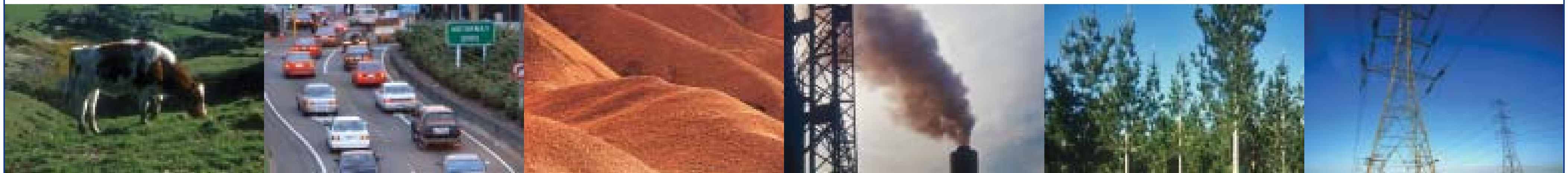
Ministry for the Environment
Manatū Mō Te Taiao

New Zealand Climate Change Office
Te Tari Rerekētanga Āhuarangi o Aotearoa

New Zealand's Greenhouse Gas Inventory 1990-2002



The National Inventory Report and
Common Reporting Format Tables

April 2004

New Zealand Climate Change Office
Te Tari Rerekētanga Āhuarangi o Aotearoa

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Executive Summary

Climate change & greenhouse gas inventory

Greenhouse gases trap the warmth from the sun and make life on Earth possible. However, over the previous 50 to 100 years, the concentration of the greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in the atmosphere has been increasing. This increased concentration produces an 'enhanced greenhouse effect' that causes Earth to heat at a faster rate 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.

In response to the First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), 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 May 1992. The UNFCCC took effect on 21 March 1994.

The long-term objective of the UNFCCC is to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Developed countries are required to address climate change through policies and measures to reduce the emission of greenhouse gases, protecting and enhancing sinks (e.g. forests), monitoring and reporting on greenhouse gas emissions and removals, and providing financial assistance to developing countries. All developed countries that ratified the UNFCCC agreed to aim to reduce greenhouse gas emissions to 1990 levels by the year 2000.

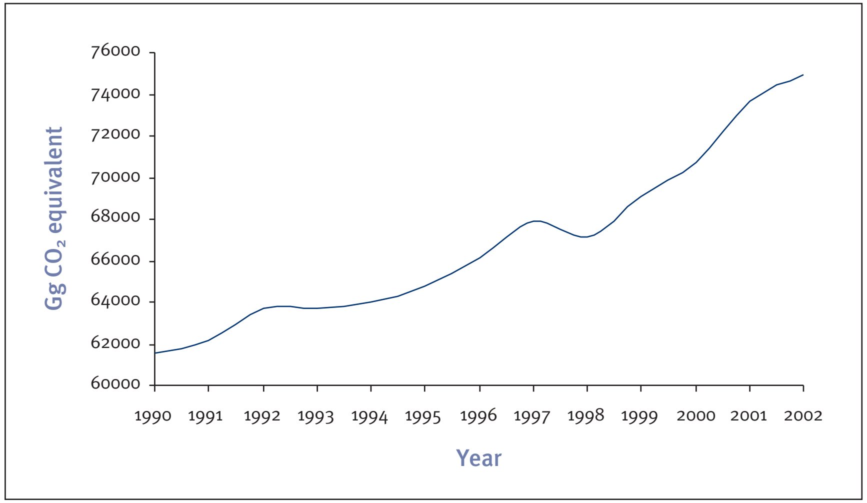
However by 2000, only a few countries made appreciable progress towards achieving their targets. In response, the Parties to the UNFCCC negotiated the Kyoto Protocol, an agreement that sets targets for greenhouse gas emissions of developed countries for 2008 to 2012 (the first commitment period). Different countries have different reduction targets to achieve or they must take responsibility for excess emissions. New Zealand's target is to reduce its greenhouse gas emissions to the level they were in 1990. The Protocol has to be signed and ratified by 55 countries (including those responsible for at least 55% of the developed world's 1990 CO_2 emissions) before it can enter into force. As at April 2004, 120 countries accounting for 44.2% of developed countries CO_2 emissions in 1990 have ratified the Protocol. New Zealand ratified the Kyoto Protocol on 19 December 2002.

The development and publication of an annual inventory of all human-induced emissions and removals of greenhouse gases in New Zealand is part of New Zealand's obligations to the UNFCCC and the Kyoto Protocol. The inventory is the tool for measuring New Zealand's progress against these obligations. 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, land use change and forestry (LUCF), and waste. The format and content of the inventory is prescribed by the UNFCCC guidelines (FCCC/CP/2002/8) and Intergovernmental Panel on Climate Change (IPCC).

National trends in New Zealand's emissions and removals

In 1990, New Zealand's total greenhouse gas emissions were equivalent to 61,639.97Gg of CO_2. In 2002, total greenhouse gas emissions have increased to 74,976.34Gg CO_2 equivalent (Figure 1.1). This equates to a 21.6% rise since 1990. Net removals of CO_2 through sinks have increased from 21,665.87Gg CO_2 in 1990 to 24,076.44Gg CO_2 in 2002.

Figure 1.1 New Zealand's total greenhouse gas emissions 1990-2002



There have also been changes in the relative amounts of the greenhouse gases emitted. Whereas CH_4 made the largest contribution to New Zealand's emissions in 1990, CO_2 is now the major greenhouse gas in New Zealand's emissions profile (Table 1.1).

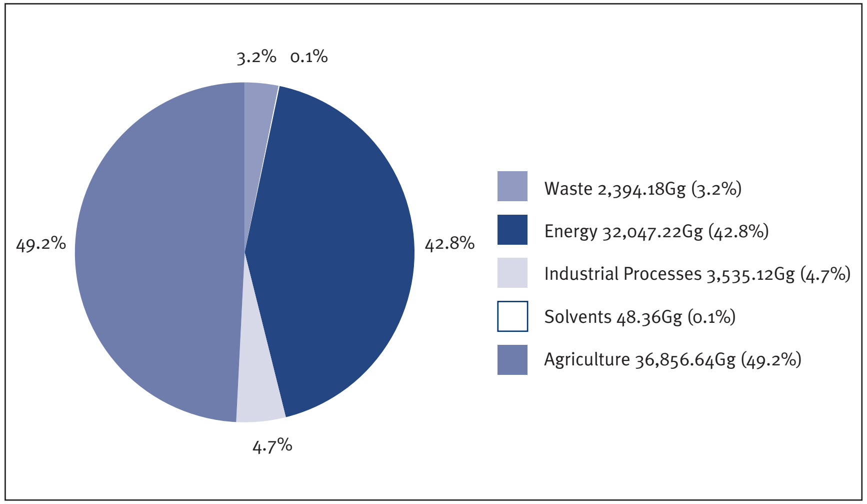
Table 1.1 Emissions of greenhouse gases 1990 and 2002

Greenhouse Gas Emissions	Gg CO_2 equivalent 1990	2002	Change from 1990 (%)
Net CO_2 emissions / removals	3,490.49	9,598.54	175.00
CO_2 emissions (without LUCF)	25,254.24	33,769.80	33.72
CH_4	25,570.53	27,562.86	7.8
N_2O	10,287.26	13,159.68	27.9
HFCs	0.00	387.59	
PFCs	515.60	83.50	-83.8
SF_6	12.33	12.91	4.7
Total emissions without CO_2 from LUCF	**61,639.97**	**74,976.34**	**21.6**

Source and sink category emission estimates and trends

New Zealand is unusual amongst developed nations in that 49.2% of total emissions in 2002 were produced by the agriculture sector (Figure 1.2). The energy sector is the other large component of New Zealand's emissions profile comprising 42.8% of total emissions in 2002. Emissions from the industrial processes and waste sectors are a much smaller component of New Zealand's emissions comprising 4.7% and 3.2% respectively of all greenhouse gas emissions in 2002. New Zealand's relatively small manufacturing base means that solvent use is lower than in many other countries.

Figure 1.2 New Zealand's sectoral emissions in 2002 (all figures Gg CO_2 equivalent)



The principal growth in New Zealand's emissions comes from the energy sector where emissions are now 35.0% above the 1990 level (Table 1.2). The increase arises largely from increased CO_2 from road transport and public electricity generation. There have also been increases in emissions from industrial processes and agricultural sectors. Emissions from waste are now 17.7% below the 1990 baseline with the majority of the reduction occurring in the solid waste disposal on land category. The LUCF sector represents the major sink for New Zealand. Removals through LUCF are 11.3% above the 1990 level.

Table 1.2 Sectoral emissions of greenhouse gases in 1990 and 2002

Sector	Gg CO_2 equivalent 1990	2002	Change from 1990 (%)
Energy	23,746.84	32,047.22	35.0
Industrial processes	2,934.09	3,535.12	20.5
Solvent and other product	41.54	48.36	16.4
Agriculture	31,911.15	36,856.64	15.5
Land-use change and forestry	-21,665.87	-24,076.44	11.1
Waste	2,908.46	2,394.18	-17.7

Contents

Chapter 1:

Introduction

1.1 Background

Over millions of years, our climate has undergone many changes – from ice ages to tropical heat and back again. Natural changes have generally been gradual, allowing people and other species to adapt or migrate, although some prehistoric climate changes may have led to the mass extinction of species.

Greenhouse gases trap the 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. The concentration of CO_2 has increased 31% since 1750, the concentration of CH_4 has increased 151% and the concentration of N_2O has increased 17% (IPCC, 2000). The increased concentration produces an 'enhanced greenhouse effect' that causes Earth to heat at a faster rate (i.e. global warming) and the climate to change. The Intergovernmental Panel on Climate Change (IPCC) 3rd assessment report (IPCC, 2001) notes that the effects of climate change due to the 'enhanced greenhouse effect' will be different in different parts of the world. However in general, temperatures and sea levels are expected to rise, and the frequency of extreme weather events are expected to increase. The changes ahead of us will be much larger and will happen more quickly than any recent natural climate variations.

The UNFCCC & the Kyoto Protocol

In 1990, the Intergovernmental Panel on Climate Change (IPCC) concluded that human-induced climate change was a real 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 greenhouse gas inventories, national or regional programmes and preparing for adaptation to the impacts of climate change. Developed countries agreed to non-binding targets to reduce greenhouse gas emissions to 1990 levels by 2000. However 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, the Parties to the UNFCCC negotiated the Kyoto Protocol.

The Kyoto Protocol aims to reduce the total greenhouse gas emissions of developed countries (and countries with economies in transition) to 5% below the level they were in 1990. The Protocol sets reduction targets for the greenhouse gas emissions of developed countries for the period 2008 to 2012, referred to as the first commitment period. Different countries have different targets to achieve. New Zealand's target is to reduce its greenhouse gas emissions to the level they were in 1990 or take responsibility for any excess emissions.

The Protocol has to be signed and ratified by 55 countries (including those responsible for at least 55% of the developed world's 1990 CO_2 emissions) before it can enter into force. As at April 2004, 120 countries accounting for 44.2% of CO_2 emissions in 1990 have ratified the Protocol. New Zealand ratified the Kyoto Protocol on 19 December 2002.

A National Greenhouse Gas Inventory

The development and publication of an annual inventory of all human-induced emissions and removals of greenhouse gases in New Zealand is part of New Zealand's obligations to the UNFCCC and the Kyoto Protocol. The inventory is the tool for measuring New Zealand's progress against these obligations. The content and format of the inventory is prescribed by the Intergovernmental Panel on Climate Change (IPCC, 1996; IPCC, 2000) and the UNFCCC reporting guidelines (FCCC/2002/CP/8). It includes two components: the national inventory report (NIR) and the common reporting format (CRF) worksheets.

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, land use change and forestry, 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, emissions of these indirect greenhouse gases are not included in New Zealand's total emissions figures.

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 (UNFCCC/CP/2002/8) 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	6,500
C_2F_6	9,200
SF_6	23,900

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 person "who is for the time being the chief executive of the Ministry for the Environment" is named 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 to estimate emissions or removals of greenhouse gases.

It is the New Zealand Climate Change Office (NZCCO) of the Ministry for the Environment (MfE) that is responsible for compiling and submitting the annual inventory to the UNFCCC. The NZCCO also oversees liaison with the UNFCCC secretariat, development of the national inventory, commissioning reviews of the inventory, and working with researchers to improve methodologies and reduce uncertainty.

The Ministry of Economic Development (MED) collects and collates all emissions from the energy sector and the CO_2 emissions from the industrial processes sector. Emissions of the non-CO_2 gases from the industrial processes sector and all emissions from the waste sector are obtained by consultants contracted by NZCCO.

The Ministry for Agriculture and Forestry (MAF) and the NZCCO manage the agriculture and land use change and forestry sectors. The inventory figures reported are underpinned by the research and modelling of researchers at New Zealand's Crown Research Institutes (CRIs) and universities.

1.3 Inventory preparation processes

New Zealand submits its national inventory to the UNFCCC secretariat by April 15th of each year. The inventory is for the base year (1990) to two years prior to the current year. Generation of the CRF and production of the NIR occurs over the period February to April. Emissions statistics and trend information from the CRF are merged into the NIR as they become available.

The data for the CRF are obtained from the various participating institutions mentioned in section 1.2 'Institutional Arrangements'. The data collection and processing methods vary for each sector and category and are described in detail in the relevant chapters. For the energy sector, MED officials enter data directly into the CRF. NZCCO officials merge the CRF worksheets from the MED with information supplied directly to the NZCCO by MAF officials, consultants and other organisations. The inventory and all required data are stored on the MfE's central computer network in a controlled file system.

The explanatory information and accompanying graphics in the NIR text are developed by officials at the NZCCO. NZCCO officials also undertake quality control procedures on the CRF, calculate the inventory uncertainty and the key source assessment.

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) and the UNFCCC guidelines on reporting and review (FCCC/CP/2002/8). 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 (IPCC, 1996) approach. Activity data (fuel consumed) are multiplied by the emission factors of specific fuels. Activity data come from the nationally collected surveys developed by Statistics New Zealand 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. There were only a few instances where emission factors were unavailable due to confidentiality and instances where natural gas was used as a feedstock.

Industrial Processes: CO_2 emissions and activity data for the industrial processes sector are supplied directly to the MED by industry sources. An IPCC Tier 1 process is used and emission factors are country specific. The non-CO_2 gases are collated via survey. Emissions of HFCs and PFCs are estimated using an IPCC Tier 2 approach. For the 2002 inventory, SF_6 emissions from large users were assessed via the IPCC Tier 2 and Tier 3a method to facilitate a change from a Tier 2 to Tier 3a methodology.

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: agricultural sector emissions are calculated by New Zealand scientists. 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 ruminants. Animal productivity data are used 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 dung deposited onto the land.

Land use change and forestry: the worksheets in the NIR for the LUCF sector are New Zealand specific, however they have been designed to be equivalent to the IPCC worksheets. Changes in planted forest stocks are assessed from forest survey data and use computer models to model the planted forest estate. Other categories in this sector are estimated from data supplied by the MAF and the New Zealand Fire Service (for wildfires). Major new work in this sector includes research on the carbon stored in soils, scrub and natural forests. Details of the research are included in Annex 3B.

Waste: emissions from the waste sector are estimated using waste survey data combined with population data. 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). Emissions from waste incineration are not estimated as there is no incineration of municipal waste in New Zealand.

1.5 Key source categories

A key source category has a significant influence on a country's total emissions in terms of the level of emissions, the trend in emissions, or both. The key source categories in the New Zealand inventory have been assessed according to the Good Practice Tier 1 Level and Trend methodologies (IPCC, 2000). These methodologies identify sources of emissions that sum to 95% of the total emissions or 95% of the trend of the inventory in absolute terms.

The key sources identified in the 2002 inventory are summarised in Table 1.5.1. The major contribution to the key source level analysis (Table 1.5.2) is CH_4 emissions from enteric fermentation in domestic livestock. This category comprises 31.5% of total emissions. Enteric fermentation is also the second largest contribution to the trend in emissions at 18.9% (Table 1.5.3). CO_2 emissions from mobile combustion from road vehicles is the second largest key source contributing 16.4% of total emissions but makes the largest contribution to the trend at 24.5%. Other categories making a large contribution are CO_2 emissions from stationary combustion of gas, animal production of N_2O from agricultural soils and CH_4 from solid waste disposal.

There was one modification to the IPCC suggested source categories to reflect New Zealand's national circumstances. The fugitive emissions from geothermal operations category was included. Complete versions of the level and trend analysis tables that show all suggested IPCC categories are included in Annex 1.

Table 1.5.1 Summary of key source categories in the 2002 inventory

IPCC source categories	Gas	Criteria for identification
Energy sector		
CO_2 emissions from stationary combustion – solid	CO_2	level, trend
CO_2 emissions from stationary combustion – liquid	CO_2	level, trend
CO_2 emissions from stationary combustion – gas	CO_2	level, trend
Mobile combustion – road vehicles	CO_2	level, trend
Mobile combustion – aviation	CO_2	level, trend
Fugitive emissions from coal mining and handling	CH_4	trend
Fugitive emissions from geothermal operations	CO_2	trend
Industrial processes sector		
CO_2 emissions from cement production	CO_2	level
CO_2 emissions from the iron and steel industry	CO_2	level
CO_2 emissions from aluminium production	CO_2	level
PFCs from aluminium production	PFCs	trend
Emissions from substitutes for ozone depleting substances	HFCs	level, trend
Agricultural sector		
CH_4 emissions from enteric fermentation in domestic livestock	CH_4	level, trend
CH_4 emissions from manure management	CH_4	level, trend
Direct N_2O emissions from agricultural soils	N_2O	level, trend
N_2O emissions from animal deposition on agricultural soils	N_2O	level, trend
Indirect N_2O emissions from nitrogen used in agriculture	N_2O	level
Waste sector		
CH_4 emissions from solid waste disposal sites	CH_4	level, trend

Table 1.5.2 Key source analysis – Tier 1 level assessment

IPCC source categories	Gas	2002	Level	Total
CH_4 emissions from enteric fermentation in domestic livestock	CH_4	23584.68	31.5	31.5
Mobile combustion – road vehicles	CO_2	12292.63	16.4	47.9
CO_2 emissions from stationary combustion – gas	CO_2	10420.49	13.9	61.8
N_2O emissions from agricultural soils – animal production	N_2O	7255.24	9.7	71.4
CO_2 emissions from stationary combustion – solid	CO_2	3394.88	4.5	76.0
Indirect N_2O emissions from nitrogen used in agriculture	N_2O	3258.01	4.3	80.3
CO_2 emissions from stationary combustion – liquid	CO_2	2491.18	3.3	83.6
Direct N_2O emissions from agricultural soils	N_2O	2104.46	2.8	86.4
CH_4 emissions from solid waste disposal sites	CH_4	2066.40	2.8	89.2
CO_2 emissions from the iron and steel industry	CO_2	1563.80	2.1	91.3
Mobile combustion – aviation	CO_2	1089.25	1.5	92.7
CH_4 emissions from manure management	CH_4	548.00	0.7	93.5
CO_2 emissions from cement production	CO_2	541.72	0.7	94.2
CO_2 emissions from aluminium production	CO_2	540.34	0.7	94.9
Emissions from substitutes for ozone depleting substances	HFCs	387.59	0.5	95.4

Table 1.5.3 Key source analysis – Tier 1 trend assessment

IPCC Source Categories	Gas	1990	2002	Trend	% trend	Total
Mobile combustion – road vehicles	CO_2	7533.73	12292.63	0.0343	24.5	24.5
CH_4 emissions from enteric fermentation in domestic livestock	CH_4	21371.9	23584.68	0.0264	18.9	43.4
Direct N_2O emissions from agricultural soils	N_2O	680.04	2104.46	0.0140	10.0	53.3
CH_4 emissions from solid waste disposal sites	CH_4	2606.10	2066.40	0.0121	8.6	62.0
CO_2 emissions from stationary combustion – gas	CO_2	7842.06	10420.49	0.0097	6.9	68.9
N_2O emissions from animal production	N_2O	6574.17	7255.24	0.0081	5.8	74.7
CO_2 emissions from stationary combustion – liquid	CO_2	2546.44	2491.18	0.0066	4.7	79.5
PFCs from aluminium production	PFC	515.60	80.70	0.0060	4.3	83.8
CO_2 emissions from stationary combustion – solid	CO_2	3229.71	3394.88	0.0059	4.2	87.9
Emissions from substitutes for ozone depleting substances	HFCs	0.00	387.59	0.0042	3.0	91.0
Mobile combustion – aviation	CO_2	772.83	1089.25	0.0016	1.2	92.2
CH_4 emissions from manure management	CH_4	573.09	548.00	0.0016	1.2	93.3
Fugitive emissions from geothermal operations	CO_2	357.34	315.24	0.0013	0.9	94.3
Fugitive emissions from coal mining and handling	CH_4	210.02	354.08	0.0011	0.8	95.0

1.6 Quality assurance and quality control

Quality assurance (QA) and quality control (QC) are an integral part of preparing New Zealand's inventory. In 2003, the NZCCO developed an initial QA/QC plan (Annex 6) as required by the UNFCCC guidelines (FCCC/CP/20002/8) to formalise, document and archive the QC and QA procedures. In preparation of the 2002 inventory, the NZCCO developed and trialed a Tier 1 QC checksheet based on the procedures suggested in Good Practice (IPCC, 2000 – refer Annex 6). The QC checksheet was trialled for all key source categories identified in the 2001 inventory level assessment.

Data entered in the CRF undergo quality control in the relevant participating organizations where the worksheets are checked for errors and omissions. The data undergo additional quality control in the NZCCO where emission estimates, activity data and emission factors are compared to those reported for the previous year and previous inventory. Any significant deviations are investigated and corrected if necessary.

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, 2003) and in 2003 by experts nominated by the UNFCCC (UNFCCC, 2004). Additional reviews of individual sectors have been commissioned by the NZCCO. A history of reviews, the key conclusions and follow up resulting from the reviews is included as QA documentation in Annex 6. In addition, the methodologies used in the agricultural and LUCF sectors have undergone scientific peer-review before being used in New Zealand's inventory.

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

1.7 Inventory uncertainty

Overall inventory uncertainty has been assessed using the IPCC Tier 1 methodology (Annex 7). The calculated uncertainty for the level of emissions in 2002 is ±20.1%. However the uncertainty in the overall trend of emissions from 1990-2002 is only ±4.6%. This is because any over or underestimates in emissions for one year are repeated in subsequent years. The trend is critical to the UNFCCC and Kyoto Protocol reporting where New Zealand's emissions are compared to the 1990 baseline. The reported uncertainty values represent the 95% confidence interval.

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) comprising 14.5% and 13.5% of the uncertainty as a percentage of total national emissions. This reflects the inherent variability present in natural systems.

Uncertainty in the trend of emissions is dominated by CO_2 emissions from the energy sector at 3.5% of the trend (Chapter 3). This is because emissions from the energy sector are rising and there is greater uncertainty in the activity data than the CO_2 emission factors. The other major contributors to trend uncertainty are CH_4 from solid waste disposal (Chapter 8, section 8.2) and consumption of HFCs (Chapter 4, section 4.7).

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 approach was used to determine uncertainty for CH_4 from enteric fermentation and N_2O from agricultural soils.

1.8 Inventory completeness

The New Zealand inventory can be described as nearly complete with 21 out of the 23 IPCC source categories that occur in New Zealand or that have emissions assessed to be above a negligible level reported. The exceptions are the abandonment of managed lands and soil carbon categories.

New Zealand does not currently report emissions or sinks from abandonment of managed lands due to a lack of data. However, some pasture does revert to scrub in marginal farming areas. Research in the Carbon Monitoring System will provide data on the abandonment of managed lands (details of the research are included in Annex 3B). Changes in soil carbon in New Zealand are not reported because New Zealand currently lacks the data to provide a comprehensive analysis of sources and sinks. However, substantial research is also underway to address the data shortage (Annex 3B).

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'. New Zealand will review emissions from these categories as resources permit.

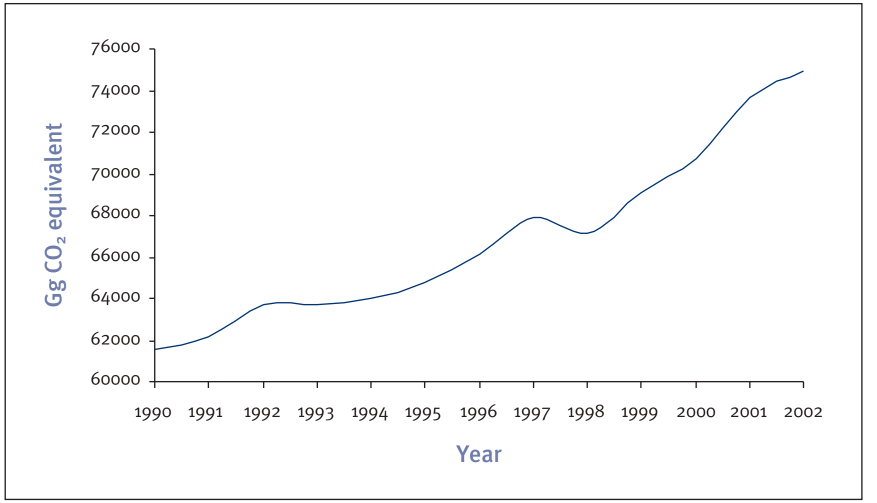
Chapter 2:

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 61,639.97Gg of CO_2. In 2002, total greenhouse gas emissions have increased by 21.6% to 74,976.34Gg CO_2 equivalent (Figure 2.1.1). Over the period 1990 to 2002, the average annual growth in overall emissions has been 1.65% per year.

Figure 2.1.1 New Zealand's total greenhouse gas emissions 1990-2002



2.2 Emission trends by gas

CO_2 and CH_4 dominate New Zealand's greenhouse gas emissions (Figure 2.2.1 and Table 2.2.1). In 2002, these gases comprised 81.8% of total CO_2 equivalent emissions. Whereas CH_4 made the largest contribution to New Zealand's emissions in 1990, CO_2 is now the major greenhouse gas in New Zealand's emissions profile. The other major gas in New Zealand's emissions profile is N_2O.

Figure 2.2.1 New Zealand's emissions by gas in 2002 (all figures Gg CO_2 equivalent)

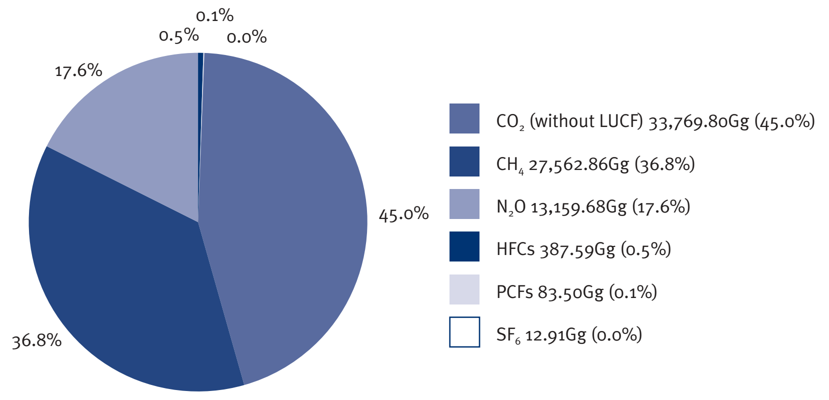
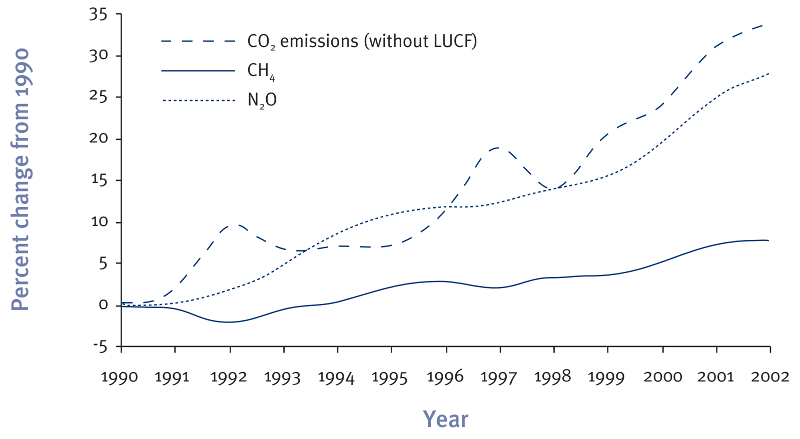


Figure 2.2.2 Change in New Zealand's emissions of CO_2, CH_4, and N_2O from 1990-2002



The largest increases over the 1990 baseline include CO_2 and N_2O, with a smaller increase in CH_4 (Figure 2.2.2). 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 2002: SF_6 emissions have increased 4.7% due to increased use in electric switchgear, emissions of PFCs have decreased 83.8% due to improvements in the aluminium smelting process, and HFC emissions have increased from 0 to 387.59Gg because of the use of HFCs as a substitute for the chlorofluorocarbons phased out under the Montreal Protocol.

Table 2.2.1 Emissions of greenhouse gases 1990 and 2002

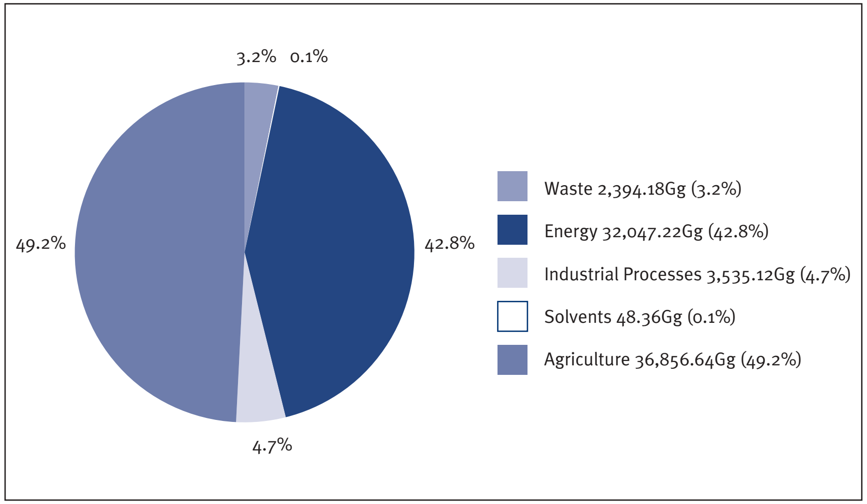
Greenhouse Gas Emissions	Gg CO_2 equivalent 1990	2002	Change from 1990 (%)
CO_2 emissions (without LUCF)	25,254.24	33,769.80	33.7
CH_4	25,570.53	27,562.86	7.8
N_2O	10,287.26	13,159.68	27.9
HFCs	0.00	387.59	
PFCs	515.60	83.50	-83.8
SF_6	12.33	12.91	4.7

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 2002, 49.2% of New Zealand's total emissions are produced by the agriculture sector, predominantly CH_4 from ruminant farm animals e.g. dairy cows and sheep, and N_2O from animal excrement and nitrogenous fertiliser use. The current level of emissions from the agriculture sector is 15.5% above the 1990 level (Figure 2.3.2).

The energy sector is the other large component of New Zealand's emissions profile comprising 42.8 % of total emissions. Emissions from the energy sector in 2002 are 35.0% over the 1990 level and represent the highest sectoral growth in emissions. The growth in emissions is primarily from road transport (increased 62.5%) and electricity generation (increased 58.1%).

Figure 2.3.1 New Zealand's sectoral greenhouse gas emissions in 2002 (all figures Gg CO_2 equivalent, percentage of national total emissions in 2002)



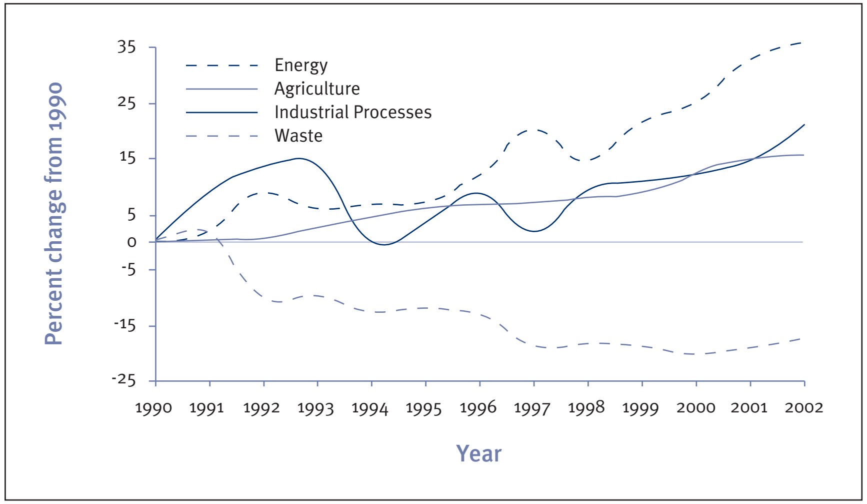
Emissions from the industrial processes and waste sectors are a much smaller component comprising 4.7% and 3.2% respectively of all greenhouse gas emissions in 2002. Industrial processes emissions have been increasing steadily and are now 20.5% over the 1990 baseline. However, emissions from waste are now 17.7% below the 1990 baseline. The majority of the reduction has occurred in the solid waste disposal on land category. New Zealand's relatively small manufacturing base means that the solvent sector is much lower than in many other countries. In 2002, the solvent sector emitted 31.63Gg of NMVOCs.

The LUCF sector represents the major sink for New Zealand removing 32.5% of all greenhouse gas emissions in 2002. Net removals in 2002 were 11.3% above net removals in 1990. Variations in planting rates and the impact of harvest regimes effect the size of this sink from year to year.

Table 2.3.1 Sectoral emissions of greenhouse gases in 1990 and 2002

Sector	Gg CO_2 equivalent 1990	Gg CO_2 equivalent 2002	Change from 1990 (%)
Energy	23,746.84	32,047.22	35.0
Industrial processes	2,934.09	3,535.12	20.5
Solvent and other product use	41.54	48.36	16.4
Agriculture	31,911.15	36,856.64	15.5
Land-use change and forestry	-21,665.87	-24,076.44	11.1
Waste	2,908.46	2,394.18	-17.7

Figure 2.3.2 Change in sectoral greenhouse gas emissions from 1990-2002



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 2002 are shown in Table 2.4.1, however, the 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 2002

Gas	Gg of gas(es)		Change from 1990
	1990	2002	(%)
NO_X	138.72	204.88	47.7
CO	564.91	732.66	29.7
NMVOC	133.56	173.13	29.6
SO_2	61.40	67.65	10.2

Emissions of CO and NO_X come largely from the energy sector. The energy sector produced 86.5% of total CO emissions in 2002. The largest single source was road transportation emissions which accounted for 71.8% of total CO emissions. Similarly, the energy sector was the largest source of NO_X emissions, with road transportation emissions comprising 50.1% of total NO_X emissions. Other large sources of NO_X emissions were from the manufacturing industries and construction category and energy industries.

The energy sector was also the largest producer of NMVOC and SO_2. The energy sector produced 68.7% of NMVOC emissions in 2002 with emissions from road transportation comprising 60.4% of total NMVOC emissions. Other major sources of NMVOC are in the solvent and other product use sector (18.3%) and the industrial processes sector (13.0%).

Emissions of SO_2 from the energy sector comprised 81.6% of total SO_2 emissions. The manufacturing industries and construction category was the largest single source at 32.0% of total SO_2 emissions. The other source of SO_2 was from the industrial processes sector.

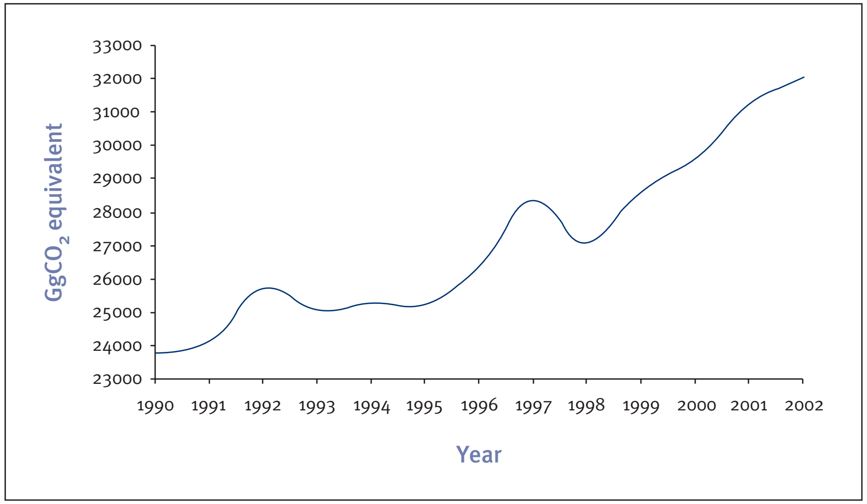
Chapter 3:

Energy

3.1 Sector overview

New Zealand's energy sector produced 32,047.22Gg CO_2 equivalent in 2002 and represented 42.8% of all greenhouse gas emissions. Emissions from the energy sector are now 35.0% above the 1990 baseline value of 23,746.84Gg CO_2 equivalent (Figure 3.1.1). The sources contributing most to this increase since 1990 are emissions from road transportation (an increase of 62.5%), public electricity and heat production (an increase of 58.1%) and the manufacture of methanol and urea (an increase of 319.6%). Emissions from the manufacture of solid fuels and other energy industries sub-category have decreased by 80.0% from 1990.

Figure 3.1.1 Energy sector emissions 1990-2002

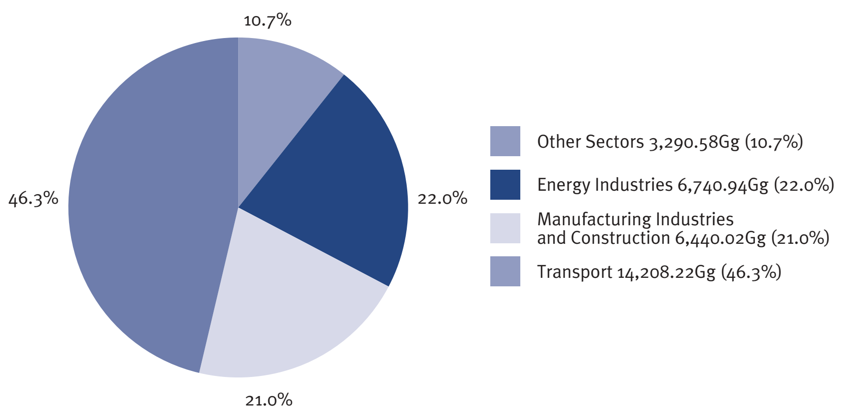


3.2 Fuel combustion (CRF 1.A)

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 sectors namely commercial, residential and agriculture/forestry/fisheries (Figure 3.2.1). These subcategories use common activity data sources and emission factors (refer Annex 2). For this reason 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 2002 (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. Generally, greenhouse gas emissions are calculated by multiplying the emission factor of specific fuels by the energy activity data. There are only a few instances where emission factors are unavailable due to confidentiality reasons and instances where natural gas was used as a feedstock.

The fuel combustion category is commonly separated into two groups – stationary combustion and mobile combustion. CO_2 emissions from the stationary combustion of gas, solid and liquid fuels were identified as key source categories for New Zealand in the 2002 inventory. The relevant good practice decision tree (Figure 2.1 in Good Practice – IPCC, 2000) identifies that to meet good practice in methodology, emissions should be estimated using data from sectors correcting for oxidation and stored carbon (the 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 reviewed all emission factors used in the energy sector in 2003 (Hale and Twomey, 2003). The review was commissioned based on recommendations from New Zealand's inventory QA procedures (Clarkson, 2001, 2002). The results of the emission factors review were assessed by an independent review panel of New Zealand energy experts prior to review recommendations being used in the inventory. In accordance with good practice, where there was a significant difference between country-specific and IPCC default emission factors, and a defensible explanation could not be obtained, New Zealand has reverted to the IPCC default emission factors (refer to Annex 2 for detailed information). The 2002 inventory incorporates the emission factors recommended by the review and agreed by the review panel.

3.2.0.3 Uncertainties and time-series consistency

Uncertainty in greenhouse gas emissions from fuel combustion varies depending on the greenhouse 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 95.5% 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, 2003).

Table 3.2.1 General uncertainty ranges for emission estimates from fuel combustion (MED, 2003)

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 6,740.94Gg CO_2 equivalent in 2002 and have increased 11.5% since 1990. The emissions profile in 2002 is dominated by emissions from public electricity and heat production which contribute 81.8 % of the total CO_2 equivalent emissions.

New Zealand's electricity generation is dominated by hydroelectric generation (60-65% of annual electricity needs) with the balance from thermal generation using mostly natural gas (but occasionally some coal). Geothermal power contributes another 6% 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 electricity generation where the main hydro stations cannot meet the demand for electricity. Generation in a 'normal' hydro year requires lower coal use and a 'dry' hydro year requires higher coal use. This is different from the steady increase in this type of emissions from coal used in electricity generation as found in many other countries.

3.2.1.2 Methodological issues

The owners of the main thermal electricity generating plants in New Zealand are Contact Energy Limited, Genesis Power Limited and Southdown Co-generation Limited. In accordance with IPCC guidelines (IPCC, 1996), where electricity generation is a secondary activity of the co-generation plant, emissions are included in the manufacturing industries category. However, where electricity generation is the primary activity of the co-generation plant the emissions are documented in the energy industries category.

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 (Annex 2).

Energy use data for petroleum refining were 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 fuels used. As there are no data available concerning non-CO_2 emissions from the refinery, the IPCC default (IPCC, 1996) emission factors for industrial boilers are used.

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 emissions factor, 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 2002 inventory, the data for electricity production and petroleum refining underwent a Tier 1 QC checklist.

3.2.1.5 Source-specific recalculations

Energy industries data were recalculated for all years to 1990 as a result of the review of energy sector emission factors. Details of the effect of the recalculation on the energy sector are included in Chapter 9.

3.2.1.6 Source-specific planned improvements

Consideration will be given to separating sectoral coal consumption into three key ranks of coal (bituminous, sub-bituminous and lignite) and using a specific emissions factor for each rank of coal.

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 6,440.02Gg CO_2 equivalent in 2002. The level of emissions in 2002 is 34.9% over the 1990 baseline. The largest single source in 2002 is emissions from natural gas consumption in the manufacture of the chemicals methanol and urea. This sub-category comprised 34.2% of emissions from manufacturing industries and construction and has increased from 525.42Gg CO_2 equivalent in 1990 to 2204.42Gg CO_2 equivalent in 2002 – an increase of 319.6%.

3.2.2.2 Methodological issues

The energy data for methanol and urea production are supplied directly to the MED by industry. CO_2 emissions are calculated by comparing the amount of carbon in the gas purchased by the plants and the amount stored in products (refer Box 4.2 in the 'Industrial Processes' chapter). The energy data have been aggregated to protect commercially sensitive information. The data for other industry uses of gas are from the energy supply and demand balance tables in the Energy Data File (MED, 2003).

CO_2 emissions from liquid fuels and coal are more straightforward to calculate than natural gas because it is assumed that all carbon in these fuels is oxidised to CO_2 during combustion. 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 combined with a sectoral allocation supplied by Coal Research Limited. These sources of activity data are further described in Annex 2. A considerable amount of coal is used in the production of steel, however virtually all of the coal is used in a direct reduction process to remove oxygen from iron sand and not as a fuel. Emissions are therefore included in the industrial process sector.

In the CRF tables, no disaggregated activity data according to fuel types and corresponding CO_2 emissions have been provided for any sub-category except for chemicals. 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 in particular.

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

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 2002 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

Manufacturing industries and construction data were recalculated for all years to 1990 as a result of the review of energy sector emission factors. Details of the effect of the recalculation on the energy sector are included in Chapter 9.

3.2.2.6 Source-specific planned improvements, if applicable

Consideration will be given to validating the sectoral allocation of coal consumption according to national circumstances and priorities for inventory development.

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 14,208.22Gg CO_2 equivalent in 2002 and have increased 60.7% from the 8,840.5Gg CO_2 equivalent emitted in 1990. The emissions profile in 2002 is dominated by emissions from road transportation which accounted for 88.6% of total transport emissions. CO_2 emissions from mobile combustion (road vehicles) was identified as a key source category in the level and trend analysis where it was the 2nd largest source and made the largest contribution to the trend (Tables 1.5.2 and 1.5.3).

3.2.3.2 Methodological issues

Emissions from transportation are compiled from the MED's energy database. It is good practice to use a Tier 1 approach 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 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, 2003). The CO_2 emission factors used in previous inventories were sourced from the New Zealand Energy Information Handbook (Baines, 1993). These were replaced with 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.

Road transport

Accurately calculating non-CO_2 emissions from road transport requires a Tier 2 or higher methodology as it is dependent on the knowledge of the distribution of emission controls in the fleet. However, the Tier 1 approach used by New Zealand is consistent with good practice for the choice of methodology, as non-CO_2 emissions from road transport are not key source categories for New Zealand and information on fuel consumption by vehicle type data is under development.

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).

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

The review of energy sector emission factors (Hale and Twomey, 2003) encompassed the emission factors used in the transport sector.

CO_2 emissions from road transport and aviation were identified as key source categories for New Zealand in the 2001 inventory. In preparation of the 2002 inventory, the data for these emissions underwent a Tier 1 QC checklist.

3.2.3.5 Source-specific recalculations

Data were recalculated for all years to 1990 as a result of the energy sector emissions factor review. Details of the recalculation on the energy sector are included in Chapter 9.

3.2.3.6 Source-specific planned improvements, if applicable

New Zealand will investigate implementing a Tier 2 method to estimate CO_2 emissions from road transportation to support the figures produced from the Tier 1 methodology.

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 category, the residential category and the agriculture, forestry and fisheries sub-category.

Emissions from 'Fuel combustion: other sectors' totalled 3,290.58Gg CO_2 equivalent in 2002 and were 11.8% over the 1990 baseline value of 2,944.25Gg CO_2 equivalent. The emissions profile in 2002 is divided between the commercial and institutional sub-category (39.3%), and the agriculture, forestry and fisheries sub-category (41.6%). The residential category comprises the remaining 19.1% 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, the emissions from the agriculture, forestry and fisheries sub-category are likely to be underestimated (MED, 2003). This is because there are no separate estimates of fuel use by this group, apart from liquid fuels used in agriculture. However, these emissions have been included in other sectors such as industry and transport and are therefore included in New Zealand's total emissions.

The solid fuel used in this sector is predominantly sub-bituminous coal, hence the emissions factor for sub-bituminous coal is used for all solid fuel emissions calculations (MED, 2003).

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 2002 inventory, the data for the other sectors category underwent a Tier 1 QC checklist.

3.2.4.5 Source-specific recalculations

Data were recalculated for all years to 1990 as a result of the energy sector emissions factor review. Details of the effect of the recalculation are included in Chapter 9.

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. 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 New Zealand, 87% (2002) of the CH_4 from coal mining comes from underground mining however most of the coal mined in New Zealand is taken from surface mines (80% in 2002). 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.

Fugitive emissions from solid fuels produced 354.08Gg CO_2 equivalent in 2002. This is an increase of 68.6% from the 210.02Gg CO_2 equivalent reported in 1990. Fugitive emissions from solid fuels (CH_4) were identified as a key source category in the 2002 trend assessment (Table 1.5.3).

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 methodology consistent with good practice is to estimate emissions using direct measurements (Tier 3) supplemented with country-specific emission factors where there is no measurement (Tier 2). 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 values for bituminous and sub-bituminous coal are combined into a single value (13.74 tCH_4/kt coal) for use on underground mining based on the relative production of bituminous and sub-bituminous coal. In 2002, the coal production by weight was 320 kt bituminous coal and 585 kt sub-bituminous coal.

Table 3.3.1 Methane release factors for New Zealand coal

Activity	New release factors (tCH_4/kt coal)	Previous release factors (tCH_4/kt coal)	Source of new emission factors
Surface mining	0.77	0.77	Mid-point IPCC default range (0.2–1.34 t/kt coal)
Underground: bituminous mining	16.75	35.2	Top end of IPCC default range (6.7–16.75 t/kt coal)
Underground: sub-bituminous mining	12.1	12.1	Beamish and Vance, 1992
Surface post mining	0.067	0.067	Mid-point IPCC default range (0.0-0.134 t/kt coal)
Underground post mining	1.6	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

The review of energy sector emission factors (Hale and Twomey, 2003) encompassed the emission factors used in this sector. In preparation of the 2002 inventory, the data for fugitive CH_4 emissions from solid fuels underwent a Tier 1 QC checklist.

3.3.1.5 Source-specific recalculations

Data were recalculated for all years from 1990 as a result of the energy sector emissions factor review. In previous submissions, the emission factors for underground coal mining were based on the New Zealand specific values established by Beamish and Vance (1992). The 2003 review of emission factors (Hale and Twomey, 2003) noted that the New Zealand factor (35.2 tCH_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 2002 inventory (16.75 t CH_4/kt coal) and will review when more country-specific information is available. Details of the effect of the recalculation are shown in Chapter 9.

3.3.1.6 Source-specific planned improvements, if applicable

Research is currently underway to determine an updated New Zealand specific emissions factor determined by direct measurement at underground coal mines.

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 1013.38Gg CO_2 equivalent in 2002. This is an increase from 930.30Gg CO_2 equivalent in 1990 – an increase of 8.9%.

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 before it enters the distribution network. 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, 2003), leaving some fugitive emissions due to the incomplete combustion. Fugitive emissions also occur in transmission and distribution of the natural gas.

This sector includes emissions from geothermal operations. Some of the energy from geothermal fields is transformed into electricity, thus emissions from these sources are reported as fugitive emissions in the energy sector. This is because they are not the result of fuel combustion, unlike the emissions reported under 'Energy Industries'. 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

Venting and flaring from oil and gas production

The CO_2 released through flaring is either supplied directly by field operators or calculated from the supplied energy data using the emission factors from Baines (1993). The Natural Gas Corporation (NGC) supplies estimates of CO_2 released during processing. These values are aggregated to derive annual emissions.

Gas transmission and distribution

Gas leakage occurs almost exclusively from low-pressure 'distribution' pipelines rather than from high-pressure 'transmission' pipelines. Approximate estimates of annual leakage from transmission pipelines provided by the NGC are about 10 tonnes of CO_2 and 100 tonnes of CH_4 (MED, 2003). 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 consumption data. The emissions data are used to calculate fugitive emission factors for the two gases.

Oil transport, refining and storage

Fugitive emissions from oil transport, refining and storage are calculated from an IPCC Tier 1 approach of activity data and emission factors. For oil transport, the fuel quantity is the total New Zealand production of crude oil reported in the Energy Data File (MED, 2003), and the CH_4 emissions factor is the midpoint of the IPCC default value range (0.745 t CH_4 / PJ). Oil refining and storage uses the same CH_4 emissions factor but the fuel quantity is the oil intake at New Zealand's single oil refinery.

Geothermal operations

The geothermal field operators measure the emissions of CO_2 and CH_4 at their plants and supply the figures to the MED. 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 varies in completeness. Some fields were not commissioned until after 1990 and hence do not have records back to 1990.

3.3.2.4 Source-specific QA/QC and verification

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

3.3.2.5 Source-specific recalculations

Emissions from the Wairakei and Ohaaki geothermal fields have been revised from 1996 onwards, however industry was not able to provide emission estimates for the years 1990-1995 on the same basis. Emissions for these years are set at the 1995 level.

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 – 2002. The majority of the CO_2 emission factors for the reference approach are New Zealand specific (Annex 2: Table A2.1). Natural gas emission factors are estimated from the sectoral approach analysis whereby the aggregated CO_2 emissions, including carbon later stored, were divided by aggregate energy use.

Comparison of the reference approach and sectoral approach total in 2002 shows that the sectoral total of CO_2 emissions is 2.94 % less than the reference total (Table 3.4.1). This is mainly related to the differences in the energy consumption data where there is a -1.75 % difference in liquid fuel consumption and a 4.03 % difference in solid fuel consumption.

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 the 'observed' figures are reported as statistical differences in the energy balance tables contained in the Energy Data File (MED, 2003).

The time-series comparison with the IEA data (IEA Statistics, 2003) shows that the differences between the sectoral and reference approach reported in CRF 2002 are 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.

Table 3.4.1 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 2002 and IEA
1990	-2.18	4.80	-6.98
1991	-0.29		
1992	-3.73	9.55	-13.28
1993	-0.95		
1994	-4.54		
1995	-1.19		
1996	2.18		
1997	3.11	7.97	-4.86
1998	2.84	6.64	-3.80
1999	3.31	0.42	2.89
2000	1.28	3.41	-2.13
2001	1.77	2.77	-1.00
2002	-2.94		

3.4.2 International bunker fuels

The data on fuel use by international transportation come from the Energy Data File (MED, 2003). 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. Examples of the calculations for methanol and ammonia/urea are shown in Boxes 4.2 and 4.3 of the industrial processes sector. 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 are listed below:

- A detailed subdivision of the manufacturing and construction source category as requested by the IPCC reporting tables is currently not available due to historical needs and practices of energy statistics collection in New Zealand.
- Some gas usage data from large industrial consumers in New Zealand and some emission factors for gas have been withheld for confidentiality reasons.
- Some of the coal production in the reference approach activity data is used in steel production. The CO_2 emissions from this coal are accounted for under the industrial processes sector and have been netted out of the energy reference approach using the *Estimating the carbon stored in products* Table (refer calculation Worksheet 1.1).
- The activity data shown in the CO_2 worksheets (Worksheet 1.2) under the sectoral approach exclude energy sources containing carbon that is later stored in manufactured products (rather than emitted during combustion) , specifically methanol and urea. This means that there is no subsequent downward adjustment required in carbon emissions and is necessary to preserve the confidentiality of the gas-use data mentioned above.
- An additional worksheet is included to cover fugitive emissions of CO_2 and CH_4 from geothermal fields where electricity or heat generation plants are in operation.

3.4.6 Ozone precursors and SO_2 from oil refining

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

Worksheets accompanying the energy sector

Module **2002 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	63.55	205.31	50.5		-2.28	220.64	1000.00	220640.00	17.80	3927392.00	3927.39		3927.39	0.99	3888.12	14256.43
	Orimulsion	0	0	0		0.00	0.00										
	Natural gas liquids	12.03	0	3.36		0.29	8.38	1000.00	8380.00	16.47	138041.45	138.04		138.04	0.99	136.66	501.09
Liquid fossil fuels - secondary	Gasoline - Regular Unleaded		30.95	0.05	0	3.26	27.64	1000.00	27640.00	18.05	499027.64	499.03		499.03	0.99	494.04	1811.47
	Gasoline - Premium Unleaded		7.03	0.6	0	1.44	4.99	1000.00	4990.00	18.27	91180.91	91.18		91.18	0.99	90.27	330.99
	Jet kerosene		5.50	0.19	27.62	2.33	-24.64	1000.00	-24640.00	18.57	-457632.00	-457.63		-457.63	0.99	-453.06	-1661.20
	Av Gas		0.61	0	0	0.02	0.59	1000.00	586.00	17.73	10388.18	10.39		10.39	0.99	10.28	37.71
	Other kerosene		0	0	0	0.00	0.00										
	Shale oil		0	0	0	0.00	0.00										
	Gas/diesel oil		12.37	0.32	3.42	2.11	6.52	1000.00	6520.00	18.95	123583.64	123.58		123.58	0.99	122.35	448.61
	Residual fuel oil		0	5.26	11.35	-0.17	-16.44	1000.00	-16440.00	20.05	-329547.27	-329.55		-329.55	0.99	-326.25	-1196.26
	LPG		0	0		0.00	0.00										
	Ethane		0	0		0.00	0.00										
	Naphtha		0	0		0.00	0.00										
	Bitumen		6.38	0	0	0.00	6.38	1000.00	6380.00	20.76	132462.71	132.46	225.89	-93.43	0.99	-92.50	-339.15
	Lubricants		0	0	0	0.00	0.00										
	Petroleum coke		0	0		0.00	0.00										
	Refinery feedstocks		20.41	0		0.44	19.97	1000.00	19970.00	19.33	386039.31	386.04		386.04	0.99	382.18	1401.32
	Other oil		0	0		0.00	0.00										
Total liquid fossil fuels		**75.58**	**288.56**	**60.28**	**42.39**	**7.44**	**254.03**		**254026.00**		**4520936.57**	**4520.94**	**225.89**	**4295.04**		**4252.09**	**15591.01**
Solid fossil fuels - primary	Anthracite	0	0	0		0.00	0.00										
	Coking coal	2122042	0	1931687		190355.00	0.00	0.03	0.00	24.20	0.00	0.00	0.00	0.00	0.98	0.00	0.00
	Other bituminous coal	146864	76466.4	0	0	0.00	223330.40	0.03	7168.91	24.20	173487.52	173.49		173.49	0.98	170.02	623.40
	Sub-bituminous coal	1971794	0	0	0	0.00	1971794.00	0.02	44562.54	24.90	1109607.36	1109.61	395.25	714.35	0.98	700.07	2566.91
	Lignite	218239	0	0		0.00	218239.00	0.02	3273.59	26.00	85113.21	85.11		85.11	0.98	83.41	305.84
	Peat	0	0	0		0.00	0.00										
Solid fossil fuels - secondary	BKB & patent fuel		0	0		0.00	0.00										
	Coke		12678.2	0		0.00	12678.20	0.03	353.72	27.90	9868.84	9.87		9.87	0.98	9.67	35.46
Total solid fossil fuels		**4458939**	**89144.6**	**1931687**	**0**	**190355.00**	**2426041.60**		**55358.76**		**1378076.92**	**1378.08**	**395.25**	**982.82**		**963.17**	**3531.61**
Total gaseous fossil fuels		**235.29**	**0**	**0**		**0.35**	**234.94**	**1000.00**	**234940.00**	**15.74**	**3697298.06**	**3697.30**	**902.38**	**2794.92**	**1.00**	**2780.95**	**10196.80**
Total fossil fuels									**544324.76**		**9596311.55**	**9596.31**	**1523.52**	**8072.79**		**7996.21**	**29319.43**
Total biomass fuels									**30410.00**		**909259.00**	**909.26**		**909.26**		**863.80**	**3167.25**
	Solid biomass								30410.00	29.90	909259.00	909.26		909.26	0.95	863.80	3167.25
	Liquid biomass								ne								ne
	Gas biomass								conf								ne

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

Module	**2002 Energy (New Zealand)**
Submodule	**CO_2 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											no
	Sub-bituminous coal	0											no
Liquid fossil fuels	Gasoline	0											
	Jet kerosene	27.62	1000	27620	18.57	512978.73	512.98	0.00	0.00	512.98	0.99	507.85	1862.11
	Gas/diesel oil	3.42	1000	3420	18.95	64824.55	64.82	0.00	0.00	64.82	0.99	64.18	235.31
	Residual fuel oil	11.35	1000	11350	20.05	227515.91	227.52	0.00	0.00	227.52	0.99	225.24	825.88
	Lubricants	0											no
	Bitumen	0	1000	0	20.76	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00
Total fossil fuels				42390								797.27	2923.31

Liquid fossil fuel data are shown initially in petajoules.

Module	**2002 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	10.88	1000.00	10880.00	20.76	225892.52	225.89	1.00	225.89
Coal oils and tars	0.00	0.03	0.00	24.24	0.00	0.00	0.75	0.00
Coal1	15.47	1000.00	15467.06	25.55	395253.61	395.25	1.00	395.25
Natural gas2	conf	1000.00	conf	conf	conf	conf	conf	902.38
Gas/diesel oil	0.00							no
LPG	0.00							no
Ethane	0.00							no
Other fuels	0.00							no
Total								1523.52

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 2002 Energy (New Zealand)
Submodule CO_2 emissions from fuel combustion by source categories (tier 1)
Worksheets 1.2 (part I)

Source and sink catergories	Energy consumption (TJ)	Carbon emis fact (t C/TJ)	Carbon content (t C)	Carbon content (Gg)	Fraction of carbon stored1	Carbon stored1 (t C)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO_2 emissions (Gg)
Total energy (parts I and II of worksheet)	533,386		8,316,242	8,316			8,316		8,238	30,205.73
1 Energy industries	116,087		1,848,964	1,849			1,849		1,834	6,725.32
a Public electricity and heat	95,590		1,514,310	1,514			1,514		1,501	5,505.24
Motor gasoline Regular	2	18.1	41	0			0	0.99	0	0.15
Motor gasoline Premium	0	18.3	0	0			0	0.99	0	0.00
Diesel	14	19.0	268	0			0	0.99	0	0.97
Heavy Fuel oil	0	20.0	0	0			0	0.99	0	0.00
Light Fuel oil	0	19.6	0	0			0	0.99	0	0.00
Sub-bituminous coal	14,210	24.9	353,829	354			354	0.98	347	1,271.43
Natural gas	81,364	14.26	1,160,172	1,160			1,160	0.995	1,154	4,232.69
b Petroleum refining	14,095		237,416	237			237		236	865.32
Fuel oil	599	19.33	11,574	12			12	0.99	11	42.01
Asphalt	1,693	20.76	35,149	35			35	0.99	35	127.59
Refinery gas	11,336	16.21	183,730	184			184	0.995	183	670.31
Natural gas	468	14.89	6,964	7			7	0.995	7	25.41
c Solid fuels and other energy[2]	6,401		97,238	97			97		97	354.76
Natural gas in synthetic petrol prodn	conf	conf	0	0			0	0.995	0	0.00
Natural gas in oil and gas extraction	conf	conf	97,238	97			97	0.995	97	354.76
2 Manufacturing and construction	159,140		1,755,517	1,756			1,756		1,739	6,375.46
Total natural gas[2]	130,236		1,097,631	1,098			1,098		1,092	4,004.52
Natural gas in methanol production	conf	conf	556,392	556			556	0.995	554	2,029.90
Natural gas in urea production	conf	conf	46,389	46			46	0.995	46	169.24
Other natural gas	conf	conf	494,850	495			495	0.995	492	1,805.38
Petrol Regular	104	18.1	1,884	2			2	0.99	2	6.84
Petrol Premium	46	18.3	842	1			1	0.99	1	3.06
Diesel	6,662	19.0	126,274	126			126	0.99	125	458.38
Heavy Fuel oil	922	20.0	18,486	18			18	0.99	18	67.11
Light Fuel oil	833	19.6	16,351	16			16	0.99	16	59.35
Aviation fuels	178	18.6	3,306	3			3	0.99	3	12.00
Av Gas	12	17.7	216	0			0	0.99	0	0.79
LPG	1,320	16.5	21,744	22			22	0.99	22	78.93
Other liquid	0	19.9	0	0			0	0.99	0	0.00
Coal	18,827	24.9	468,784	469			469	0.98	459	1,684.50
Wood (memo item)[3]	30,410	28.4	863,796	864			864	0.95	821	3,008.89
3 Transport	207,437		3,828,964	3,829			3,829		3,791	13,899.19
a Civil aviation	16,183		300,069	300			300		297	1,089.25
Aviation Fuels	15,591	18.6	289,576	290			290	0.99	287	1,051.16
Av Gas	592	17.7	10,493	10			10	0.99	10	38.09
b Road transport	183,977		3,386,386	3,386			3,386		3,353	12,292.63
Petrol Regular	85,399	18.1	1,541,843	1,542			1,542	0.99	1,526	5,596.89
Petrol Premium	24,439	18.3	446,570	447			447	0.99	442	1,621.05
Diesel	71,369	19.0	1,352,758	1,353			1,353	0.99	1,339	4,910.51
LPG	2,580	16.5	42,500	42			42	0.99	42	154.27
CNG	190	14.2889	2,715	3			3	0.995	3	9.90

Worksheets **1.2 (part II)**

Source and sink catergories	Energy Consumption (TJ)	Carbon emis fact (t C/TJ)	Carbon content (t C)	Carbon content (Gg)	Fraction of carbon stored1	Carbon stored1 (t C)	Net C emissions (Gg)	Fraction of carbon oxidised	Actual C emissions (Gg)	Actual CO_2 emissions (Gg)
c Rail transport (diesel)	2,283	19.0	43,278	43			43	0.99	43	157.10
d National navigation (fuel oil and diesel)	4,993		99,230	99			99	0.99	98	360.21
Heavy Fuel oil	2,888	20.0	57,890	58			58	0.99	57	210.14
Light Fuel oil	2,105	19.6	41,340	41			41	0.99	41	150.06
Diesel	0	19.0	0	0			0	0.99	0	0.00
Aviation bunkers (memo item)[3]	27,617	18.6	512,923	513			513	0.99	508	1,861.91
Marine bunkers (memo item)[3]	14,630		289,588	290			290		287	1,051.20
Diesel	3,278	19.0	62,133	62			62	0.99	62	225.54
Heavy Fuel oil	11,104	20.0	222,584	223			223	0.99	220	807.98
Light Fuel oil	248	19.6	4,871	5			5	0.99	5	17.68
4 Other sectors	50,722		882,797	883			883		874	3,205.77
a Commercial/institutional	21,180		352,568	353			353		349	1,280.59
Petrol Regular	89	18.1	1,615	2			2	0.99	2	5.86
Petrol Premium	24	18.3	446	0			0	0.99	0	1.62
Diesel	1,860	19.0	35,251	35			35	0.99	35	127.96
Heavy Fuel oil	0	20.0	0	0			0	0.99	0	0.00
Light Fuel oil	406	19.6	7,973	8			8	0.99	8	28.94
Aviation fuels	636	18.6	11,814	12			12	0.99	12	42.89
Av Gas	19	17.7	339	0			0	0.99	0	1.23
LPG	850	16.5	14,002	14			14	0.99	14	50.83
Coal	3,205	24.9	79,797	80			80	0.98	78	286.74
Natural gas	14,090	14.3	201,331	201			201	0.995	200	734.52
b Residential	10,221		158,360	158			158		157	576.13
Petrol Regular	4	18.1	69	0			0	0.99	0	0.25
Petrol Premium	0	18.3	0	0			0	0.99	0	0.00
Diesel	6	19.0	105	0			0	0.99	0	0.38
Heavy Fuel oil	0	20.0	0	0			0	0.99	0	0.00
Light Fuel oil	0	19.6	0	0			0	0.99	0	0.00
Aviation fuels	1	18.6	13	0			0	0.99	0	0.05
Av Gas	0	17.7	8	0			0	0.99	0	0.03
LPG	1,780	16.5	29,321	29			29	0.99	29	106.44
Coal	790	24.9	19,675	20			20	0.98	19	70.70
Natural gas	7,640	14.3	109,167	109			109	0.995	109	398.28
Wood (memo item)[3]	6,500	28.4	184,633	185			185	1	185	676.99
c Agriculture/forestry/fishing	19,322		371,869	372			372		368	1,349.05
Petrol Regular	1,130	18.1	20,394	20			20	0.99	20	74.03
Petrol Premium	212	18.3	3,874	4			4	0.99	4	14.06
Diesel	14,805	19.0	280,625	281			281	0.99	278	1,018.67
Heavy Fuel oil	170	20.0	3,407	3			3	0.99	3	12.37
Light Fuel oil	1,910	19.6	37,499	37			37	0.99	37	136.12
Aviation fuels	138	18.6	2,555	3			3	0.99	3	9.27
Av Gas	47	17.7	830	1			1	0.99	1	3.01
Coal	911	24.9	22,686	23			23	0.98	22	81.52

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 Some natural gas data are confidential.

3 Data are included only as memo items and do not contribute to the data totals.

Module	**2002 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	Total other fuels1	Total all fuels
Total energy consumption		**243,718**	**37,943**	**251,725**	**36,910**	**533,386**
Energy industries		2,308	14,210	99,569	ne	116,087
Manufacturing industries and construction		10,077	18,827	130,236	30,410	159,140
Transport	Domestic aviation	16,183				16,183
	Road	183,787		190	no	183,977
	Railways	2,283	ne			2,283
	Navigation	4,993	ne			4,993
Other sectors	Commercial/institutional	3,885	3,205	14,090	ne	21,180
	Residential	1,791	790	7,640	6,500	10,221
	Ag/forest/fish	18,411	911	ne	ne	19,322
International marine bunkers (memo item)		14,630	ne			14,630
International aviation bunkers (memo item)		27,617				27,617
Total CO_2 emissions		**16,380**	**3,395**	**10,430**	**3,686**	**30,206**
Energy industries		171	1,271	5,283	ne	6,725
Manufacturing industries and construction		686	1,684	4,005	3,009	6,375
Transport	Domestic aviation	1,089				1,089
	Road	12,283		10	no	12,293
	Railways	157	ne			157
	Navigation	360	ne			360
Other sectors	Commercial/institutional	259	287	735	ne	1,281
	Residential	107	71	398	677	576
	Ag/forest/fish	1,268	82	ne	ne	1,349
International marine bunkers (memo item)		1,051	ne			1,051
International aviation bunkers (memo item)		1,862				1,862

1 All data shown refer to wood. Emissions from wood are included as memo items only and are not included in totals.

Module 2002 Energy (New Zealand)
Submodule **Non-CO2 from fuel combustion by source category (tier 1)**
Worksheet **1.3 (1 of 3)**
Sheet **Energy consumption by fuel**

Activity			Coal quantity (TJ)	Gas quantity (TJ)	Oil quantity (TJ)	Oil quantity (road diesel) (TJ)	Wood quantity (TJ)	Charcoal quantity (TJ)	Other biomass (TJ)	Total energy (TJ)
Energy industries			14,210	99,569	2,308		0	0	ne	116,087
Manufacturing industries and construction			18,827	130,236	10,077		30,410	0	ne	189,550
Transport	Domestic aviation				16,183					16,183
	Road			190	109,838	71,369				181,397
	Railways		ne		2,283					2,283
	Navigation		ne		4,993					4,993
Other sectors	Commercial/institutional		3,205	14,090	3,885		ne	0	ne	21,180
	Residential		790	7,640	1,791		6,500	ne	ne	16,721
	Ag/forest/fish	Stationary	911	ne	1,393		ne	0	ne	2,304
		Mobile		ne	17,018					17,018
Other1			0	0	2,580		0	0	0	2,580
Total			**37,943**	**251,725**	**243,718**		**36,910**	**0**	**0**	**570,296**
International marine bunkers (memo item)			ne		14,630					14,630
International aviation bunkers (memo item)					27,617					27,617

1 Oil quantity is LPG used in road transport.

Module 2002 Energy (New Zealand)
Submodule **Non-CO2 from fuel combustion by source category (tier 1)**
Worksheet **1.3 (2-3 of 3)**
Sheet **Methane emissions**

Activity			Coal emis fact (kg/TJ)	Gas emis fact (kg/TJ)	Oil emis fact (kg/TJ)	Oil factor (road diesel) (kg/TJ)	Wood emis fact (kg/TJ)	Charcoal emis fact (kg/TJ)	Other bio. emis fact (kg/TJ)	Coal emissions (kg)	Gas emissions (kg)	Oil emissions (kg)	Oil emis. (road diesel) (kg)	Wood emissions (kg)	Charcoal emissions (kg)	Other biomass emis (kg)	Total emissions (Gg)
Energy industries			0.670	2.481	2.906					9,521	247,010	6,708		0	0	ne	0.26
Manufacturing industries and construction			0.731	1.359	2.900		14.000			13,760	176,961	29,225		425,740	0	ne	0.65
Transport	Domestic aviation				1.900							30,748					0.03
	Road			567.000	60.000	13.000					107,730	6,590,301	927,791				7.63
	Railways				13.000					ne		29,682					0.03
	Navigation				6.655					ne		33,230					0.03
Other sectors	Commercial/institutional		9.500	1.100	0.914					30,445	15,499	3,552		ne	0	ne	0.05
	Residential		285.000	0.900	0.998		285.000			225,199	6,876	1,787		1,852,500	ne	ne	2.09
	Ag/forest/fish	Stationary	9.500		4.000					8,655	ne	5,570		ne	0	ne	0.01
		Mobile			6.203						ne	105,562					0.11
Other			0.670		28.500					0	0	73,530		0	0	0	0.07
Total										**287,580**	**554,076**	**7,837,686**		**2,278,240**	**0**	**0**	**10.96**
International marine bunkers (memo item)					7.000					ne		102,410					0.10
International aviation bunkers (memo item)					1.500							41,426					0.04

Module 2002 Energy (New Zealand)
Submodule Non-CO2 from fuel combustion by source category (tier 1)
Worksheet 1.3 (2-3 of 3)
Sheet Nitrous oxide emissions (N_2O)

Activity			Coal emis fact (kg/TJ)	Gas emis fact (kg/TJ)	Oil emis fact (kg/TJ)	Oil factor (road diesel) (kg/TJ)	Wood emis fact (kg/TJ)	Charcoal emis fact (kg/TJ)	Other bio. emis fact (kg/TJ)	Coal emissions (kg)	Gas emissions (kg)	Oil emissions (kg)	Oil emis. (road diesel) (kg)	Wood emissions (kg)	Charcoal emissions (kg)	Other biomass emis (kg)	Total emissions (Gg)
Energy industries			1.500	0.090	0.291					21,315	8,961	671		0	0	ne	0.03
Manufacturing industries and construction			1.500	0.090	0.290		4.000			28,240	11,721	2,922		121,640	0	ne	0.16
Transport	Domestic aviation				1.900							30,748					0.03
	Road			0.090	1.420	3.700					17	155,970	264,064				0.42
	Railways				3.700					ne		8,448					0.01
	Navigation				1.901					ne		9,494					0.01
Other sectors	Commercial/institutional		1.300	2.100	0.397					4,166	29,589	1,542		ne	0	ne	0.04
	Residential		1.300	0.090	0.190		3.800			1,027	688	340		24,700	ne	ne	0.03
	Ag/forest/fish	Stationary	1.300		0.380					1,184	ne	529		ne	0	ne	0.00
		Mobile			3.352						ne	57,039					0.06
Other			1.500		0.090					0	0	232		0	0	0	0.00
Total										**55,933**	**50,976**	**532,001**		**146,340**	**0**	**0**	**0.79**
International marine bunkers (memo item)					2.000					ne		29,260					0.03
International aviation bunkers (memo item)					1.080							29,826					0.03

Module 2002 Energy (New Zealand)
Submodule Non-CO2 from fuel combustion by source category (tier 1)
Worksheet 1.3 (2-3 of 3)
Sheet Other oxides of Nitrogen emissions (NO_x)

Activity			Coal emis fact (kg/TJ)	Gas emis fact (kg/TJ)	Oil emis fact (kg/TJ)	Oil factor (road diesel) (kg/TJ)	Wood emis fact (kg/TJ)	Charcoal emis fact (kg/TJ)	Other bio. emis fact (kg/TJ)	Coal emissions (kg)	Gas emissions (kg)	Oil emissions (kg)	Oil emis. (road diesel) (kg)	Wood emissions (kg)	Charcoal emissions (kg)	Other biomass emis (kg)	Total emissions (Gg)
Energy industries			361.000	202.937	170.093					5,129,810	20,206,114	392,584		0	0	ne	25.73
Manufacturing industries and construction			391.441	223.902	162.000		62.000			7,369,532	29,160,109	1,632,545		1,885,420	0	ne	40.05
Transport	Domestic aviation				276.000							4,466,615					4.47
	Road			342.000	467.000	718.000					64,980	51,294,508	51,242,612				102.60
	Railways				718.000					ne		1,639,363					1.64
	Navigation				1,711.293					ne		8,544,874					8.54
Other sectors	Commercial/institutional		228.000	41.000	90.412					730,671	577,690	351,239		ne	0	ne	1.66
	Residential		219.000	42.000	62.000		105.000			173,048	320,880	111,013		682,500	ne	ne	1.29
	Ag/forest/fish	Stationary	228.000		6.700					207,727	ne	9,330		ne	0	ne	0.22
		Mobile			705.962						ne	12,014,152					12.01
Other			361.000		361.000					0	0	931,380		0	0	0	0.93
Total										**13,610,788**	**50,329,773**	**132,630,216**		**2,567,920**	**0**	**0**	**199.14**
International marine bunkers (memo item)					1,710.000					ne		25,017,300					25.02
International aviation bunkers (memo item)					280.000							7,732,760					7.73

Module 2002 Energy (New Zealand)
Submodule Non-CO2 from fuel combustion by source category (tier 1)
Worksheet 1.3 (2-3 of 3)
Sheet Carbon monoxide emissions

Activity			Coal emis fact (kg/TJ)	Gas emis fact (kg/TJ)	Oil emis fact (kg/TJ)	Oil factor (road diesel) (kg/TJ)	Wood emis fact (kg/TJ)	Charcoal emis fact (kg/TJ)	Other bio. emis fact (kg/TJ)	Coal emissions (kg)	Gas emissions (kg)	Oil emissions (kg)	Oil emis. (road diesel) (kg)	Wood emissions (kg)	Charcoal emissions (kg)	Other biomass emis (kg)	Total emissions (Gg)
Energy industries			8.600	26.460	14.009					122,206	2,634,556	32,332		0	0	ne	2.79
Manufacturing industries and construction			23.038	16.521	14.000		561.000			433,727	2,151,580	141,084		17,060,010	0	ne	19.79
Transport	Domestic aviation				114.000							1,844,906					1.84
	Road			648.000	4,590.000	303.000					123,120	504,158,012	21,624,668				525.91
	Railways				303.000					ne		691,820					0.69
	Navigation				171.129					ne		854,487					0.85
Other sectors	Commercial/institutional		190.000	8.500	13.633					608,893	119,765	52,962		ne	0	ne	0.78
	Residential		3,420.000	9.000	15.000		10,450.000			2,702,386	68,760	26,858		67,925,000	ne	ne	70.72
	Ag/forest/fish	Stationary	190.000		350.000					173,106	ne	487,411		ne	0	ne	0.66
		Mobile			610.182						ne	10,384,149					10.38
Other			8.600		1,380.000					0	0	3,560,400		0	0	0	3.56
Total										**4,040,317**	**5,097,781**	**543,859,091**		**84,985,010**	**0**	**0**	**637.98**
International marine bunkers (memo item)					171.000					ne		2,501,730					2.50
International aviation bunkers (memo item)					110.000							3,037,870					3.04

Module 2002 Energy (New Zealand)
Submodule Non-CO2 from fuel combustion by source category (tier 1)
Worksheet 1.3 (2-3 of 3)
Sheet NMVOC emissions

Activity			Coal emis fact (kg/TJ)	Gas emis fact (kg/TJ)	Oil emis fact (kg/TJ)	Oil factor (road diesel) (kg/TJ)	Wood emis fact (kg/TJ)	Charcoal emis fact (kg/TJ)	Other bio. emis fact (kg/TJ)	Coal emissions (kg)	Gas emissions (kg)	Oil emissions (kg)	Oil emis. (road diesel) (kg)	Wood emissions (kg)	Charcoal emissions (kg)	Other biomass emis (kg)	Total emissions (Gg)
Energy industries			4.750	4.500	4.750					67,498	448,059	10,963		0	0	ne	0.53
Manufacturing industries and construction			19.000	4.478	4.750		47.500			357,706	583,196	47,868		1,444,475	0	ne	2.43
Transport	Domestic aviation				17.000							275,118					0.28
	Road			81.000	885.000	102.000					15,390	97,206,937	7,279,591				104.50
	Railways				102.000					ne		232,890					0.23
	Navigation				49.037					ne		244,853					0.24
Other sectors	Commercial/institutional		190.000	4.500	4.750					608,893	63,405	18,453		ne	0	ne	0.69
	Residential		190.000	4.500	4.750		570.000			150,133	34,380	8,505		3,705,000	ne	ne	3.90
	Ag/forest/fish	Stationary	190.000		4.750					173,106	ne	6,615		ne	0	ne	0.18
		Mobile			155.061						ne	2,638,850					2.64
Other			19.000		608.000					0	0	1,568,640		0	0	0	1.57
Total										**1,357,335**	**1,144,430**	**109,539,283**		**5,149,475**	**0**	**0**	**117.19**
International marine bunkers (memo item)					49.000					ne		716,870					0.72
International aviation bunkers (memo item)					17.000							469,489					0.47

Module 2002 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		**544,667**						**51,674**	**51.674**
Coal	Low[1]	4,020	0.30%	12.50%	0.00%	15.0	350.0	1,407	1.407
	Medium[2]	24,749	0.50%	12.50%	0.00%	22.6	387.2	9,582	9.582
	High[3]	8,263	1.10%	2.50%	0.00%	32.1	668.2	5,521	5.521
Heavy fuel oil	Low							no	no
	Medium[4]	4,583	2.30%	0.00%	0.00%	44.06	1,044.0	4,784	4.784
	High							no	no
Light fuel oil	Low[5]	5,254	1.75%	0.00%	0.00%	44.46	787.2	4,136	4.136
	High							no	no
Diesel		96,998	0.24%	0.00%	0.00%	45.98	104.4	10,126	10.126
Petrol		86,729	0.01%	0.00%	0.00%	46.93	2.1	185	0.185
Jet kerosene		17,214	0.01%	0.00%	0.00%	46.4	4.3	74	0.074
Asphalt[6]		1,693	4.50%	0.00%	0.00%	41.9	2,148.0	3,636	3.636
LPG		6,530	0.00%					0	0.000
Natural gas[7]		251,725	0.00%					0	0.000
Municipal Waste								ne	ne
Industrial Waste								ne	ne
Black Liquor								ne	ne
Fuelwood		36,910	0.20%	0.00%	0.00%	12.1	331.1	12,222	12.222
Other Biomass								ne	ne
Marine bunkers (memo item)	HFO	11,104	2.30%	0.00%	0.00%	44.06	1,044.0	11,593	11.593
	LFO	248	1.75%	0.00%	0.00%	44.46	787.2	195	0.195
	Diesel	3,278	0.24%	0.00%	0.00%	45.98	104.4	342	0.342
Aviation bunkers (memo item)	Jet kero	27,617	0.01%	0.00%	0.00%	46.4	4.3	119	0.119

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.
7 Includes refinery gas and CNG.

Module 2002 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		**4.46**		**16.861**
Underground mines	Mining	0.90	13.744	12.438
	Post-mining		1.600	1.448
Surface mines	Mining	3.55	0.770	2.737
	Post-mining		0.067	0.238

Module 2002 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	71,180	4.429	0.034	315.239	2.451

Module 2002 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					**294.800**	**16.755**
Oil	Exploration				ne	ne
	Production of crude oil				ne	ne
	Transport of crude oil	63,548		0.745	ne	0.047
	Refining/storage	261,273		0.745	ne	0.195
	Distribution of oil products				ne	ne
Gas	Production/processing				ne	ne
	Transmission and distributior	73,066	21.9	215.9	1.600	15.777
	Other leakage				ne	ne
Venting and flaring from oil and gas prod.		8,343	35,142.5	88.3	293.200	0.737

Module 2002 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)
5,639,538	0.53	2,989	2.989

Module 2002 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)	4,816.7	0.70	3,371.7	3.372

Module 2002 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)
25,010	139	3,476,390	3.476

Chapter 4:

Industrial processes

4.1 Sector overview

New Zealand's industrial processes sector totalled 3515.12Gg CO_2 equivalent in 2002 and represented 4.7% of total greenhouse gas emissions. Emissions from industrial processes are now 20.5% above the 1990 baseline of 2934.09Gg CO_2 equivalent (Figure 4.1.1). The sector is dominated by emissions from the metal production category (CO_2 and PFCs) at 61.8% of sectoral emissions (Figure 4.1.2).

Figure 4.1.1 Industrial processes sector emissions 1990-2002

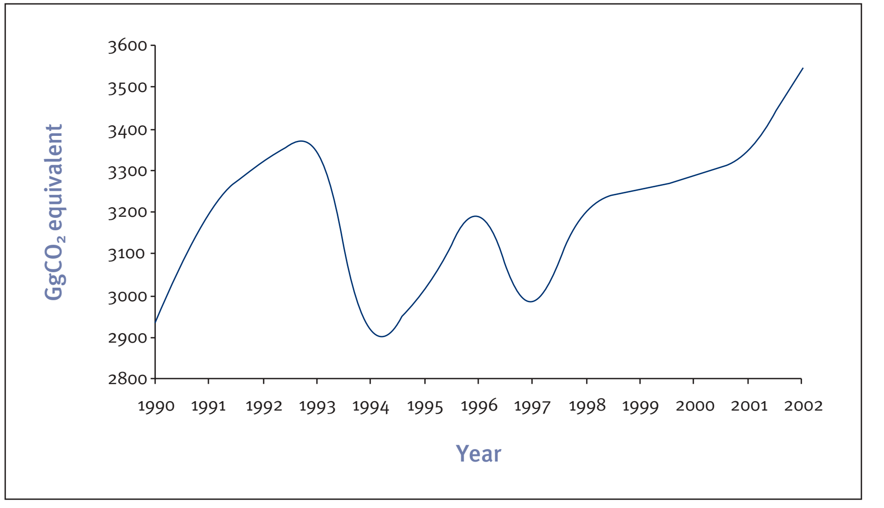
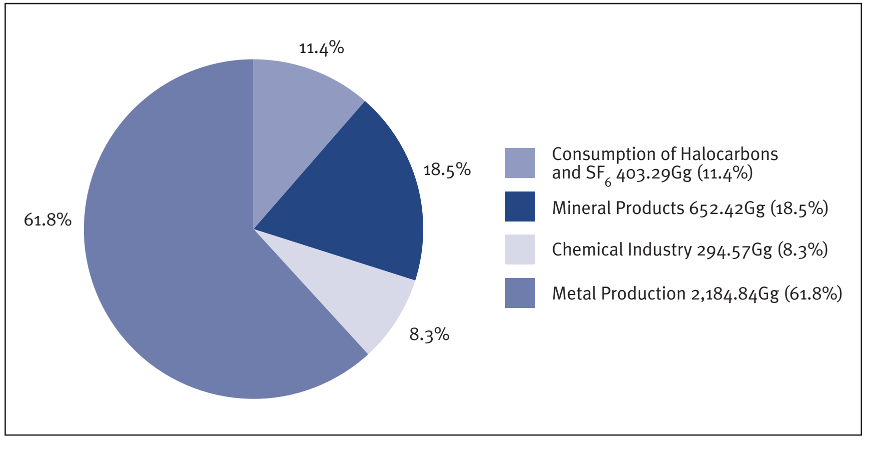


Figure 4.1.2 Industrial processes sector emissions in 2002 (all figures Gg CO_2 equivalent)



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 five industrial processes in New Zealand that emit significant quantities of CO_2 (MED, 2003);

- 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.

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 MED and reported in New Zealand Energy Greenhouse Gas Emissions 1990-2002 (MED, 2003). Production and emissions data are generally provided by industry.

Data on non-CO_2 emissions are gathered primarily through a questionnaire distributed directly to industry via consultants contracted to the NZCCO. 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 were applied to industry production data where no country-specific information was available. Full details of emission estimates and aggregate emission factors are included in the detailed category information and worksheets accompanying this sector.

4.1.2 Uncertainties

The number of companies in New Zealand producing CO_2 from industrial processes is small. The emission estimates of CO_2 supplied by the companies are considered to be accurate to ±5% (MED, 2003). The uncertainty range is based on expert opinion provided by the companies or a representative of the industry. 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 652.42Gg CO_2 in 2002. Overall, the level of emissions in the mineral products category has grown by 45.5% from the 1990 level of 448.28Gg CO_2 equivalent.

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 were identified as a key source category for New Zealand in 2002 (Tables 1.5.2 and 1.5.3).

4.2.2 Methodological issues

Cement and lime production

CO_2 emissions estimates are based on activity data and emission factors supplied to the MED by industry. It is assumed that the country-specific CO_2 emission factors (0.46t CO_2 / t cement, 0.719t CO_2 / t lime) apply to all companies manufacturing cement and lime. 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.

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 were 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 were provided by the three main road paving companies. Estimates of national consumption of bitumen for road paving were 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 2002 inventory, the New Zealand Bitumen Contractors Association provided the methodology shown in Box 4.1 for calculating the total NMVOC emissions from the use of solvents in the roading industry.

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 associated with fuel use while NMVOC and SO_2 emissions are assumed to be associated with the industrial process because they are associated with the raw materials.

4.2.3 Uncertainties and time-series consistency

Uncertainties in CO_2 emissions are assessed as ±5% as discussed in section 4.1.2. Uncertainties in non-CO_2 emissions were 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%.

It should be noted that in the 2001 inventory worksheets (NZ 2b part 1) that the value of 4.7 million tonnes of bitumen referred to the quantity of crude oil feedstock in 2001 rather than the quantity of bitumen produced. This made no effect on the NMVOC emissions reported.

4.2.4 Source-specific QA/QC and verification

CO_2 emissions from cement production were included in the trial of New Zealand's Tier 1 QC procedures in the 2002 inventory (refer Annex 6 for examples). In the process of compiling the inventory of non-CO_2 emissions, where possible activity data were cross-referenced 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

There were no source-specific recalculations performed for this category.

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/urea, methanol, hydrogen, fertiliser and formaldehyde. There is no production of nitric acid, adipic acid, carbide, coke or caprolactam in New Zealand. There are no key source categories identified for New Zealand from the chemical industries category.

Emissions from the chemical industry category comprised 294.57Gg CO_2 equivalent emissions in 2002 and have increased 90.3% from the 154.80Gg CO_2 equivalent estimated in 1990. CO_2 emissions from hydrogen production account for 67.0% 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. The process New Zealand uses for estimating emissions from ammonia is documented in Box 4.2. All CO_2 emissions from production are currently reported in the energy sector in Section 3.2.2 'Fuel combustion: manufacturing industries and construction (CRF 1A2)'. Non-CO_2 emissions are calculated from activity data and emission factors supplied by company. The company supplied emissions factor is based on measurements from historical vent valve data and is considerably lower than the IPCC defaults (refer to worksheets accompanying this sector).

Box 4.2 Calculation of CO_2 emissions from ammonia/urea production (MED, 2003)

Assumptions

- The carbon content of urea is 20% by weight.
- CO_2 emissions factor for Maui gas is 52.3 kt / PJ (2002).
- CO_2 emissions factor for Kapuni gas is 84.1 kt /PJ.
- CO_2 emissions factor for Kaimiro gas is 65.2 kt/PJ.

The resulting calculations are:

- Weight of CO_2 sequestered as carbon in urea = [(output of plant in tonnes) *0.2*44/12] tonnes.
- CO_2 potential of energy input = [(PJ Maui gas)*52.3 + (PJ Kapuni) * 84.1 + (PJ Kaimiro)* 65.2] kilotonnes.
- Actual CO_2 emissions of plant = [potential CO_2 emissions of energy input] – [CO_2 sequested in urea].

Formaldehyde

Emissions from formaldehyde are calculated from company supplied (4 plants) activity data and emission factors for CO, CH_4, methanol and formaldehyde. Emissions were calculated by multiplying individual plant activity data with individual emission factors and summing the result. The levels of CO and CH_4 were undetectable.

Methanol

Methanol is produced at two plants in New Zealand. The process to calculate CO_2 emissions is shown in Box 4.3. CO_2 emissions from energy use in methanol production are considered in the energy sector. The major non-fuel related emissions from the process are 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 (CRL Energy Ltd, 2004).

Box 4.3 Calculation of CO_2 emissions from methanol production (MED, 2003):

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.

Fertiliser

Superphosphate is produced by two companies (each with three plants). 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 New Zealand plants. 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 emissions factor for the other company was therefore applied to all activity data.

Hydrogen

Emissions of CO_2 from hydrogen production are supplied directly to the MED from the two companies involved. Most hydrogen produced in New Zealand is made by the New Zealand Refining Company as a feedstock at the Marsden Point refinery. Another firm produces a small amount which is converted to hydrogen peroxide. The hydrogen is produced from methane and steam. CO_2 is a by-product of the reaction and is vented to the atmosphere (MED, 2003).

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 were 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 activity 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

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

4.3.5 Source-specific recalculations

CH_4 from methanol production was included for the first time in the 2002 inventory due to an omission in previous CRFs. Emissions are calculated back to 1997 (when methanol production data were available).

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 comprising 2.1% and 0.7% of the level assessment respectively (Table 1.5.2). PFC emissions from aluminium production are a key source 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 2184.84Gg CO_2 equivalent emissions in 2002 and have decreased 5.9% from the 2321.07Gg CO_2 equivalent recorded in 1990. CO_2 emissions account for 96.3% of emissions in this sector with another 3.7% from PFCs. In 2002, the level of CO_2 emissions has grown by 16.7% since 1990, however the level of PFCs has decreased from the 515.60Gg CO_2 equivalent in 1990 to 80.70Gg CO_2 equivalent in 2002 (-84.3%).

The sole aluminium smelter in New Zealand has low PFC emissions because of 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 using activity data and country-specific emission factors supplied by the two iron and steel manufacturing firms. 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 estimates are obtained from data supplied by New Zealand's sole aluminium smelter. 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 and are included in the energy sector (MED, 2003).

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 Centre Worked Prebake technology in the slope equation together with smelter-specific operating parameters. Anode effect minutes per pot day is the multiple of every anode effect times the duration. Through the process control software, the smelter captures every anode effect both in terms of count and of duration. All monitoring data is logged and stored electronically, no data are estimated.

Other metal production

The only other metals produced in New Zealand are gold and silver. Gold and silver production processes are listed in IPCC (1996) as sources of non-CO_2 emissions. However, no details or emission factors are provided and no published information on emission factors has been identified. Consequently, no estimation of emissions from this source has been included in New Zealand's inventory for 2002.

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 were 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 chemical 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 were assessed by a Tier 1 QC procedure in preparation of the 2002 inventory (refer Annex 6 for examples).

4.4.5 Source-specific recalculations

There were no source-specific recalculations due to methodology changes performed for this category. However, the PFC emissions data reported in previous inventories (1990-1999) were identified by NZCCO officials as being inconsistent with company-supplied emissions records. The inconsistency has been investigated and corrected in the CRF time-series.

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 2002, emissions from this category totalled 6.73Gg 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 sector (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 were 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 were performed for this category however in the process of compiling the inventory of non-CO_2 emissions, where possible, activity data were cross-referenced between companies and industry associations to verify the data.

In the 1999, 2000 and 2001 worksheets submitted previously with NIRs, the sub-total for NMVOC from food and drink production was double-counted in the overall total. However, this did not affect the total for food and drink emissions reported in the CRF. This has been corrected in the 2002 inventory worksheets.

4.5.5 Source-specific recalculations

The 1999-2001 spreadsheets used emission factors for wine, beer and spirits that are per hectolitre and should be ten times higher (plus a density correction) per tonne. This has been corrected in the 2002 inventory and the 1999-2001 CRFs.

4.6 Production of halocarbons and SF_6 (CRF 2E)

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

4.7 Consumption of halocarbons and SF_6 (CRF 2F)

4.7.1 Description

Emissions from this category totalled 403.29Gg CO_2 equivalent in 2002. This is an increase of 3956% from the 1990 level of 9.94Gg CO_2 equivalent. The large increase is due to the replacement of CFCs and HCFCs with HFCs. HFC emissions were identified as a key source category in the trend analysis of the 2002 inventory (Table 1.5.3).

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 IPCC guidelines (1996), 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

SF_6

Actual and potential emissions of SF_6 result primarily from the use of SF_6 in electrical switchgear. For the 2002 inventory, emissions were 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. This inventory reports SF_6 emissions from the Tier 3 methodology.

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. 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 2002 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.

Table 4.7.1 HFC 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

Aerosols

Activity data on aerosol usage were provided by the only New Zealand aerosol manufacturer that is 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 were 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 (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) were 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 were 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 were 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.

4.7.4 Source-specific QA/QC and verification

No specific QA/QC activities were performed for this category. Activity data provided by industry were verified against national totals where possible. Unreturned questionnaires and anomalous data were followed up and verified to ensure an accurate record of activity data.

4.7.5 Source-specific recalculations

The 2003 survey of SF_6 use in electrical equipment revealed that the major user had been able to assess its holdings and losses of SF_6 more accurately than in the past surveys for 2000 and 2001. The losses have been re-calculated using a 1% emissions factor for the major firm and 2% for all other companies. This has reduced the assessment of emissions from electrical equipment by a significant 183kg in 2000 and 200kg in 2001.

There were some recalculations for the sub-sources of HFC/PFC emissions in the 2002 inventory resulting from new sources identified in the survey and a critical examination of previous emission estimates. The new sources are in emissions from foam where HFC emissions are now reported and in refrigeration where emissions from retired equipment are included. Other specific changes include (CRL Energy Ltd, 2004a).

Aerosols
The quantity of HFCs contained in aerosol products was revised down from 2% in 2001 inventory to 1% in the 2002 inventory for all years based on information from the Aerosol Association of Australia/New Zealand.

Metered Dose Inhalers (MDIs)
A new level of 500 million doses per annum was obtained from industry sources and implied that previous estimates were incomplete. Based on this improved information, the time-series of previous estimates was recalculated to 1995.

Fire Protection
The annual emissions factor of 1.5% of the total HFC installed is an increase from 1.33% used in the 2001 inventory. This is to allow for other suppliers to be accounted for other than just the main supplier.

Mobile Air Conditioning (MAC)
There are changes in estimates for pre-installed MAC systems and average HFC charge values (part of disposal emission estimates).

4.8 Other (CRF 2G)

4.8.1 Description

Panel products
Activity data and emission factors for NMVOC emissions were obtained from two plants that manufacture panel products. The activity data were supplemented from statistics from the MAF website. An assumption was made that the industry-supplied NMVOC emission factors were applicable to all particleboard and fibreboard production in New Zealand. There is no information in the IPCC guidelines (1996) for this category.

Worksheets accompanying the industrial process sector

Module	2002 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		**2,954**	
Cement[1]	1,176,682	541.72	0.46
Lime[1]	151,545	110.69	0.73
Hydrogen[1]	29,599	197.48	6.67
Iron and steel[1]	777,870	1,563.80	2.01
Aluminium[1]	333,538	540.34	1.62

1 Production and emissions data provided by industry and reported in Ministry of Economic Development (2002):

Module **2002 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	213.0	0.6390			0.0138						0.00300			0.00007					
NZ Steel	564.0	0.2115			0.8460					0.6486	0.00038			0.00150					0.00115
B Non-Ferrous Metals																			
NZ Aluminium Smelters	333.5	36.7			0.7170					6.4860	0.11000			0.00215					0.01945
C Inorganic Chemicals (excepting solvent use)																			
Sulphuric Acid (Ballance and Ravensdown)	550.8									2.38									0.00432
Superphosphate (Ballance and Ravensdown)	1710.3									1.61									0.00094
Urea (Ballance)	233.4		0.0607								0.000001	0.00026							
Ammonia (Ballance)	133.0																		
D Organic Chemicals																			
Formaldehyde (Orica Adhesives and Dynea)	51.0	0.0000	0.0000			0.2852					0.00000	0.00000			0.00559				
Methanol (Methanex)	2281.4	0.2281	4.5628		2.0533	11.4070					0.00010	0.00200		0.00090	0.00500				
E Non-Metallic Mineral Products																			
Cement	1075.4									1.0497	0.0000			0.0000					0.00098
Lime	150.5									0.1682									0.00112
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	125.2					0.5634									0.00450				
F Other (ISIC)																			
Paper and Pulp (chemical processes)	711.4	1.2235			1.1026	0.3912				0.0733	0.00172			0.00155	0.00055				0.00010
Paper and Pulp (mechanical processes)	839.0					0.4614									0.00055				
Panel Products (particleboard)	204.7					0.0266									0.00013				
Panel Products (fibreboard)	880.3					0.9683									0.00110				
Nitrous oxide use				0.1560															
Food and drink production																			
Wine (million litres)	78.4					0.0627									0.000833				
Beer (million litres)	309.0					0.1082									0.000350				
Spirits (million litres)	9.3					0.0201									0.002151				
Meat	1144.3					0.3433									0.000300				
Fish	318.1					0.0954									0.000300				
Poultry	134.6					0.0404									0.000300				
Sugar	230.7					2.3070									0.010000				
Margarine and solid cooking fats	0.0					0.0000									0.010000				
Cakes, biscuits and breakfast cereals	44.2					0.0442									0.001000				
Bread	255.0					2.0400									0.008000				
Animal feed	810.4					0.8104									0.001000				
Coffee roasting	5.1					0.0028									0.000550				
TOTAL		**38.99**	**4.62**	**0.16**	**4.74**	**22.50**	**0.00**	**0.00**	**0.00**	**12.42**									

Note: Use of halocarbons and SF_6 covered in separate tables

Module 1990 - 2002 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

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

Module 1990 - 2002 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

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

Module 1990 - 2002 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

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 - 2002 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

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

Module 1990 - 2002 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

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

Module 1990 - 2002 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

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	0.2	3.9	0.3	3.8
1993	4.9	6.4	2.0	9.3
1994	38.4	6.8	10.5	34.7
1995	74.3	8.4	16.6	66.1
1996	102.1	10.6	15.9	96.8
1997	63.6	10.5	14.9	59.2
1998	127.1	9.9	16.8	120.2
1999	112.3	12.6	17.8	107.1
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

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

Module 1990 - 2002 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	3.6	3.8	0	0	0.0
1993	10.4	9.3	0	0	1.1
1994	49.3	34.7	0	0	14.6
1995	97.2	66.1	0	0	31.1
1996	147.0	96.8	0	0	50.1
1997	84.1	59.2	0	0	24.8
1998	186.0	120.2	0	0	65.8
1999	165.0	107.1	0	0	57.8
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

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 - 2002 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

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 - 2002 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

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

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

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

Module 1990 - 2002 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

Module 1990 - 2002 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		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	2600	975	325	1300
1999	2900	1050	350	1400
2000	1753	29	11	40
2001	1483	29	14	42
2002	0	29	14	42

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

Chapter 5:

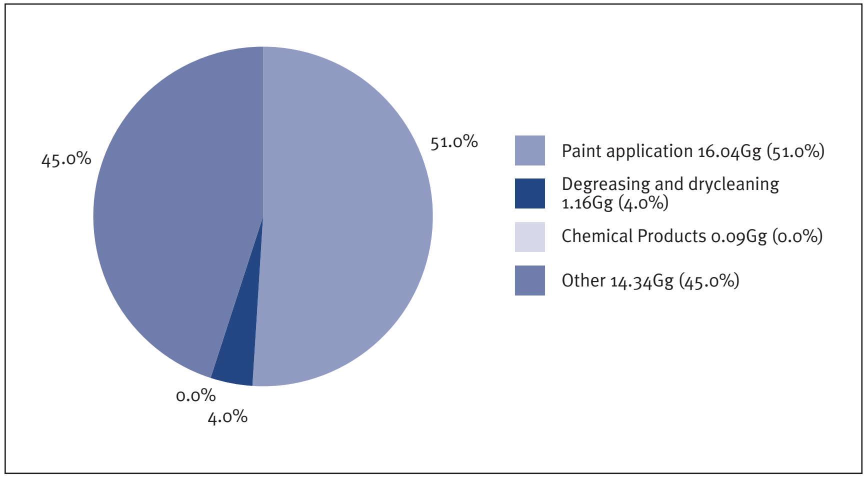
Solvent and other product use

5.1 Sector overview (CRF 3)

Solvents and related compounds are a significant source of emissions of NMVOC. The 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 2002 comprised 31.63Gg of NMVOC. This is an increase from 24.24Gg in 1990, an increase of 30.5%. 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 2002 (all figures Gg NMVOC)



Emissions of the use of N_2O for anaesthesia are included in New Zealand's inventory for the first time. In 2002, N_2O emissions from anaesthesia use totalled 0.16Gg N_2O. This is a 16.4% increase from the level calculated for 1990.

5.1.1 Description

New Zealand's relatively small manufacturing base means that solvent use is lower than in 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).

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 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, a 0.6 kg per hectolitre (100 litres) emissions factor for NMVOC has been calculated. Ethanol used for alcoholic beverage production has been reported separately.

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 2002 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 were available for emissions for 1990-2001. Emissions were calculated using the New Zealand population data as a surrogate for the emissions level. The calculated emissions factor is 0.039kg N_2O/person.

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 paints 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 EPAV and 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 2002 inventory were 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).

Worksheets accompanying the solvent and other product use sector

Module **2002 Solvent and other product use (New Zealand)**
Worksheet **NZ 3a**
Sheet **Non-CO_2 emissions**

Source Categories	ACTIVITY DATA Quantity Consumed tonnes	Emission Estimates B (Gg) Tonnes x 1000			Emission Factors C kg/year/person			
		N_20	HFC	NMVOC	CO	N_20	HFC	NMVOC
TOTAL SOLVENT EMISSIONS								
A Surface Coatings								
Architectural/ Decorative								
Organic Base	**4381**			**1.4573**				
Primers and Undercoats	1646			0.4445				0.1118
Finishing Coats - Gloss	1313			0.4463				0.1122
Finishing Coats - Semi Gloss	343			0.0891				0.0224
Finishing Coats - Flat	259			0.0673				0.0169
Clears and Satins	820			0.4102				0.1032
Water Base	**32211**			**2.0676**				
Primers and Undercoats	2689			0.1882				0.0473
Finishing Coats - Gloss	12654			0.8858				0.2228
Finishing Coats - Semi Gloss	7186			0.5031				0.1265
Finishing Coats - Flat	9042			0.4521				0.1137
Clears and Satins	640			0.0384				0.0097
Industrial								
Organic Base	**16987**			**8.4171**				
Primers and Undercoats	6502			2.2106				0.5560
Finishing Coats	9640			5.7842				1.4548
Clears	845			0.4223				0.1062
Water Base	**1404**			**0.0983**				
Primers and Undercoats	1262			0.0883				0.0222
Finishing Coats	142			0.0099				0.0025
Thinners				**3.9993**				
Solvents/Thinners	3999			3.9993				1.0059
B Degreasing and Drycleaning[2]				**1.1575**				
C Chemical Products				**0.0925**				
Ethanol[1]				0.0672				
Hydrogen Peroxide[1]				0.0253				
D Other				**14.3433**				
Printing[2]				2.0822				
Aerosols[2]				2.162				
Domestic and Commercial Use				10.099				2.5400
			Total	**31.63**				

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 2002) 3,975,900

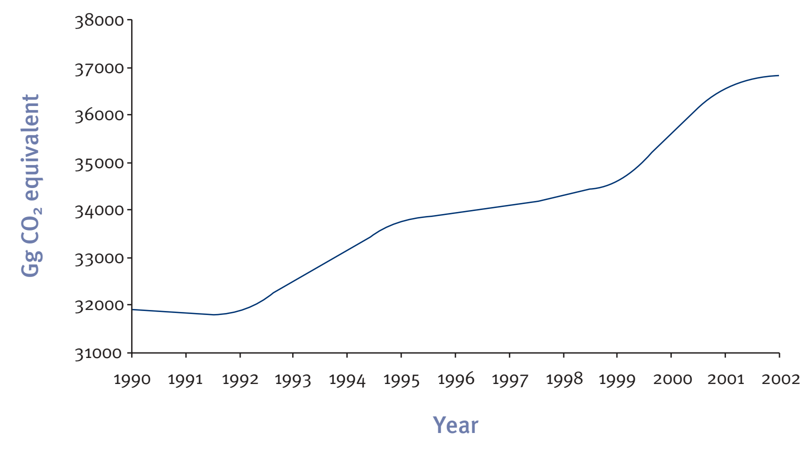
Chapter 6:

Agriculture

6.1 Sector overview

The agriculture sector emissions totalled 36,856.64Gg CO_2 equivalent and represented 49.2% of all greenhouse gas emissions in 2002. Emissions in this sector are now 15.5% higher than the 1990 baseline value of 31,911.15Gg CO_2 equivalent (Figure 6.1.1). The increase is attributable to a 10.4% increase in CH_4 emissions from enteric fermentation and a 27.6% increase in N_2O emissions from the agricultural soils category. Prescribed burning of savanna (grasslands) has been included for the first time in the 2002 inventory. Emissions from savanna burning are a minor source of emissions (1.0Gg CO_2 equivalent) but have decreased 70.2% from the 1990 level.

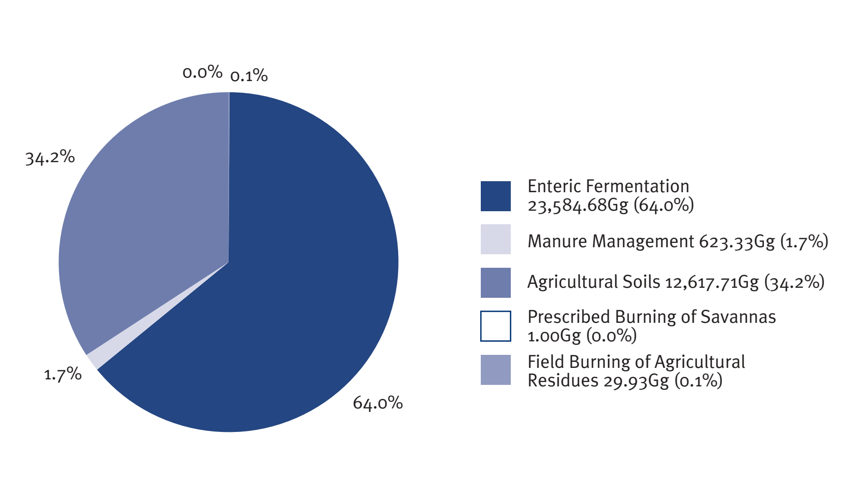
Figure 6.1.1 Agricultural sector emissions from 1990 to 2002



Emissions of CH_4 from enteric fermentation dominate the sector producing 64.0% of CO_2 equivalent emissions (Figure 6.1.2). Emissions of N_2O are the other large component with N_2O emissions from agricultural soils comprising 34.2% of 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 fertilizer.

Figure 6.1.2 Emissions from the agricultural sector in 2002 (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, the same livestock population characterisation is used as the framework for estimating emissions from enteric fermentation, manure management and agricultural soils (animal grazing). A complete time-series of the agriculture data is shown in the tables accompanying this chapter and information on livestock population census and survey procedures is included in Annex 3A.

6.2 Enteric Fermentation (CRF 4A)

6.2.1 Description

In 2002, emissions from enteric fermentation comprised 23,584.68Gg CO_2 equivalent. This represents 31.5% of New Zealand's total CO_2 equivalent emissions. The category is dominated by emissions from cattle which represent 57.9% of emissions from enteric fermentation. The current level of emissions from enteric fermentation is 10.4% 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 65.6% since 1990. This increase has been offset by decreases in emissions from sheep (-15.6%), goats (-84.7%) horses (-20.1%) and swine (-13.1%).

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 (IPCC, 1996).

CH_4 emissions from enteric fermentation have been identified as the largest key source category for New Zealand, comprising 31.5% of the level assessment and 18.1% of the trend assessment (Tables 1.5.2 and 1.5.3). 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 inventory.

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. As with any modelling approach, some assumptions are necessary to fill data gaps. These are explained in the full description of the Tier 2 approach included in Annex 3A and Clark *et al*.(2003). For the 2002 inventory, there were only minor revisions to the calculations. These included the updating of provisional animal statistics reported in the 2001 inventory, recalculating the three year average populations and minor corrections to calculation algorithms.

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 3A.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 estimate (Clark *et al*., 2003; Table 6.2.1). For 2002, the Monte Carlo numerical simulation was corroborated by analytical (that is, by the calculus) solution of an equation that captured the inventory calculation. For the 2002 inventory, compared with 2001, there were only minor changes to population data and no changes to the underlying probability distribution functions. The 95% confidence interval is calculated using the standard deviation and mean values. The mean values are the reported CH_4 emissions. For 1990-2002, the standard deviation divided by the mean was equal to 0.27.

Table 6.2.1 Enteric methane emissions 1990 and 2001 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
2002	1,123.1	528.8	1,717.4

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

The uncertainty 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 were comparable, within estimated errors, to scaled-up animal emissions. The emissions from the cows measured by IHF and averaged over 3 campaigns were 329 (±153) g CH_4/day/cow compared to 365 (±61) g CH_4/day/cow for the scaled-up measurements reported by Waghorn *et al.* (2002) and Waghorn *et al.* (2003).

6.2.5 Source-specific recalculations

The 2001 data have been recalculated using final rather than provisional animal numbers in the three year average. This increases the level of emissions reported in 2001 (refer to Chapter 9).

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 enteric CH_4 emissions 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 1.7% 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 source category for New Zealand in the 2002 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 75.33Gg CO_2 equivalent of N_2O in 2002. In comparison, agricultural soil emissions of N_2O totalled 12,617.71Gg 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 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**		

New Zealand specific methodology/emissions factors are not available for CH_4 emissions from manure management for swine, horses and poultry, but emission estimates using IPCC default emission factors are included. These estimates are considered preliminary and will undergo change if New Zealand specific emission factors are derived.

Nitrous oxide

For the N_2O calculation six alternative regimes for treating animal manure, known as animal waste management systems (AWMS), are identified in the IPCC Guidelines (1996). 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. For dairy cattle, New Zealand specific data from Haynes and Williams (1993) were used. Animals were allocated to four AWMS: (1) anaerobic lagoons, (2) pasture, range and paddock, (3) solid storage and dry-lot and (4) other systems.

The pasture, range and paddock AWMS is the predominant regime for animal waste in New Zealand as 100% of sheep, goats, deer and non-dairy cattle are allocated to it and 89% of dairy cattle. Emissions from the pasture, range and paddock AWMS are reported in the agricultural soils category.

Excretion of nitrogen for each AWMS is calculated in the worksheets accompanying this sector. A time-series of Nex values used for calculating animal production N_2O emissions is also shown in the worksheets. These parameters have been derived by using the nutrient input/output model OVERSEER® to determine the annual quantities of nitrogen deposited in excreta by grazing animals. The OVERSEER® model uses feed intake from the Tier 2 model used to determine CH_4 emissions (Clark *et al*., 2003) and an assessment of feed nitrogen content.

6.3.3 Uncertainties and time-series consistency

CH_4 estimates from the anaerobic degradation of animal waste are still preliminary and are based on the maximum potential emission of CH_4 from animal waste. Actual emissions are likely to be substantially lower in a ranging from 10 to 50% of the reported values with an uncertainty between 50 and 90% (Joblin and Waghorn, 1994).

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) which have uncertainties of -50% to +100% (IPCC, 2000), but uses a detailed livestock characterisation and New Zealand specific nitrogen excretion rates.

N_2O emissions from manure management are not a key source category for New Zealand. In contrast, uncertainties in N_2O emissions from the agricultural soils category are a key source category and have been assessed using Monte Carlo simulation. The results of the simulation are discussed in the agricultural soils category.

6.3.4 Source-specific QA/QC and verification

CH_4 emissions from manure management was identified as a key source category for New Zealand in the 2001 inventory. In preparation of the 2002 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 no recalculations for this category in the 2002 inventory.

6.3.6 Source-specific planned improvements, if applicable

Research has been undertaken on improving the estimate of CH_4 emissions from manure (Saggar *et al*., 2003). Results from the research will be reviewed and incorporated in New Zealand's inventory for 2003.

6.4 Rice cultivation (CRF 4C)

6.4.1 Description

There is no rice cultivation in New Zealand.

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 12,617.71Gg CO_2 equivalent in 2002. Emissions are 27.6% over the level in 1990. The category comprises three sub-categories:

- direct emissions from animal production (inputs from grazing animals)
- 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 source category comprising 7255.24Gg CO_2 equivalent, indirect N_2O from nitrogen used in agriculture comprised 3258.01Gg CO_2 equivalent and direct N_2O emissions from agricultural soils comprised 2104.46Gg CO_2 equivalent.

Agricultural soils may also emit or remove CO_2 and CH_4 (IPCC, 1996). CO_2 emissions from organic, mineral and limed soils are included in the LUCF 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 are nitrogen fertiliser and the excreta deposited during animal grazing.

The worksheets for this chapter list the emission factors and other parameters used in the calculations. These are IPCC factors and parameters unless otherwise indicated. In particular, two New Zealand specific factors/parameters are used: $EF_{3(PR\&P)}$ 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 89% of dairy cattle and 100% of sheep, goats, deer and non-dairy cattle are allocated to it. Grazing animal excreta dominates the nitrogen input to pastoral soils. 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 under the manure management category of the inventory. The Nex values have been calculated using the model OVERSEER® based on 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.

Indirect N_2O from nitrogen used in agriculture

Nitrogen fertiliser use is determined by the Zealand Fertiliser Manufacturers' Research Association (FertResearch) from sales records for 1990 to 2003. 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 57,541 tonnes in 1990 to 289,716 tonnes reported in 2002. The N_2O that is emitted indirectly through synthetic fertilizer and animal waste being spread on agricultural soils is shown in the worksheets accompanying this sector. 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. Emission factors are applied to the amounts of nitrogen that volatilise from synthetic fertilizer and waste.

The N_2O emitted indirectly from nitrogen lost from agricultural soils through leaching and run-off is shown in Table 5 of the worksheets. 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, analysis using the OVERSEER® nutrient budgeting model calibrated against four large scale, multi-year animal grazing trials indicated that a value of 0.07 for $Frac_{LEACH}$ more closely followed actual field emissions (Thomas *et al*., 2002). A value of 0.07 for $Frac_{LEACH}$ was adopted and used for all years.

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.

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. No animals are reported for daily spread AWMS as advised by the IPCC guidelines.

The rates of nitrogen excretion per animal for dairy cattle, non-dairy cattle, sheep and deer are derived from the OVERSEER® model as described previously. The values used for goats and poultry are unchanged from previous submissions. An emissions factor (EF_3) of 0.01 is applied to the excretion value (Carran *et al*., 1995; Muller *et al*., 1995; de Klein *et al*., 2003; Kelliher *et al*., 2003).

Direct N_2O emissions from organic soils are calculated by multiplying the area of cultivated organic soils by the IPCC default emissions factor (Table 2 of worksheet 4.5). 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). The IPCC default emissions factor (EF_2 equal to 8) is used for all years of the time-series. Prior to the 2001 inventory, there was a revision of the area of cultivated soils as the previous estimate was based on a survey undertaken in 1970. The previous survey reflected the total amount of peat soil, not cultivation.

Nitrogen excretion from the pasture range and paddock AWMS is calculated in the worksheets accompanying this chapter.

6.5.3 Uncertainties and time-series consistency

Uncertainties in N_2O emissions from agricultural soils were assessed for the 1990 and 2002 inventory using a Monte Carlo simulation of 5000 scenarios with the @RISK software (Kelliher *et al.*, 2003). 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.

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 2002 inventory. The Monte Carlo analysis confirmed that uncertainty in parameter EF_3, the emissions factor for excreta N deposited during grazing, 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 6.5.1 Uncertainties in N_2O emissions from agricultural soils for 1990 and 2002 estimated using Monte Carlo simulation

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

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

Parameter	1990 % contribution to uncertainty	2001 % contribution to uncertainty
EF_3	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.

Field studies to establish a better quantification of EF3 have been performed as part of a collaborative research effort called NzOnet[1]. NzOnet researchers in the Waikato (Hamilton), Canterbury (Lincoln) and Otago (Invermay) have measured EF3 for pastoral soils of different drainage class (de Klein *et al.*, 2003). Kelliher *et al.* (2003) assessed all available EF3 data and its distribution with respect to pastoral soil drainage class to determine an appropriate national, annual mean value. The research and analysis indicate that if excreta is separated into urine and dung, EF3 for urine and dung could be set to 0.007 for urine and 0.003 for dung respectively. However, it is recognised that the dung EF3 data are limited. Combining urine and dung EF3 values, the dairy cattle total excreta EF3 is 0.006. In comparison, the current New Zealand specific value is 0.01 and the IPCC default value is 0.02. Although the current data suggest that a reduction may be appropriate, the on-going studies do not yet provide sufficient evidence to change EF3 from the New Zealand specific value of 0.01 (Kelliher *et al.*, 2003).

[1] The research conducted by NzOnet is funded by the MAF. NzOnet draws on the skills of researchers in Crown Research Institutes and universities, and includes researchers from the private sector. NzOnet is also supported by the NZCCO.

6.5.5 Source-specific recalculations

There were no changes to the methodology or recalculations for the 2002 inventory.

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 source category for New Zealand. Previous inventories have not reported emissions from savanna burning, however there is limited burning of tussock *(Chionochloa)* grassland in the South Island for pasture renewal and weed control. This tussock burning is included in the savanna category for the 2002 inventory. 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 2002, total emissions accounted for 1.00Gg of CO_2 equivalent – a 70.2% reduction from the 3.34Gg 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). The sources are identified in the worksheets accompanying this chapter.

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 2002. 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

The 2002 inventory is the first inventory to report emissions from savanna burning.

6.7 Field burning of agricultural residues (CRF 4F)

6.7.1 Description

Burning of agricultural residues produced 29.931Gg CO_2 equivalent in 2002. Emissions are currently 18.4% over the 1990 baseline. 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. Previous inventories have also included maize, but this is now excluded as 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.

The amount of crop residues produced varies by country, crop and management system. 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.

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 (IPCC, 2000). Good practice suggests that an estimate of 10% of residue burnt may be appropriate for developed countries, however New Zealand estimates that 50% is burnt. This figure is developed from expert opinion of MAF officials working with the arable production sector.

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 were no recalculations for this category.

Worksheets accompanying the agriculture sector

Module 2002 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	5,091	77.4	393.90	0.889	4.526	398.43
Non-dairy cattle	4,565	56.2	256.80	0.909	4.150	260.95
Sheep	40,284	10.8	434.30	0.178	7.171	441.47
Goats	155	9.0	1.40	0.119	0.018	1.42
Deer	1,630	21.4	34.80	0.369	0.601	35.40
Horses	75	18.0	1.35	2.080	0.156	1.50
Swine	351	1.5	0.53	20.000	7.019	7.55
Poultry	20,971			0.117	2.454	2.45
Total			1,123.08		26.096	1,149.17

1. Horses and swine use IPCC default emission factors. Other emission factors are implied.
2. Horses, swine and poultry use IPCC default emission factors. Others from Joblin and Waghorn (1994)

Module 2002 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	66,875,237	0.001	0.105
Liquid Systems			no
Daily spread			ie
Solid storage and drylot	954,629	0.02	0.030
Pasture range and paddock			ie
Other	13,777,289	0.005	0.108
Total			0.243

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

Module **2002 Agriculture (New Zealand)**
Submodule **Prescribed burning of savanna**
Worksheet **4.3 (1 of 3)**
Sheet **Timeseries of biomass burned in savanna**

Year	Total consented area (ha)	3 yr ave of area (ha)	consented area burnt in a year	above ground biomass density1 (t/ha)	fraction burned[1]	biomass burned (t)
1989	26736					
1990	29758	31,252	6,250	28.0	0.32	55916
1991	37261	31,097	6,219	28.0	0.32	55639
1992	26271	29,905	5,981	28.0	0.32	53507
1993	26183	23,410	4,682	28.0	0.32	41885
1994	17775	17,690	3,538	28.0	0.32	31650
1995	9111	13,579	2,716	28.0	0.32	24296
1996	13851	11,937	2,387	28.0	0.32	21359
1997	12850	11,275	2,255	28.0	0.32	20173
1998	7124	8,312	1,662	28.0	0.32	14873
1999	4963	8,001	1,600	28.0	0.32	14316
2000	11916	8,317	1,663	28.0	0.32	14882
2001	8073	9,710	1,942	28.0	0.32	17374
2002	9142	8,535	1,707	28.0	0.32	15272
2003	8391					

Module **2002 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)
2002	15272	0.36	0.64	0.8	1	0.45	0.4	1982	3906	5888

Module **2002 Agriculture (New Zealand)**
Submodule **Prescribed burning of savanna**
Worksheet **4.3 (3 of 3)**
Sheet **Non-CO2 released from savanna burning**

Year	CH_4 emission ratio[2]	CO emission ratio[2]	N_2O emission ratio[2]	NO_x emission ratio[2]	N/C ratio[2]	CH_4 emissions (Gg)	CO emissions (Gg)	N_2O emissions (Gg)	NO_x emissions (Gg)	Total CH_4 and N_2O in CO_2 equivalent (Gg)
2002	0.004	0.06	0.007	0.121	0.006	0.031	0.82	0.00039	0.01	0.78

[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 2002 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	729.8		911.6		760.1			342.0		160.775		2.179
a Barley	371.7	1.2	446.1	0.83	370.3	0.5	0.9	166.6	0.4567	76.093	0.015	1.141
b Wheat	328.7	1.3	427.3	0.83	354.6	0.5	0.9	159.6	0.4853	77.446	0.012	0.929
c Oats	29.4	1.3	38.3	0.92	35.2	0.5	0.9	15.8	0.4567	7.236	0.015	0.109

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

Module 2002 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	0.804	1.333	1.072
CO	0.060	9.646	2.333	22.508
N_2O	0.007	0.015	1.571	0.024
NO_x	0.121	0.264	3.286	0.866

Module 2002 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	0.507	10.653	0.013	0.454
b Wheat	0.516	10.842	0.010	0.369
d Oats	0.048	1.013	0.001	0.043

Module 2002 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)
Synthetic fertiliser (F_{SN})	260,744,400	0.0125	3.259
Animal Waste (F_{AW})[1]	65,285,724	0.0125	0.816
N-Fixing crops (F_{BN})	4,509,600	0.0125	0.056
Crop residue (F_{CR})	8,619,601	0.0125	0.108
Total			4.239

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

Module 2002 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)	Total direct soil emissions of N_2O (Gg)
	10,109	8	0.081	6.789

1 MAF estimate 2003

Module 2002 Agriculture (New Zealand)
Submodule Agricultural soils
Worksheet 4.5 (3 of 5)
Sheet Direct nitrous oxide emissions from animal production (grazing animals)

Animal waste management syste (AWMS)	N excretion for AWMS (Nex_{AWMS}) (kg N)	Emission factor for AWMS (EF_3)[1] (kg N_2O-N/kg N)	Total direct animal prodn. emissions of N_2O (Gg)
Pasture range and	1,489,339,867	0.01	23.404

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

Module 2002 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)
	289,716,000	0.1	28,971,600	1,570,947,022	0.2	314,189,404	0.01	3.432

Module 2002 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)	Total indirect N_2O emissions from N used in agric. (Gg N_2O)	Total nitrous oxide emissions from agricultural soils (Gg N_2O)
	289,716,000	1,570,947,022	0.07	0.025	3.256	10.509	40.702

2002 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
$Frac_{FUEL}$	0	... livestock nitrogen excretion in excrements burned for fuel	
$Frac_{GASF}$	0.1	... total synthetic fertiliser emitted as NO_x or NH_3	
$Frac_{GASM}$	0.2	... total nitrogen excretion emitted as NO_x or NH_3	
$Frac_{GRAZ}$		... livestock nitrogen excreted and deposited onto soil during grazing	
$Frac_{LEACH}$	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	
$Frac_{NCR0}$	0.015	... nitrogen in non-N-fixing crops	
$Frac_{R}$	0.45	... crop residue removed from the field as crop	

2002 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	
EF_2	8	... direct emissions from organic soil mineralisation due to cultivation	IPCC GPG
EF_3 (AL)	0.001	... direct emissions from waste in the *anaerobic lagoons* AWMS	
EF_3 (SS&D)	0.02	... direct emissions from waste in the *solid waste and drylot* AWMS	
EF_3 (PR&P)	0.01	... direct emissions from waste in the *pasture range and paddock* AWMS	Based on Carran et al (1995) and Sherlock et al (1995)
EF_3 (OTHER)	0.005	... direct emissions from waste in other AWMSs	
EF_4	0.01	... indirect emissions from volatising nitrogen	
EF_5	0.025	... indirect emissions from leaching nitrogen	

Module 2002 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	4,565			no
Dairy cattle	5,091	113.9	11%	63,786,730
Poultry	20,971			no
Sheep	40,284			no
Swine	351	16.0	55%	3,088,507
Goats	155			no
Deer	1,630			no
Total (Nex_{AL})				66,875,237

1 Value for dairy cattle from Ledgard, AgResearch (2003)
2 Value for dairy cattle from Haynes and Williams (1993).

Module 2002 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	4,565	71.9	100%	328,256,254
Dairy cattle	5,091	113.9	89%	516,092,635
Poultry	20,971	0.6	3%	377,473
Sheep	40,284	14.8	100%	596,205,173
Swine	351			no
Goats	155	9.5	100%	1,471,339
Deer	1,630	28.8	100%	46,936,992
Total ($Nex_{PR\&P}$)				1,489,339,867

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 based on Haynes and Williams (1993).
3 Values for goats and deer from the Ministry of Agriculture and Forestry.

Module 2002 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	4,565			no
Dairy cattle	5,091			no
Poultry	20,971			no
Sheep	40,284			no
Swine	351	16.0	17%	954,629
Goats	155			no
Deer	1,630			no
Total ($Nex_{SS\&D}$)				954,629

Module 2002 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	4,565			no
Dairy cattle	5,091			no
Poultry	20,971	0.6	97%	12,204,958
Sheep	40,284			no
Swine	351	16.0	28%	1,572,331
Goats	155			no
Deer	1,630			no
Total (Nex_{OTHER})				13,777,289

2002 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}
81,607,155	0		0.2	65,285,724

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

2002 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}
75,160,000	0.03	4,509,600

2002 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}
289,716,000	0.9	260,744,400

2002 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}
894,480,099	0.015	75,160,000	0.03	0.55	0.50	8,619,601

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) (1000s)	Deer numbers (3 yr av) (1000s)	Swine numbers[1] (jun yr) (1000s)	Swine numbers (3 yr av) (1000s)
1989	3,302,377		4,526,056		60,568,653		1,222		835		411	
1990	3,440,815	3,390,873	4,593,160	4,596,595	57,852,192	57,860,829	1,063	1,026	1,043	1,036	395	404
1991	3,429,427	3,446,022	4,670,569	4,646,742	55,161,643	55,194,076	793	796	1,230	1,204	407	404
1992	3,467,824	3,482,464	4,676,497	4,701,676	52,568,393	52,676,132	533	559	1,340	1,270	411	405
1993	3,550,140	3,619,055	4,757,962	4,827,436	50,298,361	50,777,603	353	390	1,240	1,287	395	410
1994	3,839,200	3,826,380	5,047,848	4,996,103	49,466,054	49,526,895	284	324	1,280	1,246	423	416
1995	4,089,800	4,031,367	5,182,500	5,027,516	48,816,271	48,558,744	337	283	1,219	1,244	431	426
1996	4,165,100	4,170,300	4,852,200	4,946,933	47,393,907	47,681,393	228	264	1,232	1,264	424	424
1997	4,256,000	4,255,033	4,806,100	4,696,767	46,834,000	46,727,969	228	228	1,342	1,325	417	418
1998	4,344,000	4,305,467	4,432,000	4,627,267	45,956,000	46,156,667	228	214	1,400	1,388	412	399
1999	4,316,400	4,419,511	4,643,700	4,556,578	45,680,000	45,090,400	186	197	1,423	1,440	369	383
2000	4,598,133	4,598,133	4,594,033	4,594,033	43,635,200	43,635,200	176	176	1,496	1,491	369	364
2001	4,879,867	4,879,867	4,544,367	4,544,367	41,590,400	41,590,400	165	165	1,553	1,564	354	355
2002	5,161,600	5,091,489	4,494,700	4,565,456	39,545,600	40,284,133	155	155	1,644	1,630	341	351
2003	5,233,000		4,657,300		39,716,400		145		1,693		358	

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	20,971	75.9	74.9
2003	3,216	17,286	20,502		74.5	

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 (provisional) data from Statistics New Zealand. 1989, 1990, 1992, 1995 and 1996 from MAF survey data.

3. 1994, 1995, 1996 and 2002 (provisional) data from Statistics New Zealand. 1990, 1992 and 1993 from MAF survey data. Other estimates provided by MAF February 2003.

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

Agricultural sector calculations: emissions from field burning and agricultural soils

	Barley prodn (jun yr) (tonnes)	Barley prodn (3 yr av) (Gg)	Wheat prodn (jun yr) (tonnes)	Wheat prodn (3 yr av) (Gg)	Maize prodn (jun yr) (tonnes)	Maize prodn (3 yr av) (Gg)	Oats prodn (jun yr) (tonnes)	Oats prodn (3 yr av) (Gg)	Non-N-fixing crops (3 yr av) (kg)
1989	326,850		134,994		138,694		65,892		
1990	434,856	381.2	188,042	167.9	161,651	161.2	78,877	67.3	777,721,333
1991	382,043	378.6	180,690	186.6	183,388	169.6	57,187	64.6	799,342,333
1992	318,787	363.5	191,039	197.0	163,842	160.1	57,625	57.2	777,800,000
1993	389,523	367.9	219,414	217.5	133,069	146.6	56,793	57.4	789,326,000
1994	395,500	362.6	241,900	235.5	142,768	145.5	57,718	51.1	794,739,000
1995	302,800	355.2	245,200	254.7	160,797	171.1	38,735	45.9	826,848,333
1996	367,200	360.3	277,000	279.9	209,710	188.1	41,217	43.0	871,302,897
1997	411,000	372.7	317,379	298.8	193,806	193.2	49,065	44.2	908,949,449
1998	340,000	351.7	302,100	313.2	176,148	189.0	42,223	44.3	898,141,049
1999	304,000	315.3	320,000	316.0	197,000	184.7	41,702	39.8	855,857,115
2000	302,000	300.7	326,000	336.7	181,000	185.0	35,398	33.2	855,499,896
2001	296,000	346.3	364,000	330.5	177,000	168.7	22,400	30.9	876,447,963
2002	440,883	371.7	301,498	328.7	148,178	164.6	34,987	29.4	894,480,099
2003	378,340		320,500		168,726		30,928		

Source: Statistics New Zealand.

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

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[3] (jun yr) (tonnes)	Lentils prodn (3 yr av) (Gg)	N-fixing crops (3 yr av) (kg)
1989	24,000	47,308	71,308		3,386		
1990	24,000	57,378	81,378	80.6	3,386	3.4	83,969,333
1991	24,000	65,064	89,064	89.9	3,386	4.0	93,902,667
1992	24,000	75,290	99,290	91.9	5,204	4.5	96,410,000
1993	24,000	63,268	87,268	90.2	5,018	4.3	94,463,333
1994	24,000	59,898	83,898	83.9	2,712	2.9	86,755,667
1995	24,000	56,448	80,448	79.6	923	1.5	81,080,333
1996	24,000	50,337	74,337	76.5	923	0.9	77,397,000
1997	24,300	50,337	74,637	82.1	923	0.9	83,053,333
1998	31,200	66,200	97,400	86.1	940	0.6	86,766,667
1999	34,200	52,200	86,400	94.6	0	0.3	94,913,333
2000	36,000	64,000	100,000	86.7	0	0.0	86,700,000
2001	36,000	37,700	73,700	79.7	0	1.1	80,819,667
2002	36,000	29,457	65,457	73.0	3,302	2.2	75,160,000
2003	36,000	43,719	79,719		3,302		

1 MAF estimate

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

3 Ministry of Agriculture and Forestry. Zero has been entered when production negligible.

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	238,748,000
2002	10,109	10,109	279,148,000	289,716,000
2003	10,109		342,000,000	

1 MAF estimate 2003

2 Best estimate from MAF and sales records obtained by FertResearch

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	2,800	4.79	3.66
1991	448	2,857	4.83	3.67
1992	449	3,013	4.81	3.68
1993	450	3,029	4.79	3.66
1994	452	3,073	4.78	3.64
1995	450	3,125	4.76	3.63
1996	451	3,228	4.72	3.59
1997	448	3,239	4.65	3.54
1998	451	3,314	4.62	3.51
1999	453	3,405	4.63	3.54
2000	455	3,564	4.69	3.59
2001	458	3,669	4.84	3.66
2002	457	3610	4.85	3.67

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	376	413	553	568
1991	379	417	562	577
1992	387	422	567	583
1993	401	427	575	593
1994	405	432	581	597
1995	410	436	586	601
1996	415	438	593	601
1997	425	439	600	601
1998	423	438	603	600
1999	420	438	599	603
2000	423	437	599	607
2001	432	441	603	614
2002	433	446	604	615

Livestock productivity data for New Zealand 2004
Agricultural sector calculations: CH_4 emissions from domestic live
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	47.33	30.42
1991	47.95	31.31
1992	48.02	32.22
1993	48.89	33.10
1994	49.23	33.33
1995	49.99	33.50
1996	50.34	33.88
1997	51.45	34.53
1998	52.40	34.87
1999	53.40	35.51
2000	54.53	36.35
2001	55.06	37.13
2002	55.16	37.28

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	102.3	153.2	95.6	79.0
1991	104.7	157.4	98.3	80.8
1992	104.3	162.1	101.2	80.5
1993	104.9	165.7	103.4	81.0
1994	104.1	166.0	103.6	80.4
1995	106.2	166.3	103.8	82.0
1996	107.1	170.0	106.1	82.7
1997	110.7	176.6	110.3	85.5
1998	113.0	181.0	113.0	87.2
1999	116.0	176.0	109.8	89.6
2000	117.1	170.6	106.5	90.4
2001	118.1	168.1	104.7	92.0
2002	118.5	169.2	106.6	91.0

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	12.0	65.3	105.0	27.3
1991	12.2	66.0	105.7	26.9
1992	12.4	67.4	107.7	25.9
1993	12.7	69.3	108.1	26.6
1994	12.9	68.7	108.3	26.7
1995	13.1	68.5	108.0	27.1
1996	13.3	67.7	108.9	27.6
1997	13.6	70.0	108.5	27.5
1998	13.9	70.0	109.8	28.7
1999	13.9	71.1	111.2	28.8
2000	14.4	70.7	113.4	28.9
2001	14.6	71.5	118.4	28.9
2002	14.8	71.9	113.9	28.8

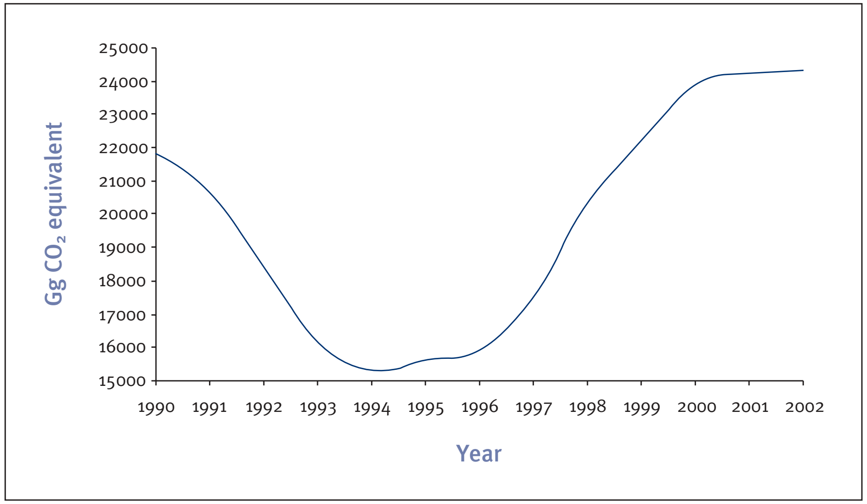
Chapter 7:

Land-Use Change and Forestry (LUCF)

7.1 Sector overview

The land-use change and forestry (LUCF) sector represented the removal of approximately 32.1% of all New Zealand's greenhouse gas emissions in 2002. Net removals in 2002 totalled 24,076.44Gg CO_2 equivalent and were 11.1% above net removals in 1990 (Figure 7.1.1).

Figure 7.1.1 LUCF sector net removals from 1990 to 2002



Emissions and removals are calculated from human activities which change the way the land is used e.g. afforestation, deforestation or changes in the amount of biomass in existing carbon pools. There are four categories:

1. Changes in forest and other woody biomass stocks.
2. Forest and grassland conversion.
3. Abandonment of managed lands.
4. CO_2 emissions and removals from soil.

A current lack of data on land-use change other than the planting of forests on grassland and changes in soil carbon limits reporting in this sector.

The worksheets accompanying this chapter are presented in a format consistent with the IPCC Guidelines (1996) but have been customised from the IPCC worksheets to match New Zealand's national methodology for estimating CO_2 emissions and removal by planted forests. Therefore, Tables 5(a)-(d) of the CRF have not been completed.

CO_2 emissions from land conversion have not been included in the removal from forests category in the reporting tables. The LUCF sector therefore shows data in both the CO_2 emissions and the CO_2 removals columns. This is to make the calculation more transparent. For completion of Table 5 and the summary tables of the CRF, the net CO_2 emissions/removals figure has been reported.

Research has been conducted on the carbon pools and possible fluxes in New Zealand's soils, shrublands and indigenous forests. The focus of the research was to make it possible to fill the gaps in the current LUCF inventory, including land-use changes other than new forest planting, the abandonment of managed lands, and changes in soil carbon. Details of the research are included in Annex 3B.

7.1.1 A history of LUCF 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 being covered by indigenous 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 3,400,000Gg 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 clearances 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 of Crown-owned indigenous forests. Commercial timber harvest from private permanent 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 permanent 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 2002 than has been emitted through forest harvesting of both the combined planted and permanent forests. The average new planting rate (land reforested or afforested) over the last 30 years has been 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 2002, 22,100 hectares of new forest was established. Between 1990 and 2002 it is estimated that 640,000 hectares of new forest has been established as a result of afforestation and reforestation activities.

7.2 Changes in forest and other woody biomass stocks (CRF 5A)

7.2.1 Description

This category accounts for all significant human interactions with forests and other woody biomass stocks which affect the CO_2 fluxes to and from the atmosphere but that do not result in land-use change. Changes in forest and other woody biomass accounted for net CO_2 removals of 26,057.00Gg CO_2 in the 2002 inventory. New Zealand calculates emissions and the removals of CO_2 from the growth of planted forests, emissions from harvesting planted forests and emissions from harvesting of indigenous forests.

7.2.2 Methodological issues

CO_2 removal has only been estimated for planted forests. Planted forests are the predominant anthropogenic sink (refer worksheet 5.12 equivalent). Surveys and forest models are used to estimate CO_2 removals and emissions. The CO_2 removals and emission estimates include both the above and below-ground biomass components (including the forest floor). Two forest models are used by Forest Research (a New Zealand Crown Research Institute) to estimate carbon removals by planted forests:

1. C_Change (Beets *et al*., 1999; previously known as the CARBON/DRYMAT model).
2. Forestry Oriented Linear Programming Interpretor (FOLPI: Garcia, 1984; Manley *et al*., 1991).

The forest models account for emissions generated from both the removal of stem wood carbon through harvesting and the emissions of non-stem wood carbon left on-site over an extended (decay) period following harvesting. The release of carbon through the small amount of harvesting of permanent forests is also accounted for. This methodology provides more accurate results than are achieved using the default 1996 IPCC methodology. The assumption is that the stem wood removed at harvest for both permanent and planted forests is oxidised in the year of harvest.

The following calculations were made to estimate emissions and the removal of CO_2 in the changes in forest and other woody biomass category:

- Removal of CO_2 by planted forests and emissions from planted forests through harvesting.
- Emissions from permanent forests from unsustainable harvesting.

Estimates are calculated for March years and are reported as three year averages as per the IPCC approach.

Removal of CO_2 by planted forests and emissions from planted forests through harvesting

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 is:

- A survey of forest growers is undertaken annually to estimate the area of forest by age, species and silvicultural regime.
- Based on the results of this survey and stem wood yield information the C_Change model is used to estimate forest biomass and carbon at one point in time.
- The forest estate planning model FOLPI 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 2002 were used to calculate removals and emissions provided in the 2002 inventory. This latest information brings in new forest area data along with data on new planting, restocking and harvesting in 2002 (NEFD, 2003).

The NEFD survey provides estimates of the forest area and merchantable stem wood volume (via yield tables) by crop-type and age class. 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 2002 is based on (a) the latest area estimates provided by the 2002 NEFD, (b) an estimate of the area to be planted during the year, (c) an estimate of the area harvested during the year which is derived from the estimate of clear fell volume production. The total estate area for the years before 2002 has been estimated through back-calculations using this latest NEFD area data combined with historic new planting and harvesting information. The area of new land planting is based on MAF statistics. These estimates are revised annually (including for the previous years, 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 (still broken down by age class) and associated area-weighted national yield table.

Modelling

The C_Change model estimates carbon stock per hectare, by component and age-class, from stem wood volume data. 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 historic data exists. The steps in the C_Change model are shown in box 7.1.

Box 7.1 Process steps in the C_Change model (Beets *et al*., 1999)

1. Stem wood volume is converted to an oven-dry biomass weight.
2. The dry weight of non-stem wood components (bark, branches, foliage, cones, stumps, roots, floor litter and understorey) is calculated from stem wood volume using allometric equations. These allometric equations take account of age, stocking and site fertility.
3. Total forest biomass is converted to carbon weight. Carbon is taken as being 50% of biomass.

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 Douglas fir (*Pseudotsuga menziesii* – 5%) and other species.

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 LUCF inventory results for 1990 to 2002. 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 permanent forests from unsustainable harvesting

Estimates of any unsustainable harvesting of permanent 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.

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 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 CARBON/ DRYMAT model runs indicate that the precision of the carbon sequestration estimates could be of the order of ±25%.

No uncertainty estimates are currently available for emissions from unsustainable harvesting of permanent forests.

7.2.4 Source-specific QA/QC and verification

There was no source-specific QA/QC performed for this category in the 2002 inventory.

7.2.5 Source-specific recalculations

New proportions of area by NEFD regime have been used to weight the carbon yield in the 2002 inventory. Area data and carbon yields underlying the models in recent reports are similar to those used previously. The difference in net managed forest CO_2 removals between this and the previous inventory are generally of the order of less than 2%.

7.2.6 Source-specific planned improvements

Further work will be undertaken to investigate whether alternative inventory and modelling approaches could be used for inventory estimates to avoid recalculation of historic estimates as a result either of changes in future intentions or as a product of the forwards and backwards forecasting required by the current model.

In addition a New Zealand Carbon Accounting System to monitor and account for all LUCF under Article 3.3 of the Kyoto Protocol is now being developed.

7.3 Forest and grassland conversion (CRF 5B)

7.3.1 Description

This category includes emissions from the conversion of existing forests and natural grasslands to other land uses such as scrubland to forest or forests to agriculture. New Zealand's emissions for forest and grassland conversion are based on shrubland being cleared in preparation for planted forests and emissions from scrubland and forest wildfires. Net emissions in the 2002 inventory are 1,200.11Gg CO_2 equivalent.

7.3.2 Methodological issues

The calculations for forest and grassland conversion are shown in worksheets NZ 5a-d.

Land clearance for new forest planting

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 scrubland. Data are available from 1993 to the present and we assume this proportion to have been around 20% prior to that time. It is assumed, for calculation purposes, that 25% of the scrub biomass is burnt on-site and that the remainder is left to decay.

The quantity of on-site biomass for both scrub and forest, used in the land conversion calculations (worksheets 5a-d), is now based on the (provisional) results of research into permanent forest and scrub (adapted from Hall *et al.,* 1998). The values reported (136 t dm/ha for scrub and 364 t dm/ha for forest) are based on a national area weighted average for biomass per hectare for a range of the principal forest and scrub vegetation classes.

Wildfire burning

Emissions from wildfire are based on fire reports collected by the National Rural Fire Authority. These reports show the areas of forest and scrub burnt. It is assumed that all forest burning occurs in natural forests. Only non-CO_2 emissions are reported here (consistent with the IPCC default method). For planted forests, fires occur relatively infrequently and fire-damaged standing trees are usually salvaged and thus appear in harvest statistics. Some areas in the Fire Authority statistics involve land clearing, however the Fire Authority does not specify whether this is for agricultural or forestry purposes. This may imply some double-counting between these figures and those allowed for in the land clearing for new forest planting calculations.

The non-CO_2 emissions estimated for burning of both forest and scrub biomass are likely to be over-estimated as not all biomass is typically consumed in a fire event. For forests, the typical fuel load combusted may only be 10-40% of on-site biomass. For scrub, 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.

7.3.3 Uncertainties and time-series consistency

No uncertainty estimates are currently available for emissions from forest and grassland conversion.

7.3.4 Source-specific QA/QC and verification

There was no source-specific QA/QC performed for this category in the 2002 inventory.

7.3.5 Source-specific recalculations

The estimate of new land planted is revised annually with actual areas updating provisional data in the previous inventory. A data entry error for 1992 was detected and corrected by NZCCO officials.

7.3.6 Source-specific planned improvements

New Zealand's development of a permanent forest, shrubland and soils Carbon Monitoring System will make it possible to fill the major gaps in the current LUCF inventory, including land-use changes other than new forest planting. The research includes a network of 40 paired soil plot sites established to monitor key changes in soil carbon when land use changes (i.e. scrub to grassland and pasture to plantation forest and vice versa). The first three paired plots were established in 2003. Details of the research are included in Annex 3B.

7.4 Abandonment of managed lands (CRF 5C)

7.4.1 Description

This category reports carbon accumulation where managed lands e.g. croplands and pastures are abandoned and left unmanaged. Only the carbon accumulation in biomass is considered with soil carbon considered in section 7.5.

New Zealand does not currently report emissions or sinks from abandonment of managed lands due to a lack of data. However, some pasture does revert to scrub in marginal farming areas. Research in the Carbon Monitoring System will provide data on the abandonment of managed lands. Details of the research are included in Annex 3B.

7.5 CO_2 emissions and removals from soil (CRF 5D)

7.5.1 Description

This category focuses on estimating net fluxes of CO_2 due to changes in soil organic carbon stocks. Release of CO_2 from the application of lime to agricultural soils is included.

The change in organic carbon content is a balance between inputs to the soil of carbon fixed by photosynthesis and losses via decomposition. The inputs and losses are determined by the interaction of climate, soil and land use and management. Changes in soil carbon in New Zealand are not reported because New Zealand currently lacks the data to provide a comprehensive analysis of sources and sinks.

Estimates of CO_2 emissions from the liming of agricultural soils were included in the 2002 inventory. The emissions relate to CO_2 being released when the carbonate containing compounds (limestone and dolomite) are added to acid soils. New Zealand's emissions in 2002 are 780.45Gg CO_2. This represents an increase of 116.6% over the level of emissions in 1990.

7.5.2 Methodological issues

The calculation for CO_2 emissions from the liming of agricultural soils are 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.

7.5.3 Uncertainties and time-series consistency

No uncertainty estimates are currently available for emissions from forest and grassland conversion.

7.5.4 Source-specific QA/QC and verification

There was no source-specific QA/QC performed for this category in the 2002 inventory.

7.5.5 Source-specific recalculations

There were no recalculations for this category.

7.5.6 Source-specific planned improvements

Research is underway to address the data shortage for reporting changes in soil carbon (refer Annex 3B).

Worksheets accompanying the land-use change and forestry sector

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

	Stem volume in plantation forest harvest1 (merch. m3)	Biomass conversion ratio2 (t dm/m3)	Dry matter in stem1 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/m3)	Biomass expansion ratio (t dm/m3)	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	5,374,273	2,687,136	365,000	0.50	2.04	372,300	186,150	2,873,286
1991	11,797,488	0.483	5,694,563	2,847,282	307,667	0.50	2.04	313,820	156,910	3,004,192
1992	12,500,583	0.482	6,027,994	3,013,997	257,333	0.50	2.04	262,480	131,240	3,145,237
1993	13,232,522	0.482	6,371,784	3,185,892	205,000	0.50	2.04	209,100	104,550	3,290,442
1994	13,987,203	0.479	6,696,855	3,348,428	158,000	0.50	2.04	161,160	80,580	3,429,008
1995	14,700,793	0.471	6,930,821	3,465,411	107,333	0.50	2.04	109,480	54,740	3,520,151
1996	15,214,390	0.455	6,925,231	3,462,616	50,000	0.50	2.04	51,000	25,500	3,488,116
1997	15,202,118	0.472	7,173,174	3,586,587	56,667	0.50	2.04	57,800	28,900	3,615,487
1998	15,746,397	0.482	7,595,071	3,797,535	57,667	0.50	2.04	58,820	29,410	3,826,945
1999	16,672,535	0.498	8,303,782	4,151,891	57,000	0.50	2.04	58,140	29,070	4,180,961
2000	18,228,284	0.496	9,040,938	4,520,469	38,333	0.50	2.04	39,100	19,550	4,540,019
2001	19,846,473	0.480	9,531,886	4,765,943	23,000	0.50	2.04	23,460	11,730	4,777,673
2002	20,866,322	0.479	9,994,013	4,997,007	16,333	0.50	2.04	16,660	8,330	5,005,337
2003	21,837,288	0.480	10,491,202	5,245,601	10,333	0.50	2.04	10,540	5,270	5,250,871

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

	Total forest estate area (net of harvest) (ha)	Total Forest estate carbon (net of harvest) (t C)	Forest estate carbon uptake (net of harvest) (t C)	Carbon in plantation forest harvest (t C)	Total forest carbon uptake (before harvest) (t C)
1990	1,234,461	117,915,474	6,457,333	2,687,136	9,144,470
1991	1,263,318	124,096,215	6,180,741	2,847,282	9,028,023
1992	1,304,059	129,808,242	5,712,027	3,013,997	8,726,024
1993	1,367,048	135,054,406	5,246,164	3,185,892	8,432,056
1994	1,442,686	140,114,339	5,059,933	3,348,428	8,408,360
1995	1,525,718	145,082,200	4,967,861	3,465,411	8,433,271
1996	1,602,483	150,147,262	5,065,062	3,462,616	8,527,678
1997	1,672,173	155,618,247	5,470,985	3,586,587	9,057,572
1998	1,729,052	161,625,122	6,006,876	3,797,535	9,804,411
1999	1,774,927	168,211,582	6,586,460	4,151,891	10,738,351
2000	1,812,242	175,256,659	7,045,077	4,520,469	11,565,546
2001	1,843,444	182,447,985	7,191,326	4,765,943	11,957,269
2002	1,869,192	189,562,737	7,114,751	4,997,007	12,111,758
2003	1,884,576	196,355,513	6,792,776	5,245,601	12,038,377

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

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

	Total forest carbon uptake (before harvest) (Gg C)	Carbon release from total forest harvest (Gg C)	Net carbon uptake in forests (Gg C)	Net CO2 uptake in forests (Gg CO2)
1990	9,144	2,873	6,271	22,994
1991	9,028	3,004	6,024	22,087
1992	8,726	3,145	5,581	20,463
1993	8,432	3,290	5,142	18,853
1994	8,408	3,429	4,979	18,258
1995	8,433	3,520	4,913	18,015
1996	8,528	3,488	5,040	18,478
1997	9,058	3,615	5,442	19,954
1998	9,804	3,827	5,977	21,917
1999	10,738	4,181	6,557	24,044
2000	11,566	4,540	7,026	25,760
2001	11,957	4,778	7,180	26,325
2002	12,112	5,005	7,106	26,057
2003	12,038	5,251	6,788	24,888

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

Module **Land-use change and forestry (New Zealand)**
Submodule **Forest and Grassland conversion**
Worksheet **NZ 5a**
Sheet **Carbon release from scrubland cleared for new forest planting**

	Scrub land cleared for forest planting1 (ha)	Clearance where scrub is burned2 (25% of total) (ha)	Quantity of biomass burned (t dm/ha = 136) (t dm)	Oxidised biomass (90% of total) (t dm)	C release from burning scrub (t C/t dm = 0.5) (t C)	**CO2 release from burning for new planting (t CO2)**	Clearance where scrub decays[2] (75% of total) (ha)	Initial quantity of biomass to decay[3] (t dm/ha =136) (t dm)	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	4,547	1,137	154,587	139,128	69,564	255,068	3,410	463,760	231,880	850,227
2003	3,873	968	131,693	118,524	59,262	217,294	2,905	395,080	197,540	724,313

All data are three year straight averages

[1] Ministry of Agriculture and Forestry. [2] Percentage assumed for calculation purposes. [3] Biomass on the land cleared is assumed to decay instantaneously.

Module **Land-use change and forestry (New Zealand)**
Submodule **Forest and Grassland conversion**
Worksheet **NZ 5b**
Sheet **Carbon release from wildfires**

	Area of scrub burned in wildfires1 (ha)	Quantity of biomass burned (t dm/ha = 136) (t dm)	Oxidised biomass (90% of total) (t dm)	C release from scrub wildfires (t C\t dm = 0.5) (t C)	Area of Forest burned in wildfires1 (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	2564	348738	313864	156932	323	117663	105897	52948
1991	2064	280659	252593	126296	207	75318	67786	33893
1992	1954	265744	239170	119585	165	60151	54136	27068
1993	2330	316812	285131	142565	239	86814	78133	39066
1994	2529	343978	309580	154790	314	114266	102839	51420
1995	2645	359765	323789	161894	472	171929	154736	77368
1996	2532	344318	309886	154943	727	264598	238138	119069
1997	3320	451565	406409	203204	762	277520	249768	124884
1998	3268	444391	399952	199976	692	251949	226754	113377
1999	3049	414709	373238	186619	403	146571	131914	65957
2000	2119	288184	259366	129683	334	121576	109418	54709
2001	1954	265789	239210	119605	282	102648	92383	46192
2002	2165	294395	264955	132478	332	120848	108763	54382
2003	2235	304005	273605	136802	386	140383	126344	63172

Module Land-use change and forestry (New Zealand)
Submodule Forest and Grassland conversion
Worksheet NZ 5c (adaptation of 5.3)
Sheet Non-CO2 emissions from the on-site burning of scrub

	Carbon release by on-site burning (t C)	Nitrogen released (t N/t c = 0.01) (t C)	Carbon in CH4 emissions (ratio = 0.012) (t C)	Nitrogen in N2O emissions (ratio = 0.007) (t N)	Nitrogen in NOx emissions (ratio = 0.121) (t N)	Carbon in CO emissions (ratio = 0.06) (t C)	CH4 emissions from burning (ratio = 1.333) Gg CH	N2O emissions from burning (ratio = 1.571) (Gg N2O)	NOx emissions from burning (ratio = 3.286) (Gg CO)	CO emissions from burning (ratio = 2.333) (Gg CO)
1990	211,688	2,117	2,540	15	256	12,701	3.386	0.023	0.842	29.632
1991	209,324	2,093	2,512	15	253	12,559	3.348	0.023	0.832	29.301
1992	249,329	2,493	2,992	17	302	14,960	3.988	0.027	0.991	34.901
1993	313,925	3,139	3,767	22	380	18,836	5.022	0.035	1.248	43.943
1994	345,489	3,455	4,146	24	418	20,729	5.526	0.038	1.374	48.362
1995	305,342	3,053	3,664	21	369	18,321	4.884	0.034	1.214	42.742
1996	312,880	3,129	3,755	22	379	18,773	5.005	0.034	1.244	43.797
1997	344,933	3,449	4,139	24	417	20,696	5.518	0.038	1.371	48.284
1998	271,305	2,713	3,256	19	328	16,278	4.340	0.030	1.079	37.977
1999	276,083	2,761	3,313	19	334	16,565	4.416	0.030	1.098	38.646
2000	220,024	2,200	2,640	15	266	13,201	3.520	0.024	0.875	30.799
2001	221,539	2,215	2,658	16	268	13,292	3.544	0.024	0.881	31.011
2002	202,042	2,020	2,424	14	244	12,122	3.232	0.022	0.803	28.282
2003	196,064	1,961	2,353	14	237	11,764	3.136	0.022	0.780	27.445

Module Land-use change and forestry (New Zealand)
Submodule Forest and Grassland conversion
Worksheet NZ 5d (adaptation of 5.3)
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 CH4 emissions (ratio = 0.012) (t C)	Nitrogen in N2O emissions (ratio = 0.007) (t N)	Nitrogen in NOx emissions (ratio = 0.121) (t N)	Carbon in CO emissions (ratio = 0.06) (t C)	CH4 emissions from burning (ratio = 1.333) Gg CH	N2O emissions from burning (ratio = 1.571) (Gg N2O)	NOx emissions from burning (ratio = 3.286) (Gg CO)	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	54,382	544	653	4	66	3,263	0.870	0.006	0.216	7.612
2003	63,172	632	758	4	76	3,790	1.011	0.007	0.251	8.843

Module 2002 Land use change and forestry (New Zealand)
Submodule Carbon emissions from liming of agricultural 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	1,773,753	0.12	212,850	780
2003	1,885,852				

1. Statistics New Zealand June year data for 1989, 1990, 1992, 1993, 1995, and 1996. 2002 is a MAF estimate based on provisional data from Statistics New Zealand
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
2003 is an extrapolation of years 2000 to 2002

2 IPCC default value

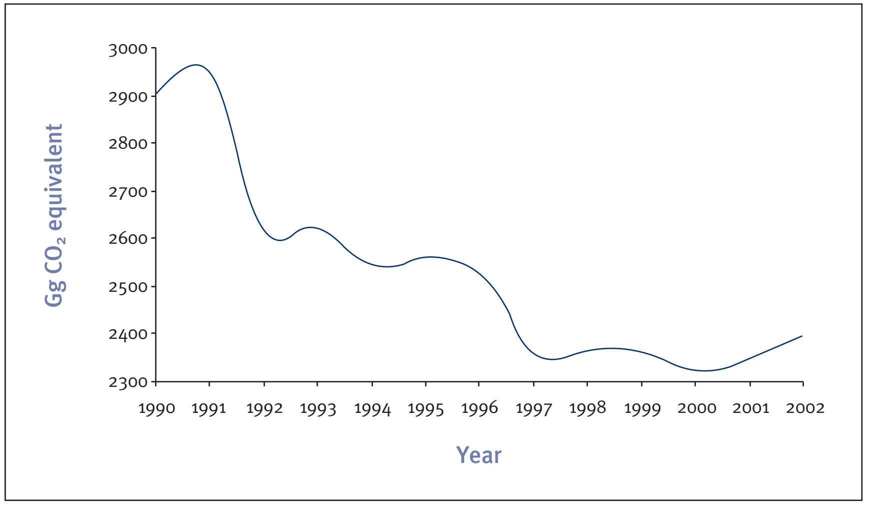
Chapter 8:

Waste

8.1 Sector overview

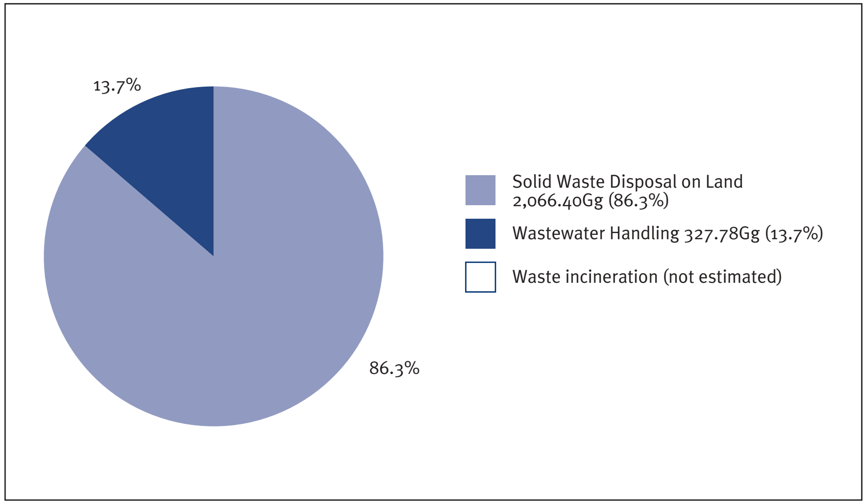
The waste sector totalled 2394.18Gg CO_2 equivalent in 2002 and represented 3.2% of all greenhouse gas emissions. Emissions in 2002 are now 17.7% below the 1990 baseline value of 2,908.46Gg CO_2 equivalent (Figure 8.1.1). The reduction has occurred in the solid waste disposal on land category, which has decreased by 20.7% as a result of initiatives to improve solid waste management practices in New Zealand.

Figure 8.1.1 Waste sector emissions from 1990 to 2002



Emissions from the waste sector are calculated in three components (Figure 8.1.2): solid waste disposal on land, wastewater handling and waste incineration (negligible emissions). CH_4 from solid waste disposal was identified as a key source category for New Zealand in 2002 (Tables 1.5.2 and 1.5.3).

Figure 8.1.2 Waste sector emissions in 2002 (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 vs. unmanaged landfills), the composition of the waste, and physical factors such as the moisture content and temperature of the SWDS. The CH_4 produced can go directly into the atmosphere via venting or leakage, or it may be flared off and converted to CO_2.

In New Zealand, managing solid wastes has traditionally meant disposing of them in landfills. In 1995, a National Landfill Census showed there were 327 legally operating landfills or SWDS in New Zealand that accepted approximately 3,180,000 tonnes of solid waste (MfE, 1997). Since that time there have been a number of initiatives to improve solid waste management practices in New Zealand. These have included preparing guidelines for the development and operation of landfills, closure and management of landfill sites, and consent conditions for landfills under 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.

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.

8.2.2 Methodological issues

New Zealand has used both the IPCC Tier 1 and Tier 2 methods to calculate emissions from solid waste (SCS Wetherill Environmental, 2002). 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).

Data on municipal solid waste (MSW) generation rates, waste composition and the percentage of MSW disposed to SWDS are obtained from the National Waste Data Report (MfE, 1997) and the Waste Analysis Protocol (WAP; MfE, 1992) surveys for the period 1993 to 1995. Based on the 1995 data, every person in New Zealand sends approximately 1.08 kg of residential waste per day to SWDS. Industrial waste that is landfilled averages approximately 1.31 kg per person per day. As a result, it is estimated that the total quantity of solid waste that is landfilled in New Zealand is 2.39 kg per person per day[2]. This value is used in the calculations for all years.

[2] It has been noted that the results for New Zealand are higher than for other OECD nations. The residential result for New Zealand includes 'bulky waste' associated with garden and home renovations. In addition, the industrial result for New Zealand includes construction and demolition waste. These two categories are counted separately by most other OECD nations.

The proportion of waste for each type of SWDS was obtained from the 1995 National Landfill Census. It is estimated that 90% of New Zealand's waste is disposed to managed SWDS and 10% to uncategorised sites (MfE, 1997). The fraction of DOC was calculated using waste composition data from the National Waste Data Report (MfE, 1997) and the Waste Analysis Protocol (WAP; MfE, 1992) surveys for the period 1993 to 1995. The IPCC (1996) default values were used for the carbon content of the various components. The DOC estimate also includes an estimate of the quantity of wood waste in the construction and demolition waste stream. Calculation of the methane generation potential was also based on the New Zealand waste statistics.

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 the ±35 percent reported in previous inventories (SCS Wetherill Environmental, 2002). 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 data is primarily from uncertainty in waste statistics based on the National Waste Data Report dated 1997, waste composition and how changes in waste management practices can alter the composition of waste to SWDS, the methane generation constant and the recovered methane rate.

The New Zealand waste composition categories from the National Waste Data Report do not exactly match the categories required for the IPCC DOC calculation. The major difference is that in New Zealand's DOC calculation, the garden waste category also includes food waste. A separation into the IPCC categories was not feasible given the available data in the National Waste Data Report. This 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 2002 inventory, the Tier 2 value of gross annual methane generation is 160.6Gg CH_4 and the Tier 1 value is 171.4Gg CH_4. The assumptions used to calculate net CH_4 emissions from gross CH_4 are the same for Tier 1 and 2.

CH_4 from solid waste disposal was identified as a key source category for New Zealand in 2001. In preparation of the 2002 inventory, the data underwent Tier 1 QC procedures (refer Annex 6 for examples).

8.2.5 Source-specific recalculations

There have been no changes introduced to the methodology for estimating greenhouse gas emissions in the solid waste disposal on land sector since the IPCC Tier 2 approach was introduced in the 2000 inventory. The emissions for 1990-2001 were recalculated based on improved population data from Statistics New Zealand.

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 in 2004. 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.

8.3.2 Methodological issues

Methane emissions from domestic wastewater treatment

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

Populations not served by municipal wastewater treatment plants have been estimated and their type of wastewater treatment assessed. The plants have been assigned to one of nine typical treatment processes. A characteristic emissions factor for each treatment is calculated from the proportion of BOD to the plant that is anaerobically degraded multiplied by the CH_4 conversion factor. The emission factors are shown in the worksheets accompanying this chapter.

It is good practice to use country-specific data for the maximum methane producing capacity factor (B_0). Where no data are available, the 1996 IPCC methodology recommends using B_0 of 0.25 CH_4 / kg COD (Chemical Oxygen Demand) or 0.6 kg CH_4 / kg BOD. The IPCC BOD value is based on a 2.5 scaling factor on COD (IPCC, 2001). New Zealand uses a B_0 of 0.25 CH_4 / kg COD but calculates a country-specific value of 0.375 kg CH_4 / kg BOD, based on a scaling-up factor of 1.5*COD. The New Zealand scaling factor is based on information from New Zealand waste sector experts (SCS Wetherill Environmental, 2002) and research (Metcalf and Eddy, 1991).

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 with 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.

[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 they estimate a year 2001 CH_4 production of 0.46Gg/year plus an additional 0.16Gg/year from unburned CH_4 from the digester-gas fuelled engines.

Oxidation ponds accumulate sludge on the pond floor. In New Zealand, these are typically only desludged every twenty 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 has been included in the inventory for that plant. Where sludge is landfilled, the CH_4 production has been included under solid waste disposal. There are a small number of treatment lagoons specifically treating septage. These lagoons are likely to produce a small amount of CH_4 and their effect is included in the calculations.

Nitrous oxide emissions from domestic wastewater treatment

New Zealand's calculation uses a modification of the IPCC methodology (IPCC, 1996). The IPCC method calculates nitrogen production based on the average per capita protein intake, however in New Zealand, raw sewage nitrogen data are available for many treatment plants. The raw sewage nitrogen data have been used to calculate a per capita domestic nitrogen production of 13 g/day and a per capita wastewater nitrogen figure of 4.75kg/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.

Nitrous oxide emissions from industrial wastewater treatment

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

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. 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 negates 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 order of magnitude accuracy.

8.3.4 Source-specific QA/QC and verification

There was no specific QA/QC performed on the wastewater handling category in the 2002 inventory.

8.3.5 Source-specific recalculations

There have been no recalculations in the 2002 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. 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 (6 incinerators), quarantine waste (three incinerators) and hazardous waste (two incinerators). Most regional and territorial councils have banned the open burning of waste.

In 2003, New Zealand's MfE proposed national environmental standards for the discharge of potentially harmful contaminants into the air. Once the proposed standards come into force, all existing low temperature waste incinerators in schools and hospitals will require a resource consent (authorisation to operate) by 2008, irrespective of existing planning rules. Such incinerators without consents will be prohibited. The MfE will work with the Ministries of Education and Health to encourage other forms of waste disposal in schools and hospitals.

Worksheets accompanying the waste sector

Module 2002 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)
3,975,900	2.39	3,468	1.00	3,468

1 Statistics New Zealand "100 years of population growth"
2 SCS Wetherill Environmental 2002

Module 2002 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	73.43	0.06	137.9	683.0	0.00	0.00	0.00	137.90	0.9	124.11
1991	3067	73.43	0.06	140.1	679.0	0.00	0.00	0.00	140.10	0.9	126.09
1992	3099	73.43	0.06	142.2	729.0	23.53	0.60	20.07	122.13	0.9	109.92
1993	3139	73.43	0.06	144.3	783.0	24.95	0.60	21.60	122.70	0.9	110.43
1994	3183	73.43	0.06	146.3	1019.0	32.02	0.60	28.11	118.19	0.9	106.37
1995	3234	73.43	0.06	148.3	1074.0	33.21	0.60	29.55	118.75	0.9	106.87
1996	3282	73.43	0.06	150.2	1203.0	36.65	0.60	33.03	117.17	0.9	105.45
1997	3317	73.43	0.06	152.1	1608.0	48.47	0.60	44.24	107.86	0.9	97.08
1998	3340	73.43	0.06	153.9	1645.0	49.25	0.60	45.47	108.43	0.9	97.58
1999	3360	73.43	0.06	155.7	1709.0	50.87	0.60	47.52	108.18	0.9	97.36
2000	3379	73.43	0.06	157.3	1700.0	50.32	0.65	51.45	105.85	0.9	95.27
2001	3413	73.43	0.06	158.9	1708.0	50.05	0.65	51.69	107.21	0.9	96.49
2002	3468	73.43	0.06	160.6	1703.0	49.10	0.65	51.26	109.34	0.9	98.41

Information in this table based on SCS Wetherill 2002

Calculations of DOC and L_o

New Zealand DOC Estimate Workshet

Waste category (NZ WAP)	Waste Quantity (tonnes)	Waste composition (% by weight)	Fraction DOC (by weight)
Paper	586,710	18	0.4
Plastic	222,600	7	0
Glass	60,420	2	0
Metal	208,290	7	0
Organic	1,135,260	36	0.17
C&D[1] non wood	330,720	10	0
C&D wood	197,160	6	0.3
Other	162,180	5	0
Pot Haz	276,660	9	0
Total	3,180,000		

1 Construction and demolition

Methane Generation Potential Calculation by Using Waste Type Data in 1995

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
0.96	0.1531	0.50	0.50	1.3333	0.0490	73.43

Module	**2002 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	**2002 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	**2002 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	3,975,900	0.01	**0.30**

1 SCS Wetherill 2002
2 Statistics New Zealand.

Module 2002 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	571,857	50	28,592,850	43%	55%	0.25	0.059	1.69
sheep/lambs	539,014	50	26,950,700	33%	55%	0.25	0.045	1.22
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								**3.83**

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

Module 2002 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	28,592,850	0.08	2,287,428	0.02	0.072
sheep/lambs	26,950,700	0.08	2,156,056	0.02	0.068
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	0.02	0.002
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**

Chapter 9:

Recalculations and improvements

9.1 The 2004 submission (2002 inventory)

In this current submission, the format of the inventory report has been restructured to fit the format outlined in the UNFCCC reporting guidelines (UNFCCC/2002/CP/8).

9.1.1 Improvements

Improvements in the 2002 inventory include:

- Including a complete set of the CRF for all years 1990-2002.
- Developing a preliminary QA/QC plan and trial of Tier 1 QC checksheets (Annex 6).
- Trialing a Tier 3 questionnaire to calculate emissions of SF_6 from electrical equipment.
- Reporting N_2O use in anaesthesia for the solvent and other product use sector.
- Reporting CH_4 from methanol production.
- Increased explanatory text in the NIR to help understanding of the methodologies and address questions raised by UNFCCC expert review teams, especially in the energy and industrial processes sectors.
- Including more general inventory background and summary information.

9.1.2 Recalculations

The overall effect of all recalculations is shown in Figure 9.1.1. The recalculations change the level of emissions reported in the 2003 submission for 1990-2000 by an average of 0.56%. There is a 1.7% change in the 2001 inventory largely due to the replacement of provisional animal numbers with actual animal numbers in the agriculture sector. This occurs every year of the inventory. Changes in 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 9.1.1 The effect of recalculation on total emissions

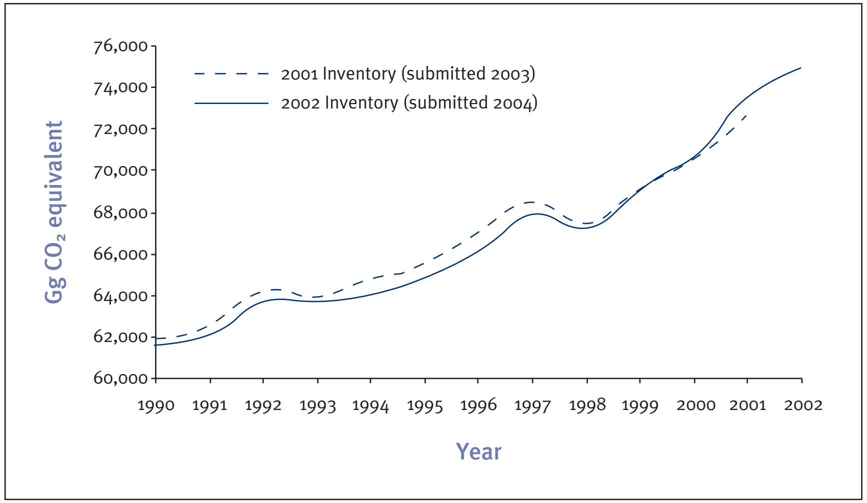
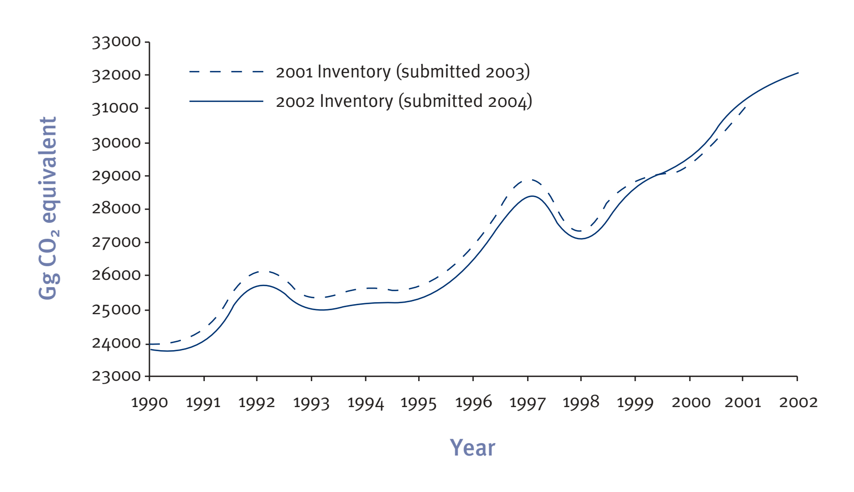


Figure 9.1.2 The effect of recalculation on the energy sector



Energy Sector

New Zealand reviewed all emission factors used in the energy sector in 2003 (Hale and Twomey, 2003). The review was commissioned based on recommendations from New Zealand's inventory QA procedures (Clarkson, 2001, 2002). The results of the emission factors review were assessed by an independent review panel of New Zealand energy experts prior to review recommendations being used in the inventory. In accordance with Good Practice (IPCC, 2000), where there was a significant difference between country-specific and IPCC default emission factors, and a defensible explanation could not be obtained, New Zealand reverted to the IPCC default emission factors (refer to Annex 2 for detailed information). The 2002 inventory incorporates the emission factors recommended by the review and agreed by the review panel. The implications on emission levels and the trend in emissions from the energy sector are shown in Figure 9.1.2.

Officials at the MED conducted an investigation into the effect of the new emission factors on the 1990 and 2002 inventory data. The analysis compared the previous emission factors with the new emission factors. The analysis identified that for:

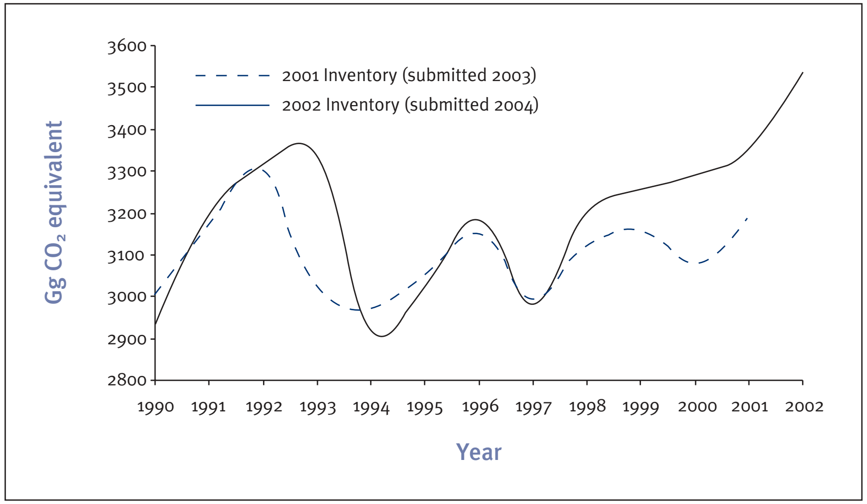
- **CO_2 emissions:** the emissions factor review had relatively little effect on CO_2 emissions. The effect on total energy sector CO_2 emissions is less than 1% in both 1990 and 2002. The category most affected by the review is transport as a result of splitting the petrol, aviation fuels and fuel oil into more specific groups. The overall effects are less than a 1% decrease in 1990 domestic transport emissions and less than a 1% increase in 2002 domestic transport emissions.
- **CH_4 emissions:** there are two categories where CH_4 emissions are significantly affected by the new emission factors. One category is fugitive emissions which are approximately 80% of total CH_4 energy emissions. The effect of changing from the New Zealand specific emissions factor to the IPCC factor is a 12% reduction in fugitive emissions for 2002. The other sector significantly affected by the review is transport, where the CH_4 emissions factor from petrol combustion was changed from a New Zealand specific value (60 tCH_4/PJ) to the top of the IPCC range (18.5 tCH_4/PJ (Annex 2).

- **N_2O emissions:** the new N_2O emission factors show a 23% decrease in 1990 emissions and a 14% decrease in 2002 emissions. The changes in emission factors arise from a change from New Zealand specific factors to IPCC factors. The net effect is a 35% decrease in 1990 emissions and a 20% decrease in 2002 emissions in the domestic transport sector.
- **NO_x emissions:** there is a 17% decrease in NO_x emissions from the 2002 level when the new emission factors are used with almost no change from the 1990 level. This change arises largely from the new emission factors for liquid fuels used in transport.
- **CO emissions:** CO emissions are approximately 30% lower in 1990 and 2002 when the new emission factors are used. Again this is largely caused by decreases to the emission factors for petrol and diesel used in domestic transport.
- **NMVOC emissions:** emissions of NMVOC decline by nearly 20% from both the 1990 and 2002 levels when using the new emission factors. This is attributed to a decrease in the emission factors for both petrol and diesel.

Industrial processes

There were changes in the estimates of non-CO_2 emissions in the industrial processes sector in the 2002 inventory. The changes resulted from new sources being identified in the survey and a critical examination of previous emission estimates. All revisions were back-calculated through to 1990 (Figure 9.1.3).

Figure 9.1.3 The effect of recalculation on the industrial processes sector



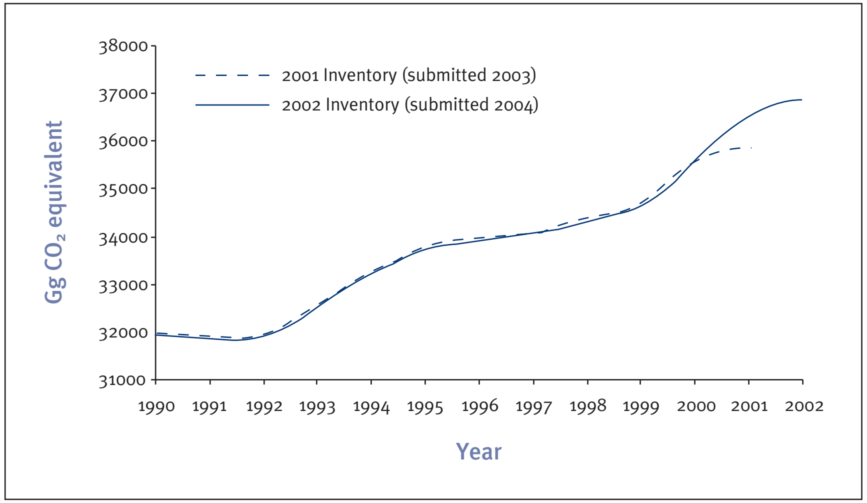
The major changes in the industrial processes sector were:

- CH_4 from methanol production was included for the first time in the 2002 inventory due to an omission in previous CRFs. Emissions are calculated back to 1997 (when methanol production data are available).
- PFC emissions data from aluminium smelting reported in previous inventories (1990-1999) were identified by NZCCO officials as being inconsistent with company-supplied emissions records. The inconsistency was investigated and corrected in all CRFs.
- The emission factors for wine, beer and spirits were found to be in error (per hectolitre) and all CRFs were corrected.
- The major user of SF_6 was able to assess holdings more accurately than in the past surveys for 2000 and 2001. The losses have been re-calculated using a 1% emissions factor for the major firm and 2% for all other companies.
- There were some recalculations for the sub-sources of HFC/PFC emissions due to new sources being identified.

Agriculture

Every year of inventory there is a recalculation for the previous year as the provisional animal population is updated with the actual population. This causes an increase in the level of emissions reported (Figure 9.1.4). The other recalculation for 2004 was the inclusion of emissions from savanna burning.

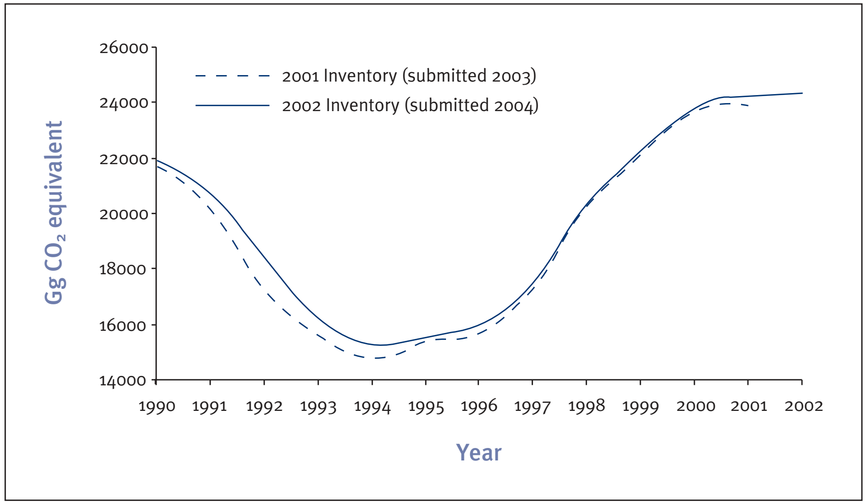
Figure 9.1.4 The effect of recalculation on the agriculture sector



Land-use change and forestry

New proportions of area by NEFD regime have been used to weight the carbon yield in the 2002 inventory. Area data and carbon yields underlying the models in recent reports are similar to those used in previous inventories. The difference in net managed forest CO_2 removals between this and the previous inventory are generally of the order of less than 2% (Figure 9.1.5)

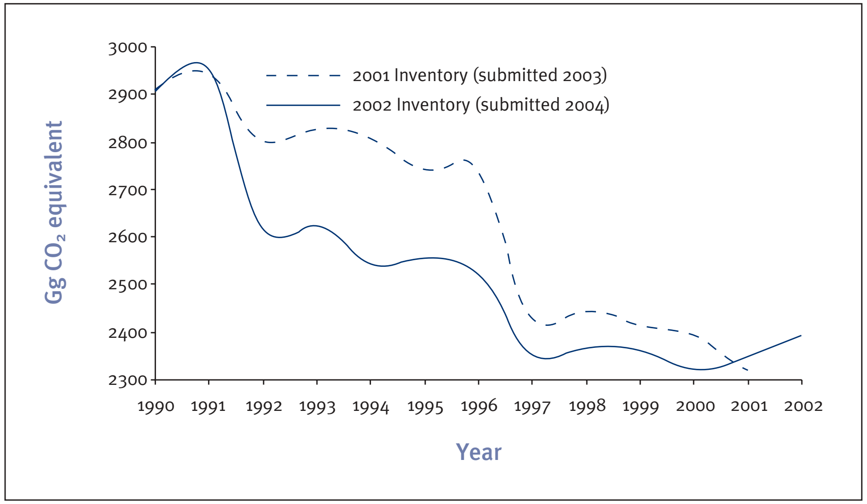
Figure 9.1.5 The effect of recalculation on LUCF net removals



Waste

The emissions for 1990-2001 from solid waste disposal sites were recalculated based on improved population data from Statistics New Zealand. The effect of the improved population data on the waste sector is shown in Figure 9.1.6.

Figure 9.1.6 The effect of recalculations on the waste sector



9.2 Improvements and recalculations in previous submissions

9.2.1 The 2003 submission (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.

9.2.2 The 2002 submission (2000 inventory)

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.

9.2.3 The 2001 submission (1999 inventory)

In the 2001 submission for the year 1999, estimates of emissions of the fluorinated gases (HFCs, PFCs and SF_6) were upgraded to IPCC (2000) Tier 2 methodology.

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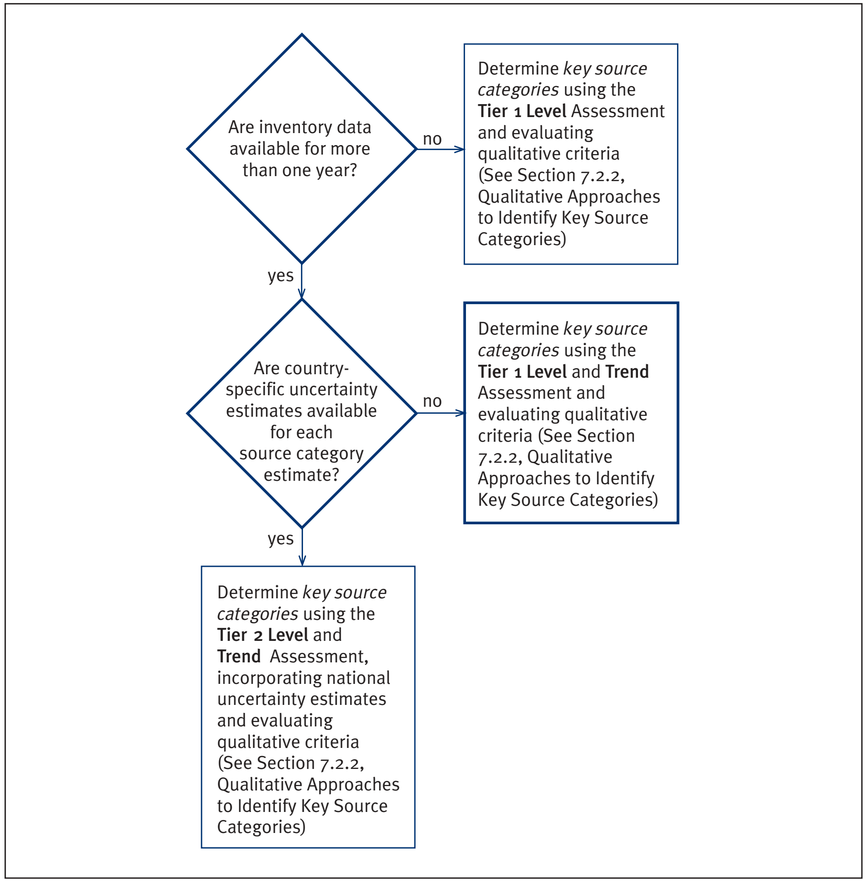
Annex 1:

Key sources

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 2002 inventory the Tier 1 Level and Trend assessment was applied. The source category level and trend assessments were calculated as per equations 7.1 and 7.2 of Good Practice (IPCC,2000). Key source categories were defined as those categories whose cumulative percentages, when summed in decreasing order of magnitude, contributed 95% of the total level or trend. The 95% threshold followed the guidelines in the Good Practice (IPCC,2000). No qualitative assessment of key source categories for both the level and trend assessment was included.

Disaggregation

The classification of source 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 source categories using CO_2 equivalent emissions and considering each greenhouse gas from each category separately.
- Aggregating source categories that use the same emission factors.

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

Tables 7.A1-7.A3 of the IPCC good practice guidance

Table A1.1 (Table 7.A1 of Good Practice)

Tier 1 Source Category Level Assessment						
IPCC Source Categories	Gas	Base year estimate	2002 estimate	Level assessment	Cumulative total
Emissions from enteric fermentation in domestic livestock	CH_4	21371.91	23584.68	31.5	31.46
Mobile combustion - road vehicles	CO_2	7533.73	12292.63	16.4	47.85
Emissions from stationary combustion - gas	CO_2	7842.06	10420.49	13.9	61.75
Emissions from agricultural soils - animal production	N_2O	6574.17	7255.24	9.7	71.43
Emissions from stationary combustion - solid	CO_2	3229.71	3394.88	4.5	75.95
Indirect emissions from nitrogen used in agriculture	N_2O	2634.95	3258.01	4.3	80.30
Emissions from stationary combustion - liquid	CO_2	2546.44	2491.18	3.3	83.62
Direct emissions from agricultural soils	N_2O	680.04	2104.46	2.8	86.43
Emissions from solid waste disposal sites	CH_4	2606.10	2066.40	2.8	89.19
Emissions from the iron and steel industry	CO_2	1345.16	1563.80	2.1	91.27
Mobile combustion - aviation	CO_2	772.83	1089.25	1.5	92.72
Emissions from manure management	CH_4	573.09	548.00	0.7	93.45
Emissions from cement production	CO_2	366.66	541.72	0.7	94.18
Emissions from aluminium production	CO_2	457.92	540.34	0.7	94.90
Emissions from substitutes for ozone depleting substances	HFCs	0.00	387.59	0.5	95.41
Mobile combustion - marine	CO_2	233.13	360.21	0.5	95.90
Fugitive emissions from coal mining and handling	CH_4	210.02	354.08	0.5	96.37
Fugitive emissions from oil and gas operations	CH_4	262.63	351.86	0.5	96.84
Fugitive emissions from geothermal operations	CO_2	357.34	315.24	0.4	97.26
Fugitive emissions from oil and gas operations	CO_2	257.85	294.80	0.4	97.65
Emissions from hydrogen production	CO_2	152.29	197.48	0.3	97.91
Emissions from wastewater handling	CH_4	156.66	169.68	0.2	98.14
Mobile combustion - road vehicles	CH_4	148.18	161.69	0.2	98.36
Emissions from wastewater handling	N_2O	145.70	158.10	0.2	98.57
Mobile combustion - rail	CO_2	77.50	157.10	0.2	98.78
Mobile combustion - road vehicles	N_2O	63.69	130.29	0.2	98.95
Emissions from lime production	CO_2	81.62	110.69	0.1	99.10
Non-CO_2 emissions from stationary combustion	N_2O	72.59	98.53	0.1	99.23
PFC's from aluminium production	PFC	515.60	80.70	0.1	99.34
Emissions from manure management	N_2O	48.36	75.33	0.1	99.44
Non-CO_2 emissions from stationary combustion	CH_4	75.20	66.47	0.1	99.53
Fugitive emissions from geothermal operations	CH_4	52.48	51.48	0.1	99.59
Emissions from agricultural residue burning	CH_4	18.77	22.49	0.0	99.62
Emissions from electrical equipment	SF_6	9.46	12.57	0.0	99.64
Mobile combustion - aviation	N_2O	6.77	9.53	0.0	99.65
emissions from agricultural residue burning	N_2O	6.51	7.44	0.0	99.66
Mobile combustion - marine	N_2O	2.13	2.94	0.0	99.67
Mobile combustion - rail	N_2O	1.29	2.62	0.0	99.67
emissions from savanna burning	CH_4	2.81	0.84	0.0	99.67
Mobile combustion - marine	CH_4	0.51	0.70	0.0	99.67
Mobile combustion - aviation	CH_4	0.46	0.65	0.0	99.67
Mobile combustion - rail	CH_4	0.31	0.62	0.0	99.68
SF_6 from other sources of SF_6	SF_6	0.48	0.33	0.0	99.68
Emissions from savanna burning	N_2O	0.53	0.16	0.0	99.68
Emissions from waste incineration	CO_2	0.00	0.00	0.0	99.68
Emissions from waste incineration	N_2O	0.00	0.00	0.0	99.68

Table A1.2 (Table 7.A2 of Good Practice)

Tier 1 Source Category Trend Assessment							
IPCC Source Categories	Gas	Base year estimate	2002 estimate	Trend assessment	Contribution to trend	Cumulative total
Mobile combustion - road vehicles	CO_2	7533.73	12292.63	0.0343	24.50	24.50
Emissions from enteric fermentation in domestic livestock	CH_4	21371.91	23584.68	0.0264	18.88	43.38
Direct emissions from agricultural soils	N_2O	680.04	2104.46	0.0140	10.00	53.39
Emissions from solid waste disposal sites	CH_4	2606.10	2066.40	0.0121	8.64	62.03
CO_2 emissions from stationary combustion - gas	CO_2	7842.06	10420.49	0.0097	6.90	68.93
Emissions from animal production	N_2O	6574.17	7255.24	0.0081	5.81	74.74
CO_2 emissions from Stationary combustion - liquid	CO_2	2546.44	2491.18	0.0066	4.75	79.48
PFCs from aluminium production	PFC	515.60	80.70	0.0060	4.28	83.76
CO_2 emissions from stationary combustion - solid	CO_2	3229.71	3394.88	0.0059	4.18	87.94
Emissions from substitutes for ozone depleting substances	HFCs	0.00	387.59	0.0042	3.04	90.98
Mobile combustion - aviation	CO_2	772.83	1089.25	0.0016	1.17	92.15
Emissions from manure management	CH_4	573.09	548.00	0.0016	1.17	93.31
Fugitive emissions from geothermal operations	CO_2	357.34	315.24	0.0013	0.94	94.25
Fugitive emissions from coal mining and handling	CH_4	210.02	354.08	0.0011	0.77	95.02
Emissions from cement production	CO_2	366.66	541.72	0.0010	0.75	95.77
Mobile combustion - marine	CO_2	233.13	360.21	0.0008	0.60	96.37
Emissions from the iron and steel industry	CO_2	1345.16	1563.80	0.0008	0.57	96.94
Mobile combustion - rail	CO_2	77.50	157.10	0.0007	0.49	97.43
Indirect N2O emissions from nitrogen used in agriculture	N_2O	2634.95	3258.01	0.0006	0.41	97.84
Mobile combustion - road vehicles	N_2O	63.69	130.29	0.0006	0.41	98.26
Fugitive emissions from oil and gas operations	CH_4	262.63	351.86	0.0004	0.25	98.51
Non-CO_2 emissions from stationary combustion	CH_4	75.20	66.47	0.0003	0.20	98.71
Emissions from wastewater handling	CH_4	156.66	169.68	0.0002	0.16	98.87
Emissions from wastewater handling	N_2O	145.70	158.10	0.0002	0.15	99.02
Fugitive emissions from oil and gas operations	CO_2	257.85	294.80	0.0002	0.15	99.17
Mobile combustion - road vehicles	CH_4	148.18	161.69	0.0002	0.15	99.31
Emissions from manure management	N_2O	48.36	75.33	0.0002	0.13	99.44
Emissions from aluminium production	CO_2	457.92	540.34	0.0002	0.13	99.57
Emissions from hydrogen production	CO_2	152.29	197.48	0.0001	0.10	99.67
Fugitive emissions from geothermal operations	CH_4	52.48	51.48	0.0001	0.10	99.77
Emissions from lime production	CO_2	81.62	110.69	0.0001	0.09	99.85
Non-CO_2 emissions from stationary combustion	N_2O	72.59	98.53	0.0001	0.08	99.93
Emissions from savanna burning	CH_4	2.81	0.84	0.0000	0.02	99.96
Mobile combustion - aviation	N_2O	6.77	9.53	0.0000	0.01	99.97
SF_6 emissions from electrical equipment	SF_6	9.46	12.57	0.0000	0.01	99.97
Mobile combustion - rail	N_2O	1.29	2.62	0.0000	0.01	99.98
Emissions from savanna burning	N_2O	0.53	0.16	0.0000	0.00	99.99
Emissions from agricultural residue burning	N_2O	6.51	7.44	0.0000	0.00	99.99
Mobile combustion - marine	N_2O	2.13	2.94	0.0000	0.00	99.99
CH4 emissions from agricultural residue burning	CH_4	18.77	22.49	0.0000	0.00	99.99
Mobile combustion - rail	CH_4	0.31	0.62	0.0000	0.00	100.00
SF_6 from other sources of SF_6	SF_6	0.48	0.33	0.0000	0.00	100.00
Mobile combustion - aviation	CH_4	0.46	0.65	0.0000	0.00	100.00
Mobile combustion - marine	CH_4	0.51	0.70	0.0000	0.00	100.00
Emissions from waste incineration	CO_2	0.00	0.00	0.0000	0.00	100.00
Emissions from waste incineration	N_2O	0.00	0.00	0.0000	0.00	100.00

Table A1.3 (Table 7.A3 of Good Practice)

Quantitative method used: Tier 1			
IPCC Source Categories	**Gas**	**Key Source Category flag**	**Criteria for Identification**
Energy Sector			
CO_2 emissions from stationary combustion - solid	CO_2	yes	level, trend
CO_2 emissions from stationary combustion - liquid	CO_2	yes	level, trend
CO_2 emissions from stationary combustion - gas	CO_2	yes	level, trend
Non-CO_2 emissions from stationary combustion	CH_4		
Non-CO_2 emissions from stationary combustion	N_2O		
Mobile combustion - road vehicles	CO_2	yes	level, trend
Mobile combustion - road vehicles	CH_4		
Mobile combustion - road vehicles	N_2O		
Mobile combustion - aviation	CO_2	yes	level, trend
Mobile combustion - aviation	CH_4		
Mobile combustion - aviation	N_2O		
Mobile combustion - marine	CO_2		
Mobile combustion - marine	CH_4		
Mobile combustion - marine	N_2O		
Mobile combustion - rail	CO_2		
Mobile combustion - rail	CH_4		
Mobile combustion - rail	N_2O		
Fugitive emissions from coal mining and handling	CH_4	yes	trend
Fugitive emissions from oil and gas operations	CO_2		
Fugitive emissions from oil and gas operations	CH_4		
Fugitive emissions from geothermal operations	CO_2	yes	trend
Fugitive emissions from geothermal operations	CH_4		
Industrial sector			
Emissions from cement production	CO_2	yes	level
Emissions from lime production	CO_2		
Emissions from the iron and steel industry	CO_2	yes	level
Emissions from adipic acid production	N_2O		
Emissions from nitric acid production	N_2O		
Emissions from hydrogen production	CO_2		
Emissions from aluminium production	CO_2	yes	level
PFC's from aluminium production	PFC	yes	trend
SF_6 from magnesium production	SF_6		
SF_6 from other sources of SF_6	SF_6		
SF_6 from production of SF_6	SF_6		
Emissions from electrical equipment	SF_6		
PFC, HFCand SF6 emissions from semiconductor manufacturing	SF_6		
Emissions from substitutes for ozone depleting substances	Several	yes	level, trend
HFC-23 emissions from HCFC-22 manufacture	HFC		
Agricultural Sector			
Emissions from enteric fermentation in domestic livestock	CH_4	yes	level, trend
Emissions from manure management	CH_4	yes	level, trend
Emissions from manure management	N_2O		
Direct emissions from agricultural soils	N_2O	yes	level, trend
Emissions from animal deposition on agricultural soils	N_2O	yes	level, trend
Indirect emissions from nitrogen used in agriculture	N_2O	yes	level
Emissions from rice production	CH_4		
Emissions from agricultural residue burning	CH_4		
Emissions from agricultural residue burning	N_2O		
Emissions from burning savannna	CH_4		
Emissions from burning savannna	N_2O		
Waste sector			
Emissions from solid waste disposal sites	CH_4	yes	level, trend
Emissions from wastewater handling	CH_4		
Emissions from wastewater handling	N_2O		
Emissions from waste incineration	CO_2		
Emissions from waste incineration	N_2O		

Annex 2:

Detailed discussion of methodology and data for estimating CO_2 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).

Table A2.1 CO_2 emission factors for liquid fuels

Liquid fuel type	New Emission Factors (kt CO_2/PJ)	Old Emission Factors (ktCO_2/PJ)	Source of new emission factors
Gasoline (petrol)	66.2 (regular) 67.0 (premium)[1]	66.6	NZRC data from 1990-2002.
Diesel	69.5	68.7	NZRC data from 1990-2002.
Fuel oil	73.5 (HFO) 72.0 (LFO)	73.7	NZRC data from 1990-2002.
Aviation gasoline	65	68.7	BP import data records.
Jet kerosene	68.1	68.7	NZRC data from 1990-2002.
LPG	60.4	60.4	Baines, 1993 (confirmed by checks of 2002 gas data).

[1] Premium petrol was introduced in 1995.

New Zealand's review of emission factors (Hale and Twomey, 2003) identified a number of non-CO_2 emission factors 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 (Tables A2.2 and A2.3). The value used by New Zealand in the 2002 inventory is either the IPCC value that was closest match to New Zealand's conditions or the mid-point value from the IPCC range.

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

Many of the sources in the stationary combustion category already used the IPCC (1996) emission factors, however there were minor changes related to the re-interpretation of the IPCC tables to get the closest match to New Zealand conditions (Table A2.4). All emission factors from the IPCC Guidelines are converted from NCV to GCV. 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 2002 inventory.

Table A2.2 CH_4 and N_2O emission factors for liquid fuels (in transport)

Fuel type(s)	Units	New emission factors	Old emission factors	Source of new emission factors
Petrol	tCH_4/PJ	18.5[1]	60	IPCC Tier 2 (Table I-27) mid point grossed down
Diesel	tCH_4/PJ	3.8[1]	13	IPCC Tier 2 (Table I-30) grossed down
Fuel oil	tCH_4/PJ	6.65	14	IPCC Tier 2 (Table I-48) grossed down
Aviation fuels	tCH_4/PJ	1.9	1.5	IPCC Tier 2 (Table I-47) grossed down
LPG	tCH_4/PJ	28.5	40	IPCC Tier 2 (Table I-44) grossed down
Petrol	tN_2O/PJ	1.42	3	IPCC Good practice (Table 2.7) grossed down
Diesel	tN_2O/PJ	3.70	3	IPCC Good practice (Table 2.7) grossed down
Fuel oil	tN_2O/PJ	1.9	1.8	IPCC Tier 2 (Table I-48) grossed down
Aviation fuels	tN_2O/PJ	1.9	1.1	IPCC Tier 1 (Table I-8) grossed down
LPG	tN_2O/PJ	0.57	2.8	IPCC Tier 1 (Table I-8) grossed down

[1] The new factors apply from 1993 onwards (Hale and Twomey, 2003).

Table A2.3 CO, NO_x, NMVOC emission factors for liquid fuels (in transport)

Fuel type(s)	Units	New emission factors	Old emission factors	Source of new emission factors
Petrol	ktCO/PJ	4.59	6.96	IPCC Tier 2 (Table I-27/29) mid grossed down
Diesel	ktCO/PJ	0.303	0.485	IPCC Tier 2 (Table I-30/32) grossed down
Fuel oil	ktCO/PJ	0.171	0.044	IPCC Tier 2 (Table I-48) grossed down
Aviation fuels	ktCO/PJ	0.114	0.114	IPCC Tier 2 (Table I-47) grossed down
LPG	ktCO/PJ	1.38	1.38	IPCC Tier 2 (Table I-44) grossed down
Petrol	$ktNO_x/PJ$	0.21[1]	0.467	IPCC Tier 2 (Table I-27/29) mid point grossed down
Diesel	$ktNO_x/PJ$	0.64[1]	0.718	IPCC Tier 2 (Table I-30/32) grossed down
Fuel oil	$ktNO_x/PJ$	1.71	1.995	IPCC Tier 2 (Table I-48) grossed down
Aviation fuels	$ktNO_x/PJ$	0.276	0.276	IPCC Tier 2 (Table I-47) grossed down
LPG	$ktNO_x/PJ$	0.361	0.361	IPCC Tier 2 (Table I-44) grossed down
Petrol	ktNMVOC /PJ	0.885	1.08	IPCC Tier 2 (Table I-27/29) mid grossed down
Diesel	ktNMVOC /PJ	0.102	0.171	IPCC Tier 2 (Table I-30/32) grossed down
Fuel oil	ktNMVOC /PJ	0.049	0.105	IPCC Tier 2 (Table I-48) grossed down
Aviation fuels	ktNMVOC /PJ	0.017	0.017	IPCC Tier 2 (Table I-47) grossed down
LPG	ktNMVOC /PJ	0.608	0.608	IPCC Tier 2 (Table I-44) grossed down

[1] The new factors apply from 1993 onwards (Hale and Twomey, 2003).

Table A2.4 Changes in emission factors for stationary combustion

Category	Units	New emission factors	Old emission factors	Source of new emission factors
Agri – Stationary	tCH_4/PJ	4.0	2.9	IPCC Tier 2 (Table I-49) grossed down
Agri – Stationary	tN_2O/PJ	0.38	0.3	IPCC Tier 2 (Table I-16) grossed down
Agri – Stationary	ktCO/PJ	0.35	0.014	IPCC Tier 2 (Table I-49) grossed down
Agri – Stationary	$ktNO_x/PJ$	0.007	0.162	IPCC Tier 2 (Table I-16) grossed down
LPG Commercial	tCH_4/PJ	1.0	9.7	IPCC Tier 2 (Table I-18) grossed down
Petrol Diesel / Elec generation	$ktNO_x/PJ$	1.3	0.209	IPCC Tier 2 (Table I-15) grossed down

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 that are 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 sectors do not match 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 NZCCO 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. Futhermore 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. Conducting an updated sectoral coal partitioning will be considered according to national circumstances and priorities for inventory development.

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 A2.5). 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. There were no changes to the New Zealand specific CO_2 emission factors suggested by the Hale and Twomey (2003) review. All New Zealand values are within 2% of the IPCC defaults (1996). The non-CO_2 emission factors are defaults from the IPCC Guidelines (1996) and no uncertainty values are provided.

Table A2.5 CO_2 emission factors for solid fuels

Solid fuel type	Emissions factor (tC/TJ)	Emissions factor (tCO_2/TJ)	Source
Coking coal	24.2	88.8	Baines, 1993
Other bituminous coal	24.2	88.8	Baines, 1993
Sub-bituminous coal	24.9	91.2	Baines, 1993
Lignite	26.0	95.2	Baines, 1993
Coke	27.9	102.3	Baines, 1993

There were only two changes to the non-CO_2 emission factors for solid fuels. The CO emissions factor from household coal use increased from 0.456 kt/PJ to 3.42 kt/PJ (IPCC Tier 2, Table I-18, grossed down) reflecting that the coal stoves category was a better match to New Zealand conditions than coal furnaces. The N_2O emissions factor for coal used in cement/lime manufacture increased from 1.3 t/PJ to 1.5t/PJ (IPCC Tier 1, Table I-8, grossed down) as a result of the previous New Zealand factor lacking sufficient supporting documentation. There were also changes to the fugitive emissions from coal mining emission factors. These are discussed in Section 3.3.1 'Fugitive emissions from fuels: Solid fuels (CRF 1B1)'.

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 is shown in Table A2.6. 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).

Table A2.6 Natural gas CO_2 emission factors

Gas stream	Emission factors (t CO2/TJ)
Maui	52.3 (2002 yr data)
'Treated'	52.5 (2002 yr data)
Kapuni LTS	84.1 (no variation assumed)
Waihapa/Ngaere	56.2 (no variation assumed)
Kaimiro	65.2 (no variation assumed)
McKee	54.2 (no variation assumed)
Ngatoro	46.3 (no variation assumed)

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 52.3 kt CO_2/PJ in 2002 and the other half is treated gas (52.5 kt CO_2/PJ). The average value of 52.4 kt CO_2/PJ is used for the 2002 inventory (Table A2.7).

Table A2.7 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

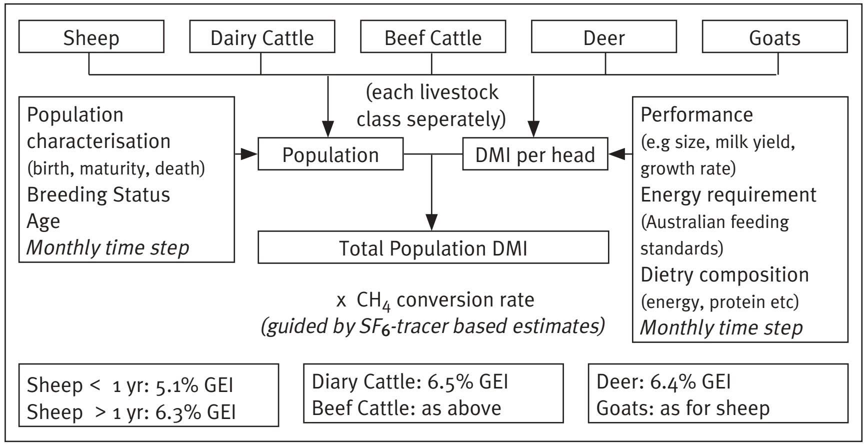
Annex 3:

Detailed methodologies for source or sink categories

Annex 3.A 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. An overview of the model is presented in Figure A3.1 with detailed information provided in the following sections.

Figure A3.1 Schematic of New Zealand's enteric methane calculation methodology



3.A.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 tables, 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 were used to compile the inventory. To ensure consistency, the same data sources have been 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 are collected by the MAF. This information is used as a surrogate for changes in animal liveweight. Other information is collected at irregular intervals or from small survey populations. In general, no routine comprehensive surveys are conducted except for slaughter weight of animals.

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), average liveweights of deer (breeding and growing hinds and stags) and monthly energy concentrations of the diets consumed by beef cattle, sheep, dairy cattle and deer.

Dairy cattle: data on milk production were provided by the MAF. 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 were obtained by dividing the total milk produced by the total number of milking dairy cows and heifers. Milk composition data were taken from the Livestock Improvement Corporation (LIC) national statistics. For all years, lactation length was assumed to be 280 days.

Average weight data for dairy cows were obtained by taking into account the proportion of each breed in the national herd and its age structure based on data about breed and age structure from the LIC. Dairy cow liveweights are only available from 1996 onwards. For earlier years in the time-series, liveweights were estimated using the trend in liveweights from 1996 to 2002 together with data on the breed composition of the national herd. Growing dairy replacements at birth were 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. 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 were 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 large framed Continentals. 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 highly insensitive 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 were 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 were assumed to be 9% of an adult cow weight for heifers and 10% of the adult cow weight for steers and bulls. Growth between weight at birth and slaughter is assumed to be linear.

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] were 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 were 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 were assumed to be 9% of the adult ewe weight with all lambs assumed to be born on 1st September. Growing breeding and non-breeding ewe hoggets were assumed to reach full adult size at the time of mating when aged 20 months. Adult wethers were 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 were assumed to have a total milk yield of 100 litres. Breeding rams were 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.

Deer: liveweights of growing hinds and stags were 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 were 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 1989 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 source 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. CH_4 emissions from goats for all years were assumed to average the same per head as the average sheep in 1990 (i.e. total sheep emissions/total sheep number). The goat value was not indexed to sheep over time because there is no evidence to support the kind of productivity increases that have been seen in sheep.

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 were calculated using algorithms developed in Australia (CSIRO, 1990). These were chosen as they specifically include methods to estimate the energy requirements of grazing animals. The method estimates a maintenance requirement (a function of liveweight, the level of productivity 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 were performed monthly.

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.

[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 were then obtained assuming a killing out percentage of 45%.

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 from grazing ruminants. A database of these data is being constructed and systematically examined to obtain generalised relationships between feed 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 3A1 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 were adopted for use in this inventory calculation. Table 3A.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 3A.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	6 ± 0.5	6 ± 0.5	5 ± 0.5

In the 2001 inventory, changes to the emission factors from the previous fixed emission factors for sheep, deer and goats caused significant differences. The downward revision for sheep was explained by:

- A fall of 15 to 20% in the estimate of CH_4 emissions per unit of intake in older sheep.
- An almost 30% decrease in the estimated emissions per head in younger sheep.
- The ewe and lamb liveweights assumed for the earlier emissions factor were 10% higher than those in the 2001 inventory.
- The previous model kept animal numbers constant throughout the year and had only three categories (ewes, lambs and growing sheep) whereas the revised 2001 model takes into account ewe and lamb mortality and has nine classes. Several of the animal classes have lower intakes and consequently lower CH_4 emissions than the growing sheep class.
- Technical errors were also made in the previous estimates of CH_4 emission per head from deer and goats. These errors were corrected.

Table 3A.2 Time-series of implied emission factors for enteric fermentation (kg methane per animal per annum)

Year	Dairy cattle	Beef cattle	Sheep	Deer	Goats
1990	70.2	50.8	8.9	19.7	8.9
1991	70.7	51.3	9.1	19.4	8.9
1992	72.5	52.4	9.1	19.3	8.9
1993	72.9	53.8	9.3	19.2	8.9
1994	73.0	53.3	9.4	19.3	8.9
1995	72.7	53.1	9.6	19.6	8.9
1996	73.4	52.4	9.7	20.0	8.9
1997	73.0	54.2	10.0	20.5	8.9
1998	73.9	54.3	10.1	20.7	8.9
1999	75.1	55.2	10.1	20.8	8.9
2000	77.0	54.9	10.5	20.9	8.9
2001	74.7	56.0	10.6	20.9	8.9
2002	77.4	56.3	10.8	21.4	9.0
Previous fixed EF	76.8	67.5	15.1	30.6	16.5

3A.2 Uncertainty of animal population data

Details of the most recent surveys and census is included to provide an understanding of the livestock statistics process and uncertainty figures. The information documented is from Statistics New Zealand.

2003 Agricultural Production Survey

The target population for the 2003 *Agricultural Production* survey was 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 2003. The estimated proportion of eligible businesses responding to the 2003 Agricultural Production Survey is 85 percent. These businesses contribute 87 percent of the total agricultural output. The sample error and percentage imputed are shown in Table 3A3.

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 imputed values for farmers and growers in the 2002 Agricultural Production Census who have not returned a completed questionnaire. The method of imputation is random ‘hot deck’ imputation.

Table 3A.3 Provisional sampling error and imputation levels for the 2003 *Agricultural Production* survey

Statistic	Sample errors at 95% confidence interval (%)	Percentage of total estimate imputed
Ewe hoggets put to ram	4	12
Breeding ewes 2 tooth and over	2	12
Total number of sheep	2	11
Total lambs marked or tailed	2	11
Beef cows and heifers (in calf) 2 years and over	2	12
Beef cows and heifers (in calf) 1 – 2 years	5	11
Total number of beef cattle	2	12
Calves born alive to beef heifers/cows	3	12
Dairy cows and heifers, in milk or calf	2	14
Total number of dairy cattle	2	14
Calves born alive to dairy heifers/cows	3	13
Female deer mated	4	9
Total number of deer	4	9
Fawns or calves weaned on the farm	4	9
Area of potatoes harvested	1	12
Area of wheat harvested	4	11
Area of barley harvested	4	13

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 3A.4 gives the sample errors based on a 95% confidence level for the survey data collected in 1999.

Table 3A.4 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

Annex 3.B Research on the carbon stocks in soils, scrub and natural forests

Major work in the LUCF sector includes research and implementing monitoring of the carbon stocks and fluxes in soils, shrublands and indigenous forests. This research was initiated by the MfE in 1996 and is being carried out jointly by two of New Zealand's Crown Research Institutes – Landcare Research and Forest Research. The research has provided information to fill some major gaps in the current inventory for LUCF including impacts of land-use change (including abandonment of managed lands). This five-year research project had the following objectives:

- The estimation of carbon storage in soils, shrublands and indigenous 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 indigenous 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 indigenous forests were consistent with current forest inventory practices in other countries. Furthermore, the soils that the system represented were 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 indigenous 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. The vegetation CMS records a range of standard tree and other botanical measurements and site characteristics for each 20x20m plot. 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.

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 sites will be established to monitor key changes in soil carbon when land-use changes (i.e. scrub to grassland and grassland to Kyoto forest and vice versa). The first four paired plots sites were established in 2003.

A nationwide Land Cover Database (LCDB1) which contains 18 land cover types was completed in 2000. SPOT satellite imagery from 1996/1997 provided the key information inputs to LCDB1. A further national mapping exercise for LCDB2 will be completed by July 2004. LCDB2 increases the number of land cover classes mapped (to 43) and improves the thematic depth for forest classes. LCDB2 is also likely to draw on ancillary land use data from annual landowner surveys.

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 the preparation of the New Zealand 2002 national greenhouse gas inventory, work started 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 2002 inventory

Tier 1 quality checks for key sources (as identified in the level analysis of the 2001 national inventory) were completed on the 2002 data. Two of these checklists with the results are included as examples in this Annex. Quality control checks on data in the energy sector for 2002 also checked previous year's data as the energy worksheets (provided by MED) are linked. Checks on Table 10 in the CRF were used to identify any outliers or inconsistencies in the trends from 1990-2002.

In addition to the QC checks undertaken with the Tier 1 QC checklists, a number of informal checks on the data were completed including checking sectoral spreadsheets and methodology reports for inconsistencies as well as visual checks once data were entered into the CRF. Checks on the energy sector data for anomalies and inconsistencies were carried out by officials both in the MED and the NZCCO. Trends from 1990 to 2002 were examined using data from 2002 (using new emission factors for energy) and data from 2001 for the energy and industrial processes sectors.

Some specific findings included:

- PFC emissions data reported in previous inventories (1980-1999) were found to be inconsistent with company supplied emissions. This was corrected for the 2002 inventory and previous CRF.
- An outlier identified in energy data for 2001 (using 2002 data). This was traced to the wrong emissions factor being used (petrol instead of gas) for liquid fuels. This was subsequently corrected.
- Some data in the solvent sectoral spreadsheet for 2000 were shifted up one line causing emissions not to line up with the source. These were corrected.

- Activity data for asphalt roofing were found to be inconsistent in previous years (1999 and some earlier years) with the values stated in 2000-2002 sectoral worksheets. This was traced to some confusion in previous years over total bitumen and asphalt roading activity data. It was confirmed with the consultant who carried out the industrial processes work that the value stated in the 2002 worksheet was the correct one.
- Several cell reference errors in energy files were picked up by MED officials and fixed by MED and NZCCO officials. A detailed document listing these errors and when they were fixed is filed on the computer network at the MfE.

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 2003 a review was undertaken of emission factors used in the energy sector. Most of the recommendations were implemented. A review of the industrial processes sector was also undertaken and the recommendations are being addressed.

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

Plans for the future are to implement the procedures outlined and scheduled in New Zealand's inventory QA/QC plan (refer 6A.3), specifically to:

- Hold a copy of CVs of people from external agencies who provide uncertainty estimates and who undertake expert reviews of part of the national inventory (expert qualifications).
- Quality control checks (Tier 1) extended to include some non key sources in the 2005 NIR (2003 data).
- Tier 1 checks to be revised where necessary to include all relevant checks on the NZ data (where possible) and this is to be reflected in the checklist.
- Start quality control (Tier 2) checks on some of the key sources.

A6.3 Quality control and quality assurance plan

Purpose of plan

New Zealand's greenhouse gas inventory quality control and quality assurance plan is designed to improve the transparency, consistency, comparability, completeness and confidence in the New Zealand national greenhouse gas inventory.

New Zealand's plan closely follows the definitions, guidelines and processes presented in Chapter 8 'Quality Assurance and Quality Control' of the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000).

Definitions

1. Quality Control: Quality Control (QC) comprises the routine technical activities used to measure and control the quality of the inventory as it is being developed.
2. Quality Assurance (QA) activities include a system of review procedures conducted by personnel not directly involved in the inventory compilation/development process.

Principles of the QC/QA plan

The QC/QA plan is intended to ensure transparency and quality of New Zealand's greenhouse gas inventory. The principles of the plan include:

- Applying greater QC effort for key source categories and for those source categories where data and methodological changes have occurred recently.
- Periodically checking the validity of all information as changes in sample size, methods of collection or frequency of data collection occur.
- Conducting the general procedures outlined in General QC Procedures (Tier 1) on all parts of the inventory over a period of time.
- Balancing efforts between development and implementation of QC/QA procedures and continuous improvement of inventory estimates.
- Customising the QC procedures to the resources available and the particular characteristics of New Zealand's greenhouse gas inventory.
- Confirming that national statistical agencies and other agencies supplying data to the inventory have implemented QC/QA procedures.

Responsibilities

The inventory agency responsible for co-ordinating the QC/QA plan is the New Zealand Climate Change Office (NZCCO). The NZCCO is also the lead agency for compiling New Zealand's greenhouse gas inventory.

The QC/QA plan

This document specifies the QC/QA procedures to be used in New Zealand's greenhouse gas inventory. The QC/QA plan also includes reporting, documentation and archiving procedures.

The plan is to have a 'living' document that can be modified as appropriate i.e. when changes in processes occur or on advice from independent reviewers.

QC/QA procedures

The QC procedures comprise general (Tier 1) procedures and source category-specific procedures (Tier 2).

Tier 1 procedures: the focus of Tier 1 QC techniques is on the processing, handling, documenting, archiving and reporting procedures that are common to all the inventory source categories. Tier 1 QC checks will be used routinely throughout the preparation of the annual inventory and will usually involve cross-checks, recalculation and/or visual inspections. The results of the Tier 1 activities and procedures will be documented as described in the 'Documentation, Archiving and Reporting' section in this Annex.

Tier 2 procedures: Tier 2 QC procedures are directed at specific types of data used for individual source categories. The source category-specific measures will be applied on a case-by-case basis focusing on key source categories and on source categories where significant methodological and data revisions have occurred. Source category-specific QC activities will include QC of emissions data, activity data and uncertainty estimates.

The QC procedures that need to be implemented by the inventory agency will depend on the method used to estimate the emissions for a given source category. Where emissions estimates are developed by outside agencies and the QC activities performed by the outside agency meet QC requirements, the QC activities of the outside agency will be referenced as part of the inventory QC.

The results of the Tier 2 activities and procedures will be documented as described in the 'Documentation, Archiving and Reporting' section in this Annex.

Quality Assurance: quality assurance procedures will involve external reviewers conducting an unbiased review of the national inventory or parts of the inventory.

Experts conducting reviews will complete the Documentation of Experts' Qualifications. The expert's qualifications will be reviewed by the NZCCO prior to commencing the review.

The results of the QA activities and procedures will be documented as described in the 'Documentation, Archiving and Reporting' section in this Annex.

QC/QA schedule:

The QC/QA procedures will be included in the 2002 inventory onwards.

Tier 1 QC: all key sources identified in the NIR of the previous year should undergo a Tier1 QC process every year. A selection of non-key source categories will be reviewed each year with the goal of ensuring all sectors are periodically reviewed.

Tier 2 QC: a selection of key sources identified in the NIR of the previous year will undergo a Tier 2 QC each year. The selection of sources will be determined from the contribution of the key source to New Zealand's national inventory, comments from the UNFCCC reviews of New Zealand's NIR and CRF tables, uncertainty in the emission estimates from categories and whether the category has undergone significant change in methodology or data.

QA: expert reviews of sectors will be undertaken as resources permit. It is anticipated to undertake at least one expert review every year. The priority for QA review is determined from the contribution of the key source or sector to New Zealand's national inventory, comments from the UNFCCC reviews of New Zealand's NIR and CRF tables, uncertainty in the emission estimates from categories, availability of expert reviewers and whether the category has undergone significant change in methodology or data.

Documentation, archiving and reporting

All information required to produce the national emissions inventory and the inventory itself (the NIR and accompanying CRF tables) will be documented and archived by the inventory agency.

Electronic copies of information will be stored in a clearly identified directory on the MfE's networked computer system and be archived by the MfE's standard network backup routine. No files necessary for the inventory will be stored on local computer hard drives.

Where emission estimates are developed by outside agencies, a copy of the necessary documentation will be held by the inventory agency.

Documentation will include sufficient information to enable all activity data, emission factors, uncertainty calculations, expert judgements and QC/QA information to be recalled, reproduced, justified or traced to the referenced source.

A summary of implemented QA/QC activities and key findings will be included in New Zealand's NIR.

A6.4 Example worksheets for QC procedures in 2002

TIER 1: INDIVIDUAL SOURCE CATEGORY CHECKLIST Ver 1.0

Inventory Checked: 2002

Source Category: 1A3b 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 2004 NIR (2002 data)**	**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. Ensure any recommended changes to emission factors from the energy sector have been implemented and correctly recorded in the NIR worksheets.	SoniaP 2/3/04; checked description of emission factors for petrol and diesel-these have changed from the 2003 NIR due to review of energy EFs (see Hale and Twomey report). The old petrol EF was 66.6 kt CO2/PJ. The new values used are 66.2 for all petrol until 1995 then 66.2 for regular petrol and 67.0 for premium petrol from 1996. The diesel EF has changed from 68.7 kt CO2/PJ to 69.5 (NZRC derived). Adequate description of activity data and emission factors in NIR	New emission factors used are those recommended by the review report of energy emission factors. The EF's in the NIR worksheet once converted from C to CO2 EF's are the same as those in the Hale and Twomey energy EF review.	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.	SoniaP 3/304; 1. visual check of module names in worksheets 1.1, 1.2 and 1.3 for all energy sector sub categories. 2.	Inconsistencies found in naming of modules on worksheets 1.1 and 1.2. The module name for worksheet 1.1 (1-3 of 5) was Energy 2002 (NZ) while further down table 1.1 (4-5 of 5) and 1.1(supplemental) were labelled as Energy 1990 (NZ). This also occurred in worksheet 1.2 between part 1 (labelled 2002) and part 2 (labelled 1990).	Contacted Stuart Black from MED who was involved with compiling the worksheets. He confirmed that the module titles with 1990 in them were wrong (copying error). The three incorrectly labeled module titles were corrected in the NIR worksheets.
	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.	SoniaP 3/3/04; 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 183,958 compared with 183,957.55 in the CRF. Test passed. 2. Value in Table 4.2 in MED report is 109.84 PJ while the aggregated petrol activity data in NIR worksheet 1.2 is 109.84 PJ (109842 TJ). Test passed.	None
Check that emissions are calculated correctly.	Reproduce a representative sample of emissions calculations.	Using the figures in the NIR worksheets, calculate emmissions manually (using calculator) and compare to emissions figure from worksheet.	SoniaP 3/304; Calculated CO2 emissions from road transportation (petrol and diesel) using figures from worksheet 1.2	Values calculated were 5611.17 Gg CO2 compared to 5597.05 in NIR worksheet (petrol-regular); 1623.52 compared to 1621.10 Gg CO2 in NIR (petrol-premium) and 4928.32 compared with 4916.53 Gg CO2 calculated in NIR for diesel. Differences are 0.15-0.25%. Test passed.	None
	Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.		SoniaP 3/3/04; Take petrol activity data from Table 4.2 in MED's Energy GHG emissions document (value is 109.84 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 7231 Gg CO2; Value in working spreadsheet is 7218.15 (regular & premium petrol aggregated together). Difference is 0.18%. 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	SoniaP 3/3/04; 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). Units missing on worksheet 1.2 (overview) for total energy consumption and CO2 emissions	Units (TJ for activity data and Gg for total CO2 emissions) have been added to the overview spreadsheet table.
	Check that units are correctly carried through from beginning to end of 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 CO2.	SoniaP 3/3/04: 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	None
			SoniaP 4/3/04; Check data is shown to 2 decimal places for final emissions estimates (Gg)	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. Worksheet 1.2 (overview) does not show any decimal places for final CO2 emissions.	CO2 emissions in worksheet 1.2 (overview) changed to 2 decimal places to be consistent with other tables.
	Check that temporal and spatial adjustment factors are used correctly.				

Tier 1 QC Activity & Procedures					
QC Activity	**Procedures**	**Procedures adopted for 2004 NIR (2002 data)**	**Brief description of check applied (include date/person & reference if required)**	**Results of check (include reference if required)**	**Corrective Actions Taken**
Check the integrity of database and/or spreadsheet files.	Confirm that the appropriate data processing steps are correctly represented in the database.				
	Confirm that data relationships are correctly represented in the database.	1. Check labels on NIR worksheets are consistent with previous year's NIR 2. Ensure the addition or deletion of datalines are adequately explained			
	Ensure that data fields are properly labelled and have the correct design specifications.		SoniaP 3/3/04; 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 energy sector EF review	None
	Ensure that adequate documentation of database and model structure and operation are archived.	energy sector-Al production agricultural sector-use of animal numbers for methane and nitrous oxide emission calculations			
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 the totals (activity data and emissions) in the overview/summary tables in the NIR worksheets reference to the correct cells in the sectoral worksheets.	SoniaP 5/4/04; Check mobile road combustion activity data and CO2 emissions totals from worksheet 1.2 and the overview worksheet.	Activity data exactly the same and CO2 emissions 12,293 in worksheet 1.2 compared with 12,292.63 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.	no check in 2002 apart from other checks already done on checking NIR worksheets and CRF. In the future checks on the QA/QC procedures of external agencies (MED, MAF, Statistics NZ & contractors) will show correct transcription between intermediate worksheets/reports & final NIR worksheets & CRF.	SoniaP 4/3/04; Check road transportation energy consumption and CO2 emissions totals from worksheet 1.2 and the overview worksheet.	Energy consumption totals are the same-visual inspection checked cells correctly referenced from overview table to sectoral worksheet 1.2.	None
	Check that emissions data are correctly transcribed between different intermediate products				
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.				
	If necessary, duplicate error calculations or a small sample of the probability distributions used by Monte Carlo analyses.				

Tier 1 QC Activity & Procedures					
QC Activity	**Procedures**	**Procedures adopted for 2004 NIR (2002 data)**	**Brief description of check applied (include date/person & reference if required)**	**Results of check (include reference if required)**	**Corrective Actions Taken**
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.				
	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	SoniaP 4/3/03; 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.	Found reports stored on MfE computer network: m:\ClimateChange\greenhouse gas inventory\sector information\Energy * 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 methodological and data changes resulting in recalculations.	Check for temporal consistency in time series input data for each source category.				
	Check for consistency in the algorithm/method used for calculations throughout the time series.	Check table 10 in CRF to ensure source category data is entered for all years-1990 to 2002.	SoniaP 1/4/04; Check Table 10 for completeness	energy sector is complete in Table 10-sheets s1-s3 and s5.	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.				
	Check that known data gaps that result in incomplete source category emissions estimates are documented.				
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 Table 10 estimates for all previous years and explain any significant changes. Make sure changes due to the energy sector EFs are documented in table 8(b) of the CRF.	SoniaP 5/4/04; Graphed transport from Table10s1, s3 and s3 to find any outliers or inconsistencies.	Found drop in CH_4 emissions from ~7 Gg to ~2 Gg (1996-2001). When checking summary tables in the CRF for for those particular years found the values around 2Gg were incorrect. Looks like data was entered in the incorrect dataline.	Corrected CH_4 emissions from transport in Table 10 from 1996-2001 for CRFs 1997-2002.

TIER 1: INDIVIDUAL SOURCE CATEGORY CHECKLIST Ver 1.0

Inventory Checked: 2002

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 2004 NIR (2002 data)**	**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. Ensure any recommended changes to emission factors from the energy sector have been implemented and correctly recorded in the NIR worksheets.	SoniaP 1/4/04; checked description of activity data and emission factors in the 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.	SoniaP 1/4/04; 1. visual check of module names in NIR worksheets for all agriculture sources. 2.	The year 2001 was still on the name of the tables in timeseries ag data rev 2004.xls (animal number tables). Other tables were correctly named with the year 2002.	Tables were updated with titles using correct years.
	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.	SoniaP 1/4/04; 1. Visual check by comparing enteric fermentation figures from NIR worksheet 4.1 with CRF Table 4s1.	1. Total value in NIR worksheet was 1123.08Gg compared with 1123.08Gg. 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 (using calculator) and compare to emissions figure from worksheet.	SoniaP 1/4/04; Calculated dairy cattle CH4 enteric fermentation emissions using figures from worksheet 4.1	Value calculated was 372.66 Gg compared with 372.52 Gg on the worksheet. Test passed.	None
	Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.				
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	SoniaP 1/4/04; visual inspection of units labelled in worksheets 4.1-4.5 and all related tables in agricultural sector.	Units labelling O.K for all worksheets in agricultural sector.	None
	Check that units are correctly carried through from beginning to end of 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 CO2.	SoniaP 1/4/04; Checked conversion from kg (kg/head/yr as emission factor) to Gg for final emissions for CH4 (for enteric fermentation & manure management) were taken into account in NIR worksheet 4.1	Conversion factors are correct	None
	Check that temporal and spatial adjustment factors are used correctly.				

QC Activity	Procedures	Procedures adopted for 2004 NIR (2002 data)	Brief description of check applied (include date/person & reference if required)	Results of check (include reference if required)	Corrective Actions Taken
Check the integrity of database and/or spreadsheet files.	Confirm that the appropriate data processing steps are correctly represented in the database.				
	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 datalines are adequately explained	SoniaP 1/4/04; Visual check- compared data field labels for worksheets in 2004 NIR with those in 2003.	Consistent with tabels and worksheet labels in 2003 NIR	None
	Ensure that adequate documentation of database and model structure and operation are archived.				
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.	energy sector-Al production agricultural sector-use of animal numbers for methane and nitrous oxide emission calculations	SoniaP 5/4/04; Checked animal numbers in NIR worksheet and CRF tables for consistency	NIR worksheet 4.1 and CRF tables 4A and 4B(a) consistent. Found Table 4B(b) values for swine (356 vs 351), goats (165 vs 155) and poultry (20864 vs 20917) were inconsistent with those in NIR worksheet.	Corrected swine, goat and poultry numbers in Table 4B(b) of CRF
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.	Check the totals (activity data and emissions) in the overview/summary tables in the NIR worksheets reference to the correct cells in the sectoral worksheets.	SoniaP 5/4/04; Visual check of enteric fermentation values in Summary1As2 sheet with table 10s2 in CRF. Also checked correct summation of CH4 from different animal classes in Table 4s1.	All total values of CH4 from enteric fermentation agree between summary sheets at 1123.08Gg.	None
	Check that emissions data are correctly transcribed between different intermediate products	no check in 2002 apart from other checks already done on checking NIR worksheets and CRF. In the future checks on the QA/QC procedures of external agencies (MED, MAF, Statistics NZ & contractors) will show correct transcription between intermediate worksheets/reports & final NIR worksheets & CRF.			
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.				
	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.				
	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	SoniaP 5/4/04; Ensure report on methane emissions from enteric fermentation is stored in an easily accessible place.	Found report in Len Brown's office-Ag Sector Methane Filemaster box	None
	Check integrity of any data archiving arrangements of outside organisations involved in inventory preparation.				

Tier 1 QC Activity & Procedures					
Check methodological and data changes resulting in recalculations.	Check for temporal consistency in time series input data for each source category.				
	Check for consistency in the algorithm/method used for calculations throughout the time series.				
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.	Check table 10 in CRF to ensure source category data is entered for all years-1990 to 2002.	SoniaP 5/4/04; Check Table 10s2 (CH4) for enteric fermentation is filled out for years 1990-2002	Table 10s2 is completed.	None
	Check that known data gaps that result in incomplete source category emissions estimates are documented.				
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 Table 10 estimates for all previous years and explain any significant changes. Make sure changes due to the energy sector EFs are documented in table 8(b) of the CRF.	SoniaP 5/4/04; Visual check of Table 10s2 to look for any outliers for the time period 1990-2002	No outliers detected	None

A6.5 QA summary worksheet

QUALITY ASSURANCE CHECKLIST

Includes all reviews up to and including the 2002 Inventory Report:

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								
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	Not documented. 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.	Hard copy kept in NZCCO office
	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	Not documented (prior to QA procedures developed) 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 NZCCO office
	Review of Energy Sector Greenhouse Gas Emissions Factors. A report to the Energy Modelling and Statistics Unit of the Ministry of Economic Development. (as a response to the previous reviews by T.S. Clarkson)	March 2003	Hale & Twomey Limited Level 4, Gleneagles building 69-71 The Terrace POBox 10444 Wellington New Zealand.	Not documented (prior to QA procedures developed)	To undertake a review of the energy sector emissions factors used in NZ's GHG inventury and to recommend what emissions factors should be used for each GHG and what further work the Ministry should arrange.	1. Changes recommended for the vast majority of emissions factors, including reverting to IPCC recommended factor. 2. Methodology could also be improved eg by splitting petrol to premium and regular. 3. Further work includes - review of coal CO2 emissions factors, review of coal CH4 fugitive emissions, routine updating of gas emissions moving to tier 3 calculation for Transport (MOT's Vehicle Fleet emissions model). 4. NZ standardise on kt/PJ as standard unit 5. Show emission factors to sufficient significant digits to indicate where grossing down has occurred.	1. Addressed-new recommended factors being used in 2004 inventory report. 2. Addressed-this has been implemented in 2004 inventory report. 3. This will depend on the time and resources of MED... 4. Consensus has not been reached on this issue. 5. This is addressed in the 2004 inventory report.	Hard copy kept in NZCCO office with draft also stored on Mfe computer 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.	Hard copy kept in NZCCO office with draft also stored on Mfe computer network.

QUALITY ASSURANCE CHECKLIST

Includes all reviews up to and including the 2002 Inventory Report:

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)				Papers kept in Ag sector filemaster box in NZCCO
	Report to MAF: Revised Nitrous Oxide Emissions from New Zealand Agricultural Soil: 1990-2001	2003	F.M. Kelliher, S.F. Ledgard, H. Clark, A.S. Walcroft, M. Buchan & R.R. Sherlock	Not documented (prior to QA procedures developed)	Revision of nitrous oxide emissions from agricultural soils 1990-2001-including recommendations for inventory improvement	1. N_2O emissions from grazing animal's urine & dung excreta should be estimated using separate emission factors (these to be determined from available & future measurements of NzOnet). 2. Grazing animal feed intake should be determined by the model by Clark et.al. to connect N_2O and CH_4 emissions inventories. 3. Nitrogen excretion by grazing animals should be determined using model OVERSEER 4. Sales records should be used to determine N fertiliser use.	1. Not able to be done at present-explanation in NIR. 2. Has been addressed-model used. 3. Has been addressed-model used 4. Has been addressed-sales records now used.	Report kept in Ag sector filemaster box in NZCCO
	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 NZCCO
Expert review of Land use change and forestry Sector								
Expert review of Waste Sector								

Annex 7:

Uncertainty analysis (Table 6.1 of the IPCC good practice guidance)

Uncertainty analysis (Table 6.1 of the IPCC good practice guidance)

Uncertainty calculation for the New Zealand Greenhouse Gas Inventory 1990 - 2002 (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 total national emissions in year t	type A sensitivity	type b sensitvity	uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
Energy sector	CO_2	22850.60	30815.77	5	0	5	2.06	0.0489	0.5003	0.0000	3.5374	3.54
Industrial processes sector	CO_2	2403.65	2954.03	5	0	5	0.20	0.0005	0.0480	0.0000	0.3391	0.34
Energy sector	CH_4	749.78	987.54	5	50	50	0.66	0.0012	0.0160	0.0613	0.1134	0.13
CRF2A - mineral products	CH_4	0.00	0.00	25	75	79	0.00	0.0000	0.0000	0.0000	0.0000	0.00
CRF2B - chemical industry	CH_4	2.52	97.09	45	120	128	0.17	0.0015	0.0016	0.1832	0.1003	0.21
CRF4A - enteric fermentation	CH_4	21371.91	23584.68	1	46	46	14.48	-0.0390	0.3829	-1.7950	0.5415	1.87
CRF4B - manure management	CH_4	573.09	548.00	1	90	90	0.66	-0.0024	0.0089	-0.2178	0.0126	0.22
CRF4E- prescribed burning	CH_4	2.81	0.84	20	50	54	0.00	0.0000	0.0000	-0.0021	0.0004	0.00
CRF4F - burning of residues	CH_4	18.77	22.49	50	40	64	0.02	0.0000	0.0004	-0.0002	0.0258	0.03
CRF5B - forest and grassland conversion	CH_4	88.89	86.14	100	100	141	0.16	-0.0004	0.0014	-0.0357	0.1978	0.20
CRF 6A - Solid waste disposal	CH_4	2606.10	2066.40	35	10	35	0.97	-0.0179	0.0335	-0.1791	1.6605	1.67
CRF 6B - wastewater handling	CH_4	156.66	169.68	60	10	60	0.14	-0.0003	0.0028	-0.0034	0.2337	0.23
Energy sector	N_2O	146.47	243.91	5	50	50	0.16	0.0011	0.0040	0.0534	0.0280	0.06
CRF4D -Agricultural soils	N_2O	9889.17	12617.71	1	80	80	13.47	0.0095	0.2048	0.7632	0.2897	0.82
CRF4B - manure management	N_2O	48.36	75.33	1	90	90	0.09	0.0003	0.0012	0.0241	0.0017	0.02
CRF4E- prescribed burning	N_2O	0.53	0.16	20	50	54	0.00	0.0000	0.0000	-0.0004	0.0001	0.00
CRF4F - burning of residues	N_2O	6.51	7.44	50	30	58	0.01	0.0000	0.0001	-0.0002	0.0085	0.01
CRF5B - forest and grassland conversion	N_2O	8.99	8.68	100	100	141	0.02	0.0000	0.0001	-0.0037	0.0199	0.02
CRF6B - wastewater handling	N_2O	145.70	158.10	10	1100	1100	2.32	-0.0003	0.0026	-0.3416	0.0363	0.34
CRF2F	HFCs	0.00	387.59	120	0	120	0.62	0.0063	0.0063	0.0000	1.0678	1.07
CRF2C	PFCs	515.60	83.50	30	0	30	0.03	-0.0088	0.0014	0.0000	0.0575	0.06
CRF2F	SF_6	12.33	12.91	10	0	10	0.00	0.0000	0.0002	0.0000	0.0030	0.00
Total		**61598.43**	**74927.98**		**Uncertainty in the year**		**20.1%**		**Uncertainty in the trend**			**4.6%**

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).

4. Agricultural soils uncertainty data calculated from normal distribution used in Monte Carlo Simulation (97.5 percentile - mean)/ mean *100

Annex 8:

Trend tables from the 2002 Common Reporting Format

Trend tables from the 2002 Common Reporting Format

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

New Zealand
2002
2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year [1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	(Gg)													
1. Energy	0.00	22,850.60	23,227.57	24,899.30	24,166.82	24,316.24	24,299.74	25,254.62	27,347.76	25,923.26	27,537.19	28,057.58	30,107.30	30,815.77
A. Fuel Combustion (Sectoral Approach)	0.00	22,235.41	22,527.32	24,232.60	23,538.92	23,640.35	23,674.62	24,612.42	26,678.16	25,271.34	26,921.53	27,478.41	29,489.82	30,205.73
1. Energy Industries		6,030.84	6,114.13	7,500.53	6,558.31	5,418.62	4,688.87	5,278.54	6,876.80	5,200.61	6,529.92	6,153.76	7,623.41	6,725.22
2. Manufacturing Industries and Construction		4,727.81	5,149.31	4,758.26	4,916.94	5,320.78	5,481.36	5,813.08	5,893.68	5,871.76	5,853.89	6,147.49	6,254.82	6,175.40
3. Transport		8,617.20	8,625.04	9,007.58	9,397.20	10,125.83	10,844.47	11,001.94	11,254.78	11,448.92	11,726.47	12,351.26	12,755.56	13,899.39
4. Other Sectors		2,855.17	2,640.54	2,914.44	2,626.47	2,775.12	2,659.92	2,518.93	2,654.90	2,751.82	2,812.26	2,825.89	2,855.21	3,205.77
5. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Fugitive Emissions from Fuels	0.00	615.19	700.34	666.69	627.91	675.89	625.12	642.19	669.60	650.92	614.65	579.16	618.49	610.04
1. Solid Fuels		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Oil and Natural Gas		615.19	700.34	666.69	627.91	675.89	625.12	642.19	669.60	650.92	614.65	579.16	618.49	610.04
2. Industrial Processes	0.00	2,403.65	2,529.26	2,665.28	2,794.97	2,692.61	2,770.36	2,764.96	2,632.45	2,761.26	2,883.44	2,853.99	2,932.52	2,954.02
A. Mineral Products		408.28	437.16	500.52	533.25	565.96	586.02	588.91	598.68	574.81	638.25	629.77	627.61	652.42
B. Chemical Industry		152.29	166.66	158.18	161.06	178.21	142.58	166.76	158.49	176.79	177.28	182.92	187.16	197.48
C. Metal Production		1,843.08	1,925.44	2,006.58	2,080.67	1,948.44	2,041.76	2,017.58	1,875.28	2,010.83	2,067.91	2,041.30	2,118.74	2,104.16
D. Other Production														
E. Production of Halocarbons and SF_6														
F. Consumption of Halocarbons and SF_6														
G. Other														
3. Solvent and Other Product Use														
4. Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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 Change and Forestry [3]	0.00	-21,763.75	-20,429.65	-17,984.79	-15,678.99	-14,732.17	-15,195.42	-15,404.05	-17,168.25	-20,200.51	-21,990.03	-23,642.98	-23,974.26	-24,171.26
A. Changes in Forest and Other Woody Biomass Stocks		-22,994.00	-22,087.00	-20,403.00	-18,853.00	-18,258.00	-18,015.00	-18,478.00	-19,954.00	-21,917.00	-24,044.00	-25,760.00	-26,325.00	-26,057.00
B. Forest and Grassland Conversion		870.01	1,319.22	2,001.49	2,722.71	3,030.00	2,279.22	2,569.44	2,251.92	1,131.33	1,421.49	1,435.22	1,619.61	1,107.29
C. Abandonment of Managed Lands														
D. CO_2 Emissions and Removals from Soil		360.24	338.13	416.72	451.29	495.83	540.36	484.51	533.83	585.16	632.48	681.80	731.13	780.45
E. Other														
6. Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A. Solid Waste Disposal on Land														
B. Waste-water Handling														
C. Waste Incineration														
D. Other														
7. Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Emissions/Removals with LUCF [4]	0.00	3,490.49	5,327.18	9,579.79	11,282.81	12,276.68	11,874.68	12,615.53	12,811.95	8,484.01	8,430.60	7,268.59	9,066.77	9,598.54
Total Emissions without LUCF [4]	0.00	25,254.24	25,756.83	27,564.58	26,961.80	27,008.85	27,070.10	28,019.58	29,980.20	28,684.53	30,420.63	30,911.57	33,041.03	33,769.80
Memo Items:														
International Bunkers	0.00	2,374.00	2,195.89	2,177.11	2,244.33	2,754.99	2,692.76	2,695.84	2,819.32	2,772.71	2,856.89	2,502.19	2,678.40	2,913.11
Aviation		1,341.23	1,281.50	1,310.96	1,329.64	1,431.51	1,568.50	1,634.51	1,700.87	1,700.51	1,942.07	1,756.67	1,879.98	1,861.91
Marine		1,032.87	914.35	866.15	914.70	1,323.49	1,124.26	1,061.34	1,118.45	1,072.20	914.82	745.52	798.42	1,051.20
Multilateral Operations														
CO_2 Emissions from Biomass		2,687.11	2,883.76	2,718.36	2,864.17	3,260.29	3,287.03	3,266.18	2,924.80	3,077.82	3,097.42	3,108.03	3,113.71	3,918.96

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

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[(1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
							(Gg)							
Total Emissions	**0.00**	**1,217.44**	**1,213.29**	**1,193.99**	**1,212.32**	**1,225.12**	**1,242.28**	**1,251.20**	**1,245.61**	**1,256.33**	**1,262.74**	**1,284.68**	**1,309.67**	**1,312.32**
1. Energy	**0.00**	**35.70**	**32.48**	**32.99**	**32.75**	**34.76**	**36.98**	**43.89**	**39.80**	**41.85**	**45.31**	**44.30**	**45.47**	**47.03**
A. Fuel Combustion (Sectoral Approach)	0.00	10.70	10.82	10.61	10.63	10.42	10.38	10.23	10.26	10.17	10.06	10.16	10.28	10.96
1. Energy Industries		0.26	0.28	0.33	0.29	0.24	0.20	0.22	0.27	0.21	0.26	0.26	0.31	0.26
2. Manufacturing Industries and Construction		0.41	0.44	0.42	0.42	0.49	0.51	0.53	0.48	0.51	0.52	0.54	0.53	0.65
3. Transport		7.22	7.13	7.19	7.21	7.20	7.23	7.07	7.09	7.05	6.93	7.04	7.12	7.79
4. Other Sectors		2.81	2.54	2.50	2.70	2.50	2.45	2.41	2.42	2.41	2.35	2.33	2.24	2.26
5. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Fugitive Emissions from Fuels	0.00	25.81	22.06	22.58	22.12	24.34	26.80	32.65	29.54	31.68	35.25	34.14	35.27	36.07
1. Solid Fuels		10.80	8.74	8.88	8.71	10.19	12.90	19.98	13.63	16.74	16.84	16.34	16.97	16.86
2. Oil and Natural Gas		15.01	14.32	13.67	13.41	14.15	13.89	13.67	15.91	16.94	18.41	17.80	18.29	19.21
2. Industrial Processes	**0.00**	**0.12**	**0.12**	**0.10**	**0.12**	**0.12**	**0.12**	**0.10**	**2.51**	**3.31**	**4.13**	**4.99**	**4.42**	**4.62**
A. Mineral Products		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Chemical Industry		0.12	0.12	0.10	0.12	0.12	0.12	0.10	2.51	3.31	4.13	4.99	4.42	4.62
C. Metal Production														
D. Other Production														
E. Production of Halocarbons and SF_6		0	0	0	0	0	0	0	0	0	0	0	0	
F. Consumption of Halocarbons and SF_6		0	0	0	0	0	0	0	0	0	0	0	0	
G. Other		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3. Solvent and Other Product Use		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	
4. Agriculture	**0.00**	**1,046.83**	**1,042.11**	**1,039.09**	**1,055.88**	**1,069.98**	**1,084.53**	**1,087.14**	**1,090.99**	**1,097.69**	**1,102.67**	**1,127.90**	**1,151.18**	**1,150.29**
A. Enteric Fermentation		1,017.71	1,014.22	1,011.41	1,028.11	1,041.74	1,056.85	1,058.63	1,062.77	1,069.75	1,075.87	1,100.60	1,123.97	1,123.08
B. Manure Management		27.29	26.94	26.61	26.78	27.13	27.45	27.45	27.12	26.85	26.57	26.27	26.12	26.10
C. Rice Cultivation		NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
D. Agricultural Soils		NE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
E. Prescribed Burning of Savannas		0.11	0.13	0.13	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.04	0.04	0.04
F. Field Burning of Agricultural Residues		0.89	0.92	0.98	0.94	0.95	0.96	1.08	1.05	1.05	0.99	0.99	1.04	1.07
G. Other		NE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5. Land-Use Change and Forestry	**0.00**	**4.23**	**2.89**	**4.42**	**5.65**	**6.35**	**6.12**	**6.91**	**7.52**	**6.15**	**5.47**	**4.40**	**4.28**	**4.10**
A. Changes in Forest and Other Woody Biomass Stocks														
B. Forest and Grassland Conversion		4.23	2.89	4.42	5.65	6.35	6.12	6.91	7.52	6.15	5.47	4.40	4.28	4.10
C. Abandonment of Managed Lands														
D. CO_2 Emissions and Removals from Soil														
E. Other														
6. Waste	**0.00**	**131.56**	**133.60**	**117.43**	**117.96**	**113.99**	**114.51**	**113.16**	**104.79**	**105.32**	**105.16**	**103.09**	**104.32**	**106.48**
A. Solid Waste Disposal on Land		124.30	126.10	109.90	110.48	106.40	106.90	105.50	97.10	97.60	97.40	95.30	96.50	98.40
B. Waste-water Handling		7.46	7.50	7.53	7.36	7.59	7.61	7.66	7.69	7.72	7.76	7.79	7.82	8.08
C. Waste Incineration														
D. Other														
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
		NE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Memo Items:		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	
International Bunkers	**0.00**	**0.15**	**0.12**	**0.11**	**0.12**	**0.16**	**0.15**	**0.14**	**0.15**	**0.14**	**0.13**	**0.11**	**0.12**	**0.14**
Aviation		0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Marine		0.13	0.09	0.09	0.09	0.13	0.11	0.10	0.11	0.10	0.09	0.07	0.08	0.10
Multilateral Operations														
CO_2 Emissions from Biomass		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	

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

New Zealand
2002
2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
							(Gg)							
Total Emissions	**0.00**	**33.18**	**33.25**	**33.61**	**34.66**	**35.86**	**36.71**	**37.07**	**37.24**	**37.70**	**38.36**	**39.64**	**41.33**	**42.45**
1. Energy	**0.00**	**0.47**	**0.47**	**0.50**	**0.52**	**0.56**	**0.59**	**0.60**	**0.62**	**0.62**	**0.65**	**0.68**	**0.70**	**0.78**
A. Fuel Combustion (Sectoral Approach)	0.00	0.47	0.47	0.50	0.52	0.56	0.59	0.60	0.62	0.62	0.65	0.68	0.70	0.78
1. Energy Industries		0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.03	0.03	0.03	0.03
2. Manufacturing Industries and Construction		0.12	0.12	0.12	0.13	0.14	0.14	0.14	0.15	0.15	0.13	0.13	0.14	0.16
3. Transport		0.24	0.24	0.26	0.28	0.31	0.33	0.34	0.36	0.37	0.39	0.42	0.43	0.47
4. Other Sectors		0.09	0.08	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.12
5. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Fugitive Emissions from Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid Fuels		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Oil and Natural Gas		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Industrial Processes	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A. Mineral Products		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Chemical Industry		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. Metal Production		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Other Production														
E. Production of Halocarbons and SF_6														
F. Consumption of Halocarbons and SF_6														
G. Other														
3. Solvent and Other Product Use		**0.13**	**0.14**	**0.14**	**0.14**	**0.14**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.16**
4. Agriculture	**0.00**	**32.09**	**32.14**	**32.46**	**33.48**	**34.63**	**35.44**	**35.79**	**35.93**	**36.38**	**37.02**	**38.27**	**39.93**	**40.97**
A. Enteric Fermentation														
B. Manure Management		0.16	0.16	0.16	0.17	0.18	0.19	0.20	0.21	0.21	0.22	0.23	0.24	0.24
C. Rice Cultivation														
D. Agricultural Soils		31.90	31.96	32.27	33.29	34.43	35.22	35.56	35.70	36.15	36.78	38.03	39.67	40.70
E. Prescribed Burning of Savannas		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F. Field Burning of Agricultural Residues		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
G. Other														
5. Land-Use Change and Forestry	**0.00**	**0.03**	**0.03**	**0.03**	**0.04**	**0.04**	**0.04**	**0.05**	**0.05**	**0.04**	**0.04**	**0.03**	**0.03**	**0.03**
A. Changes in Forest and Other Woody Biomass Stocks														
B. Forest and Grassland Conversion		0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.04	0.04	0.03	0.03	0.03
C. Abandonment of Managed Lands														
D. CO_2 Emissions and Removals from Soil														
E. Other														
6. Waste	**0.00**	**0.47**	**0.47**	**0.48**	**0.48**	**0.48**	**0.49**	**0.49**	**0.49**	**0.50**	**0.50**	**0.50**	**0.51**	**0.52**
A. Solid Waste Disposal on Land														
B. Waste-water Handling		0.47	0.47	0.48	0.48	0.48	0.49	0.49	0.49	0.50	0.50	0.50	0.51	0.52
C. Waste Incineration														
D. Other														
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:														
International Bunkers	**0.00**	**0.05**	**0.05**	**0.05**	**0.05**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.05**	**0.05**	**0.06**
Aviation		0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Marine		0.03	0.03	0.02	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03
Multilateral Operations		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

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

New Zealand
2002
2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	(Gg)													
Emissions of HFCs[3] - CO_2 equivalent (Gg)	0.00	0.00	0.00	1.82	5.46	25.79	83.86	139.88	114.20	218.66	174.81	173.25	254.17	387.59
HFC-23														
HFC-32		0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0074	0.0000	0.0001	0.0009
HFC-41														
HFC-43-10mee														
HFC-125		0.0000	0.0000	0.0000	0.0001	0.0012	0.0085	0.0067	0.0185	0.0093	0.0104	0.0041	0.0128	0.0194
HFC-134														
HFC-134a		0.0000	0.0000	0.0014	0.0042	0.0160	0.0299	0.0716	0.0378	0.1128	0.0757	0.1054	0.1239	0.1922
HFC-152a		0.0000	0.0000	0.0000	0.0000	0.0001	0.0012	0.0004	0.0002	0.0004	0.0017	0.0006	0.0000	0.0000
HFC-143														
HFC-143a		0.0000	0.0000	0.0000	0.0000	0.0004	0.0079	0.0071	0.0095	0.0094	0.0130	0.0064	0.0189	0.0216
HFC-227ea		0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0001
HFC-236fa														
HFC-245ca														
Emissions of PFCs[3] - CO_2 equivalent (Gg)	0.00	515.60	651.64	638.10	524.80	183.60	147.90	265.40	166.20	138.20	74.20	59.25	59.25	83.90
CF_4		0.0680	0.0844	0.0830	0.0680	0.0240	0.0190	0.0180	0.0210	0.0180	0.0100	0.0077	0.0077	0.0110
C_2F_6		0.0080	0.0112	0.0110	0.0090	0.0030	0.0020	0.0040	0.0030	0.0010	0.0010	0.0010	0.0010	0.0010
C_3F_8		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0048	0.0001	0.0000	0.0000	0.0000	0.0000	0.0004
C_4F_{10}														
$c\text{-}C_4F_8$														
C_5F_{12}														
C_6F_{14}														
Emissions of SF_6[3] - CO_2 equivalent (Gg)	0.00	12.33	12.88	13.69	14.10	14.41	15.01	14.79	15.30	31.07	33.46	11.95	12.05	12.91
SF_6		0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0013	0.0014	0.0005	0.0005	0.0005

Chemical	GWP
HFCs	
HFC-23	11700
HFC-32	650
HFC-41	150
HFC-43-10mee	1300
HFC-125	2800
HFC-134	1000
HFC-134a	1300
HFC-152a	140
HFC-143	300
HFC-143a	3800
HFC-227ea	2900
HFC-236fa	6300
HFC-245ca	560
PFCs	
CF_4	6500
C_2F_6	9200
C_3F_8	7000
C_4F_{10}	7000
$c\text{-}C_4F_8$	8700
C_5F_{12}	7500
C_6F_{14}	7400
SF_6	23900

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

New Zealand
2002
2004

GREENHOUSE GAS EMISSIONS	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	CO_2 equivalent (Gg)													
Net CO_2 emissions/removals		3,490.49	5,227.18	8,579.79	11,282.81	12,276.68	11,874.68	12,535.53	12,811.95	8,084.02	8,418.66	7,268.59	9,666.77	9,598.34
CO_2 emissions (without LUCF)[2]		25,234.24	25,796.83	27,564.58	26,901.80	27,808.85	27,878.30	28,019.58	29,980.28	28,684.53	30,428.63	30,811.57	33,841.83	33,789.80
CH_4		25,570.53	25,481.24	25,073.78	25,458.73	25,727.52	26,087.78	26,275.24	26,157.84	26,283.08	26,517.51	26,877.54	27,303.11	27,562.86
N_2O		10,287.26	10,387.76	10,618.23	10,766.03	11,116.73	11,379.22	11,491.36	11,546.09	11,087.03	11,098.64	12,285.76	12,811.47	13,159.68
HFCs		0.00	0.00	1.82	5.46	25.79	83.80	139.08	114.28	210.08	174.81	173.25	254.17	187.59
PFCs		315.60	651.64	618.18	524.80	383.60	107.50	265.40	166.28	138.78	74.28	59.25	59.25	83.90
SF_6		12.35	12.88	13.62	14.10	14.41	15.81	14.79	15.38	11.07	13.46	11.95	12.83	12.91
Total (with net CO_2 emissions/removals)		**39,876.22**	**41,780.78**	**45,725.34**	**48,851.93**	**49,344.74**	**49,588.85**	**50,721.61**	**50,889.58**	**46,924.06**	**47,121.21**	**46,778.34**	**49,706.81**	**50,885.08**
Total (without CO_2 from LUCF)[2][4]		**61,639.97**	**62,230.38**	**63,718.13**	**63,718.92**	**64,876.91**	**64,783.47**	**66,205.66**	**67,977.83**	**67,126.57**	**69,211.24**	**70,419.32**	**73,681.87**	**74,976.54**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	CO_2 equivalent (Gg)													
1. Energy		23,746.84	24,077.09	25,747.77	25,816.36	25,228.78	25,259.53	26,362.69	28,175.86	27,037.86	28,698.26	29,396.46	31,280.41	32,047.22
2. Industrial Processes		2,924.09	3,196.78	3,320.98	3,241.76	2,818.95	2,819.24	3,180.37	2,980.85	3,205.01	3,252.58	3,202.31	3,251.81	3,535.12
3. Solvent and Other Product Use		41.54	42.78	43.09	43.71	44.32	44.95	45.88	46.19	46.58	46.81	47.12	47.43	48.34
4. Agriculture		31,911.15	31,852.85	31,881.53	32,552.69	33,203.29	33,768.85	33,922.78	34,048.48	34,538.23	34,611.98	35,558.95	36,351.55	36,856.64
5. Land-Use Change and Forestry[3]		-21,663.87	-20,339.59	-17,882.65	-15,548.31	-14,585.26	-15,853.51	-15,324.37	-16,990.29	-20,858.26	-21,863.67	-23,541.39	-21,875.33	-24,076.48
6. Waste		2,988.46	2,951.38	2,614.83	2,625.96	2,542.56	2,557.83	2,528.36	2,552.49	2,266.72	2,363.54	2,219.89	2,348.82	2,294.18
7. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[2] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO_2 emissions and removals from Land-Use Change and Forestry.

[3] Net emissions.

[4] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table Summary2 if Parties report non-CO2 emissions from LUCF.

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