062	3.51	M	R
Industrial processes sector	CO_2	2,666.52	3450.30	5	0	5	0.23	0.0033	0.0559	0.0000	0.3955	0.40	M	R
Energy sector	CH_4	797.03	794.25	5	50	50	0.53	-0.0028	0.0129	-0.1425	0.0910	0.17	D	R
CRF2A - mineral products	CH_4	NO	NO											
CRF2B - chemical industry	CH_4	20.16	45.69	0	80	80	0.05	0.0003	0.0007	0.0274	0.0000	0.03	D	R
CRF4A - enteric fermentation	CH_4	21553.97	23714.98	2	53	53	16.75	-0.0407	0.3844	-2.1559	1.0873	2.41	M	M
CRF4B - manure management	CH_4	583.30	745.88	2	100	100	0.99	0.0006	0.0121	0.0583	0.0342	0.07	M	M
CRF4E- prescribed burning	CH_4	2.82	0.70	20	60	63	0.00	0.0000	0.0000	-0.0027	0.0003	0.00	D	R
CRF4F - burning of residues	CH_4	18.78	18.88	50	40	64	0.02	-0.0001	0.0003	-0.0026	0.0216	0.02	D	R
LULUCF sector	CH_4	93.54	75.15	10	35	36	0.04	-0.0006	0.0012	-0.0220	0.0172	0.03		
CRF 6A - Solid waste disposal	CH_4	2177.70	1507.49	0	20	20	0.40	-0.0185	0.0244	-0.3704	0.0000	0.37	M	R
CRF 6B - wastewater handling	CH_4	156.66	166.95	0	20	20	0.04	-0.0004	0.0027	-0.0077	0.0000	0.01	D	R
Energy sector	N_2O	151.26	265.05	5	50	50	0.18	0.0013	0.0043	0.0656	0.0304	0.07	D	R
CRF4D -Agricultural soils	N_2O	10021.98	12768.17	5	73	73	12.44	0.0092	0.2070	0.6740	1.4635	1.61	M	M
CRF4B - manure management	N_2O	37.93	63.50	5	100	100	0.08	0.0003	0.0010	0.0281	0.0073	0.03		
CRF4E- prescribed burning	N_2O	0.51	0.13	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	6.20	50	40	64	0.01	0.0000	0.0001	-0.0011	0.0071	0.01	D	R
LULUCF sector	N_2O	9.49	7.63	10	35	36	0.00	-0.0001	0.0001	-0.0022	0.0017	0.00		
CRF6B - wastewater handling	N_2O	146.92	163.92	0	1200	1200	2.62	-0.0002	0.0027	-0.2898	0.0000	0.29	D	R
CRF2F	HFCs	0.00	597.36	120	50	130	1.03	0.0097	0.0097	0.4841	1.6433	1.71	D	R
CRF2C	PFCs	515.60	80.70	0	30	30	0.03	-0.0089	0.0013	-0.2659	0.0000	0.27	M	M
CRF2F	SF_6	9.46	21.49	5	20	21	0.01	0.0002	0.0003	0.0032	0.0025	0.00		
Total emissions/removals		**61691.64**	**75084.58**		**Uncertainty in the year**		**21.2%**		**Uncertainty in the trend**			**4.9%**		

assumptions as per IPCC GPG

1. where only total uncertainty is known for a source category then the following rules have been used.

a) if uncertainity is assumed to be correlated across years, then total uncertainty is entered as emission factor uncertainty

b) if uncertainty is assumed not to be correlated across years, then the total uncertainty is entered as activity data uncertainty

2. Column K: The same emission factor is used in both years and the emission factors are fully correlated.

3. Column L: The activity data in both years is assumed independent (not correlated).

Note that the total emissions shown will not equal the total reported in the CRF/NIR as not every source is specified in the uncertainty analysis

Annex 8:

Worksheets for all sectors

A8.1 Worksheets for the energy sector

Module	**2004 Energy (New Zealand)**
Submodule	**CO_2 emissions from energy sources (reference approach)**
Worksheet	**1.1 (1-3 of 5)**
Sheet	**Emissions from domestic fuel combustion**

Fuel type		Production	Imports	Exports	Inter-national bunkers	Stock change	Apparent consump-tion	Conversion factor (TJ/unit)	Apparent consump-tion (TJ)	Carbon emis fact (t C/TJ)	Carbon content (t C)	Carbon content (Gg)	Carbon stored (Gg)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO2 emissions (Gg)
Liquid fossil fuels - primary	Crude oil	42.53	200.89	33.45		-3.58	213.56	1,000	213,558.53	17.80	3,801,341.83	3,801.34		3,801.34	0.99	3,763.33	13,798.87
	Orimulsion	0.00	0.00	0.00		0.00	0.00										
	Natural gas liquids	9.52	0.39	0.75		0.23	8.94	1,000	8,937.82	16.47	147,230.27	147.23		147.23	0.99	145.76	534.45
Liquid fossil fuels - secondary	Gasoline - Regular Unleaded		29.72	0.00	0	0.93	28.79	1,000	28,789.44	18.05	519,780.31	519.78		519.78	0.99	514.58	1,886.80
	Gasoline - Premium Unleaded		11.31	0.00	0	4.08	7.24	1,000	7,235.36	18.27	132,209.70	132.21		132.21	0.99	130.89	479.92
	Jet kerosene		13.10	0.00	38.04	1.87	-26.81	1,000	- 26,812.20	18.57	- 497,975.60	- 497.98		- 497.98	0.99	- 493.00	- 1,807.65
	Av Gas		0.70	0.00	0.00	0.06	0.63	1,000	634.95	17.73	11,255.93	11.26		11.26	0.99	11.14	40.86
	Other kerosene		0.00	0.00	0.00	0.00	0.00										
	Shale oil		0.00	0.00	0.00	0.00	0.00										
	Gas/diesel oil		36.22	0.24	1.53	0.98	33.47	1,000	33,472.03	18.95	634,447.10	634.45		634.45	0.99	628.10	2,303.04
	Residual fuel oil		0.00	2.62	8.80	0.20	-11.62	1,000	- 11,620.21	19.91	- 231,347.80	- 231.35		- 231.35	0.99	- 229.03	- 839.79
	LPG		0.00	0.00		0.00	0.00										
	Ethane		0.00	0.00		0.00	0.00										
	Naphtha		0.00	0.00		0.00	0.00										
	Bitumen		7.30	0.00	0.00	-0.34	7.64	1,000	7,639.74	20.76	158,601.08	158.60	261.93	- 103.33	0.99	- 102.30	- 375.10
	Lubricants		0.00	0.00	0.00	0.00	0.00										
	Petroleum coke		0.00	0.00		0.00	0.00										
	Refinery feedstocks		16.12	0.00		2.17	13.95	1,000	13,953.45	17.80	248,371.32	248.37		248.37	0.99	245.89	901.59
	Other oil		0.00	0.00		0.00	0.00										
Total liquid fossil fuels		**52.05**	**315.76**	**37.06**	**48.37**	**6.59**	**275.79**		**275,788.91**		**4,923,914.15**	**4,923.91**	**261.93**	**4,661.98**		**4,615.36**	**16,922.99**
Solid fossil fuels - primary	Anthracite	0.00	0.00	0.00		0.00	0.00										
	Coking coal	2,467,897.00	0.00	1,908,418.22		559,478.78	0.00	0.03	0.00	24.22	-	0.00	0.00	-	0.98	0.00	0.00
	Other bituminous coal	58,716.00	53,976.92	0.00	0.00	0.00	112,692.92	0.03	3,617.44	24.22	87,607.88	87.61		87.61	0.98	85.86	314.80
	Sub-bituminous coal	2,389,353.00	822,156.04	0.00	0.00	0.00	3,211,509.04	0.02	72,580.10	24.87	1,805,265.14	1,805.27	450.70	1,354.57	0.98	1,327.48	4,867.42
	Lignite	239,428.00	3.45	0.00		0.00	239,431.45	0.02	3,591.47	25.96	93,247.67	93.25		93.25	0.98	91.38	335.07
	Peat	-	0.00	0.00		0.00	0.00										
Solid fossil fuels - secondary	BKB & patent fuel		0.00	0.00		0.00	0.00										
	Coke		13,653.02	0.00		0.00	13,653.02	0.03	380.92	27.90	10,627.65	10.63		10.63	0.98	10.42	38.19
Total solid fossil fuels		**5,155,394.00**	**889,789.43**	**1,908,418.22**	**0.00**	**559478.78**	**3,577,286.43**		**80,169.94**		**1,996,748.34**	**1,996.75**	**450.70**	**1,546.05**		**1,515.13**	**5,555.48**
Total gaseous fossil fuels		**160.64**	**0.00**	**0.00**		**0.10**	**160.54**	**1,000**	**160,540.44**	**16.13**	**2,588,816.06**	**2,588.82**	**511.09**	**2,077.72**	**1.00**	**2,067.33**	**7,580.22**
Total fossil fuels									**516,499.29**		**9,509,478.55**	**9,509.48**	**1,223.72**	**8,285.75**		**8,197.82**	**30,058.69**
Total biomass fuels							**36.47**		**36466.00**		**1,034,548.64**	**1,034.55**		**1,034.55**		**984.64**	**3,610.34**
	Solid biomass	35.00					35.00	1,000	35000.00	28.41	994,175.00	994.18		994.18	0.95	944.47	3,463.04
	Liquid biomass								ne								ne
	Gas biomass	1.47					1.47	1,000	1,466.00	27.54	40,373.64	40.37		40.37	1.00	40.17	147.30

Liquid and gaseous fossil fuel data are shown initially in petajoules. Solid fossil fuel data are shown initially in tonnes.

Module 2004 Energy (New Zealand)
Submodule CO2 emissions from energy sources (reference approach)
Worksheet 1.1 (4-5 of 5)
Sheet Emissions from international bunkers

Fuel type		Quantities delivered	Conversion factor (TJ/unit)	Quantities delivered (TJ)	Carbon emis fact (t C/TJ)	Carbon content (t C)	Carbon content (Gg)	Fraction of carbon stored	Carbon stored (Gg)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)
Solid fossil fuels	Other bituminous coal	0.00										
	Sub-bituminous coal	0.00										
Liquid fossil fuels	Gasoline	0.00										
	Jet kerosene	38.04	1,000	38040.91	18.57	706,523.48	706.52	0.00	0.00	706.52	0.99	699.46
	Gas/diesel oil	1.53	1,000	1529.29	18.95	28,987.08	28.99	0.00	0.00	28.99	0.99	28.70
	Residual fuel oil	8.80	1,000	8799.80	19.91	175,196.08	175.20	0.00	0.00	175.20	0.99	173.44
	Lubricants	0.00										
	Bitumen	0.00	1,000	0.00	20.76	0.00	0.00	0.00	0.00	0.00	0.99	0
Total fossil fuels				48,370.01								901.60

Liquid fossil fuel data are shown initially in petajoules.

Module 2004 Energy (New Zealand)
Submodule CO2 emissions from energy sources (reference approach)
Worksheet 1.1 (supplemental)
Sheet Estimating the carbon stored in products

Fuel type	Estimated fuel quantities	Conversion factor (TJ/unit)	Estimated quantities (TJ)	Carbon emis fact (t C/TJ)	Carbon content (t C)	Carbon content (Gg)	Fraction of carbon stored	Carbon stored (Gg)
Naphtha	0.00							no
Lubricants	0.00							no
Bitumen	12.62	1,000	12,617.24	20.76	261,933.94	261.93	1.00	261.93
Coal oils and tars	0.00	0.03	0.00	24.24	0.00	0.00	0.75	0.00
Coal1	17.6366650	1,000	17,636.67	25.55	450,696.96	450.70	1.00	450.70
Natural gas2	conf	1,000	conf	conf	conf	conf	conf	511.09
Gas/diesel oil	0.00							no
LPG	0.00							no
Ethane	0.00							no
Other fuels	0.00							no
Total								1,223.72

All data are shown initially in petajoules, except coal oils and tars, which is shown in tonnes.
1 Refers to coal used in the production of iron and steel. This carbon is emitted but is reported in the industrial processes sector.
2 Refers to gas used in the production of methanol, synthetic petrol and urea. Some natural gas data are confidential.

Module 2004 Energy (New Zealand)
Sub-module CO2 emissions from fuel combustion by source categories (tier 1)
Worksheets 1.2 (part I)

Source and sink categories	Energy consumption (TJ)	Carbon emis fact (t C/TJ)	Carbon content (t C)	Carbon content (Gg)	Fraction of carbon stored1	Carbon stored1 (t C)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO2 emissions (Gg)
Total energy (parts I and II of worksheet)[2]	**432,922.89**		**8,190,074.52**	**8,190.07**			**8,190.07**		**8,101.66**	**29,706.08**
Total Liquid Fuels	**251,044.90**		**4,643,535.66**	**4,643.54**			**4,643.54**	**0.99**	**4,597.10**	**16,856.03**
Total Coal	**63,691.73**		**1,616,593.00**	**1,616.59**			**1,616.59**	**0.98**	**1,584.26**	**5,808.96**
Total Gaseous Fuels	**118,186.27**		**1,929,945.85**	**1,929.95**			**1,929.95**	**1.00**	**1,920.30**	**7,041.09**
1 Energy industries[2]	**104,434.76**		**1,978,142.40**	**1,978.14**			**1,978.14**		**1,952.37**	**7,158.68**
a Public electricity and heat	**85,169.41**		**1,671,602.04**	**1,671.60**			**1,671.60**	**8.91**	**1,647.61**	**6,041.22**
Total Liquid Fuels	**23.11**		**436.88**	**0.44**			**0.44**	**6.93**	**0.43**	**1.59**
Petrol Regular	1.22	18.05	22.03	0.02			0.02	0.99	0.02	0.08
Petrol Premium	0.00	18.27	0.00	0.00			0.00	0.99	0.00	0.00
Diesel	21.89	18.95	414.85	0.41			0.41	0.99	0.41	1.51
Heavy Fuel oil	0.00	20.05	0.00	0.00			0.00	0.99	0.00	0.00
Light Fuel oil	0.00	19.64	0.00	0.00			0.00	0.99	0.00	0.00
Jet Kerosene	0.00	18.57	0.00	0.00			0.00	0.99	0.00	0.00
Av Gas	0.00	17.73	0.00	0.00			0.00	0.99	0.00	0.00
Coal	41,126.00	25.35	1,042,454.09	1,042.45			1,042.45	0.98	1,021.61	3,745.89
Natural gas	44,020.31	14.28	628,711.07	628.71			628.71	1.00	625.57	2,293.75
Biogas (memo item)3	1,059.00	28.41	30,080.90	30.08			30.08	1.00	29.93	109.75
b Petroleum refining	**13,522.42**		**225,943.36**	**225.94**			**225.94**	**3.97**	**224.57**	**823.42**
Total Liquid Fuels	**2,495.79**		**48,911.18**	**48.91**			**48.91**	**1.98**	**48.42**	**177.55**
Fuel oil	653.07	18.96	12,383.18	12.38			12.38	0.99	12.26	44.95
Asphalt	1,842.72	19.82	36,528.00	36.53			36.53	0.99	36.16	132.60
Total Natural Gas	**11,026.63**		**177,032.18**	**177.03**			**177.03**	**1.99**	**176.15**	**645.87**
Refinery gas	10,948.41	16.06	175,867.36	175.87			175.87	1.00	174.99	641.62
Natural gas	78.22	14.89	1,164.82	1.16			1.16	1.00	1.16	4.25
c Solid fuels and other energy	**5,742.92**		**80,596.99**	**80.60**			**80.60**	**1.99**	**80.19**	**294.04**
Total Natural Gas	**5,742.92**		**80,596.99**	**80.60**			**80.60**	**1.99**	**80.19**	**294.04**
Natural gas in synthetic petrol production	0.00	0.00	0.00	0.00			0.00	1.00	0.00	0.00
Natural gas in oil and gas extraction	5,742.92	14.03	80,596.99	80.60			80.60	1.00	80.19	294.04

Module	**2004 Energy (New Zealand)**
Sub-module	**CO2 emissions from fuel combustion by source categories (tier 1)**
Worksheets	**1.2 (part II)**

Source and sink categories	Energy consumption (TJ)	Carbon emis fact (t C/TJ)	Carbon content (t C)	Carbon content (Gg)	Fraction of carbon stored1	Carbon stored1 (t C)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO2 emissions (Gg)
2 Manufacturing and construction[2]	**66,032.19**		**1,384,534.62**	**1,384.53**			**1,384.53**	**1.00**	**1,370.77**	**5,026.17**
a Iron and Steel	**1,832.61**		**26,373.99**	**26.37**			**26.37**		**26.24**	**96.22**
Natural gas	1,832.61	14.39	26,373.99	26.37			26.37	1.00	26.24	96.22
c Chemicals (methanol production)	**conf**	**conf**	**221,370.84**	**221.37**			**221.37**	**1.00**	**220.26**	**807.63**
Natural gas in methanol production[4]	conf	conf	221,370.84	221.37			221.37	1.00	220.26	807.63
f Other	**64,199.57**		**1,136,789.79**	**1,136.79**			**1,136.79**		**1,124.27**	**4,122.31**
Total Liquid Fuels	**13,728.10**		**252,639.98**	**252.64**			**252.64**		**250.11**	**917.08**
Petrol Regular	256.05	18.05	4,622.87	4.62			4.62	0.99	4.58	16.78
Petrol Premium	123.66	18.27	2,259.68	2.26			2.26	0.99	2.24	8.20
Diesel	9,252.46	18.95	175,376.24	175.38			175.38	0.99	173.62	636.62
Heavy Fuel oil	107.64	20.05	2,157.66	2.16			2.16	0.99	2.14	7.83
Light Fuel oil	696.51	19.64	13,676.93	13.68			13.68	0.99	13.54	49.65
Jet Kerosene	146.70	18.57	2,724.70	2.72			2.72	0.99	2.70	9.89
Av Gas	11.21	17.73	198.72	0.20			0.20	0.99	0.20	0.72
LPG	3,133.86	16.47	51,623.17	51.62			51.62	0.99	51.11	187.39
Other liquid	0.00	19.88	0.00	0.00			0.00	0.99	0.00	0.00
Coal	14,602.28	25.46	371,723.07	371.72			371.72	0.98	364.29	1,335.72
Total Natural Gas	**35,869.20**		**512,426.74**	**512.43**			**512.43**	**1.99**	**509.86**	**1,869.50**
Autoproduction	14,951.09	14.14	211,384.44	211.38			211.38	1.00	210.33	771.20
Other natural gas	20,918.11	14.39	301,042.30	301.04			301.04	1.00	299.54	1,098.30
Total Biomass	**32,763.16**		**930,376.31**	**930.38**			**930.38**	**2.00**	**930.33**	**3,411.23**
Wood (memo item)[3]	32,461.16	28.41	922,059.23	922.06			922.06	1.00	922.06	3,380.88
Biogas - Autoproduction (memo item)[3]	302.00	27.54	8,317.08	8.32			8.32	1.00	8.28	30.34

Module **2004 Energy (New Zealand)**
Sub-module **CO2 emissions from fuel combustion by source categories (tier 1)**
Worksheets **1.2 (part III)**

Source and sink categories	Energy Consumption (TJ)	Carbon emis fact (t C/TJ)	Carbon content (t C)	Carbon content (Gg)	Fraction of carbon stored1	Carbon stored1 (t C)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO2 emissions (Gg)
3 Transport	**210,412.73**		**3,887,129.06**	**3,887.13**			**3,887.13**	**10.90**	**3,848.27**	**14,110.33**
a Civil aviation	**17,711.43**		**328,437.25**	**328.44**			**328.44**	**1.98**	**325.15**	**1,192.23**
Jet Kerosene	17,105.42	18.57	317,694.39	317.69			317.69	0.99	314.52	1,153.23
Av Gas	606.01	17.73	10,742.86	10.74			10.74	0.99	10.64	39.00
b Road transport	**185,636.56**		**3,420,629.24**	**3,420.63**			**3,420.63**	**4.96**	**3,386.44**	**12,416.93**
Total Liquid Fuels	**185,450.56**		**3,417,952.42**	**3,417.95**			**3,417.95**		**3,383.77**	**12,407.17**
Petrol Regular	85,078.13	18.05	1,536,046.96	1,536.05			1,536.05	0.99	1,520.69	5,575.85
Petrol Premium	25,879.62	18.27	472,891.21	472.89			472.89	0.99	468.16	1,716.60
Diesel	73,298.87	18.95	1,389,346.69	1,389.35			1,389.35	0.99	1,375.45	5,043.33
LPG	1,193.95	16.47	19,667.56	19.67			19.67	0.99	19.47	71.39
CNG	186.00	14.39	2,676.81	2.68			2.68	1.00	2.66	9.77
c Rail transport (diesel)	**2,457.00**	**18.95**	**46,571.32**	**46.57**			**46.57**	**0.99**	**46.11**	**169.05**
d National navigation (fuel oil and diesel)	**4,607.74**		**91,491.25**	**91.49**			**91.49**	**2.97**	**90.58**	**332.11**
Diesel	0.00	18.95	0.00	0.00			0.00	0.99	0.00	0.00
Heavy Fuel oil	2,473.79	20.05	49,588.30	49.59			49.59	0.99	49.09	180.01
Light Fuel oil	2,133.95	19.64	41,902.95	41.90			41.90	0.99	41.48	152.11
Marine bunkers (memo item)[3]	10,244.31		203,559.38	203.56			203.56		201.52	738.92
Diesel	1,536.33	18.95	29,120.42	29.12			29.12	0.99	28.83	105.71
Heavy Fuel oil	8,423.21	20.05	168,847.11	168.85			168.85	0.99	167.16	612.92
Light Fuel oil	284.77	19.64	5,591.85	5.59			5.59	0.99	5.54	20.30
Aviation bunkers (memo item)[3]	38,040.98	0.00	706,524.68	706.52			706.52	0.99	699.46	2,564.68
Av Fuels	38,040.98	18.57	706,524.68	706.52			706.52	0.99	699.46	2,564.68

Module **2004 Energy (New Zealand)**
Sub-module **CO2 emissions from fuel combustion by source categories (tier 1)**
Worksheets **1.2 (part IV)**

Source and sink categories	Energy Consumption (TJ)	Carbon emis fact (t C/TJ)	Carbon content (t C)	Carbon content (Gg)	Fraction of carbon stored1	Carbon stored1 (t C)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO2 emissions (Gg)
4 Other sectors	**52,043.22**		**940,268.45**	**940.27**			**940.27**		**930.25**	**3,410.90**
a Commercial/institutional	**25,606.31**		**466,864.02**	**466.86**			**466.86**	**9.90**	**461.43**	**1,691.92**
Total Liquid Fuels	**6,449.40**		**119,031.44**	**119.03**			**119.03**	**7.92**	**117.84**	**432.08**
Petrol Regular	102.40	18.05	1,848.81	1.85			1.85	0.99	1.83	6.71
Petrol Premium	371.89	18.27	6,795.42	6.80			6.80	0.99	6.73	24.67
Diesel	3,409.51	18.95	64,625.69	64.63			64.63	0.99	63.98	234.59
Heavy Fuel oil	349.13	20.05	6,998.50	7.00			7.00	0.99	6.93	25.40
Light Fuel oil	276.94	19.64	5,438.12	5.44			5.44	0.99	5.38	19.74
Jet Kerosene	644.92	18.57	11,977.88	11.98			11.98	0.99	11.86	43.48
Av Gas	16.89	17.73	299.34	0.30			0.30	0.99	0.30	1.09
LPG	1,277.73	16.47	21,047.68	21.05			21.05	0.99	20.84	76.40
Coal	6,571.77	25.37	166,713.96	166.71			166.71	0.98	163.38	599.06
Natural gas	12,585.14	14.39	181,118.62	181.12			181.12	1.00	180.21	660.78
Biogas (memo item)[3]	105.21	27.54	2,897.53	2.90			2.90	1.00	2.88	10.57
b Residential	**9,996.03**		**158,337.12**	**158.34**			**158.34**	**9.90**	**157.03**	**575.78**
Total Liquid Fuels	**2,213.64**		**36,468.67**	**36.47**			**36.47**	**7.92**	**36.10**	**132.38**
Petrol Regular	1.45	18.05	26.27	0.03			0.03	0.99	0.03	0.10
Petrol Premium	0.00	18.27	0.00	0.00			0.00	0.99	0.00	0.00
Diesel	0.37	18.95	6.97	0.01			0.01	0.99	0.01	0.03
Heavy Fuel oil	0.00	20.05	0.00	0.00			0.00	0.99	0.00	0.00
Light Fuel oil	0.00	19.64	0.00	0.00			0.00	0.99	0.00	0.00
Jet Kerosene	0.14	18.57	2.59	0.00			0.00	0.99	0.00	0.01
Av Gas	0.43	17.73	7.55	0.01			0.01	0.99	0.01	0.03
LPG	2,211.25	16.47	36,425.30	36.43			36.43	0.99	36.06	132.22
Coal	858.95	25.88	22,229.84	22.23			22.23	0.98	21.79	79.88
Natural gas	6,923.45	14.39	99,638.61	99.64			99.64	1.00	99.14	363.51
Wood (memo item)[3]	2,538.71	28.41	72,112.05	72.11			72.11	1.00	72.11	264.41
c Agriculture/forestry/fishing	**16,440.87**		**315,067.31**	**315.07**			**315.07**	**7.91**	**311.78**	**1,143.20**
Total Liquid Fuels	**15,908.14**		**301,595.27**	**301.60**			**301.60**	**6.93**	**298.58**	**1,094.79**
Petrol Regular	1,088.78	18.05	19,657.36	19.66			19.66	0.99	19.46	71.36
Petrol Premium	97.66	18.27	1,784.46	1.78			1.78	0.99	1.77	6.48
Diesel	12,691.68	18.95	240,564.94	240.56			240.56	0.99	238.16	873.25
Heavy Fuel oil	0.00	20.05	0.00	0.00			0.00	0.99	0.00	0.00
Light Fuel oil	1,816.19	19.64	35,663.39	35.66			35.66	0.99	35.31	129.46
Jet Kerosene	158.97	18.57	2,952.47	2.95			2.95	0.99	2.92	10.72
Av Gas	54.87	17.73	972.66	0.97			0.97	0.99	0.96	3.53
Coal	532.74	25.29	13,472.04	13.47			13.47	0.98	13.20	48.41

Sheets 1-16 of worksheet 1-2 have been combined. Only New Zealand relevant source and sink categories have been included.

1 Energy containing carbon which is later stored is not included in the energy consumption reported here.
2 Does not include energy use for methanol production.
3 Data are included only as memo items and do not contribute to the data totals
4 Natural gas consumption data for methanol production is confidential.

Module **2004 Energy (New Zealand)**
Submodule **CO2 from fuel combustion by source category (tier 1)**
Worksheet **1.2 overview (totals)**

		Total liquid fossil TJ	Total solid fossil	Total gaseous fossil1	Total biomass fuels[2]	Total all fuels
Total energy consumption		**251,044.90**	**63,691.73**	**118,186.27**	**36,466.08**	**432,922.89**
Energy industries		2,518.89	41,126.00	60,789.86	1,059.00	104,434.76
Manufacturing industries and construction		13,728.10	14,602.28	37,701.81	32,763.16	66,032.19
Transport	Civil aviation	17,711.43				17,711.43
	Road	185,450.56		186.00	no	185,636.56
	Railways	2,457.00	ne			2,457.00
	Navigation	4,607.74	ne			4,607.74
Other sectors	Commercial/institutional	6,449.40	6,571.77	12,585.14	105.21	25,606.31
	Residential	2,213.64	858.95	6,923.45	2,538.71	9,996.03
	Ag/forest/fish	15,908.14	532.74	ne	ne	16,440.87
International marine bunkers (memo item)		10,244.31	ne			10,244.31
International aviation bunkers (memo item)		38,040.98				38,040.98
Total CO2 emissions		**16,856.03**	**5,808.96**	**7,041.09**	**3,795.95**	**29,706.08**
Energy industries		179.13	3,745.89	3,233.66	109.75	7,158.68
Manufacturing industries and construction		917.08	1,335.72	2,773.36	3,411.23	5,026.17
Transport	Civil aviation	1,192.23				1,192.23
	Road	12,407.17		9.77	no	12,416.93
	Railways	169.05	ne			169.05
	Navigation	332.11	ne			332.11
Other sectors	Commercial/institutional	432.08	599.06	660.78	10.57	1,691.92
	Residential	132.38	79.88	363.51	264.41	575.78
	Ag/forest/fish	1,094.79	48.41	ne	ne	1,143.20
International marine bunkers (memo item)		738.92	ne			738.92
International aviation bunkers (memo item)		2,564.68				2,564.68

1 The figures for "Manufacturing industries and construction" and total gaseous fuels do not include gas used for methanol production, which is confidential.
2 Emissions from biomass (wood and biogas) are included as memo items only and are not included in totals.

Module 2004 Energy (New Zealand)
Submodule Non-CO2 emissions from fuel combustion by source categories (tier 1)
Worksheets 1.3 (part I)

Source and sink categories	Energy consumption (TJ)	CH4 Emission Factor (t CH4/TJ)	N2O Emission Factor (t N2O/TJ)	NOX Emission Factor (t NOX/TJ)	CO Emission Factor (t CO/TJ)	NMVOC Emission Factor (t NMVOC/TJ)	CH4 Emissions t CH4	N2O Emissions t N2O	NOX Emissions t NOX	CO Emissions t CO	NMVOC Emissions t NMVOC
Total energy (parts I and II of worksheet)[1]	**451,972.35**						**4,525.65**	**855.02**	**155,558.63**	**601,846.88**	**115,624.63**
1 Energy industries	**105,493.76**						**177.59**	**70.89**	**27,786.45**	**1,935.95**	**485.63**
a Public electricity and heat	**86,228.41**						**149.35**	**68.67**	**23,610.23**	**1,628.72**	**398.32**
Total Liquid Fuels	**23.11**						**0.02**	**0.01**	**4.83**	**0.35**	**0.11**
Distillate	23.11	0.00086	0.00038	0.20900	0.01520	0.00475	0.02	0.01	4.83	0.35	0.11
Residual	0.00	0.00086	0.00029	0.19000	0.01425	0.00475	0.00	0.00	0.00	0.00	0.00
Coal	41,126.00	0.00067	0.00152	0.36100	0.00855	0.00475	27.35	62.51	14,846.49	351.63	195.35
Natural Gas	44,020.31	0.00275	0.00009	0.19800	0.02880	0.00450	120.84	3.96	8,716.02	1,267.78	198.09
Bio Gas	1,059.00	0.00108	0.00207	0.04050	0.00846	0.00450	1.14	2.19	42.89	8.96	4.77
b Petroleum refining	**13,522.42**						**21.01**	**1.70**	**2,884.06**	**214.20**	**61.47**
Oil	2,495.79	0.00285	0.00029	0.16150	0.01425	0.00475	7.11	0.71	403.07	35.56	11.85
Gas	11,026.63						13.89	0.99	2,480.99	178.63	49.62
Natural Gas	78.22	0.00126	0.00009	0.22500	0.01620	0.00450	0.10	0.01	17.60	1.27	0.35
Refinery Gas	10,948.41	0.00126	0.00009	0.22500	0.01620	0.00450	13.79	0.99	2,463.39	177.36	49.27
c Solid fuels and other energy	**5,742.92**						**7.24**	**0.52**	**1,292.16**	**93.04**	**25.84**
Natural Gas in synthetic petrol prodn	0.00	0.00126	0.00009	0.22500	0.01620	0.00450	0.00	0.00	0.00	0.00	0.00
Natural Gas in oil and Gas extraction	5,742.92	0.00126	0.00009	0.22500	0.01620	0.00450	7.24	0.52	1,292.16	93.04	25.84
2 Manufacturing and construction[1]	**81,378.72**						**656.36**	**171.46**	**27,162.61**	**22,361.70**	**2,417.39**
a Iron and Steel	**1,832.61**						**2.31**	**0.16**	**412.34**	**29.69**	**8.25**
Natural Gas	1,832.61	0.00126	0.00009	0.22500	0.01620	0.00450	2.31	0.16	412.34	29.69	8.25
c Chemicals (methanol production)[2]	**conf**						**54.74**	**3.91**	**9,774.99**	**703.80**	**195.50**
Natural Gas	conf	conf	conf	conf	conf	conf	54.74	3.91	9,774.99	703.80	195.50
f Other	**79,546.11**						**599.31**	**167.38**	**16,975.28**	**21,628.22**	**2,213.65**
Total Liquid Fuels	13,728.10						7.85	5.72	1,037.46	209.24	65.21
Distillate	9,632.18	0.00019	0.00038	0.06175	0.01520	0.00475	1.83	3.66	594.79	146.41	45.75
Residual	962.06	0.00285	0.00029	0.16150	0.01425	0.00475	2.74	0.27	155.37	13.71	4.57
LPG	3,133.86	0.00105	0.00057	0.09168	0.01568	0.00475	3.27	1.79	287.30	49.12	14.89
Total Coal	**14,602.28**						**11.27**	**21.15**	**6,038.01**	**489.89**	**277.44**
Lime and Cement	5,489.36	0.00095	0.00133	0.50065	0.07505	0.01900	5.21	7.30	2,748.25	411.98	104.30
Other	9,112.92	0.00067	0.00152	0.36100	0.00855	0.01900	6.06	13.85	3,289.76	77.92	173.15
Total Natural Gas							67.40	3.23	7,666.89	769.46	161.41
Autoproduction	14,951.09	0.00275	0.00009	0.19800	0.02880	0.00450	41.04	1.35	2,960.32	430.59	67.28
Other	20,918.11	0.00126	0.00009	0.22500	0.01620	0.00450	26.36	1.88	4,706.57	338.87	94.13
Total Biomass	**36,264.65**						**512.79**	**137.28**	**2,232.92**	**20,159.62**	**1,709.58**
Wood	35,962.65	0.01425	0.00380	0.06175	0.56050	0.04750	512.47	136.66	2,220.69	20,157.06	1,708.23
Biogas	302.00	0.00108	0.00207	0.04050	0.00846	0.00450	0.33	0.63	12.23	2.55	1.36

Module **2004 Energy (New Zealand)**
Submodule **Non-CO2 emissions from fuel combustion by source categories (tier 1)**
Worksheets **1.3 (part II)**

Source and sink categories	Energy consumption (TJ)	CH4 Emission Factor (t CH4/TJ)	N2O Emission Factor (t N2O/TJ)	NOX Emission Factor (t NOX/TJ)	CO Emission Factor (t CO/TJ)	NMVOC Emission Factor (t NMVOC/TJ)	CH4 Emissions t CH4	N2O Emissions t N2O	NOX Emissions t NOX	CO Emissions t CO	NMVOC Emissions t NMVOC
3 Transport	**210,412.73**						**2,547.15**	**481.89**	**85,376.74**	**536,975.89**	**107,161.34**
a Civil aviation	**17,711.43**						**33.65**	**33.65**	**4,879.50**	**2,019.10**	**302.87**
Jet Kerosene	17,105.42	0.00190	0.00190	0.27550	0.11400	0.01710	32.50	32.50	4,712.54	1,950.02	292.50
Av Gas	606.01	0.00190	0.00190	0.27550	0.11400	0.01710	1.15	1.15	166.96	69.08	10.36
b Road transport	**185,636.56**						**2,473.52**	**430.38**	**71,037.78**	**533,424.27**	**106,381.10**
Total Liquid Fuels	185,450.56						2,368.06	430.37	70,974.17	533,303.74	106,366.03
Petrol	110,957.75	0.01853	0.00143	0.21090	4.59135	0.88493	2,055.49	158.11	23,400.99	509,445.86	98,189.29
Diesel	73,298.87	0.00380	0.00371	0.64315	0.30305	0.10165	278.54	271.57	47,142.17	22,213.22	7,450.83
LPG	1,193.95	0.02850	0.00057	0.36100	1.37750	0.60800	34.03	0.68	431.01	1,644.66	725.92
CNG	186.00	0.56700	0.00009	0.34200	0.64800	0.08100	105.46	0.02	63.61	120.53	15.07
c Rail transport (diesel)	**2,457.00**	**0.00380**	**0.00371**	**0.64315**	**0.30305**	**0.10165**	**9.34**	**9.10**	**1,580.22**	**744.59**	**249.75**
d National navigation (fuel oil and diesel)	**4,607.74**						**30.64**	**8.75**	**7,879.23**	**787.92**	**227.62**
Diesel	0.00	0.00665	0.00190	1.71000	0.17100	0.04940	0.00	0.00	0.00	0.00	0.00
Fuel oil	4,607.74	0.00665	0.00190	1.71000	0.17100	0.04940	30.64	8.75	7,879.23	787.92	227.62
Aviation bunkers	38,040.96	0.00190	0.00190	0.27550	0.11400	0.01710	72.28	72.28	10,480.28	4,336.67	650.50
Marine bunkers	10,329.10						68.69	19.63	17,662.76	1,766.28	510.26
Diesel	1,529.29	0.00665	0.00190	1.71000	0.17100	0.04940	10.17	2.91	2,615.09	261.51	75.55
Fuel Oil	8,799.80	0.00665	0.00190	1.71000	0.17100	0.04940	58.52	16.72	15,047.66	1,504.77	434.71
4 Other sectors	**54,687.14**						**1,144.55**	**130.77**	**15,232.84**	**40,573.33**	**5,560.26**
a Commercial/institutional	**25,711.52**						**81.77**	**37.58**	**2,545.72**	**1,445.76**	**1,336.38**
Total Liquid Fuels	**6,449.40**						**5.63**	**2.57**	**533.39**	**89.77**	**30.63**
Distillate Fuel oil	3,883.80	0.00067	0.00038	0.06175	0.01520	0.00475	2.58	1.48	239.82	59.03	18.45
Residual Fuel oil	1,287.88	0.00133	0.00029	0.16150	0.01425	0.00475	1.71	0.37	207.99	18.35	6.12
LPG	1,277.73	0.00105	0.00057	0.06698	0.00969	0.00475	1.34	0.73	85.58	12.38	6.07
Coal	6,571.77	0.00950	0.00133	0.22800	0.19000	0.19000	62.43	8.74	1,498.36	1,248.64	1,248.64
Natural Gas	12,585.14	0.00108	0.00207	0.04050	0.00846	0.00450	13.59	26.05	509.70	106.47	56.63
Biogas	105.21	0.00108	0.00207	0.04050	0.00846	0.00450	0.11	0.22	4.26	0.89	0.47
b Residential	**12,534.74**						**976.88**	**12.67**	**803.97**	**29,550.47**	**1,651.93**
Total Liquid Fuels	**2,213.64**						**2.31**	**1.26**	**98.94**	**21.04**	**10.51**
Distillate Fuel oil	1.82	0.00067	0.00019	0.06175	0.01520	0.00475	0.00	0.00	0.11	0.03	0.01
Residual Fuel oil	0.56	0.00133	0.00019	0.16150	0.01425	0.00475	0.00	0.00	0.09	0.01	0.00
LPG	2,211.25	0.00105	0.00057	0.04465	0.00950	0.00475	2.31	1.26	98.73	21.01	10.50
Coal	858.95	0.28500	0.00133	0.17100	3.42000	0.19000	244.80	1.14	146.88	2,937.60	163.20
Natural Gas	6,923.45	0.00090	0.00009	0.04230	0.00900	0.00450	6.23	0.62	292.86	62.31	31.16
Wood	2,538.71	0.28500	0.00380	0.10450	10.45000	0.57000	723.53	9.65	265.30	26,529.52	1,447.06
c Agriculture/forestry/fishing	**16,440.87**						**85.90**	**80.51**	**11,883.16**	**9,577.10**	**2,571.95**
Total Liquid Fuels	**15,908.14**						**80.84**	**79.80**	**11,761.69**	**9,475.88**	**2,470.73**
Distillate Fuel oil - Stationary	693.91	0.00380	0.02850	1.14000	0.35150	0.16150	2.64	19.78	791.05	243.91	112.07
Residual Fuel oil - Stationary	371.95	0.00380	0.02850	1.14000	0.35150	0.16150	1.41	10.60	424.02	130.74	60.07
Petrol - Mobile	1,127.11	0.01853	0.00143	0.21090	4.59135	0.88493	20.88	1.61	237.71	5,174.96	997.41
Diesel - Mobile	12,057.09	0.00380	0.00371	0.64315	0.30305	0.10165	45.82	44.67	7,754.52	3,653.90	1,225.60
Fuel Oil - Mobile	1,462.24	0.00665	0.00190	1.71000	0.17100	0.04940	9.72	2.78	2,500.44	250.04	72.23
Aviation fuels - Mobile	195.83	0.00190	0.00190	0.27550	0.11400	0.01710	0.37	0.37	53.95	22.32	3.35
Coal	532.74	0.00950	0.00133	0.22800	0.19000	0.19000	5.06	0.71	121.46	101.22	101.22

Only New Zealand relevant source and sink categories have been included.
1 Does not include energy use for methanol production.
2 Natural gas consumption data for methanol production is confidential.

Module 2004 Energy (New Zealand)
Submodule Fugitive emissions from geothermal activities (tier 1)
Worksheet NZ 1.6 (additional)

Category	Fuel quantity (TJ)	CO2 emis fact (kg/GJ)	CH4 emis fact (kg/GJ)	CO2 emissions (Gg)	CH4 emissions (Gg)
Elec. generation and heat	70,312.00	3.98	0.03	279.67	2.42

Module 2004 Energy (New Zealand)
Submodule Fugitive emissions from coal mining and handling (tier 1)
Worksheet 1.4 (adapted)

Category			Coal production (Mt)	CH4 emis fact (Gg/Mt)	CH4 emissions (Gg)
Total			**5.16**		**14.85**
Underground mines	Mining		0.73		9.98
		Bituminous	0.26	16.75	4.28
		Sub-bituminous	0.47	12.10	5.71
	Post-mining			1.60	1.16
Surface mines	Mining		4.43	0.77	3.41
	Post-mining			0.07	0.30

Module 2004 Energy (New Zealand)
Submodule Fugitive emissions from oil
Worksheet 1.5 (adapted)

Category		Fuel quantity (TJ)
Total		
Oil	Exploration	
	Production of crude oil	
	Transport of crude oil	42,348.00
	Refining/storage	214,021.00
	Distribution of oil products	
Gas	Production/processing	
	Transmission / Distribution	62,363.31
	Other leakage	ne
Venting and flaring from oil and gas prod.		1,116.44

Module 2004 Energy (New Zealand)
Submodule Ozone precursors and SO2 from oil refining
Worksheet 1.8-1 (additional)
Sheet NMVOC emissions from oil refining (tier 1)

Crude oil Throughput (m3)	Emission factor (kg/m3)	Emissions (t)	Emissions (Gg)
5,487,717.95	0.53	2,908.49	2.91

Module 2004 Energy (New Zealand)
Submodule Ozone precursors and SO2 from oil refining
Worksheet 1.8-2
Sheet SO2 from sulphur recovery plants (tier 2)

Quantity of sulphur recovered (t)	Emission factor (kg/t)	Emissions (kg)	Emissions (Gg)
21,423.00	139.00	2,977,797.00	2.98

Module 2004 Energy (New Zealand)
Submodule Ozone precursors and SO2 from oil refining
Worksheet 1.8-3
Sheet NMVOC emissions from storage and handling (tier 2)

Storage type	Crude oil throughput (kt)	Emission factor (kg/t)	Emissions (t)	Emissions (Gg)
Floating roof (primary seals)	4,704.05	0.70	3,292.84	3.29

A8.2 Worksheets for the industrial processes sector

Module	**2004 Industrial Processes (New Zealand)**
Worksheet	**NZ 2a**
Sheet	**CO2 emissions**

Source category	Production Quantity (t)	CO2 emissions (Gg)	CO2 emis factor (t/t)
Total industrial processes		**3,444.36**	
Cement[1]	1,216,191.00	484.77	0.40
Lime[1]	167,407.34	122.08	0.73
Hydrogen[1]	27,185.07	175.43	6.45
Urea[1]	262,274.00	378.27	1.44
Iron and steel[1]	890,352.00	1,731.51	1.94
Aluminium[1]	350,299.00	552.29	1.58

1 Production and emissions data provided by industry and reported in Ministry of Economic Development (2005)

Module **2004 Industrial process (New Zealand)**
Worksheet **NZ 2b**
Sheet **Non-CO_2 emissions**

Source Categories	ACTIVITY DATA	Emission Estimates						Aggregate Emission Factor					
	A Production Quantity (kt)	B Full Mass of Pollutants (Gg) Tonnes x 1000						C Tonne of pollutant per tonne of product (t/t)					
		CO	CH4	N20	NOx	NMVOC	SO2	CO	CH4	N20	NOx	NMVOC	SO2
A Iron and Steel													
Steel	C	0.9779			0.9615			C			C		C
B Non-Ferrous Metals													
NZ Aluminium Smelters	347.0	38.2			0.7		6.9	0.11000			0.00215		0.02000
C Inorganic Chemicals (excepting solvent use)													
Sulphuric Acid (Ballance and Ravensdown)	500.7						1.74						0.00348
Superphosphate (Ballance and Ravensdown)	1584.3						0.81						0.00084
Urea (Ballance)	263.0												
Ammonia (Ballance)	151.2												
D Organic Chemicals													
Formaldehyde (Orica Adhesives and Dynea)	56.61	0.0000	0.0000			0.0849		0.00000	0.00000			0.00150	
Methanol (Methanex)	1087.8	0.1088	2.1756		0.9790	5.4390		0.00010	0.00200		0.00090	0.00500	
E Non-Metallic Mineral Products													
Cement	985.6		0.0000		0.0000		0.6415	0.0000			0.0000		0.00065
Lime	165.3						0.0797						0.00048
Asphalt Roofing	0.3	0.0000				0.0007		0.000010				0.00240	
Road Paving	156.6	0.0055			0.0132	2.8188	0.0188	0.000035			0.000084	0.01800	0.000120
Glass	C					0.6313	0.1705					C	C
F Other (ISIC)													
Paper and Pulp (chemical processes)	724.0	0.0000			0.0000	0.3982	0.0746	0.00000			0.00000	0.00055	0.00010
Paper and Pulp (mechanical processes)	844.8					0.4647						0.00055	
Panel Products (particleboard)	175.5					0.1492						0.00085	
Panel Products (fibreboard)	640.5					1.3451						0.00210	
Nitrous oxide use	0.16			0.1560						1.0000			
Food and drink production													
Wine (million litres)	110.5					0.0884						0.00083	
Beer (million litres)	312.9					0.1095						0.00035	
Spirits (million litres)	8.3					0.0167						0.00215	
Meat	1269.0					0.3807						0.00030	
Fish	334.8					0.1004						0.00030	
Poultry	147.3					0.0442						0.00030	
Sugar	227.8					2.2779						0.01000	
Margarine and solid cooking fats	66.4					0.3986						0.00600	
Cakes, biscuits and breakfast cereals	76.1					0.0761						0.00100	
Bread	241.8					1.9344						0.00800	
Animal feed	848.5					0.8485						0.00100	
Coffee roasting	6.2					0.0034						0.00055	
	3649.68					6.2788							

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. Aerosol 1 of 2
Sheet HFCs from aerosols (based on equation 3.35[1])

Year	Quantity HFC-134a contained in aerosol products sold in year t (tonnes)[2]	Emission factor	Quantity HFC-134a contained in aerosol products sold in year t-1 (tonnes)	Emission of HFC-134a (tonnes)
1992	0.0	0.5	0.0	0.0
1993	0.0	0.5	0.0	0.0
1994	0.0	0.5	0.0	0.0
1995	0.0	0.5	0.0	0.0
1996	2.5	0.5	0.0	1.3
1997	5.9	0.5	2.5	4.2
1998	9.1	0.5	5.9	7.5
1999	12.1	0.5	9.1	10.6
2000	16.1	0.5	12.1	14.1
2001	16.9	0.5	16.1	16.5
2002	17.1	0.5	16.9	17.0
2003	17.1	0.5	17.1	17.1
2004	17.3	0.5	17.1	17.2

1. IPCC (2001) Equation 3.35
2. Only HFC used in aerosols is HFC-134a

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. Aerosols 2 of 2
Sheet Imports and domestic production of aerosols

Year of import	Aerosol imports		Domestic loading HFC (tonnes)	Aerosol exports	Total HFC contained in products in NZ (tonnes)
	Number of Units	HFC[1] (tonnes)		HFC[2] (tonnes)	
1992	3,300,000	0.0	0.0	0.0	0.0
1993	4,000,000	0.0	0.0	0.0	0.0
1994	5,400,000	0.0	0.0	0.0	0.0
1995	8,700,000	0.0	0.0	0.0	0.0
1996	13,100,000	2.2	3.0	2.7	2.5
1997	16,800,000	5.6	3.0	2.7	5.9
1998	17,400,000	8.8	3.0	2.7	9.1
1999	17,500,000	11.8	3.0	2.7	12.1
2000	18,848,536	15.8	3.0	2.7	16.1
2001	19,773,731	16.6	3.0	2.7	16.9
2002	20,000,000	16.8	3.0	2.7	17.1
2003	20,000,000	16.8	3.0	2.7	17.1
2004	20,000,000	16.8	4.5	4.1	17.3

1. Assumes average propellant charge = 84 grams, 1.0±0.5% of all imported aerosols contain HFCs from 2000 with a gradual phase-in from 1996-2000.
2. Based on the statement that 90% of this product is exported.

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MDIs 1 of 1
Sheet HFCs from metered dose inhalers

Year[1]	Estimated no. of doses (millions)	Proportion of HFC-134a doses	Emission of HFC-134a (tonnes)[2]
1995	500.0	1%	0.4
1996	500.0	5%	1.9
1997	500.0	5%	1.9
1998	500.0	5%	1.9
1999	497.2	8%	2.8
2000	477.4	9%	3.3
2001	485.2	39%	14.0
2002	486.3	68%	25.0
2003	474.8	73%	26.1
2004	469.4	76%	26.7

1. HFC-134a not used in MDIs before 1995
2. Only HFC used in MDIs is HFC-134a; average 0.075 gram per dose

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. Fire protection 1 of 1
Sheet Annual emissions from the fire protection industry

Year[1]	Total HFC-227a installed		Emission rate	Emissions of HFC-227a (tonnes)
	Streaming (tonnes)	Portable (tonnes)		
1994	1.6	0	0.015	0.02
1995	3.2	0	0.015	0.05
1996	4.8	0	0.015	0.07
1997	6.4	0	0.015	0.10
1998	8.0	0	0.015	0.12
1999	10.2	0	0.015	0.15
2000	11.4	0	0.015	0.17
2001	12.6	0	0.015	0.19
2002	17.0	0	0.015	0.26
2003	19.4	0	0.015	0.29
2004	21.2	0	0.015	0.32

1. No evidence for use of HFC-227a in fire protection industry before 1994

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. Foam blowing 1 of 1
Sheet Annual emissions from the foam blowing industry

Year[1]	HFC usage[2] (tonnes)	Emission rate first year	Emission rate later years	Emissions of HFC (tonnes)
2000	0.5	0.100	0.045	0.05
2001	0.5	0.100	0.045	0.07
2002	0.5	0.100	0.045	0.10
2003	0.5	0.100	0.045	0.12
2004	1.5	0.100	0.045	0.24
2005	1.5	0.100	0.045	0.31

1. Assumed no use of HFC in foam blowing industry before 2000
2. HFC-134a from 2000-2003 and HFC-245fa/365mfc from 2004-2005.

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. RAC 1 of 4
Sheet Stationary Refrigeration and Air Conditioning - annual sales of refrigerant (input to Box 3.4 equation)

Year	Domestically manufactured chemical (tonnes)	Imported bulk chemical (tonnes)	Exported bulk chemical (tonnes)	Chemical in imported equipment (tonnes)	Chemical in exported equipment (tonnes)	Annual sales (tonnes)
1990	0	0.0	0	0	0.0	0.0
1991	0	0.0	0	0	0.0	0.0
1992	0	2.0	0	0.1	0.8	1.3
1993	0	6.0	0	0.2	3.0	3.2
1994	0	51.2	0	2.3	7.2	46.3
1995	0	111.2	0	7.8	18.6	100.4
1996	0	159.8	0	9.3	19.8	149.3
1997	0	61.4	0	10.3	20.5	51.2
1998	0	197.5	0	9.4	21.2	185.6
1999	0	145.5	0	12.5	22.4	135.6
2000	0	124.1	0	11.1	24.3	110.9
2001	0	186.9	0	12.1	25.5	173.4
2002	0	231.7	0	14.4	25.6	220.5
2003	0	298.0	0	20.7	27.5	291.1
2004	0	222.3	0	35.7	30.8	227.2

1. IPCC (2001) Box 3.4 equation

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. RAC 2 of 4
Sheet Stationary Refrigeration and Air Conditioning - total charge of new equipment (input to Box 3.4 equation)

Year	Chemical to charge domestically manufactured + imported equipment (tonnes) 2	Chemical contained in factory charged imported equipment (tonnes)	Chemical contained in factory charged exported eqpmnt (tonnes)	Total charge of new equipment (tonnes)
1990	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0
1992	1.2	0.1	0.8	0.5
1993	2.4	0.2	3.0	-0.4
1994	8.6	2.3	7.2	3.7
1995	20.0	7.8	18.6	9.2
1996	25.0	9.3	19.8	14.5
1997	30.0	10.3	20.5	19.8
1998	28.1	9.4	21.2	16.2
1999	37.0	12.5	22.4	27.1
2000	31.3	11.1	24.3	18.1
2001	28.7	12.1	25.5	15.2
2002	28.0	14.4	25.6	16.8
2003	36.5	20.7	27.5	29.7
2004	45.4	35.7	30.8	50.2

1. IPCC (2001) Box 3.4 equation
2. Can not distinguish chemical to charge domestically manufactured and imported non-factory charged equipment.

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. RAC 3 of 4
Sheet All HFC and PFC emissions from stationary refrigeration

Year	Annual sales of new refrigerant (tonnes)	Total charge of new equipment (tonnes)	Emissions from retiring NZ eqpt. (tonnes)	Amount of intentional destruction (tonnes)	Emissions[2] (tonnes)
1990	0.0	0.0	0.0	0	0.0
1991	0.0	0.0	0.0	0	0.0
1992	1.3	0.5	0.0	0	0.8
1993	3.2	-0.4	0.0	0	3.6
1994	46.3	3.7	0.0	0	42.6
1995	100.4	9.2	0.0	0	91.2
1996	149.3	14.5	0.0	0	134.8
1997	51.2	19.8	0.0	0	31.4
1998	185.6	16.2	0.0	0	169.4
1999	135.6	27.1	0.0	0	108.5
2000	110.9	18.1	0.0	0.1	92.6
2001	173.4	15.2	0.0	0.3	157.9
2002	220.5	16.8	0.1	0.4	203.4
2003	291.1	29.7	0.3	0.7	261.0
2004	227.2	50.2	1.1	1.1	177.0

1. IPCC (2001) equation 3.40
2. The methodology produces a negative number for 1992, thus 0 has been entered for this year.

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MAC 1 of 4
Sheet Mobile air conditioning Equation 3.45[1] (input to equation 3.44[1])

Year[2]	Total virgin HFC-134a[3] in first-fill MAC systems (tonnes)	Emission factor	First-fill emissions HFC-134a (tonnes)
1994	2.9	0.005	0.015
1995	10.8	0.005	0.054
1996	15.8	0.005	0.079
1997	11.0	0.005	0.055
1998	8.2	0.005	0.041
1999	6.9	0.005	0.035
2000	5.5	0.005	0.028
2001	4.6	0.005	0.023
2002	2.9	0.005	0.014
2003	3.3	0.005	0.017
2004	1.9	0.005	0.009

1. IPCC (2001) Equations 3.44 and 3.45
2. No use recorded before 1994
3. HFC-134a the only HFC used in MAC

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MAC 2 of 4
Sheet Mobile air conditioning Equation 3.46[1] (input to equation 3.44[1])

Year[2]	Total annual virgin HFC-134a[3]	HFC in first-fill MAC systems					Operation emissions HFC-134a
		Buses	Trucks	Cars/vans	Cars/vans (new)	Total	
	(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)
1994	5.0	0.2	1.0	1.7	0.0	2.9	2.1
1995	15.0	0.2	3.3	6.9	0.3	10.8	4.2
1996	30.0	0.3	3.3	10.2	2.0	15.8	14.2
1997	40.0	0.3	2.8	6.5	1.4	11.0	29.0
1998	50.0	0.2	2.3	5.0	0.8	8.2	41.8
1999	52.0	0.3	2.5	3.9	0.2	6.9	45.1
2000	54.0	0.3	2.6	2.4	0.2	5.5	48.5
2001	56.0	0.3	2.7	1.3	0.3	4.6	51.4
2002	58.0	0.4	1.9	0.4	0.2	2.9	55.1
2003	60.0	0.4	1.9	0.4	0.6	3.3	56.7
2004	62.0	0.3	1.1	0.4	0.1	1.9	60.1

1. IPCC (2001) Equations 3.44 and 3.45
2. No use recorded before 1994
3. This model of MAC refrigerant use approximately follows the highly variable quantities provided by suppliers.

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MAC 3 of 4 (IPCC (2001) equation 3.47)
Sheet HFC-134a emissions from mobile air conditioning (equation 3.44[1])

Year	Annual scrap rate of vehicles with MAC using HFC-134a	Number of vehicles with MAC using HFC-134a	Average HFC-134a charge per vehicle (kg)	Destruction (tonnes)	Disposal emissions (tonnes)
1994	0.000	90,780	0.86	0	0.04
1995	0.012	200,564	0.81	0	1.98
1996	0.017	318,586	0.80	0	4.38
1997	0.032	446,168	0.81	0	11.40
1998	0.022	580,065	0.79	0	9.98
1999	0.017	755,133	0.78	0	9.77
2000	0.020	925,705	0.77	0	14.00
2001	0.023	1,101,395	0.77	0	19.34
2002	0.024	1,290,412	0.77	0	23.76
2003	0.022	1,506,253	0.76	0	25.14
2004	0.024	1,722,148	0.76	0	30.94

1. IPCC (2001) Equations 3.44 and 3.47

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MAC 4 of 4
Sheet HFC-134a emissions from mobile air conditioning (equation 3.44[1])

Year[2]	First-fill emissions (tonnes)	Operation emissions (tonnes)	Disposal emissions[3] (tonnes)	Intentional destruction (tonnes)	Annual emissions of HFC-134a (tonnes)
1994	0.015	2.1	0.04	0	2.1
1995	0.054	4.2	1.98	0	6.3
1996	0.079	14.2	4.38	0	18.7
1997	0.055	29.0	11.40	0	40.5
1998	0.041	41.8	9.98	0	51.8
1999	0.035	45.1	9.77	0	54.9
2000	0.028	48.5	14.00	0	62.5
2001	0.023	51.4	19.34	0	70.8
2002	0.014	55.1	23.76	0	78.9
2003	0.017	56.7	25.14	0	81.8
2004	0.009	60.1	30.94	0	91.1

1. IPCC (2001) Equation 3.44
2. No use recorded before 1994
3. Calculated using IPCC (2001) equation 3.47

Module 1990 - 2004 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. RAC 4 of 4
Sheet All HFC and PFC emissions from stationary refrigeration[1]

Year	Bulk emissions (tonnes)	HFC-32 (tonnes)	HFC-125 (tonnes)	HFC-134a[2] (tonnes)	HFC-143a (tonnes)	HFC-152a (tonnes)	PFC-218 (tonnes)
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.8	0.0	0.0	0.8	0.0	0.0	0.0
1993	3.6	0.0	0.0	3.6	0.0	0.0	0.0
1994	42.6	0.0	1.2	40.7	0.4	0.4	0.0
1995	91.2	0.4	0.5	80.5	7.9	1.2	0.8
1996	134.8	0.0	6.7	115.8	7.1	0.4	4.8
1997	31.4	0.0	10.5	11.0	9.3	0.2	0.3
1998	169.4	0.0	9.5	142.1	9.4	0.4	8.0
1999	108.5	7.4	10.4	77.9	11.0	1.7	0.0
2000	92.6	0.0	4.1	82.1	6.4	0.0	0.0
2001	157.9	3.4	27.6	99.9	26.1	0.9	0.0
2002	203.4	3.0	47.6	99.8	51.8	0.0	1.1
2003	261.0	5.0	53.9	140.1	60.2	0.0	1.8
2004	177.0	6.2	49.5	71.6	48.7	0.0	1.0

1. Calculated as bulk imports - exported in eqpt - charge for new NZ eqpt - destruction + eqpt retirement
2. HFC-134a calculated by difference after detailed consideration of other gases.

Module 1990 - 2004 Emissions of Sulphur Hexafluoride (New Zealand)
Worksheet
Sheet SF_6 from Electrical Equipment and Other Sources (based on equations 3.13, 3.17, 3.18 and 3.22)

Year	Potential SF_6 Emissions (kg)[1]	Emissions from Electrical Equipment (kg)[2]	Emissions from Other Sources[4] (kg)[3]	Actual SF_6 Emissions (kg)
1990	2030	396	120	516
1991	2256	409	131	540
1992	1393	423	147	570
1993	2026	435	153	588
1994	1842	448	155	603
1995	1566	466	162	628
1996	2240	485	134	619
1997	2354	505	135	640
1998	1952	439	148	587
1999	1851	414	138	552
2000	1753	499	11	510
2001	1535	501	14	514
2002	2523	536	14	550
2003	1939	722	11	733
2004	1901	888	11	899

1. IPCC (2001) Equation 3.18
2. IPCC (2001) Equation 3.13 (Tier 3c) for the few utilities with detailed data and Equation 3.17 (Tier 2b) for others.
3. IPCC (2001) Equation 3.22
4. SF_6 use in magnesium casting ceased in 1998

A8.3 Worksheets for the solvents sector

Module — **2004 Solvent and other product use (New Zealand)**
Worksheet — **NZ 3a**
Sheet — **Non-CO_2 emissions**

Source Categories	ACTIVITY DATA Quantity Consumed tonnes	NMVOC fraction	Emission Estimates (Gg) NMVOC	Emission Factors kg/year/person NMVOC
TOTAL SOLVENT EMISSIONS				
A Surface Coatings	**60584**		***16.48***	
Architectural/ Decorative				
Organic Base	**4500**		**1.4969**	
Primers and Undercoats	1691	0.27	0.4566	0.1118
Finishing Coats - Gloss	1348	0.34	0.4584	0.1122
Finishing Coats - Semi Gloss	352	0.26	0.0915	0.0224
Finishing Coats - Flat	266	0.26	0.0691	0.0169
Clears and Satins	843	0.50	0.4213	0.1032
Water Base	**33086**		**2.1237**	
Primers and Undercoats	2762	0.07	0.1934	0.0473
Finishing Coats - Gloss	12997	0.07	0.9098	0.2228
Finishing Coats - Semi Gloss	7382	0.07	0.5167	0.1265
Finishing Coats - Flat	9288	0.05	0.4644	0.1137
Clears and Satins	657	0.06	0.0394	0.0097
Industrial				
Organic Base	**17448**		**8.6458**	
Primers and Undercoats	6678	0.34	2.2707	0.5560
Finishing Coats	9902	0.60	5.9413	1.4548
Clears	868	0.50	0.4338	0.1062
Water Base	**1442**		**0.1009**	
Primers and Undercoats	1296	0.07	0.0907	0.0222
Finishing Coats	146	0.07	0.0102	0.0025
Thinners			**4.1080**	
Solvents/Thinners	4108	1.00	4.1080	1.0059
B Degreasing and Drycleaning[2]	990		**0.9900**	
C Chemical Products			**0.0868**	
Ethanol[1]	10000		0.0480	
Hydrogen Peroxide[1]	16310		0.0388	
D Other			**14.3815**	
Printing[2]	3220		2.0930	
Aerosols[2]			1.915	
Domestic and Commercial Use			10.373	2.5400
			31.93	

Emission factors derived on a kg/person/year basis (EPAV and USEPA)
1. Emissions calculated on production not consumption data
2. Emissions calculated from import not consumption data

A8.4 Worksheets for the agriculture sector

Animal numbers in New Zealand Revised 2004

Agricultural sector calculations: emissions from domestic livestock and agricultural soils

	Dairy cattle[1] (jun yr)	Dairy cattle (3 yr av)	Non-dairy cattle[1] (jun yr)	Non-dairy cattle (3 yr av)	Sheep numbers[1] (jun yr)	Sheep numbers (3 yr av)	Goat numbers[1] (jun yr) (1000s)	Goat numbers (3 yr av) (1000s)	Deer numbers[2] (jun yr)	Deer numbers (3 yr av)	Swine numbers[1] (jun yr) (1000s)	Swine numbers (3 yr av) (1000s)
1989	3,302,377		4,526,056		60,568,653		1,222		834,972		411	
1990	3,440,815	3,390,873	4,593,160	4,596,595	57,852,192	57,860,829	1,063	1,026	1,042,986	1,035,915	395	404
1991	3,429,427	3,446,022	4,670,569	4,646,742	55,161,643	55,194,076	793	796	1,229,788	1,204,193	407	404
1992	3,467,824	3,482,464	4,676,497	4,701,676	52,568,393	52,676,132	533	559	1,339,804	1,269,824	411	405
1993	3,550,140	3,619,049	4,757,962	4,827,436	50,298,361	50,777,603	353	390	1,239,880	1,286,611	395	410
1994	3,839,184	3,826,380	5,047,848	4,996,106	49,466,054	49,526,895	284	324	1,280,148	1,246,352	423	416
1995	4,089,817	4,031,366	5,182,508	5,027,512	48,816,271	48,558,744	337	283	1,219,029	1,243,856	431	426
1996	4,165,098	4,170,305	4,852,179	4,946,896	47,393,907	47,681,393	228	264	1,232,391	1,264,401	424	424
1997	4,256,000	4,255,033	4,806,000	4,696,726	46,834,000	46,727,969	228	228	1,341,784	1,324,601	417	418
1998	4,344,000	4,305,470	4,432,000	4,627,235	45,956,000	46,156,630	228	214	1,399,629	1,388,297	412	399
1999	4,316,409	4,419,515	4,643,705	4,556,578	45,679,891	45,093,255	186	197	1,423,478	1,439,739	369	383
2000	4,598,136	4,598,136	4,594,029	4,594,029	43,643,873	43,643,873	175	175	1,496,110	1,490,786	369	364
2001	4,879,862	4,879,862	4,544,354	4,543,221	41,607,855	41,607,855	164	164	1,552,770	1,565,593	354	355
2002	5,161,589	5,047,684	4,491,281	4,554,078	39,571,837	40,243,931	153	153	1,647,900	1,630,023	342	358
2003	5,101,600	5,139,096	4,626,600	4,521,994	39,552,100	39,459,512	142	142	1,689,400	1,698,800	377	369
2004	5,154,100	5,118,800	4,448,100	4,527,667	39,254,600	39,572,433	131	137	1,759,100	1,720,000	389	385
2005	5,100,700		4,508,300		39,910,600				1,711,500		389	

1. 1994, 1995, 1996, 1999 and 2002 data from Statistics New Zealand. Other estimates provided by MAF based on a combination of official livestock survey data, information from the Meat and Wool Board Economic Service,and CES Forecast estimates.

Animal numbers in New Zealand (thousands) Revised 2004
Agricultural sector calculations: emissions from domestic livestock and agricultural soils

	Poultry numbers layers[1,4] (June yr)	Poultry others and broilers[2,4] (June yr)	Poultry numbers total (June yr)	Poultry numbers (3 yr av)	Horse numbers[3] (jun yr)	Horse numbers (3 yr av)
1989	3,324	4,925	8,249		98.0	
1990	2,996	6,089	9,085	8,670	94.0	94.0
1991	2,908	5,770	8,677	8,677	90.0	90.6
1992	2,819	5,450	8,270	8,988	87.9	88.4
1993	2,862	7,154	10,016	10,016	87.2	81.0
1994	2,905	8,858	11,762	11,762	67.8	74.5
1995	2,947	10,561	13,509	12,914	68.6	68.0
1996	3,210	10,262	13,472	13,953	67.7	68.5
1997	3,211	11,667	14,878	14,878	69.1	69.1
1998	3,212	13,072	16,284	16,284	70.4	70.4
1999	3,213	14,476	17,690	17,690	71.8	71.8
2000	3,215	15,881	19,096	19,096	73.1	73.1
2001	3,216	17,286	20,502	20,502	74.5	74.5
2002	3,217	18,691	21,908	21,499	75.9	76.9
2003	3,218	18,868	22,086	22,389	80.4	77.7
2004	3,219	19,954	23,173	23,183	76.9	78.1
2005	3,220	21,069	24,289		76.9	

1. 1995, 1996 and 2002 (provisional) data from Statistics New Zealand. 1989, 1990 and 1992 from M
   Other estimates provided by MAF February 2003.
2. 2002 data from Statistics New Zealand. 1989, 1990, 1992, 1995 and 1996 from MAF survey data.
2003-2005 data not available from Statistics New Zealand and are extrapolated.
3. 1994, 1995, 1996 and 2002 data from Statistics New Zealand. 1990, 1992 and 1993 from MAF sur
2003-2005 data not available from Statistics New Zealand and are extrapolated.
4. Poultry numbers for 2005 extrapolated

Livestock productivity data for New Zealand 2004
Agricultural sector calculations: CH_4 emissions from domestic livestock
Table 1: Average weights, average annual milk yields and average milk composition of dairy cattle in New Zealand 1990-2004. All data are three year averages.

	Dairy cow weights (kg)	Milk yields (litres/year)	Milk fat (percent)	Milk protein (percent)
1990	447	2801	4.85	3.58
1991	449	2858	4.88	3.61
1992	450	3011	4.90	3.63
1993	451	3029	4.90	3.62
1994	452	3076	4.89	3.61
1995	451	3121	4.88	3.61
1996	452	3227	4.85	3.59
1997	449	3247	4.82	3.58
1998	451	3303	4.80	3.58
1999	453	3430	4.81	3.61
2000	456	3625	4.83	3.63
2001	458	3670	4.84	3.66
2002	457	3680	4.85	3.67
2003	457	3628	4.88	3.70
2004	456	3660	4.91	3.69

Livestock productivity data for New Zealand 2004
Agricultural sector calculations: CH_4 emissions from domestic livestock
Table 2: Average weights of beef cattle in New Zealand 1990-2004
All data are three year averages

	Beef cow weights (kg)	Heifer weights at slaughter (kg)	Bull weights at slaughter (kg)	Steer weights at slaughter (kg)
1990	379	413	553	568
1991	381	417	562	577
1992	389	422	566	584
1993	403	427	574	593
1994	406	432	581	598
1995	412	436	585	601
1996	418	438	593	601
1997	430	438	600	601
1998	426	438	603	599
1999	423	437	599	602
2000	423	437	599	607
2001	432	441	603	614
2002	433	446	605	615
2003	430	453	608	617
2004	433	457	615	620

Livestock productivity data for New Zealand 2004
Agricultural sector calculations: CH_4 emissions from domestic livestock
Table 3: Weights of ewes and lambs in New Zealand 1990-2004
All data are three year averages

	Ewe weights (kg)	Lamb weights at slaughter (kg)
1990	48.4	31.2
1991	49.0	32.1
1992	49.1	33.0
1993	49.6	33.6
1994	49.4	33.5
1995	49.7	33.4
1996	50.0	33.7
1997	51.1	34.4
1998	52.0	34.7
1999	53.0	35.4
2000	54.1	36.2
2001	54.7	37.0
2002	54.8	37.1
2003	55.1	37.6
2004	56.2	38.1

Livestock productivity data for New Zealand 2004
Agricultural sector calculations: CH_4 emissions from domestic livestock
Table 4: Weights of deer in New Zealand 1990-2004
All data are three year averages

	Breeding hind live weight (kg)	Breeding stag live weight (kg)	Growing stag live weight at slaughter (kg)	Growing hind live weight at slaughter (kg)
1990	112.5	153.2	95.6	79.0
1991	115.1	157.4	98.3	80.8
1992	114.7	162.1	101.2	80.5
1993	115.4	165.7	103.4	81.0
1994	114.5	166.0	103.6	80.4
1995	116.8	166.3	103.8	82.0
1996	117.8	170.0	106.1	82.7
1997	121.8	176.6	110.3	85.5
1998	124.3	181.0	113.0	87.2
1999	127.6	175.9	109.8	89.6
2000	128.8	170.6	106.5	90.4
2001	129.9	168.1	104.9	91.2
2002	130.2	167.5	104.6	91.4
2003	130.1	165.6	103.4	91.3
2004	130.8	162.0	101.1	91.8

Livestock productivity data for New Zealand 2004
Agricultural sector calculations: CH_4 emissions from domestic livestock
Table 5: Assumed monthly energy concentrations of the diets consumed by beef cattle, sheep, dairy cattle and deer for all years 1990-2004

	Dairy cattle and deer MJ ME/kg dry matter	Beef cattle and sheep MJ ME/kg dry matter
July	12.6	10.8
August	11.5	10.8
September	11.7	11.4
October	12.0	11.4
November	11.6	11.4
December	10.8	9.9
January	11.1	9.9
February	10.6	9.9
March	10.7	9.6
April	11.3	9.6
May	12.0	9.6
June	11.7	10.8

Livestock productivity data for New Zealand 2004
Agriculture sector calculations: emissions from domestic livestock and soils
Table 6: Nitrogen excretion (Nex) for grazing animals

	Sheep (kg/head/yr)	Non-dairy cattle (kg/head/yr)	Dairy cattle (kg/head/yr)	Deer (kg/head/yr)
1990	12.16	65.89	106.24	20.96
1991	12.35	66.73	107.14	20.71
1992	12.47	68.09	109.56	20.57
1993	12.67	70.07	110.21	20.47
1994	12.73	69.37	110.33	20.58
1995	12.87	69.09	109.82	20.91
1996	13.10	68.15	110.65	21.31
1997	13.50	70.71	110.30	21.88
1998	13.61	70.62	111.51	22.18
1999	13.77	71.62	113.33	22.32
2000	14.01	71.30	116.31	22.37
2001	14.34	72.87	116.38	22.34
2002	14.34	72.44	116.50	22.36
2003	14.60	72.60	116.13	22.10
2004	14.83	72.55	117.00	22.03

Module	**2004 Agriculture (New Zealand)**
Submodule	**Domestic livestock emissions from enteric fermentation and manure management**
Worksheet	**4.1 (1 of 2)**
Sheet	**Methane emissions**

Livestock type	Number of animals (3 yr av) (1000s)	Emission factor for enteric fermentation[1] (kg CH_4/head/yr)	Emissions from enteric fermentation (Gg)	Emission factor for manure management[2] (kg CH_4/head/yr)	Emissions from manure management (Gg)	Total CH_4 emissions from dom livestock (Gg)
Dairy cattle	5,119	79.4	406.31	0.889	4.551	410.87
Non-dairy cattle	4,528	56.2	254.49	0.909	4.116	258.60
Sheep	39,572	10.8	427.38	0.178	7.044	434.42
Goats	137	9.0	1.23	0.180	0.025	1.25
Deer	1,720	22.0	37.90	0.369	0.635	38.53
Horses	78	18.0	1.41	2.080	0.162	1.57
Swine	385	1.5	0.58	20.000	7.697	8.27
Poultry	23,183	NE	NE	0.117	2.712	2.71
Total			1,129.28		26.941	1,156.23

1. Horses, goats and swine use IPCC default emission factors for enteric fermentation.
1. Enteric emission factors for dairy, non-dairy, sheep and deer are implied emission factors
2. Manure management: Horses, goats, swine and poultry use IPCC default emission factors from IPCC Reference Manual B-7 & B-6
2. Manure management: Dairy, non-dairy cattle, sheep and deer from Joblin and Waghorn (1994)

Module	**2004 Agriculture (New Zealand)**
Submodule	**Domestic livestock emissions from enteric fermentation and manure management**
Worksheet	**4.1 (2 of 2)**
Sheet	**Nitrous oxide emissions from manure management**

Animal waste management system (AWMS)	N excretion for each AWMS ($Nex_{(AWMS)}$) (kg N)	Emission factor for each AWMS (EF_3) (kg N_2O-N/kg N)	Emissions from domestic livestock (Gg N_2O)
Anaerobic lagoons	33,331,062	0.001	0.052
Liquid Systems			NO
Daily spread			IE
Solid storage and drylot	1,046,773	0.02	0.033
Pasture range and paddock			IE
Other	15,216,318	0.005	0.120
Total			0.205

N_2O emissions from daily spread and pasture range and paddock are reported under agricultural soils.

2004 Agriculture (New Zealand)
Table 4.17 (IPCC Workbook, adapted)
Parameter values for agricultural emissions of nitrous oxide

Parameter	Value	Fraction of ...	Additional sources
$Frac_{BURN}$	0.5	... crop residue burned in fields	Ministry of Agriculture and Forestry (expert opinion)
$Frac_{BURNL}$	0	... Legume crop residue burned in fields	Ministry of Agriculture and Forestry (expert opinion)
$Frac_{FUEL}$	0	... livestock nitrogen excretion in excrements burned for fuel	Practice does not occur in New Zealand
$Frac_{GASF}$	0.1	... total synthetic fertiliser emitted as NO_x or NH_3	IPCC Reference manual Table 4.19
$Frac_{GASM}$	0.2	... total nitrogen excretion emitted as NO_x or NH_3	IPCC Reference manual Table 4.19
$Frac_{GRAZ}$		... livestock nitrogen excreted and deposited onto soil during grazing	Refer worksheet 4.1Supplemental
$Frac_{LEACH}$	0.07	... nitrogen input to soils that is lost through leaching and run-off	Thomas et al (2002)
$Frac_{NCRBF}$	0.03	... nitrogen in N-fixing crops	IPCC Reference manual Table 4.19
$Frac_{NCR0}$	0.015	... nitrogen in non-N-fixing crops	IPCC Reference manual Table 4.19
$Frac_{R}$	0.45	... crop residue removed from the field as crop	IPCC Reference manual Table 4.19

2004 Agriculture (New Zealand)
Table 4.18 (IPCC Workbook, adapted)
Emission factors for agricultural emissions of nitrous oxide

Emission factor	Value	Emission factor for ...	Additional sources
EF_1	0.01	... direct emissions from N input to soil	IPCC GPG Table 4.17
EF_2	8	... direct emissions from organic soil mineralisation due to cultivation	IPCC GPG Table 4.17
EF_3 (AL)	0.001	... direct emissions from waste in the *anaerobic lagoons* AWMS	IPCC GPG Table 4.12
EF_3 (SS&D)	0.02	... direct emissions from waste in the *solid waste and drylot* AWMS	IPCC GPG Table 4.12
EF_3 (PR&P)	0.01	... direct emissions from waste in the *pasture range and paddock* AWMS	Carran etal (1995), Sherlock et al (1995), Kelliher et al.(2003)
EF_3 (OTHER)	0.005	... direct emissions from waste in other AWMSs	IPCC GPG Table 4.13 (poultry manure without bedding) and swine deep litter < 1 month
EF_4	0.01	... indirect emissions from volatising nitrogen	IPCC GPG Table 4.18
EF_5	0.025	... indirect emissions from leaching nitrogen	IPCC GPG Table 4.18

Module 2004 Agriculture (New Zealand)
Submodule Domestic livestock emissions
Worksheet 4.1 (supplemental) for worksheet 4.1 (2 of 2)
Sheet Nitrogen excretion from anaerobic lagoons (AWMS=AL)

Livestock type	Number of animals (3 yr av) (1000s)	Nitrogen excretion[1] (Nex) (kg/head/yr)	Percentage of nitrogen excretion in AWMS=AL[2]	Nitrogen excretion from AL (kg N)
Non-dairy cattle	4,528			no
Dairy cattle	5,119	117.0	5%	29,944,444
Poultry	23,183			no
Sheep	39,572			no
Swine	385	16.0	55%	3,386,618
Goats	137			no
Deer	1,720			no
Horses	78			no
Total (Nex_{AL})				33,331,062

1 Nex value for dairy cattle based on Ledgard, AgResearch (2003)
2 Value for dairy cattle from Ledgard and Brier (2004).

Module 2004 Agriculture (New Zealand)
Submodule Agricultural soils
Worksheet 4.1 (supplemental) for worksheet 4.5 (3 of 5)
Sheet Nitrogen excretion from pasture range and paddock (AWMS=PR&P)

Livestock type	Number of animals (3 yr av) (1000s)	Nitrogen excretion[1] (Nex) (kg/head/yr)	Percentage of nitrogen excretion in AWMS=PR&P[2 3]	Nitrogen excretion from PR&P (kg N)
Non-dairy cattle	4,528	72.5	100%	328,464,729
Dairy cattle	5,119	117.0	95%	568,944,432
Poultry	23,183	0.6	3%	417,285
Sheep	39,572	14.8	100%	586,942,285
Swine	385			no
Goats	137	9.5	100%	1,296,750
Deer	1,720	22.0	100%	37,895,664
Horses	78	25.0	100%	1,951,792
Total ($Nex_{PR\&P}$)				1,525,912,937

1 Values for sheep, non-dairy and dairy cattle, and deer from Ledgard, AgResearch (2003)
Values from goats from Ulyatt (pers comm).
2 Value for dairy cattle from Ledgard and Brier (2004).
3 Values for goats and deer from the Ministry of Agriculture and Forestry.

Module 2004 Agriculture (New Zealand)
Submodule Domestic livestock emissions
Worksheet 4.1 (supplemental) for worksheet 4.1 (2 of 2)
Sheet Nitrogen excretion from solid storage and drylot (AWMS=SS&D)

Livestock type	Number of animals (3 yr av) (1000s)	Nitrogen excretion (Nex) (kg/head/yr)	Percentage of nitrogen excretion in AWMS=SS&D	Nitrogen excretion from SS&D (kg N)
Non-dairy cattle	4,528			no
Dairy cattle	5,119			no
Poultry	23,183			no
Sheep	39,572			no
Swine	385	16.0	17%	1,046,773
Goats	137			no
Deer	1,720			no
Horses	78			no
Total ($Nex_{SS\&D}$)				1,046,773

Module 2004 Agriculture (New Zealand)
Submodule Domestic livestock emissions
Worksheet 4.1 (supplemental) for worksheet 4.1 (2 of 2)
Sheet Nitrogen excretion from other management systems (AWMS=OTHER)

Livestock type	Number of animals (3 yr av) (1000s)	Nitrogen excretion (Nex) (kg/head/yr)	Percentage of nitrogen excretion in AWMS=OTHER	Nitrogen excretion from OTHER (kg N)
Non-dairy cattle	4,528			no
Dairy cattle	5,119			no
Poultry	23,183	0.6	97%	13,492,221
Sheep	39,572			no
Swine	385	16.0	28%	1,724,097
Goats	137			no
Deer	1,720			no
Horses	0			no
Total (Nex_{OTHER})				15,216,318

2004 Agriculture (New Zealand)
F_{AW} calculation for worksheet 4.5 (1 of 5)
Nitrogen input to agricultural soils from animal waste (supplemental worksheet 4.5A)

N excretion spread from all AWMSs (kg N)[1]	Fraction of N excretion burned for fuel	Fraction of N excretion deposited onto soil during grazing	Fraction of N excretion emitted as NO_x or NH_3	Nitrogen input from animal waste (kg N)
Nex_{spread}	x $(1-(Frac_{FUEL}$	+ $Frac_{GRAZ}$	+ $Frac_{GASM}))$	= F_{AW}
49,594,153	0		0.2	39,675,323

1 Animal waste in all AWMS except *pasture range and paddock*.
2 FracGRAZ is not required as waste from grazing livestock is already excluded.

2004 Agriculture (New Zealand)
F_{BN} calculation for worksheet 4.5 (1 of 5)
Nitrogen input to agricultural soils from N-fixing crops

Production of pulses and soyabeans (kg dry biomass)	Fraction of nitrogen in N-fixing crops	Nitrogen input from N-fixing crops (kg N)
$Crop_{BF}$	x $Frac_{NCRBF}$	x 2 = F_{BN}
61,800,000	0.03	3,708,000

2004 Agriculture (New Zealand)
F_{SN} calculation for worksheet 4.5 (1 of 5)
Nitrogen input to agricultural soils from synthetic fertiliser use

Synthetic fertiliser use (kg N)	One minus the fraction of syn. fertiliser emitted as NO_x or NH_3	Nitrogen input from synthetic fertiliser use (kg N)
N_{FERT}	x $(1-Frac_{GASF})$	= F_{SN}
345,240,000	0.9	310,716,000

2004 Agriculture (New Zealand)
F_{CR} calculation for worksheet 4.5 (1 of 5)
Nitrogen input to agricultural soils from crop residues (supplemental worksheet 4.5B)

Production of non-N-fixing crops (kg dry biomass)	Fraction of nitrogen in non-N-fixing crops	Production of pulses and soyabeans (kg dry biomass)	Fraction of nitrogen in N-fixing crops	One minus the fraction of crop residue removed from field as crop	One minus the fraction of crop residue burned in the field	Nitrogen input from crop residues (F_{CR}) (kg N)
$(Crop_0$	x $Frac_{NCR0}$	+ $Crop_{BF}$	x $Frac_{NCRBF})$	x $(1 - Frac_R)$	x $(1 - Frac_{BURN})$	x 2 = F_{CR}
		61,800,000	0.03	0.55	1	2,039,400
796,073,478	0.015			0.55	0.50	6,567,606
						8,607,006

Module 2004 Agriculture (New Zealand)
Submodule Agricultural soils
Worksheet 4.5 (1 of 5)
Sheet Direct nitrous oxide emissions from agricultural soils (excluding histosols)

Type of N input to soil	Amount of N input to soil (kg N)	Emission factor for direct emissions (EF_1) (kg N_2O-N/kg N)	Direct soil emissions (excl. histosols) (Gg N_2O-N)	Direct soil emissions (excl. histosols) (Gg N_2O)
Synthetic fertiliser (F_{SN})	310,716,000	0.01	3.107	4.883
Animal Waste (F_{AW})[1]	39,675,323	0.01	0.397	0.623
N-Fixing crops (F_{BN})	3,708,000	0.01	0.037	0.058
Crop residue (F_{CR})	8,607,006	0.01	0.086	0.135
Total			3.627	5.700

1 Based on animal waste in all AWMS except *pasture range and paddock*.

Module 2004 Agriculture (New Zealand)
Submodule Agricultural soils
Worksheet 4.5 (2 of 5)
Sheet Direct nitrous oxide emissions from agricultural soils (histosols)

	Area of cultivated organic soils[1] (ha) (F_{OS})	Emission factor for direct soil emissions (EF_2) (kg N_2O-N/ha/yr)	Direct soil emissions from histosols (Gg N_2O-N)	Direct soil emissions from histosols (Gg N_2O)
	345,240,000	8	2,761.920	4,340.160

1 MAF estimate

Module 2004 Agriculture (New Zealand)
Submodule Agricultural soils
Worksheet 4.5 (3 of 5)
Sheet Direct nitrous oxide emissions from animal production (grazing animals)

Pasture,range and paddock AWMS	N excretion for AWMS PRP (kg N)	Emission factor for AWMS ($EF_{3\ PRP}$)[1] (kg N_2O-N/kg N)	Total direct animal prodn. emissions of N_2O-N (Gg)	Total direct animal prodn. emissions of N_2O (Gg)
PRP	1,525,912,937	0.01	15.259	23.979

1 Value based on Carran et al (1995) and Sherlock et al (1995).

Module 2004 Agriculture (New Zealand)
Submodule Agricultural soils
Worksheet 4.5 (4 of 5)
Sheet Indirect nitrous oxide emissions from nitrogen used in agriculture (atmospheric deposition of NH_3 and NO_x)

	Synthetic fertiliser applied to soil (N_{FERT}) (kg N)	Fraction of syn. fertiliser N that volatises ($Frac_{GASF}$)	Amount of syn. N applied to soil that volatises (kg N)	Total nitrogen excreted by livestock (kg N)	Fraction of N excretion that volatises ($Frac_{GASM}$)	Amount of N excretion that volatises (kg N)	Emission factor (EF_4) (kg N_2O-N/ kg volatised N)	Indirect N_2O emissions from atmos. deposition (Gg N_2O-N)	Indirect N_2O emissions from atmos. deposition (Gg N_2O)
	345,240,000	0.1	34,524,000	1,575,507,090	0.2	315,101,418	0.01	3.496	5.494

Module 2004 Agriculture (New Zealand)
Submodule Agricultural soils
Worksheet 4.5 (5 of 5)
Sheet Indirect nitrous oxide emissions from nitrogen used in agriculture (leaching) and total nitrous oxide emissions from agricultural soils

	Synthetic fertiliser applied to soil (N_{FERT}) (kg N)	Total nitrogen excreted by livestock (kg N)	Fraction of nitrogen that leaches ($Frac_{LEACH}$)	Emission factor (EF_5) (kg N_2O-N/ kg leached N)	Indirect N_2O emissions from leaching (Gg N_2O-N)	Indirect N_2O emissions from leaching (Gg N_2O)
	345,240,000	1,575,507,090	0.07	0.025	3.361	5.282

Module 2004 Agriculture (New Zealand)
Submodule Agricultural soils
Worksheet 4.5 (4 of 5)
Sheet Total nitrous oxide emissions agricultural soils

	Total indirect N_2O emissions from N used in agric. (Gg N_2O)	Total direct N_2O emissions (Gg N_2O)	Total nitrous oxide emissions from agricultural soils (Gg N_2O)
	10.776	4,369.838	4,380.614

Module 2004 **Agriculture (New Zealand)**
Submodule **Prescribed burning of savanna**

Year	Otago consented area (ha)	Canterbury consented area (ha)	Southland consented[3] area (ha)	Total consented area (ha)	3 yr ave consented area (ha)	assume 20% consented area (ha) burr	above ground bio-mass density	fraction burned	biomass burnt (t)
1989	11310.0	15425.7	5445.0	32180.7					
1990	14332.0	15425.7	5634.0	35391.7	36471.2	7294.2	0.0	0.32	0.0
1991	22020.0	15241.2	4580.0	41841.2	36108.1	7221.6	0.0	0.32	0.0
1992	10740.0	15531.5	4820.0	31091.5	34571.7	6914.3	0.0	0.32	0.0
1993	15229.0	10953.5	4600.0	30782.5	27819.7	5563.9	0.0	0.32	0.0
1994	7875.0	9900.0	3810.0	21585.0	22006.2	4401.2	0.0	0.32	0.0
1995	7485.0	1626.0	4540.0	13651.0	17770.7	3554.1	0.0	0.32	0.0
1996	4790.0	9061.0	4225.0	18076.0	16109.0	3221.8	0.0	0.32	0.0
1997	5895.0	6955.0	3750.0	16600.0	14466.7	2893.3	0.0	0.32	0.0
1998	1810.0	5314.0	1600.0	8724.0	10919.3	2183.9	0.0	0.32	0.0
1999	1.0	4963.0	2470.0	7434.0	9921.3	1984.3	0.0	0.32	0.0
2000	2425.0	9491.0	1690.0	13606.0	10424.3	2084.9	0.0	0.32	0.0
2001	3770.0	4303.0	2160.0	10233.0	11943.7	2388.7	0.0	0.32	0.0
2002	350.0	8792.0	2850.0	11992.0	10972.0	2194.4	0.0	0.32	0.0
2003	4670.0	3721.0	2300.0	10691.0	10901.7	2180.3	0.0	0.32	0.0
2004	1125.0	2714.0	6183.0	10022.0	8986.0	1797.2	28.0	0.3	16102.9
2005	0.0	200.0	6045.0	6245.0					

Notes
[1] from Ian J. Payton & Grant Pearce (2001) Does fire deplete the physical and biological resources of tall-tussock (Chionochloa) grasslands? The latest attempt at some answers . Pp. 243-249 in proceedings: Bushfire 2001. Australasian Bushfire Conference.

3-6 July 2001, Christchurch, New Zealand
[2] from Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual

Module **2004 Agriculture (New Zealand)**
Submodule **Prescribed burning of savanna**
Worksheet **4.3 (3 of 3)**
Sheet **Non-CO2 released from savanna burning**

Year	CH4 emission ratio2	CO emission ratio2	N2O emission ratio2	NOx emission ratio2	N/C ratio2	CH4 emissions (Gg)	CO emissions (Gg)	N2O emissions (Gg)	NOx emissions (Gg)	Total CH4 and N2O in CO2 equivalent (Gg)
2004	0.00	0.06	0.01	0.12	0.01	0.033	0.869	0.000	0.015	0.822

1 from Ian J. Payton & Grant Pearce (2001) Does fire deplete the physical and biological resources of tall-tussock (Chionochloa) grasslands? The latest attempt at some answers . Pp. 243-249 in proceedings: Bushfire 2001. Australasian Bushfire Conference.
3-6 July 2001, Christchurch, New Zealand
2 from Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual

Module **2004 Agriculture (New Zealand)**
Submodule **Prescribed burning of savanna**
Worksheet **4.3 (2 of 3)**
Sheet **Total carbon released from burning**

Year	biomass burned (t)	fraction of live material1	fraction of dead material1	fraction live material oxidised2	fraction dead material oxidised2	C content of live biomass (living)2	C content dead biomass2	carbon released from live biomass (t)	carbon released from dead biomass (t)	total carbon released (t)
2004	16103	0.36	0.64	0.8	1	0.45	0.4	2090	4119	6209

Non-N-fixing crop yields in New Zealand Revised 2004

Agricultural sector calculations: emissions from field burning and agricultural soils

	Barley prodn (jun yr) (tonnes)	Barley prodn (3 yr av) (Gg)	Wheat prodn (jun yr) (tonnes)	Wheat prodn (3 yr av) (Gg)	Maize prodn (jun yr) (tonnes)	Maize prodn (3 yr av) (Gg)	Oats prodn (jun yr) (tonnes)	Oats prodn (3 yr av) (Gg)	Non-N-fixing crops (3 yr av) (kg)
1989	326,850		134,994		138,694		65,892		
1990	434,856	381.2	188,042	167.9	161,651	161.2	78,877	67.3	777,721,333
1991	382,043	378.6	180,690	186.6	183,388	169.6	57,187	64.6	799,342,333
1992	318,787	363.5	191,039	197.0	163,842	160.1	57,625	57.2	777,800,000
1993	389,523	367.9	219,414	217.5	133,069	146.6	56,793	57.4	789,326,000
1994	395,500	362.6	241,900	235.5	142,768	145.5	57,718	51.1	794,739,000
1995	302,800	355.2	245,200	254.7	160,797	171.1	38,735	45.9	826,848,333
1996	367,200	360.3	277,000	279.9	209,710	188.1	41,217	43.0	871,302,897
1997	411,000	372.7	317,379	298.8	193,806	193.2	49,065	44.2	908,949,449
1998	340,000	351.7	302,100	313.2	176,148	189.0	42,223	44.3	898,141,049
1999	304,000	315.3	320,000	316.0	197,000	184.7	41,702	39.8	855,857,115
2000	302,000	300.7	326,000	336.7	181,000	185.0	35,398	33.2	855,499,896
2001	296,000	346.3	364,000	330.5	177,000	168.9	22,400	30.9	876,670,963
2002	440,883	371.7	301,498	328.5	148,847	174.3	34,987	29.1	903,682,667
2003	378,340	348.4	319,977	292.4	197,182	180.7	29,934	30.9	852,478,478
2004	226,082	290.1	255,860	289.6	196,000	187.1	27,845	29.3	796,073,478
2005	266,000		293,000		168,000		30,000		

Source: Statistics New Zealand.

Estimates provided by MAF for 1998, 1999, 2000, 2001, 2004 and 2005

N-fixing crop yields in New Zealand Revised 2004

Agricultural sector calculations: emissions from field burning and agricultural soils

	Processed peas prodn[1,3] (jun yr) (tonnes dry weight)	Peas prodn[2,3] (jun yr) (tonnes)	Peas Processed[3] and Seed Peas (tonnes DW)	Peas prodn (3 yr av) (Gg)	Lentils prodn[3] (jun yr) (tonnes)	Lentils prodn (3 yr av) (Gg)	N-fixing crops (3 yr av) (kg)
1989	24,000	47,308	71,308		3,386		
1990	24,000	57,378	81,378	80.6	3,386	3.4	83,969,333
1991	24,000	65,064	89,064	89.9	3,386	4.0	93,902,667
1992	24,000	75,290	99,290	91.9	5,204	4.5	96,410,000
1993	24,000	63,268	87,268	90.2	5,018	4.3	94,463,333
1994	24,000	59,898	83,898	83.9	2,712	2.9	86,755,667
1995	24,000	56,448	80,448	79.6	923	1.5	81,080,333
1996	24,000	50,337	74,337	76.5	923	0.9	77,397,000
1997	24,300	50,337	74,637	82.1	923	0.9	83,053,333
1998	31,200	66,200	97,400	86.1	940	0.6	86,766,667
1999	34,200	52,200	86,400	94.6	0	0.3	94,913,333
2000	36,000	64,000	100,000	86.7	0	0.0	86,700,000
2001	36,000	37,700	73,700	79.7	0	1.1	80,819,667
2002	36,000	29,457	65,457	67.2	3,302	1.8	68,953,000
2003	31,200	31,200	62,400	61.6	2,000	2.4340	64,053,000
2004	28,500	28,500	57,000	59.8	2,000	2.0000	61,800,000
2005	28,500	31,500	60,000		2,000		

1 MAF estimate. Zero has been entered when production negligible.

2 Statistics New Zealand. 1998, 1999, 2000, 2001 estimates provided by MAF.

Production pea data for 2003 calculated from area in peas.

3 MAF estimates for 2004 and 2005

Miscellaneous agricultural data Revised 2004

Agricultural sector calculations: emissions from agricultural soils

	Cultivated organic soils (ha)[1] (jun yr)	Cultivated organic soils (ha) (3 yr av)	Synthetic fertiliser use (kg N)[2] (jun yr)	Synthetic fertiliser use (kg N) (3 yr av)
1989	10,109		51,663,000	
1990	10,109	10,109	59,265,000	57,540,667
1991	10,109	10,109	61,694,000	63,693,667
1992	10,109	10,109	70,122,000	78,637,000
1993	10,109	10,109	104,095,000	99,449,333
1994	10,109	10,109	124,131,000	126,496,333
1995	10,109	10,109	151,263,000	143,058,000
1996	10,109	10,109	153,780,000	149,446,000
1997	10,109	10,109	143,295,000	150,847,333
1998	10,109	10,109	155,467,000	155,193,667
1999	10,109	10,109	166,819,000	170,460,667
2000	10,109	10,109	189,096,000	201,305,000
2001	10,109	10,109	248,000,000	248,765,333
2002	10,109	10,109	309,200,000	298,200,000
2003	10,109	10,109	337,400,000	331,533,333
2004	10,109	10,109	348,000,000	345,240,000
2005	10,109		350,320,000	

1 MAF estimate 2003

2 Best estimate from MAF and sales records obtained by FertResearch

Module	**2004 Agriculture (New Zealand)**
Submodule	**Field burning of agricultural residues**
Worksheet	**4.4 (1 and 2 of 3)**
Sheet	**Calculation of carbon and nitrogen releases**

Crops	Production (3 yr av) (Gg crop)	Residue to crop ratio	Quantity of residue (Gg biomass)	Dry matter fraction	Quantity of dry residue (Gg dm)	Fraction burned in fields[1]	Fraction oxidised	Biomass burned (Gg dm)	Carbon fraction of residue	Carbon released (Gg C)	Nitrogen-carbon ratio	Nitrogen released (Gg N)
Cereals	609.0		762.7		636.5			171.8		80.895		1.091
a Barley	290.1	1.2	348.2	0.83	289.0	0.3	0.9	78.0	0.4567	35.634	0.015	0.535
b Wheat	289.6	1.3	376.5	0.83	312.5	0.3	0.9	84.4	0.4853	40.946	0.012	0.491
c Oats	29.3	1.3	38.0	0.92	35.0	0.3	0.9	9.4	0.4567	4.315	0.015	0.065

1 Ministry of Agriculture and Forestry.
Maize no longer included in calculation as no maize residue burning occurs - MAF 2003

Module	**2004 Agriculture (New Zealand)**
Submodule	**Field burning of agricultural residues**
Worksheet	**4.4 (3 of 3)**
Sheet	**Total non-CO_2 trace gas emissions from cereals**

	Emission ratio to C or N	Emissions (Gg C or N)	Conversion ratio	Emissions (Gg of gas)
CH_4	0.005	0.404	1.333	0.539
CO	0.060	4.854	2.333	11.325
N_2O	0.007	0.008	1.571	0.012
NO_x	0.121	0.132	3.286	0.434

Module	**2004 Agriculture (New Zealand)**
Submodule	**Field burning of agricultural residues**
Worksheet	**4.4 (supplementary)**
Sheet	**Calculation of carbon and nitrogen releases per crop type**

Crops	Emissions of CH_4 (Gg)	Emissions of CO (Gg)	Emissions of N_2O (Gg)	Emissions of NO_x (Gg)
Cereals				
a Barley	0.238	4.989	0.006	0.213
b Wheat	0.273	5.732	0.005	0.195
d Oats	0.029	0.604	0.001	0.026

A8.5 Worksheets for the LULUCF sector

Module Land-use change and forestry (New Zealand)
Submodule Changes in forest and other woody biomass stocks
Worksheet Equivalent to 5.1 (2 of 3)
Sheet Carbon release from harvesting in *Pinus radiata* plantations (temperate) and native forests

	Stem volume in plantation forest harvest[1] (merch. m^3)	Biomass conversion ratio[2] (t dm/m^3)	Dry matter in stem[1 3] t C/t dm = 0.5 (t dm)	Carbon in plantation forest harvest [1] (t C)	Stem volume in native forest harvest (merch. m3)	Biomass conversion ratio (t dm/m^3)	Biomass expansion ratio (t dm/m^3)	Dry matter in total native forest harvest (t dm)	Carbon in native forest harvest (t C) t C/t dm = 0.5	Carbon release from total forest harvest (t C)
1990	10,813,787	0.461	4,985,514	2,492,757	365,000	0.50	2.04	372,300	186,150	2,678,907
1991	11,797,488	0.461	5,439,033	2,719,516	307,667	0.50	2.04	313,820	156,910	2,876,426
1992	12,500,583	0.461	5,763,183	2,881,591	257,333	0.50	2.04	262,480	131,240	3,012,831
1993	13,232,522	0.461	6,100,631	3,050,316	205,000	0.50	2.04	209,100	104,550	3,154,866
1994	13,987,203	0.461	6,448,564	3,224,282	158,000	0.50	2.04	161,160	80,580	3,304,862
1995	14,700,793	0.461	6,777,553	3,388,776	107,333	0.50	2.04	109,480	54,740	3,443,516
1996	15,214,390	0.461	7,014,338	3,507,169	50,000	0.50	2.04	51,000	25,500	3,532,669
1997	15,202,118	0.461	7,008,681	3,504,340	56,667	0.50	2.04	57,800	28,900	3,533,240
1998	15,746,397	0.461	7,259,611	3,629,806	57,667	0.50	2.04	58,820	29,410	3,659,216
1999	16,672,535	0.461	7,686,591	3,843,296	57,000	0.50	2.04	58,140	29,070	3,872,366
2000	18,228,284	0.461	8,403,843	4,201,922	38,333	0.50	2.04	39,100	19,550	4,221,472
2001	19,711,404	0.461	9,087,610	4,543,805	23,000	0.50	2.04	23,460	11,730	4,555,535
2002	20,419,021	0.461	9,413,846	4,706,923	16,667	0.50	2.04	17,000	8,500	4,715,423
2003	20,106,098	0.461	9,269,577	4,634,789	9,667	0.50	2.04	9,860	4,930	4,639,719
2004	19,133,626	0.462	8,843,636	4,421,818	7,667	0.50	2.04	7,820	3,910	4,425,728

Module Land-use change and forestry (New Zealand)
Submodule Changes in forest and other woody biomass stocks
Worksheet Equivalent to 5.1 (1 of 3)
Sheet Carbon uptake in *Pinus radiata* plantations (temperate)

	Total forest estate area (net of harvest) (ha)	Total Forest estate carbon (net of harvest) (t C)	Forest estate carbon uptake (net of harvest) (t C)	Forest Estate Crop uptake (before harvest) (t C)	Forest Estate Shrub uptake (before harvest) (t C)	Forest Estate DOM* uptake (before harvest) (t C)	Forest Estate soil (not included in total carbon) (t C)	Carbon in plantation forest harvest (t C)	Total forest carbon uptake (before harvest) (t C)
1990	1,184,884	112,041,802	5,811,122	6,498,460	101,754	1,703,666	1,912,774	2,492,757	8,303,880
1991	1,211,537	117,564,626	5,522,825	6,581,928	99,189	1,561,224	2,451,739	2,719,516	8,242,341
1992	1,250,219	122,795,595	5,230,968	6,609,125	96,645	1,406,790	3,747,978	2,881,591	8,112,560
1993	1,312,586	127,875,773	5,080,178	6,687,033	96,750	1,346,712	6,342,142	3,050,316	8,130,494
1994	1,388,015	132,923,040	5,047,267	6,791,309	98,162	1,382,078	7,743,524	3,224,282	8,271,549
1995	1,471,062	137,973,594	5,050,553	6,971,401	100,456	1,367,473	8,534,784	3,388,776	8,439,330
1996	1,547,997	143,149,902	5,176,308	7,224,150	104,327	1,355,001	7,792,911	3,507,169	8,683,477
1997	1,618,343	148,719,074	5,569,172	7,585,467	110,398	1,377,647	6,932,627	3,504,340	9,073,512
1998	1,675,967	154,599,528	5,880,454	8,054,681	121,234	1,334,344	5,619,383	3,629,806	9,510,260
1999	1,722,793	160,733,279	6,133,751	8,448,682	126,144	1,402,221	4,489,120	3,843,296	9,977,047
2000	1,761,242	166,945,582	6,212,302	8,784,702	127,029	1,502,493	3,683,150	4,201,922	10,414,224
2001	1,794,483	173,288,966	6,343,385	8,978,906	120,781	1,787,503	3,084,228	4,543,805	10,887,190
2002	1,823,075	179,708,653	6,419,686	9,146,109	115,437	1,865,062	2,448,320	4,706,923	11,126,609
2003	1,847,130	186,510,386	6,801,733	9,388,698	115,706	1,932,118	1,770,614	4,634,789	11,436,522
2004	1,865,374	193,674,595	7,164,209	9,751,426	126,510	1,708,091	974,838	4,421,818	11,586,027

Module Land-use change and forestry (New Zealand)
Submodule Changes in forest and other woody biomass stocks
Worksheet Equivalent of 5.1 (3 of 3)
Sheet Net Carbon uptake in forest

	Total forest carbon uptake (before harvest) (Gg C)	Carbon release from total forest harvest (Gg C)	Carbon uptake from Crop (before harvest) (Gg C)	Carbon uptake from shrub (before harvest) (Gg C)	Carbon uptake dead matter (before harvest) (Gg C)	Carbon uptake in soil (not included in total uptake) (Gg C)	Net carbon uptake in forests (Gg C)	Net CO2 uptake in forests (Gg CO2)
1990	8,304	2,679	6,498	102	1,704	1,913	5,625	20,625
1991	8,242	2,876	6,582	99	1,561	2,452	5,366	19,675
1992	8,113	3,013	6,609	97	1,407	3,748	5,100	18,699
1993	8,130	3,155	6,687	97	1,347	6,342	4,976	18,244
1994	8,272	3,305	6,791	98	1,382	7,744	4,967	18,211
1995	8,439	3,444	6,971	100	1,367	8,535	4,996	18,318
1996	8,683	3,533	7,224	104	1,355	7,793	5,151	18,886
1997	9,074	3,533	7,585	110	1,378	6,933	5,540	20,314
1998	9,510	3,659	8,055	121	1,334	5,619	5,851	21,454
1999	9,977	3,872	8,449	126	1,402	4,489	6,105	22,384
2000	10,414	4,221	8,785	127	1,502	3,683	6,193	22,707
2001	10,887	4,556	8,979	121	1,788	3,084	6,332	23,216
2002	11,127	4,715	9,146	115	1,865	2,448	6,411	23,508
2003	11,437	4,640	9,389	116	1,932	1,771	6,797	24,922
2004	11,586	4,426	9,751	127	1,708	975	7,160	26,254

Module Land-use change and forestry (New Zealand)
Submodule Land converted to forest
Worksheet
Sheet Carbon release from grassland (woody vegetation) cleared for new forest planting

	Grassland cleared for forest planting[1] (ha)	Clearance where scrub is burned[2] (25% of total) (ha)	Quantity of biomass burned (t dm/ha = 136) (t dm)	Oxidised biomass (90% of total) (t dm)	C release from burning scrub (t C/t dm = 0.5) (t C)	CO2 release from burning for new planting (t CO2)	Clearance where scrub decays[2] (75% of total) (ha)	Initial quantity of biomass to decay[3] (t dm/ha =136) (t dm)	Added biomass left to decay after fire (10 %) (t dm)	C release from decay over period (t C/t dm = 0.5) (t C)	CO2 release from decay for new planting (t CO2)
1990	3,885	971	132,106	118,895	59,448	217,975	2,914	396,318	0	198,159	726,582
1991	3,579	895	121,679	109,511	54,756	200,771	2,684	365,038	0	182,519	669,236
1992	5,427	1,357	184,507	166,056	83,028	304,436	4,070	553,520	0	276,760	1,014,787
1993	6,784	1,696	230,656	207,590	103,795	380,582	5,088	691,968	0	345,984	1,268,608
1994	11,200	2,800	380,800	342,720	171,360	628,320	8,400	1,142,400	0	571,200	2,094,400
1995	8,569	2,142	291,346	262,211	131,106	480,721	6,427	874,038	0	437,019	1,602,403
1996	11,933	2,983	405,711	365,140	182,570	669,423	8,950	1,217,132	0	608,566	2,231,409
1997	10,323	2,581	350,971	315,874	157,937	579,102	7,742	1,052,912	0	526,456	1,930,339
1998	5,955	1,489	202,470	182,223	91,112	334,076	4,466	607,410	0	303,705	1,113,585
1999	7,229	1,807	245,775	221,197	110,599	405,528	5,422	737,324	0	368,662	1,351,761
2000	7,072	1,768	240,448	216,403	108,202	396,739	5,304	721,344	0	360,672	1,322,464
2001	7,950	1,988	270,311	243,280	121,640	446,014	5,963	810,934	0	405,467	1,486,712
2002	5,720	1,430	194,480	175,032	87,516	320,892	4,290	583,440	0	291,720	1,069,640
2003	6,249	1,562	212,455	191,209	95,605	350,550	4,687	637,364	0	318,682	1,168,501
2004	4,559	1,140	154,995	139,495	69,748	255,741	3,419	464,984	0	232,492	852,471

Module Land-use change and forestry (New Zealand)
Submodule Grassland remaining grassland/forest land remaining forest land
Worksheet
Sheet Carbon release from wildfires

	Area of grassland burned in wildfires[1] (ha)	Quantity of biomass burned (t dm/ha = 136) (t dm)	Oxidised biomass (90% of total) (t dm)	C release from scrub wildfires (t C\t dm = 0.5) (t C)	Area of Forest burned in wildfires[1] (ha)	Quantity of biomass burned (t dm/ha = 364) (t dm)	Oxidised biomass (90 % of total) (t dm)	C release from forest wildfires (t C/t dm = 0.5) (t C)
1990	2,564	348,738	313,864	156,932	323	117,663	105,897	52,948
1991	2,064	280,659	252,593	126,296	207	75,318	67,786	33,893
1992	1,954	265,744	239,170	119,585	165	60,151	54,136	27,068
1993	2,330	316,812	285,131	142,565	239	86,814	78,133	39,066
1994	2,529	343,978	309,580	154,790	314	114,266	102,839	51,420
1995	2,645	359,765	323,789	161,894	472	171,929	154,736	77,368
1996	2,532	344,318	309,886	154,943	727	264,598	238,138	119,069
1997	3,320	451,565	406,409	203,204	762	277,520	249,768	124,884
1998	3,268	444,391	399,952	199,976	692	251,949	226,754	113,377
1999	3,049	414,709	373,238	186,619	403	146,571	131,914	65,957
2000	2,119	288,184	259,366	129,683	334	121,576	109,418	54,709
2001	1,954	265,789	239,210	119,605	282	102,648	92,383	46,192
2002	2,165	294,440	264,996	132,498	283	102,891	92,602	46,301
2003	2,030	276,080	248,472	124,236	284	103,255	92,929	46,465
2004	1,898	258,098	232,288	116,144	285	103,740	93,366	46,683

Module Land-use change and forestry (New Zealand)
Submodule Forest land remaining forest land
Worksheet
Sheet Non-CO2 emissions from the on-site burning of forests

	Carbon release by on-site burning (t C)	Nitrogen released (t N/t c = 0.01) (t C)	Carbon in CH_4 emissions (ratio = 0.012) (t C)	Nitrogen in N_2O emissions (ratio = 0.007) (t N)	Nitrogen in NO_x emissions (ratio = 0.121) (t N)	Carbon in CO emissions (ratio = 0.06) (t C)	CH_4 emissions from burning (ratio = 1.333) (Gg CH_4)	N_2O emissions from burning (ratio = 1.571) (Gg N2O)	NO_x emissions from burning (ratio = 3.286) (Gg NOx)	CO emissions from burning (ratio = 2.333) (Gg CO)
1990	52,948	529	635	4	64	3,177	0.847	0.006	0.211	7.412
1991	33,893	339	407	2	41	2,034	0.542	0.004	0.135	4.744
1992	27,068	271	325	2	33	1,624	0.433	0.003	0.108	3.789
1993	39,066	391	469	3	47	2,344	0.625	0.004	0.155	5.469
1994	51,420	514	617	4	62	3,085	0.823	0.006	0.204	7.198
1995	77,368	774	928	5	94	4,642	1.238	0.009	0.308	10.830
1996	119,069	1,191	1,429	8	144	7,144	1.905	0.013	0.473	16.667
1997	124,884	1,249	1,499	9	151	7,493	1.998	0.014	0.497	17.481
1998	113,377	1,134	1,361	8	137	6,803	1.814	0.012	0.451	15.870
1999	65,957	660	791	5	80	3,957	1.055	0.007	0.262	9.233
2000	54,709	547	657	4	66	3,283	0.875	0.006	0.218	7.658
2001	46,192	462	554	3	56	2,771	0.739	0.005	0.184	6.466
2002	46,301	463	556	3	56	2,778	0.741	0.005	0.184	6.481
2003	46,465	465	558	3	56	2,788	0.743	0.005	0.185	6.504
2004	46,683	467	560	3	56	2,801	0.747	0.005	0.186	6.535

Module Land-use change and forestry (New Zealand)
Submodule Grassland remaining grassland
Worksheet
Sheet Non-CO2 emissions from the on-site burning of scrub - WILDFIRE ONLY

	Carbon release by on-site burning (t C)	Nitrogen released (t N/t c = 0.01) (t C)	Carbon in CH_4 emissions (ratio = 0.012) (t C)	Nitrogen in N_2O emissions (ratio = 0.007) (t N)	Nitrogen in NO_x emissions (ratio = 0.121) (t N)	Carbon in CO emissions (ratio = 0.06) (t C)	CH_4 emissions from burning (ratio = 1.333) Gg CH	N_2O emissions from burning (ratio = 1.571) (Gg N2O)	NO_x emissions from burning (ratio = 3.286) (Gg NOx)	CO emissions from burning (ratio = 2.333) (Gg CO)
1990	156,932	1,569	1,883	11	190	9,416	2.510	0.017	0.624	21.967
1991	126,296	1,263	1,516	9	153	7,578	2.020	0.014	0.502	17.679
1992	119,585	1,196	1,435	8	145	7,175	1.913	0.013	0.475	16.739
1993	142,565	1,426	1,711	10	173	8,554	2.280	0.016	0.567	19.956
1994	154,790	1,548	1,857	11	187	9,287	2.476	0.017	0.615	21.668
1995	161,894	1,619	1,943	11	196	9,714	2.590	0.018	0.644	22.662
1996	154,943	1,549	1,859	11	187	9,297	2.478	0.017	0.616	21.689
1997	203,204	2,032	2,438	14	246	12,192	3.250	0.022	0.808	28.445
1998	199,976	2,000	2,400	14	242	11,999	3.199	0.022	0.795	27.993
1999	186,619	1,866	2,239	13	226	11,197	2.985	0.021	0.742	26.123
2000	129,683	1,297	1,556	9	157	7,781	2.074	0.014	0.516	18.153
2001	119,605	1,196	1,435	8	145	7,176	1.913	0.013	0.476	16.742
2002	132,498	1,325	1,590	9	160	7,950	2.119	0.015	0.527	18.547
2003	124,236	1,242	1,491	9	150	7,454	1.987	0.014	0.494	17.391
2004	116,144	1,161	1,394	8	141	6,969	1.858	0.013	0.462	16.258

Module Land-use change and forestry (New Zealand)
Submodule Grassland converted to forest land
Worksheet
Sheet Non-CO2 emissions from the on-site burning of scrub - CONTROLLED BURN ONLY

	Carbon release by on-site burning (t C)	Nitrogen released (t N/t c = 0.01) (t C)	Carbon in CH_4 emissions (ratio = 0.012) (t C)	Nitrogen in N_2O emissions (ratio = 0.007) (t N)	Nitrogen in NO_x emissions (ratio = 0.121) (t N)	Carbon in CO emissions (ratio = 0.06) (t C)	CH_4 emissions from burning (ratio = 1.333) Gg CH	N_2O emissions from burning (ratio = 1.571) (Gg N2O)	NO_x emissions from burning (ratio = 3.286) (Gg NOx)	CO emissions from burning (ratio = 2.333) (Gg CO)
1990	59,448	594	713	4	72	3,567	0.951	0.007	0.236	8.321
1991	54,756	548	657	4	66	3,285	0.876	0.006	0.218	7.665
1992	83,028	830	996	6	100	4,982	1.328	0.009	0.330	11.622
1993	103,795	1,038	1,246	7	126	6,228	1.660	0.011	0.413	14.529
1994	171,360	1,714	2,056	12	207	10,282	2.741	0.019	0.681	23.987
1995	131,106	1,311	1,573	9	159	7,866	2.097	0.014	0.521	18.352
1996	182,570	1,826	2,191	13	221	10,954	2.920	0.020	0.726	25.556
1997	157,937	1,579	1,895	11	191	9,476	2.526	0.017	0.628	22.108
1998	91,112	911	1,093	6	110	5,467	1.457	0.010	0.362	12.754
1999	110,599	1,106	1,327	8	134	6,636	1.769	0.012	0.440	15.482
2000	108,202	1,082	1,298	8	131	6,492	1.731	0.012	0.430	15.146
2001	121,640	1,216	1,460	9	147	7,298	1.946	0.013	0.484	17.027
2002	87,516	875	1,050	6	106	5,251	1.400	0.010	0.348	12.250
2003	95,605	956	1,147	7	116	5,736	1.529	0.011	0.380	13.383
2004	69,748	697	837	5	84	4,185	1.116	0.008	0.277	9.763

Module Land-use change and forestry (New Zealand)
Submodule Carbon emissions from liming soils

	Total annual amount of limestone (Mg)	Total annual amount of limestone (3 yr average) (Mg C)	Carbon conversion factor	Carbon emissions from liming (Mg C)	Emissions of CO2 (Gg CO2)
1989	662,753				
1990	817,127	787,329	0.12	94,479	346
1991	882,107	882,107	0.12	105,853	388
1992	947,087	951,619	0.12	114,194	419
1993	1,025,662	1,033,210	0.12	123,985	455
1994	1,126,880	1,126,880	0.12	135,226	496
1995	1,228,097	1,152,047	0.12	138,246	507
1996	1,101,163	1,180,840	0.12	141,701	520
1997	1,213,261	1,213,261	0.12	145,591	534
1998	1,325,360	1,325,360	0.12	159,043	583
1999	1,437,458	1,437,458	0.12	172,495	632
2000	1,549,556	1,549,556	0.12	185,947	682
2001	1,661,655	1,661,655	0.12	199,399	731
2002	1,773,753	1,666,600	0.12	199,992	733
2003	1,564,392	1,634,179	0.12	196,101	719
2004	1,564,392	1,564,392	0.12	187,727	688
2005	1,564,392				

Land use change matrix from 1997 to 2002 (based on the LCDB1 and LCDB2 data)

		Land area categories from LCDB1 (1997) (kha)										
		FMp	FMn	CMa	CMp	GMh	GMl	WM	WU	S	O	Total
	FMp	1904.478	10.841	0.007	0.015	90.986	39.611	0.000	0.000	0.027	0.023	2045.988
	FMn	0.020	8182.228	0.000	0.000	0.281	0.005	0.000	0.000	0.031	0.033	8182.598
	CMa	0.000	0.003	333.590	0.000	0.119	0.000	0.000	0.000	0.000	0.006	333.719
	CMp	0.212	0.000	1.363	77.954	4.197	0.000	0.000	0.000	0.000	0.000	83.726
LCDB2	GMh	0.132	0.928	0.000	0.000	8883.802	0.903	0.000	0.000	0.027	0.000	8885.793
2002	GMl	1.250	2.801	0.000	0.000	0.135	5475.786	0.000	0.000	0.034	0.213	5480.217
	WM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001
	WU	0.000	0.001	0.000	0.000	0.646	0.019	0.000	531.244	0.038	0.014	531.960
	S	0.544	0.019	0.000	0.023	5.006	0.026	0.000	0.000	214.844	0.000	220.462
	O	0.002	0.192	0.000	0.000	0.043	0.018	0.000	0.000	0.000	1056.841	1057.095
	Total	1906.638	8197.012	334.960	77.992	8985.215	5516.369	0.000	531.244	215.000	1057.129	**26821.559**
	Net	139.350	-14.414	-1.241	5.734	-99.422	-36.152	0.001	0.716	5.462	-0.034	

Land use change matrix from 1997 to 1998 (an example showing interpolated annual changes)

		Implied land use changes from 1997 to 1998 (kha)										
				1997								
		FMp	FMn	CMa	CMp	GMh	GMl	WM	WU	S	O	Total
1998	FMp	1906.206	2.168	0.001	0.003	18.197	7.922	0.000	0.000	0.005	0.005	1934.508
	FMn	0.004	8194.055	0.000	0.000	0.056	0.001	0.000	0.000	0.006	0.007	8194.129
	CMa	0.000	0.001	334.686	0.000	0.024	0.000	0.000	0.000	0.000	0.001	334.712
	CMp	0.042	0.000	0.273	77.984	0.839	0.000	0.000	0.000	0.000	0.000	79.139
	GMh	0.026	0.186	0.000	0.000	8964.932	0.181	0.000	0.000	0.005	0.000	8965.330
	GMl	0.250	0.560	0.000	0.000	0.027	5508.252	0.000	0.000	0.007	0.043	5509.138
	WM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	WU	0.000	0.000	0.000	0.000	0.129	0.004	0.000	531.244	0.008	0.003	531.387
	S	0.109	0.004	0.000	0.005	1.001	0.005	0.000	0.000	214.969	0.000	216.093
	O	0.000	0.038	0.000	0.000	0.009	0.004	0.000	0.000	0.000	1057.071	1057.122
	total	1906.638	8197.012	334.960	77.992	8985.215	5516.369	0.000	531.244	215.000	1057.129	**26821.559**
	net	27.870	-2.883	-0.248	1.147	-19.884	-7.230	0.000	0.143	1.092	-0.007	

Land use change matrix from 2003 to 2004 (an example showing extrapolated annual changes for 2003)

		Extrapolated land use changes from 2003 to 2004 (kha)										
				2003								
		FMp	FMn	CMa	CMp	GMh	GMl	WM	WU	S	O	Total
2004	FMp	2073.426	2.168	0.001	0.003	18.197	7.922	0.000	0.000	0.005	0.005	2101.728
	FMn	0.004	8176.758	0.000	0.000	0.056	0.001	0.000	0.000	0.006	0.007	8176.832
	CMa	0.000	0.001	333.197	0.000	0.024	0.000	0.000	0.000	0.000	0.001	333.222
	CMp	0.042	0.000	0.273	84.865	0.839	0.000	0.000	0.000	0.000	0.000	86.019
	GMh	0.026	0.186	0.000	0.000	8845.626	0.181	0.000	0.000	0.005	0.000	8846.024
	GMl	0.250	0.560	0.000	0.000	0.027	5464.870	0.000	0.000	0.007	0.043	5465.756
	WM	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001
	WU	0.000	0.000	0.000	0.000	0.129	0.004	0.000	532.104	0.008	0.003	532.247
	S	0.109	0.004	0.000	0.005	1.001	0.005	0.000	0.000	221.523	0.000	222.647
	O	0.000	0.038	0.000	0.000	0.009	0.004	0.000	0.000	0.000	1057.030	1057.081
	total	2073.858	8179.715	333.471	84.872	8865.908	5472.987	0.001	532.104	221.555	1057.088	**26821.559**

A8.6 Worksheets for the waste sector

Module **2004 Waste (New Zealand)**
Submodule **Methane emissions from solid waste disposal sites**
Worksheet **6.1A (supplemental)**

Total population[1]	MSW generation rate[2] (kg/cap/day)	Annual MSW generated (Gg/yr)	Fraction of MSW to SWDs	Total MSW to SWDSs (Gg)
4039400	2.07	3045	1.00	3,045

[1] Statistics New Zealand "100 years of population growth"
[2] Solid Waste Analysis Protocol (2003 results), Ministry for the Environment

Module **2004 Waste (New Zealand)**
Submodule **Methane emissions from solid waste disposal sites (tier 2)**
Worksheet **6.1**

Year	Total annual MSW disposed to SWDs (Gg MSW)	Methane generation potential (L_o)	Methane Generation rate constant (k)	Gross annual methane generation (model output)	Total annual MSW disposed to SWDs with LFG systems (Gg MSW)	Percentage of MSW with LFG systems (%)	Estimated average LFG system collection efficiency (%)	Recovered methane per year (Gg CH_4)	Net methane generation (Gg CH_4)	One minus oxidation correction factor	Net methane emissions (Gg CH_4)
1990	2,977	69.55	0.06	115.3	1050.1	35.80	0.00	0.00	115.3	0.9	103.8
1991	3,069	69.55	0.06	116.8	1089.3	35.72	0.00	0.00	116.8	0.9	105.1
1992	3,101	69.55	0.06	118.2	1138.9	36.95	0.09	3.53	114.7	0.9	103.2
1993	3,141	69.55	0.06	119.5	1230.6	39.47	0.09	3.95	115.5	0.9	104.0
1994	3,185	69.55	0.06	120.9	1410.2	44.64	0.10	6.59	114.3	0.9	102.9
1995	3,184	69.55	0.06	122.2	1511.1	47.13	0.23	18.46	103.7	0.9	93.4
1996	3,161	68.84	0.06	123.3	1649.3	50.64	0.23	19.16	104.1	0.9	93.7
1997	3,138	68.13	0.06	124.2	1842.5	55.84	0.28	21.11	103.1	0.9	92.8
1998	3,116	67.42	0.06	124.9	1827.1	54.89	0.33	25.32	99.6	0.9	89.7
1999	3,093	66.71	0.06	125.4	1911.2	57.09	0.40	32.88	92.5	0.9	83.3
2000	3,070	66.01	0.06	125.8	1939.2	59.58	0.38	32.56	93.2	0.9	83.9
2001	3,047	65.30	0.06	125.9	1915.3	60.55	0.39	35.87	90.0	0.9	81.0
2002	3,024	64.59	0.06	126.0	2013.9	65.10	0.42	39.13	86.9	0.9	78.2
2003	3,001	63.88	0.06	125.9	2117.1	69.88	0.42	41.21	84.7	0.9	76.2
2004	3,034	64.05	0.06	125.8	2192.9	71.44	0.44	46.00	79.8	0.9	71.9

Information in this table based on SCS Wetherill 2002, Solid Waste Analysis Protocol (2003 results), 2002 Landfill Review and Audit and Waste Management New Zealand 2005.

2004 Calculations of DOC and L_o
New Zealand DOC Estimate Worksheet

Waste category (NZ WAP)	Waste Quantity (tonnes)	Waste composition (% by weight)	Fraction DOC (by weight)
Paper	386,697	13	0.4
Plastic	207,050	7	0
Glass	82,211	3	0
Ferrous Metal	140,063	5	0
Non ferr metal	33,493	1	0
Organic	752,080	25	0.17
Rubble/concrete	496,312	16	0
Timber	380,607	13	0.3
Rubber	39,583	1	0
Nappies/Sanitary	60,897	2	0
Textiles	115,705	4	0
Pot Haz	353,203	12	0
Total	3,044,857	100	

Methane Generation Potential Calculation by Using Waste Type Data in 2004

Methane correction factor (MCF)	Degradable organic carbon (DOC) GgC/Gg waste	Fraction of DOC dissimilated (DOC_F)	Fraction by volume of CH_4	Conversion from C to CH_4	Methane Generation Potential (L_o) $GgCH_4$/Gg waste	Methane Generation Potential (L_o) m^3CH_4/Mg waste
0.984	0.1303	0.50	0.50	1.3333	0.0427	64.06

Module 2004 Waste (New Zealand)
Submodule Methane emissions from domestic and commercial wastewater treatment
Worksheet NZ 6.2
Sheet Estimation of emission factor for wastewater handling systems

Wastewater handling system[1]	Fraction of wastewater treated by the handling system[1] (percent)	Methane conversion factor for the handling system	Product	Maximum methane producing capacity (kg CH_4/kg BOD) B_o	Emission factor for domestic/ commercial wastewater (kg CH4/kg BOD)
Anaerobic pond	1.7	0.65	0.01105	0.375	0.00415
Imhoff tank	0.3	0.55	0.00186	0.375	0.00070
Septic tank	7.4	0.40	0.02974	0.375	0.01115
Oxidation pond	10.7	0.20	0.02131	0.375	0.00799
Facultative aerated pd	1.8	0.10	0.00181	0.375	0.00068
Fully mixed aerated pd	1.6	0	0	0.375	0
Activated sludge	31.2	0	0	0.375	0
Other aerobic plant	12.6	0	0	0.375	0
Milliscreening[2]	24.0	0	0	0.375	0
Aerobic[3]	8.4	0.10	0.00836	0.375	0.00313
Aggregate MCF					0.0278

1 SCS Wetherill 2002
2 Milliscreening or no treatment
3 Methane from sludge

Module 2004 Waste (New Zealand)
Submodule Waste sector summary

	CH_4 (Gg/year)	N_2O (Gg/year)
Solid waste	71.86	
Wastewater - dom	3.98	0.30
Wastewater - ind	3.97	0.23
Total	79.80	0.54

Module 2004 Waste (New Zealand)
Submodule Methane emissions from domestic and commercial wastewater and sludge treatment
Worksheet NZ 6.2
Sheet Estimation of methane emissions from domestic/commercial wastewater and sludge

	Total organic product[1] (kg BOD/yr)	Emission factor (kg CH_4/ kg BOD	CH_4 emissions without recovery/ flaring (kg CH_4/yr)	CH_4 recovered and/or flared[2] (kg CH_4/yr)	Net CH_4 emissions (Gg CH_4/yr)
Wastewater	143,033,614	0.0278	3,976,137	0	4.0
Sludge[2]					0.0
Total					4.0

1 SCS Wetherill 2002
2 Almost all CH4 generated from aerobic sludge handling is collected therefore does not contribute to methane emissions, thus emissions from sludge have not been estimated; after methane recovery net emissions of methane from sludge are zero.

Module 2004 Waste (New Zealand)
Submodule Indirect nitrous oxide emissions from human sewage
Worksheet 6.4 (adapted)

Per capita wastewater N (kg/person/ year)[1]	Total Population[2]	Emission factor (EF_6) (kg N_2O-N/kg sewage-N produced)	Total N_2O emissions (Gg)
4.75	4,083,900	0.01	**0.30**

1 SCS Wetherill 2002
2 Statistics New Zealand.

Annex 9:

Trend tables from the 2004 Common Reporting Format

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2006 v1.3
NEW ZEALAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**9,473.4954**	**27,064.0304**	**12,878.7480**	**597.1317**	**87.7000**	**21.4861**	**50,122.5916**
1. Energy	**30,588.6023**	**794.2531**	**265.0518**				**31,647.9072**
A. Fuel Combustion (Sectoral Approach)	29,706.0778	95.0378	265.0518				30,066.1674
1. Energy Industries	7,158.6831	3.7294	21.9774				7,184.3900
2. Manufacturing Industries and Construction	5,026.1673	13.7828	53.1494				5,093.0994
3. Transport	14,110.3276	53.4901	149.3871				14,313.2048
4. Other Sectors	3,410.8998	24.0355	40.5379				3,475.4732
5. Other	NA	NA	NA				NA
B. Fugitive Emissions from Fuels	882.5245	699.2153	IE,NA,NE,NO				1,581.7398
1. Solid Fuels	NA,NE	311.8801	NA,NE				311.8801
2. Oil and Natural Gas	882.5245	387.3352	IE,NE,NO				1,269.8597
2. Industrial Processes	**3,450.2965**	**45.6880**	**NA,NO**	**597.3597**	**87.7000**	**21.4861**	**4,202.5303**
A. Mineral Products	612.7920	NA	NA				612.7920
B. Chemical Industry	553.7041	45.6880	NA,NO	NA	NA	NA,NO	599.3921
C. Metal Production	2,283.8003	IE,NA,NE,NO	NA	NA,NO	80.7000	IE,NA,NO	2,364.5003
D. Other Production	NA						NA
E. Production of Halocarbons and SF_6				NA,NO	NO	NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				597.3597	7.0000	21.4861	625.8458
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NA**		**48.3600**				**48.3600**
4. Agriculture		**24,472.8749**	**12,393.7930**				**36,866.6679**
A. Enteric Fermentation		23,714.9772					23,714.9772
B. Manure Management		745.8770	63.4982				809.3752
C. Rice Cultivation		NO					NO
D. Agricultural Soils [3]		NE,NO	12,326.4489				12,326.4489
E. Prescribed Burning of Savannas		0.6954	0.1270				0.8224
F. Field Burning of Agricultural Residues		11.3253	3.7189				15.0442
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry [1]	**-24,565.4034**	**75.1492**	**7.6266**				**-24,482.6277**
A. Forest Land	-25,506.4924	31.4941	3.1962				-25,471.8021
B. Cropland	-549.7246	NA,NO	NA,NE,NO				-549.7246
C. Grassland	666.4376	43.6550	4.4304				714.5230
D. Wetlands	0.7223	NO	NE,NO				0.7223
E. Settlements	97.1575	NE,NO	NE,NO				97.1575
F. Other Land	38.1638	NE,NO	NE,NO				38.1638
G. Other		NO	NA,NO				688.3325
6. Waste	**NA,NE,NO**	**1,676.0653**	**163.9166**				**1,839.9818**
A. Solid Waste Disposal on Land	NA,NE	1,509.1153					1,509.1153
B. Waste-water Handling		166.9500	163.9166				330.8666
C. Waste Incineration	NE	NE	NE				NE
D. Other	NO	NO	NO				NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	3,303.6052	2.9603	28.4900				3,335.0554
Aviation	2,564.6846	1.5178	22.4061				2,588.6086
Marine	738.9206	1.4425	6.0838				746.4469
Multilateral Operations	**NE**	**NE**	**NE**				**NE**
CO_2 Emissions from Biomass	**3,795.9545**						**3,795.9545**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	74,605.2192
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	50,122.5916

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

TABLE 10 EMISSIONS TRENDS (CO_2)
(Sheet 1 of 5)
(Part 1 of 2)

Inventory 2004
Submission 2006 v1.3
NEW ZEALAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**22,706.8638**	**23,093.4818**	**24,850.9794**	**24,132.2253**	**24,331.9909**	**24,176.0571**	**25,228.4128**	**27,517.6374**	**26,053.5464**	**27,343.3145**
A. Fuel Combustion (Sectoral Approach)	22,085.7748	22,385.8516	24,176.4239	23,498.1334	23,654.6081	23,540.2235	24,579.5691	26,816.3788	25,379.5441	26,713.6633
1. Energy Industries	6,033.0866	6,107.8172	7,556.5118	6,541.0043	5,414.0048	4,678.4263	5,254.0881	6,866.0079	5,190.1918	6,419.3085
2. Manufacturing Industries and Construction	4,568.3961	4,972.3336	4,617.6227	4,737.1246	5,159.9412	5,050.5596	5,556.9727	5,940.6411	6,015.4325	5,693.0523
3. Transport	8,632.8050	8,639.9631	9,024.7479	9,440.6414	10,143.7333	10,855.8742	10,941.5881	11,257.7299	11,448.8523	11,698.5632
4. Other Sectors	2,851.4871	2,665.7377	2,977.5416	2,779.3630	2,936.9287	2,955.3635	2,826.9201	2,752.0000	2,725.0675	2,902.7393
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	621.0890	707.6302	674.5555	634.0919	677.3827	635.8335	648.8436	701.2586	674.0023	629.6511
1. Solid Fuels	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
2. Oil and Natural Gas	621.0890	707.6302	674.5555	634.0919	677.3827	635.8335	648.8436	701.2586	674.0023	629.6511
2. Industrial Processes	**2,666.5221**	**2,791.5537**	**2,897.8142**	**3,043.7973**	**2,948.2050**	**3,024.9704**	**2,993.7832**	**2,896.5588**	**3,053.4448**	**3,217.3820**
A. Mineral Products	453.9916	442.8743	506.2298	559.2469	572.2439	592.6055	587.8326	605.7003	581.2946	645.1438
B. Chemical Industry	425.2064	440.0643	402.0251	423.8701	448.3287	423.2651	409.7422	434.2864	479.1388	526.0127
C. Metal Production	1,787.3242	1,908.6151	1,989.5593	2,060.6803	1,927.6325	2,009.0998	1,996.2084	1,856.5722	1,993.0114	2,046.2255
D. Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry[(2)]	**-19,080.9481**	**-17,645.4924**	**-15,901.9652**	**-14,755.1406**	**-14,379.2003**	**-15,231.0386**	**-15,561.8086**	**-17,238.4406**	**-19,456.1860**	**-20,056.0790**
A. Forest Land	-19,754.8928	-18,355.7985	-16,637.5163	-15,521.2508	-15,181.1867	-16,038.7580	-16,376.8575	-18,062.4138	-20,324.1423	-20,968.0173
B. Cropland	-501.3169	-504.7750	-508.2323	-511.6903	-515.1476	-518.6053	-522.0629	-525.5202	-528.9779	-532.4363
C. Grassland	704.2152	701.5166	698.8179	696.1196	693.4217	690.7230	688.0251	685.3260	682.6274	679.9291
D. Wetlands	0.7223	0.7223	0.7223	0.7223	0.7223	0.7223	0.7223	0.7223	0.7223	0.7223
E. Settlements	97.1575	97.1575	97.1575	97.1575	97.1575	97.1575	97.1575	97.1575	97.1575	97.1575
F. Other Land	26.7417	27.5576	28.3734	29.1889	30.0054	30.8213	31.6371	32.4526	33.2688	34.0842
G. Other	346.4248	388.1271	418.7122	454.6123	495.8271	506.9005	519.5697	533.8350	583.1583	632.4815
6. Waste	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
A. Solid Waste Disposal on Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
B. Waste-water Handling										
C. Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO2 emissions including net CO2 from LULUCF [(3)]	**6,292.4377**	**8,239.5430**	**11,846.8284**	**12,420.8820**	**12,900.9956**	**11,969.9889**	**12,660.3873**	**13,175.7556**	**9,650.8051**	**10,504.6175**
Total CO2 emissions excluding net CO2 from LULUCF [(3)]	**25,373.3859**	**25,885.0355**	**27,748.7936**	**27,176.0226**	**27,280.1959**	**27,201.0275**	**28,222.1959**	**30,414.1962**	**29,106.9911**	**30,560.6965**
Memo Items:										
International Bunkers	**2,374.1613**	**2,194.8700**	**2,177.5539**	**2,244.2893**	**2,755.2214**	**2,692.8896**	**2,696.3615**	**2,819.7338**	**2,772.8555**	**2,856.9977**
Aviation	1,340.9830	1,281.6762	1,311.1985	1,329.6277	1,431.6214	1,568.6113	1,634.7244	1,708.8468	1,700.5404	1,942.0746
Marine	1,033.1784	913.1938	866.3554	914.6615	1,323.6000	1,124.2783	1,061.6371	1,110.8870	1,072.3151	914.9232
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 Emissions from Biomass	2,600.7087	2,792.9516	2,662.0549	2,692.7771	3,170.0048	3,200.5740	3,145.3945	2,960.7580	3,091.2663	3,805.4396

Note: All footnotes for this table are given at the end of the table on sheet 5.

TABLE 10 EMISSIONS TRENDS (CO_2)
(Sheet 1 of 5)
(Part 2 of 2)

Inventory 2004
Submission 2006 v1.3
NEW ZEALAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
1. Energy	**27,868.1551**	**29,781.2021**	**29,781.8879**	**31,206.4826**	**30,588.6023**	**34.7108**
A. Fuel Combustion (Sectoral Approach)	27,280.8523	29,152.8588	29,178.8454	30,562.6502	29,706.0778	34.5032
1. Energy Industries	6,049.7275	7,265.5471	6,421.7353	7,518.5162	7,158.6831	18.6571
2. Manufacturing Industries and Construction	5,899.0642	6,007.2631	6,317.6916	5,876.3360	5,026.1673	10.0204
3. Transport	12,281.1819	12,657.6878	13,230.7051	13,787.2979	14,110.3276	63.4501
4. Other Sectors	3,050.8787	3,222.3609	3,208.7135	3,380.5001	3,410.8998	19.6183
5. Other	NA	NA	NA	NA	NA	0.0000
B. Fugitive Emissions from Fuels	587.3028	628.3433	603.0424	643.8324	882.5245	42.0931
1. Solid Fuels	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.0000
2. Oil and Natural Gas	587.3028	628.3433	603.0424	643.8324	882.5245	42.0931
2. Industrial Processes	**3,168.6277**	**3,260.6654**	**3,248.1562**	**3,474.5673**	**3,450.2965**	**29.3931**
A. Mineral Products	637.2197	634.9222	659.4324	645.3028	612.7920	34.9787
B. Chemical Industry	512.5027	555.3167	537.6845	570.3253	553.7041	30.2201
C. Metal Production	2,018.9053	2,070.4264	2,051.0392	2,258.9393	2,283.8003	27.7776
D. Other Production	NA	NA	NA	NA	NA	0.0000
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other	NA	NA	NA	NA	NA	0.0000
3. Solvent and Other Product Use	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	0.0000
4. Agriculture						
A. Enteric Fermentation						
B. Manure Management						
C. Rice Cultivation						
D. Agricultural Soils						
E. Prescribed Burning of Savannas						
F. Field Burning of Agricultural Residues						
G. Other						
5. Land Use, Land-Use Change and Forestry[(2)]	**-20,322.2994**	**-20,617.0525**	**-21,342.4420**	**-22,836.2644**	**-24,565.4034**	**28.7431**
A. Forest Land	-21,278.2216	-21,616.9564	-22,339.1821	-23,813.3998	-25,506.4924	29.1148
B. Cropland	-535.8936	-539.3520	-542.8093	-546.2666	-549.7246	9.6561
C. Grassland	677.2311	674.5325	671.8334	669.1351	666.4376	-5.3645
D. Wetlands	0.7223	0.7223	0.7223	0.7223	0.7223	0.0000
E. Settlements	97.1575	97.1575	97.1575	97.1575	97.1575	0.0000
F. Other Land	34.9001	35.7155	36.5321	37.3483	38.1638	42.7124
G. Other	681.8048	731.1281	733.3040	719.0388	688.3325	98.6961
6. Waste	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**0.0000**
A. Solid Waste Disposal on Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.0000
B. Waste-water Handling						
C. Waste Incineration	NE	NE	NE	NE	NE	0.0000
D. Other	NO	NO	NO	NO	NO	0.0000
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**0.0000**
Total CO2 emissions including net CO2 from LULUCF[(3)]	**10,714.4834**	**12,424.8149**	**11,687.6020**	**11,844.7855**	**9,473.4954**	**50.5537**
Total CO2 emissions excluding net CO2 from LULUCF[(3)]	**31,036.7828**	**33,041.8675**	**33,030.0440**	**34,681.0500**	**34,038.8988**	**34.1520**
Memo Items:						
International Bunkers	**2,502.2225**	**2,670.4168**	**2,974.4184**	**3,023.2488**	**3,303.6052**	**39.1483**
Aviation	1,756.6747	1,879.9517	1,918.7194	2,230.2458	2,564.6846	91.2541
Marine	745.5478	790.4651	1,055.6991	793.0030	738.9206	-28.4808
Multilateral Operations	NE	NE	NE	NE	NE	0.0000
CO_2 Emissions from Biomass	3,887.2160	3,350.0029	3,514.6333	3,568.4617	3,795.9545	45.9585

Note: All footnotes for this table are given at the end of the table on sheet 5.

TABLE 10 EMISSIONS TRENDS (CH_4)
(Sheet 2 of 5)
(Part 1 of 2)

Inventory 2004
Submission 2006 v1.3
NEW ZEALAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Total CH_4 emissions	**1,209.7849**	**1,202.2880**	**1,197.9749**	**1,214.5979**	**1,229.5752**	**1,234.3949**	**1,242.2683**	**1,251.0298**	**1,251.9013**	**1,257.7778**
1. Energy	37.9536	32.7691	32.4263	31.6342	33.2924	35.6644	35.4820	37.2103	40.0391	42.1062
A. Fuel Combustion (Sectoral Approach)	9.9902	9.7097	9.7144	9.6151	8.9541	8.4997	7.8650	7.4257	6.8378	6.2708
1. Energy Industries	0.2628	0.2806	0.3179	0.2935	0.2372	0.1934	0.2176	0.2712	0.2035	0.2571
2. Manufacturing Industries and Construction	0.3815	0.4218	0.3951	0.4023	0.4877	0.5116	0.5358	0.5299	0.5532	0.6509
3. Transport	7.1163	7.1486	7.1800	7.2002	6.7770	6.3722	5.7388	5.2685	4.7400	4.0796
4. Other Sectors	2.2296	1.8587	1.8214	1.7191	1.4522	1.4225	1.3727	1.3562	1.3410	1.2832
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	27.9635	23.0594	22.7120	22.0191	24.3383	27.1646	27.6170	29.7846	33.2013	35.8354
1. Solid Fuels	12.9584	8.7340	9.0388	8.6082	10.1859	13.4714	13.9432	13.8761	16.2593	16.8421
2. Oil and Natural Gas	15.0051	14.3254	13.6732	13.4109	14.1524	13.6932	13.6738	15.9085	16.9420	18.9933
2. Industrial Processes	**0.9600**	**1.6400**	**1.3900**	**1.5600**	**1.9560**	**2.7480**	**3.6930**	**3.8100**	**3.5870**	**4.0000**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	0.9600	1.6400	1.3900	1.5600	1.9560	2.7480	3.6930	3.8100	3.5870	4.0000
C. Metal Production	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use										
4. Agriculture	**1,055.1842**	**1,051.1250**	**1,048.7931**	**1,064.0057**	**1,077.2756**	**1,088.6403**	**1,094.5745**	**1,101.7648**	**1,104.5230**	**1,114.9450**
A. Enteric Fermentation	1,026.3797	1,022.1559	1,019.5196	1,033.9559	1,046.2922	1,056.7959	1,062.1198	1,069.0095	1,071.7445	1,081.8407
B. Manure Management	27.7760	27.9207	28.2470	29.0098	29.9539	30.8191	31.3936	31.6516	31.6939	32.0758
C. Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Prescribed Burning of Savannas	0.1342	0.1329	0.1272	0.1024	0.0810	0.0654	0.0593	0.0532	0.0402	0.0365
F. Field Burning of Agricultural Residues	0.8943	0.9155	0.8993	0.9377	0.9485	0.9600	1.0018	1.0504	1.0445	0.9919
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land Use, Land-Use Change and Forestry	**4.4541**	**4.1115**	**4.6422**	**5.8674**	**6.5699**	**6.3428**	**7.1304**	**7.7362**	**6.3707**	**5.6865**
A. Forest Land	1.7228	1.8703	2.5084	3.3660	3.8729	3.5322	4.4310	4.2647	2.9509	2.4804
B. Cropland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Grassland	2.7313	2.2412	2.1338	2.5014	2.6970	2.8106	2.6994	3.4714	3.4198	3.2061
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Waste	**111.2329**	**112.6424**	**110.7233**	**111.5305**	**110.4813**	**100.9995**	**101.3884**	**100.5086**	**97.3816**	**91.0400**
A. Solid Waste Disposal on Land	103.7729	105.1424	103.1933	103.9705	102.8913	93.3695	93.7284	92.8186	89.6616	83.2800
B. Waste-water Handling	7.4600	7.5000	7.5300	7.5600	7.5900	7.6300	7.6600	7.6900	7.7200	7.7600
C. Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Memo Items:										
International Bunkers	0.1345	0.1221	0.1181	0.1230	0.1641	0.1494	0.1450	0.1515	0.1475	0.1394
Aviation	0.0378	0.0361	0.0369	0.0375	0.0403	0.0442	0.0461	0.0482	0.0479	0.0547
Marine	0.0967	0.0860	0.0811	0.0855	0.1238	0.1052	0.0990	0.1034	0.0996	0.0847
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 Emissions from Biomass										

Note: All footnotes for this table are given at the end of the table on sheet 5.

TABLE 10 EMISSIONS TRENDS (CH_4)
(Sheet 2 of 5)
(Part 2 of 2)

Inventory 2004
Submission 2006 v1.3
NEW ZEALAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
Total CH_4 emissions	**1,274.8826**	**1,289.6467**	**1,286.7472**	**1,285.6731**	**1,288.7634**	**6.5283**
1. Energy	40.4280	41.8136	41.0562	39.9839	37.8216	-0.3480
A. Fuel Combustion (Sectoral Approach)	5.8039	5.2535	4.8529	4.4290	4.5256	-54.6994
1. Energy Industries	0.2488	0.2932	0.2477	0.2411	0.1776	-32.4135
2. Manufacturing Industries and Construction	0.6772	0.5965	0.6312	0.5867	0.6563	72.0506
3. Transport	3.6496	3.2445	2.9055	2.4715	2.5471	-64.2070
4. Other Sectors	1.2283	1.1193	1.0685	1.1297	1.1445	-48.6661
5. Other	NA	NA	NA	NA	NA	0.0000
B. Fugitive Emissions from Fuels	34.6241	36.5600	36.2034	35.5549	33.2960	19.0695
1. Solid Fuels	16.1922	16.9739	16.8609	15.8215	14.8514	14.6086
2. Oil and Natural Gas	18.4319	19.5862	19.3425	19.7334	18.4445	22.9220
2. Industrial Processes	**4.8213**	**4.2600**	**4.5628**	**1.9354**	**2.1756**	**126.6269**
A. Mineral Products	NA	NA	NA	NA	NA	0.0000
B. Chemical Industry	4.8213	4.2600	4.5628	1.9354	2.1756	126.6269
C. Metal Production	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	0.0000
D. Other Production						
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other	NA	NA	NA	NA	NA	0.0000
3. Solvent and Other Product Use						
4. Agriculture	**1,133.3803**	**1,150.2262**	**1,150.8179**	**1,155.5806**	**1,165.3750**	**10.4428**
A. Enteric Fermentation	1,099.6123	1,115.5857	1,115.4973	1,119.7129	1,129.2846	10.0260
B. Manure Management	32.7361	33.5542	34.2093	34.8421	35.5180	27.8729
C. Rice Cultivation	NO	NO	NO	NO	NO	0.0000
D. Agricultural Soils	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.0000
E. Prescribed Burning of Savannas	0.0384	0.0439	0.0404	0.0401	0.0331	-75.3231
F. Field Burning of Agricultural Residues	0.9935	1.0424	1.0710	0.9856	0.5393	-39.6986
G. Other	NO	NO	NO	NO	NO	0.0000
5. Land Use, Land-Use Change and Forestry	**4.6087**	**4.4829**	**4.2616**	**4.0672**	**3.5785**	**-19.6574**
A. Forest Land	2.3133	2.3488	1.9170	1.8589	1.4997	-12.9503
B. Cropland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
C. Grassland	2.2954	2.1342	2.3446	2.2083	2.0788	-23.8881
D. Wetlands	NO	NO	NO	NO	NO	0.0000
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.0000
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.0000
G. Other	NO	NO	NO	NO	NO	0.0000
6. Waste	**91.6443**	**88.8640**	**86.0486**	**84.1060**	**79.8126**	**-28.2473**
A. Solid Waste Disposal on Land	83.8543	81.0440	78.1886	76.1960	71.8626	-30.7501
B. Waste-water Handling	7.7900	7.8200	7.8600	7.9100	7.9500	6.5684
C. Waste Incineration	NE	NE	NE	NE	NE	0.0000
D. Other	NO	NO	NO	NO	NO	0.0000
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**0.0000**
	NA	NA	NA	NA	NA	0.0000
Memo Items:						
International Bunkers	0.1184	0.1261	0.1517	0.1399	0.1410	4.8217
Aviation	0.0495	0.0530	0.0541	0.0643	0.0723	91.2567
Marine	0.0689	0.0731	0.0977	0.0757	0.0687	-28.9608
Multilateral Operations	NE	NE	NE	NE	NE	0.0000
CO_2 Emissions from Biomass						

Note: All footnotes for this table are given at the end of the table on sheet 5.

TABLE 10 EMISSIONS TRENDS (N_2O)
(Sheet 3 of 5)
(Part 1 of 2)

Inventory 2004
Submission 2006 v1.3
NEW ZEALAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Total N_2O emissions	**33.2481**	**33.3015**	**33.5603**	**34.4344**	**35.3726**	**36.0784**	**36.4313**	**36.7494**	**36.9578**	**37.6278**
1. Energy	**0.4879**	**0.4858**	**0.5244**	**0.5442**	**0.5875**	**0.6229**	**0.6320**	**0.6542**	**0.6575**	**0.7054**
A. Fuel Combustion (Sectoral Approach)	0.4879	0.4858	0.5244	0.5442	0.5875	0.6229	0.6320	0.6542	0.6575	0.7054
1. Energy Industries	0.0205	0.0164	0.0298	0.0208	0.0185	0.0193	0.0209	0.0317	0.0222	0.0296
2. Manufacturing Industries and Construction	0.1185	0.1263	0.1172	0.1215	0.1423	0.1388	0.1395	0.1339	0.1388	0.1610
3. Transport	0.2403	0.2427	0.2603	0.2797	0.3068	0.3403	0.3498	0.3654	0.3750	0.3880
4. Other Sectors	0.1085	0.1003	0.1171	0.1223	0.1200	0.1244	0.1218	0.1232	0.1215	0.1267
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO
1. Solid Fuels	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
2. Oil and Natural Gas	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO
2. Industrial Processes	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	0.1340	0.1380	0.1390	0.1410	0.1430	0.1450	0.1480	0.1490	0.1500	0.1510
4. Agriculture	**32.1217**	**32.1755**	**32.3810**	**33.2249**	**34.1130**	**34.7730**	**35.1084**	**35.3991**	**35.6026**	**36.2283**
A. Enteric Fermentation										
B. Manure Management	0.1224	0.1231	0.1255	0.1322	0.1430	0.1511	0.1571	0.1611	0.1659	0.1718
C. Rice Cultivation										
D. Agricultural Soils	31.9768	32.0295	32.2333	33.0698	33.9474	34.5993	34.9279	35.2136	35.4127	36.0339
E. Prescribed Burning of Savannas	0.0017	0.0016	0.0016	0.0013	0.0010	0.0008	0.0007	0.0007	0.0005	0.0005
F. Field Burning of Agricultural Residues	0.0208	0.0212	0.0207	0.0215	0.0216	0.0218	0.0226	0.0237	0.0234	0.0221
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land Use, Land-Use Change and Forestry	**0.0306**	**0.0283**	**0.0319**	**0.0403**	**0.0452**	**0.0436**	**0.0490**	**0.0532**	**0.0438**	**0.0391**
A. Forest Land	0.0118	0.0129	0.0172	0.0231	0.0266	0.0243	0.0305	0.0293	0.0203	0.0171
B. Cropland	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C. Grassland	0.0188	0.0154	0.0147	0.0172	0.0185	0.0193	0.0186	0.0239	0.0235	0.0220
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
G. Other	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
6. Waste	**0.4739**	**0.4739**	**0.4839**	**0.4839**	**0.4839**	**0.4939**	**0.4939**	**0.4939**	**0.5039**	**0.5039**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	0.4739	0.4739	0.4839	0.4839	0.4839	0.4939	0.4939	0.4939	0.5039	0.5039
C. Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Memo Items:										
International Bunkers	**0.0654**	**0.0607**	**0.0601**	**0.0619**	**0.0757**	**0.0743**	**0.0743**	**0.0777**	**0.0764**	**0.0789**
Aviation	0.0378	0.0361	0.0369	0.0375	0.0403	0.0442	0.0461	0.0482	0.0479	0.0547
Marine	0.0276	0.0246	0.0232	0.0244	0.0354	0.0301	0.0283	0.0295	0.0284	0.0242
Multilateral Operations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 Emissions from Biomass										

Note: All footnotes for this table are given at the end of the table on sheet 5.

TABLE 10 EMISSIONS TRENDS (N_2O)
(Sheet 3 of 5)
(Part 2 of 2)

Inventory 2004
Submission 2006 v1.3
NEW ZEALAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
Total N_2O emissions	**38.7828**	**40.2425**	**41.2905**	**42.1860**	**41.5443**	**24.9524**
1. Energy	**0.7387**	**0.7505**	**0.7840**	**0.8384**	**0.8550**	**75.2332**
A. Fuel Combustion (Sectoral Approach)	0.7387	0.7505	0.7840	0.8384	0.8550	75.2332
1. Energy Industries	0.0252	0.0342	0.0326	0.0592	0.0709	245.0992
2. Manufacturing Industries and Construction	0.1660	0.1507	0.1561	0.1645	0.1714	44.6727
3. Transport	0.4154	0.4285	0.4520	0.4713	0.4819	100.5137
4. Other Sectors	0.1321	0.1371	0.1433	0.1434	0.1308	20.4753
5. Other	NA	NA	NA	NA	NA	0.0000
B. Fugitive Emissions from Fuels	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	0.0000
1. Solid Fuels	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.0000
2. Oil and Natural Gas	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	0.0000
2. Industrial Processes	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**0.0000**
A. Mineral Products	NA	NA	NA	NA	NA	0.0000
B. Chemical Industry	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
C. Metal Production	NA	NA	NA	NA	NA	0.0000
D. Other Production						
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other	NA	NA	NA	NA	NA	0.0000
3. Solvent and Other Product Use	0.1520	0.1530	0.1560	0.1560	0.1560	16.4179
4. Agriculture	**37.3565**	**38.7942**	**39.8072**	**40.6382**	**39.9800**	**24.4642**
A. Enteric Fermentation						
B. Manure Management	0.1783	0.1861	0.1917	0.1970	0.2048	67.4087
C. Rice Cultivation						
D. Agricultural Soils	37.1557	38.5843	39.5911	40.4186	39.7627	24.3486
E. Prescribed Burning of Savannas	0.0005	0.0005	0.0005	0.0005	0.0004	-75.3231
F. Field Burning of Agricultural Residues	0.0220	0.0232	0.0240	0.0221	0.0120	-42.4058
G. Other	NO	NO	NO	NO	NO	0.0000
5. Land Use, Land-Use Change and Forestry	**0.0317**	**0.0308**	**0.0293**	**0.0280**	**0.0246**	**-19.6574**
A. Forest Land	0.0159	0.0161	0.0132	0.0128	0.0103	-12.9503
B. Cropland	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.0000
C. Grassland	0.0158	0.0147	0.0161	0.0152	0.0143	-23.8881
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.0000
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.0000
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.0000
G. Other	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
6. Waste	**0.5039**	**0.5139**	**0.5139**	**0.5254**	**0.5288**	**11.5691**
A. Solid Waste Disposal on Land						
B. Waste-water Handling	0.5039	0.5139	0.5139	0.5254	0.5288	11.5691
C. Waste Incineration	NE	NE	NE	NE	NE	0.0000
D. Other	NO	NO	NO	NO	NO	0.0000
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**0.0000**
	NA	NA	NA	NA	NA	0.0000
Memo Items:						
International Bunkers	**0.0692**	**0.0739**	**0.0820**	**0.0859**	**0.0919**	**40.4881**
Aviation	0.0495	0.0530	0.0541	0.0643	0.0723	91.2567
Marine	0.0197	0.0209	0.0279	0.0216	0.0196	-28.9608
Multilateral Operations	NE	NE	NE	NE	NE	0.0000
CO_2 Emissions from Biomass						

Note: All footnotes for this table are given at the end of the table on sheet 5.

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF_6)
(Sheet 4 of 5)
(Part 1 of 2)

Inventory 2004
Submission 2006 v1.3
NEW ZEALAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of HFCs[4] - (Gg CO_2 equivalent)	**IE,NA,NO**	**IE,NA,NO**	**1.0400**	**4.6800**	**59.1855**	**145.2672**	**224.9557**	**139.8795**	**327.0413**	**266.4695**
HFC-23	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-32	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0004	NA,NO	NA,NO	NA,NO	0.0074
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-125	NA,NO	NA,NO	NA,NO	NA,NO	0.0012	0.0005	0.0067	0.0105	0.0095	0.0104
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-134a	NA,NO	NA,NO	0.0008	0.0036	0.0429	0.0871	0.1377	0.0576	0.2033	0.1462
HFC-152a	NA,NO	NA,NO	NA,NO	NA,NO	0.0004	0.0012	0.0004	0.0002	0.0004	0.0017
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-143a	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0079	0.0071	0.0093	0.0094	0.0110
HFC-227ea	NA,NO	NA,NO	NA,NO	NA,NO	0.0000	0.0001	0.0001	0.0001	0.0001	0.0002
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed HFCs[5] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of PFCs[4] - (Gg CO_2 equivalent)	**515.6000**	**651.6400**	**638.1000**	**524.8000**	**183.6000**	**147.5000**	**265.4000**	**166.2000**	**130.2000**	**74.2000**
CF_4	0.0680	0.0844	0.0826	0.0680	0.0240	0.0190	0.0300	0.0210	0.0100	0.0100
C_2F_6	0.0080	0.0112	0.0110	0.0090	0.0030	0.0020	0.0040	0.0030	0.0010	0.0010
C_3F_8	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0008	0.0048	0.0003	0.0080	NA,NO
C_4F_{10}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
$c-C_4F_8$	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_5F_{12}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_6F_{14}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed PFCs[5] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of SF6[4] - (Gg CO_2 equivalent)	**12.3324**	**12.9060**	**13.6230**	**14.0532**	**14.4117**	**15.0092**	**14.7941**	**15.2960**	**14.0293**	**13.1928**
SF_6	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006

Note: All footnotes for this table are given at the end of the table on sheet 5.

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF_6)
(Sheet 4 of 5)
(Part 2 of 2)

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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
Emissions of HFCs[(4)] - (Gg CO_2 equivalent)	**246.9944**	**440.9499**	**619.8302**	**728.6311**	**597.1317**	**100.0000**
HFC-23	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-32	NA,NO	0.0034	0.0030	0.0050	0.0062	100.0000
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-125	0.0041	0.0276	0.0476	0.0539	0.0495	100.0000
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-134a	0.1621	0.2012	0.2208	0.2653	0.2065	100.0000
HFC-152a	NA,NO	0.0009	NA,NO	NA,NO	NA,NO	0.0000
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-143a	0.0064	0.0261	0.0518	0.0602	0.0487	100.0000
HFC-227ea	0.0002	0.0002	0.0003	0.0003	0.0003	100.0000
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
Unspecified mix of listed HFCs[(5)] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
Emissions of PFCs[(4)] - (Gg CO_2 equivalent)	**59.2500**	**59.2500**	**88.4000**	**93.3000**	**87.7000**	**-82.9907**
CF_4	0.0077	0.0077	0.0110	0.0110	0.0110	-83.8235
C_2F_6	0.0010	0.0010	0.0010	0.0010	0.0010	-87.5000
C_3F_8	NA,NE,NO	NA,NO	0.0011	0.0018	0.0010	100.0000
C_4F_{10}	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
$c-C_4F_8$	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
C_5F_{12}	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
C_6F_{14}	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
Unspecified mix of listed PFCs[(5)] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
Emissions of SF6[(4)] - (Gg CO_2 equivalent)	**12.1890**	**12.3085**	**13.1450**	**17.5187**	**21.4861**	**74.2248**
SF_6	0.0005	0.0005	0.0006	0.0007	0.0009	74.2248

Note: All footnotes for this table are given at the end of the table on sheet 5.

TABLE 10 EMISSION TRENDS (SUMMARY)
(Sheet 5 of 5)
(Part 1 of 2)

Inventory 2004
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NEW ZEALAND

GREENHOUSE GAS EMISSIONS	**Base year (1990)**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**
CO2 emissions including net CO_2 from LULUCF(3)	6,292.4377	8,239.5430	11,846.8284	12,420.8820	12,900.9956	11,969.9889	12,660.3873	13,175.7556	9,650.8051	10,504.6175
CO2 emissions excluding net CO_2 from LULUCF(3)	25,373.3859	25,885.0355	27,748.7936	27,176.0226	27,280.1959	27,201.0275	28,222.1959	30,414.1962	29,106.9911	30,560.6965
CH_4	25,405.4821	25,248.0471	25,157.4739	25,506.5562	25,821.0800	25,922.2935	26,087.6346	26,271.6267	26,289.9273	26,413.3336
N_2O	10,306.9241	10,323.4562	10,403.6865	10,674.6604	10,965.4947	11,184.3029	11,293.7130	11,392.3003	11,456.9046	11,664.6040
HFCs	IE,NA,NO	IE,NA,NO	1.0400	4.6800	59.1855	145.2672	224.9557	139.8795	327.0413	266.4695
PFCs	515.6000	651.6400	638.1000	524.8000	183.6000	147.5000	265.4000	166.2000	130.2000	74.2000
SF_6	12.3324	12.9060	13.6230	14.0532	14.4117	15.0092	14.7941	15.2960	14.0293	13.1928
Total (including net CO_2 from LULUCF)(3)	**42,532.7763**	**44,475.5923**	**48,060.7518**	**49,145.6319**	**49,944.7675**	**49,384.3616**	**50,546.8847**	**51,161.0581**	**47,868.9077**	**48,936.4173**
Total (excluding net CO_2 from LULUCF)(3), (6)	**61,613.7244**	**62,121.0848**	**63,962.7170**	**63,900.7724**	**64,323.9678**	**64,615.4003**	**66,108.6933**	**68,399.4987**	**67,325.0937**	**68,992.4963**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**Base year (1990)**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**
1. Energy	23,655.1469	23,932.2302	25,694.4911	24,965.2583	25,213.2580	25,118.0963	26,169.4525	28,501.8448	27,098.1838	28,446.2306
2. Industrial Processes	3,214.6145	3,490.5397	3,579.7672	3,620.0905	3,246.4782	3,390.4548	3,576.4860	3,297.9443	3,600.0424	3,655.2443
3. Solvent and Other Product Use	41.5400	42.7800	43.0900	43.7100	44.3300	44.9500	45.8800	46.1900	46.5000	46.8100
4. Agriculture	32,116.5840	32,048.0217	32,062.7803	32,643.8327	33,197.8056	33,641.0739	33,869.6633	34,110.7723	34,231.7742	34,644.6151
5. Land Use, Land-Use Change and Forestry(7)	-18,977.9197	-17,550.3891	-15,794.5852	-14,619.4199	-14,227.2300	-15,084.3219	-15,396.8734	-17,059.4938	-19,308.8248	-19,924.5426
6. Waste	2,482.8106	2,512.4098	2,475.2084	2,492.1603	2,470.1258	2,274.1085	2,282.2763	2,263.8004	2,201.2321	2,068.0598
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)(7)	**42,532.7763**	**44,475.5923**	**48,060.7518**	**49,145.6319**	**49,944.7675**	**49,384.3616**	**50,546.8847**	**51,161.0581**	**47,868.9077**	**48,936.4173**

TABLE 10 EMISSION TRENDS (SUMMARY)
(Sheet 5 of 5)
(Part 2 of 2)

Inventory 2004
Submission 2006 v1.3
NEW ZEALAND

GREENHOUSE GAS EMISSIONS	2000	2001	2002	2003	2004	Change from base to latest reported year
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	(%)
CO2 emissions including net CO_2 from LULUCF[3]	10,714.4834	12,424.8149	11,687.6020	11,844.7855	9,473.4954	50.5537
CO2 emissions excluding net CO_2 from LULUCF[3]	31,036.7828	33,041.8675	33,030.0440	34,681.0500	34,038.8988	34.1520
CH_4	26,772.5342	27,082.5814	27,021.6906	26,999.1351	27,064.0304	6.5283
N_2O	12,022.6758	12,475.1608	12,800.0513	13,077.6551	12,878.7480	24.9524
HFCs	246.9944	440.9499	619.8302	728.6311	597.1317	100.0000
PFCs	59.2500	59.2500	88.4000	93.3000	87.7000	-82.9907
SF_6	12.1890	12.3085	13.1450	17.5187	21.4861	74.2248
Total (including net CO_2 from LULUCF)[3]	**49,828.1268**	**52,495.0655**	**52,230.7191**	**52,761.0256**	**50,122.5916**	**17.8446**
Total (excluding net CO_2 from LULUCF)[3], [6]	**70,150.4262**	**73,112.1181**	**73,573.1611**	**75,597.2900**	**74,687.9950**	**21.2197**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	(%)
1. Energy	28,946.1547	30,891.9399	30,887.1129	32,306.0540	31,647.9072	33.7887
2. Industrial Processes	3,588.3088	3,862.6338	4,065.3502	4,354.6605	4,202.5303	30.7320
3. Solvent and Other Product Use	47.1200	47.4300	48.3600	48.3600	48.3600	16.4179
4. Agriculture	35,381.4885	36,180.9547	36,507.4222	36,865.0233	36,866.6679	14.7901
5. Land Use, Land-Use Change and Forestry[7]	-20,215.6952	-20,513.3566	-21,243.8657	-22,742.1856	-24,482.6277	29.0059
6. Waste	2,080.7501	2,025.4637	1,966.3395	1,929.1134	1,839.9818	-25.8912
7. Other	NA	NA	NA	NA	NA	0.0000
Total (including LULUCF)[7]	**49,828.1268**	**52,495.0655**	**52,230.7191**	**52,761.0256**	**50,122.5916**	**17.8446**

[1] The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the COP. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

[2] Fill in net emissions/removals as reported in table Summary 1.A. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[3] The information in these rows is requested to facilitate comparison of data, because Parties differ in the way they report CO_2 emissions and removals from LULUCF.

[4] Enter actual emissions estimates. If only potential emissions estimates are available, these should be reported in this table and an indication for this be provided in the documentation box. Only in these rows are the emissions expressed as CO_2 equivalent emissions.

[5] In accordance with the UNFCCC reporting guidelines, HFC and PFC emissions should be reported for each relevant chemical. However, if it is not possible to report values for each chemical (i.e. mixtures, confidential data, lack of disaggregation), this row could be used for reporting aggregate figures for HFCs and PFCs, respectively. Note that the unit used for this row is Gg of CO_2 equivalent and that appropriate notation keys should be entered in the cells for the individual chemicals.

[6] These totals will differ from the totals reported in table Summary 2 if Parties report non-CO_2 emissions from LULUCF.

[7] Includes net CO_2, CH_4 and N_2O from LULUCF.

Documentation box:

• Parties should provide detailed explanations on emissions trends in Chapter 2: Trends in Greenhouse Gas Emissions and, as appropriate, in the corresponding Chapters 3 - 9 of the NIR. Use this documentation box to provide references to relevant sections of the NIR if any additional information and further details are needed to understand the content of this table.

• Use the documentation box to provide explanations if potential emissions are reported.

CO2:SO2 emissions: These values have been updated due to new information. Emission factors supplied by industry-these vary depending on the processing technology and the input materials. An average emission factor of 0.5 kg SO2/t lime has been calculated.

NOx and CO: Emissions assumed to be totally associated with fuel use rather than industrial process so are counted with other fuel combustion emissions in the energy sector: 1AA.2 "Manufacturing Industries and Construction".