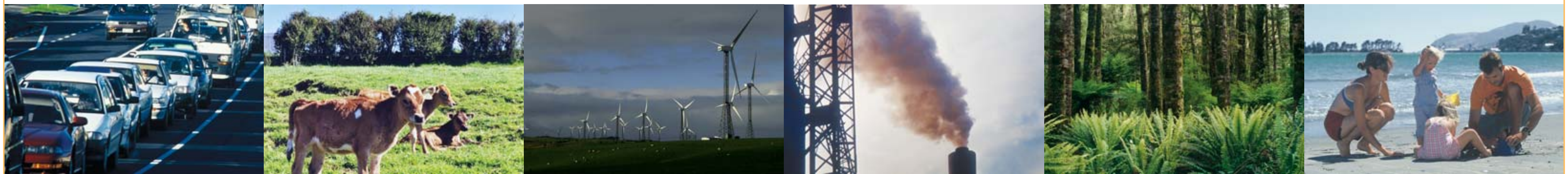
Ministry for the Environment
Manatū Mō Te Taiao

New Zealand's Greenhouse Gas Inventory 1990-2003



The National Inventory Report and Common Reporting Format Tables

April 2005

Ministry for the
Environment
Manatū Mō Te Taiao

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Acknowledgements

Lead authors

Len Brown	Ministry for the Environment
Sonia Petrie	Ministry for the Environment

Key contributors

Helen Plume	Ministry for the Environment
Ram SriRamaratnam & Stuart Black	Ministry of Economic Development
Gerald Rys & Paul Lane	Ministry of Agriculture and Forestry

Technical contributors and contracted specialists

Industrial processes sector: Wayne Hennessy, CRL Energy Ltd (non-CO_2 emissions and solvents)

Agriculture sector: Harry Clark, AgResearch; Frank Kelliher, Landcare Research; Stewart Ledgard, AgResearch; David Lillis, Ministry of Agriculture and Forestry

Land use change and forestry sector: Steve Wakelin, Forest Research; Peter Stephens, Ministry for the Environment

Waste sector: Scott Gulliver, Ministry for the Environment; Tom Wetherill and Woody Xiao, Waste Management NZ

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Executive Summary

Climate change & greenhouse gas inventory

Greenhouse gases trap 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 (CO_2), methane (CH_4) and nitrous oxide (N_2O) in the atmosphere has 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 (UNFCCC) 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, prepare for adaptation to the impacts of climate change and monitor emissions trends via greenhouse gas inventories. In May 1992, developed countries agreed to non-binding targets to reduce greenhouse gas emissions to 1990 levels by 2000.

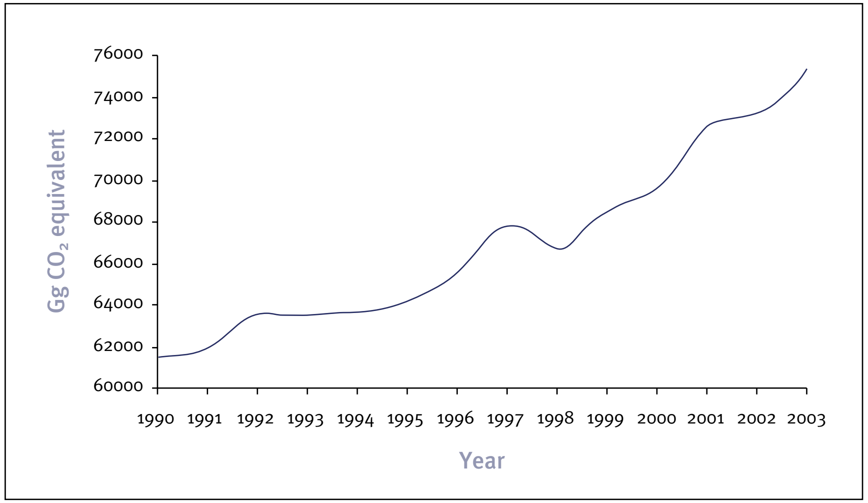
Only a few countries made appreciable progress towards achieving their targets. The international community recognised that the UNFCCC alone was not enough to ensure greenhouse gas levels would be reduced to safe levels, and that more urgent action was needed. After two and a half years of negotiations, the Kyoto Protocol was adopted in 1997. 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 reducing its emissions to the level they were in 1990. The Protocol came into force on 16 February 2005.

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 and the Kyoto Protocol. The inventory is the tool for measuring New Zealand's progress against these obligations. The inventory totals emissions and removals of the gases CO_2, CH_4, 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.

National trends in New Zealand's emissions and removals

In 1990, New Zealand's total greenhouse gas emissions were equivalent to 61,525.43Gg of CO_2. In 2003, total greenhouse gas emissions were 75,345.29Gg CO_2 equivalent equating to a 22.5% rise since 1990 (Figure 1.1). Net removals of CO_2 through forest sinks increased from 21,366.19Gg CO_2 in 1990 to 22,861.60Gg CO_2 in 2003.

Figure 1.1 New Zealand's total greenhouse gas emissions 1990-2003



There have also 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 attributed to increased growth in the energy sector compared to the agriculture sector.

Table 1.1 Emissions of greenhouse gases in 1990 and 2003

Greenhouse gas emissions	Gg CO_2 equivalent 1990	2003	Change from 1990 (%)
Net CO_2 emissions / removals	3,944.36	11,833.84	200.02
CO_2 emissions (without LULUCF)	25,314.81	34,699.55	37.07
CH_4	25,283.98	26,644.97	5.38
N_2O	10,398.71	13,499.53	29.82
HFCs	0.00	403.96	NA
PFCs	515.60	84.90	-83.53
SF_6	12.33	12.38	0.39
Total emissions without CO_2 from LULUCF	**61,525.43**	**75,345.29**	**22.5**

Source and sink category emission estimates and trends

New Zealand is unusual amongst developed nations in that 49.4% of total emissions in 2003 were produced by the agriculture sector (Figure 1.2). 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 15.6% above the 1990 level (Table 1.2).

The energy sector is the other large component of New Zealand's emissions profile comprising 42.9% of total emissions in 2003. Emissions from the energy sector are now 37.0% above the 1990 level (Table 1.2). The growth in energy emissions is primarily from road transport (an increase of 58.4%) and electricity generation (an increase of 83.3%). The large increase in electricity generation is because 2003 was a dryer year than usual, resulting in less hydro-electric generation and a greater reliance on coal.

In contrast to most other developed nations, emissions from the industrial processes and waste sectors are a much smaller component of New Zealand's emissions, comprising only 5.3% and 2.3% respectively of all greenhouse gas emissions in 2003. Emissions from the waste sector are now 29.3% 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.

The LULUCF sector represents the major sink for New Zealand, removing 30.3% of all greenhouse gas emissions in 2003. Net removals in 2003 are 7.0% above net removals in 1990. Variations in planting rates and the impact of harvest regimes affect the size of this sink from year to year.

Figure 1.2 New Zealand's sectoral emissions in 2003 (all figures Gg CO_2 equivalent)

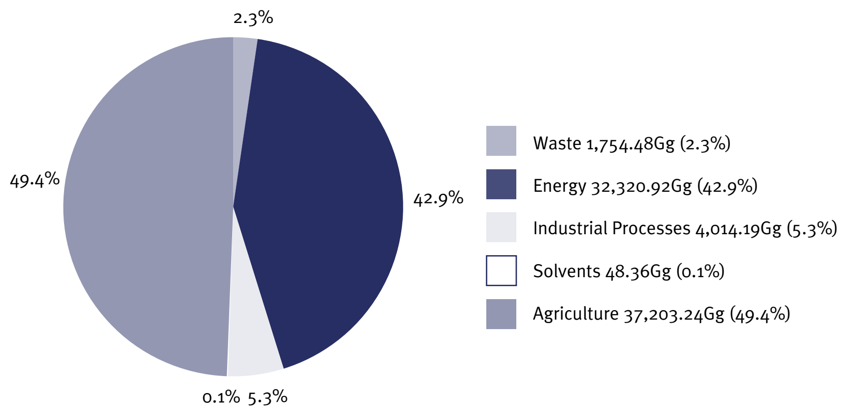


Table 1.2 Sectoral emissions of greenhouse gases in 1990 and 2003

Sector	Gg CO_2 equivalent 1990	2003	Change from 1990 (%)
Energy	23,594.11	32,320.92	35.7
Industrial processes	3,211.70	4,014.19	25.0
Solvent and other products	41.54	48.36	16.4
Agriculture	32,193.76	37,203.24	15.6
Land-use change and forestry	-21,366.19	-22,861.60	7.0
Waste	2,480.06	1,754.48	-29.3

Contents

Note: Common Reporting Format tables for 1990–2005 can be found on the CD included at the end of this report.

Annexes to New Zealand's National Inventory Report for 2003

Chapter 1:

Introduction

1.1 Background

Greenhouse gases trap warmth from the sun and make life on Earth possible. Without them, too much heat would escape and the surface of the planet would freeze. However, over the previous 50 to 100 years, the concentration of the greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in the atmosphere has been increasing. Since 1750, the concentration of CO_2 has increased 31%, the concentration of CH_4 has increased 151% and the concentration of N_2O has increased 17% (IPCC, 2001). The increased concentration of these gases produces an 'enhanced greenhouse effect' that decreases the amount of Earth's heat that is radiated back into space. The effects on the climate due to the 'enhanced greenhouse effect' will be different in different parts of the world (IPCC, 2001). However in general, temperatures and sea levels are expected to rise, and the frequency of extreme weather events such as droughts and floods are expected to increase. The changes ahead of us are expected to be larger and to happen more quickly than any recent natural climate variations.

1.1.1 The UNFCCC & the Kyoto Protocol

In 1990, the Intergovernmental Panel on Climate Change (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.

All countries that ratify the UNFCCC are required to address climate change through national or regional programmes to prepare for adaptation to the impacts of climate change, protect and enhance sinks (e.g. forests), monitor emissions trends via greenhouse gas inventories and provide financial assistance to developing countries. Developed countries 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, Annex I Parties (i.e. developed countries and countries with economies in transition) 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 objectives, principles and institutions, but significantly strengthens it by committing Annex I Parties 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 Parties that ratify the Protocol shall individually or jointly ensure that their aggregate anthropogenic greenhouse gas emissions do not exceed their 'assigned amounts' with a view to reducing their overall emissions by at least 5% below 1990 levels in the 1st commitment period (2008 to 2012).

The 'assigned amount' is the maximum amount of emissions (measured as the equivalent in CO_2) that a Party may emit over the commitment period in order to comply with its emissions target. New Zealand's target is to reduce its emissions to the level they were in 1990, therefore the assigned amount over the 1st commitment period is the gross emissions in 1990 multiplied by five (i.e. 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).

To achieve their targets, Annex I Parties must put in place domestic policies and measures to address emissions. Emissions may also be offset by increasing the amount of greenhouse gases removed from the atmosphere by carbon 'sinks' in the LULUCF sector. The Kyoto Protocol also defined three 'flexibility mechanisms' to lower the overall costs of achieving its emissions targets – the clean development mechanism (CDM), Joint Implementation (JI) and emissions trading. These mechanisms enable Parties to access cost-effective opportunities to reduce emissions or to remove carbon from the atmosphere 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 New Zealand Government's Climate Change website (www.climatechange.govt.nz) and the website of the UNFCCC (www.unfccc.int).

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 to 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 IPCC (1996; 2000; 2003) and relevant decisions of the Conference of the Parties (COP), 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 technical review process administered by the UNFCCC secretariat.

The inventory reports emissions and removals of the gases CO_2, CH_4, N_2O, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) from six sectors: energy, industrial processes, solvents, agriculture, 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 CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 are reported in New Zealand's total emissions under the UNFCCC and are counted in the target for the Kyoto Protocol.

Global warming potentials (GWPs) are used to convert emissions of each gas to an equivalent amount of CO_2 i.e. GWPs 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 (Table 1.1).

Table 1.1 Common GWP values from the IPCC Second Assessment Report (1995)

Gas	Global warming potential
CO_2	1
CH_4	21
N_2O	310
CF_4 (PFC)	6,500
C_2F_6 (PFC)	9,200
SF_6	23,900

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. Although New Zealand is yet to formally describe the national system, many of the arrangements detailed in the guidelines for national systems are described in this National Inventory Report (NIR) e.g. designation of the national identity and assignment of responsibilities for inventory preparation, and the development of remaining requirements in progress.

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 Subpart 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 MfE also produces estimates of emissions and removals from the LULUCF sector (except planted forests) and the waste sector.

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 consultants.

The Ministry for Agriculture and Forestry (MAF) manages the agriculture sector and removals 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.

1.3 Inventory preparation processes

New Zealand submits its national inventory to the UNFCCC secretariat by 15 April each year. The inventory is for 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 NIR occurs over the period February to April as activity data statistics and emissions data become available from the various participating institutions mentioned in section 1.2 'Institutional Arrangements'. National inventory compilation occurs at the MfE. MfE officials also undertake quality control procedures on emissions data, calculate the inventory uncertainty and the key category assessment. The inventory and all required data for the submission to the UNFCCC are stored on the MfE's central computer network in a controlled file system.

1.4 Methodologies and data

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 come from nationally collected surveys developed by Statistics New Zealand (New Zealand's national statistics agency) and industry-supplied information (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 not well supported. In the 2003 inventory, the Tier 1 emissions from road transport are supplemented with the results from a Tier 2 model.

Industrial processes: CO_2 emissions and activity data for the industrial processes sector are supplied directly to the MED by industry sources. A combination of IPCC Tier 1 and Tier 2 processes are used and emission factors are country specific. Activity data for the non-CO_2 gases are collated via survey. Emissions of HFCs and PFCs are estimated using an IPCC Tier 2 approach and SF_6 emissions from large users are assessed via a Tier 3a method.

Solvents: New Zealand's relatively small manufacturing base means that solvent use is lower than in many other countries. Estimates of emissions are calculated using a consumption-based approach. Activity data are obtained via a survey of industry.

Agriculture: Animal numbers are obtained from Statistics New Zealand, supplemented by estimates from the MAF. A Tier 2 methodology is used to estimate CH_4 emissions from dairy, beef, sheep and deer. The methodology uses animal productivity data to estimate dry matter intake and CH_4 production is determined from this intake. The same dry matter intake data are used to calculate N_2O emissions from excreta. A Tier 1 approach is used for non-significant species.

Land-use change and forestry: In previous inventories, New Zealand has only included information on net changes in the living biomass from the LULUCF category 'forest land remaining forest land (planted forest)' and emissions and removals from the planting of forest on grassland. In the 2003 inventory, New Zealand has improved the completeness of the LULUCF sector reporting by including a Tier 1 estimate for all LULUCF land use categories from 1997 to 2003. The procedure uses a modified national land cover dataset developed from remote sensing. Data for 1990 are not yet available but will be developed as part of the New Zealand Carbon Accounting System (NZCAS) described in Annex 3.2. These additional data will enable New Zealand to submit a complete time-series for all LULUCF categories. Changes in planted forest stocks are assessed from forest survey data and computer modelling of the planted forest estate. Ongoing work in this sector includes research on the carbon stored in soils, grassland with woody vegetation and natural forests (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. CH_4 and N_2O emissions from domestic and industrial wastewater handling are calculated using a refinement of the IPCC methodology (IPCC, 1996). New Zealand has not estimated emissions from waste incineration as they are considered 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

Good Practice Guidance (GPG) (IPCC, 2000) identifies a key category as "one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both". Key categories are identified within the inventory so that the resources available for inventory preparation 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% of the total emissions or 95% of the trend of the inventory in absolute terms.

LULUCF categories have been included in the key category analysis for the first time in the 2003 inventory. 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 considered as key.

The key categories identified in the 2003 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 24.5% and 22.6% of the total respectively. CH_4

emissions from enteric fermentation in domestic livestock are the largest single source of emissions, comprising 31.3% of total emissions in 2003 (Table 1.5.2 (b)). The next largest contribution to emissions is CO_2 emissions from road transportation, comprising 16.1% of total emissions in 2003.

The largest contribution to the trend analysis is from CO_2 emissions from road transportation, followed by CH_4 emissions from enteric fermentation in domestic livestock and forest land remaining forest land. 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% 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 2003 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 – road vehicles	CH_4	trend
Mobile combustion – aviation	CO_2	level, trend
Fugitive emissions from geothermal operations	CO_2	trend
Industrial processes sector		
Emissions from cement production	CO_2	level
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	Several	level, trend
Agricultural sector		
Emissions from enteric fermentation in domestic livestock	CH_4	level, trend
Emissions from manure management	CH_4	level, trend
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 2003 inventory – Tier 1 level assessment including LULUCF (a) and excluding LULUCF (b)

(a) Tier 1 Category Level Assessment - including LULUCF

IPCC source categories	Gas	2003 estimate Gg	Level assessment	Cumulative total
Forest land remaining forest land	CO_2	25583.91	24.5	24.5
Emissions from enteric fermentation in domestic livestock	CH_4	23592.21	22.6	47.1
Mobile combustion – road vehicles	CO_2	12094.67	11.6	58.7
Emissions from stationary combustion – gas	CO_2	8558.10	8.2	66.9
Emissions from agricultural soils – animal production	N_2O	7454.62	7.1	74.1
Emissions from stationary combustion – solid	CO_2	5435.29	5.2	79.3
Indirect emissions from nitrogen used in agriculture	N_2O	3328.82	3.2	82.5
Emissions from stationary combustion – liquid	CO_2	2797.95	2.7	85.2
Direct emissions from agricultural soils	N_2O	2185.55	2.1	87.3
Conversion to forest land	CO_2	1765.49	1.7	88.9
Emissions from the iron and steel industry	CO_2	1716.80	1.6	90.6
Emissions from solid waste disposal sites	CH_4	1425.48	1.4	92.0
Mobile combustion – aviation	CO_2	1158.33	1.1	93.1
Conversion to grassland	CO_2	688.02	0.7	93.7
Cropland remaining cropland	CO_2	653.46	0.6	94.4
Emissions from manure management	CH_4	549.44	0.5	94.9
Emissions from aluminium production	CO_2	542.14	0.5	95.4

(b) Tier 1 Source Category Level Assessment – excluding LULUCF

IPCC source categories	Gas	2003 estimate Gg	Level assessment	Cumulative total
Emissions from enteric fermentation in domestic livestock	CH_4	23592.21	31.3	31.3
Mobile combustion – road vehicles	CO_2	12094.67	16.1	47.4
Emissions from stationary combustion – gas	CO_2	8558.10	11.4	58.7
Emissions from agricultural soils – animal production	N_2O	7454.62	9.9	68.6
Emissions from stationary combustion – solid	CO_2	5435.29	7.2	75.8
Indirect emissions from nitrogen used in agriculture	N_2O	3328.82	4.4	80.2
Emissions from stationary combustion – liquid	CO_2	2797.95	3.7	84.0
Direct emissions from agricultural soils	N_2O	2185.55	2.9	86.9
Emissions from the iron and steel industry	CO_2	1716.80	2.3	89.1
Emissions from solid waste disposal sites	CH_4	1425.48	1.9	91.0
Mobile combustion – aviation	CO_2	1158.33	1.5	92.6
Emissions from manure management	CH_4	549.44	0.7	93.3
Emissions from aluminium production	CO_2	542.14	0.7	94.0
Emissions from cement production	CO_2	527.47	0.7	94.7
Emissions from substitutes for ozone depleting substances	HFCs	403.96	0.5	95.3

Table 1.5.3 Key category analysis for the 2003 inventory – Tier 1 trend assessment

Tier 1 Source Category Trend Assessment IPCC source categories	Gas	Base year estimate Gg	2003 estimate Gg	Trend assessment	Contribution to trend	Cumulative total
Including LULUCF activities						
Mobile combustion – road vehicles	CO_2	7534.65	12094.67	0.031	16.9	16.9
Emissions from enteric fermentation in domestic livestock	CH_4	21530.77	23592.21	0.030	16.3	33.2
Forest land remaining forest land	CO_2	22677.47	25583.91	0.024	12.9	46.1
Emissions from stationary combustion – solid	CO_2	3169.41	5435.29	0.017	9.2	55.3
Direct emissions from agricultural soils	N_2O	585.22	2185.55	0.016	8.7	63.9
Emissions from solid waste disposal sites	CH_4	2177.70	1425.48	0.013	7.3	71.3
Emissions from stationary combustion – gas	CO_2	7682.58	8558.10	0.009	5.0	76.3
Emissions from agricultural soils – animal production	N_2O	6767.81	7454.62	0.009	4.9	81.2
Conversion to forest land	CO_2	960.59	1765.49	0.006	3.5	84.6
PFCs from aluminium production	PFC	515.60	80.70	0.006	3.2	87.9
Emissions from substitutes for ozone depleting substances	HFCs	0.00	403.96	0.004	2.4	90.3
Emissions from stationary combustion – liquid	CO_2	2546.55	2797.95	0.003	1.9	92.2
Mobile combustion – aviation	CO_2	772.83	1158.33	0.002	1.2	93.4
Fugitive emissions from geothermal operations	CO_2	357.34	269.11	0.002	1.0	94.4
Emissions from manure management	CH_4	574.51	549.44	0.002	0.9	95.3
Additional key categories when excluding LULUCF activities						
Mobile combustion – road vehicles	CH_4	148.20	50.44	0.002	0.9	95.5

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 MfE developed a QA/QC plan in 2004 as required by the UNFCCC guidelines (FCCC/CP/20004/8) to formalise, document and archive the QC and QA procedures.

1.6.1 Quality control

In the preparation of the 2003 inventory, the MfE continued to develop the Tier 1 QC checksheet first used in the preparation of the 2002 inventory. The Tier 1 checksheet is based on the procedures suggested in Good Practice Guidance (IPCC, 2000 – refer Annex 6). For the 2003 inventory, the Tier 1 QC checksheets were used on all key categories and a selection on non-key source categories. Officials from the MED completed the QC checksheets on the energy sector prior to providing the emissions data to MfE.

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 2003 inventory, the MfE used the data checking procedures included in the CRF Reporter software to ensure the data submitted to the UNFCCC secretariat were complete.

1.6.2 Quality assurance

Quality assurance reviews of individual sectors and categories are commissioned by the MfE. As part of the QA procedures for the 2003 inventory, the quality management system was reviewed by consultants, a peer review on substitutes for ozone depleting substances (as part of the industrial processes sector) was commissioned, and a parameter change in the agricultural sector was peer-reviewed before being included in the 2003 inventory. A history of reviews, their key conclusions and follow up are 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 which conducts its own rigorous quality assurance and quality control procedures on the data.

1.6.3 UNFCCC annual inventory review

New Zealand's greenhouse gas inventory was reviewed in 2001 and 2002 as part of a pilot study of the technical review process (UNFCCC, 2001a, 2001b, 2002), where the inventory was subject to detailed in-country, centralised and desk review procedures. In 2003 and 2004, the inventory was reviewed during a centralised review procedure. In all cases, the reviews were conducted by an expert review team comprised of experts nominated by Parties to the UNFCCC. Transcripts of the reviews are available from the UNFCCC website (www.unfccc.int).

1.7 Inventory uncertainty

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

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 i.e. excluding LULUCF removals.

The calculated uncertainty for New Zealand's total inventory (emissions and removals) in 2003 is ±16.9%. However the uncertainty in the overall trend from 1990-2003 is lower at only ±4.2%. The uncertainty in total emissions is ±21.1% with ±4.9% 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 12.0% and 9.1% 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 e.g. 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 is also a major contribution to the uncertainty for 2003 at 6.7% 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% of the total.

Uncertainty in the trend is dominated by CO_2 emissions from the energy sector, at 2.6% 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% confidence intervals developed from the Monte Carlo simulation were extended to the 2003 inventory.

1.8 Inventory completeness

The New Zealand inventory for the 2003 year can be described as nearly complete with all IPCC source categories that occur in New Zealand or that have emissions assessed to be above a negligible level reported. Planned improvements in the inventory will address required improvements in methodologies (e.g. CH_4 emissions from manure management) and in activity data (e.g. the recovered CH_4 from solid waste disposal sites and attempt to quantify small sources of emissions previously reported as negligible e.g. soda ash production).

New Zealand reports emissions and removals from the LULUCF categories 'forest land remaining forest land' for planted forests and for 'grassland converted to forest land' for all years 1990-2003, however data for the other LULUCF categories (natural forests, cropland, grassland, wetland, settlement and other land) are not available for 1990 to 1996. This is an inconsistency in the time-series that New Zealand will correct with data developed as part of the New Zealand Carbon Accounting System (NZCAS). Development of the NZCAS will also reduce the uncertainty by using country-specific emission and removal factors and utilise UNFCCC category specific activity data. 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 ('NE'). New Zealand will review emissions from these categories as resources permit.

Chapter 2:

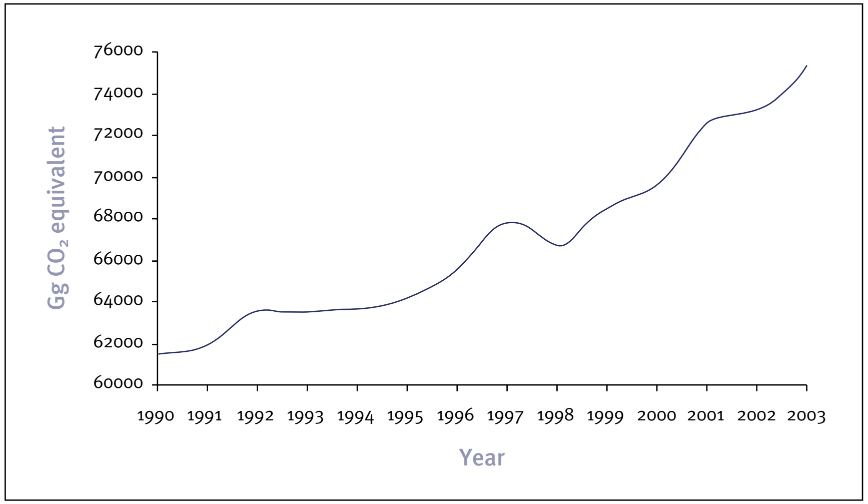
Trends in greenhouse gas emissions

2.1 Emission trends for aggregated greenhouse gas emissions

In 1990, New Zealand's total greenhouse gas emissions were equivalent to 61,525.43Gg of CO_2. In 2003, total greenhouse gas emissions increased by 22.5% to 75,345.29Gg CO_2 equivalent (Figure 2.1.1). Over the period 1990 to 2003, the average annual growth in overall emissions has been 1.48% 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 hydro-electric generation, which cannot meet the demand for electricity 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.

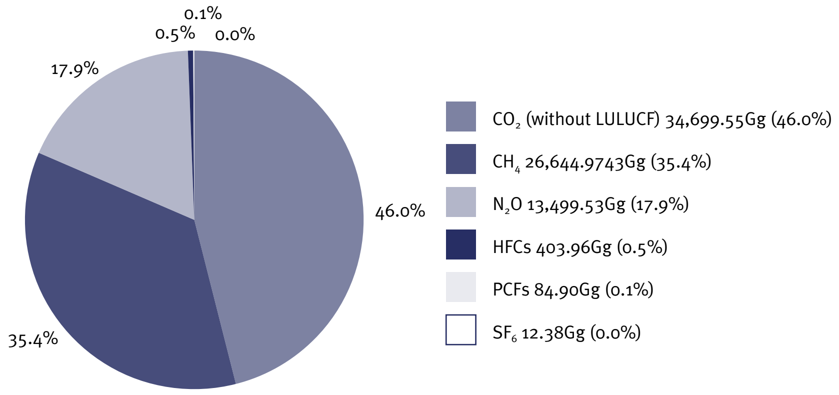
Figure 2.1.1 New Zealand's total greenhouse gas emissions 1990-2003



2.2 Emission trends by gas

CO_2 and CH_4 dominate New Zealand's increase in greenhouse gas emissions (Figures 2.2.1, 2.2.2 and Table 2.2.1). In 2003, these gases comprised 81.4% 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 third major gas in New Zealand's emissions profile is N_2O.

Figure 2.2.1 New Zealand's emissions by gas in 2003 (all figures Gg CO_2 equivalent)



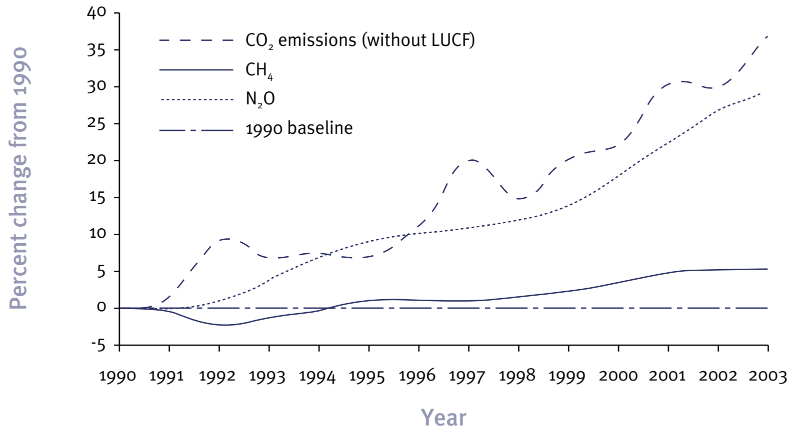
The growth in CO_2 represents the increased emissions from the energy sector. The growth in N_2O is from increased emissions from animal excreta and the increased use of nitrogenous fertilisers in agriculture e.g. the amount of nitrogenous fertilisers used has increased five-fold since 1990.

Although the contribution of the other gases in the inventory is less than 1% of the total emissions, these gases have also undergone relative changes between 1990 and 2003: emissions of PFCs have decreased 83.5% due to improvements in the aluminium smelting process and HFC emissions have increased from 0 to 403.96 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 in 1990 and 2003

Greenhouse gas emissions	Gg CO_2 equivalent 1990	Gg CO_2 equivalent 2003	Change from 1990 (%)
CO_2 emissions (without LULUCF)	25,314.81	34,699.55	37.1
CH_4	25,283.98	26,644.97	5.4
N_2O	10,398.71	13,499.53	29.8
HFCs	0.00	403.96	NA
PFCs	515.60	84.90	-83.5
SF_6	12.33	12.38	0.39

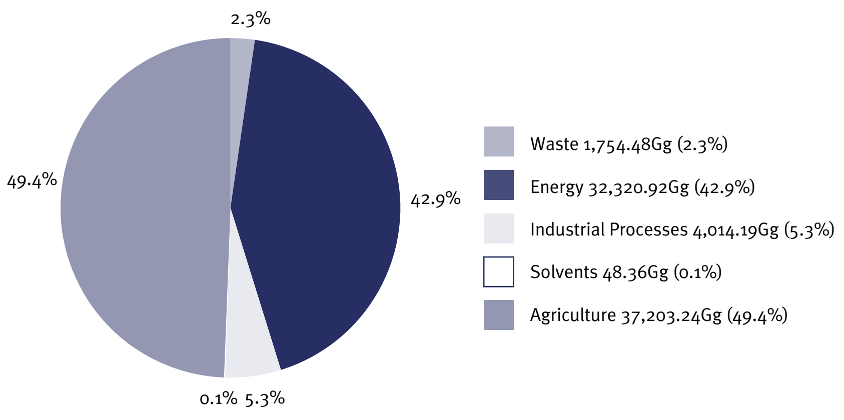
Figure 2.2.2 Change in New Zealand's emissions of CO_2, CH_4, and N_2O from 1990-2003



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 2003, 49.4% of New Zealand's total emissions were produced by the agriculture sector, predominantly CH_4 from ruminant farm animals e.g. dairy cows and sheep, and N_2O from animal excreta and nitrogenous fertiliser use. The current level of emissions from the agriculture sector is 15.6% 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 2003 (all figures Gg CO_2 equivalent, percentage of national total emissions in 2003)



The energy sector is the other large component of New Zealand's emissions profile comprising 42.9% of total emissions (refer Chapter 3). Emissions from the energy sector in 2003 are 37.0% over the 1990 level and represent the highest sectoral growth in emissions. The growth in emissions is primarily from road transport (increased 58.4%) and electricity generation (increased 83.3%). The 2003 year was a dryer year than usual, resulting in greater reliance on coal for electricity generation. Emissions of CO_2 from New Zealand's only power station able to run on coal (and gas) approximately doubled between 2002 and 2003.

Emissions from the industrial processes and waste sectors are a much smaller component comprising 5.3% and 2.3% respectively of all greenhouse gas emissions in 2003. Emissions from the industrial processes sector have been increasing steadily and are now 25.0% over the 1990 baseline. This growth is primarily from increased CO_2 emissions from cement production (an increase of 44% over 1990) and urea (nitrogenous fertiliser) manufacture (an increase of 41% over 1990). The increase has been offset by PFC emissions from aluminium manufacture decreasing by 84% since 1990 as a result of improvements to the smelting process (refer section 4.4.2 – aluminium).

Emissions from the waste sector are now 29.3% below the 1990 baseline. The majority of this 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.

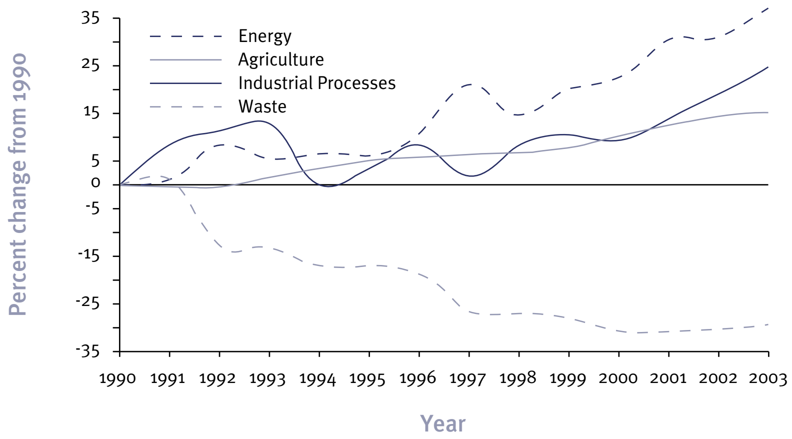
New Zealand's relatively small manufacturing base means that the solvent sector is much lower than in many other countries. In 2003, the solvent sector emitted 31.61 Gg of NMVOC.

The 'land-use, land-use change and forestry' (LULUCF) sector represents the major sink for New Zealand removing 30.3% of all greenhouse gas emissions in 2003. Net removals in 2003 were 7.0% 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 2003

Greenhouse gas emissions	Gg CO_2 equivalent 1990	2003	Change from 1990 (%)
Energy	23,594.11	32,320.92	37.0
Industrial processes	3,211.70	4,014.19	25.0
Solvent and other product use	41.54	48.36	16.4
Agriculture	32,193.76	37,203.24	15.6
Land-use, land-use change and forestry	-21,366.19	-22,861.60	7.0
Waste	2,480.06	1,754.48	-29.3

Figure 2.3.2 Change in sectoral greenhouse gas emissions from 1990-2003



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 2003 are shown in Table 2.4.1. However, these totals are not included in New Zealand's total emissions. There have been marked increases in the emissions of all gases.

Table 2.4.1 Emissions of indirect greenhouse gases and SO_2 in 1990 and 2003

Greenhouse gas emissions	Gg CO_2 equivalent 1990	2003	Change from 1990 (%)
NO_x	138.48	168.60	21.8
CO	574.09	682.83	18.9
NMVOC	135.47	166.18	22.7
SO_2	60.67	79.33	30.8

Emissions of CO and NO_x come largely from the energy sector. The energy sector produced 85.7% of total CO emissions in 2003. The largest single source was road transportation emissions which accounted for 88.6% of the energy sector CO emissions or 75.9% of total CO emissions. Similarly, the energy sector was the largest source of NO_x emissions (96.8%) with road transportation emissions comprising 40.9% of total NO_x emissions. Other large sources of NO_x emissions are from the 'manufacturing industries and construction' category (17.4%) and energy industries (17.6%).

The energy sector was also the largest producer of NMVOC and SO_2. The energy sector produced 71.5% of NMVOC emissions in 2003 with emissions from road transportation comprising 62.2% of total NMVOC emissions. Other major sources of NMVOC are in the 'solvent and other product use' sector (19.0%) and the industrial processes sector (9.5%).

Emissions of SO_2 from the energy sector comprised 84.0% of total SO_2 emissions. The 'manufacturing industries and construction' category was the largest single source at 29.0% of total SO_2 emissions. The other source of SO_2 was from the industrial processes sector.

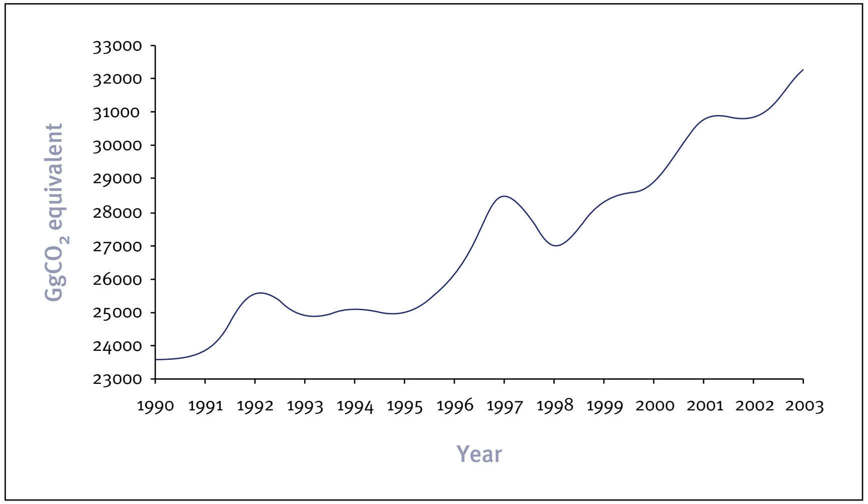
Chapter 3:

Energy

3.1 Sector overview

The energy sector produced 32,320.92 Gg CO_2 equivalent in 2003 and represented 42.9% of New Zealand's total greenhouse gas emissions. Emissions from the energy sector are now 37.0% above the 1990 baseline value of 23,594.11 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 58.4%) and public electricity and heat production (an increase of 83.3%). Emissions from the 'manufacture of solid fuels and other energy industries' sub-category have decreased by 80.6% from 1990, mainly due to the discontinuation of synthetic petrol production in 1997.

Figure 3.1.1 Energy sector emissions 1990-2003

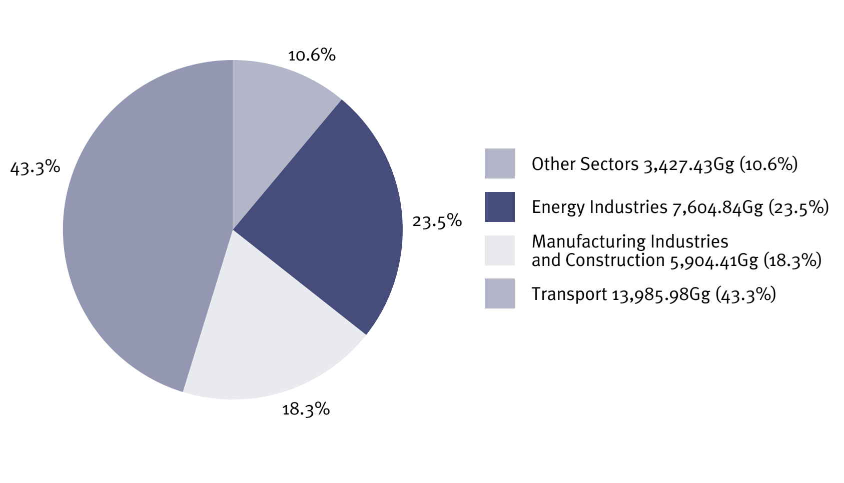


3.2 Fuel combustion (CRF 1.A)

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 sub-categories – 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 2003 inventory. Information about methodologies, emission factors, uncertainty and quality assurance relevant to several sub-categories are discussed below rather than repeated in individual sub-categories.

Figure 3.2.1 Emissions from the energy sector: fuel combustion category in 2003 (all figures Gg CO_2 equivalent)



3.2.0.2 Methodological issues

Energy sector emissions for New Zealand's inventory are compiled from the MED's energy database along with the relevant emission factors (Annex 2). Generally, greenhouse gas emissions are calculated by multiplying the emissions 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 source categories for New Zealand in the 2003 inventory. The relevant good practice decision tree (Figure 2.1 in IPCC, 2000) identifies that to meet good practice in methodology, emissions should be estimated using data from sectors correcting for oxidation and stored carbon (a Tier 1 Sectoral Approach). The decision is based on New Zealand having data on fuel combusted by sector but not by plant. The New Zealand methodologies 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 commissioned 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 a justifiable explanation could not be obtained, 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, are used in the 2003 inventory and will be used in future inventories.

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% and will be 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 96.6% 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. In addition, 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, 2004).

Table 3.2.1 General uncertainty ranges for emission estimates from fuel combustion (MED, 2004)

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

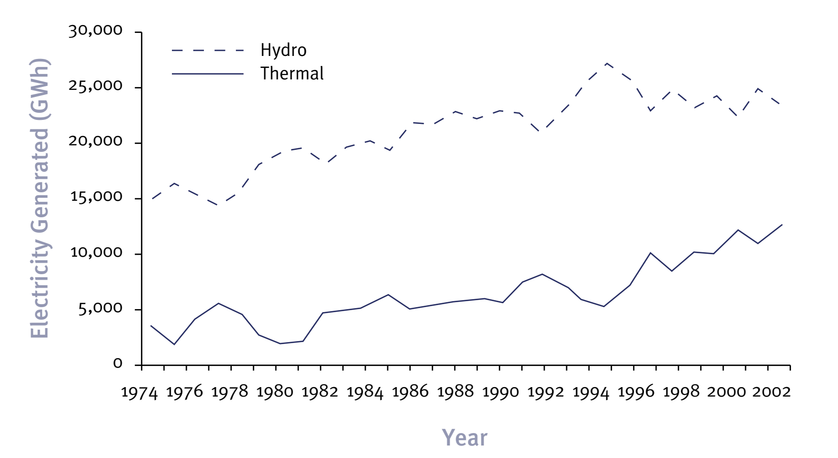
This category comprises emissions from fuels burnt in stationary combustion including combustion for public electricity and heat production, petroleum refining, and the manufacture of solid fuels and other energy industries.

Emissions in the energy industries category totalled 7,604.84 Gg CO_2 equivalent in 2003 and have increased 26.0% since 1990. The emissions profile in 2003 is dominated by emissions from public electricity and heat production which contributed 84.1 % of the CO_2 equivalent emissions from the energy industries category.

New Zealand's electricity generation is dominated by hydro-electric generation (approximately 60% of annual electricity needs) with most of the balance coming from thermal generation using largely natural gas with some coal. Geothermal power contributes another 7% and there are also contributions from other renewable sources such as wind and co-generation using wood. The emissions from public electricity generation show large year-to-year fluctuations because of the use of thermal stations to supplement the hydro-electric generation which cannot meet the demand for electricity during 'dry' hydro years i.e. years where rainfall and snow-melt inputs do not meet outflows. 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 2003, clearly illustrates that when the level of hydro-electric generation decreases, the level of thermal generation (gas, coal and oil) increases. However, it should be noted that since 1998 there has been 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 1974-2003



2003 was a dryer year than usual, resulting in greater reliance on coal for electricity generation. Emissions from New Zealand's only plant able to run on coal (and gas) approximately doubled between 2002 and 2003. Despite the dry year, emissions from gas used for electricity generation declined, reflecting a lack of available gas.

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 in the 'electricity and heat production' category while emissions from other co-generation plants are included in the 'manufacturing industries and construction (other)' sub-category.

Petroleum refining

Energy use data for petroleum refining are supplied to the MED by the New Zealand Refining Company Limited. In general, emission factors are used to derive CO_2 emissions using the energy in the fuels consumed. 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 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 emissions factor for this gas is therefore lower for end users than when it is used by the gas field itself and the IEF for the 'manufacturing of solid fuels and other energy industries' category is significantly higher than the typical gaseous fuel IEFs for other categories. The sequestration of carbon in synthetic petrol more than made up for this differential 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% less than the GCV.

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 category. In preparation of the 2003 inventory, the data for electricity production and petroleum refining underwent a Tier 1 QC checklist.

3.2.1.5 Source-specific recalculations

Some double-counting of emissions in previous inventories was discovered (refer Chapter 9). As a result, gas and coal emissions in the 'electricity and heat production' category for the years 1999-2002 have been revised downward. There have been some other minor recalculations which are documented in the common reporting format tables. Details of the effect of the recalculation on the energy sector are included in Chapter 9.

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 5904.41 Gg CO_2 equivalent in 2003, 28.8% over the 1990 baseline. The largest single source in 2003 is the 'chemicals' sub-category, made up entirely of emissions from natural gas consumption in the manufacture of methanol. Emissions from this source have roughly halved since 2002, largely due to a decline in the availability of low-priced natural gas. However, emissions from methanol production still comprised

16.8% of emissions from the ‘manufacturing industries and construction’ category and has increased from 376.97 Gg CO_2 equivalent in 1990 to 992.51Gg CO_2 equivalent in 2003 (an increase of 163.3%).

Emissions from natural gas consumption in the manufacture of urea have been re-allocated from the ‘chemicals’ sub-category in the energy sector to the ‘chemical industry’ sub-category in the industrial processes sector. This was in response to the UNFCCC review of New Zealand’s inventory (UNFCCC, 2005).

3.2.2.2 Methodological issues

The energy data for methanol production are supplied directly to the MED. CO_2 emissions are calculated by comparing the amount of carbon in the gas purchased by the plants and the amount stored in methanol (refer Box 3.1). The data for gas use in iron and steel-making are also supplied direct to the MED. The data for other industry uses of gas are from the energy supply and demand balance tables in the Energy Data File (MED, 2004).

Box 3.1 Calculation of CO_2 emissions from methanol production (MED, 2004)

Assumptions
- Synthetic petrol is 85.8% carbon by weight.
- Methanol is 37.5% carbon by weight.
- CO_2 emissions factor for Maui Gas is 52.3 kt / PJ (2002) (refer Annex 2).
- CO_2 emissions factor for Kapuni gas is 84.1 kt /PJ.
- CO_2 emissions factor for mixed feed gas is 52.4kt/PJ.

The resulting calculations are:
- Weight of carbon in gas to Methanex = [(PJ Maui)*52.3 + (PJ Kapuni)*84.1 + (PJ mixed feed)*52.4].
- 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].
- Total emissions of CO_2 = [(weight of carbon in gas to Methanex)-(weight of carbon sequestered)] * 44/12.

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 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 ironsand 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 ANZSIC codes, similar to the 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 higher 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 sub-category ‘chemicals’ has an entry because it relates to gas used by Methanex.

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 2003 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

There have been substantial recalculations for this category affecting all years from 1990:

- Emissions from gas used in the iron and steel industry are provided separately for the first time – previously they were included under the ‘other non-specified’ sub-category.

- Emissions from urea production have been reallocated from the 'chemicals' sub-category in the energy sector to the 'chemical industry' sub-category in the industrial processes sector.
- Separate emission factors are now used in coal consumption for the three key ranks of coal (bituminous, sub-bituminous and lignite).
- Estimates of emissions from coal use have been affected by the decision to base the activity data solely on the Coal Sales Survey conducted by Statistics New Zealand.
- Emissions estimates for the 2002 year have been substantially revised due to corrections regarding sales misreporting by the oil-companies.
- From 1999, LPG consumption estimates have been revised upwards.

3.2.3 Fuel combustion: transport (CRF 1A3)

3.2.3.1 Description

This category comprises emissions from fuels burnt 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 13,985.98 Gg CO_2 equivalent in 2003 and have increased 57.9% from the 8,856.58 Gg CO_2 equivalent emitted in 1990. The emissions profile in 2003 is dominated by emissions from road transportation which accounted for 87.8% of total transport emissions. CO_2 emissions from mobile combustion (road vehicles) were identified as having a major influence on the trend in New Zealand's emissions in the key category trend analysis (Table 1.5.3).

In the 2003 NIR, New Zealand has included a description and results from a Tier 2 bottom-up approach for estimating emissions from road transportation. This information, and the emissions reported in the common reporting format, are included to support the Tier 1 estimate.

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 for calculating CO_2 emissions as this provides the most reliable estimate. However, it is also good practice to use a Tier 2, bottom-up, approach to confirm the Tier 1 estimate (IPCC, 2000). The current New Zealand methodology is a Tier 1 approach estimating emissions using country specific and IPCC default emission factors.

Activity data on the consumption of fuel by the transport sector are extracted from the *Deliveries of Petroleum Fuels by Industry* survey conducted by Statistics New Zealand. LPG and CNG consumption figures are reported in the Energy Data file (MED, 2004). Prior to the 2002 inventory, the CO_2 emission factors used in inventories were sourced from the New Zealand Energy Information Handbook (Baines, 1993). These are replaced with the emission factors for individual liquid fuels derived from NZRC 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 (refer UNFCCC, 2005).

Road transport

New Zealand has developed a Tier 2 bottom-up approach for estimating emissions from road transportation using the Ministry of Transport (MoT) Vehicle Fleet Model. It is good practice to use the Tier 2 approach in parallel for two reasons. It provides an important quality check and reliable bottom up calculated CO_2 emissions. This increases confidence in the underlying activity data and is important in underpinning the botton up calculation of non CO_2 emissions (IPCC, 2000).

The Vehicle Fleet Model's inputs include vehicle type, fuel type, number of vehicles, vehicle kilometres travelled (VKT) and fuel economy for different vehicle types. Model outputs include fuel consumed per kilometre in different driving conditions and the total fuel consumed per annum for the vehicle classes in the fleet. Emissions are calculated from the entire national fleet per year using country-specific and IPCC default emission factors for the different fuels (see Annex A2.4 for further details).

Figures 3.2.2 and 3.2.3 show the comparison between the MoT Vehicle Fleet Model and the data available from the MED (which have been used in the Tier 1 calculations) for CO_2 emissions from petrol and diesel used in road transportation. It is obvious there is a divergence occurring between the model and MED statistics from 2001 onwards. The MED values suggest a sudden and significant increase in petrol demand (and hence emissions from this source) over the past three years. Without detailed study it is difficult to accurately explain what is causing this, but factors that could be involved include increased shift in VKT congestion level driving in urban/suburban road networks, shift towards larger vehicle sizes within a given class and increased non-road use. For diesel, the discrepancies are more easily explained. There is the difficulty in accurately apportioning road versus non-road use in the MED values. The main variables within the model to consider are the fuel consumption factors, especially variation in terms of vehicle load and terrain travelled. Another significant variable is the VKT breakdown within the heavy truck fleet. It is acknowledged the model calculations of emissions resulting from diesel needs more refining.

Figure 3.2.2 Comparison of CO_2 emissions from road transportation using petrol between the MED data (Tier 1) and the MoT model (Tier 2)

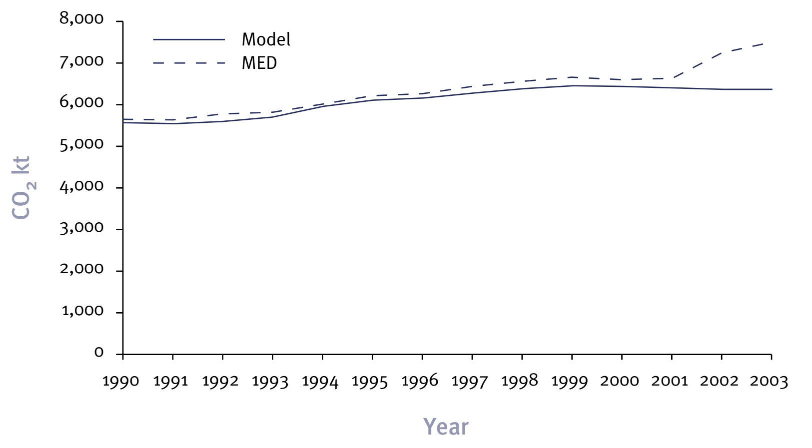
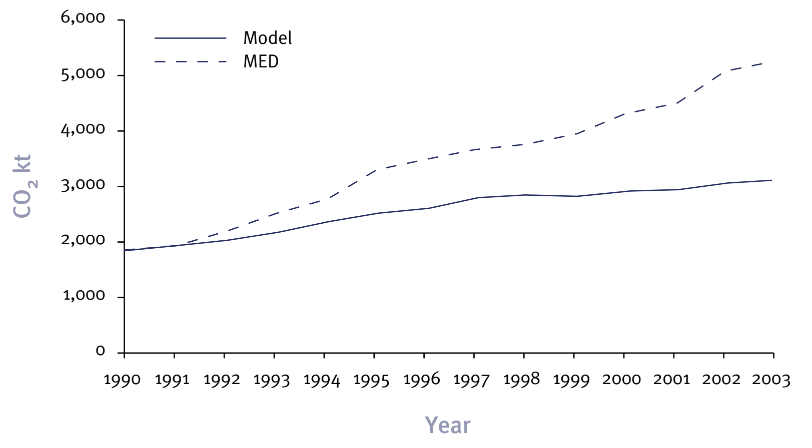


Figure 3.2.3 Comparison of CO_2 emissions from road transportation using diesel between the MED data (Tier 1) and the MoT model (Tier 2)



Navigation

Good practice in methodology choice for navigation in New Zealand is to use a Tier 1 approach with country-specific carbon contents 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. Therefore there is no basis to split the domestic and international components of fuel use for international flights with a domestic leg. This is the case because aviation and marine fuel use information is sourced from the oil companies rather than from the airlines or the shipping companies.

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 source categories for New Zealand in the 2003 inventory. In preparation of the 2003 inventory, the data for these emissions underwent a Tier 1 QC checklist.

3.2.3.5 Source-specific recalculations

Emissions estimates for the 2002 year have been substantially revised due to corrections made regarding misreporting of sales data by the oil-companies. Emissions from LPG and CNG consumption in some years have also been affected by activity data revisions. Finally, CH_4 and NO_x emission factors for road and rail transport, and also mobile agriculture, are interpolated between the New Zealand specific emission factors and the IPCC default factors as recommended by Hale and Twomey (2003). In previous years, New Zealand-specific emission factors were used for all years.

3.2.4 Fuel combustion: other sectors (CRF 1A4)

3.2.4.1 Description

This sector comprises emissions from fuels burnt in the commercial/institutional sub-category, the residential sub-category and the agriculture, forestry and fisheries sub-category.

Emissions from the 'Fuel combustion: other sectors' category totalled 3,427.43 Gg CO_2 equivalent in 2003 and are 17.9% over the 1990 baseline value of 2,908.04 Gg CO_2 equivalent. The emissions profile in 2003 is divided between the commercial and institutional sub-category (40.8%), and the agriculture, forestry and fisheries sub-category (42.5%). The residential sub-category comprises the remaining 16.7% 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 sub-category are likely to be underestimated (MED, 2004). 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.

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 2003 inventory, the data for the 'other sectors' category underwent a Tier 1 QC checklist.

3.2.4.5 Source-specific recalculations

Separate emission factors have been calculated and are used for the three key ranks of coal (bituminous, sub-bituminous and lignite). Estimates of emissions from coal have been affected by the decision to base the activity data solely on the Coal Sales Survey conducted by Statistics New Zealand. There have also been some recalculations to emissions from liquid fuels due to revisions to the activity data provided by the oil companies for 2002 and revisions to LPG consumption data from 1999 onwards.

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 solid fuels produced 332.25.Gg CO_2 equivalent in 2003. This is an increase of 22.1% from the 272.17 Gg CO_2 equivalent reported in 1990. New Zealand's fugitive emissions from solid fuels are a product of coal mining operations.

CH_4 is created during coal formation. The amount of CH_4 released during coal mining is dependent 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 2003, 76.9% of the CH_4 from coal mining (including post-mining emissions) came from underground mining, however, most of the coal mined in New Zealand is taken from surface mines (84.3% in 2003). There is no flaring of CH_4 at coal mines and CH_4 is rarely captured for industrial uses. CH_4 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). The emission factors used for surface mining, handling of surface-mined coal and handling of underground-mined coal are the middle values from the IPCC default range (Table 3.3.1). The emissions factor for underground mining of bituminous coal is the top end of the IPCC default range. New Zealand continues to use a New Zealand-specific emissions factor for underground mining of sub-bituminous coal (Beamish and Vance, 1992). In 2003, coal production from underground mining by weight was 222 kt bituminous coal and 591 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 (tCH_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 2003 inventory, the data for fugitive CH_4 emissions from solid fuels underwent a Tier 1 QC checklist.

3.3.1.5 Source-specific recalculations

Fugitive emissions from coal mining have been recalculated in most years due to revisions to data on tonnes of coal mined from surface and underground mines. Further information on these recalculations can be found in Chapter 9.

3.3.1.6 Source-specific planned improvements, if applicable

The 2003 review of emission factors (Hale and Twomey, 2003) noted that the New Zealand factor (35.2 t CH_4/kt coal) was more than twice the top end of the IPCC Tier 1 range and was based on a small sample of mines. In response, New Zealand has adopted the top end of the IPCC range of emission factors for the 2003 inventory (16.75 t CH_4/kt coal).

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

3.3.2.1 Description

Fugitive emissions from oil and gas comprised 1066.01Gg CO_2 equivalent in 2003. This is an increase of 13.8% from 936.40 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 in 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% (MED, 2004), leaving some fugitive emissions due to the incomplete combustion. Fugitive emissions also occur in transmission and distribution of the natural gas.

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

3.3.2.2 Methodological issues

The methodologies for natural gas are based on data from field operators or calculated from supplied energy data and country specific emission factors. 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

Estimates of 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 2003 from transmission pipelines, provided by the NGC, are less than 30 tonnes of CO_2 and approximately 230 tonnes of CH_4 (MED, 2004). 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% of the gas entering the distribution system is unaccounted for and that around half of this (1.75%) 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 are calculated using an IPCC Tier 1 approach with activity data and emission factors. For oil transport, the fuel activity data are the total New Zealand production of crude oil reported in the Energy Data File (MED, 2004) and the CH_4 emissions 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. However, the CH_4 emissions factor for refining is the same as that for transportation, while the emissions factor for storage is 0.14 t CH_4 / PJ (a New Zealand specific emissions factor). The combined emissions factor for refining and storage is 0.885 t CH_4 / PJ, derived by adding the emission 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. 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 vary 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

CH_4 emissions from one of the geothermal fields have been revised for the years 2000-2002.

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 used as a check for combustion related emissions. The check is performed for all years from 1990 to 2003.

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 weighted average of emission factors for each of New Zealand's gas-fields where the weights are provided by the level of production at each field. This differs from previous inventories, where the emission 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 2003 shows that the reference total of CO_2 emissions is 0.40 % less than the sectoral total (Table 3.4.1). This is mainly related to the differences in the energy consumption, although it is difficult to compare energy consumption in the reference approach with energy consumption in the sectoral approach.

In the New Zealand energy sector inventory, 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 'observed' figures are reported as statistical differences in the energy balance tables contained in the Energy Data File (MED, 2004).

The activity data and calculated emissions for the major fuel categories are not directly comparable between the reference approach and the sectoral approach. 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, so estimates of emissions provided by the two approaches are not very different. Another difference between the two approaches 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 at least theoretically counted against crude oil.

The time-series comparison with the IEA data (IEA Statistics, 2004) shows that the differences between the sectoral and reference approach reported in CRF 2003 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 2003 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 2003 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		

3.4.2 International bunker fuels

The data on fuel use by international transportation come from the Energy Data File (MED, 2004). 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. 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 at present.

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' 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. This situation has improved since the last submission with the inclusion of gas used in iron and steel making.
- 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 are 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 sulphur dioxide 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.

Chapter 4:

Industrial processes

4.1 Sector overview

New Zealand's industrial processes sector totalled 4014.19 Gg CO_2 equivalent in 2003 and represented 5.3% of total greenhouse gas emissions. Emissions from industrial processes are now 25% above the 1990 baseline of 3211.70 Gg CO_2 equivalent (Figure 4.1.1). The sector is dominated by emissions from the metal production category (CO_2 and PFCs) at 58.3% of sectoral emissions (Figure 4.1.2).

Figure 4.1.1 Industrial processes sector emissions 1990-2003

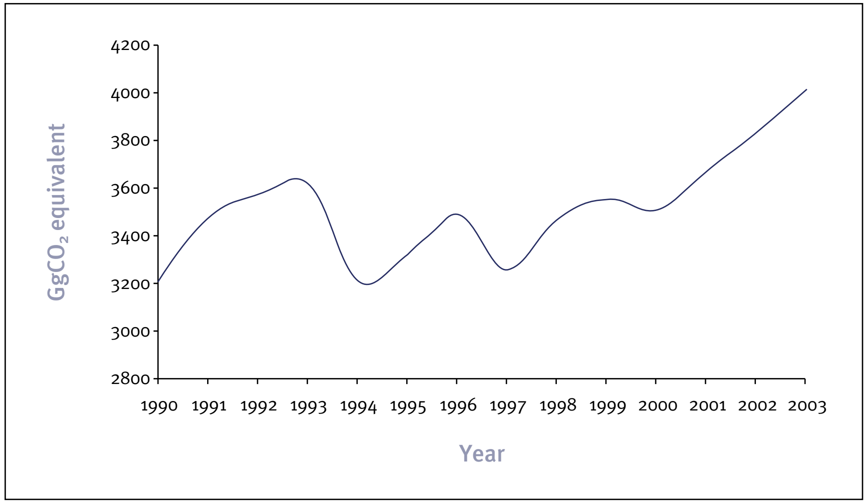
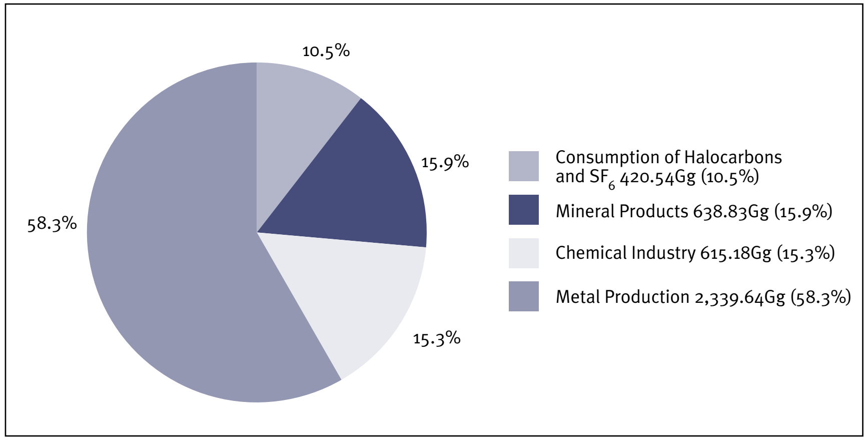


Figure 4.1.2 Industrial processes sector emissions in 2003 (all figures Gg CO_2 equivalent)



The emissions included in the industrial processes sector arise from the chemical transformation of materials from one substance to another. 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, 2004):

- 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.

Although fuel is also often combusted in the manufacturing process, emissions arising from combustion are included in the energy sector. Additionally, CO_2 emissions related to energy production e.g. refining crude oil and the production of synthetic petrol from natural gas, are also considered within the energy sector.

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) and reported in the publication 'New Zealand Energy Greenhouse Gas Emissions 1990-2003' (MED, 2004). Production and emissions data are provided to the MED by industry.

Data on non-CO_2 emissions are gathered primarily 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. 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 detailed category information and 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% (MED, 2004). 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 638.83 Gg CO_2 in 2003. Overall, the level of emissions in the mineral products category has grown by 42.5% from the 1990 level of 448.28 Gg CO_2. 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 (83%) and lime (17%). CO_2 emissions from cement production are identified as a key category for New Zealand in 2003 (Tables 1.5.2 and 1.5.3). 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

Lime production

CO_2 emissions from lime production are supplied to the MED by industry. Emissions are calculated by multiplying the amount of lime produced by an emissions factor. Prior to 2002, a single New Zealand specific emissions factor based on the typical levels of impurities in the lime produced in New Zealand was applied to all lime produced. In 2002 and 2003, the emission factors used were plant-specific but there has been little change to the implied emissions factor – from 0.72 t CO_2 / t lime in 2001 to 0.73 t CO_2 / t lime in 2002 and 2003.

Cement production

Since 1997, estimates of emissions from cement production have been calculated by multiplying the amount of clinker produced by a plant-specific emissions 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 MgCO3 into MgO and CO_2 are counted along with emissions from the decomposition of CaCO3. Only one of the two cement companies currently operating in New Zealand takes account of CO_2 emissions from non-recycled cement kiln dust. Although failing to take account of CaO lost in cement kiln dust has a small impact on CO_2 emissions, New Zealand will endeavour to obtain estimates of these losses for the company in question in time for the next inventory submission in 2006.

For the years 1990 to 1997, emissions are calculated using a Tier 1 methodology as clinker data (which is needed for the Tier 2 methodology) for these years is not available. Total cement production is multiplied by a country specific emissions factor (0.51 t CO_2 / t cement). While the implied emissions factor for 2003 is lower than this (0.43 t CO_2 / t cement), the implied emissions factor in 1997 (0.49 t CO_2 / t cement) is quite close. Therefore, the use of a Tier 1 methodology prior to 1997 has probably not had a large impact on the accuracy of emissions estimated for these years. However, New Zealand will investigate whether clinker data for all years can be sourced so that CO_2 emissions from cement production can be calculated using the Tier 2 methodology for the entire time series.

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% of the SO_2 will be absorbed by the alkaline clinker product. New Zealand uses the SO_2 emissions factor supplied by industry from the wet process kilns. For lime manufacture, the SO_2 emissions vary with the technology used. SO_2 emissions are calculated by multiplying individual plant activity data with individual SO_2 plant emission factors and summing the result.

Asphalt roofing

There is only one company manufacturing asphalt roofing in New Zealand. Emissions are calculated using activity data supplied by the company. 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 35% of the bitumen used for road paving is used for asphalt and 65% 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 (CRL Energy Ltd, 2004).

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. However, 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%, there is no possibility of this level of NMVOC emissions. For the 2003 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.

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. There is no information from which an estimate of SO_2 emissions (from sodium sulphate decomposition) can be made.

It has been assumed that the IPCC emissions factor is based on total glass production which includes recycled glass input. NO_x and CO emissions are assumed to be linked with fuel use while NMVOC and SO_2 emissions are assumed to be linked with the industrial process because they are associated with the raw materials.

Soda ash production and use

Negligible quantities of soda ash or sodium carbonate are produced in New Zealand. The guidelines (FCCC/SBSTA/2004/8) state that the NE notation is applicable and this is the notation used in the CRF Reporter software. It is acknowledged there is a lack of data for this source and gaining an estimate of soda ash for inclusion in the next inventory has been added to the New Zealand improvement plan (part of the QA/QC system).

4.2.3 Uncertainties and time-series consistency

Uncertainties in CO_2 emissions are assessed as ± 5% 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, 2004).

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%	+20%
Lime	+1 to +10% (varies by producer)	+30%
Asphalt roofing	+20%	+40%
Road paving with asphalt	+10%	+15 to +25% (varies with factors in calculation equation)
Glass	0%	+50%

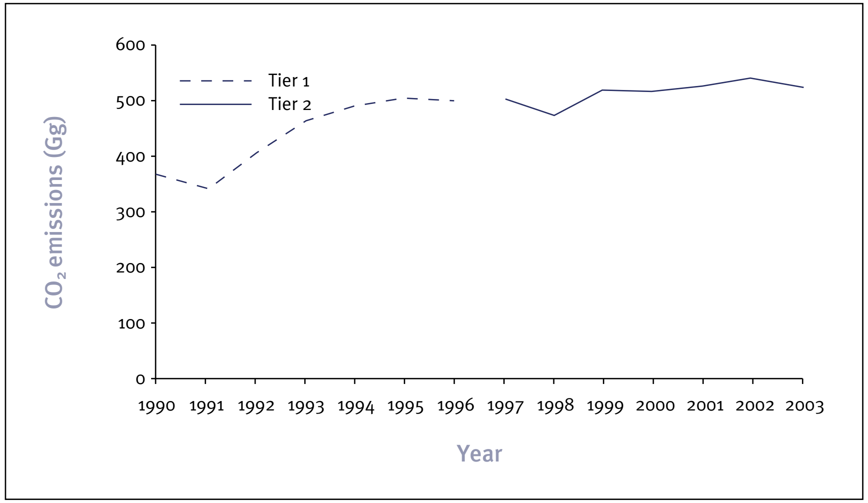
4.2.4 Source-specific QA/QC and verification

CO_2 emissions from cement production were identified as a key source category for New Zealand in the 2003 inventory. 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 cross-referenced, where possible, between companies and industry associations to verify the data. The small number of companies in this category facilitates obtaining a complete coverage of the category.

4.2.5 Source-specific recalculations

As explained in section 4.2.2, two different methods have been used to create the times series for cement production. There is not a large jump between 1996 and 1997 (when the methodology changed) and recalculation method options in Table 7.5 in Chapter 7 of IPCC Good Practice Guidance (2000) do not appear to be appropriate in this case for recalculating emissions from 1996 back to 1990. The 1996 IPCC guidelines for cement production (section 2.3.1) state that “the differences between the lime content and production of clinker and cement, in most countries, are not significant enough to affect the emission estimates”. Therefore the data across the entire time-series using two different methods remains in the CRF without recalculation.

Figure 4.2.1 CO_2 emissions from cement production using Tier and Tier 2 methods



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, coke or caprolactam in New Zealand.

Emissions from the chemical industry category comprised 615.18 Gg CO_2 equivalent emissions in 2003 and have increased 37.3% from the 448.17 Gg CO_2 equivalent estimated in 1990. CO_2 emissions from ammonia/urea production account for 63.4% 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 carbon in the gas used to produce the urea is eventually released. Accordingly, just as with energy sector emissions, emissions are calculated by multiplying the quantities of the different types of gas used by their respective emission factors (Annex 2.3) In previous inventories it was assumed that a proportion of the carbon in the gas was permanently sequested in the urea. In accordance with IPCC guidelines it is now assumed that the carbon in urea is eventually released after it is applied to the land.

CO_2 emissions from urea production were previously reported in the energy sector in Section 3.2.2 – 'Fuel combustion: manufacturing industries and construction (CRF 1A2)' but are now included in this section. The emissions have been reallocated given that they arise due to the similar nature and processes as emissions from ammonia production, which are classified as industrial process emissions. This change was recommended in the UNFCCC review of New Zealand's 2002 inventory (UNFCCC, 2004).

Non-CO_2 emissions are calculated from activity data and emission factors supplied by the company. The company supplied emission factors are based on measurements from historical vent valve data and are considerably lower than the IPCC defaults (Annex 8.2 worksheets).

Formaldehyde

Formaldehyde is produced at four plants in New Zealand. Emissions are calculated from company supplied activity data and emission factors for CO and CH_4. Emissions are calculated by multiplying individual plant activity data with individual emission factors and summing the result. The levels of CO and CH_4 are usually very small or undetectable.

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) and are considered in the energy sector. The major non-fuel related emissions from the process are from NMVOC. 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, 2004).

Fertiliser

Superphosphate is produced by two companies (each with three plants) in New Zealand. Both companies have supplied activity data and emission factors. 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 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 and one set was identified as an outlier. The SO_2 emissions factor for the other company was therefore applied to all activity data.

Hydrogen

Estimates of 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 methane and steam. CO_2 is a by-product of the reaction and is vented to the atmosphere. The implied emissions factor is 6.51 tonne CO_2/tonne H_2 produced (MED, 2004).

4.3.3 Uncertainties and time-series consistency

Uncertainties in CO_2 emissions are assessed as ± 5% 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, 2004). 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 a ctivity data	Uncertainty in emission factors
Ammonia /Urea	± 2%	± 30%
Formaldehyde	± 20 to ±40% (varies per plant)	± 20 to ±80% (varies per plant)
Methanol	0 %	± 30 to ±80% (varies per gas)
Fertiliser	± 10% sulphuric acid ± 20% superphosphate	± 15% sulphuric acid ± 15 to ±30% superphosphate (varies per plant)

4.3.4 Source-specific QA/QC and verification

Improvements in New Zealand's QA/QC system has lead to QC checks being extended to a selection of non key source categories. In preparation of the 2003 inventory, hydrogen production emissions underwent a Tier 1 QC check.

4.3.5 Source-specific recalculations

Emissions of CH_4 from methanol production were included for the first time in the 2002 inventory due to an omission in previous submissions. Emissions were back-calculated to 1997. The time-series has been updated again by the MED. This enabled CH_4 emissions for all years in the time-series to be calculated using the IPCC default emissions factor of 2 g CH_4/kg production.

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 industry comprised 2,339.64 Gg CO_2 equivalent in 2003 and have increased 1.5% from the 2,305.79 Gg CO_2 equivalent recorded in 1990. CO_2 emissions account for 96.6% of emissions in this category with another 3.4% from PFCs. In 2003, the level of CO_2 emissions has increased by 26.4% 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 2003, a decrease of 84.3%.

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

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 emissions factor applied to the sub-bituminous coal used as a reducing agent is 93.7 kt CO_2 / PJ. This emissions 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 does not strictly adhere to the Tier 2 methodology 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 by the steel plants. 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 emissions factor based on the average implied emissions factor for the plant for the years 2000-2004 (around 0.1 t CO_2 / t steel). 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.

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). 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 (NZAS, 2005). The data reflect anode oxidisation which is responsible for almost 90% of the CO_2 emissions from aluminium production. The remainder come from fuel combustion (various fuels are used – heavy fuel oil, LPG, petrol and diesel) and are included in the energy sector (MED, 2004; NZAS, 2005).

Emissions of the two PFCs from the production of aluminium (CF_4 and C_2F_6) are supplied by the operator of New Zealand's sole aluminium smelter. The IPCC default emission factors are used for other non-CO_2 emissions apart from 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.

The PFC emissions from aluminium smelting are calculated using a Tier 2 method. This involves using the IPCC default coefficients for CWPB 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 (no data are 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 CWPB technology are used. To convert to tonnes of CO_2 equivalents, the estimates of CF_4 and C_2F_6 are multiplied by the global warming potentials 6,500 and 9,200 respectively. 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. Gold and silver production processes are listed in the 'Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories' 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 2003.

4.4.3 Uncertainties and time-series consistency

Uncertainty in CO_2 emissions is assessed as ± 5% 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, 2004). 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% (CO), ± 50% (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, 2004a).

4.4.4 Source-specific QA/QC and verification

CO_2 emissions from iron and steel production and aluminium production are key source categories for New Zealand. These sources have undertaken a Tier 1 QC check in preparation of the 2003 inventory.

4.4.5 Source-specific recalculations

CO_2 emissions from iron and steel production have been recalculated for all years to 1990 as a result of errors being identified with the assumed carbon content of scrap and steel in previous inventories (emissions were over-estimated). This has resulted in a two-fold reduction in emissions.

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 2003, emissions from this category totalled 6.68 Gg NMVOC.

4.5.2 Methodological issues

Pulp and paper

Emissions are reported from chemically produced pulp of which the Kraft process constitutes 95% of production. The split between mechanical and chemical pulp production is 52/48%. Estimates of emissions from the chemical pulping process are calculated from production figures obtained from Statistics New Zealand and the MAF. 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. The NMVOC emissions factor has also been applied to the thermomechanical pulp processes to estimate the emissions from that source (CRL Energy Ltd, 2004).

Food and drink

NMVOC are produced during the fermentation process and during all processes in food processing. 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. It is assumed that losses in spirit production represent total NMVOC emissions from New Zealand's production of spirits.

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, 2004). 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	0%	±50% (chemical pulp) ±70% (thermal pulp)
Food – alcoholic beverages	0% (beer and wine) ±20% (spirits)	±80% (beer and wine) ±60% (spirits)
Food – food production	±5-20% (varies with food)	±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 due to methodology changes performed for this category.

4.6 Production of halocarbons and sulphur hexafluoride (CRF 2E)

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

4.7 Consumption of halocarbons and sulphur hexafluoride (CRF 2F)

4.7.1 Description

Emissions from HFCs totalled 403.96 Gg CO_2 equivalent in 2003. This is an increase of 382% from the 1995 level of 83.77 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 trend analysis of the 2003 inventory (Table 1.5.3). SF_6 emissions have increased from 9.46 Gg CO_2 equivalent in 1990 to 12.38 Gg CO_2 equivalent in 2003, an increase of 30.9%.

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 early 1990's 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/air conditioning, fire protection and other.

The emissions inventory for SF_6 is broken down into two source categories: electrical equipment and other. One electricity company accounts for 80-90% of the charge of SF_6.

4.7.2 Methodological issues

Sulphur hexafluoride

Actual and potential emissions of SF_6 result primarily from the use of SF_6 in electrical switchgear. For the 2003 inventory, emissions are calculated using the Tier 3 methodology for the majority of electrical switchgear emissions and supplemented by information from equipment manufacturers and servicing contractors. One firm representing 80-90% of the total SF_6 held in equipment provided sufficient information for the Tier 3 approach. A Tier 2 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, 2004a). Potential emissions of SF_6 were calculated and included in the 2003 inventory.

HFCs/PFCs

The total quantity of HFC and PFC imported each year is based on data supplied by the MED. This is derived from an annual survey of all importers and distributors of these chemicals. Further information was collected directly from importers and distributors to identify the end users of the imported bulk chemicals and to determine the proportion of bulk chemical used in each sub-source category. Estimates of non-bulk imports of HFCs, PFCs and SF_6 are obtained directly from industry associations, Statistics New Zealand and New Zealand manufacturers of aerosol products. The MED has in previous years compiled a detailed breakdown of bulk HFCs, however this was not available for the 2003 inventory. In the absence of this data, the breakdown has been extrapolated from the 2001 data (CRL Energy Ltd, 2004a).

Specific information required to complete the inventory was obtained via a questionnaire sent to New Zealand's importers of HFCs/PFCs, the main producers/exporters of household domestic/commercial refrigeration equipment, foam blowing companies, mobile air conditioning installers/servicers, fire protection companies and the only producer of HFC based aerosols. 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 1a method (bulk imports minus bulk exports). Due to a lack of disaggregated data for the years 1999-2001 for refrigeration, potential emissions from refrigeration could not be calculated and as a result the total potential emissions for consumption of halocarbons for those years are underestimated.

Table 4.7.1 Halocarbon and SF_6 calculation methods and emission factors

HFC source	Calculation method	Emission factors
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 sources		
Electrical equipment	IPCC GPG 2001 Eqn 3.17	Tier 3 approach based on overall consumption and disposal with country specific EF of 1%.
Other applications	IPCC GPG 2001 Eqn 3.22	No emission factor required as 100% is emitted within 2 yrs.

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 2003 are provided by the sole New Zealand supplier. The weighted average quantity of propellant per dose was calculated from information supplied by industry. HFC-134a was not used in 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, 2004a).

Foam

The survey revealed only one New Zealand manufacturer importing HFCs for foam blowing and some of the product is exported overseas. The manufacturer started HFC usage in 2000. There is insufficient data to estimate the proportion of HFC emissions exported (CRL Energy 2004a).

Stationary refrigeration/air conditioning

Emissions are estimated from factory charged equipment and all other equipment which is charged on site. Activity data to complete IPCC equation 3.40 (IPCC, 2000) are obtained from the survey.

Fire protection

There are two main supply companies using HFCs in New Zealand. The annual emissions factor for all years is estimated to be 1.5% of the total amount of HFC installed.

Mobile air conditioning (MAC)

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.

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, 2004a)

HFC source	Uncertainty estimates
Aerosols	±53% for aerosol imports, ±30% in locally manufactured aerosols and ±10% from emissions from MDIs.
Solvents	Not occurring.
Foam	±50% in activity level and ±50% in emission factors.
Mobile Air Conditioning	Vehicle numbers are assessed to have low uncertainty. Proportion of vehicles with MAC is highly uncertain and ±25% on the amount of HFC supplied to the MAC industry.
Stationary Refrigeration/ Air Conditioning	±15% on total HFC/PFC imported and in locally charged equipment. ±60% in factory charged equipment. ±20% in total HFC/PFC proportion used for charging new commercial refrigeration units (largest source of uncertainty).
Fire Protection	±10% on the total amount of HFC installed and ±30% in the annual emissions factor.
SF_6 source	
Electrical equipment	±20% (Transpower) and ±60% (other companies) in emission factors. ±10% for total SF_6 installed. ±30% for SF_6 in new and retired equipment.
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 2003 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

There are no source-specific recalculations due to methodology changes performed for this category.

4.8 Other (CRF 2G)

4.8.1 Description

Panel products

Activity data and emission factors for NMVOC emissions are obtained from two plants that manufacture panel products. The activity data are supplemented from statistics from the MAF website. 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:

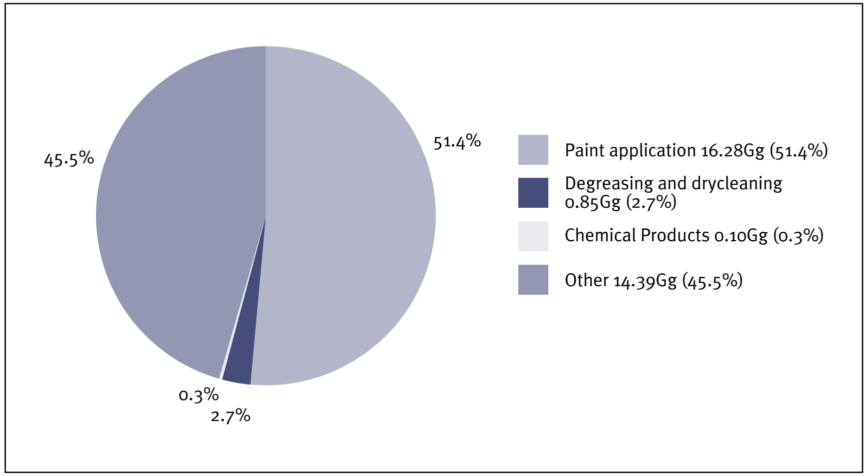
Solvent and other product use

5.1 Sector overview (CRF 3)

Solvents and related compounds are a significant source of emissions of NMVOC. 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 from the solvents and other product use sector in 2003 comprised 31.61 Gg of NMVOC. This is an increase of 30.4% from 24.24 Gg in 1990. The categories dominating the sector are NMVOC emissions from paint application and other uses (Figure 5.1.1).

Figure 5.1.1 Emissions of NMVOC from the solvent and other product use sector in 2003 (all figures Gg NMVOC)



In 2003, N_2O emissions from anaesthesia use totalled 0.16 Gg N_2O or 48.36 Gg CO_2 equivalent. This is a 16.4% increase over the 1990 baseline.

5.1.1 Description

New Zealand's relatively small manufacturing base results in lower solvent use compared to many other countries. Ethanol and methanol are the only solvents produced in New Zealand and the majority of both products are exported. All other solvents are imported, including some ethanol and methanol (for quality and price reasons).

5.1.2 Methodological issues

The IPCC guidelines (IPCC, 1996) do not provide detailed methodologies for emissions from solvents and other product use, but documents 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, 2004). 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

Consumption of perchloroethylene is assumed to equal the volume of imports. Import information is supplied from Statistics New Zealand.

Chemical products (manufacturing and processing)

The solvents tetrabutyl urea and alkyl benzene are used in the production of hydrogen peroxide. Emissions 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.

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 emissions factor for NMVOC of 0.6 kg per hectolitre (100 litres) has been calculated. Ethanol used for alcoholic beverage production has been reported under food and drink production in the industrial processes sector.

Other

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. Consumption data are obtained from a survey of the industry and Auckland Regional Council (1997) data. In the degreasing/drycleaning, printing and aerosols sub-categories, it is assumed that import data provided more consistent estimates than the Auckland Regional Council data. It is assumed that the emissions rate per capita derived by the United States Environmental Protection Agency (USEPA) are applicable to the average product use in New Zealand (CRL Energy Ltd, 2004). The emissions factor used (cumulative total for all products) is 2.54 kg NMVOC per capita per year (USEPA, 1985).

N_2O for anaesthesia

Activity data for 2003 are obtained from the importer of N_2O. 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 some is used in scientific analysis. No activity data are available for emissions in 1990-2003. Emissions are back-calculated for using the New Zealand population data as a surrogate for the emissions level. The calculated implied emissions factor is 0.039kg N_2O per capita.

5.1.3 Uncertainties and time-series consistency

Estimates of uncertainty are based on the assessment of the consultant (CRL Energy Ltd, 2004) which is based on information provided by industry in the questionnaires and discussions with respondents. The overall uncertainties are assessed to be:

- paint application: +60% (activity levels for paint application appear to significantly over-estimate paint sales)
- degreasing/drycleaning: +30%
- chemical product emissions: +20%
- printing, aerosols and domestic/commercial use: +80% (individual uncertainties are assessed to be +50%, +20% and +60% respectively)
- N_2O for anaesthesia: +5% 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 2003 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, 2000).

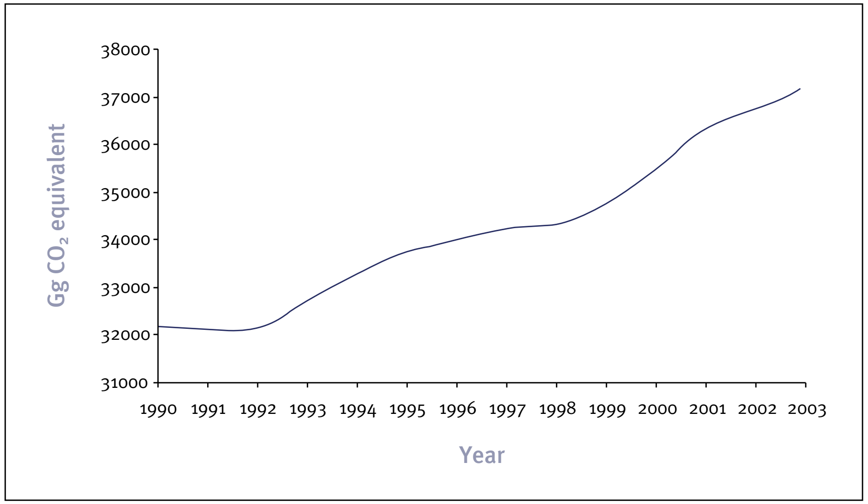
Chapter 6:

Agriculture

6.1 Sector overview

The agriculture sector emissions totalled 37,203.24Gg CO_2 equivalent and represented 49.4% of all greenhouse gas emissions in 2003. Emissions in this sector are now 15.6% higher than the 1990 level of 32,193.76Gg CO_2 equivalent (Figure 6.1.1). The increase is attributable to a 9.6% increase in CH_4 emissions from enteric fermentation and a 29.4% increase in N_2O emissions from the agricultural soils category.

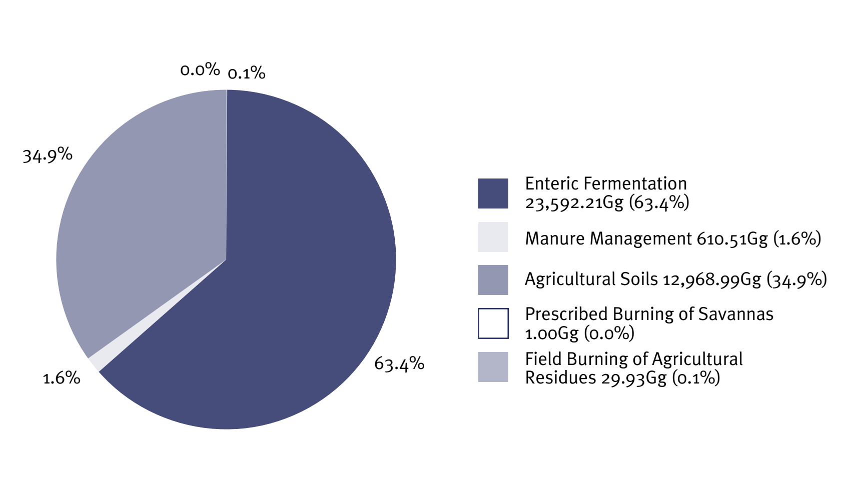
Figure 6.1.1 Agricultural sector emissions from 1990 to 2003



Emissions of CH_4 from enteric fermentation dominate the sector producing 63.4% of CO_2 equivalent emissions in the sector (Figure 6.1.2) and 31.3% of New Zealand's total emissions. N_2O emissions from agricultural soils are the other major component of the sector comprising 34.9% of agricultural 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 all 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 2003 (all figures Gg CO_2 equivalent)



Since 1984, there have been changes in the balance of livestock species. There has been a trend for increased dairy production and deer numbers for meat and velvet production due to the 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. At the same time there has been an expansion of the land used for plantation forestry. 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.

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 is 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 2003, emissions from enteric fermentation comprised 23,592.21Gg CO_2 equivalent. This represents 31.3% of New Zealand's total CO_2 equivalent emissions. The category is dominated by emissions from cattle which represent 57.6% of emissions from enteric fermentation. The current level of emissions from enteric fermentation is 9.6% 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 70.3% since 1990. This increase has been offset by decreases in emissions from sheep (-18.9%), goats (-86.1%) horses (-16.0%) and swine (-13.8%).

CH_4 is produced as a by-product of digestion in ruminants e.g. 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.

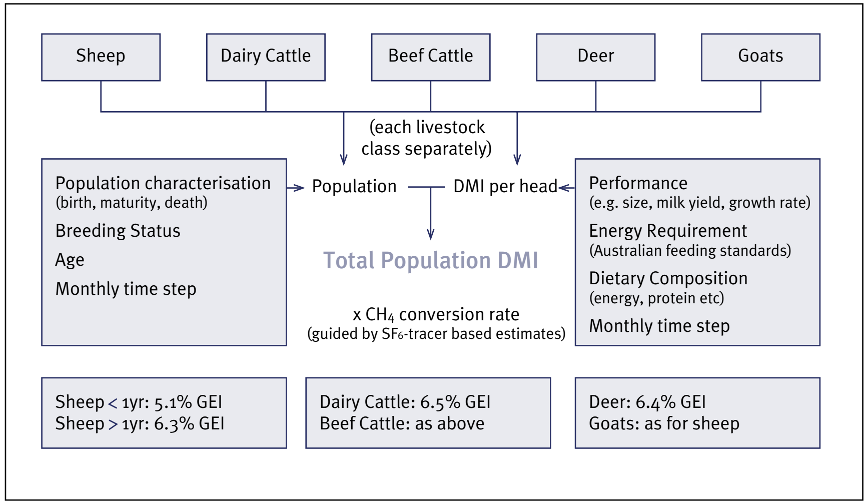
CH_4 emissions from enteric fermentation have been identified as the largest key category for New Zealand in the level assessment (excluding LULUCF). In accordance with good practice (IPCC, 2000), the methodology for estimating CH_4 emissions from enteric fermentation in domestic livestock was revised to a Tier 2 methodology for the 2001 and subsequent inventories.

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 IEFs for dairy cattle and beef cattle from 1990 to 2003. 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 2003 inventory, the uncertainty in the annual estimate was calculated using the 95% confidence interval determined from the Monte Carlo simulation as a percentage of the mean value i.e. in 2001, the uncertainty in annual emissions was ± 53%.

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% of New Zealand's total emissions and removals for 2003, and is the largest single component affecting the national total. However, in the trend from 1990 to 2003 the uncertainty from enteric fermentation is only 1.9% 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 CH_4 emissions in 1990, 2001 and 2003 and the 95% 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
2003	1,123.4	530.0	1,718.8

Note: The CH_4 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 (in press) 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

For the 2003 inventory, there are revisions due to a modification of the Tier 2 model to use industry data for milk yield rather than MAF estimates, using differential growth rates for stock up to weaning. This includes an allowance of N in milk powder fed to calves and correcting small errors in population models and data inputs. The provisional livestock population data for 2003 was updated to actual numbers and the corresponding three year average populations for 2001, 2002 and 2003 updated.

Sheep numbers used for the calculations between 1993 and 1996 were corrected. In these years a category 'other' appeared on the Statistics New Zealand data. Expert opinion is that these animals were probably new born lambs that were on the farm when the census is completed. In the 2003 inventory, these animals were treated as lambs and added to the lamb total for the purposes of estimating CH_4 and N_2O emissions.

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 to maximise the benefit of the existing programmes, and to develop a collaborative approach to improve the certainty of CH_4 emissions. This is funded through the MAF. 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 2 approach for CH_4 emissions from enteric fermentation and manure management is a consequence of the research conducted by the expert group.

6.3 Manure management (CRF 4B)

6.3.1 Description

CH_4 and N_2O are produced during the anaerobic decomposition and storage of manure. Emissions from the manure management category comprised 2.3% 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 2003 level and trend assessments (Tables 1.5.2 and 1.5.3).

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 62.0Gg CO_2 equivalent of N_2O in 2003. In comparison, agricultural soil emissions of N_2O totalled 12,969.0Gg CO_2 equivalent.

6.3.2 Methodological issues

Methane

Estimates of CH_4 emissions from manure management for cattle, sheep and goats are derived from Joblin and Waghorn (1994). Joblin and Waghorn used stock numbers, feed intake and digestibility data from Ulyatt (1992) to estimate total faecal output from cattle, sheep, goats and deer at approximately 16 million tonnes dry weight in 1990. The CH_4 estimates are based on the maximum potential emissions of CH_4 from animal waste. Therefore, actual emissions are likely to be substantially lower than the values reported (Joblin and Waghorn, 1994). The same emission factors are used for each year of the inventory (Table 6.3.1).

Table 6.3.1 Derivation of New Zealand emission factors for CH_4 emissions from manure

Animal class	Faecal dry matter (1000 t)	Estimated maximum CH_4 potential (1000 t)	Emissions factor (kg/animal/year)
Dairy cattle	2683.6	3.1	0.889
Non-dairy cattle	3647.5	4.2	0.909
Sheep	9009.1	10.3	0.178
Goats	115.4	0.1	0.119
Deer	313.5	0.4	0.369
Total	15769.1		

Although these emission factors are much lower than the IPCC default values, which are 32 and 6 kg CH_4/head/year for dairy and beef respectively, the IPCC defaults are not applicable to New Zealand conditions. For example, in New Zealand, dairy cows and beef animals are managed similarly on the pasture yet the IPCC emissions factor varies by a factor of 5. New Zealand specific emission factors are not available for CH_4 emissions from manure management for swine, horses and poultry. 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 these were applicable to New Zealand farming practices. For dairy cattle, New Zealand specific data from Ledgard and Brier (2004) were used.

The pasture, range and paddock AWMS is the predominant regime for animal waste in New Zealand. All sheep, goats, deer and non-dairy cattle excreta are allocated to the pasture, range and paddock AWMS. For dairy cattle, 95% of excreta are allocated to pasture, range and paddock and 5% 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 AWMS is shown in the agricultural worksheets in Annex 8. A time-series of Nex values used for calculating animal production N_2O emissions is also shown in the worksheets. The Nex values show an increase over time caused by the increases in animal production. The nutrient input/output model OVERSEER® 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.

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 $AWMS_{PRP}$ (manure deposited on pasture, range and paddock) which is a country specific factor (0.01 kg N_2O-N/kg N). The IPCC default values have uncertainties of -50% to +100% (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 of CH_4 emissions from enteric fermentation and N_2O from agricultural soils.

6.3.4 Source-specific QA/QC and verification

CH_4 emissions from manure management were identified as a key category for New Zealand in the 2002 inventory. In preparation of the 2003 inventory, the data for this category underwent a Tier 1 QC checklist (refer Annex 6 for examples).

6.3.5 Source-specific recalculations

There were substantial recalculations for this sector in the 2003 inventory. The major change was a redistribution of waste between AWMS for dairy cows. In previous inventories, 11% of dairy excreta were in anaerobic lagoons and 89% on pasture, range and paddock. A MAF commissioned study by Ledgard and Brier (2004) showed that values of 5% in lagoons and 95% on pasture are a more accurate representation of New Zealand dairy farming. The change in allocation of excreta was peer-reviewed by an independent scientist before being incorporated in the New Zealand inventory.

The CH_4 emissions factor for goats was changed from 0.12kg CH_4/head/yr (the IPCC value for a cool climate) to 0.18kg CH_4/head/yr (the IPCC value for temperate climate). All other livestock using IPCC values are allocated to a temperate climate. The change was made to make the allocation of goats consistent with other livestock. Revisions to the Tier 2 model to calculate dry matter intake also affected the Nex and consequently the N_2O emissions from manure management (refer to section 6.2.5).

6.3.6 Source-specific planned improvements, if applicable

New Zealand has developed a Tier 2 methodology to improve the estimate of CH_4 emissions from manure management. However, time constraints meant this method was not used for the 2003 inventory. Estimates using the Tier 2 method will be included in the next inventory submission in 2006.

6.4 Rice cultivation (CRF 4C)

6.4.1 Description

There is no rice cultivation in New Zealand. The 'NO' notation is used in the CRF.

6.5 Agricultural soils (CRF 4D)

6.5.1 Description

The agricultural soils category is the source of most N_2O emissions in New Zealand comprising 12,969.0Gg CO_2 equivalent in 2003. Emissions are 29.4% 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 three of these sub-categories have been identified as key sources for New Zealand (Tables 1.5.2 and 1.5.3). Direct soil emissions from animal production is the fourth largest key category comprising 7,455.5Gg CO_2 equivalent, indirect N_2O from nitrogen used in agriculture comprised 3,329.4Gg CO_2 equivalent and direct N_2O emissions from agricultural soils comprised 2,185.5Gg CO_2 equivalent.

CO_2 emissions from limed soils are included 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. Two New Zealand specific factors/parameters are used: EF_{3PRP} and $Frac_{LEACH}$. These factors 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.

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% of dairy cattle and 100% of sheep, goats, deer and non-dairy cattle are allocated to it. The emissions calculation is based on the livestock population multiplied by nitrogen excretion (Nex) values and the percentage of the population on the pasture, range and paddock AWMS. The Nex and allocation to AWMS are discussed in section 6.3.2 – nitrous oxide. The Nex values have been calculated using the model OVERSEER® 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 emissions factor for EF_{3PRP} 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 better quantification of EF_{3PRP}. Field studies have been performed as part of a collaborative research effort called NzOnet. The parameter EF_{3PRP} 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_{3PRP} data and their distribution with respect to pastoral soil drainage class to determine an appropriate national, annual mean value. The complete EF_{3PRP} 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 emissions 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% well-drained, 17% imperfectly drained and 9% poorly drained (Sherlock et al., 2001).

The research and analysis to date indicates that if excreta is separated into urine and dung, 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_{3PRP}. The IPCC default value of EF_{3PRP} is 0.002.

Indirect N_2O from nitrogen used in agriculture

The N_2O emitted indirectly from nitrogen lost from agricultural soils through leaching and run-off is shown in the agricultural worksheets in Annex 8. This nitrogen enters water systems and eventually the sea with quantities of N_2O being emitted along the way. The amount of nitrogen that leaches is taken as 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% higher than those estimated using the OVERSEER® nutrient budgeting model (the model provides average estimates of the fate of nitrogen (N) for a range of pastoral, arable and horticultural systems. In pastoral systems, N leaching is determined by the amount of N in fertilizer, farm dairy 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 estimates were closer for farms using high rates of N fertilizer, 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 two-fold higher than measured values. This indicated that a value of 0.07 for $Frac_{LEACH}$ more closely followed actual field emissions (Thomas et al., 2002) and this value was adopted and used for all years as it reflected 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 fertilizer use (SN), spreading animal waste as fertilizer (AW), nitrogen fixing in soils by crops (BW) and decomposition of crop residues left on fields (CR). 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 New 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 five fold increase in nitrogen fertiliser use over the 12 years, from 51,786 tonnes in 1990 to 298,380 tonnes in 2003. The calculation of N_2O that is emitted indirectly through synthetic fertilizer and animal waste being spread on agricultural soils is shown in the agricultural worksheets in Annex 8. Some of the nitrogen contained in these compounds is emitted into the atmosphere as ammonia (NH_3) and 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 F_{AW} 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 the IPCC default value of EF_1 of 0.0125 kg N_2O-N/kg N.

Direct N_2O emissions from organic soils are calculated by multiplying the area of cultivated organic soils by an emissions factor. Recent analysis identified 202,181 hectares of organic soils of which it is estimated that 5% (i.e. 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% of soils are classified as well-drained, while only 9% are classified as poorly drained. For the 2003 inventory, the uncertainty in the annual estimate was calculated using the 95% confidence interval determined from the Monte Carlo simulation as a percentage of the mean value i.e. in 2002, the uncertainty in annual emissions was +74% and -42%.

Table 6.5.1 Uncertainties in N_2O emissions from agricultural soils for 1990, 2002 and 2003 estimated using Monte Carlo simulation (1990, 2002) and the 95% CI (2003)

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	41.8	24.2	72.7

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. Uncertainty in N_2O emissions contributes 9.1% of the uncertainty in New Zealand's total emissions and removals in 2003 and 1.23% to the trend in emissions and removals from 1990-2003. 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.

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 2003 inventory. The Monte Carlo analysis confirmed that uncertainty in parameter EF_{3PRP} has the most influence on total uncertainty accounting for 91% 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_{3PRP}	90.8	88.0
EF_4	2.9	3.3
Sheep N Excretion	2.5	1.8
EF_5	2.2	2.8
Dairy N excretion	0.5	0.7
$Frac_{GASM}$	0.5	0.5
EF_1	0.3	2.4
Beef N excretion	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 MAF using urea production figures and industrial applications (including resin manufacture for timber processing) data.

6.5.5 Source-specific recalculations

Emissions from the agricultural soils category were recalculated for all years because of changes in the allocation of dairy cattle excreta between lagoons and pasture (refer 6.3.5), changes in the Nex values from modifications to the model for calculating dry matter intake (refer 6.2.5) and including an allowance for N stored in wool fleece, a correction of sheep numbers for 1993 through 1996 (refer 6.2.5), a recalculation of fertiliser sales figures for 2001 and 2002 from revised information, and correction of an error in inputs from crop residue. Previous inventories showed 50% of the residue from pulses and soyabeans being ploughed in but agricultural practice in New Zealand is to plough all residues into the soil.

N_2O emissions from horse excreta were not included in New Zealand's previous inventories. Emissions for horses were included in 2003 and back-calculated for all years.

6.5.6 Source-specific planned improvements

The work of N_2Onet 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 as savanna burning. 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 2003, total emissions accounted for 1.00Gg of CO_2 equivalent - a 70.0% reduction from the 3.33Gg CO_2 equivalent estimated 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 the Resource Management Act (1991) for burning. Only those areas with a consent are legally allowed to be burned. Expert opinion obtained from land managers is that approximately 20% 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 2003. 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 (i.e. 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% (Payton and Pearce, 2001). However, many IPCC parameters vary by ±50% 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 2003 inventory.

6.7 Field burning of agricultural residues (CRF 4F)

6.7.1 Description

Burning of agricultural residues produced 30.53Gg CO_2 equivalent in 2003. Emissions are currently 21.0% over the level in 1990. Burning of agricultural residues is not identified as a key source 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).

6.7.2 Methodological issues

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

Good practice suggests that an estimate of 10% 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). New Zealand estimates that common agricultural practice is that 50% of stubble is burnt. This figure is developed from expert opinion of MAF 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.

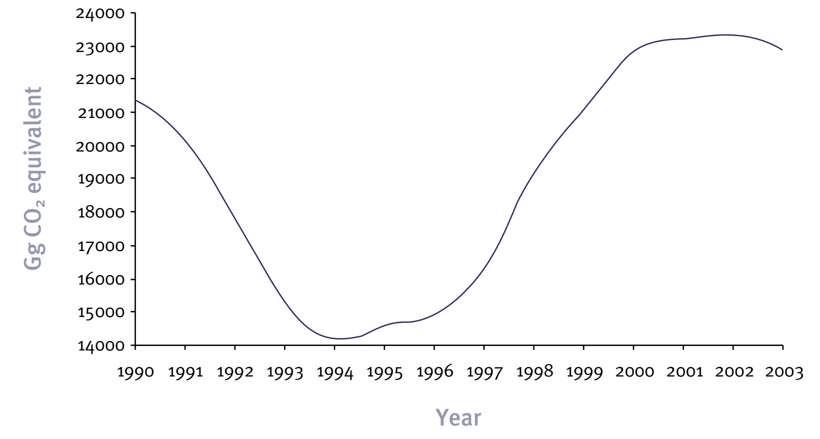
Chapter 7:

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 30.3% of all New Zealand's greenhouse gas emissions in 2003. Net removals from the LULUCF sector in 2003 totalled 22,861.60 Gg CO_2 equivalent and are 7.0% above net removals in 1990 (Figure 7.1.1).

Figure 7.1.1 LULUCF sector net removals from 1990 to 2003



7.1.1 A history of LULUCF in New Zealand

Prior to the first human settlement by Polynesians in about 1250 AD, approximately 75% of New Zealand's land area was estimated as natural forest. The forest area had reduced to about 60% by the mid-nineteenth century and was further reduced to the current approximate 23% 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*., 2003).

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 on-going forest removal. By the 1970's, 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% 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 2003 than has been emitted through forest harvesting of both the combined planted and natural forests. The average new planting rate (land reforested or afforested) over the last 30 years has been, on average, 44,900 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 2003, 19,900 hectares of new forest was established. Between 1990 and 2003 it is estimated that 660,000 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 (e.g. peat land) and that does not fall into the forest land, cropland, grassland or settlements categories. Natural rivers and lakes are unmanaged sub-divisions on wetlands.
- Settlements – all developed land, including transportation infrastructure and human settlements unless they are already included in 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 categories, and covering the period 1990 through to 2003, 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 requirements for the UNFCCC LULUCF inventory and Kyoto Protocol. Details of the monitoring system are included in Annex 3.2.

In previous inventories, New Zealand has only included information on net changes in the living biomass from forestry land use and emissions and removals from the planting of forest on grassland. To improve the completeness of the LULUCF sector reporting, New Zealand has modified an existing national land cover dataset to generate a Tier 1 calculation for the other LULUCF land categories. This calculation also enables a comprehensive key category analysis including the LULUCF sector and to trial the LULUCF CRF tables. New Zealand has also included a Tier 1 calculation of the country-specific model used for planted forestry to support the modelled values.

New Zealand has not yet developed 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. The Tier 1 calculation is provided for the years 1997 onwards.

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 LCDB's 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. The land categories to be mapped and monitored through NZCAS will be designed specifically for reporting under the UNFCCC and Kyoto Protocol, and will replace LCDB data in the inventory in the future.

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% of the surface area of New Zealand. Additional information on the processing to generate LCDB1 and LCDB2 is included in Annex 3.3. To complete the UNFCCC inventory, the land cover classes in the LCDB1 and LCDB2 were mapped to the applicable LULUCF categories (Table A3C.1).

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 sub-divisions are included in each land use category in the NIR. Land use change matrices including sub-divisions 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 2002-2003 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 i.e. 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 stock

Changes in carbon pools within a land-use category and between categories use 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, 2003), divided by the stock change factors for high producing grassland i.e. 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)		
	FLU	FMG	FI
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	222 t C ha-1	1st rotation, 28 years old (Wakelin, 2004).
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	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	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 (Gw=3.5 tonnes dm ha-1 (an average of the conifer (3.0) and broadleaf (4.0) values), R = 0.24, Cfrac = 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 (Gw=14.5 tonnes dm ha-1 (pinus), R = 0.23, Cfrac = 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), Cfrac = 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), Cfrac = 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 2003 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 LCDB2 also include 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 per cent 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 23,818.43 Gg CO_2 in the 2003 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 and recreation purposes. 99.9% 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 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 i.e. 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 an 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% of the forest area is planted in *Pinus radiata*, a forest is usually composed 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.
- Based on the results of this survey and stem wood volumes the C_Change model (Beets et al., 1999) is used to estimate forest biomass and carbon at one point in time. C_Change was previously known as the CARBON/DRYMAT model.
- The Forestry Oriented Linear Programming Interpretor (FOLPI) (Garcia, 1984; Manley et al., 1991) is also used to time-shift the estate forwards to forecast future forest growth and forest management, including harvesting.
- The models also time-shift historic estimates of CO_2 removals and emissions backwards using the latest available data.

Planted forest survey data: the results of the National Exotic Forest Description (NEFD) survey as at 1 April 2003 are used to calculate removals and emissions provided in the 2003 inventory. This latest information brings in new forest area data along with data on new planting, restocking and harvesting in 2003 (MAF, 2004).

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 2003 is based on (a) the latest area estimates provided by the 2003 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 2002 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 MAF statistics. These estimates are revised and recalculated annually as provisional estimates are replaced by confirmed actual areas.

To simplify the subsequent modelling, all crop-types are then aggregated to form a single, national area weighted crop-type (broken down by year of planting) and associated area-weighted national yield table. 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.

Modelling: the C_Change model estimates carbon stock per hectare, by component and annual age-class, from stem wood volume data (box 7.1). The second of the two models, FOLPI is a linear programming model that optimises the management of the forest estate across time while maximising the discounted harvest volume. The model simulates actual rates of planting and harvesting where time-series data exists.

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.

Several simplifications have been made in the C_Change model. Firstly it is assumed that all forests grow in a medium wood density region in New Zealand i.e. the trees have average wood density. Secondly, the model takes the weighted national crop-type as being wholly *Pinus radiata* when in fact around 10% of the estate is made up of other species such as Douglas-fir (5%) (*Pseudotsuga menziesii*), other exotic softwoods (2%) and exotic hardwoods (3%).

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 2003. 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. 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%. It is assumed that 25% 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 calculations (worksheets 5a-d), 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.

The non-CO_2 emissions estimated for burning of both forest biomass and grassland with woody vegetation are likely to be over-estimated as not all biomass is typically consumed in a fire event. For mature forests, the typical fuel load combusted may only be 10-40% of on-site biomass. For grassland with woody vegetation, the upper value could be somewhat higher (depending on seasonal and other factors), though combustion is again unlikely to be complete for wildfire events. The current assumptions reflect a lack of data on the percentage of fuel load combusted.

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.

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 (FLU, FMG, FI) 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 (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 i.e. equation 3.2.7 is based on the extracted roundwood volume rather than the area of forest harvested or disturbed (equation 3.2.9). The annual area of deforestation was calculated from the total area of LCDB1 forest classes that had changed to harvested forest in LCDB2, divided by the five years. Carbon stocks in living biomass for planted and natural forest were those documented in Table 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 were 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) (136t 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% 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 i.e. comparing annual NEFD survey versus remote sensing and extrapolation of previous interpolated planting trends, the lack of forest age data from the LCDB analysis, mapping of LCDB classes to LULUCF categories and the selection of 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 land (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 re-calculated.

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% for wood density, ±15% for carbon allocation and ±5% for carbon content. Combining the uncertainties indicates that the proportional error in the carbon sequestration estimates is likely to be at least ±16%. The total national planted area is considered to be accurate to within ±5% (MAF, 2003) and the yield tables are assumed to be accurate to within ±5%.

A sensitivity analysis was conducted using the above accuracy ranges for total planted area and commercial yield, and a proportional uncertainty error of ±16%. The C-Change (CARBON/ DRYMAT) model runs indicate that the precision of the carbon stock estimates could be of the order of ±25%. 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 6.7% of New Zealand's total emissions and removals in 2003. This is the third largest source of uncertainty in New Zealand's total for a given year. Forest land introduces 2.2% uncertainty into the trend in the national total from 1990 to 2003. 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.

The 2003 planted forests removals and emissions have been compared for consistency with the 2002 estimates (Wakelin S, *Carbon Inventory of NZ's Planted Forests [calculations revised as at April 2005]*, Forest Research, Contract Report, April 2005).

7.2.5 Source-specific recalculations

New proportions of area by NEFD regime are used to weight the carbon yield in the 2003 inventory. Area data and carbon yields underlying the models in recent reports are similar to those used previously.

Backcasting and recalculation of 1990-2002 values have been included as in previous years i.e. 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 re-calculated. The difference in net managed forest CO_2 removals between this and the previous inventory is generally of the order of less than 2%.

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 complete 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.

7.3 Cropland (CRF 5B)

7.3.1 Description

The 2003 inventory is the first inventory where New Zealand has reported emissions and removals from cropland remaining cropland and from land converted to cropland. In 2003, the net CO_2 removals were 583.87 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, oil seeds, vegetables, root crops and forages. Perennial crops include orchards, vineyards and plantations except where these lands meet the criteria for forest land.

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

7.3.2 Methodological issues

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

Cropland remaining cropland

Living biomass: as per GPG-LULUCF, 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% 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 e.g. (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 i.e. 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 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.
- EF1: the emissions 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 and 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% (95% 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 were 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 2003, the net emissions from grassland were 688.02 Gg CO_2. These emissions are from the sub-category ‘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% of New Zealand (Tate *et al*., 2004). The LCDB analysis used in the 2003 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% (95% 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 were 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 (e.g. 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 into the unmanaged wetlands category (Annex 3.3). Other LCDB classes e.g. herbaceous freshwater vegetation, commonly associated as a wetland in New Zealand, have been categorised as grassland following the GPG-LULUCF definitions. In 2003, 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 and 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 i.e. 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% 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 were 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 2003, the net emissions from settlements were 97.2 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 5.46kha (Table 7.1.1). The largest single category change in area was from high producing grassland converted to settlement, averaging 1.0 kha yr^{-1}.

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 e.g. 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% 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 were 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 do not fall into any of the other five land-use categories. The other land category is included in New Zealand's land area for checking overall consistency of land area and tracking conversions to and from other land. In 2003, the net emissions from other land were 31.6 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 e.g. 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 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% based on the uncertainty in carbon stocks lost during the conversion to other land e.g. GPG-LULUCF Table 3.4.2.

7.7.4 Category-specific QA/QC and verification

No specific QA/QC and verification were 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.

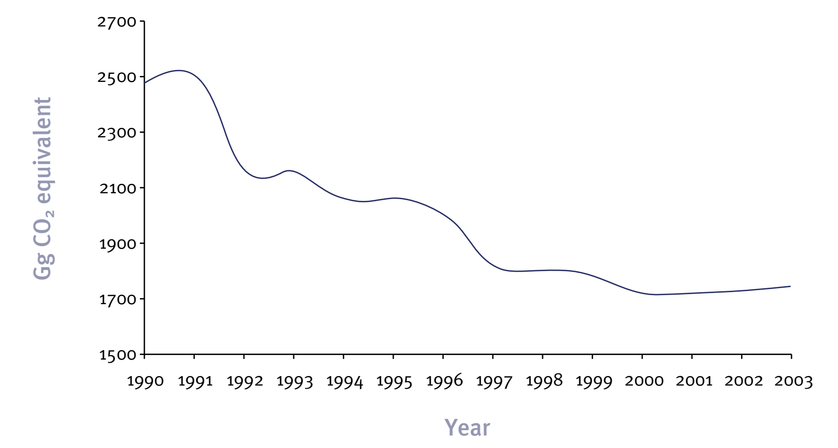
Chapter 8:

Waste

8.1 Sector overview

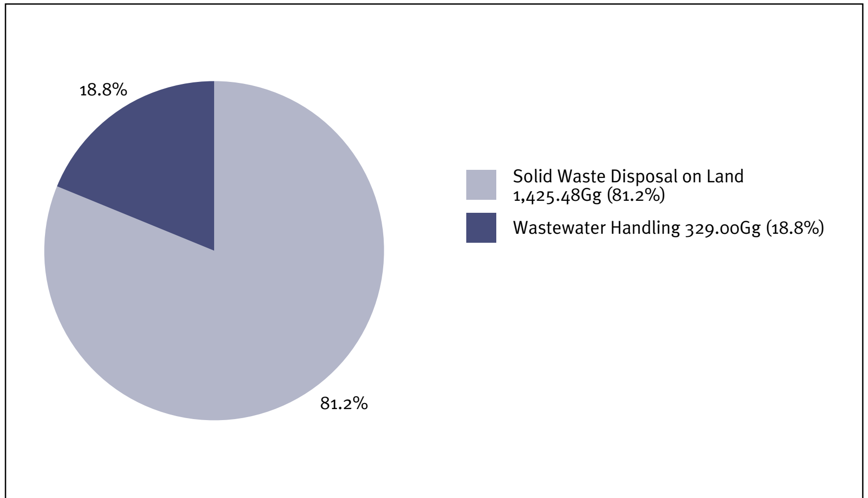
The waste sector totalled 1,754.48 Gg CO_2 equivalent in 2003 and represented 2.3% of all greenhouse gas emissions. Emissions in 2003 are now 29.2% below the 1990 baseline value of 2,480.06 Gg CO_2 equivalent (Figure 8.1.1). The reduction has occurred in the 'solid waste disposal on land' category, which has decreased by 34.5% as a result of initiatives to improve solid waste management practices in New Zealand.

Figure 8.1.1 Waste sector emissions from 1990 to 2003



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 and not estimated). CH_4 from solid waste disposal was identified as a key category for New Zealand in 2003 (Tables 1.5.2 and 1.5.3).

Figure 8.1.2 Waste sector emissions in 2003 (all figures Gg CO_2 equivalent)



Disposal and treatment of industrial and municipal waste can produce emissions of CO_2, CH_4, and NMVOC. The CO_2 is produced from the decomposition of organic material, however these emissions 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 versus 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 the Resource Management Act. As a result of these initiatives, a number of poorly located and substandard landfills have been closed and communities increasingly rely on modern regional disposal facilities for disposal of their solid waste. The 2002 Landfill Review and Audit discovered that there were 115 legally operating landfills in New Zealand - a reduction of 65% from 1995.

Recently, the 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, 2002) 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 methods to calculate emissions from solid waste. The data reported in the CRF follow the IPCC Tier 2, first order decay methodology (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 surveys (SWAP; MfE, 2003) 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% of New Zealand's waste was disposed to managed SWDS and 10%

to uncategorised sites (MfE, 1997)[2]. 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 waste statistics.

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 2003 was 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 was selected 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. These figures are consistent with good practice (IPCC, 2000).

The recovered CH_4 rate per year was estimated based on information from a previous survey of SWDS that serve populations of over 20,000 in New Zealand. The survey information was updated based on local knowledge and experience (SCS Wetherill Environmental, 2002).

8.2.3 Uncertainties and time-series consistency

The overall estimated level of uncertainty is estimated at ±20 percent, which is an improvement from previously reported uncertainties. The improvement is 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 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. The effect of this difference is mediated by the use of IPCC default carbon contents which are similar for the non-food (17% carbon content) and food categories (15% 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. For the 2003 inventory, the Tier 2 value of gross annual CH_4 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 2002. In preparation of the 2003 inventory, the data underwent Tier 1 QC procedures (refer Annex 6 for examples).

8.2.5 Source-specific recalculations

There have been several changes introduced to the methodology for estimating greenhouse gas emissions in the solid waste disposal on land sector for this inventory. The publishing of the 2002 Landfill Review and Audit and the 2003 SWAP baseline results presented an opportunity to recalculate total solid waste sent to landfills and the composition of that stream from 1995 to 2003.

Total solid waste sent to landfill was reported in 1995 and 2002. The intervening years and 2003 were given linearly equivalent totals. Recalculations based on changed total solid waste were carried out back to 1995.

[2] 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.

The solid waste stream composition in 1995 was redefined using the 2002 SWAP classifications to enable methodological consistency. The major difference between waste type data in 1995 and that of the 2002 SWAP is the reduction in the quantity of the solid waste stream classified as organic (reclassified as 'putrescibles') in 1995 from 36% to 28.2%. There was a corresponding increase in construction and demolition non-wood (reclassified as 'rubble/concrete'). This change is mostly due to soil moving from the organic waste category to rubble/concrete.

Recalculations were performed back to 1990 as a result of the reclassifications, resulting in a lower $L_0(x)$ than in previous reports, and a reduced 1990 baseline.

8.2.6 Source-specific planned improvements

New Zealand will consider reviewing the data and assumptions used for calculations in the solid waste disposal on land category during the 2005 calendar year. In particular, estimates of recovered CH_4 from solid waste disposal sites may be improved. Updated information will be included in New Zealand's next submission.

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 around 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 70g 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 CH_4 producing capacity factor (B_o). Where no data are available, the 1996 IPCC methodology recommends using B_o 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, 2001). New Zealand uses a B_o 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 the accompanying worksheets). 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[3]. 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 are used to calculate a per capita domestic nitrogen production of 13 g/day and a per capita wastewater nitrogen figure of 4.75 kg/person/year. The IPCC default method uses an emissions factor (EF_6) to calculate the proportion of raw sewage nitrogen converted to N_2O. New Zealand uses the IPCC default value of 0.01 kg N_2O-N /kg sewage N (Annex 8.6).

[3] An exception is the Christchurch sewage treatment plant that uses anaerobic lagoons for sludge treatment. Based on volatile solids reduction measurements in the lagoons, it is estimated that year 2001 CH_4 production of 0.46 Gg/year plus an additional 0.16 Gg/year from unburned CH_4 from the digester-gas fuelled engines.

Nitrous oxide emissions from industrial wastewater treatment

The IPCC does not offer a methodology for estimating N_2O emissions from industrial wastewater handling. Emissions are calculated using an emissions factor (kg N_2O-N / kg wastewater N) to give the proportion of total nitrogen in the wastewater converted to N_2O. The total nitrogen was calculated by adopting the COD load from the CH_4 emissions calculations and using a ratio of COD to nitrogen in the wastewater for each industry (Annex 8.6)

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% to +60% (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% 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, EF_6, has an uncertainty of –80% to +1,200% (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 2003 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 2003 inventory. The major change was in the 2000 inventory, where the calculations for CH_4 emissions from industrial wastewater handling were changed to COD from BOD. This change was because COD is the preferred IPCC measure (IPCC, 1996) and reliable COD measurements were available from the meat industry - the largest source of industrial wastewater CH_4 emissions.

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. Most regional and territorial councils have banned the open burning of waste and there is no incineration of municipal waste in New Zealand. The only incineration is for small specific waste streams including medical waste (five incinerators), veterinary and laboratory waste (six incinerators), quarantine waste (three incinerators) and hazardous waste (two incinerators). 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 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. Such incinerators without consents will be prohibited. The MfE is working with the Ministries of Education and Health to encourage other forms of waste disposal in schools and hospitals.

Chapter 9:

Recalculations and improvements

This chapter summarises the recalculations and improvements made to the New Zealand greenhouse gas inventory since the submission of the 2004 NIR (2002 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 emission 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. The 2003 inventory includes estimates for potential emissions from HFCs, SF_6, CO and NO_x emissions from aluminium production back to 1990 which were all recorded as NE in the 2002 inventory.

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 2003 inventory uses an average of the 2002, 2003 and 2004 year numbers. The 2002 and 2003 years are actual data, but only provisional data is available for the 2004 year. In the 2004 inventory, the provisional 2004 figures will be replaced by actual figures and the 2003 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.

9.1 Explanations and justifications for recalculations

9.1.1 Energy sector

Emission factors

- Separate emission factors are used for the first time in the 2003 inventory for the three key ranks of coal (bituminous, sub-bituminous and lignite). Previously, the emissions factor for sub-bituminous coal was used for all coal use.

- In accordance with the recommendations in Hale and Twomey (2003), the CH_4 emission factors for gasoline and diesel used in road transport, rail transport and mobile agriculture should have been changed from New Zealand specific factors to IPCC default emission factors. The NO_x emission factors for the same fuels and sectors should also have been updated. In each case, the New Zealand specific emission factors were used for all years in the 2002 inventory. This has been fixed by using the recommended emission factors in this inventory.

Activity data revisions

- During 2004, a review of the data provided by the oil companies to Statistics New Zealand via the Deliveries of Petroleum Fuels by Industry (DPFI) survey uncovered substantial misreporting of certain liquid fuels. This lead to some revisions of liquid fuel consumption data, especially for 2002. The result is that energy sector emissions from liquid fuels are lower for the 2002 year than reported in last year's inventory. The emissions estimate for the transport sector has also been decreased given that the bulk of liquid fuels are used in this sector.
- Fugitive emissions from coal mining have been recalculated due to the revision of data on tonnes of coal mined from surface and underground mines. New Zealand has switched to a new data series (that is considered to be of higher quality) based on energy resource levy payment.
- From 1999, LPG consumption in the transport sector has been revised downward and emissions in the 'manufacturing industries and construction' category have been revised upwards.

Methodology revisions

- A Tier 2 approach has been developed in line with good practice to be used in parallel with emissions from road transport (estimated using the Tier 1 approach). The Tier 2 methodology provides an important quality check for the Tier 1 top-down approach for calculating CO_2 emissions. A reliable and accurate bottom-up CO_2 emissions estimate increases confidence in the underlying activity data used for the inventory and these attributes in turn are important for the bottom-up calculation of CH_4 and N_2O emissions from road transport.

Reallocations

- In previous inventories, estimates of sectoral coal consumption shares were based on surveys undertaken by Coal Research Limited (CRL) in 1990 and 1995 with the exceptions of the electricity generation, steel production and residential categories. Sectoral coal shares in other years were based on interpolated values (between 1990 and 1995) and extrapolated values (after 1995). However, total coal consumption across all categories (excluding electricity generation) was based on Statistics New Zealand's Annual Coal Sales Survey. In order to avoid basing emissions estimates on extrapolated data and to be consistent with national energy statistics, estimates of sectoral coal use are now based exclusively on the Coal Sales Survey. This change has resulted in a reallocation of emissions from the 'manufacturing industries and construction' category to the 'commercial/institutional' category. There have also been some reallocations of emissions to and from the agriculture/forestry/fishing subcategories depending on the year.
- Emissions from gas used in the iron and steel industry are provided separately for the first time - previously they were included in the 'manufacturing industries and construction (other)' category.
- Emissions from urea production are no longer included under 'chemicals' in the energy sector and are included under 'industry chemicals' in the industrial processes sector. The rationale behind this re-allocation of urea production is one step further on from ammonia production (ammonia is used in the production of urea) and most of the emissions are emitted in the stage where ammonia is being produced. In New Zealand, all ammonia produced is used in the production of urea.
- Fugitive emissions previously assigned to the 'natural gas\transmission' category have been reallocated to the 'natural gas\distribution' category as almost all of the emissions from gas transportation are actually from the distribution network rather than from the transmission network. Emissions from transmission and distribution are combined for confidentiality reasons.
- Fugitive emissions previously assigned to the 'venting and flaring\flaring\combined' category have been reallocated to the 'venting and flaring\flaring\gas' category as virtually all of the flaring is of gas. There was only an insignificant amount of condensate flaring in 1991.

Other (errors)

- In previous inventories there was some double-counting of emissions in the 'public electricity and heat production' and 'manufacturing industries and construction (other)' categories. The emissions were subtracted from the 'electricity and heat production' category as it was decided to re-classify the co-generation plants.
- There have also been several other minor re-calculations. These are documented in the common reporting format tables.

9.1.2 Industrial processes sector

Mineral products – cement production

The calculation of CO_2 emissions from cement production uses Tier 1 methodology (1990-1996) and Tier 2 methodology (1997-2003). In previous inventories, a Tier 1 methodology was used for all years.

Chemical industry – urea

As mentioned in the previous section, emissions from urea production have been re-allocated from the energy sector to the industrial processes sector. Further, CO_2 emissions from urea production have been revised upwards since the 2002 inventory as the carbon sequested in the urea is no longer taken into account. This carbon is now assumed to be released when the urea is applied to the land.

Chemical industry – methanol production

Activity data for methanol production back to 1990 became available so CH_4 emissions for the entire time-series were able to be calculated (the 2002 inventory was only able to use activity data back to 1997).

Metal production – iron and steel

Emissions from iron and steel production have been revised downward due to methodological changes and corrections in the data supplied by one of the steel plants. Firstly, New Zealand is now accounting for the amount of carbon sequested in the steel produced by New Zealand's biggest steel maker, which produces steel from ironsand. Secondly, there have been revisions to the CO_2 emissions from New Zealand's other plant which produces steel from mainly scrap metal using an electric arc furnace. Estimates have been based on a mass balance approach. However, due to errors in the assumed carbon contents of the scrap metal input and the steel produced, the levels of emissions for the 2002 inventory were grossly over-estimated. For all years from 2000, emissions have been re-calculated based on corrected carbon content values of scrap and steel. Due to lack of data for the years prior to 2000, it is assumed (based on the average implied emissions factor since 2000) that 1 t of steel produced is associated with 0.1 t of CO_2. Emissions of CO_2 from iron and steel production now range from 11 kt to 21 kt compared with 24 kt to 70 kt previously.

Consumption of halocarbons and SF_6

There were inconsistencies in the methods used to estimate SF_6 emissions for the years 1998 and 1999 compared with the rest of the time-series in the 2002 inventory which resulted in the emissions approximately doubling for those years. This has been corrected by interpolating values for those years using the average SF_6 values for the periods 1994-97 and 2000-03.

9.1.3 Solvents and other products

No recalculations made for this sector.

9.1.4 Agriculture sector

Animal statistics

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

Sheep numbers used for the calculations between 1993 and 1996 were corrected. In these years a category 'other' appeared on the Statistics New Zealand data. Expert opinion is that these animals were probably new born lambs that were on the farm when the census is completed. In the 2003 inventory, these animals were treated as lambs and added to the lamb total for the purposes of estimating CH_4 and N_2O emissions.

Enteric fermentation

The Tier 2 model used to estimate emissions from enteric fermentation was modified to update several factors and correct small errors in algorithms (refer to section 6.2.5).

Manure management

There were substantial recalculations for this source in the 2003 inventory. The main change was the redistribution of waste between AWMS for dairy cows, from 11% of dairy excreta in anaerobic lagoons and 89% on pasture in previous inventories, to 5% in lagoons and 95% on pasture in the 2003 inventory (see section 6.3.5).

The CH_4 emissions factor for goats was changed from 0.12 kg CH_4/head/yr (the IPCC value for a cool climate) to 0.18 kg CH_4/head/yr (the IPCC value for a temperate climate) to make the allocation of goats consistent with other livestock using IPCC default values.

Agricultural soils

Emissions from the agricultural soils category were recalculated due to a number of changes (further details can be found in section 6.5.5):

- reallocation of dairy excreta between lagoons and pasture
- changes in the N_{ex} values
- correction of sheep numbers from 1993 to 1996
- recalculation of fertiliser sales figures from updated information
- correction of an error in inputs from crop residue
- N_2O from horse excreta included for 2003 and back-calculated for all years.

Nitrogenous fertiliser usage

The nitrogenous fertiliser statistics for 2002 were revised due to a re-examination of sales figures. This affected the 2001 and 2002 inventory. No other years were affected.

9.1.5 LULUCF

In previous inventories, New Zealand has only included information on net changes in the living biomass from the LULUCF category 'forest land remaining forest land (planted forest)' and emissions and removals from the planting of forest on grassland. In the 2003 inventory, New Zealand has improved the completeness of the LULUCF sector reporting by including a Tier 1 estimate for all LULUCF land-use categories from 1997 to 2003. This has reduced the estimates of LULUCF for the years 1997-2002. As a result of using the LULUCF categories, land previously reported by New Zealand as non-forest scrubland is classified as grassland as per GPG-LULUCF definitions.

Removals in planted forest for all years (1990-2002) are also recalculated as a result of backcasting and recalculation of the planted estate from the current forest model. New proportions of area by NEFD regime are used to weight the carbon yield for planted forests.

9.1.6 Waste

There have been changes to the methodology for the solid waste disposal category. The publishing of the 2002 Landfill Review and Audit and the 2003 SWAP baseline results allowed the total solid waste sent to landfill to be recalculated and re-analysis of the composition of the waste stream from 1995-2003 (see section 8.2.5 for further details).

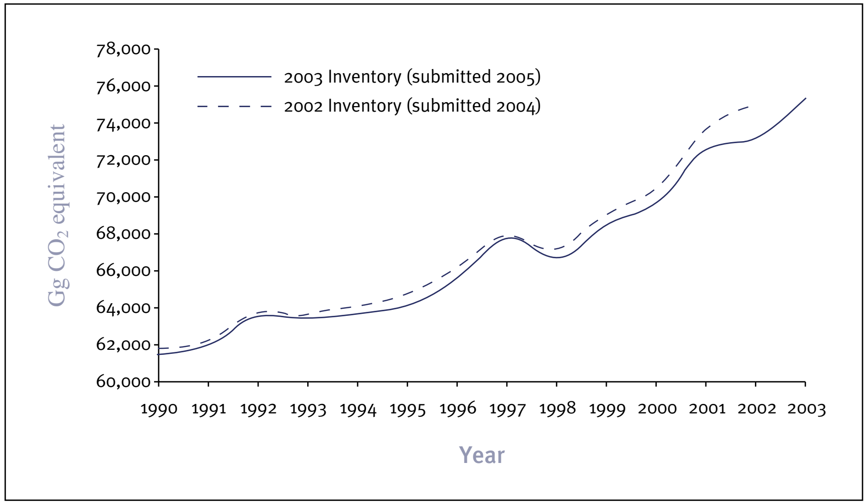
9.2 Implications for emission levels

The overall effect of all recalculations is shown in Figure 9.3.1. There is a 2.3% reduction in emissions for the 2002 year primarily because of the correction of liquid fuel data in the energy sector.

9.3 Implications for emission trends

In New Zealand's 2002 inventory, emissions were 21.6% over the level reported in 1990. In the 2003 inventory, New Zealand's total emissions for 2003 are 22.5% over the level in 1990. As a result of the recalculations, total emissions for 2002 decreased and emissions for 2002 were recalculated as being 19.0% 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.

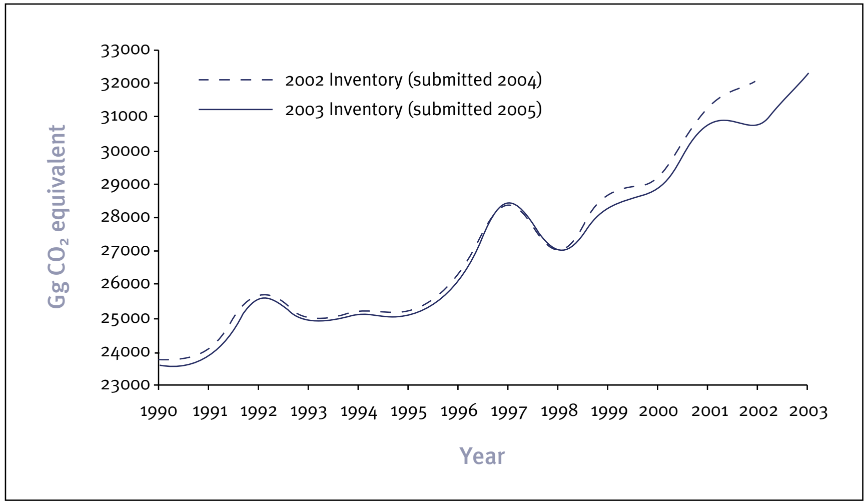
Figure 9.3.1 The effect of recalculation on total emissions



Energy sector

Several recalculations affecting most categories in the energy sector (as explained in section 9.1.1) have occurred in this inventory. Figure 9.3.2 shows that apart from the correction of fuel data in 2002, the overall effect of the recalculations was small.

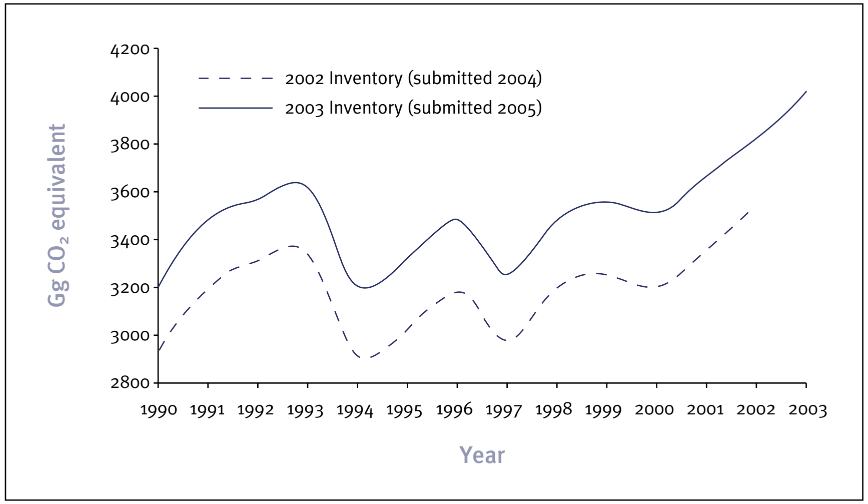
Figure 9.3.2 The effect of recalculation on the energy sector



Industrial processes

There were a number of recalculations within the industrial processes sector in this inventory (explained in section 9.1.2) with the biggest effect being the inclusion for the first time of ammonia/urea emissions (Figure 9.3.3).

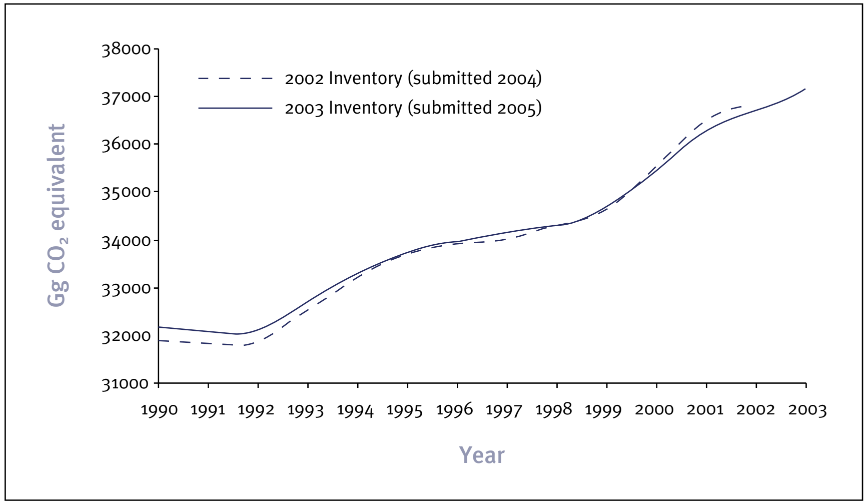
Figure 9.3.3 The effect of recalculation on the industrial processes sector



Agriculture

There are a number of recalculations within the agriculture sector in this inventory (explained in section 9.1.4). The combined effect of these emissions has had only a small effect on the total emissions from the agriculture sector.

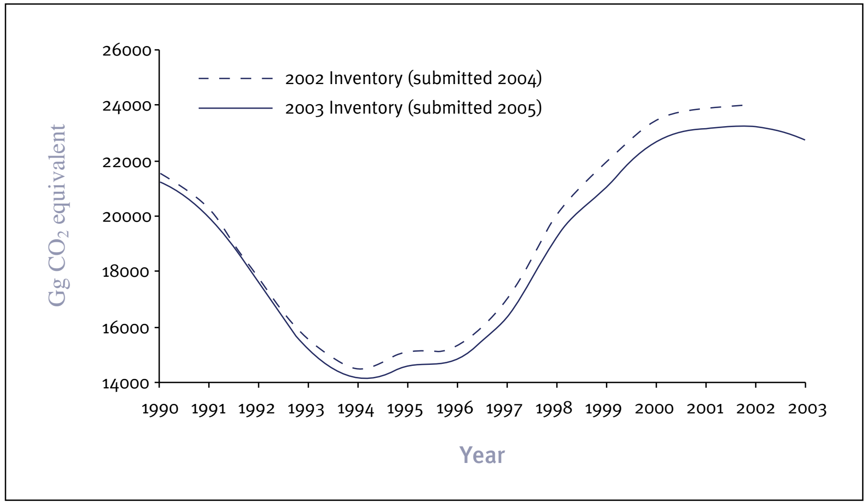
Figure 9.3.4 The effect of recalculation on the agriculture sector



LULUCF

The recalculations within the LULUCF sector (explained in section 9.1.5) in this inventory has resulted in a small decrease in net removals (Figure 9.3.5). The decrease is more pronounced for the years 1997-2003 because the emissions from all LULUCF categories are included, whereas the information was not available for 1990-1996.

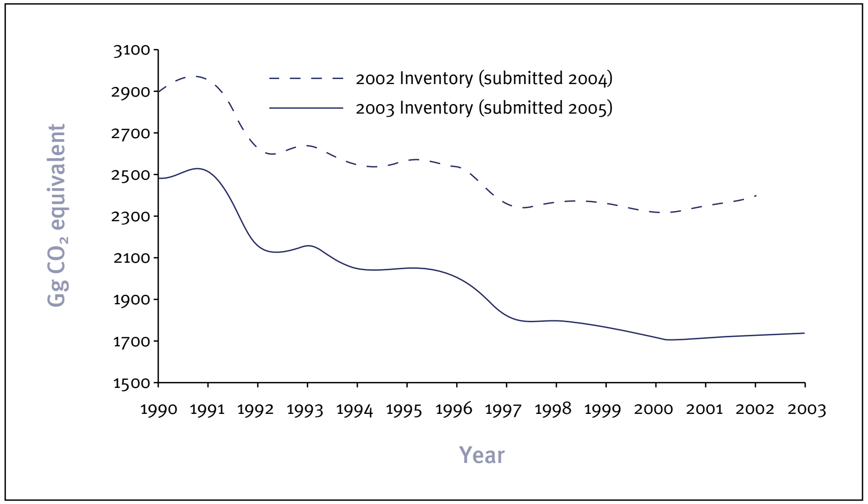
Figure 9.3.5 The effect of recalculation on LULUCF net removals



Waste

The emissions for 1990-2002 from solid waste disposal sites based on changed total solid waste are recalculated back to 1995 and recalculations as a result of the reclassification of the waste stream were performed back to 1990. These resulted in a lower $L_o(x)$ value compared with previous inventories and a 15% reduction in the 1990 baseline as shown in Figure 9.3.6.

Figure 9.3.6 The effect of recalculations on the waste sector



9.4 Recalculations in response to the review process and planned improvements

9.4.1 Response to the review process

The UNFCCC secretariat conducted a centralised review of New Zealand's inventory (UNFCCC, 2005). Table 9.2 provides an overview of the actions taken to improve the NIR and inventory in response to the comments made by the expert review team (ERT).

A few tasks have not been finished in time to be incorporated into this inventory submission but are included in the New Zealand improvement plan to be actioned during 2005 (with the aim of being included in the next submission in 2006).

Table 9.4 Details of improvements to the NIR and inventory in response to the UNFCCC 2004 review

ERT comment	Action taken
Improve transparency of methodological descriptions of country-specific methods & EFs (esp. agricultural sector).	There are continuous improvements in transparency. The NIR has increased in size by 18% since last year's inventory.
Include complete set of EFs used in energy sector.	Included in Annex 2 of the NIR.
Include national energy balance in future NIRs to improve transparency.	Recommendation noted with a view to incorporating this in a future submission.
Indicate whether information on international bunker fuels obtained from MED and Statistics NZ is in accordance with IPCC GPG.	More information will be included in the next submission.
Variability in CO_2 IEFs for gaseous fuels.	Additional information has been added to the NIR.
Implement Tier 2 methodology to estimate CO_2 emissions from road transportation.	A Tier 2 model was implemented and some results included in the 2005 NIR.
Review method of estimating CO_2 emissions from cement production.	Additional explanation was added to the NIR.
More information on iron and steel methodology for CO_2 emissions.	Additional explanation was included in the NIR.
Estimate and report potential emissions for halocarbons & SF_6.	Potential emissions included in the CRF.
Report ammonia production under industrial processes rather than energy sector.	Ammonia/urea production included in the industrial processes sector in NIR.
Soda ash production/use should be estimated and reported.	New Zealand will endeavour to get an estimate during 2005 to be included in the 2006 submission.
Various comments on explanations of country specific EFs and methodologies in the agricultural sector.	Additional explanations have been included in the NIR.
Use default values to give estimate for C fluxes in subcategories previously reported as NE.	A Tier 1 value was calculated for all LULUCF categories (where GPG provided a Tier 1 method) for the years 1997-2003. A lack of any data prevented completing the time-series 1990-1996.
Various comments on the waste sector to improve completeness and update MSW generation waste data.	Total SWD values were updated and a recalculation of the time-series was included in the 2005 NIR. Investigations to get estimates on sub-categories not currently reported are being undertaken and results reported in future submissions.

9.4.3 Planned improvements

Improvements to methodology/emission factors are discussed under each sector and/or category as appropriate. New Zealand will undertake additional Tier 2 checks of key categories as resources permit.

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. Although New Zealand is yet to formally describe the national system, many of the arrangements detailed in the guidelines for national systems are described in this NIR e.g. designation of the national identity and assignment of responsibilities for inventory preparation, and the development of remaining requirements in progress.

The MfE anticipates adding additional human resources to ensure sufficient capacity for timely performance for estimating anthropogenic greenhouse gas emissions by sources and removals by sinks (FCCC/CP/2001/13/Add.3). The MfE will also investigate application or development of an inventory information system to improve inventory generation processes.

9.5 Summary of recent improvements to the inventory

9.5.1 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 were available.
- Using the UNFCCC CRF Reporter tool to improve the quality of data entered into the CRF.

9.5.2 Improvements in the 2002 inventory

In the 2004 submission for the 2002 inventory, the focus was to provide a complete series of common reporting format tables for 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 sectors.

9.5.3 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 on-going 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.

9.5.4 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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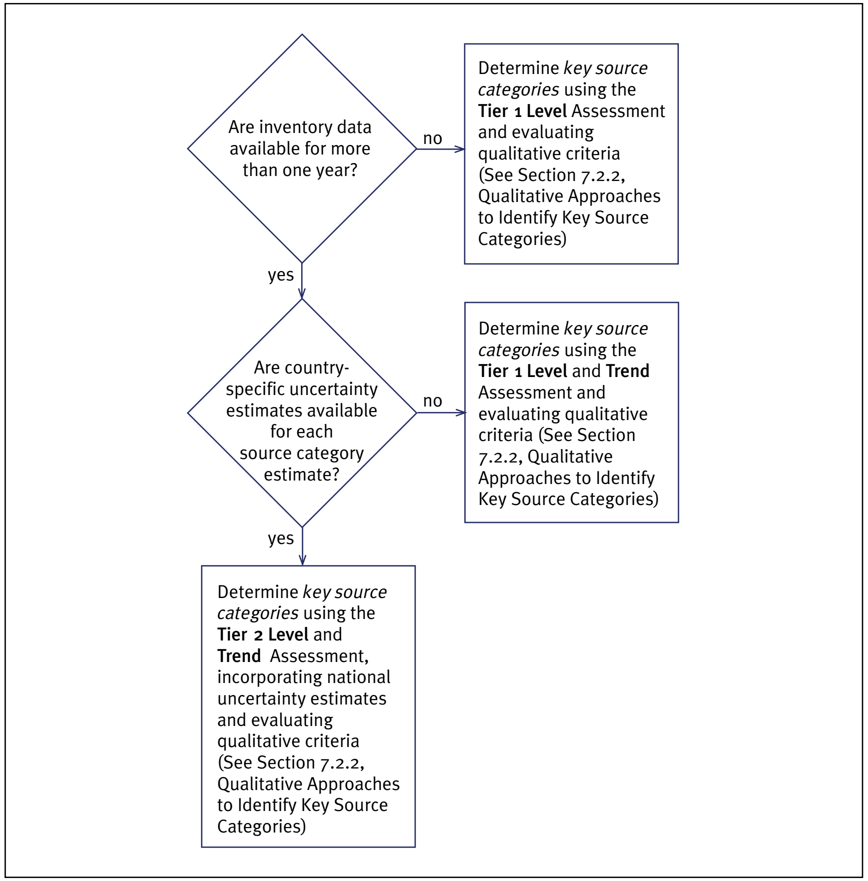
Annex 1:

Key sources

A1.1: Methodology used for identifying key sources

The key sources 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 2003 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% of the total level or trend. Categories occurring between 95% and 97% of the cumulative total were qualitatively assessed as to whether or not 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 the 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% of the total emissions and removals in 2003. Key categories are those that comprise 95% of the total.

Tier 1 Source Category Level Assessment – including LULUCF				
IPCC Source Categories	Gas	2003 estimate Gg	Level assessment	Cumulative total
Forest land remaining forest land	CO_2	25583.91	24.5	24.5
Emissions from enteric fermentation in domestic livestock	CH_4	23592.21	22.6	47.1
Mobile combustion – road vehicles	CO_2	12094.67	11.6	58.7
Emissions from stationary combustion – gas	CO_2	8558.10	8.2	66.9
Emissions from agricultural soils – animal production	N_2O	7454.62	7.1	74.1
Emissions from stationary combustion – solid	CO_2	5435.29	5.2	79.3
Indirect emissions from nitrogen used in agriculture	N_2O	3328.82	3.2	82.5
Emissions from stationary combustion – liquid	CO_2	2797.95	2.7	85.2
Direct emissions from agricultural soils	N_2O	2185.55	2.1	87.3
Conversion to forest land	CO_2	1765.49	1.7	88.9
Emissions from the iron and steel industry	CO_2	1716.80	1.6	90.6
Emissions from solid waste disposal sites	CH_4	1425.48	1.4	92.0
Mobile combustion – aviation	CO_2	1158.33	1.1	93.1
Conversion to grassland	CO_2	688.02	0.7	93.7
Cropland remaining cropland	CO_2	653.46	0.6	94.4
Emissions from manure management	CH_4	549.44	0.5	94.9
Emissions from aluminium production	CO_2	542.14	0.5	95.4

Tier 1 Source Category Level Assessment – including LULUCF				
IPCC Source Categories	Gas	2003 estimate Gg	Level assessment	Cumulative total
Emissions from cement production	CO_2	527.47	0.5	95.9
Emissions from substitutes for ozone-depleting substances	HFCs	403.96	0.4	96.3
Fugitive emissions from oil and gas operations	CO_2	380.93	0.4	96.7
Mobile combustion – marine	CO_2	370.94	0.4	97.0
Fugitive emissions from coal mining and handling	CH_4	332.25	0.3	97.3
Fugitive emissions from geothermal operations	CO_2	269.11	0.3	97.6
Emissions from hydrogen production	CO_2	184.35	0.2	97.8
Emissions from wastewater handling	CH_4	166.11	0.2	97.9
Mobile combustion – rail	CO_2	164.19	0.2	98.1
Emissions from wastewater handling	N_2O	162.89	0.2	98.2
Mobile combustion – road vehicles	N_2O	129.91	0.1	98.4
Emissions from lime production	CO_2	111.36	0.1	98.5
Non-CO_2 emissions from stationary combustion	N_2O	104.62	0.1	98.6
Conversion to settlement	CO_2	97.17	0.1	98.7
PFCs from aluminium production	PFC	80.70	0.1	98.7
Conversion to cropland	CO_2	69.59	0.1	98.8
Emissions from manure management	N_2O	61.07	0.1	98.9
Fugitive emissions from geothermal operations	CH_4	51.13	0.0	98.9
Mobile combustion – road vehicles	CH_4	50.44	0.0	99.0

Table A1.2 (Table 7.A2 of Good Practice) showing the results of the key category trend analysis for 99% of the total emissions and removals in 2003. Key categories are those that comprise 95% of the total.

Tier 1 Source Category Trend Assessment – including LULUCF						
IPCC Source Categories	Gas	Base year estimate Gg	2003 estimate Gg	Trend assess-ment	Contri-bution to trend	Cumulative total
Mobile combustion – road vehicles	CO_2	7534.65	12094.67	0.031	16.9	16.9
Emissions from enteric fermentation in domestic livestock	CH_4	21530.77	23592.21	0.030	16.3	33.2
Forest land remaining forest land	CO_2	22677.47	25583.91	0.024	12.9	46.1
Emissions from stationary combustion – solid	CO_2	3169.41	5435.29	0.017	9.2	55.3
Direct emissions from agricultural soils	N_2O	585.22	2185.55	0.016	8.7	63.9
Emissions from solid waste disposal sites	CH_4	2177.70	1425.48	0.013	7.3	71.3
Emissions from stationary combustion – gas	CO_2	7682.58	8558.10	0.009	5.0	76.3
Emissions from agricultural soils – animal production	N_2O	6767.81	7454.62	0.009	4.9	81.2
Conversion to forest land	CO_2	960.59	1765.49	0.006	3.5	84.6

Tier 1 Source Category Trend Assessment – including LULUCF						
IPCC Source Categories	Gas	Base year estimate Gg	2003 estimate Gg	Trend assess-ment	Contri-bution to trend	Cumulative total
PFCs from aluminium production	PFC	515.60	80.70	0.006	3.2	87.9
Emissions from substitutes for ozone-depleting substances	HFCs	0.00	403.96	0.004	2.4	90.3
Emissions from stationary combustion – liquid	CO_2	2546.55	2797.95	0.003	1.9	92.2
Mobile combustion – aviation	CO_2	772.83	1158.33	0.002	1.2	93.4
Fugitive emissions from geothermal operations	CO_2	357.34	269.11	0.002	1.0	94.4
Emissions from manure management	CH_4	574.51	549.44	0.002	0.9	95.3
Mobile combustion – road vehicles	CH_4	148.20	50.44	0.001	0.8	96.1
Emissions from the iron and steel industry	CO_2	1329.40	1716.80	0.001	0.5	96.6

Tier 1 Source Category Trend Assessment – including LULUCF						
IPCC Source Categories	Gas	Base year estimate Gg	2003 estimate Gg	Trend assess-ment	Contri-bution to trend	Cumulative total
Emissions from cement production	CO_2	366.66	527.47	0.001	0.5	97.1
Mobile combustion – rail	CO_2	77.50	164.19	0.001	0.4	97.5
Mobile combustion – marine	CO_2	247.82	370.94	0.001	0.4	97.9
Indirect emissions from nitrogen used in agriculture	N_2O	2668.96	3328.82	0.001	0.4	98.2
Fugitive emissions from oil and gas operations	CO_2	263.95	380.93	0.001	0.3	98.6
Mobile combustion – road vehicles	N_2O	64.25	129.91	0.001	0.3	98.9
Non-CO_2 emissions from stationary combustion	CH_4	60.19	40.72	0.000	0.2	99.1

Annex 2:

Methodology and data for estimating emissions from fossil fuel combustion

New Zealand emission factors are based on GCV 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 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 by Industry* survey. Statistics New Zealand is New Zealand's national statistical office and administers the Statistics Act 1975.

The *Delivery of Petroleum Fuels by Industry* is a quarterly survey. The purpose of the survey is to provide data on the amount of fuel delivered by 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% uncertainty associated with the sectoral energy allocation although the annual totals are likely to be more certain (MED, 2003).

The survey 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[4]). 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% (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 emissions factor used by New Zealand is either the IPCC value that was the 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 2003 inventory. All emission factors from the IPCC Guidelines are converted from NCV to GCV.

[4] 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

	Emission factor (t CO_2/TJ)	Emission factor (t C/TJ)
Gas		
Maui	52.0 (2003)	14.2 (2003)
Treated	52.6 (2003)	14.3 (2003)
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 emission 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

	Emissions 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

	Emissions 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	0.38	IPCC Tier 2 (table 1-16) distillate oil boilers
Mobile Sources		
LPG	0.57	IPCC Tier 1 (table 1-8) oil – all sources except aviation
Petrol	1.42	IPCC Tier 2 (table 2.7 in 'Good practice...' (2000)) US gasoline vehicles (uncontrolled)
Diesel	3.7	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 (i.e. units with the wrong New Zealand Standard Industrial Classification), respondent error (i.e. 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 are 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% is assumed to cover these issues (MED, 2003).

The sectoral partitioning used for coal was examined in 2003 by MfE officials. There was concern in extrapolating sectoral allocations from 1995 to 2002 given some probable changes in sectoral coal usage. However, coal industry experts (W.Hennessy pers comm.) did not consider a survey could be justified because of the difficulty and expense in collating and verifying data from a number of sectors. Furthermore, data for 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%. Therefore the estimated uncertainty in coal emission factors is taken as ± 3% (MED, 2003). An uncertainty of ± 2% is used for the sub-bituminous coal used in public electricity generation. All New Zealand values are within 2% 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%. Whenever the error between the meter reading and actual gas supplied exceeds 2%, adjustments are made to the reported quantities of gas supplied. The uncertainty is therefore assumed to have an upper limit of ± 2% (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% (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 52.0 kt CO_2/PJ in 2002 and the other half is treated gas (52.6 kt CO_2/PJ). The average value of 52.3 kt CO_2/PJ is used for the 2003 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

A2.4: A Tier 2 assessment of road transport emissions

In line with good practice, New Zealand has developed a Tier 2 model for estimating CO_2, CH_4 and N_2O emissions from mobile combustion to support the Tier 1 estimate. The Tier 2 model is described below.

In New Zealand every vehicle is registered, and licensed annually, with information held on the make, model and other attributes of the vehicle in a centralised database – the Motor Vehicle Register. This provides information on the composition of the vehicle fleet and variation over time. The New Zealand Ministry of Transport maintains a Vehicle Fleet Model (VFM) which translates the fleet composition profiles into environmental performance measures. Within this process, the VFM calculates fuel used by the vehicle fleet, based on data as available and supporting estimates on vehicle fuel economy and usage.

The inputs to the model, which strongly influence how much fuel is used, include:

1. Fuel economy estimates for the different vehicle classes i.e. technical efficiency, type of engine and emission control technology, and vehicle/engine size. Also, for the heavy freight sector, consideration of the load transported.
2. Estimates of activity – distance travelled annually by vehicle class and also the driving conditions. This involves distributing the Vehicle Kilometres Travelled (VKT) over different road types and congestion levels. Standard conventions, common to road and traffic engineering, are used.

Limited data sources are available for direct use in calibrating this model. Determining the input factors requires an expert judgement of likely efficiency of the fleet and driving patterns. These factors will be refined as data sources develop. For example, new entrants to the fleet now have their standard reference fuel consumption measure recorded in the database, and more sophisticated procedures are in process for monitoring VKT. In time, this information will be available as a routine, coherent data source. In the meantime, an expert assessment of fuel economy is used. Numbers are based on knowledge of the available vehicle technology and fuel consumption performance relationships, and variability in fuel use with different driving conditions.

The VKT estimates are derived from comparison with various survey sources and derived estimates, including local and national road surveys and analysis of typical annual mileages by vehicle type, using information from the Motor Vehicle Registry. Then, an expert judgement is made as to how this total is allocated to vehicle class.

The fleet model is built up from a series of data spread sheets. The major steps are:

- The base data is the fleet for each calendar year split by vehicle class (e.g. cars, buses, light commercial vehicles, heavy goods vehicles by weight categories, and motorcycles) and also by fuel (primarily diesel and petrol).
- For each vehicle class, an assumption on the average fuel economy for that class is added. This assumption is based on known data on vehicle age, makes and models and is weighted by the percentage of different vehicles in that class. For instance, New Zealand has a large market for pre-used vehicle imports from Japan in addition to Australian, US and EURO standard vehicles.

- The fleet model then multiplies the likely fuel economy for each class, by a figure for annual VKT by each class, across the range of different driving conditions.
- The model output is in fuel consumed in litres, per km in different driving conditions, and then the total per annum for the vehicle classes in the fleet. Finally, using country specific (for CO_2) and IPCC (for CH_4 and N_2O) emission factors for the different fuels (petrol, diesel, LPG and CNG), greenhouse gas emissions are calculated from the national fleet per annum.

Because there are a number of inputs to the model that are based on expert judgement there is need for sensitivity analysis. In particular, the input figures of indicative vehicle fuel economy for each vehicle class and distance kilometres travelled for each class are varied to assess the sensitivity of the model to changes in those variables.

The focus of the model has been on refining understanding of the light fleet, rather than the heavy fleet. The fuel economy of the heavy vehicle classes (which use the majority of the diesel fuel in New Zealand) is particularly sensitive to changes in load carried and terrain, both of which vary significantly in New Zealand. In time, more data are expected to become available on the characteristics of heavy vehicle travel, allowing refinements to be made to the model. The model is based on a micro-inventory approach which identifies the factors that most affect the confidence in the results. It is also noted that off road, non-registered vehicles, that commonly use diesel, are not included in the model.

Emission factors

The model uses the pre-2002 inventory petrol and diesel emission factors, as the model in its present form cannot split the petrol use into regular and premium as per the 2003 inventory. These emission factors are:

- CO_2: 66.6 kt/PJ for petrol and 68.7 kt/PJ for diesel
- Petrol: density 0.75, GCV 45.9 MJ/kg; gives CO_2 emissions at 2.30 kg/litre
- Diesel: density 0.84, GCV 45.7 MJ/kg; gives CO_2 emissions at 2.64 kg/litre

The 1996 IPCC guidelines provided the emission factors for CH_4 and N_2O. They were selected as per the corresponding vehicle technology categories used in the vehicle fleet model. The calculation process starts from the g/kg of fuel consumption indices. These are translated to the required g/km emission rates by correlating with the fuel consumption rates for New Zealand fleet type vehicles, to calculate total output against the fleet VKT baselines.

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 sub-divided 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. 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 i.e. the slaughter weight of all livestock exported from New Zealand is 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 accompanying the agriculture sector (Chapter 6). The data include average liveweights, milk yields and milk composition of dairy cows, average liveweights of beef cattle (beef cows, heifers, bulls and steers), average liveweights of sheep (ewes and lambs) and average liveweights of deer (breeding and growing hinds and stags).

Dairy cattle

Data on milk production are provided by Livestock Improvement Corporation (LIC, 2004). 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 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 live-weights 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% of the weight of the average cow and 90% of the weight of the average adult cow at calving. Growth between birth and calving (at two years of age) is assumed to be linear, however the growth rates are not assumed to be constant as higher growth rates apply prior to weaning when animals receive milk as part of their diet. The birth date of all calves was assumed to be mid-August.

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 Jersey's 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% 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 (e.g. Friesian and some beef breeds). Because these categories of animal make only small contributions to total emissions e.g. breeding dairy bulls contribute 0.089% 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 sub-categories (heifers, steers and bulls) was estimated from the carcass weight at slaughter. Liveweights at birth are assumed to be 9% of an adult cow weight for heifers and 10% of the adult cow weight for steers and bulls. Growth rates of all growing animals between birth and slaughter are assumed to be linear, however the growth rates are not assumed to be constant as higher growth rates apply prior to weaning when animals receive milk as part of their diet.

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[5] 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% for ewes and 45% for lambs. Lamb birth liveweights are assumed to be 9% of the adult ewe weight with all lambs assumed to be born on 1 September. Growing breeding and non-breeding ewe hoggets are assumed to reach full adult size at the time of mating when aged 20 months. Adult wethers are assumed to be the same weight as adult breeding females.

No within year pattern of liveweight change was assumed for either adult wethers or adult ewes. All ewes rearing a lamb are assumed to have a total milk yield of 100 litres. Breeding rams are assumed to weigh 40% 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.

[5] 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%. A fawn birthweight of 9% 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, 1985).

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 emissions 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 (e.g. milk yield and liveweight gain), physiological state (e.g. 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 allow 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[6] 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.

[6] 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 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 http://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% or 91% 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.

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 return a completed questionnaire.

The 1999 Livestock Survey

The frame for the 1999 Agricultural Production survey was based on a national database of farms called AgriBase which is maintained by AgriQuality New Zealand Ltd (formerly 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% 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

	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% 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 Tate et al.(1997), as containing 570 Mt C for all natural vegetation (i.e. 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., 2003). 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 in a significantly advanced methodology as 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 use 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's 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 will be established to monitor key changes in soil carbon when land-use changes i.e. scrub to grassland, grassland to Kyoto forest and vice versa. The first four paired plots 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; Allen et al., 2003). 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, 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 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 15m 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 in 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 landcover 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 LCDB2 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 (i.e. grassland, shrubland and 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%. 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%), natural forest (95%), mangrove (97%), planted forest (90%), horticultural (95%), pastoral (98%), scrubland (89%), tussock (95%), and wetlands (87%).

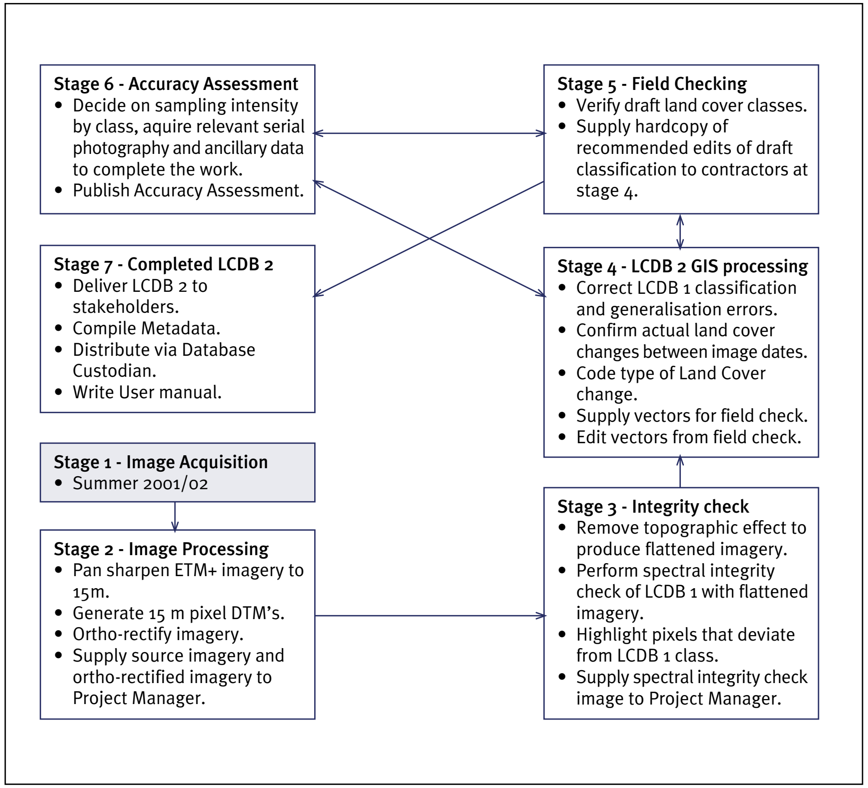


Table A3.3.1 Mapping of LCDB classification to the IPCC land-use categories

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 2003 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 2003 inventory

Tier 1 quality control (QC) checks for key sources (as identified in the level and trend analysis of the 2002 national inventory) and a selection of non key sources were completed on the 2003 data. Two of these checklists, with the results, are included as examples in this Annex. The checks incorporated in the CRF Reporter software (time-series consistency, recalculation and completeness checks) were undertaken to identify any outliers and inconsistencies in the trends from 1990-2003.

In addition to the QC checks undertaken with the Tier 1 QC checklists, a Tier 2 quality check was carried out on solid waste disposal (a key source category).

Some specific findings and improvements included:

- SF_6 data for 1998 and 1999 reported in the 2002 inventory was about twice as high as that of all other years in the time-series. This was traced to an inconsistency in the method used to estimate emissions for those years compared to the rest of the time-series. This was corrected for the 2003 inventory.
- Rounding errors were found in a table used to enter data for total emissions of HFC-134a for mobile air conditioning in the 2002 inventory. This was fixed in the 2003 inventory as separate entries were made for first-fill, operation and disposal emissions with the CRF software correctly summing these sub-sources to give total emissions.
- CH_4 emissions from ammonia production for the years 2002 and 2003 were around half of that in previous years even though production levels were similar to previous years. This was traced to incorrect emission factors and activity data being used. This was corrected in the 2003 inventory.
- SO_2 emissions from aluminium production for the years 2000 and 2001 were found to be missing. Values were interpolated. Emissions for NO_x and CO for the entire time-series were back calculated using emission factors provided by the smelter for the 2003 data.

- Activity data for asphalt roofing in 1994 were entered as 0.4 kt in the 2002 inventory which was almost 10 times higher than activity data for the years around it. After consultation with the external consultant who gathered the data, it was decided to change the figure to 0.05 (the same value as previous years) as it is likely to have been a transcription error.
- A transcription error in the SF_6 estimates from Mg foundries prior to the year 2000 was found in the previous inventory. This was fixed for the 2003 inventory.
- Potential emissions for the consumption of halocarbons and SF_6 were calculated for the whole time-series for the first time. Potential emissions for SF_6 for the years 1990, 1998 and 1999 were interpolated as data was missing for those years.

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. It shows that during 2004, a peer review was undertaken of emissions from substitutes for ozone-depleting substances (as part of the industrial processes sector). New Zealand has taken note of the recommendations and will implement these as time and resources allow (the recommendation that potential emissions be calculated and included in future inventories has been addressed and included in this inventory submission). A review of New Zealand's Quality Assurance/Quality Control programme was also undertaken in late 2004.
New Zealand has noted these recommendations and is working to address the issues raised.

Documentation and archiving of important reports and resources have continued including email correspondence related to clarification of methodologies used by external agencies.

Procedures scheduled in New Zealand's QA/QC plan for 2004/05 that have been implemented include:

- Tier 1 quality control checks extended to include a selection of non key sources for the 2003 data in the inventory.
- Tier 1 quality control checklists updated to include relevant checks on New Zealand data.
- Tier 2 quality control checks on solid waste disposal (key source category).
- Holding copies of CVs of people from external agencies who undertake expert reviews of parts of the national inventory.

A6.3: Future development of the QA/QC system

New Zealand will aim to implement the recommendations from the quality management review report during 2005 as time and resources allow. This will lead to a more structured QA/QC programme and a timetable for completing Tier 1 quality checks on all source categories and Tier 2 quality control checks for key source categories.

A6.4: Example worksheets for QC procedures in 2003

TIER 1: INDIVIDUAL SOURCE CATEGORY CHECKLIST

Inventory Checked:	2003
Source Category:	4A Enteric fermentation-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 2005 NIR (2003 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 13/04/05: 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-SP	S. Petrie 13/04/05: 1. Checked module names in worksheets for consistency. 2. Check references cited in text are correctly referenced in the reference chapter.	1. Tables labeled correctly. 2. Some references cited in text missing in reference chpater and several references no longer cited in main text	corrected reference chapter
	Cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors.	1. Cross check activity data from NIR worksheets with that in the CRF for transcription errors. 2. Check activity data figures from orginal source with data in the CRF.	1. MfE-SP 2. MfE-SP	S. Petrie 13/04/05: 1. visual check by comparing enteric fermentation figures from NIR worksheet with that in the CRF reporter	Value in NIR worksheet is 1117.00Gg compared with 1123.44Gg in the CRF reporter. This was traced to a difference in the total CH4 from dairy cattle: 402.37 Gg in NIR worksheet and 408.81 in CRF reporter.	Checked this with Len-confirmed the CRF value is the correct one. He will change the value in the NIR worksheet.
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-SP	S. Petrie 13/04/05: Calculated dairy cattle CH4 enteric fermentation emissions using figures from worksheet 4.1	Value was 402.35Gg compared with 402.37 Gg. 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.	MAF	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-SP	S. Petrie 13/04/05: visual inspection of units labeled in agricultural worksheets	labeling of units in worksheets O.K	none
	Check that units are correctly carried through from beginning to end of calculations.	check appropriate units are used throughout calculations				
	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	S. Petrie 13/04/05: 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 that temporal and spatial adjustment factors are used correctly.					

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	MAF	limited time meant this check was not undertaken		
	Confirm that data relationships are correctly represented in the database.	confirm data relationships within model are appropriate	MAF	limited time meant this check was not undertaken		
	Ensure that data fields are properly labelled and have the correct design specifications.	Ensure the addition or deletion of datalines are adequately explained	MfE-SP	S. Petrie 13/04/05: check worksheet tables for obvious gaps in the data-series	footnotes at bottom of tables generaaly explain missing data (which is usually population data for 2004 which is not yet available)	
	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.	MAF	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.	MAF/MfE	consistency of animal number dataset was looked into and improved as part of recalculations in the agricultural sector		see comments under recalculations and improvements in the NIR
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. 2. Compare total enteric fermentation CH4 emissions in CRF with those provided by Harry Clark and MAF	MfE-SP	S.Petrie 13/04/05: 1. sum CH4 emissions from dairy cattle and non-dairy cattle and compare with total in CRF reporter 2. Compare CRF value for total CH4 from enteric fermentation with value from model	1. The summed value of 663.3 Gg from dairy and non-dairy cattle is the same as the total for cattle	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. It is anticipated during 2005 the QA/QC system will be improved and various checks of this nature will be able to be completed for the next inventory submission.		on-going. It is anticipated during 2005 the QA/QC system will be improved and various checks of this nature will be able to be completed for the next inventory submission.
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 uncertainty analysis are recorded & archived. Check calculated uncertainties are completed and correct	due to time constraints this has not been documented			
	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	on-going. It is anticipated during 2005 the QA/QC system will be improved and various checks of this nature will be able to be completed for the next inventory submission.		on-going. It is anticipated during 2005 the QA/QC system will be improved and various checks of this nature will be able to be completed ofr the next inventory submission.
	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 13/04/05: 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 computer network which is regularly backed up.	none
	Check integrity of any data archiving arrangements of outside organisations involved in inventory preparation.	Check data archiving arrangements at MAF	MfE	on-going. It is anticipated during 2005 the QA/QC system will be improved and various checks of this nature will be able to be completed for the next inventory submission.		
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			
	Check for consistency in the algorithm/method used for calculations throughout the time series.	Confirm with MAF the method used for estimating CH4 from enteric fermentation is consistent throughout the time series	MfE-SP	S. Petrie 13/04/05: 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 13/04/05: 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.	Compare current inventory source category estimates with CRF tables from 2004 report	MfE-SP	S.Petrie 13/04/05: Several recalculations from this source has meant the value is different from that in the 2004 report.	A value of 1116.98Gg for enteric fermentation in 2002 for this inventory cf with value of 1123.08Gg in 2002 inventory-result of recalculations	none

TIER 1: INDIVIDUAL SOURCE CATEGORY CHECKLIST

Inventory Checked: 2003
Source Category: 1AA3b Mobile combustion from road vehicles-CO2
Estimates prepared by: Ministry of Economic Development
Working spreadsheet(s)

Tier 1 QC Activity & Procedures						
QC Activity	**Procedures**	**Procedures adopted for 2005 NIR (2003 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.	1. Check activity data and emission factors are described in the NIR report and any changes from previous years are adequately documented. 2. Ensure any recommended changes to emission factors from the energy sector have been implemented and correctly recorded in the NIR worksheets	1. NZCCO-SP 2. MED - Ram SriRamaratnam (7/04/05)	New EFs adopted for the 2004 submission (2002 data) has been used for the 2003 data as well since the variability of C content and calorific value of liquid fuels is less than 5% . They will require an update when there are any "significant" changes to fuel specification as anticipated.	Hale & Twomey (2003)	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.	1. MED - Ram SriRamaratnam (7/04/05) 2. NZCCO-SP	Visual check of module name in worksheets 1.1, 1.2 and 1.3 for all energy sector sub-categories.	No inconsistencies found with respect to the naming of modules or the references cited in the relevant source sector chapter in the NIR.	None.
	Cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors.	1. Cross check activity data from NIR worksheets with that in the CRF for transcription errors. 2. Check activity data figures from orginal source (eg MED GHG report for energy sector) with data in the CRF.	1. MED - Stuart Black 2. MED - Ram SriRamaratnam (7/04/05)	1. visual check by comparing road transportation energy consumption figure from worksheet 1.2 (part 1) in NIR with road transportation energy consumption figure in Table 1A(a) in CRF. 2. Checked petrol activity data-comparing figures in MED's GHG Emissions report with figures in NIR worksheet 1.2 (adding up regular and premium petrol figures).	1. Value in worksheet 1.2 was 180,817 compared with same figure in the CRF. Test passed. 2. Value in Table 4.2 in MED report is 113.71 PJ (Prior to revision by SNZ in late 2004) while the aggregated petrol activity data in NIR worksheet 1.2 is 107.82 PJ (10782TJ). Test passed.	None.
Check that emissions are calculated correctly.	Reproduce a representative sample of emissions calculations.	Using the figures in the NIR worksheets, calculate emissions manually and compare to emissions figure from worksheet.	MED - Ram SriRamaratnam (7/04/05)	Calculated CO2 emissions from road transportation (petrol and diesel) using figures from worksheet 1.2	Values calculated were 5559.99 Gg CO2 compared to 5504.39 in NIR worksheet (petrol-regular); 1596.57 compared to 1580.61 Gg CO2 in NIR (petrol-premium) and 4983.69 compared with 4933.85 Gg CO2 calculated in NIR for diesel. Differences are less than 1%. Test passed.	None.
	Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.			Take petrol activity data from Table 4.2 in MED's Energy GHG emissions document (value is 107.8 PJ) multiplied by average weighted petrol EF (66.5 kt/PJ). This figure was multiplied by 0.99 (fraction oxidised) to get Gg CO2 produced	Result is 7097 Gg CO2; Value in working spreadsheet is 7085 (regular & premium petrol aggregated together). Difference is 0.17%. Test passed.	None.
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	MED - Ram SriRamaratnam (7/04/05)	visual inspection of units labelled in worksheet 1.1 and 1.2 (including overview sheet)	Labelling fine for worksheets 1.1 and 1.2 (parts 1 & 2).	None.
	Check that units are correctly carried through from beginning to end of calculations.	Check correct units are used in calculations	MED - Ram SriRamaratnam (7/04/05)			
	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 CO2 (where appropriate).	MED - Ram SriRamaratnam (7/04/05)	Checked units, including conversion factors in petrol (regular) calculation on worksheet 1.2 in NIR. TJ * tonnes C/TJ = tonnes C. tonnes C/1000= Gg C. Gg C * 44/12 (molecular mass CO2/C) = Gg CO2.	Conversion factors are correct . Checked all energy sector data on NIR worksheets 1.1and 1.2 Worrksheets 1.1 and 1.2 (sectoral tables) are consistent with 2 decimal places for final CO2 emissions.	None.
	Check that temporal and spatial adjustment factors are used correctly.					

Check the integrity of database and/or spreadsheet files.	Confirm that the appropriate data processing steps are correctly represented in the database.		MED - Ram SriRamaratnam (7/04/05)	The energy GHG database at MED consists of linked spreadsheets organised primarily according to sector.		None.
	Confirm that data relationships are correctly represented in the database.					
	Ensure that data fields are properly labelled and have the correct design specifications.	1. Check labels on NIR worksheets are consistent with previous year's NIR 2. Ensure the addition or deletion of data lines are adequately explained	NZCCO-SP	Visual check-compared data field labels for worksheets 1.1 and 1.2 with the 2003 NIR worksheets.	Gasoline has been split into two separate data lines (for regular and premium gasoline). Av Gas is a new data line (split aviation fuel) compared to 2003 NIR worksheet 1.1 (1-3 of 5) Bitumen has been added as a new data line under liquid fossil fuels in worksheet 1.1 (4-5 of 5) compared to 2003 NIR. In worksheet 1.2 gasoline has once again been split as well as fuel oil (heavy and light) and Av gas has been added as an extra data line. All of these additions were due to recommendations in the 2003	None.
	Ensure that adequate documentation of database and model structure and operation are archived.	Ensure adequate documentation of spreadsheet structure and how the emissions are calculated	MED			
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.		MED - Ram SriRamaratnam (11/04/05)	Check mobile road combustion activity data and CO_2 emissions totals from worksheet 1.2 and the overview worksheet.	Activity data exactly the same and CO_2 emissions 12,094.67 in worksheet 1.2 compared with 12,094.67 Gg in overview worksheet. Test passed.	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 CO_2 emissions from all fuels for road transportation & compare with values in road transportation node in CRF reporter. 2. Compare total road CO_2 emissions in CRF with those provided from the original source	MED - Stuart Black (14/04/05)	Check mobile road combustion CO_2 emissions total from the road transportation node is consistent with internal worksheets and with the NIR.	The transportantion node gives 12094.67 Gg, exactly the same as the figure in worksheet 1.2 and the estimate calculated based on the figures in the internal worksheets. Test passed.	None.
	Check that emissions data are correctly transcribed between different intermediate products	Document QA/QC procedures within MED that show correct transcription between intermediate worksheets and final entry of data into CRF reporter	MED - Stuart Black (14/04/05)	Brief desription of how consistency between MED's internal worksheets and the NIR worksheets is ensured.	Emissions estimates for MED's publication *Energy Greenhouse Gas Emissions* and CO_2 estimates for the CRF are calculated independently, although the activity data is calculated only once. CO_2 estimates for each purpose are checked against each other. Note that the emissions estimates in the Energy Greenhouse Gas Emissions do not assume unoxidised carbon so the estimates in this publication are not directly comparable with the figures in the CRF.	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.	Confirm qualifications of those experts providing uncertaintity estimates	MED	Nothing to communicate at this stage.		
	Check that qualifications, assumptions and expert judgements are recorded. Check that calculated uncertainties are complete and calculated correctly.	Check there is a documentation record of assumptions and expert judgements for uncertainty estimates.	MED			
	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 emissions estimates & uncertainty analysis.	MED - Ram SriRamaratnam (12/04/05)	Internal documentation at MED is facilitated by the preparation of the annual Energy Greenhouse Gas Emissions report. The 2003 report was prepared in 2004.		None.
	Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review.	1. Check to ensure copies of reports of sector reviews and methodologies are archived. 2. Check inventory data is archived appropriately at MED	1. NZCCO-Len? 2. MED - Ram SriRamaratnam (12/04/05)	Make sure energy sector emission factor review by Hale and Twomey is archived in the NZCCO and easily accessible. Also ensure other reports written in response to that report are archived.	Reports stored on MfE computer network: m:\ClimateChange\greenhouse gas inventory\sector information\Energy. The reports are also stored at MED. * Emissions Factor Review Report * Implications for energy emissions June 2003 * Energy EF review-changes resulting from peer review of HT report	None.
	Check integrity of any data archiving arrangements of outside organisations involved in inventory preparation.	Check data archiving arangements at MED	NZCCO-Len/SP?			
Check methodological and data changes resulting in recalculations.	Check for temporal consistency in time series input data for each source category.	record results from time series consistency check in CRF reporter software	NZCCO			
	Check for consistency in the algorithm/method used for calculations throughout the time series.	Confirm that method used to estimate CO_2 from mobile combustion is consistent for all years	MED - Stuart Black (14/04/05)	Check that the IEFs shown in the CRF reporter are consistent with the correct emission factors being used in all years.	*The IEFs for gasoline range between 65.54 and 65.8, consistent with changes in the mix between premium and regular unleaded and with the adoption of separate emission factors for premium and regular form 1996. *The IEF for diesel is 68.81 in all years. *The IEF for LPG is 59.8 in all years. *The IEF for natural gas ranges between 51.81 and 52.58, consistent with changes in the natural gas emission factor used.	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.	CRF reporter checks	NZCCO-SP	S. Petrie: check energy sector passes completeness checks	first run through found a number of gaps-mainly lack of explanations for IE and NE comments	in consultation with Stuart Black filled in these gaps and re-an checks which now passed
	Check that known data gaps that result in incomplete source category emissions estimates are documented.	ensure any known data gaps are documented	NZCCO-SP		no gaps in data series	None.
Compare estimates to previous estimates.	For each source category, current inventory estimates should be compared to previous estimates. If there are significant changes or departures from expected trends, recheck estimates and explain any difference.	Compare current inventory source category estimates with CRF tables from 2004 report	NZCCO-SP	S. Petrie compare total for road combustion in CRF report with that in 2002 CRF table	Value of 11680.74 Gg CO_2 for 2002 (in 2003 CRF) compared with 12,292.63 Gg for 2002 in 2002 inventory. The difference is due to misreporting of liquid fuels by oil companies in 2002 which has been fixed in the 2003 inventory and the correct emission factors (as recommended by Hale and Twomey) used	None.

A6.5: 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 being developed and will start to be implemented in 2004 inventory report. 3. Review of emission factors occurred in 2003. 4. Addressed in 2004 inventory report.	Shortcut to Energy Sector Review by Tom Clarkson.lnk
	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 Len'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 inventory and to recommend what emissions factors should be used for each GHG and what further work the Ministry should arrange.	1. Changes recommended for the vast majority of emissions factors, including reverting to IPCC recommended factor. 2. Methodology could also be improved eg by splitting petrol to premium and regular. 3. Further work includes - review of coal 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 Len'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.	Shortcut to Industrial Processes review Doug Sheppard 30 06 03.doc.lnk
	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.		..\..\03 - Sector Reports\02 - Industrial Processes\Revised Comments on inventory of HFC, PFC and sf6 emisisons 16'8'04.doc

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**
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. N2O 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 N2O and CH4 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.	..\..\03 - Sector Reports\04 - Agriculture\N2O A Revised Nitrous Oxide Emissions Inventory for New Zealand 1990 - 2001 Kelliher.doc
	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 Len'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.		Shortcut to CH4 UlyattMetReport2fin - review.doc.lnk
	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 increse 7% from 38,716 to 41,398.	Follow up with MAF to ensure consistency	..\..\03 - Sector Reports\04 - Agriculture\CB502 reestimation of sheep in 1991 report.doc
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.	Plans to address this during 2005 calender year	REV CCO_Report from WGillies final.doc

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 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. 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 i.e. excluding LULUCF removals.

A7.1: Tier 1 uncertainty calculation

The uncertainty in activity data and emission/removal factors shown in Tables A7.1 and A7.2 are equal to half the 95% confidence interval divided by the mean and expressed as a percentage. The reason for halving the 95% confidence interval is that the value corresponds to the familiar plus or minus value when uncertainties are loosely quoted as 'plus or minus x%'. 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 labeled '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% 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% increase in emissions of a given source category and gas in the current year only.

Uncertainties that are fully correlated between years will be associated with Type A sensitivities and uncertainties that are not correlated between years will be associated with Type B sensitivities.

In Tables A7.1 and A7.2, the figure 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

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	22652.63	31229.51	5	0	5	1.50	0.0410	0.3666	0.0000	2.5921	2.59	M	R
Industrial processes sector	CO_2	2662.18	3470.04	5	0	5	0.17	0.0025	0.0407	0.0000	0.2880	0.29	M	R
LULUCF sector - forest land	CO_2	23638.06	27349.40	5	25	25	6.69	-0.0185	0.3210	-0.4634	2.2701	2.32	M	R
LULUCF sector other land use categories	CO_2	NE	1540.60	15	184	185	2.73						M	R
Energy sector	CH_4	796.92	840.98	5	50	50	0.41	-0.0016	0.0099	-0.0789	0.0698	0.11	D	R
CRF2A - mineral products	CH_4	NO	NO											
CRF2B - chemical industry	CH_4	21.59	42.91	45	120	128	0.05	0.0002	0.0005	0.0232	0.0321	0.04	D	R
CRF4A - enteric fermentation	CH_4	21530.77	23592.21	2	53	53	12.00	-0.0323	0.2769	-1.7136	0.7833	1.88	M	M
CRF4B - manure management	CH_4	574.51	549.44	2	100	100	0.53	-0.0018	0.0064	-0.1805	0.0182	0.18	M	M
CRF4E- prescribed burning	CH_4	2.82	0.84	20	60	63	0.00	0.0000	0.0000	-0.0018	0.0003	0.00	D	R
CRF4F - burning of residues	CH_4	18.78	22.91	50	40	64	0.01	0.0000	0.0003	0.0000	0.0190	0.02	D	R
LULUCF sector	CH_4	88.90	85.68	10	35	36	0.03	-0.0003	0.0010	-0.0095	0.0142	0.02		
CRF 6A - Solid waste disposal	CH_4	2177.70	1425.48	0	20	20	0.27	-0.0146	0.0167	-0.2910	0.0000	0.29	M	R
CRF 6B - wastewater handling	CH_4	156.66	166.11	0	20	20	0.03	-0.0003	0.0019	-0.0060	0.0000	0.01	D	R
Energy sector	N_2O	144.56	250.43	5	50	50	0.12	0.0009	0.0029	0.0431	0.0208	0.05	D	R
CRF4D -Agricultural soils	N_2O	10021.98	12968.99	5	73	73	9.10	0.0082	0.1522	0.6010	1.0765	1.23	M	M
CRF4B - manure management	N_2O	15.91	61.07	5	100	100	0.06	0.0005	0.0007	0.0488	0.0051	0.05		
CRF4E- prescribed burning	N_2O	0.51	0.15	20	60	63	0.00	0.0000	0.0000	-0.0003	0.0001	0.00	D	R
CRF4F - burning of residues	N_2O	6.46	7.61	50	40	64	0.00	0.0000	0.0001	-0.0001	0.0063	0.01	D	R
LULUCF sector	N_2O	9.02	8.70	10	35	36	0.00	0.0000	0.0001	-0.0010	0.0014	0.00		
CRF6B - wastewater handling	N_2O	145.70	162.89	0	1200	1200	1.87	-0.0002	0.0019	-0.2176	0.0000	0.22	D	R
CRF2F	HFCs	0.00	403.96	105	60	121	0.47	0.0047	0.0047	0.2845	0.7041	0.76	D	R
CRF2C	PFCs	515.60	80.70	0	30	30	0.02	-0.0065	0.0009	-0.1938	0.0000	0.19	M	M
CRF2F	SF_6	9.46	12.38	66	63	91	0.01	0.0000	0.0001	0.0006	0.0136	0.01		
Total emissions/removals		**85190.71**	**104272.99**		**Uncertainty in the year**		**16.9%**		**Uncertainty in the trend**			**4.2%**		

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 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 - 2003 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	22652.63	31229.51	5	0	5	2.07	0.0564	0.5074	0.0000	3.5876	3.59	M	R
Industrial processes sector	CO_2	2662.18	3470.04	5	0	5	0.23	0.0034	0.0564	0.0000	0.3986	0.40	M	R
Energy sector	CH_4	796.92	840.98	5	50	50	0.56	-0.0022	0.0137	-0.1096	0.0966	0.15	D	R
CRF2A - mineral products	CH_4	NO	NO											
CRF2B - chemical industry	CH_4	21.59	42.91	45	120	128	0.07	0.0003	0.0007	0.0321	0.0444	0.05	D	R
CRF4A - enteric fermentation	CH_4	21530.77	23592.21	2	53	53	16.60	-0.0449	0.3833	-2.3822	1.0841	2.62	M	M
CRF4B - manure management	CH_4	574.51	549.44	2	100	100	0.73	-0.0025	0.0089	-0.2504	0.0252	0.25	M	M
CRF4E- prescribed burning	CH_4	2.82	0.84	20	60	63	0.00	0.0000	0.0000	-0.0025	0.0004	0.00	D	R
CRF4F - burning of residues	CH_4	18.78	22.91	50	40	64	0.02	0.0000	0.0004	-0.0001	0.0263	0.03	D	R
LULUCF sector	CH_4	88.90	85.68	10	35	36	0.04	-0.0004	0.0014	-0.0132	0.0197	0.02		
CRF 6A - Solid waste disposal	CH_4	2177.70	1425.48	0	20	20	0.38	-0.0202	0.0232	-0.4033	0.0000	0.40	M	R
CRF 6B - wastewater handling	CH_4	156.66	166.11	0	20	20	0.04	-0.0004	0.0027	-0.0084	0.0000	0.01	D	R
Energy sector	N_2O	144.56	250.43	5	50	50	0.17	0.0012	0.0041	0.0596	0.0288	0.07	D	R
CRF4D -Agricultural soils	N_2O	10021.98	12968.99	5	73	73	12.59	0.0113	0.2107	0.8231	1.4899	1.70	M	M
CRF4B - manure management	N_2O	15.91	61.07	2	100	100	0.08	0.0007	0.0010	0.0676	0.0028	0.07		
CRF4E- prescribed burning	N_2O	0.51	0.15	20	60	63	0.00	0.0000	0.0000	-0.0005	0.0001	0.00	D	R
CRF4F - burning of residues	N_2O	6.46	7.61	50	40	64	0.01	0.0000	0.0001	-0.0002	0.0087	0.01	D	R
LULUCF sector	N_2O	9.02	8.70	10	35	36	0.00	0.0000	0.0001	-0.0013	0.0020	0.00		
CRF6B - wastewater handling	N_2O	145.70	162.89	0	1200	1200	2.59	-0.0003	0.0026	-0.3031	0.0000	0.30	D	R
CRF2F	HFCs	0.00	403.96	105	60	121	0.65	0.0066	0.0066	0.3938	0.9745	1.05	D	R
CRF2C	PFCs	515.60	80.70	0	30	30	0.03	-0.0089	0.0013	-0.2684	0.0000	0.27	M	M
CRF2F	SF_6	9.46	12.38	66	63	91	0.01	0.0000	0.0002	0.0008	0.0188	0.02		
Total emissions/removals		**61552.65**	**75383.00**		**Uncertainty in the year**		**21.1%**		**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 uncertainity 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	**2003 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	International bunkers	Stock change	Apparent consumption	Conversion factor (TJ/unit)	Apparent consumption (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 CO_2 emissions (Gg)
Liquid fossil fuels - primary	Crude oil	49.19	217.66	41.85		5.47	219.52	1,000	219,524.64	17.80	3,907,538.60	3,907.54		3,907.54	0.99	3,868.46	14,184.37
	Orimulsion	0.00	0.00	0.00		0.00	0.00										
	Natural gas liquids	9.60	0.54	1.24		0.38	8.52	1,000	8,523.36	16.47	140,402.98	140.40		140.40	0.99	139.00	509.66
Liquid fossil fuels - secondary	Gasoline - Regular Unleaded		27.50	0.00	0.00	-0.86	28.36	1,000	28,356.89	18.05	511,970.75	511.97		511.97	0.99	506.85	1,858.45
	Gasoline - Premium Unleaded		8.97	0.62	0.00	-2.49	10.83	1,000	10,834.17	18.27	197,969.92	197.97		197.97	0.99	195.99	718.63
	Jet kerosene		8.30	0.00	33.08	-0.93	-23.85	1,000	-23,851.22	18.57	-442,982.13	-442.98		-442.98	0.99	-438.55	-1,608.03
	Av Gas		0.60	0.00	0.00	-0.14	0.74	1,000	744.20	17.73	13,192.64	13.19		13.19	0.99	13.06	47.89
	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		15.26	0.30	2.27	-2.70	15.40	1,000	15,396.89	18.95	291,841.07	291.84		291.84	0.99	288.92	1,059.38
	Residual fuel oil		1.17	1.85	8.77	2.83	-12.28	1,000	-12,275.72	19.91	-244,398.45	-244.40		-244.40	0.99	-241.95	-887.17
	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		6.57	0.00	0.00	0.59	5.98	1,000	5,979.99	20.76	124,144.60	124.14	243.72	-119.57	0.99	-118.38	-434.04
	Lubricants		0.00	0.00	0.00	0.00	0.00										
	Petroleum coke		0.00	0.00		0.00	0.00										
	Refinery feedstocks		17.48	0.00		-1.09	18.57	1,000	18,565.74	17.80	330,470.16	330.47		330.47	0.99	327.17	1,199.61
	Other oil		0.00	0.00		0.00	0.00										
Total liquid fossil fuels		**58.80**	**304.06**	**45.87**	**44.11**	**1.08**	**271.80**		**271,798.95**		**4,830,150.14**	**4,830.15**	**243.72**	**4,586.43**		**4,540.57**	**16,648.76**
Solid fossil fuels - primary	Anthracite	0	0	0		0	0										
	Coking coal	2249738	0	2210066		39672	0	0.0321	0.00	24.22	0.00	0.00	0.00	0.00	0.98	0.00	0.00
	Other bituminous coal	101283	92253	0	0	0	193536	0.0321	6,212.50	24.22	150,455.55	150.46		150.46	0.98	147.45	540.64
	Sub-bituminous coal	2576555	329436	0	0	0	2905991	0.0226	65,675.41	24.87	1,633,526.46	1,633.53	448.66	1,184.87	0.98	1,161.17	4,257.64
	Lignite	252336	25	0		0	252361	0.015	3,785.42	25.96	98,283.21	98.28		98.28	0.98	96.32	353.16
	Peat	0	0	0		0	0										
Solid fossil fuels - secondary	BKB & patent fuel		0	0		0	0										
	Coke		5225	0		0	5225	0.0279	145.79	27.90	4,067.46	4.07		4.07	0.98	3.99	14.62
Total solid fossil fuels		**5179912**	**426940**	**2210066**	**0**	**39672**	**3357114**		**75,819.11**		**1,886,332.68**	**1,886.33**	**448.66**	**1,437.68**		**1,408.92**	**5,166.05**
Total gaseous fossil fuels		179	0	0		0	**179**	**1,000**	**179,274.61**	15.83	**2,837,550.31**	**2,837.55**	**468.69**	**2,368.86**	0.995	**2,357.02**	**8,642.39**
Total fossil fuels									**526,892.67**		**9,554,033.13**	**9,554.03**	**1,161.06**	**8,392.97**		**8,306.51**	**30,457.20**
Total biomass fuels									**35,645.00**		**1,011,124.34**	**1,011.12**		**1,011.12**		**962.53**	**3,529.29**
	Solid biomass	34.06					34.06	1,000	34,059.00	28.41	967,445.90	967.45		967.45	0.95	919.07	3,369.94
	Liquid biomass								ne								ne
	Gas biomass	1.59					1.59	1,000	1,586.00	27.54	43,678.44	43.68		43.68	0.995	43.46	159.35

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

Module **2003 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)	Actual CO_2 emissions (Gg)
Solid fossil fuels	Other bituminous coal	0.00											no
	Sub-bituminous coal	0.00											no
Liquid fossil fuels	Gasoline	0.00											
	Jet kerosene	33.08	1,000	33,079.93	18.57	614,384.53	614.38	0.00	0.00	614.38	0.99	608.24	2,230.22
	Gas/diesel oil	2.27	1,000	2,266.31	18.95	42,956.83	42.96	0.00	0.00	42.96	0.99	42.53	155.93
	Residual fuel oil	8.77	1,000	8,765.54	19.91	174,513.85	174.51	0.00	0.00	174.51	0.99	172.77	633.49
	Lubricants	0.00											no
	Bitumen	0.00	1,000	0.00	20.76	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00
Total fossil fuels				44,111.77								823.54	3,019.63

Liquid fossil fuel data are shown initially in petajoules.

Module **2003 Energy (New Zealand)**
Submodule **CO_2 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	11.74	1,000	11739.69	20.76	243715.86	243.72	1	243.72
Coal oils and tars	0.00	0.0325	0.00	24.24	0.00	0.00	0.75	0.00
Coal[1]	17.56	1,000	17556.77	25.55	448655.30	448.66	1	448.66
Natural gas[2]	conf	1,000	conf	conf	conf	conf	conf	468.69
Gas/diesel oil	0.00							no
LPG	0.00							no
Ethane	0.00							no
Other fuels	0.00							no
Total								1161.06

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 — **2003 Energy (New Zealand)**
Sub-module — **CO_2 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 stored[1]	Carbon stored[1] (t C)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO_2 emissions (Gg)
Total energy (parts I and II of worksheet)[2]	**452,091.86**		**8,427,515.84**	**8,427.52**			**8,427.52**		**8,339.86**	**30,579.47**
Total Liquid Fuels	**246,390.28**		**4,566,560.87**	**4,566.56**			**4,566.56**	**0.99**	**4,520.90**	**16,576.62**
Total Coal	**61,610.41**		**1,512,604.77**	**1,512.60**			**1,512.60**	**0.98**	**1,482.35**	**5,435.29**
Total Gaseous Fuels	**144,091.17**		**2,348,350.20**	**2,348.35**			**2,348.35**	**0.995**	**2,336.61**	**8,567.56**
1 Energy industries[2]	**121,091.77**		**2,090,137.48**	**2,090.14**			**2,090.14**		**2,067.71**	**7,581.60**
a Public electricity and heat	**100,730.63**		**1,759,687.70**	**1,759.69**			**1,759.69**	**9**	**1,739.19**	**6,377.05**
Total Liquid Fuels	**32.68**		**617.93**	**0.62**			**0.62**	**7**	**0.61**	**2.24**
Motor gasoline Regular	1.64	18.05	29.66	0.03			0.03	0.99	0.03	0.11
Motor gasoline Premium	0.00	18.27	0.00	0.00			0.00	0.99	0.00	0.00
Diesel	31.04	18.95	588.28	0.59			0.59	0.99	0.58	2.14
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	32,063.00	24.31	779,454.35	779.45			779.45	0.98	763.87	2,800.84
Natural gas	68,634.95	14.27	979,615.41	979.62			979.62	0.995	974.72	3,573.96
Biogas (memo item)[3]	922.06	28.41	26,191.14	26.19			26.19	0.995	26.06	95.55
b Petroleum refining	**14,001.98**		**236,443.09**	**236.44**			**236.44**	**4**	**234.98**	**861.58**
Total Liquid Fuels	**2,777.79**		**56,740.36**	**56.74**			**56.74**	**2**	**56.17**	**205.97**
Fuel oil	651.61	19.33	12,596.18	12.60			12.60	0.99	12.47	45.72
Asphalt	2,126.18	20.76	44,144.18	44.14			44.14	0.99	43.70	160.24
Total Natural Gas	**11,224.19**		**179,702.73**	**179.70**			**179.70**	**2**	**178.80**	**655.62**
Refinery gas	11,152.70	16.02	178,638.00	178.64			178.64	0.995	177.74	651.73
Natural gas	71.50	14.89	1,064.73	1.06			1.06	0.995	1.06	3.88
c Solid fuels and other energy	6,359.17		94,006.70	94.01			94.01	2	93.54	342.97
Total Natural Gas	6,359.17		**94,006.70**	**94.01**			**94.01**	**2**	**93.54**	**342.97**
Natural gas in synthetic petrol production	0.00	na	0.00	0.00			0.00	0.995	0.00	0.00
Natural gas in oil and gas extraction	6,359.17	14.78	94,006.70	94.01			94.01	0.995	93.54	342.97

Module	**2003 Energy (New Zealand)**
Sub-module	**CO_2 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 stored[1]	Carbon stored[1] (t C)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO_2 emissions (Gg)
2 Manufacturing and construction[2]	**73,112.98**		**1,610,766.15**	**1,610.77**			**1,610.77**	**1**	**1,592.78**	**5,840.19**
a Iron and Steel	**2,491.15**		**35,513.94**	**35.51**			**35.51**		**35.34**	**129.57**
Natural gas	2,491.15	14.26	35,513.94	35.51			35.51	0.995	35.34	129.57
c Chemicals (methanol production)	**conf**	**conf**	**271,466.78**	**271.47**			**271.47**	**1**	**270.11**	**990.40**
Natural gas in methanol production[4]	conf	conf	271,466.78	271.47			271.47	0.995	270.11	990.40
f Other	**70,621.83**		**1,303,785.43**	**1,303.79**			**1,303.79**		**1,287.33**	**4,720.22**
Total Liquid Fuels	**11,051.43**		**203,446.67**	**203.45**			**203.45**		**201.41**	**738.51**
Petrol Regular	81.80	18.05	1,476.84	1.48			1.48	0.99	1.46	5.36
Petrol Premium	57.21	18.27	1,045.32	1.05			1.05	0.99	1.03	3.79
Diesel	6,686.41	18.95	126,737.89	126.74			126.74	0.99	125.47	460.06
Heavy Fuel oil	313.31	20.05	6,280.45	6.28			6.28	0.99	6.22	22.80
Light Fuel oil	964.34	19.64	18,936.08	18.94			18.94	0.99	18.75	68.74
Jet Kerosene	183.78	18.57	3,413.25	3.41			3.41	0.99	3.38	12.39
Av Gas	13.20	17.73	233.94	0.23			0.23	0.99	0.23	0.85
LPG	2,751.39	16.47	45,322.89	45.32			45.32	0.99	44.87	164.52
Other liquid	0.00	19.88	0.00	0.00			0.00	0.99	0.00	0.00
Coal	23,977.48	24.79	594,404.14	594.40			594.40	0.98	582.52	2,135.89
Total Natural Gas	**35,592.92**		**505,934.62**	**505.93**			**505.93**	**2**	**503.40**	**1,845.82**
Autoproduction	16,913.83	14.17	239,644.57	239.64			239.64	0.995	238.45	874.30
Other natural gas	18,679.09	14.26	266,290.05	266.29			266.29	0.995	264.96	971.51
Total Biomass	**31,187.20**		**885,447.32**	**885.45**			**885.45**	**2**	**885.38**	**3,246.39**
Wood (memo item)[3]	30,695.78	28.41	871,913.56	871.91			871.91	1	871.91	3,197.02
Biogas - Autoproduction (memo item)[3]	491.42	27.54	13,533.76	13.53			13.53	0.995	13.47	49.38

Module **2003 Energy (New Zealand)**
Sub-module **CO_2 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 stored[1]**	**Carbon stored[1] (t C)**	**Net C emissions (Gg)**	**Fraction of carbon oxidised**	**Actual C emissions (Gg)**	**Actual CO_2 emissions (Gg)**
3 Transport	**205,553.09**		**3,798,369.87**	**3,798.37**			**3,798.37**	**11**	**3,760.40**	**13,788.13**
a Civil aviation	**17,208.24**		**319,100.10**	**319.10**			**319.10**	**2**	**315.91**	**1,158.33**
Jet Kerosene	16,612.31	18.57	308,535.84	308.54			308.54	0.99	305.45	1,119.99
Av Gas	595.93	17.73	10,564.26	10.56			10.56	0.99	10.46	38.35
b Road transport	**180,816.62**		**3,331,851.48**	**3,331.85**			**3,331.85**	**5**	**3,298.55**	**12,094.67**
Total Liquid Fuels	**180,634.62**		**3,329,256.88**	**3,329.26**			**3,329.26**		**3,295.96**	**12,085.20**
Petrol Regular	83,987.81	18.05	1,516,361.65	1,516.36			1,516.36	0.99	1,501.20	5,504.39
Petrol Premium	23,829.44	18.27	435,428.84	435.43			435.43	0.99	431.07	1,580.61
Diesel	71,707.75	18.95	1,359,187.89	1,359.19			1,359.19	0.99	1,345.60	4,933.85
LPG	1,109.62	16.47	18,278.49	18.28			18.28	0.99	18.10	66.35
CNG	182.00	14.26	2,594.60	2.59			2.59	0.995	2.58	9.47
c Rail transport (diesel)	**2,386.35**	**18.95**	**45,232.15**	**45.23**			**45.23**	**0.99**	**44.78**	**164.19**
d National navigation (fuel oil and diesel)	**5,141.89**		**102,186.13**	**102.19**			**102.19**	**3**	**101.16**	**370.94**
Diesel	0.00	18.95	0.00	0.00			0.00	0.99	0.00	0.00
Heavy Fuel oil	2,977.84	20.05	59,692.14	59.69			59.69	0.99	59.10	216.68
Light Fuel oil	2,164.05	19.64	42,493.99	42.49			42.49	0.99	42.07	154.25
Marine bunkers (memo item)[3]	**11,031.84**		**218,458.12**	**218.46**			**218.46**		**216.27**	**793.00**
Diesel	2,266.31	18.95	42,956.83	42.96			42.96	0.99	42.53	155.93
Heavy Fuel oil	8,257.46	20.05	165,524.52	165.52			165.52	0.99	163.87	600.85
Light Fuel oil	508.08	19.64	9,976.78	9.98			9.98	0.99	9.88	36.22
Aviation bunkers (memo item)[3]	**33,079.93**	**0.00**	**614,384.53**	**614.38**			**614.38**	**1**	**608.24**	**2,230.22**
Av Fuels	33,079.93	18.57	614,384.53	614.38			614.38	0.99	608.24	2,230.22

Module	2003 Energy (New Zealand)
Sub-module	CO_2 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 stored[1]	Carbon stored[1] (t C)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO_2 emissions (Gg)
4 Other sectors	**52,334.02**		**928,242.34**	**928.24**			**928.24**		**918.97**	**3,369.56**
a Commercial/institutional	**22,118.70**		**382,032.09**	**382.03**			**382.03**	**10**	**378.08**	**1,386.30**
Total Liquid Fuels	**5,203.98**		**96,771.42**	**96.77**			**96.77**	**8**	**95.80**	**351.28**
Petrol Regular	77.90	18.05	1,406.52	1.41			1.41	0.99	1.39	5.11
Petrol Premium	14.44	18.27	263.92	0.26			0.26	0.99	0.26	0.96
Diesel	2,270.81	18.95	43,042.25	43.04			43.04	0.99	42.61	156.24
Heavy Fuel oil	777.75	20.05	15,590.29	15.59			15.59	0.99	15.43	56.59
Light Fuel oil	370.17	19.64	7,268.87	7.27			7.27	0.99	7.20	26.39
Jet Kerosene	614.96	18.57	11,421.52	11.42			11.42	0.99	11.31	41.46
Av Gas	17.17	17.73	304.38	0.30			0.30	0.99	0.30	1.10
LPG	1,060.76	16.47	17,473.67	17.47			17.47	0.99	17.30	63.43
Coal	4,178.93	24.81	103,698.58	103.70			103.70	0.98	101.62	372.62
Natural gas	12,735.79	14.26	181,562.10	181.56			181.56	0.995	180.65	662.40
Biogas (memo item)[3]	171.20	27.54	4,714.94	4.71			4.71	0.995	4.69	17.20
b Residential	**9,629.54**		**150,946.04**	**150.95**			**150.95**	**10**	**149.71**	**548.95**
Total Liquid Fuels	**1,923.81**		**31,705.72**	**31.71**			**31.71**	**8**	**31.39**	**115.09**
Petrol Regular	3.33	18.05	60.16	0.06			0.06	0.99	0.06	0.22
Petrol Premium	0.00	18.27	0.00	0.00			0.00	0.99	0.00	0.00
Diesel	3.63	18.95	68.85	0.07			0.07	0.99	0.07	0.25
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	0.23	18.57	4.31	0.00			0.00	0.99	0.00	0.02
Av Gas	0.43	17.73	7.55	0.01			0.01	0.99	0.01	0.03
LPG	1,916.19	16.47	31,564.86	31.56			31.56	0.99	31.25	114.58
Coal	834.73	25.50	21,286.99	21.29			21.29	0.98	20.86	76.49
Natural gas	6,871.00	14.26	97,953.33	97.95			97.95	0.995	97.46	357.37
Wood (memo item)[3]	2,560.69	28.41	72,736.26	72.74			72.74	1	72.74	266.70
c Agriculture/forestry/fishing	**20,585.78**		**395,264.21**	**395.26**			**395.26**	**8**	**391.17**	**1,434.30**
Total Liquid Fuels	**20,029.50**		**381,503.50**	**381.50**			**381.50**	**7**	**377.69**	**1,384.86**
Petrol Regular	1,058.41	18.05	19,109.15	19.11			19.11	0.99	18.92	69.37
Petrol Premium	174.07	18.27	3,180.80	3.18			3.18	0.99	3.15	11.55
Diesel	15,140.16	18.95	286,974.76	286.97			286.97	0.99	284.11	1,041.72
Heavy Fuel oil	1,630.45	20.05	32,683.12	32.68			32.68	0.99	32.36	118.64
Light Fuel oil	1,834.06	19.64	36,014.35	36.01			36.01	0.99	35.65	130.73
Jet Kerosene	155.55	18.57	2,888.97	2.89			2.89	0.99	2.86	10.49
Av Gas	36.80	17.73	652.35	0.65			0.65	0.99	0.65	2.37
Coal	556.27	24.74	13,760.71	13.76			13.76	0.98	13.49	49.45

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 **2003 Energy (New Zealand)**
Submodule **CO_2 from fuel combustion by source category (tier 1)**
Worksheet **1.2 overview (totals)**

		Total liquid fossil TJ	Total solid fossil	Total gaseous fossil[1]	Total biomass fuels[2]	Total all fuels
Total energy consumption		**246,390**	**61,610**	**144,091**	**34,841**	**452,092**
Energy industries		2,810	32,063	86,218	922	121,092
Manufacturing industries and construction		11,051	23,977	38,084	31,187	73,113
Transport	Civil aviation	17,208				17,208
	Road	180,635		182	no	180,817
	Railways	2,386	ne			2,386
	Navigation	5,142	ne			5,142
Other sectors	Commercial/institutional	5,204	4,179	12,736	171	22,119
	Residential	1,924	835	6,871	2,561	9,630
	Ag/forest/fish	20,030	556	ne	ne	20,586
International marine bunkers (memo item)		11,032	ne			11,032
International aviation bunkers (memo item)		33,080				33,080
Total CO_2 emissions		**16,577**	**5,435**	**8,568**	**3,626**	**30,579**
Energy industries		208	2,801	4,573	96	7,582
Manufacturing industries and construction		739	2,136	2,966	3,246	5,840
Transport	Civil aviation	1,158				1,158
	Road	12,085		9	no	12,095
	Railways	164	ne			164
	Navigation	371	ne			371
Other sectors	Commercial/institutional	351	373	662	17	1,386
	Residential	115	76	357	267	549
	Ag/forest/fish	1,385	49	ne	ne	1,434
International marine bunkers (memo item)		793	ne			793
International aviation bunkers (memo item)		2,230				2,230

1 The figures for 'Manfufacturing 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 **2003 Energy (New Zealand)**
Submodule **Non-CO_2 emissions from fuel combustion by source categories (tier 1)**
Worksheets **1.3 (part I)**

		CH_4	N_2O	NO_X	CO	NMVOC	CH_4	N_2O	NO_X	CO	NMVOC
Source and sink categories	**Energy consumption (TJ)**	**Emission Factor (t CH_4/TJ)**	**Emission Factor (t N_2O/TJ)**	**Emission Factor (t NO_X/TJ)**	**Emission Factor (t CO/TJ)**	**Emission Factor (t NMVOC/TJ)**	**Emissions t CH_4**	**Emissions t N_2O**	**Emissions t NO_X**	**Emissions t CO**	**Emissions t NMVOC**
Total energy (parts I and II of worksheet)[1]	**486,933.33**						**4417.11**	**807.84**	**163142.01**	**585051.06**	**112383.70**
1 Energy industries	**122,013.83**						**241.84**	**58.61**	**29615.35**	**2580.99**	**557.78**
a Public electricity and heat	**101,652.69**						**210.93**	**56.22**	**25209.10**	**2260.76**	**465.46**
Total Liquid Fuels	**32.68**						**0.03**	**0.01**	**6.83**	**0.50**	**0.16**
Distillate	32.68	0.00086	0.00038	0.20900	0.01520	0.00475	0.03	0.01	6.83	0.50	0.16
Residual	0.00	0.00086	0.00029	0.19000	0.01400	0.00475	0.00	0.00	0.00	0.00	0.00
Coal	32,063.00	0.00067	0.00150	0.36100	0.00860	0.00475	21.48	48.09	11574.74	275.74	152.30
Natural Gas	68,634.95	0.00275	0.00009	0.19800	0.02880	0.00450	188.40	6.18	13589.72	1976.69	308.86
Bio Gas	922.06	0.00110	0.00210	0.04100	0.00850	0.00450	1.01	1.94	37.80	7.84	4.15
b Petroleum refining	**14,001.98**						**22.65**	**1.82**	**2975.44**	**218.48**	**63.70**
Oil	2,777.79	0.00290	0.00029	0.16200	0.01400	0.00475	8.06	0.81	450.00	38.89	13.19
Gas	**11,224.19**						**14.59**	**1.01**	**2525.44**	**179.59**	**50.51**
Natural Gas	71.50	0.00130	0.00009	0.22500	0.01600	0.00450	0.09	0.01	16.09	1.14	0.32
Refinery Gas	11,152.70	0.00130	0.00009	0.22500	0.01600	0.00450	14.50	1.00	2509.36	178.44	50.19
c Solid fuels and other energy	**6,359.17**						**8.27**	**0.57**	**1430.81**	**101.75**	**28.62**
Natural Gas in synthetic petrol prodn	0.00	0.00130	0.00009	0.22500	0.01600	0.00450	0.00	0.00	0.00	0.00	0.00
Natural Gas in oil and Gas extraction	6,359.17	0.00130	0.00009	0.22500	0.01600	0.00450	8.27	0.57	1430.81	101.75	28.62
2 Manufacturing and construction[1]	**104,300.10**						**555.59**	**169.54**	**29306.90**	**19163.76**	**2311.88**
a Iron and Steel	**2,491.15**						**3.24**	**0.22**	**560.51**	**39.86**	**11.21**
Natural Gas	2,491.15	0.00130	0.00009	0.22500	0.01600	0.00450	3.24	0.22	560.51	39.86	11.21
c Chemicals (methanol production)[2]	**conf**						**49.74**	**3.44**	**8608.88**	**612.19**	**172.18**
Natural Gas	conf	conf	conf	conf	conf	conf	49.74	3.44	8608.88	612.19	172.18
f Other	**101,808.95**						**502.61**	**165.87**	**20137.52**	**18511.71**	**2128.49**
Total Liquid Fuels	**11,051.43**						**8.46**	**3.98**	**785.88**	**149.16**	**52.49**
Distillate	6,825.42	0.00019	0.00029	0.06200	0.01500	0.00475	1.30	1.98	423.18	102.38	32.42
Residual	1,474.62	0.00290	0.00029	0.16200	0.01400	0.00475	4.28	0.43	238.89	20.64	7.00
LPG	2,751.39	0.00105	0.00057	0.04500	0.00950	0.00475	2.89	1.57	123.81	26.14	13.07
Total Coal	**23,977.48**						**17.59**	**34.87**	**9419.95**	**568.60**	**455.57**
Lime and Cement	5,457.72	0.00095	0.00130	0.50100	0.07500	0.01900	5.18	7.10	2734.32	409.33	103.70
Other	18,519.76	0.00067	0.00150	0.36100	0.00860	0.01900	12.41	27.78	6685.63	159.27	351.88
natural gas	35,592.92	0.00130	0.00009	0.22500	0.01600	0.00450	46.27	3.20	8008.41	569.49	160.17
Total Biomass	**31,187.12**						**430.28**	**123.81**	**1923.28**	**17224.46**	**1460.26**
Wood	30,695.70	0.01400	0.00400	0.06200	0.56100	0.04750	429.74	122.78	1903.13	17220.29	1458.05
Biogas	491.42	0.00110	0.00210	0.04100	0.00850	0.00450	0.54	1.03	20.15	4.18	2.21

Module **2003 Energy (New Zealand)**

Submodule **Non-CO_2 emissions from fuel combustion by source categories (tier 1)**

Worksheets **1.3 (part II)**

		CH_4	N_2O	NO_X	CO	NMVOC	CH_4	N_2O	NO_X	CO	NMVOC
Source and sink categories	**Energy consumption (TJ)**	**Emission Factor (t CH_4/TJ)**	**Emission Factor (t N_2O/TJ)**	**Emission Factor (t NO_X/TJ)**	**Emission Factor (t CO/TJ)**	**Emission Factor (t NMVOC/TJ)**	**Emissions t CH_4**	**Emissions t N_2O**	**Emissions t NO_X**	**Emissions t CO**	**Emissions t NMVOC**
3 Transport	**205,553.09**						**2477.88**	**470.36**	**84066.76**	**521821.88**	**104209.74**
a Civil aviation	**17,208.24**						**32.70**	**32.70**	**4749.47**	**1961.74**	**292.54**
Jet Kerosene	16,612.31	0.00190	0.00190	0.27600	0.11400	0.01700	31.56	31.56	4585.00	1893.80	282.41
Av Gas	595.93	0.00190	0.00190	0.27600	0.11400	0.01700	1.13	1.13	164.48	67.94	10.13
b Road transport	**180,816.62**						**2401.93**	**419.07**	**68997.40**	**518257.82**	**103421.84**
Total Liquid Fuels	**180,634.62**						**2298.73**	**419.05**	**68935.16**	**518139.88**	**103407.10**
Petrol	107,817.24	0.01850	0.00142	0.21000	4.59000	0.88500	1994.62	153.10	22641.62	494881.15	95418.26
Diesel	71,707.75	0.00380	0.00370	0.64000	0.30300	0.10200	272.49	265.32	45892.96	21727.45	7314.19
LPG	1,109.62	0.02850	0.00057	0.36100	1.38000	0.60800	31.62	0.63	400.57	1531.28	674.65
CNG	182.00	0.56700	0.00009	0.34200	0.64800	0.08100	103.19	0.02	62.24	117.94	14.74
c Rail transport (diesel)	**2,386.35**	0.00380	0.00370	0.64000	0.30300	0.10200	**9.07**	**8.83**	**1527.26**	**723.06**	**243.41**
d National navigation (fuel oil and diesel)	**5,141.89**						**34.19**	**9.77**	**8792.62**	**879.26**	**251.95**
Diesel	0.00	0.00665	0.00190	1.71000	0.17100	0.04900	0.00	0.00	0.00	0.00	0.00
Fuel oil	5,141.89	0.00665	0.00190	1.71000	0.17100	0.04900	34.19	9.77	8792.62	879.26	251.95
Aviation bunkers	**33,079.93**	0.00150	0.00190	0.28000	0.11000	0.01700	**49.62**	**62.85**	**9262.38**	**3638.79**	**562.36**
Marine bunkers	**11,031.84**						**77.22**	**22.06**	**18864.45**	**1886.45**	**540.56**
Diesel	2,266.31	0.00700	0.00200	1.71000	0.17100	0.04900	15.86	4.53	3875.39	387.54	111.05
Fuel Oil	8,765.54	0.00700	0.00200	1.71000	0.17100	0.04900	61.36	17.53	14989.07	1498.91	429.51
4 Other sectors	**55,066.30**						**1141.80**	**109.33**	**20153.00**	**41484.44**	**5304.29**
a Commercial/institutional	**22,290.30**						**58.86**	**34.56**	**4331.34**	**974.69**	**876.80**
Total Liquid Fuels	**5,203.98**						**4.96**	**2.02**	**505.96**	**70.98**	**24.72**
Distillate Fuel oil	2,363.16	0.00067	0.00038	0.06200	0.01500	0.00475	1.58	0.90	146.52	35.45	11.23
Residual Fuel oil	1,780.05	0.00130	0.00029	0.16200	0.01400	0.00475	2.31	0.52	288.37	24.92	8.46
LPG	1,060.76	0.00100	0.00057	0.06700	0.01000	0.00475	1.06	0.60	71.07	10.61	5.04
Coal	4,178.93	0.00950	0.00130	0.22800	0.19000	0.19000	39.70	5.43	952.80	794.00	794.00
Natural Gas	12,735.79	0.00110	0.00210	0.22500	0.00850	0.00450	14.01	26.75	2865.55	108.25	57.31
Biogas	171.60	0.00110	0.00210	0.04100	0.00850	0.00450	0.19	0.36	7.04	1.46	0.77
b Residential	**12,190.22**						**975.80**	**12.53**	**827.03**	**29694.08**	**1658.25**
Total Liquid Fuels	**1,923.81**						**1.92**	**1.09**	**86.77**	**18.32**	**9.14**
Distillate Fuel oil	6.96	0.00067	0.00019	0.06200	0.01500	0.00475	0.00	0.00	0.43	0.10	0.03
Residual Fuel oil	0.66	0.00000	0.00019	0.16150	0.01425	0.00475	0.00	0.00	0.11	0.01	0.00
LPG	1,916.19	0.00100	0.00057	0.04500	0.00950	0.00475	1.92	1.09	86.23	18.20	9.10
Coal	834.73	0.28500	0.00130	0.21900	3.42000	0.19000	237.90	1.09	182.81	2854.77	158.60
Natural Gas	6,871.00	0.00090	0.00009	0.04200	0.00900	0.00450	6.18	0.62	288.58	61.84	30.92
Wood	2,560.69	0.28500	0.00380	0.10500	10.45000	0.57000	729.80	9.73	268.87	26759.16	1459.59
c Agriculture/forestry/fishing	**20,585.78**						**107.14**	**62.25**	**14994.63**	**10815.67**	**2769.25**
Total Liquid Fuels	**20,029.50**						**101.86**	**61.53**	**14867.80**	**10709.98**	**2663.55**
Distillate Fuel oil - Stationary	818.63	0.00380	0.00038	0.06200	0.35200	0.00475	3.11	0.31	50.76	288.16	3.89
Residual Fuel oil - Stationary	403.29	0.00380	0.00038	0.06200	0.35200	0.00475	1.53	0.15	25.00	141.96	1.92
Petrol - Mobile	1,170.86	0.01850	0.00142	0.21000	4.59000	0.88500	21.66	1.66	245.88	5374.25	1036.21
Diesel - Mobile	14,383.15	0.00380	0.00370	0.64000	0.30300	0.10200	54.66	53.22	9205.21	4358.09	1467.08
Fuel Oil - Mobile	3,098.30	0.00665	0.00190	1.71000	0.17100	0.04900	20.60	5.89	5298.09	529.81	151.82
Aviation fuels - Mobile	155.27	0.00190	0.00190	0.27600	0.11400	0.01700	0.30	0.30	42.86	17.70	2.64
Coal	556.27	0.00950	0.00130	0.22800	0.19000	0.19000	5.28	0.72	126.83	105.69	105.69

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 **2003 Energy (New Zealand)**
Submodule **SO_2 emissions from fuel combustion by source categories (tier 1)**
Worksheet **1.4**

Fuel type		Fuel consumption (TJ)	Sulphur content (%)	Sulphur retention in ash (%)	Abatement efficiency (%)	Gross cal. value (TJ/kt)	SO_2 emis fact (kg/TJ)	SO_2 emissions (t)	SO_2 emissions (Gg)
Total		334,419						63,656	63.656
Coal	Low[1]	4,795	0.30%	12.50%	0.00%	15.0	350.0	1,678	1.678
	Medium[2]	46,113	0.50%	12.50%	0.00%	22.6	387.2	17,854	17.854
	High[3]	10,702	1.10%	2.50%	0.00%	32.1	668.2	7,151	7.151
Heavy fuel oil	Low							no	no
	Medium[4]	6,351	2.30%	0.00%	0.00%	44.06	1,044.0	6,631	6.631
	High							no	no
Light fuel oil	Low[5]	5,333	1.75%	0.00%	0.00%	44.46	787.2	4,198	4.198
	High							no	no
Diesel		98,226	0.24%	0.00%	0.00%	45.98	104.4	10,254	10.254
Petrol		109,286	0.01%	0.00%	0.00%	46.93	2.1	233	0.233
Jet kerosene		18,230	0.01%	0.00%	0.00%	46.4	4.3	79	0.079
Asphalt[6]		2,126	4.50%	0.00%	0.00%	41.9	2,148.0	4,567	4.567
LPG			0.00%					no	no
Natural gas			0.00%					no	no
Municipal Waste								ne	ne
Industrial Waste								ne	ne
Black Liquor								ne	ne
Fuelwood		33,256	0.20%	0.00%	0.00%	12.1	331.1	11,012	11.012
Other Biomass								ne	ne
Marine bunkers (memo item)	HFO	8,257	2.30%	0.00%	0.00%	44.06	1,044.0	8,621	8.621
	LFO	508	1.75%	0.00%	0.00%	44.46	787.2	400	0.400
	Diesel	2,266	0.24%	0.00%	0.00%	45.98	104.4	237	0.237
Aviation bunkers (memo item)	Jet kero	33,080	0.01%	0.00%	0.00%	46.4	4.3	143	0.143

1 Lignite coal.
2 Sub-bituminious coal.
3 Bituminous coal.
4 All HFO assumed to be medium sulphur.
5 All LFO assumed to be low sulphur.
6 Includes other liquids in manufacturing and construction.

Module 2003 Energy (New Zealand)
Submodule Fugitive emissions from coal mining and handling (tier 1)
Worksheet 1.6 (adapted)

Category			Coal production (Mt)	CH_4 emis fact (Gg/Mt)	CH_4 emissions (Gg)
Total			**5.18**		**15.82**
Underground mines	Mining		**0.81**		**10.87**
		Bituminous	0.22	16.75	3.71
		Sub-bituminous	0.59	12.1	7.15
	Post-mining			1.6	1.30
Surface mines	Mining		4.37	0.77	3.36
	Post-mining			0.067	0.29

Module 2003 Energy (New Zealand)
Submodule Fugitive emissions from oil and gas handling (tier 1)
Worksheet 1.7 (adapted)

Category		Fuel quantity (TJ)	CO_2 emis fact (kg/TJ)	CH_4 emis fact (kg/TJ)	CO_2 emissions (Gg)	CH_4 emissions (Gg)
Total					**380.929**	**17.37**
Oil	Exploration				ne	ne
	Production of crude oil				ne	ne
	Transport of crude oil	49,195		0.745	ne	0.04
	Refining/storage	220,103		0.885	ne	0.19
	Distribution of oil products				ne	ne
Gas	Production/processing				ne	ne
	Transmission / Distribution	65,910	21.6	249.38	1.42	16.44
	Other leakage	ne	ne	ne	ne	ne
Venting and flaring from oil and gas prod.		1,708		412.83	379.51	0.71

Module 2003 Energy (New Zealand)
Submodule Fugitive emissions from geothermal activities (tier 1)
Worksheet NZ 1a (additional)

Category	Fuel quantity (TJ)	CO_2 emis fact (kg/GJ)	CH_4 emis fact (kg/GJ)	CO_2 emissions (Gg)	CH_4 emissions (Gg)
Elec. generation and heat	69,187	3.890	0.035	269.11	2.43

Module 2003 Energy (New Zealand)
Submodule Ozone precursors and SO2 from oil refining
Worksheet 1.8 (additional)
Sheet NMVOC emissions from oil refining (tier 1)

Crude oil Throughput (m3)	Emission factor (kg/m3)	Emissions (t)	Emissions (Gg)
5,643,657	0.53	2,991	2.99

Module 2003 Energy (New Zealand)
Submodule Ozone precursors and SO2 from oil refining
Worksheet 1.8 (3 of 4)
Sheet SO2 from sulphur recovery plants (tier 2)

Quantity of sulphur recovered (t)	Emission factor (kg/t)	Emissions (kg)	Emissions (Gg)
26,476	139	3,680,164	3.68

Module 2003 Energy (New Zealand)
Submodule Ozone precursors and SO2 from oil refining
Worksheet 1.8 (4 of 4)
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)	4,837	0.70	3,386	3.39

A8.2: Worksheets for the industrial processes sector

Module	**2003 Industrial process (New Zealand)**
Worksheet	**NZ 2a**
Sheet	**CO_2 emissions**

Source category	Production Quantity (t)	CO_2 emissions (Gg)	CO_2 emis factor (t/t)
Total industrial processes		**3,470**	
Cement[1]	1,239,580	527.47	0.43
Lime[1]	152,180	111.36	0.73
Hydrogen[1]	28,303	184.35	6.51
Urea[1]	269,428	387.92	1.44
Iron and steel[1]	845,328	1,716.80	2.03
Aluminium[1]	333,653	542.14	1.62

1 Production and emissions data provided by industry and reported in Ministry of Economic Development (2004):

Module 2003 Industrial Processes (New Zealand)
Worksheet
Sheet CH_4 and CO emissions-ammonia/urea production

Year	Urea production kt	Ammonia production kt	CH_4 EF t/t	CH_4 emissions Gg	CO EF t/t	CO emissions Gg
1990	171.08	97.52	7.00E-03	0.68	5.00E-06	4.88E-04
1991	171.01	97.48	7.00E-03	0.68	5.00E-06	4.87E-04
1992	146.96	83.77	7.00E-03	0.59	5.00E-06	4.19E-04
1993	165.14	94.13	7.00E-03	0.66	5.00E-06	4.71E-04
1994	172.22	98.17	7.00E-03	0.69	5.00E-06	4.91E-04
1995	170.68	97.29	7.00E-03	0.68	5.00E-06	4.86E-04
1996	145.35	82.85	7.00E-03	0.58	5.00E-06	4.14E-04
1997	167.74	95.61	7.00E-03	0.67	5.00E-06	4.78E-04
1998	200.93	114.53	7.00E-03	0.80	5.00E-06	5.73E-04
1999	230.60	131.44	7.00E-03	0.92	5.00E-06	6.57E-04
2000	227.24	129.53	7.00E-03	0.91	5.00E-06	6.48E-04
2001	250.55	142.81	7.00E-03	1.00	5.00E-06	7.14E-04
2002	234.30	133.55	7.00E-03	0.93	5.00E-06	6.68E-04
2003	269.43	153.57	7.00E-03	1.08	5.00E-06	7.68E-04

Module 2003 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	HFC	PFC	SF6	SO2	CO	CH4	N20	NOx	NMVOC	HFC	PFC	SF6	SO2
A Iron and Steel																			
Pacific Steel	217.0	0.0007			0.0127						0.000003			0.00006					
NZ Steel	628.0	0.2355			0.9420					0.7222	0.000375			0.00150					0.001150
B Non-Ferrous Metals																			
NZ Aluminium Smelters	333.6	36.7			0.7172					6.5060	0.11000			0.00215					0.01950
C Inorganic Chemicals (excepting solvent use)																			
Sulphuric Acid (Ballance and Ravensdown)	541.6									2.35									0.00434
Superphosphate (Ballance and Ravensdown)	1719.4									1.62									0.00094
Urea (Ballance)	269.4																		
Ammonia (Ballance)	153.6	0.0008	0.1075								0.000005	0.00070							
D Organic Chemicals																			
Formaldehyde (Orica Adhesives and Dynea)	52.1	0.0000	0.0000			0.2912					0.00000	0.00000			0.00559				
Methanol (Methanex)	967.7	0.0968	1.9354		0.8709	4.8385					0.00010	0.00200		0.00090	0.00500				
E Non-Metallic Mineral Products																			
Cement	1050.8				0.0000					1.0266	0.0000			0.0000					0.00098
Lime	161.7									0.1803									0.00111
Asphalt Roofing	0.1	0.0000				0.0002					0.000010				0.00245				
Road Paving	105.0	0.0037			0.0088	2.5200				0.0126	0.000035			0.000084	0.02400				0.000120
Glass	114.8					0.5166									0.00450				
F Other (ISIC)																			
Paper and Pulp (chemical processes)	623.4	1.0723			0.9663	0.3429				0.0642	0.00172			0.00155	0.00055				0.00010
Paper and Pulp (mechanical processes)	795.2					0.4374									0.00055				
Panel Products (particleboard)	197.9					0.0257									0.00013				
Panel Products (fibreboard)	871.2					0.9583									0.00110				
Food and drink production																			
Wine (million litres)	68.0					0.0544									0.000833				
Beer (million litres)	313.0					0.1096									0.000350				
Spirits (million litres)	8.7					0.0173									0.002151				
Meat	1255.6					0.3767									0.000300				
Fish	297.1					0.0891									0.000300				
Poultry	142.9					0.0429									0.000300				
Sugar	228.6					2.2860									0.010000				
Margarine and solid cooking fats	0.0					0.0000									0.010000				
Cakes, biscuits and breakfast cereals	44.6					0.0446									0.001000				
Bread	260.0					2.0800									0.008000				
Animal feed	797.0					0.7970									0.001000				
Coffee roasting	5.6					0.0031									0.000550				
TOTAL		**38.11**	**2.04**	**0.00**	**3.52**	**15.83**	**0.00**	**0.00**	**0.00**	**12.48**									

Note: Use of halocarbons and SF6 covered in separate tables

Module 1990 - 2003 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	2.8	0.5	0.0	1.4
1993	3.4	0.5	2.8	3.1
1994	5.3	0.5	3.4	4.4
1995	13.0	0.5	5.3	9.2
1996	17.5	0.5	13.0	15.2
1997	20.6	0.5	17.5	19.0
1998	20.1	0.5	20.6	20.4
1999	19.1	0.5	20.1	19.6
2000	21.1	0.5	19.1	20.1
2001	22.0	0.5	21.1	21.6
2002	22.8	0.5	22.0	22.4
2003	23.6	0.5	22.8	23.2

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

Module 1990 - 2003 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: Number of Units	Aerosol imports: HFC[1] (tonnes)	Domestic loading HFC (tonnes)	Total HFC contained in products (tonnes)
1992	3,300,000	2.8	0.0	2.8
1993	4,000,000	3.4	0.0	3.4
1994	5,400,000	4.5	0.8	5.3
1995	8,700,000	7.3	5.7	13.0
1996	13,100,000	11.0	6.5	17.5
1997	16,800,000	14.1	6.5	20.6
1998	17,400,000	14.6	5.5	20.1
1999	17,500,000	14.7	4.4	19.1
2000	18,848,536	15.8	5.3	21.1
2001	19,773,731	16.6	5.4	22.0
2002	20,000,000	16.8	6.0	22.8
2003	21,000,000	17.6	6.0	23.6

1. Assumes average propellant charge = 84 grams, 1.0±0.5% of all imported aerosols contain HFCs

Module 1990 - 2003 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	526.4	7%	2.8
2000	510.1	9%	3.3
2001	835.4	39%	24.4
2002	716.4	73%	39.1
2003	634.7	66%	31.3

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 - 2003 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: Streaming (tonnes)	Total HFC-227a installed: Portable (tonnes)	Emission rate	Emissions of HFC-227a (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

1. Use of HFC-227a in fire protection industry not occurring before 1994

Module 1990 - 2003 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-134a usage (tonnes)	Emission rate first year	Emission rate later years	Emissions of HFC-134a (tonnes)
2000	1.5	0.100	0.045	0.15
2001	1.5	0.100	0.045	0.22
2002	1.5	0.100	0.045	0.29
2003	1.5	0.100	0.045	0.35

1. Assumed no use of HFC-134a in foam blowing industry before 2000

Module 1990 - 2003 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	0.0	0	3.9	0.3	3.6
1993	0	6.0	0	6.4	2.0	10.4
1994	0	53.0	0	6.8	10.5	49.3
1995	0	105.4	0	8.4	16.6	97.2
1996	0	152.3	0	10.6	15.9	147.0
1997	0	88.5	0	10.5	14.9	84.1
1998	0	192.9	0	9.9	16.8	186.0
1999	0	170.1	0	12.6	17.8	165.0
2000	0	134.0	0	11.9	19.0	126.9
2001	0	184.9	0	11.5	18.9	177.5
2002	0	257.2	0	15.5	19.6	253.1
2003	0	300.2	0	17.2	20.7	296.8

1. IPCC (2001) Box 3.4 equation

Module 1990 - 2002 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
1991	0.0	0	0.0	0.0
1992	0.0	3.7	0.3	3.4
1993	4.7	6.4	2.0	9.1
1994	36.5	6.8	10.5	32.8
1995	71.2	8.4	16.6	63.0
1996	98.0	10.6	15.9	92.7
1997	62.1	10.5	14.9	57.7
1998	122.1	9.9	16.8	115.2
1999	110.3	12.6	17.8	105.1
2000	94.1	11.9	19.0	87.0
2001	140.4	11.5	18.9	133.1
2002	168.4	15.5	19.6	164.3
2003	194.8	17.2	20.7	191.4

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

Module 1990 - 2003 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 equipment (tonnes)	Amount of intentional destruction (tonnes)	Emissions[2] (tonnes)
1990	0.0	0.0	0	0	0.0
1991	0.0	0.0	0	0	0.0
1992	3.4	3.4	0	0	0.0
1993	10.0	9.1	0	0	0.9
1994	46.1	32.8	0	0	13.3
1995	92.0	63.0	0	0	29.0
1996	140.0	92.7	0	0	47.3
1997	81.6	57.7	0	0	23.9
1998	177.7	115.2	0	0	62.5
1999	158.7	105.1	0	0	53.6
2000	126.9	87.0	0	0	39.9
2001	177.5	133.1	0	0	44.5
2002	253.1	164.3	0.8	0	89.6
2003	296.8	191.4	2.6	0	108.0

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 - 2003 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	0.0	0	3.9	0.3	3.6
1993	0	6.0	0	6.4	2.0	10.4
1994	0	53.0	0	6.8	10.5	49.3
1995	0	105.4	0	8.4	16.6	97.2
1996	0	152.3	0	10.6	15.9	147.0
1997	0	88.5	0	10.5	14.9	84.1
1998	0	192.9	0	9.9	16.8	186.0
1999	0	170.1	0	12.6	17.8	165.0
2000	0	134.0	0	11.9	19.0	126.9
2001	0	184.9	0	11.5	18.9	177.5
2002	0	257.2	0	15.5	19.6	253.1
2003	0	300.2	0	17.2	20.7	296.8

1. IPCC (2001) Box 3.4 equation

Module 1990 - 2002 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
1991	0.0	0	0.0	0.0
1992	0.0	3.7	0.3	3.4
1993	4.7	6.4	2.0	9.1
1994	36.5	6.8	10.5	32.8
1995	71.2	8.4	16.6	63.0
1996	98.0	10.6	15.9	92.7
1997	62.1	10.5	14.9	57.7
1998	122.1	9.9	16.8	115.2
1999	110.3	12.6	17.8	105.1
2000	94.1	11.9	19.0	87.0
2001	140.4	11.5	18.9	133.1
2002	168.4	15.5	19.6	164.3
2003	194.8	17.2	20.7	191.4

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

Module 1990 - 2003 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 equipment (tonnes)	Amount of intentional destruction (tonnes)	Emissions[2] (tonnes)
1990	0.0	0.0	0	0	0.0
1991	0.0	0.0	0	0	0.0
1992	3.4	3.4	0	0	0.0
1993	10.0	9.1	0	0	0.9
1994	46.1	32.8	0	0	13.3
1995	92.0	63.0	0	0	29.0
1996	140.0	92.7	0	0	47.3
1997	81.6	57.7	0	0	23.9
1998	177.7	115.2	0	0	62.5
1999	158.7	105.1	0	0	53.6
2000	126.9	87.0	0	0	39.9
2001	177.5	133.1	0	0	44.5
2002	253.1	164.3	0.8	0	89.6
2003	296.8	191.4	2.6	0	108.0

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 - 2003 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

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 - 2003 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	Annual virgin 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	3.2	0.2	1.0	1.7	0.0	2.9	0.3
1995	20.8	0.2	3.3	6.9	0.3	10.8	10.0
1996	37.5	0.3	3.3	10.2	2.0	15.8	21.7
1997	12.9	0.3	2.8	6.5	1.4	11.0	1.9
1998	54.6	0.2	2.3	5.0	0.8	8.2	46.3
1999	27.4	0.3	2.5	3.9	0.2	6.9	20.5
2000	44.1	0.3	2.6	2.4	0.2	5.5	38.5
2001	46.3	0.3	2.7	1.3	0.3	4.6	41.7
2002	62.1	0.4	1.9	0.4	0.2	2.9	59.3
2003	48.6	0.4	1.9	0.4	0.6	3.3	45.3

1. IPCC (2001) Equations 3.44 and 3.45
2. No use recorded before 1994

Module 1990 - 2002 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

1. IPCC (2001) Equations 3.44 and 3.47

Module 1990 - 2002 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	0.3	0.04	0	0.3
1995	0.054	10.0	1.98	0	12.1
1996	0.079	21.7	4.38	0	26.2
1997	0.055	1.9	11.40	0	13.3
1998	0.041	46.3	9.98	0	56.3
1999	0.035	20.5	9.77	0	30.3
2000	0.028	38.5	14.00	0	52.5
2001	0.023	41.7	19.34	0	61.1
2002	0.014	59.3	23.76	0	83.0
2003	0.017	45.3	25.14	0	70.4

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

Module 1990 - 2003 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. RAC 4 of 4
Sheet All HFC and PFC emissions from stationary refrigeration

Year	Bulk emissions (tonnes)	HFC-32 (tonnes)	HFC-125 (tonnes)	HFC-134a (tonnes)	HFC-143a (tonnes)	HFC-152 (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	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	1.1	0.0	0.0	1.1	0.0	0.0	0.0
1994	14.6	0.0	1.2	11.3	0.4	0.4	0.0
1995	31.1	0.4	0.5	18.2	7.9	1.2	0.8
1996	50.1	0.0	6.7	28.3	7.1	0.4	4.8
1997	24.8	0.0	10.5	3.6	9.3	0.2	0.3
1998	65.8	0.0	9.5	35.2	9.4	0.4	8.0
1999	57.8	7.4	10.4	23.0	11.0	1.7	0.0
2000	39.9	0.0	4.1	29.3	6.4	0.0	0.0
2001	44.5	0.1	12.8	16.6	14.9	0.0	0.0
2002	89.6	0.9	19.4	47.4	21.6	0.0	0.4
2003	108.0	1.8	23.6	55.3	26.6	0.0	0.6

Module 1990 - 2003 Emissions of Sulphur Hexafluoride (New Zealand)
Worksheet
Sheet SF_6 from Electrical Equipment and Other Sources (based on equations 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	489	11	500
2001	1483	490	14	504
2002	2014	526	14	540
2003	2182	507	11	518

1. IPCC (2001) Equation 3.18
2. IPCC (2001) Equation 3.17
3. IPCC (2001) Equation 3.22

A8.3: Worksheets for the solvents sector

Module **2003 Solvent and other product use (New Zealand)**
Worksheet **NZ 3a**
Sheet **Non-CO_2 emissions**

Source Categories	ACTIVITY DATA Quantity Consumed tonnes	Emissions Estimates B (Gg) Tonnes x 1000			Emission Factors C kg/year/person		
		N_20	HFC	NMVOC	N_20	HFC	NMVOC
TOTAL SOLVENT EMISSIONS							
A Surface Coatings							
Architectural/ Decorative							
Organic Base	**4447**			**1.4795**			
Primers and Undercoats	1671			0.4513			0.1118
Finishing Coats - Gloss	1333			0.4531			0.1122
Finishing Coats - Semi Gloss	348			0.0904			0.0224
Finishing Coats - Flat	263			0.0683			0.0169
Clears and Satins	833			0.4164			0.1032
Water Base	**32702**			**2.0990**			
Primers and Undercoats	2730			0.1911			0.0473
Finishing Coats - Gloss	12846			0.8992			0.2228
Finishing Coats - Semi Gloss	7296			0.5107			0.1265
Finishing Coats - Flat	9180			0.4590			0.1137
Clears and Satins	650			0.0390			0.0097
Industrial							
Organic Base	**17245**			**8.5452**			
Primers and Undercoats	6601			2.2442			0.5560
Finishing Coats	9787			5.8722			1.4548
Clears	857			0.4287			0.1062
Water Base	**1425**			**0.0998**			
Primers and Undercoats	1281			0.0897			0.0222
Finishing Coats	144			0.0101			0.0025
Thinners				**4.0602**			
Solvents/Thinners	4060			4.0602			1.0059
B Degreasing and Drycleaning[2]				**0.8450**			
C Chemical Products				**0.0980**			
Ethanol[1]				0.0624			
Hydrogen Peroxide[1]				0.0356			
D Other				**14.3873**			
Printing[2]				1.8893			
Aerosols[2]				2.245			
Domestic and Commercial Use				10.253			2.5400
Nitrous oxide use		0.16			0.04		
	Total	**0.16**		**31.61**			

Emission factors derived on a kg/person/year basis, [1] Emissions calculated on production not consumption data, [2] Emissions calculated from import not consumption data

POPULATION (end of 2003) 4,036,400 (Population data based on provisional data of 4024400 as at 30/9/03)

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	5,049,071	4,491,281	4,559,966	39,571,837	40,289,383	153	153	1,647,900	1,630,023	342	350
2003	5,105,761	5,165,017	4,644,263	4,517,115	39,688,458	39,427,232	142	142	1,689,400	1,692,267	355	351
2004	5,227,700		4,415,800		39,021,400		131		1,739,500		355	

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.
2. MAF estimates February 2003

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

	Poultry numbers layers[1] (June yr)	Poultry others and broilers[2] (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	78.9
2004	3,219	19,954	23,173		80.4	

1. 1995, 1996 and 2002 (provisional) data from Statistics New Zealand. 1989, 1990 and 1992 from MAF survey data.
   Other estimates provided by MAF February 2003.
2. 2002 data from Statistics New Zealand. 1989, 1990, 1992, 1995 and 1996 from MAF survey data.
3. 1994, 1995, 1996 and 2002 data from Statistics New Zealand. 1990, 1992 and 1993 from MAF survey data.
2003 and 2004 data not available in time for inventory from Statistics New Zealand and are extrapolated.

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) (tonnes)	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	328.7	148,847	164.9	34,987	29.4	894,777,432
2003	378,340	399.2	320,500	314.2	168,949	162.2	30,928	32.3	907,883,198
2004	378,340		320,500		168,949		30,928		

Source: Statistics New Zealand.

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

2004 production not processed by Statistics New Zealand, set equal to 2003.

N-fixing crop yields in New Zealand Revised 2004

Agricultural sector calculations: emissions from field burning and agricultural soils

	Processed peas prodn[1] (jun yr) (tonnes dry weight)	Peas prodn[2] (jun yr) (tonnes)	Peas Processed and Seed Peas (tonnes DW)	Peas prodn (3 yr av) (Gg)	Lentils prodn[1] (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	75.1	3,302	1.8	76,886,333
2003	31,200	55,000	86,200	78.4	2,000	2.4	80,819,667
2004	28,500	55,000	83,500		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. 2004 data set to 2003 as no data.

Micsellaneous 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		348,000,000	

1 MAF estimate 2003

2 Best estimate from MAF and sales records obtained by FertResearch

Module **2002 Agriculture (New Zealand)**

Submodule **Prescribed burning of savanna**

Year	Otago consented area (ha)	Canterbury consented area (ha)	Southland consented area (ha)	Total consented area (ha)	3 yr ave consented area (ha)	assume 20% consented area (ha) burnt	above ground 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	28.0	0.32	65254.9
1991	22020.0	15241.2	4580.0	41841.2	36108.1	7221.6	28.0	0.32	64605.3
1992	10740.0	15531.5	4820.0	31091.5	34571.7	6914.3	28.0	0.32	61856.4
1993	15229.0	10953.5	4600.0	30782.5	27819.7	5563.9	28.0	0.32	49775.5
1994	7875.0	9900.0	3810.0	21585.0	22006.2	4401.2	28.0	0.32	39373.9
1995	7485.0	1626.0	4540.0	13651.0	17770.7	3554.1	28.0	0.32	31795.6
1996	4790.0	9061.0	4225.0	18076.0	16109.0	3221.8	28.0	0.32	28822.5
1997	5895.0	6955.0	3750.0	16600.0	14466.7	2893.3	28.0	0.32	25884.0
1998	1810.0	5314.0	1600.0	8724.0	10919.0	2183.8	28.0	0.32	19536.5
1999	0.0	4963.0	2470.0	7433.0	9921.0	1984.2	28.0	0.32	17750.8
2000	2425.0	9491.0	1690.0	13606.0	10424.0	2084.8	28.0	0.32	18650.8
2001	3770.0	4303.0	2160.0	10233.0	11943.7	2388.7	28.0	0.32	21369.8
2002	350.0	8792.0	2850.0	11992.0	10972.0	2194.4	28.0	0.32	19631.3
2003	4670.0	3721.0	2300.0	10691.0	10901.7	2180.3	28.0	0.32	19505.5
2004	1125.0	2714.0	6183.0	10022.0					

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 **2003 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)
2003	0.00	0.06	0.01	0.12	0.01	0.040	1.053	0.000	0.018	0.996

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 **2003 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)
2003	19505	0.36	0.64	0.8	1	0.45	0.4	2532	4989	7521

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 1990-2002. 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	3679	4.86	3.67
2003	458	3673	4.88	3.70

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 1990-2002
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	429	453	608	617

Livestock productivity data for New Zealand 2004
Agricultural sector calculations: CH_4 emissions from domestic liv
Table 3: Weights of ewes and lambs in New Zealand 1990-200
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

Livestock productivity data for New Zealand 2004
Agricultural sector calculations: CH_4 emissions from domestic livestock
Table 4: Weights of deer in New Zealand 1990-2002
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	129.5	168.9	105.4	90.9

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 1990-2002

	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 livestoc
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	27.37
1991	12.35	66.73	107.14	27.07
1992	12.47	68.09	109.56	26.88
1993	12.67	70.07	110.21	26.75
1994	12.73	69.37	110.33	26.88
1995	12.87	69.09	109.82	27.31
1996	13.10	68.15	110.65	27.81
1997	13.50	70.71	110.30	28.55
1998	13.61	70.62	111.51	28.93
1999	13.77	71.62	113.33	29.13
2000	13.98	71.30	116.31	29.21
2001	14.35	72.91	116.39	29.18
2002	14.39	72.40	116.63	29.17
2003	14.60	72.72	116.88	28.93

Module	**2003 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	5,165	79.1	408.81	0.889	4.592	413.40
Non-dairy cattle	4,517	56.3	254.49	0.909	4.106	258.60
Sheep	39,427	10.6	419.44	0.178	7.018	426.45
Goats	142	9.0	1.28	0.180	0.026	1.30
Deer	1,692	22.1	37.48	0.369	0.624	38.10
Horses	79	18.0	1.42	2.080	0.164	1.58
Swine	351	1.5	0.53	20.000	7.015	7.54
Poultry	22,389	NE	NE	0.117	2.619	2.62
Total			1,123.44		26.164	1,149.60

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	**2003 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	33,270,822	0.001	0.052
Liquid Systems			NO
Daily spread			IE
Solid storage and drylot	953,995	0.02	0.030
Pasture range and paddock			IE
Other	14,601,554	0.005	0.115
Total			0.197

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

2003 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

2003 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	0.0125	... 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 2003 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	4,517			no
Dairy cattle	5,165	116.9	5%	30,184,369
Poultry	22,389			no
Sheep	39,427			no
Swine	351	16.0	55%	3,086,453
Goats	142			no
Deer	1,692			no
Horses	79			no
Total (Nex_{AL})				33,270,822

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

Module 2003 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	4,517	72.7	100%	328,484,614
Dairy cattle	5,165	116.9	95%	573,503,009
Poultry	22,389	0.6	3%	402,998
Sheep	39,427	14.6	100%	575,599,847
Swine	351			no
Goats	142	9.5	100%	1,349,317
Deer	1,692	28.9	100%	48,962,585
Horses	79	25.0	100%	1,972,083
Total ($Nex_{PR\&P}$)				1,530,274,453

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 2003 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	4,517			no
Dairy cattle	5,165			no
Poultry	22,389			no
Sheep	39,427			no
Swine	351	16.0	17%	953,995
Goats	142			no
Deer	1,692			no
Horses	79			no
Total ($Nex_{SS\&D}$)				953,995

Module 2003 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	4,517			no
Dairy cattle	5,165			no
Poultry	22,389	0.6	97%	13,030,268
Sheep	39,427			no
Swine	351	16.0	28%	1,571,285
Goats	142			no
Deer	1,692			no
Horses	0			no
Total (Nex_{OTHER})				14,601,554

2003 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}
48,826,371	0		0.2	39,061,096

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

2003 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}
80,819,667	0.03	4,849,180

2003 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}
331,533,333	0.9	298,380,000

2003 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}
		80,819,667	0.03	0.55	1	2,667,049
907,883,198	0.015			0.55	0.50	7,490,036
						10,157,085

Module **2003 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	745.6		929.4		775.2			348.8		163.675		2.233
a Barley	399.2	1.2	479.0	0.83	397.6	0.5	0.9	178.9	0.4567	81.711	0.015	1.226
b Wheat	314.2	1.3	408.4	0.83	339.0	0.5	0.9	152.5	0.4853	74.029	0.012	0.888
c Oats	32.3	1.3	42.0	0.92	38.6	0.5	0.9	17.4	0.4567	7.935	0.015	0.119

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

Module **2003 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	0.818	1.333	1.091
CO	0.060	9.820	2.333	22.914
N_2O	0.007	0.016	1.571	0.025
NO_x	0.121	0.270	3.286	0.888

Module **2003 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	0.545	11.440	0.013	0.487
b Wheat	0.494	10.364	0.010	0.353
d Oats	0.053	1.111	0.001	0.047

Module 2003 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})	298,380,000	0.0125	3.730	5.861
Animal Waste (F_{AW})[1]	39,061,096	0.0125	0.488	0.767
N-Fixing crops (F_{BN})	4,849,180	0.0125	0.061	0.095
Crop residue (F_{CR})	10,157,085	0.0125	0.127	0.200
Total			4.406	6.923

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

Module 2003 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)
	10,109	8	0.081	0.127

1 MAF estimate

Module 2003 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	1,530,274,453	0.01	15.303	24.047

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

Module 2003 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)
	331,533,333	0.1	33,153,333	1,579,100,824	0.2	315,820,165	0.01	3.490	5.484

Module 2003 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)
	331,533,333	1,579,100,824	0.07	0.025	3.344	5.254

Module 2003 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)
	10.738	31.097	41.835

A8.5: Worksheets for the LULUCF sector

Module **LULUCF**
Submodule **Forest remaining Forest**
Carbon stock change in living biomass
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	0.497	5,375,576	2,687,788	365,000	0.50	2.04	372,300	186,150	2,873,938
1991	11,797,488	0.483	5,695,944	2,847,972	307,667	0.50	2.04	313,820	156,910	3,004,882
1992	12,500,583	0.482	6,029,456	3,014,728	257,333	0.50	2.04	262,480	131,240	3,145,968
1993	13,232,522	0.482	6,373,329	3,186,664	205,000	0.50	2.04	209,100	104,550	3,291,214
1994	13,987,203	0.479	6,698,479	3,349,240	158,000	0.50	2.04	161,160	80,580	3,429,820
1995	14,700,793	0.472	6,932,502	3,466,251	107,333	0.50	2.04	109,480	54,740	3,520,991
1996	15,214,390	0.455	6,926,911	3,463,455	50,000	0.50	2.04	51,000	25,500	3,488,955
1997	15,202,119	0.472	7,174,913	3,587,457	56,667	0.50	2.04	57,800	28,900	3,616,357
1998	15,746,397	0.482	7,596,912	3,798,456	57,667	0.50	2.04	58,820	29,410	3,827,866
1999	16,672,535	0.498	8,305,796	4,152,898	57,000	0.50	2.04	58,140	29,070	4,181,968
2000	18,228,285	0.493	8,981,586	4,490,793	38,333	0.50	2.04	39,100	19,550	4,510,343
2001	19,711,404	0.472	9,304,012	4,652,006	23,000	0.50	2.04	23,460	11,730	4,663,736
2002	20,419,017	0.459	9,371,459	4,685,729	16,333	0.50	2.04	16,660	8,330	4,694,059
2003	20,508,697	0.459	9,421,909	4,710,955	10,333	0.50	2.04	10,540	5,270	4,716,225

All data are three-year straight averages.
[1] Estimated using Forest Research models.
[2] Derived from the model results contained in columns 1 and 3.
[3] No adjustment from stem volume to total biomass volume is made here as on-site decay is accounted for in the carbon uptake data.

Module **LULUCF**
Submodule **Forest remaining Forest**
Worksheet **Carbon stock change in living biomass**
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)	Carbon in plantation forest harvest (t C)	Total forest carbon uptake (before harvest) (t C)
1990	1,219,430	116,176,914	6,370,915	2,687,788	9,058,703
1991	1,248,034	122,306,137	6,129,224	2,847,972	8,977,196
1992	1,288,486	127,955,851	5,649,714	3,014,728	8,664,442
1993	1,351,055	133,108,509	5,152,657	3,186,664	8,339,322
1994	1,426,089	138,037,423	4,928,914	3,349,240	8,278,154
1995	1,508,665	142,872,726	4,835,303	3,466,251	8,301,554
1996	1,585,196	147,819,449	4,946,723	3,463,455	8,410,178
1997	1,654,972	153,194,165	5,374,716	3,587,457	8,962,173
1998	1,711,807	159,077,011	5,882,846	3,798,456	9,681,302
1999	1,758,009	165,567,822	6,490,811	4,152,898	10,643,709
2000	1,796,162	172,556,270	6,988,448	4,490,793	11,479,241
2001	1,828,624	179,724,098	7,167,828	4,652,006	11,819,834
2002	1,855,950	186,832,330	7,108,232	4,685,729	11,793,962
2003	1,877,472	193,815,031	6,982,700	4,710,955	11,693,655

All data are three year straight averages.
Data were estimated using Forest Research Institute models.

Module **LULUCF**
Submodule **Forest remaining Forest**
Worksheet **Carbon stock change in living biomass**
Sheet **Net Carbon uptake in forest**

	Total forest carbon uptake (before harvest) (Gg C)	Carbon release from total forest harvest (Gg C)	Net carbon uptake in forests (Gg C)	Net CO2 uptake in forests (Gg CO2)
1990	9,059	2,874	6,185	22,677
1991	8,977	3,005	5,972	21,898
1992	8,664	3,146	5,518	20,234
1993	8,339	3,291	5,048	18,510
1994	8,278	3,430	4,848	17,777
1995	8,302	3,521	4,781	17,529
1996	8,410	3,489	4,921	18,044
1997	8,962	3,616	5,346	19,601
1998	9,681	3,828	5,853	21,463
1999	10,644	4,182	6,462	23,693
2000	11,479	4,510	6,969	25,553
2001	11,820	4,664	7,156	26,239
2002	11,794	4,694	7,100	26,033
2003	11,694	4,716	6,977	25,584

All data are three year straight averages.
Data were estimated using Forest Research Institute models.

Module LULUCF
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 vegetation 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 vegetation (t C/t dm = 0.5) (t C)	CO2 release from burning for new planting (t CO2)	Clearance where grassland decays[2] (75% of total) (ha)	Initial quantity of biomass to decay[3] (t dm/ha =136) (t dm)	C release from decay (t C/t dm = 0.5) (t C)	CO2 release from decay for new planting (t CO2)
1990	3,579	895	121,679	109,511	54,756	200,771	2,684	365,038	182,519	669,236
1991	5,427	1,357	184,507	166,056	83,028	304,436	4,070	553,520	276,760	1,014,787
1992	8,480	2,120	288,320	259,488	129,744	475,728	6,360	864,960	432,480	1,585,760
1993	11,200	2,800	380,800	342,720	171,360	628,320	8,400	1,142,400	571,200	2,094,400
1994	12,464	3,116	423,776	381,398	190,699	699,230	9,348	1,271,328	635,664	2,330,768
1995	9,376	2,344	318,773	286,895	143,448	525,975	7,032	956,318	478,159	1,753,250
1996	10,323	2,581	350,971	315,874	157,937	579,102	7,742	1,052,912	526,456	1,930,339
1997	9,263	2,316	314,953	283,458	141,729	519,673	6,948	944,860	472,430	1,732,243
1998	4,662	1,166	158,508	142,657	71,329	261,538	3,497	475,524	237,762	871,794
1999	5,847	1,462	198,809	178,928	89,464	328,035	4,386	596,428	298,214	1,093,451
2000	5,905	1,476	200,759	180,683	90,341	331,252	4,429	602,276	301,138	1,104,173
2001	6,662	1,666	226,519	203,867	101,934	373,757	4,997	679,558	339,779	1,245,856
2002	4,880	1,220	165,920	149,328	74,664	273,768	3,660	497,760	248,880	912,560
2003	4,654	1,164	158,236	142,412	71,206	261,089	3,491	474,708	237,354	870,298

All data are three year straight averages
[1] Ministry of Agriculture and Forestry
[2] Percentage assumed for calculation purposes.

Module LULUCF
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 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	2,236	304,096	273,686	136,843	287	104,468	94,021	47,011

Module **LULUCF**
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	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	47,011	470	564	3	57	2,821	0.752	0.005	0.187	6.581

Module **LULUCF**
Submodule **Grassland remaining grassland**
Worksheet
Sheet **Non-CO2 emissions from the on-site burning of grassland - 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	136,843	1,368	1,642	10	166	8,211	2.189	0.015	0.544	19.155

Module **LULUCF**
Submodule **Grassland converted to forest land**
Worksheet
Sheet **Non-CO2 emissions from the on-site burning of grassland - 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	54,756	548	657	4	66	3,285	0.876	0.006	0.218	7.665
1991	83,028	830	996	6	100	4,982	1.328	0.009	0.330	11.622
1992	129,744	1,297	1,557	9	157	7,785	2.075	0.014	0.516	18.162
1993	171,360	1,714	2,056	12	207	10,282	2.741	0.019	0.681	23.987
1994	190,699	1,907	2,288	13	231	11,442	3.050	0.021	0.758	26.694
1995	143,448	1,434	1,721	10	174	8,607	2.295	0.016	0.570	20.080
1996	157,937	1,579	1,895	11	191	9,476	2.526	0.017	0.628	22.108
1997	141,729	1,417	1,701	10	171	8,504	2.267	0.016	0.564	19.839
1998	71,329	713	856	5	86	4,280	1.141	0.008	0.284	9.985
1999	89,464	895	1,074	6	108	5,368	1.431	0.010	0.356	12.523
2000	90,341	903	1,084	6	109	5,420	1.445	0.010	0.359	12.646
2001	101,934	1,019	1,223	7	123	6,116	1.631	0.011	0.405	14.269
2002	74,664	747	896	5	90	4,480	1.194	0.008	0.297	10.451
2003	71,206	712	854	5	86	4,272	1.139	0.008	0.283	9.967

Module **LULUCF**
Submodule **Carbon emissions from liming soils**
Worksheet **5.5**
Sheet **3 of 4 (adapted)**

	Total annual amount of limestone[1] (Mg)	**Total annual amount of limestone (3yr average) (Mg)**	**Carbon conversion factor[2]**	**Carbon emissions from liming (MgC)**	**Emissions of CO_2 (Gg)**
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. Statistics New Zealand June year data for 1989, 1990, 1992, 1993, 1995, 1996, 2002, 20(
1991 estimate is average of 1990 and 1992
1994 estimate is average of 1993 and 1995
1997 to 2001 is interpolated between 1996 and 2002
Data for 2004 was not processed in time for inclusion in the inventory and is set equal to 20(

2 IPCC default value

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 2003 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 2003 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	2975	69.55	0.06	115.2	683.0	0.00	0.00	0.00	115.22	0.9	103.70
1991	3067	69.55	0.06	116.5	679.0	0.00	0.00	0.00	116.55	0.9	104.89
1992	3099	69.55	0.06	117.9	729.0	23.53	0.60	20.07	97.81	0.9	88.03
1993	3139	69.55	0.06	119.2	783.0	24.95	0.60	21.60	97.65	0.9	87.88
1994	3183	69.55	0.06	120.6	1019.0	32.02	0.60	28.11	92.54	0.9	83.28
1995	3182	69.55	0.06	122.0	1074.0	33.21	0.60	29.55	92.41	0.9	83.17
1996	3159	68.84	0.06	123.1	1203.0	36.65	0.60	33.03	90.02	0.9	81.02
1997	3136	68.13	0.06	123.9	1608.0	48.47	0.60	44.24	79.70	0.9	71.73
1998	3113	67.42	0.06	124.6	1645.0	49.25	0.60	45.47	79.15	0.9	71.23
1999	3091	66.71	0.06	125.1	1709.0	50.87	0.60	47.52	77.60	0.9	69.84
2000	3068	66.01	0.06	125.5	1700.0	50.32	0.65	51.45	74.01	0.9	66.61
2001	3045	65.30	0.06	125.6	1708.0	50.05	0.65	51.69	73.94	0.9	66.55
2002	3022	64.59	0.06	125.7	1703.0	49.10	0.65	51.26	74.40	0.9	66.96
2003	3045	63.88	0.06	125.6	1631.0	47.70	0.65	50.22	75.42	0.9	67.88

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

2003 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 2003

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
0.9813	0.1303	0.50	0.50	1.3333	0.0426	63.88

Module 2003 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 2003 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 2003 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	4,039,400	0.01	**0.30**

[1] SCS Wetherill 2002
[2] Statistics New Zealand.

Module **2003 Waste (New Zealand)**
Submodule **Methane emissions from industrial wastewater and sludge handling**
Worksheet **NZ 6.3 (modified)**

	Total industrial output (tonne product/year)	Degradable organic component (kg COD/ tonne product)	Total industrial organic wastewater (kg COD/yr) TOW_{ind}	Proportion of industry using anaerobic treatment (without CH_4 collection)	Proportion of incoming COD degraded anaerobically in anaerobic plant	Maximum CH_4 producing capacity (kg CH_4/kg COD) B_0	Emission factor (kg CH_4/ kg incoming COD)	CH_4 emissions (Gg/year)
Meat industry								
beef	600,000	50	30,000,000	43%	55%	0.25	0.059	1.77
sheep/lambs	545,000	50	27,250,000	33%	55%	0.25	0.045	1.24
pigs	48,338	50	2,416,900	40%	55%	0.25	0.055	0.13
venison	27,081	50	1,354,050	40%	55%	0.25	0.055	0.07
goats	1,285	50	64,250	40%	55%	0.25	0.055	0.00
poultry	111,000	123	13,653,000	20%	55%	0.25	0.028	0.38
Leather and skins	85,000	180	15,300,000	0%	70%	0.25	0.000	0.00
Pulp and paper			56,889,552	100%	2%	0.25	0.005	0.28
Wool scouring	183,000	22	4,026,000	9%	29%	0.25	0.007	0.03
Wine[1]								0.02
Beverages				0%			0	
Dairy processing	1,714,363	5.8	9,943,305	0%			0	
Food processing				0%			0	
Metals and minerals				0%			0	
Petrochemical				0%			0	
Plastics				0%			0	
Textiles				0%			0	
Iron and steel				0%			0	
Non-ferrous metals				0%			0	
Fertiliser				0%			0	
Total								**3.93**

1 Emissions estimate for wine from Savage 1997. All other data from SCS Wetherill 2002

Module **2003 Waste (New Zealand)**
Submodule **Nitrous oxide emissions from industrial wastewater handling**
Worksheet (adapted from 6.3 and 6.4)

	Total industrial organic wastewater (kg COD/yr) TOW_{ind}	Ratio of N to COD in wastewater	Total Nitrogen in wastewater (kg N/yr)	Emission factor (EF_6) (kg N_2O-N/kg wastewater-N	N2O emissions (Gg/year)
Meat industry					
beef	30,000,000	0.08	2,400,000	0.02	0.075
sheep/lambs	27,250,000	0.08	2,180,000	0.02	0.069
pigs	2,416,900	0.08	193,352	0.02	0.006
venison	1,354,050	0.08	108,324	0.02	0.003
goats	64,250	0.08	5,140	0.02	0.000
poultry	13,653,000	0.08	1,092,240	0.02	0.034
Leather & skins	15,300,000	0.08	1,224,000	0.02	0.038
Pulp and paper	56,889,552	0.0038	216,180	0.00	
Wool scouring	4,026,000	0.018	72,468	0.01	0.001
Wine					
Beverages					
Dairy processing	9,943,305	0.018	178,979	0.0025	0.001
Food processing					
Metals & mins					
Petrochemical					
Plastics					
Textiles					
Iron and steel					
Non-ferrous					
Fertiliser					
Total					**0.23**

Annex 9:

Trend tables from the 2003 Common Reporting Format

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

NEW ZEALAND
2003
2005

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	**22,652.6323**	**23,040.6307**	**24,798.1322**	**24,075.0182**	**24,263.4540**	**24,141.2548**	**25,188.0743**	**27,543.3665**	**26,011.3207**	**27,292.2076**
A. Fuel Combustion (Sectoral Approach)	22,031.3465	22,332.5861	24,123.2683	23,440.5281	23,585.4837	23,505.1896	24,538.8780	26,841.6028	25,336.8622	26,662.1948
1. Energy Industries	6,024.7996	6,099.4373	7,542.9562	6,529.8761	5,389.6471	4,674.4840	5,241.4246	6,843.3344	5,175.8577	6,410.2624
2. Manufacturing Industries and Construction	4,538.6117	4,942.4410	4,592.2955	4,707.3963	5,130.3417	5,036.4416	5,543.5950	6,000.9413	5,997.1613	5,682.2815
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	2,835.1302	2,650.7447	2,963.2688	2,762.6142	2,921.7615	2,938.3899	2,812.2702	2,739.5972	2,714.9909	2,871.0877
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	621.2858	708.0446	674.8639	634.4902	677.9703	636.0652	649.1963	701.7637	674.4585	630.0129
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	621.2858	708.0446	674.8639	634.4902	677.9703	636.0652	649.1963	701.7637	674.4585	630.0129
2. Industrial Processes	**2,662.1821**	**2,787.2158**	**2,893.3275**	**3,039.1210**	**2,943.2796**	**3,019.7925**	**2,988.0816**	**2,890.9232**	**3,047.7134**	**3,212.2415**
A. Mineral Products	448.2800	437.1627	500.5182	553.2498	565.9611	586.0167	580.9092	598.6790	574.0420	638.2510
B. Chemical Industry	426.5780	441.4380	403.2500	425.1910	449.6860	424.6760	410.9640	435.6720	480.6600	527.7650
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	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3. Solvent and Other Product Use	**IE,NE**	**IE,NE**	**IE,NE**	**IE,NE**	**IE,NE**	**IE,NE**	**IE,NE**	**IE,NE**	**IE,NE**	**IE,NE**
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils (2)										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry	**-21,370.4538**	**-20,100.5490**	**-17,663.6191**	**-15,241.8085**	**-14,160.8152**	**-14,652.0220**	**-14,924.8874**	**-16,459.2679**	**-19,304.5579**	**-21,112.2871**
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 CO_2 emissions including net CO_2 from LUCF (4)	**3,944.3606**	**5,727.2975**	**10,027.8406**	**11,872.3308**	**13,045.9184**	**12,509.0253**	**13,251.2684**	**13,975.0218**	**9,754.4762**	**9,392.1620**
Total CO_2 emissions excluding net CO_2 from LUCF (4)	**25,314.8144**	**25,827.8465**	**27,691.4597**	**27,114.1393**	**27,206.7336**	**27,161.0473**	**28,176.1559**	**30,434.2897**	**29,059.0341**	**30,504.4491**
Memo Items:										
International Bunkers	**2,374.1423**	**2,194.8290**	**2,176.9807**	**2,244.1642**	**2,755.1750**	**2,692.8488**	**2,696.2108**	**2,819.6890**	**2,772.8246**	**2,856.9927**
Aviation	1,340.9639	1,281.6352	1,310.6254	1,329.5027	1,431.5750	1,568.5705	1,634.5737	1,708.8020	1,700.5094	1,942.0695
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	**2,599.1348**	**2,791.6400**	**2,661.0056**	**2,691.9901**	**3,169.4801**	**3,200.3117**	**3,145.3945**	**2,961.6107**	**3,092.7435**	**3,808.2256**

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

(Sheet 1 of 5) 2003
(Part 2 of 2) 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	%
1. Energy	**27,843.2089**	**29,728.2110**	**29,768.2913**	**31,229.5125**	**37.8626**
A. Fuel Combustion (Sectoral Approach)	27,255.6394	29,099.5078	29,152.8920	30,579.4734	38.7998
1. Energy Industries	6,041.9167	7,240.1963	6,420.4940	7,581.5967	25.8398
2. Manufacturing Industries and Construction	5,890.7774	5,990.9960	6,304.1824	5,840.1897	28.6779
3. Transport	12,281.1819	12,657.6878	13,230.7051	13,788.1302	59.7178
4. Other Sectors	3,041.7635	3,210.6277	3,197.5105	3,369.5568	18.8502
5. Other	NA	NA	NA	NA	0.0000
B. Fugitive Emissions from Fuels	587.5694	628.7032	615.3993	650.0391	4.6280
1. Solid Fuels	NA,NE	NA,NE	NA,NE	NA,NE	0.0000
2. Oil and Natural Gas	587.5694	628.7032	615.3993	650.0391	4.6280
2. Industrial Processes	**3,162.8373**	**3,255.2304**	**3,242.8502**	**3,470.0353**	**30.3455**
A. Mineral Products	629.7730	627.6370	652.4170	638.8270	42.5063
B. Chemical Industry	514.1590	557.1670	539.3940	572.2690	34.1534
C. Metal Production	2,018.9053	2,070.4264	2,051.0392	2,258.9393	26.3867
D. Other Production	NE	NE	NE	NE	0.0000
E. Production of Halocarbons and SF_6					
F. Consumption of Halocarbons and SF_6					
G. Other	NE	NE	NE	NE	0.0000
3. Solvent and Other Product Use	**IE,NE**	**IE,NE**	**IE,NE**	**IE,NE**	**0.0000**
4. Agriculture					
A. Enteric Fermentation					
B. Manure Management					
C. Rice Cultivation					
D. Agricultural Soils (2)					
E. Prescribed Burning of Savannas					
F. Field Burning of Agricultural Residues					
G. Other					
5. Land Use, Land-Use Change and Forestry	**-22,823.3545**	**-23,190.9988**	**-23,330.8121**	**-22,865.7081**	**6.9968**
6. Waste	**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	0.0000
B. Waste-water Handling					
C. Waste Incineration	NE	NE	NE	NE	0.0000
D. Other	NO	NO	NO	NO	0.0000
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**0.0000**
Total CO_2 emissions including net CO_2 from LUCF (4)	**8,182.6917**	**9,792.4426**	**9,680.3294**	**11,833.8397**	**200.0192**
Total CO_2 emissions excluding net CO_2 from LUCF (4)	**31,006.0462**	**32,983.4414**	**33,011.1415**	**34,699.5478**	**37.0721**
Memo Items:					
International Bunkers	**2,502.2198**	**2,670.4131**	**2,974.4184**	**3,023.2188**	**27.3394**
Aviation	1,756.6720	1,879.9480	1,918.7194	2,230.2158	66.3144
Marine	745.5478	790.4651	1,055.6991	793.0030	23.2463
Multilateral Operations	**NE**	**NE**	**NE**	**NE**	**0.0000**
CO_2 Emissions from Biomass	**3,890.8019**	**3,355.4603**	**3,520.8058**	**3,625.8473**	

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

TABLE 10 EMISSIONS TRENDS (CH_4) NEW ZEALAND
(Sheet 2 of 5) 2003
(Part 1 of 2) 2005

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	**1,203.9988**	**1,196.0021**	**1,175.6560**	**1,189.8507**	**1,200.1805**	**1,214.1620**	**1,218.2463**	**1,217.2955**	**1,221.8350**	**1,232.5942**
1. Energy	37.9484	32.7610	32.4207	31.6283	33.2826	35.6502	35.4672	36.9458	40.0152	42.0355
A. Fuel Combustion (Sectoral Approach)	9.9827	9.7025	9.7083	9.6097	8.9447	8.4867	7.8497	7.4058	6.8150	6.2004
1. Energy Industries	0.2634	0.2812	0.3186	0.2942	0.2379	0.1941	0.2182	0.2718	0.2042	0.2579
2. Manufacturing Industries and Construction	0.3777	0.4176	0.3912	0.3983	0.4792	0.4991	0.5207	0.5079	0.5247	0.5760
3. Transport	7.1163	7.1486	7.1800	7.2002	6.7768	6.3718	5.7381	5.2676	4.7387	4.0781
4. Other Sectors	2.2254	1.8552	1.8185	1.7170	1.4508	1.4218	1.3727	1.3585	1.3474	1.2885
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	27.9657	23.0585	22.7123	22.0186	24.3379	27.1635	27.6174	29.5400	33.2002	35.8350
1. Solid Fuels	12.9605	8.7340	9.0388	8.6082	10.1859	13.4714	13.9432	13.6306	16.2593	16.8421
2. Oil and Natural Gas	15.0052	14.3245	13.6735	13.4104	14.1521	13.6921	13.6742	15.9095	16.9409	18.9930
2. Industrial Processes	**1.0280**	**1.7080**	**1.4490**	**1.6260**	**2.0250**	**2.8160**	**3.7510**	**3.8770**	**3.6670**	**4.1033**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	1.0280	1.7080	1.4490	1.6260	2.0250	2.8160	3.7510	3.8770	3.6670	4.1033
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	**1,053.6608**	**1,048.9578**	**1,046.0159**	**1,060.8875**	**1,073.7006**	**1,084.6042**	**1,090.0191**	**1,096.6949**	**1,098.9097**	**1,108.5949**
A. Enteric Fermentation	1,025.2747	1,020.9187	1,018.3487	1,033.1250	1,045.5367	1,056.0998	1,061.4970	1,068.4534	1,070.9870	1,081.0173
B. Manure Management	27.3575	26.9907	26.6407	26.7224	27.1344	27.4790	27.4611	27.1378	26.8381	26.5491
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	**0.2016**	**0.1853**	**0.2105**	**0.2689**	**0.3023**	**0.2915**	**0.3290**	**0.3579**	**0.2930**	**0.2605**
6. Waste	**111.1600**	**112.3900**	**95.5600**	**95.4400**	**90.8700**	**90.8000**	**88.6800**	**79.4200**	**78.9500**	**77.6000**
A. Solid Waste Disposal on Land	103.7000	104.8900	88.0300	87.8800	83.2800	83.1700	81.0200	71.7300	71.2300	69.8400
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	0.1316	0.1190	0.1146	0.1196	0.1621	0.1456	0.1406	0.1468	0.1426	0.1323
Aviation	0.0298	0.0285	0.0292	0.0296	0.0319	0.0349	0.0364	0.0380	0.0378	0.0432
Marine	0.1018	0.0905	0.0854	0.0900	0.1303	0.1107	0.1042	0.1088	0.1048	0.0891
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)

NEW ZEALAND
2003
2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	%
Total CH_4 emissions	**1,245.9897**	**1,263.0712**	**1,265.0155**	**1,268.8083**	**5.3829**
1. Energy	40.3580	41.8021	41.1411	40.0466	5.5291
A. Fuel Combustion (Sectoral Approach)	5.7349	5.2415	4.8402	4.4171	55.7525
1. Energy Industries	0.2495	0.2939	0.2483	0.2418	8.1703
2. Manufacturing Industries and Construction	0.5994	0.5708	0.6032	0.5556	47.1146
3. Transport	3.6479	3.2425	2.9032	2.4779	65.1803
4. Other Sectors	1.2382	1.1343	1.0855	1.1418	48.6921
5. Other	NA	NA	NA	NA	0.0000
B. Fugitive Emissions from Fuels	34.6231	36.5606	36.3009	35.6295	27.4043
1. Solid Fuels	16.1922	16.9739	16.8609	15.8215	22.0753
2. Oil and Natural Gas	18.4308	19.5867	19.4400	19.8080	32.0071
2. Industrial Processes	**4.9704**	**4.4103**	**4.6558**	**2.0434**	**98.7743**
A. Mineral Products	NA	NA	NA	NA	0.0000
B. Chemical Industry	4.9704	4.4103	4.6558	2.0434	98.7743
C. Metal Production	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	0.0000
3. Solvent and Other Product Use					
4. Agriculture	**1,126.0519**	**1,142.2849**	**1,144.2056**	**1,150.7340**	**9.2129**
A. Enteric Fermentation	1,098.7404	1,115.0634	1,116.9759	1,123.4387	9.5744
B. Manure Management	26.2797	26.1351	26.1175	26.1640	4.3626
C. Rice Cultivation	NO	NO	NO	NO	0.0000
D. Agricultural Soils	NE,NO	NE,NO	NE,NO	NE,NO	0.0000
E. Prescribed Burning of Savannas	0.0384	0.0439	0.0404	0.0401	70.1088
F. Field Burning of Agricultural Residues	0.9935	1.0424	1.0718	1.0912	22.0075
G. Other	NO	NO	NO	NO	0.0000
5. Land Use, Land-Use Change and Forestry	**0.2093**	**0.2039**	**0.1931**	**0.1943**	**3.6186**
6. Waste	**74.4000**	**74.3700**	**74.8200**	**75.7900**	**31.8190**
A. Solid Waste Disposal on Land	66.6100	66.5500	66.9600	67.8800	34.5419
B. Waste-water Handling	7.7900	7.8200	7.8600	7.9100	6.0322
C. Waste Incineration	NE	NE	NE	NE	0.0000
D. Other	NO	NO	NO	NO	0.0000
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**0.0000**
	NA	NA	NA	NA	0.0000
Memo Items:					
International Bunkers	0.1116	0.1188	0.1455	0.1268	3.6259
Aviation	0.0391	0.0418	0.0427	0.0496	66.3144
Marine	0.0726	0.0769	0.1028	0.0772	24.1276
Multilateral Operations	**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) NEW ZEALAND
(Sheet 3 of 5) 2003
(Part 1 of 2) 2005

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	**33.5442**	**33.6285**	**33.9342**	**34.8772**	**35.9172**	**36.6874**	**37.0543**	**37.3649**	**37.6127**	**38.3359**
1. Energy	**0.4663**	**0.4670**	**0.4961**	**0.5118**	**0.5552**	**0.5891**	**0.5991**	**0.6202**	**0.6251**	**0.6611**
A. Fuel Combustion (Sectoral Approach)	0.4663	0.4670	0.4961	0.5118	0.5552	0.5891	0.5991	0.6202	0.6251	0.6611
1. Energy Industries	0.0206	0.0164	0.0298	0.0208	0.0185	0.0194	0.0208	0.0315	0.0221	0.0296
2. Manufacturing Industries and Construction	0.1216	0.1297	0.1204	0.1247	0.1464	0.1431	0.1437	0.1378	0.1430	0.1517
3. Transport	0.2398	0.2422	0.2597	0.2791	0.3062	0.3396	0.3490	0.3646	0.3742	0.3872
4. Other Sectors	0.0844	0.0786	0.0862	0.0872	0.0841	0.0871	0.0856	0.0863	0.0859	0.0925
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	**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**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	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
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	**32.4738**	**32.5535**	**32.8190**	**33.7443**	**34.7389**	**35.4631**	**35.8170**	**36.1056**	**36.3374**	**37.0237**
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	32.3290	32.4076	32.6712	33.5892	34.5733	35.2894	35.6366	35.9202	36.1476	36.8294
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	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0002**	**0.0002**	**0.0001**	**0.0001**
6. Waste	**0.4700**	**0.4700**	**0.4800**	**0.4800**	**0.4800**	**0.4900**	**0.4900**	**0.4900**	**0.5000**	**0.5000**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	0.4700	0.4700	0.4800	0.4800	0.4800	0.4900	0.4900	0.4900	0.5000	0.5000
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	**0.0669**	**0.0620**	**0.0613**	**0.0632**	**0.0776**	**0.0758**	**0.0758**	**0.0792**	**0.0779**	**0.0802**
Aviation	0.0378	0.0361	0.0369	0.0375	0.0403	0.0442	0.0461	0.0482	0.0479	0.0547
Marine	0.0291	0.0259	0.0244	0.0257	0.0372	0.0316	0.0298	0.0311	0.0299	0.0255
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)

NEW ZEALAND
2003
2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	%
Total N_2O emissions	**39.6108**	**41.2578**	**42.4935**	**43.5469**	**29.8193**
1. Energy	**0.6938**	**0.7184**	**0.7497**	**0.8078**	**73.2354**
A. Fuel Combustion (Sectoral Approach)	0.6938	0.7184	0.7497	0.8078	73.2354
1. Energy Industries	0.0252	0.0339	0.0323	0.0586	185.0074
2. Manufacturing Industries and Construction	0.1562	0.1554	0.1610	0.1695	39.4763
3. Transport	0.4146	0.4277	0.4511	0.4704	96.1624
4. Other Sectors	0.0978	0.1014	0.1052	0.1093	29.5003
5. Other	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	0.0000
1. Solid Fuels	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	0.0000
2. Industrial Processes	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**0.0000**
A. Mineral Products	NA	NA	NA	NA	0.0000
B. Chemical Industry	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	0.0000
C. Metal Production	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	0.0000
3. Solvent and Other Product Use	**0.1520**	**0.1530**	**0.1560**	**0.1560**	**16.4179**
4. Agriculture	**38.2649**	**39.8763**	**41.0777**	**42.0575**	**29.5121**
A. Enteric Fermentation					
B. Manure Management	0.1783	0.1861	0.1917	0.1970	61.0004
C. Rice Cultivation				NA	0
D. Agricultural Soils	38.0641	39.6664	40.8615	41.8354	29.4055
E. Prescribed Burning of Savannas	0.0005	0.0005	0.0005	0.0005	70.1088
F. Field Burning of Agricultural Residues	0.0220	0.0232	0.0240	0.0246	17.9270
G. Other	NO	NO	NO	NO	0.0000
5. Land Use, Land-Use Change and Forestry	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**3.6186**
6. Waste	**0.5000**	**0.5100**	**0.5100**	**0.5254**	**11.7969**
A. Solid Waste Disposal on Land					
B. Waste-water Handling	0.5000	0.5100	0.5100	0.5254	11.7969
C. Waste Incineration	NE	NE	NE	NE	0.0000
D. Other	NO	NO	NO	NO	0.0000
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**0.0000**
	NA	NA	NA	NA	0.0000
Memo Items:					
International Bunkers	**0.0702**	**0.0750**	**0.0834**	**0.0849**	**26.9841**
Aviation	0.0495	0.0530	0.0541	0.0629	66.3144
Marine	0.0207	0.0220	0.0294	0.0221	24.1276
Multilateral Operations	**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) NEW ZEALAND

(Sheet 4 of 5) 2003

(Part 1 of 2) 2005

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[(5)] - (Gg CO_2 equivalent)	**IE,NA,NO**	**NA,NO**	**1.8200**	**5.4600**	**25.8655**	**83.7772**	**139.0257**	**114.2695**	**210.6913**	**174.8195**
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,NE,NO	NA,NE,NO	NA,NE,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	IE,NA,NO	NA,NO	0.0014	0.0042	0.0161	0.0398	0.0716	0.0379	0.1138	0.0757
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	0.0004	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 [(6)] - (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[(5)] - (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,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.0008	0.0048	0.0003	0.0080	NA,NE,NO
C_4F_{10}	NA,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-C_4F_8	NA,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_5F_{12}	NA,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_6F_{14}	NA,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
Unspecified mix of listed PFCs [(6)] - (Gg CO_2 equivalent)	NA,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
Emissions of SF_6[(5)] - (Gg CO_2 equivalent)	**12.3324**	**12.6431**	**12.9777**	**14.0532**	**14.4117**	**15.0092**	**14.7941**	**15.2960**	**14.0293**	**13.1928**
SF_6	0.0005	0.0005	0.0005	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)

NEW ZEALAND
2003
2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	%
Emissions of HFCs(5) - (Gg CO_2 equivalent)	**173.2844**	**254.1239**	**387.6822**	**403.9601**	**100.0000**
HFC-23	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-32	NA,NE,NO	0.0001	0.0009	0.0018	100.0000
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-125	0.0041	0.0128	0.0194	0.0236	100.0000
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-134a	0.1054	0.1239	0.1923	0.1806	100.0000
HFC-152a	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.0000
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-143a	0.0064	0.0149	0.0216	0.0266	100.0000
HFC-227ea	0.0002	0.0002	0.0003	0.0003	100.0000
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
Unspecified mix of listed HFCs (6) - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	0.0000
Emissions of PFCs(5) - (Gg CO_2 equivalent)	**59.2500**	**59.2500**	**83.5000**	**84.9000**	**83.5337**
CF_4	0.0077	0.0077	0.0110	0.0110	83.8235
C_2F_6	0.0010	0.0010	0.0010	0.0010	87.5000
C_3F_8	NA,NE,NO	NA,NE,NO	0.0004	0.0006	100.0000
C_4F_{10}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0.0000
$c\text{-}C_4F_8$	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0.0000
C_5F_{12}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0.0000
C_6F_{14}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0.0000
Unspecified mix of listed PFCs (6) - (Gg CO_2 equivalent)	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0.0000
Emissions of SF_6(5) - (Gg CO_2 equivalent)	**11.9500**	**12.0456**	**12.5714**	**12.3802**	**0.3876**
SF_6	0.0005	0.0005	0.0005	0.0005	0.3876

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

TABLE 10 EMISSION TRENDS (SUMMARY) NEW ZEALAND
(Sheet 5 of 5) 2003
(Part 1 of 2) 2005

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)
CO_2 emissions including net CO_2 from LULUCF[4]	3,944.3606	5,727.2975	10,027.8406	11,872.3308	13,045.9184	12,509.0253	13,251.2684	13,975.0218	9,754.4762	9,392.1620
CO_2 emissions excluding net CO_2 from LULUCF [4]	25,314.8144	25,827.8465	27,691.4597	27,114.1393	27,206.7336	27,161.0473	28,176.1559	30,434.2897	29,059.0341	30,504.4491
CH_4	25,283.9751	25,116.0440	24,688.7769	24,986.8644	25,203.7913	25,497.4010	25,583.1726	25,563.2059	25,658.5346	25,884.4773
N_2O	10,398.7099	10,424.8469	10,519.5908	10,811.9245	11,134.3448	11,373.0872	11,486.8337	11,583.1309	11,659.9233	11,884.1405
HFCs	IE,NA,NO	NA,NO	1.8200	5.4600	25.8655	83.7772	139.0257	114.2695	210.6913	174.8195
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	12.6431	12.9777	14.0532	14.4117	15.0092	14.7941	15.2960	14.0293	13.1928
Total (including net CO_2 from LULUCF)[4]	**40,154.9780**	**41,932.4715**	**45,889.1060**	**48,215.4329**	**49,607.9317**	**49,625.7999**	**50,740.4945**	**51,417.1240**	**47,427.8546**	**47,422.9921**
Total (excluding net CO_2 from LULUCF)[4], [7]	**61,525.4318**	**62,033.0205**	**63,552.7251**	**63,457.2414**	**63,768.7469**	**64,277.8219**	**65,665.3820**	**67,876.3920**	**66,732.4125**	**68,535.2792**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)
1. Energy	23,594.1102	23,873.3693	25,632.7451	24,897.8622	25,134.5120	25,072.5288	26,118.6178	28,511.4834	27,045.4305	28,379.8830
2. Industrial Processes	3,211.7025	3,487.3669	3,576.6542	3,617.5802	3,209.6818	3,325.2149	3,486.0724	3,268.1057	3,479.6410	3,560.6231
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	32,193.7569	32,119.6971	32,140.2241	32,739.3637	33,316.7606	33,770.2643	33,993.6749	34,223.3260	34,341.6954	34,757.8542
5. Land Use, Land-Use Change and Forestry [8]	-21,366.1916	-20,096.6317	-17,659.1675	-15,236.1232	-14,154.4226	-14,645.8581	-14,917.9305	-16,451.7011	-19,298.3622	-21,106.7782
6. Waste	2,480.0600	2,505.8900	2,155.5600	2,153.0400	2,057.0700	2,058.7000	2,014.1800	1,819.7200	1,812.9500	1,784.6000
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF) [8]	**40,154.9780**	**41,932.4715**	**45,889.1060**	**48,215.4329**	**49,607.9317**	**49,625.7999**	**50,740.4945**	**51,417.1240**	**47,427.8546**	**47,422.9921**

TABLE 10 EMISSION TRENDS (SUMMARY) NEW ZEALAND
(Sheet 5 of 5) 2003
(Part 2 of 2) 2005

GREENHOUSE GAS EMISSIONS	2000	2001	2002	2003	Change from base to latest reported year
	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	(%)
CO_2 emissions including net CO_2 from LULUCF[4]	8,182.6917	9,792.4426	9,680.3294	11,833.8397	200.0192
CO_2 emissions excluding net CO_2 from LULUCF [4]	31,006.0462	32,983.4414	33,011.1415	34,699.5478	37.0721
CH_4	26,165.7829	26,524.4942	26,565.3261	26,644.9743	5.3829
N_2O	12,279.3339	12,789.9169	13,172.9809	13,499.5297	29.8193
HFCs	173.2844	254.1239	387.6822	403.9601	100.0000
PFCs	59.2500	59.2500	83.5000	84.9000	83.5337
SF_6	11.9500	12.0456	12.5714	12.3802	0.3876
Total (including net CO_2 from LULUCF)[4]	**46,872.2928**	**49,432.2732**	**49,902.3899**	**52,479.5839**	**30.6926**
Total (excluding net CO_2 from LULUCF)[4], [7]	**69,695.6474**	**72,623.2720**	**73,233.2020**	**75,345.2920**	**22.4620**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	Change from base to latest reported year
	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	CO2 equivalent (Gg)	(%)
1. Energy	28,905.7929	30,828.7499	30,864.6664	32,320.9222	36.9872
2. Industrial Processes	3,511.7005	3,673.2662	3,824.3756	4,014.1870	24.9863
3. Solvent and Other Product Use	47.1200	47.4300	48.3600	48.3600	16.4179
4. Agriculture	35,509.2091	36,349.6438	36,762.3977	37,203.2368	15.5604
5. Land Use, Land-Use Change and Forestry [8]	-22,818.9297	-23,186.6867	-23,326.7299	-22,861.6001	6.9989
6. Waste	1,717.4000	1,719.8700	1,729.3200	1,754.4781	29.2566
7. Other	NA	NA	NA	NA	0.0000
Total (including LULUCF) [8]	**46,872.2928**	**49,432.2732**	**49,902.3899**	**52,479.5839**	**30.6926**

(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 Parties with economies in transition that use a base yea

(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 rowr, if it is not possible to report values for each chemical (i.e. mixtures, confidential data, lack of disaggregation), this row 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.

Ministry for the Environment
Manatū Mō Te Taiao

Ministry for the Environment PO Box 10362 Wellington New Zealand
Email info@climatechange.govt.nz **www.**climatechange.govt.nz **www.**mfe.govt.nz