Climate Change
The New Zealand Response II
New Zealand's Second National Communication under the Framework Convention on Climate Change

JUNE 1997

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New Zealand's Second National Communication
under the Framework Convention on Climate Change
ERRATA SHEET

New Zealand recently provided emissions data to the Framework Convention on Climate Change (FCCC) Secretariat in its Second National Communication. For the first time, emissions data on sulphur hexafluoride (SF_6) were reported. However, the initial methodology used for producing SF_6 inventory data was flawed. New data is now provided.

The FCCC requires that Parties report potential emissions of SF_6. In addition to providing the revised data on potential SF_6 emissions, Table 1 includes an estimate of actual emissions, using the advanced IPCC methodology.

Table 1: Summary of SF_6 Emissions Estimates in New Zealand

Year	SF_6 Emissions (Gg)		
	Emissions reported in NZ's Second National Communication	**Potential Emissions**	**Actual Emissions and Projections**
1990	0.023	0.0009	0.0002
1991	0.021	0.0023	0.0002
1992	0.007	0.0014	0.0002
1993	0.023	0.0021	0.0002
1994	0.184	0.0018	0.0002
1995	0.182	0.0016	0.0002
2000	0.212	0.0031	0.0003
2005	0.246	0.0035	0.0003
2010	0.285	0.0037	0.0004
2020	0.383	0.0053	0.0142

Source: Montgomery Watson, June 1997.[1]

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[1] 'An Assessment of SF_6 Emissions Data, Issues and Mitigation Options'. Montgomery Watson, June 1997. Report commissioned by the Ministry for the Environment .

1 Foreword

International efforts to address the global issue of climate change have reached a mid point between the entry into force of the Framework Convention on Climate Change in March 1994, and the year 2000 target date for developed country commitments. It is appropriate in this context for New Zealand to be presenting its second national communication. This communication provides a mid-course report on New Zealand's progress towards meeting all its commitments under the FCCC. We recognise that our commitments relate not just to limiting emissions of all greenhouse gases and to protecting and enhancing sinks, but to a range of other matters. These include the commitment to contribute to the financial mechanism to assist developing countries in complying with their obligations such as reporting greenhouse gas inventories under the FCCC, and actions taken to prepare for the impacts of climate change in New Zealand.

In addressing New Zealand's FCCC commitments and recognising the risks posed by climate change, successive New Zealand governments have undertaken initiatives to limit greenhouse gas emissions and to protect and enhance sinks. Policy to address climate change is continually evolving. We are currently in the midst of a number of policy initiatives which may result in a change of policy approach for limiting emissions, in particular, carbon dioxide. The outcome of the Berlin Mandate negotiations will be a significant factor in this process.

This second national communication contains detailed background on New Zealand's current emissions, including greenhouse gas inventory information covering the years 1990 to 1995. It provides the context for New Zealand's emissions, an update on the effectiveness of policies implemented to date, and an outline of the domestic policy issues which are under consideration.

As stated in the first national communication, governments need to show joint leadership on the issue of climate change, recognising that all sectors and interests must play their part. Business, environment groups and individuals must all contribute in their own way to the global effort. Protection of the climate system, and what that implies for future generations, requires a truly global approach, with workable, durable international solutions that eventually involve all countries.

Rt Hon Don McKinnon
Minister of Foreign Affairs and Trade

Hon Simon Upton
Minister for the Environment

2 Executive summary

Introduction

The New Zealand Government recognises the risks posed by global climate change, and is committed to the continued development of a comprehensive strategy on climate change which, over time, aims to address emissions of all greenhouse gases and to protect and enhance greenhouse gas sinks and reservoirs.

This second national communication provides a progress report on the measures New Zealand has taken to meet its commitments under the Framework Convention on Climate Change. Policy measures have been implemented as outlined in the first national communication. The estimated results of these measures are provided in this second national communication along with inventory statistics for the period 1990 to 1995 and projected emissions and removals to 2020.

Policy measures have concentrated on reducing the rate of growth of carbon dioxide (CO_2) emissions. Carbon sequestration by (planted) forests remains a central part of New Zealand's approach to mitigating carbon dioxide emissions. New Zealand's policy approach also recognises the importance of other greenhouse gas emissions, in particular from the agricultural sector.

New policy initiatives include additional funding through a Budget "Green Package" which is assisting the Government achieve its environmental and conservation objectives, including addressing the risks of climate change. The climate change policy areas benefiting from this funding are improving inventories and investigating policy for reducing non-CO_2 greenhouse gas emissions, developing and implementing a comprehensive monitoring programme for carbon storage in New Zealand soils, monitoring carbon in indigenous forests and scrublands, and further protection of the store of carbon in indigenous forests by enhancing pest and weed control.

New Zealand continues to play an active part in the on-going international negotiations under the Berlin Mandate, seeking to achieve an outcome for commitments beyond 2000 that is consistent with principles of cost effectiveness and lowest possible cost outlined in the Framework Convention on Climate Change.

Greenhouse gas inventory

New Zealand's greenhouse gas inventory covers emissions of the greenhouse gases carbon dioxide(CO_2) methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and sulphurhexafluoride (SF_6) as well as the indirect greenhouse gases carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOCs). Limited data are also available on emissions of sulphur dioxide (SO_2). Carbon dioxide removals in the land use change and forestry sector are reported for planted forests only. The reported figure takes into account emissions of carbon dioxide associated with harvest of planted and indigenous forest, fires and land clearance for forest planting.

Table 2.1: 1990 inventory summary. All data is presented in gigagrams (Gg).

Greenhouse Gas Source / Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total emissions and removals	**25,475**	**-20,571**	**1,706.0**	**47.5**	**113.4**	**703.9**	**178.9**	**neg**	**0.089**	**0.023**	**16.3**
All Energy	23,0		32.4	2.6	109.9	655.5	137.0				ne
Industrial Processes	2,3		0.1	nr	2.3	0.9	16.7	neg	0.089	0.023	16.3
Solvents & Other Product Use							25.2				
Agriculture			1,513.5	44.9	0.2	3.8					
Land Use Change & Forestry	net	-20,571	5.0	neg	1.1	43.7					
Waste			155.0	ne							
International Bunkers Total	**2,4**		**0.2**	**0.05**	**27.0**	**5.6**	**3.7**				**ne**

Notes: neg = negligible; ne = not estimated; nr = not reported. net = emissions netted into removals figure.

Table 2.2: 1995 inventory summary. All data is presented in gigagrams (Gg).

Greenhouse Gas Source / Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total emissions and removals	**27,368**	**-13,490**	**1,634.9**	**46.6**	**133.6**	**797.2**	**200.6**	**0.141**	**0.029**	**0.183**	**20.8**
All Energy	24,6		35.0	2.5	129.1	724.8	153.7				ne
Industrial Processes	2,7		0.1	nr	2.7	1.1	18.9	0.141	0.029	0.183	20.8
Solvents & Other Product Use							28.0				
Agriculture			1,460.4	44.1	0.2	4.0					
Land Use Change & Forestry	net	-13,490	7.7	neg	1.7	67.3					
Waste			131.8	ne							
International Bunkers Total	**2,7**		**0.25**	**0.06**	**30.4**	**6.0**	**4.1**				**ne**

Note: neg = negligible; ne = not estimated; nr = not reported. net = emissions netted into removals figure.

For the purposes of comparison, summary inventory emissions data are presented in Table 2.3 using Global Warming Potentials (GWPs), with carbon dioxide equivalent radiative forcing impacts over a 100 year time horizon. This gives an overall sense of New Zealand's contribution to radiative forcing from greenhouse gas emissions. This data should be regarded as indicative only, given the uncertainties in the GWPs themselves, and taking into account that reported emissions of HFCs and SF_6 are potential rather than actual emissions.

Table 2.3: Emissions and removals of greenhouse gases in New Zealand in 1990 and 1995 presented in carbon dioxide equivalent form using 100 year Global Warming Potentials[i] (GWPs). All amounts are in gigagrams (Gg).

	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs	PFCs	SF_6
1990	25,475	-20,571	35,868	14,880	negligible	585	478[b]
1995	27,368	-13,490	34,335	14,446	182[b]	195	4302[b]

Notes: a IPCC 1995 Global Warming Potentials (GWPs) are CO_2 = 1, CH_4 = 21, N_2O = 310, HFC 134a = 1300, PFCs (CF_4) = 6500, and SF_6 = 23900.
b Reported emissions of HFCs and SF_6 are potential rather than actual emissions. Release of most of these gases to the atmosphere is likely to take place over a number of years, rather than all occur in the year of importation.

The three most important greenhouse gases in New Zealand's inventory are methane, carbon dioxide and nitrous oxide. Overall, inventory data show that relative to 1990, carbon dioxide emissions are increasing, methane emissions are decreasing, and nitrous oxide emissions are reasonably stable. Of the remaining gases in the inventory, all show an increase since 1990, except for PFCs which have decreased by 66%. In radiative forcing terms, methane and nitrous oxide, principally from the agricultural sector, made up approximately 60% of New Zealand's total emissions in 1995. CO_2 emissions contributed 33% and SF_6, PFCs and HFCs made up the balance.

In 1995 carbon dioxide emissions totaled 27,368 Gg (27.4 million tonnes), an increase of seven percent since 1990. Fossil fuel combustion and fugitive fuel emissions accounted for 90% of New Zealand's carbon dioxide emissions, with the remainder coming from industrial processes. The amount of carbon, reported as 13,490 Gg (13.5 million tonnes) of carbon dioxide, sequestered by planted forests in 1995 was equal to almost 50% of the emissions of carbon dioxide from fossil fuel combustion and industrial processes in that year.

At 40% of the total, the transport sector is the single largest contributor to New Zealand's carbon dioxide emissions. It also accounts for the largest portion of the growth in carbon dioxide emissions since 1990. Fossil fuel combustion by industry, energy and transformation industries and the commercial/institutional, agriculture/fishing/forestry and residential sectors (small combustion) contribute 20%, 17%, 4%, 4%, and 2% to the total respectively. Fugitive fuel emissions (namely carbon dioxide released from the exploitation of geothermal energy, and the venting and flaring of natural gas and oil) amount to a further 2%.

In 1995 methane emissions totalled 1,635 Gg (1.6 million tonnes), a decrease of 4% since 1990. The agricultural sector dominates methane emissions, with almost 90% of the total 1995 emissions coming from ruminant animals and their waste. This sector also accounts for most of the decrease in emissions. Other contributors to methane emissions are the waste sector 8%, fugitive fuel emissions around 2%, and fossil fuel combustion less than 1%.

The agricultural sector is also responsible for the majority of emissions of nitrous oxide. Although there is some uncertainty regarding the accuracy of the estimated emissions of nitrous oxide from New Zealand soils, current data show that around 94% of nitrous oxide emissions are of agricultural origin. Fossil fuel combustion is responsible for almost all of the remainder.

As required, emissions from international bunker fuels are included separately in the inventory data.

Policy measures and their effects

The New Zealand Government has introduced, or has under consideration, a number of policy measures which directly or indirectly impact on emissions or removals of greenhouse gases.

<u>Carbon dioxide emissions</u>

Policy measures already being implemented to address the rate of growth of carbon dioxide emissions, include:

- voluntary agreements with industry;
- legislative and regulatory reform in the energy sector;
- energy efficiency and renewable energy measures;
- use of the Resource Management Act; and
- specific transport sector measures.

Although it is difficult to measure the individual contribution of each of the measures listed above, it is considered that they have and will contribute significantly to the projected 20% reduction in growth of CO_2 emissions from 1990 to 2000, and about 25% of 1990 to 2020 growth. These estimates have been constructed using a 3% GDP growth rate and the difference between "with measures" and "business as usual" projections. It is acknowledged that the difference may not all be attributable to the effects of policy measures. There are,

however, some initial outcomes from the policy measures, which even at this early stage give some confidence in the projections. These initial outcomes are summarised in Box 2.1.

Box 2.1: Estimated initial outcomes from selected carbon dioxide policy measures.

Voluntary agreements with industry: The key result from the voluntary agreements is that they encompass those industries responsible for over 40% of New Zealand's total CO_2 emissions, and although CO_2 emissions for the economy as a whole are projected to be 22 percent higher in 2000 relative to 1990, emissions for the voluntary agreement signatories as a group are only projected to increase by about 9 percent.

Energy Efficiency Strategy: A range of measures covering all energy using sectors has been introduced in a staged manner over three years from 1994 to date. The majority of these programmes work in an indirect way to facilitate market responses. It is difficult to accurately predict how much CO_2 these indirect programmes will save because of problems in correctly attributing impacts. Some other programmes which operate through mechanisms such as financial incentives and standards have a directly measurable effect on CO_2 emissions, but have yet to be fully implemented. Taking into account the various uncertainties, it is still expected that the Energy Efficiency Strategy (including the Energy Saver Fund) is capable of leading to a reduction of around 300 Gg of CO_2 in 2000, or around one per cent of projected emissions under "business as usual".

Work is underway on the design of least cost options that could result in additional reductions of carbon dioxide emissions, including a low-level carbon charge and a domestic emissions trading regime. Further domestic policy responses will be considered in the context of developments at the international level. To this end, New Zealand is an active participant in international initiatives exploring practical options for the implementation of multilateral policy measures such as international emissions trading. The shape of further commitments arising from the Berlin Mandate process, and the possible development of international policy measures will be a key influence on future domestic policy development in New Zealand.

Carbon dioxide removals

The protection and enhancement of carbon sinks and reservoirs, including commercial planted forests and indigenous forests, are a central part of New Zealand's policy approach. Measures have been introduced, including changes to taxation and qualifying company regimes, which have resulted in considerable expansion of planted forest since 1990. From 1990 to 1995 approximately 265,000 hectares in total has been added to the planted forest estate.

An annual new planting rate of around 70,000 hectares is projected to continue for the remainder of the decade, resulting in total removals in 2000 of almost 19,000 Gg CO_2. At a planting rate of 55,000 hectares per year after 2000, removals in 2020 are estimated at almost 32,000 Gg CO_2. Both these estimates take into account CO_2 emissions from wildfires, controlled burning and scrub clearance for forest planting.

Cumulative carbon dioxide emissions and removals

Cumulative net emissions to the atmosphere attributable to New Zealand give a more accurate measure of New Zealand's total contribution to the atmospheric stock of carbon dioxide. This approach compares cumulative emissions of carbon dioxide with the increase in planted forest stocks in the same timeframe.

Cumulative emissions over the period 1990 - 2020 from energy and industrial processes are expected to total 1000 million tonnes CO_2. For planted forests, net of emissions from harvesting and other emissions from land use changes, carbon storage is projected to increase by 640 million tonnes CO_2 over this same period. The projected removal of carbon dioxide

from the atmosphere by planted forests over the total period 1990 - 2020 is therefore estimated to mitigate, on average, 63% of the total gross carbon dioxide emissions from energy sources and industrial processes during this period. Projections of cumulative gross CO_2 emissions, total increases in planted forest stocks (CO_2 removals less harvest and land use change emissions) and total cumulative (net) CO_2 emissions to the atmosphere are illustrated in Figure 2.1.

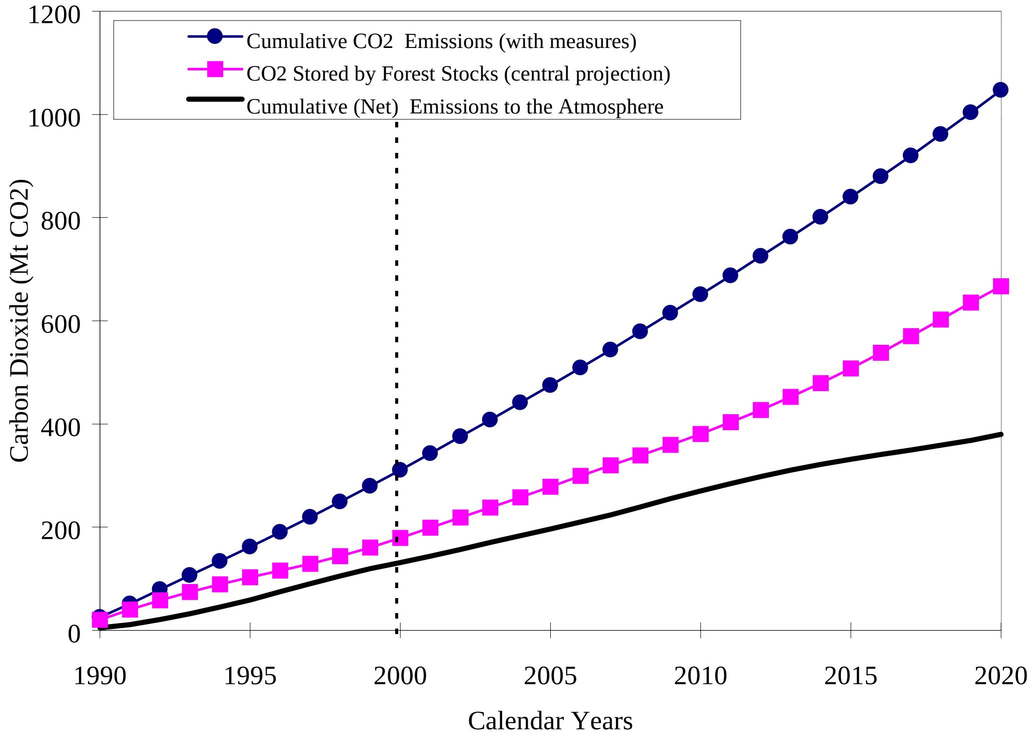

Figure 2.1: Cumulative gross CO_2 emissions, forest stocks and total cumulative (net) CO_2 emissions to the atmosphere.
Source: Ministry for the Environment, 1997

<u>Policy measures for methane and nitrous oxide</u>

In New Zealand, the policy measure that has had the most profound effect on methane and nitrous oxide emissions (which come predominantly from the agricultural sector) was the withdrawal of agricultural subsidies in the mid 1980s. The effects of subsidy removal have continued into this decade, and have led to overall decreasing ruminant animal numbers, resulting in decreasing methane emissions, and more moderate application of fertilizers, resulting in nitrous oxide emissions being lower than they might otherwise have been. Forestry expansion is also contributing to a reduction in livestock numbers through land removal from agriculture, and thus to a reduction in methane emissions.

Acknowledging the role of methane and nitrous oxide from the agricultural sector in New Zealand's greenhouse gas profile, an important part of the policy response has been to increase research investment, both to better quantify the size of the emissions, and to provide a basis for future policy development.

Methane emissions from waste are being addressed through the Government's Waste Management Policy, which promotes cleaner production and waste minimisation initiatives

and improved landfill management. There is also an increase in the amount of landfill gas being extracted for energy production.

Overall, total methane emissions are expected to be almost 10% below 1990 levels in 2000, and 6% below 1990 levels in 2020. For nitrous oxide the equivalent figures are 3% and 4% below 1990 levels, although the latter figure should be regarded with more caution than the other projections as the data is considered to be highly uncertain.

Policy measures for other gases

The lack of inventory data on the minor gases in New Zealand has recently been addressed with an initial compilation of emissions of non-CO_2 gases from industrial processes and the use of solvents. This compilation includes NMVOCs, HFCs, PFCs and SF_6. With the exception of PFCs from aluminium smelting, where policy has already been implemented, analysis of policy options is at an early stage.

Most of the PFC emissions in New Zealand come from the country's single aluminium smelter. The conditions attached to the air discharge consent for the smelter are expected to keep PFC emissions at or below 1990 levels. PFC emissions from the smelter have declined by 66% since 1990 and are expected to remain at about 0.03 Gg per year through to 2020.

Vulnerability and adaptation

Climate change impacts on New Zealand have been assessed using a scenario approach. A comprehensive impacts assessment was done in 1990. This has been supplemented by information gained from research programmes which have increased understanding of New Zealand's climate and how this may change in the future together with increased understanding of the underlying responses to the environment of a range of plant and animal species. The capacity to assess vulnerability and adaptation to climate change within New Zealand has also been enhanced by a collaborative interdisciplinary research effort which has developed a system for integrated assessment for application from a national down to a site-specific scale.

Using the scenario approach, in general terms, warming is expected to be similar for both the North and South Island but winter temperatures may rise faster than summer temperatures in more southern parts of the country; there are likely to be changes in rainfall and windiness; and seasonal snow storage in the South Island is likely to decrease. Changes in the severity and frequency of climatic extremes could have the greatest immediate impacts. The costs and benefits of climate change will not be spread evenly between different sectors of the economy, nor between different regions, with the adverse effects of climate change likely to be most severe for those parts of the environment and society that are least able to adjust.

Adaptation measures are being taken by local authorities, concentrating on coastal policy and natural hazard mitigation.

Finance and technology

New Zealand contributed NZ$10.4 million to the 1994-97 replenishment to the Global Environment Facility (GEF), almost twice its assessed share.

New Zealand's Official Development Assistance (ODA) programme has a strong regional component, with ongoing contributions to mitigation and adaptation work particularly in the South Pacific. In 1996/97 ODA expenditure on such activities through bilateral, regional and other multilateral channels was around NZ$8.5 million. A new ODA strategy for the South Pacific has been approved for dealing with global environmental issues, including climate

change. This strategy will complement and add to existing programmes and will involve new funding.

Research and systematic observation

New Zealand continues to promote and collaborate in climate change research and systematic observations.   Estimated public expenditure in this area for the 1996/97 financial year is NZ$16.4 million, an increase of over fifteen percent since 1993/94. Goals for this research include reducing uncertainties about climate change and its impacts, and improving understanding of the range of possible responses.

New Zealand is located in a data-sparse region of the south-west Pacific, making observations of atmosphere and ocean climate and of greenhouse gases an important contribution to global and regional monitoring of climate variability and change.

The Government appointed National Science Strategy Committee for Climate Change continues to provide advice and coordination on climate change research issues.

Education, training and public participation

The Government has produced material on climate change for the general public, schools and specialised audiences. A public workshop was held following the release of the IPCC Second Assessment Report to enable the IPCC findings to be presented authoritatively, to bring them to the attention of New Zealanders, and to enable discussion of their relevance to New Zealand and the South Pacific. Government agencies continue to hold regular meetings with environment NGOs, business and industry groups, local government and professional bodies, providing an opportunity to raise issues relevant to climate change policy development. There have also been further opportunities for the public to participate through consultation meetings and written submissions in the recent policy development work related to carbon dioxide emission reduction.

Summary tables as outlined in the guidelines for the preparation of national communications by Annex I Parties.

Table 1A: Summary of policies and measures: Carbon dioxide (CO_2)

<table>
<tr><th rowspan="2">Policy/measure</th><th rowspan="2">Type of instrument</th><th rowspan="2">Objective</th><th rowspan="2">Sector</th><th rowspan="2">Status</th><th colspan="4">Estimate of mitigation impact (Gg)[1]</th><th rowspan="2">Intermediate indicator of progress</th></tr>
<tr><th>2000</th><th>2005</th><th>2010</th><th>2020</th></tr>
<tr><td>Reduction in CO_2 emissions.</td><td>Voluntary agreements between industry and government</td><td>Reduction in CO_2 emissions</td><td>Industry</td><td>Implemented</td><td colspan="4" rowspan="3">Reductions in source CO_2 emissions from the policy measures taken together is estimated as the difference between the with measures and BAU projections. This difference is about 20% of 1990 to 2000 growth, and about 25% of 1990 to 2020 growth. The policy measures will have contributed significantly to the difference, although their indiviual contributions are not measureable on a comparable basis to the difference between the BAU and the with measures projections.</td><td>Annual reporting of progress against target, subject to independent verification. Reports are being submitted.</td></tr>
<tr><td>Energy sector reform</td><td>Legislative and regulatory changes</td><td>Energy sector reform</td><td>Energy</td><td>Implemented</td><td></td></tr>
<tr><td>Energy efficiency strategy</td><td>Government programmes</td><td>Promotion of energy efficiency and conservation</td><td>Energy consumers</td><td>Implemented</td><td>An ongoing programme evaluation strategy will include indicators on emissions.</td></tr>
<tr><td>Other</td><td></td><td></td><td></td><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="10">Notes: Other includes the use of the Resource Management Act 1991, actions by local authorities and the development and implementation of transport sector measures..</td></tr>
</table>

Table 1B: Summary of policies and measures: Methane (CH_4)

<table>
<tr><th rowspan="2">Policy/measure</th><th rowspan="2">Type of instrument</th><th rowspan="2">Objective</th><th rowspan="2">Sector</th><th rowspan="2">Status</th><th colspan="4">Estimate of mitigation impact (Gg)[1]</th><th rowspan="2">Intermediate indicator of progress</th></tr>
<tr><th>2000</th><th>2005</th><th>2010</th><th>2020</th></tr>
<tr><td>Reduction in agricultural subsidies</td><td>Government regulation</td><td>Agricultural reform</td><td>Agriculture</td><td>Implemented</td><td>122.458</td><td>113.078</td><td>103.700</td><td>84.942</td><td>Livestock statistics and emission factors for different livestock classes available.</td></tr>
<tr><td>Animal waste management systems</td><td>Local government regulation</td><td>Water quality</td><td>Agriculture</td><td>Implemented in some regions[2]</td><td colspan="4">Estimates of reductions are not easily quantified.</td><td>Loading limits have been implemented in some regions. An indicator of the resulting effect on emissions is not available yet.</td></tr>
<tr><td>Animal productivity programmes</td><td>Government and industry research funding</td><td>Increase productivity</td><td>Agriculture</td><td>Implemented</td><td colspan="4">Estimates of reductions are not easily quantified.</td><td>Indicators available for increase productivity but no the resulting effect on emissions.</td></tr>
<tr><td colspan="10">Notes: 1 If agricultural reform had not occurred, it is unlikely livestock number changes, in response to market forces, would have occurred to the same extent. Quantifying the changes is difficult. Here the overall change in emissions from the reduction in overall livestock units has been used.
2 Under the Resource Management Act 1991, regional councils can make rules for the treatment of animal wastes for regional water quality reasons. To date, not all regional councils have adopted rules.</td></tr>
</table>

Table 1C: Summary of policies and measures: Nitrous oxide (N_2O)

Policy/measure	Type of instrument	Objective	Sector	Status	Estimate of mitigation impact (Gg)[1]				Intermediate indicator of progress
					2000	2005	2010	2020	
Reduction in agricultural subsidies	Government regulation	Agricultural reform	Agriculture	Implemented	Estimates of reductions are not easily quantified.				Not yet implemented.
Nitrogen application rules (for animal wastes and fertiliser use)	Local government regulation	Water quality	Agriculture	Implemented in some regions[2]	Estimates of reductions are not easily quantified.				Loading limits have been implemented in some regions. An indicator of the resulting effect on emissions is not available yet.
Code of practice for fertiliser use	Voluntary industry code of practice	Environmental impacts and efficient fertiliser use	Agriculture	To be implemented	Estimates of reductions are not easily quantified.				Not yet implemented.

Notes: 1 The removal of agricultural subsidies encourages efficient production because farmers aim to minimise production costs. For example, without subsidies, farmers have no incentive to use excessive amounts of fertiliser as the cost of the fertiliser will reduce their profits.
2 Under the Resource Management Act 1991, regional councils can make rules for the treatment of animal wastes or for the application of fertilisers for regional water quality reasons. To date, not all regional councils have adopted rules.

Table 1D: Summary of policies and measures: Perfluorocarbons (PFCs)

Policy/measure	Type of instrument	Objective	Sector	Status	Estimate of mitigation impact (Gg)				Intermediate indicator of progress
					2000	2005	2010	2020	
Reduction of PFCs	Resource consent condition	Use of best technical option to minimise emissions.	Aluminium smelting	Implemented	-0.056	-0.057	-0.057	-0.057	Annual reporting; review of resource consent conditions.

Table 2: Summary of projections of anthropogenic emissions of carbon dioxide (CO_2) (gigagrams)

	1990	1995	2000	2005	2010	2020
Fuel Combustion: energy and transformation industries	6,079	4,741	7,472	8159	8956	11681
Fuel combustion: industry	4,766	5,416	5,480	5,983	6,269	6,570
Fuel combustion: transport	8,748	10,983	11,955	13,055	14,628	18,251
Other	2,881	2,864	2,372	2,255	2,255	27,54
Total	**25,475**	**27,368**	**31,080**	**33,570**	**36,310**	**43,560**

Note: Other includes CO_2 emissions from industrial processes and fugitive emissions.

Table 3: Summary of projections of removals of carbon dioxide (CO_2) by sinks and reservoirs (gigagrams)

	1990	1995	2000	2005	2010	2020
Land-use change and forestry	-20,571	-13,490	-18,944	-20,807	-21,208	-31,654

Note: The projections include an allowance for emissions from land use changes: wild fires and prescribed burning, and the clearing of scrub for planted forestry.

Table 4: Summary of projections of anthropogenic emissions of methane (CH_4) (gigagrams)

	1990	1995	2000	2005	2010	2020
Fuel Combustion	7.81	7.96	8.37	8.84	9.35	10.56
Fugitive emissions from fuels	24.54	27.06	25.19	26.17	27.07	28.29
Industrial processes	0.12	0.12	0.17	0.17	0.17	0.17
Enteric fermentation	1,495.27	1,442.72	1,374.26	1,383.54	1,392.82	1,411.38
Animal wastes	18.02	17.52	16.58	16.67	16.77	16.97
Rice cultivation						
Waste	155.06	131.67	111.20	117.22	122.03	130.50
Other	5.12	7.88	6.30	6.08	6.05	6.06
Total	**1,706.0**	**1,634.9**	**1,541.5**	**1,552.0**	**1,573.8**	**1,604.0**

Note:Other includes CH_4 emissions from land-use change and forestry and field burning of agricultural residues.

Table 5: Summary of projections of anthropogenic emissions of nitrous oxide (N_2O) (gigagrams)

	1990	1995	2000	2005	2010	2020
Transport	0.362	0.455	0.460	0.505	0.555	0.664
Other energy sources	2.258	2.039	2.547	2.058	2.075	2.177
Industrial processes	nr	nr				
Agriculture	44.87	44.10	43.05	43.05	43.05	43.05
Waste	ne	ne	ne	ne	ne	ne
Other	0.03	0.06	0.04	0.04	0.04	0.04
Total	**47.5**	**46.7**	**46.0**	**45.6**	**45.7**	**45.7**

Notes:Other includes CH_4 emissions from land-use change and forestry and field burning of agricultural residues.
N_2O from agriculture projected forward at 2000 emission level as data is too uncertain to do otherwise.
nr = not reported

Table 6: Summary of projections of anthropogenic emissions of other greenhouse gases (gigagrams)

	1990	1995	2000	2005	2010	2020
SF_6[1]	0.023	0.183	0.212	0.246	0.285	0.383
HFCs[1]	neg	0.141	0.164	0.190	0.220	0.295
PFCs[2]	0.089	0.029	0.034	0.035	0.035	0.037
Other (specify)						

Notes:1 Potential rather than actual emissions
2 Closer to actual emissions as the majority are from aluminium smelting.

Table 7: Summary of projections of anthropogenic emissions of precursors and sulphur dioxide (SO_2) (gigagrams)

	1990	1995	2000	2005	2010	2020
CO	703.9	797.3	853.6	930.4	1,015.5	1,231.9
NO_x	113.7	133.6	153.9	170.8	186.4	225.4
NMVOCs	178.9	200.6	216.2	238.1	264.4	326.4
SO_2	16.3	20.8	31.6	34.9	38.9	48.0

Notes: SO_2 has been estimated for industrial processes only.

Table 8: Summary of key variables and assumptions in the projections analysis

		1990	1995	2000	2005	2010	2020
World coal prices (US$/tonne)		$51.17	$51.17	$51.17	$51.17	$51.17	$51.17
World oil prices (US$/bbl)		$24.20	$17.64	$23.46	$25.90	$25.90	$25.90
Residential energy prices[1] (NZ$/GJ)	*Electricity*	$23.44	$26.38	$27.53	$26.65	$25.82	$30.24
	Oil	$16.17	$10.66	$13.22	$15.47	$16.10	$16.10
	Gas	$9.52	$11.24	$12.13	$12.80	$13.54	$13.95
	Coal	$10.00	$8.97	$9.26	$9.26	$9.26	$9.26
Industrial/Commercial energy prices[1] (NZ$/GJ)	*Electricity*	$27.56	$22.35	$23.06	$21.86	$21.08	$26.02
	Oil	$13.56	$9.39	$10.15	$11.07	$11.10	$11.19
	Gas	$7.81	$7.50	$8.05	$8.50	$8.99	$9.26
	Coal	$3.95	$3.54	$3.74	$3.74	$3.74	$3.74
GDP[2] (NZ$ millions)		35,728	40,274	46,598	54,020	62,624	84,161
Primary energy demand (Petajoules)		603	664				

Notes: 1. New Zealand dollars December 1988.
2. The GDP figures are real 1982/83 dollars.

Table 9: Financial contributions to the operating entities of the financial mechanism, regional and other multilateral institutions and programmes.

	Contributions (millions of US dollars)		
	1994	1995	1996
Global Environment Facility	1.682	1.682	1.682
Multilateral institutions			
World Bank	0.163	0.163	0.276
International Finance Corporation	0.114	-	0.260
Asian Development Bank	1.533	3.315	3.900
United Nations Development Programme	2.438	2.600	3.120
International Fund for Agricultural Development	0.455	0.260	0.397
International Development Agency	8.297	8.034	7.800
Multilateral scientific programmes			
Intergovernmental Panel on Climate Change			0.007
Multilateral training programmes			
Geothermal Institute Diploma	0.739	0.659	0.813
South Pacific Environment Programme (SPREP)	0.488	0.488	0.488

Table 10: Bilateral financial contributions related to the implementation of the Convention, 1995 and 1996 (millions of US dollars).

	Mitigation			**Adaptation**
Recipient country/group of countries	Energy	Transport	Forestry	
1995:				
ASEAN		0.273		
Indonesia	0.035	0.035		
South Pacific Region			3.357	0.827
1996:				
South Pacific Forum countries	0.244			
Indonesia	0.143			
South Pacific Region			3.932	0.514

Chapter 3: Background

3.1 The enhanced greenhouse effect

The Earth is surrounded by a thin film of gases forming the atmosphere. It is the composition of this atmosphere that distinguishes the Earth from the other planets in our solar system and creates the conditions necessary for the diversity of life on the Earth's surface and in the oceans.

The composition of the atmosphere has changed over geological time (see Figure 3.1). Such changes usually take place over thousands of years. Human activity over the last two hundred years has measurably changed the composition of the atmosphere through the emission of greenhouse gases. Since pre-industrial times carbon dioxide (CO_2) concentration in the atmosphere has increased by about 28%, methane (CH_4) by 145% and nitrous oxide (N_2O) by 13% (IPCC, 1995). These are the three main greenhouse gases. Fluorinated compounds, including the chlorofluorocarbons[1] (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are also greenhouse gases. Although their atmospheric concentrations are small, they have very long atmospheric lifetimes.

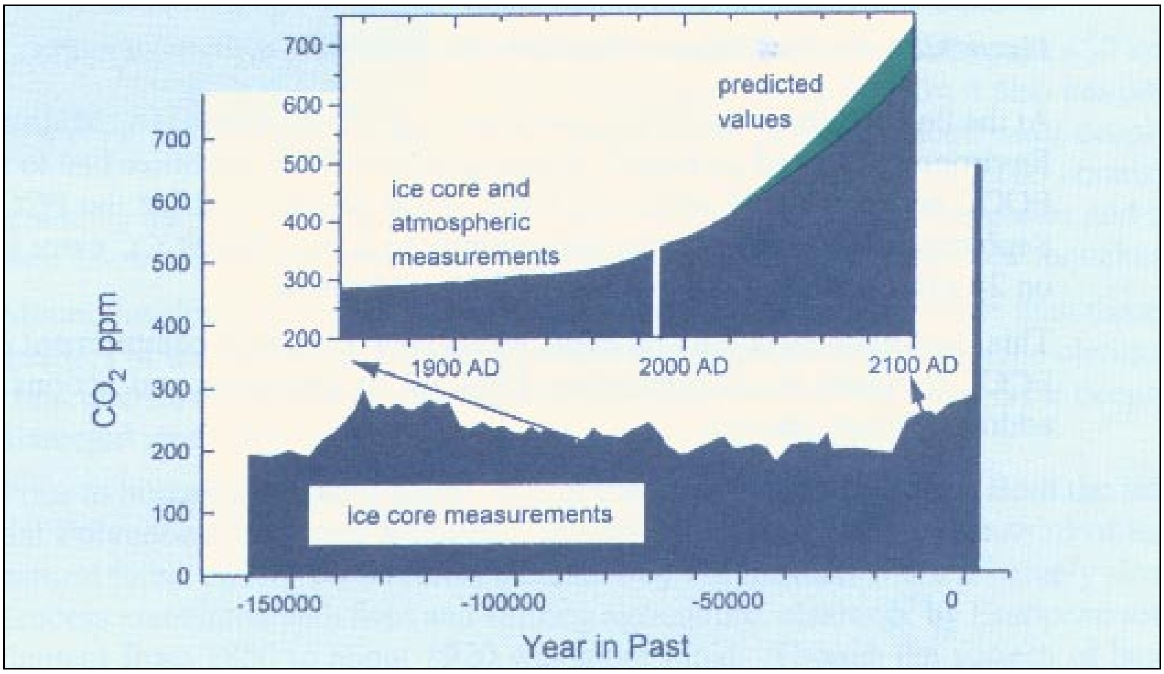

Figure 3.1: Carbon dioxide concentrations past, present, and future. Source: M. Manning, NIWA, 1994

Greenhouse gases have the potential to increase the Earth's average temperature by trapping some of the heat the Earth radiates back into space (see Figure 3.2). The greater the concentration of greenhouse gases in the atmosphere, the greater the potential for a warmer planet and changes to the climate.

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[1] Chlorofluorocarbons (CFCs) have been phased out in developed countries and production is falling in the rest of the world. Due to atmospheric cooling associated with ozone depletion, CFCs are judged to have zero net global warming potential.

3.2 The United Nations Framework Convention on Climate Change

In 1988 the United Nations General Assembly resolved to protect the global climate for present and future generations. At the General Assembly's instruction, the UN Environment Programme (UNEP) and the World Meteorological Organisation (WMO) established the Intergovernmental Panel on Climate Change (IPCC). The first IPCC report in 1990 concluded that human-induced climate change is a real threat. The IPCC report and peer review process involved hundreds of scientists from many countries.

In 1990 the United Nations General Assembly, reflecting growing international concern about the potential problem of climate change, established the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC/FCCC). The FCCC was finalised and adopted in New York on 9 May 1992. It was opened for signature soon afterwards in June 1992 at the United Nations Conference on Environment and Development (often referred to as the 'Earth Summit', or UNCED), held in Rio de Janeiro.

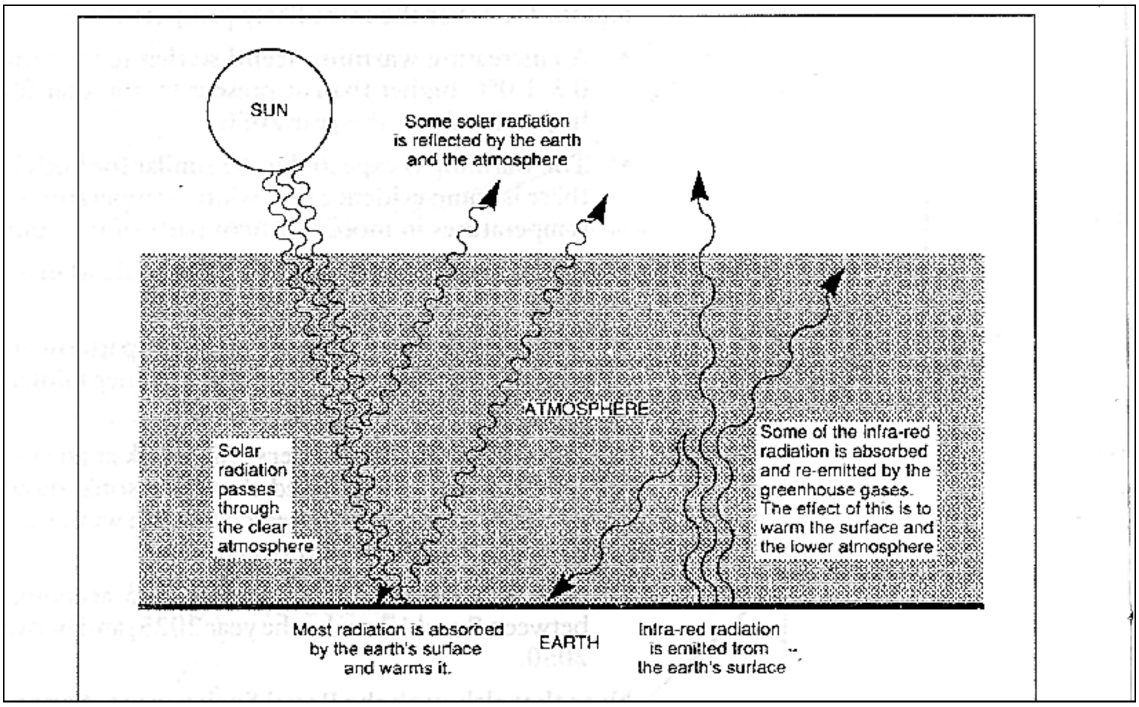

Figure 3.2: A simplified diagram illustrating the greenhouse effect. Source: IPCC, 1990

At the Earth Summit the FCCC was signed by 155 countries. The Minister for the Environment signed on behalf of New Zealand. Fifty countries had to ratify the FCCC before it could enter into force. New Zealand ratified the FCCC in September, 1993, and was the 34th country to do so. The FCCC came into force in March 1994. Since then the Conference of the Parties to the FCCC (the COP) has met twice - in Berlin in March 1995 (COP1), and in Geneva in July 1996 (COP2).

COP1 decided that Article 4.2 (a) and (b)[2] of the FCCC are not adequate to achieve the objective of the Convention[3]. As part if its decision, COP1 established the "Berlin Mandate"

[2] Article 4 of the FCCC is titled "Commitments". In particular, Article 4.2 (a) and (b) refer to some of the commitments of Annex I Parties, such as New Zealand, which have been broadly interpreted as aiming to return

process which is negotiating strengthened commitments for developed country Parties (and other Parties included in Annex I to the FCCC) for the period after 2000. At the same time, although there are to be no new commitments for developing country Parties as part of the Berlin Mandate outcome, the Berlin Mandate makes reference to advancing the implementation of existing commitments of these Parties. The Berlin Mandate process is set to conclude at the third Conference of the Parties to be held in Kyoto, Japan, in December 1997.

COP2 evaluated progress to date on this Berlin Mandate process and issued a Ministerial Declaration as part of its proceedings. The Ministerial Declaration endorsed the findings of the Second Assessment Report of the IPCC including that "the balance of evidence suggests a discernible human influence on global climate". The Declaration also called on Ministers to instruct their representatives to accelerate negotiations on the text of a legally binding instrument to be completed in time for the third Conference of the Parties (COP3). Although the Ministerial Declaration is a non-consensus document, it nevertheless sends clear signals about the likely legally binding nature of the next set of commitments for Annex I Parties.

New Zealand, in its first national communication, met its commitment under the FCCC to report by 21 September 1994, on its emissions and actions taken to address climate change. The in-depth review of New Zealand's first national communication was carried out in the period June to November 1995, and included a visit by the review team from 3 to 9 July 1995. The four person review team included experts from Sri Lanka, Slovakia, and the United Kingdom, and was coordinated by a member of the FCCC secretariat. The main findings of their report (FCCC/IDR.1/NZL, 1996) are contained in Box 3.1.

This second national communication updates much of the information in the first national communication, reporting on progress towards meeting its FCCC commitments since the end of 1994.

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emissions of all greenhouse gases to 1990 levels by 2000. Annex I Parties include developed countries, countries with economies in transition, and the European Union.

[3] Article 2 of the FCCC is a statement of the ultimate objective of the Convention which is to stabilise atmospheric concentrations of greenhouse gases at a level that would prevent dangerous anthropogenic interference with the climate system, such a level to be achieved within a timeframe that would allow ecosystems to adapt to climate change, that ensures that food production is not threatened, and that enables economic development to proceed in a sustainable manner.

Box 3.1: In-depth review of New Zealand's first national communication.

The report on the in-depth review of New Zealand's first national communication noted the following:

- New Zealand's net approach to carbon dioxide;
- relatively low CO_2 emissions per capita compared with other OECD countries;
- generally low energy prices;
- economic restructuring having consequences for emissions of greenhouse gases;
- considerable sequestration of carbon in planted forests;
- uncertainties (in both directions) associated with indigenous forest carbon storage levels, and the general lack of data in this area making projections impossible;
- the projected growth rate in CO_2 emissions, and the intention to introduce a carbon charge at the end of 1997 if emissions growth reduction is not on track;
- the importance of methane emissions in New Zealand's emissions profile and that projected methane emissions will be below 1990 levels in 2000;
- policy initiatives since the national communication was submitted, namely, the signing of voluntary agreements, the establishment of the Energy Saver Fund, the decision under the RMA on the Taranaki Combined Cycle power station and the establishment of the Working Group on CO_2 Policy;
- New Zealand's contribution to the GEF being more than twice its assessed share;
- New Zealand's geographic location with respect to climate change science and monitoring responsibilities;
- an assessment of climate change impacts on New Zealand has been done, but that the need for a comprehensive adaptation strategy is recognised.
- New Zealand has established regular consultations on climate change with non-governmental organisations.

Chapter 4: New Zealand National Circumstances

4.1 Geography

New Zealand consists of two large, and a number of smaller, islands located in the southwest Pacific Ocean between 33° and 55° south latitude. It has a combined land area of 270,500 square kilometres, which makes it similar in size to Japan or the British Isles. It has an extensive Exclusive Economic Zone, with the marine area covering 14 times the land area. New Zealand is isolated, relatively uncrowded, and endowed with natural resources such as fresh water, coal, and natural gas/petroleum.

New Zealand is 1600 km long and spans 450 km at its widest point. At 11,500 km it also has one of the longest, and, in some places, most deeply indented coastlines in the world. The country straddles the boundary of the Pacific and Indo-Australian tectonic plates and is well known for its active volcanoes, geothermal areas, and frequent earthquakes.

Mountains dominate much of the New Zealand landscape and more than three-quarters of the land area is higher than 200 metres above sea level. One obvious consequence of the intense mountain building in New Zealand's past is the deeply dissected landscape carved by numerous steep, fast-flowing rivers.

Prior to human settlement about 75% of the country was forested. Both the initial Polynesian, and later European, settlers each cleared about one-third of the natural forest cover. While forest clearance by Polynesians was a relatively slow process associated with fires and shifting agriculture, clearance by European settlement from 1850 to about 1920 was more rapid. Though the pattern of land clearance was essentially established by 1920, further controversial clearance of natural forest continued until the mid 1980s when the combined effects of conservation initiatives and the removal of land development subsidies largely stopped the activity. About 80% of natural forest resource is state owned with the remainder being privately owned, half by Maori. Almost all the state owned natural forest is in national parks, forest parks, and other reserves, with only about 2% being managed for wood production. About 90% of the private natural forests serve protective functions with the remainder being considered to be commercially viable for sustainable wood production under current market conditions. Introduced animals, particularly the Australian brush tail possum, deer and goats have caused significant damage to the quality of native forest.

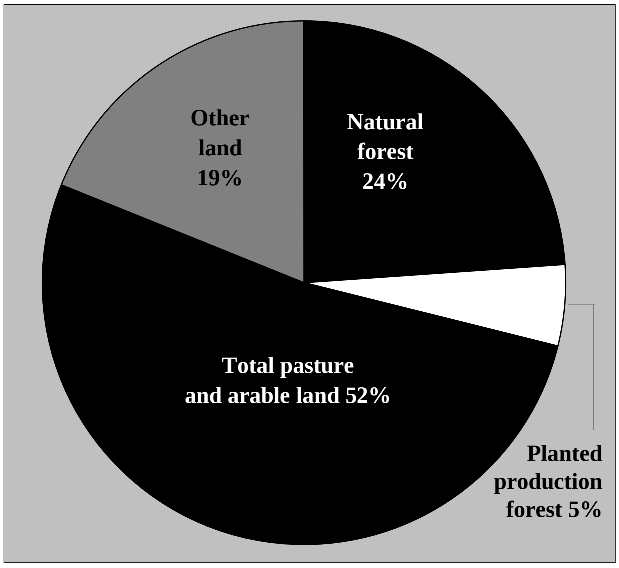


Figure 4.1: Land use in New Zealand
Source: Ministry of Forestry, 1995

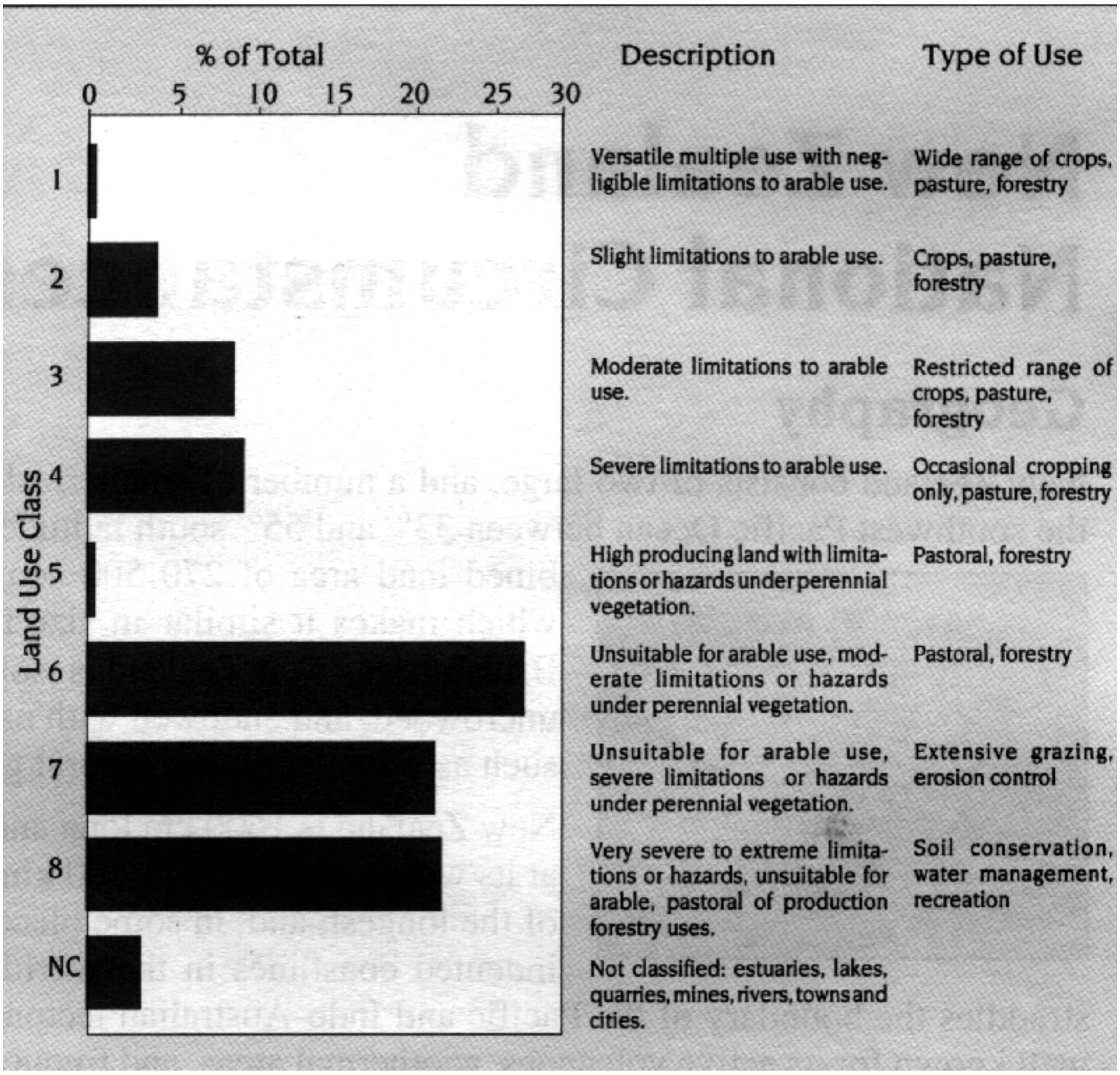


Figure 4.2: Land use capability in New Zealand. Source: DSIR Land Resources, 1991

Much of the country supports managed ecosystems: pasture, production forests, and crop-land (see Figures 4.1 and 4.2). The total area of farmland is about 178,000 square kilometres or 66% of the national land area. The 1.5 million hectares (as assessed in March, 1995) of sustainably managed, largely non-indigenous planted forest provides almost 99% of New Zealand's wood production. The predominant non-indigenous species is *Pinus radiata*.

4.2 Climate

As a long, narrow, mountainous country with the nearest large land mass (Australia) more than 2,000 km away, New Zealand's climate is largely influenced by:

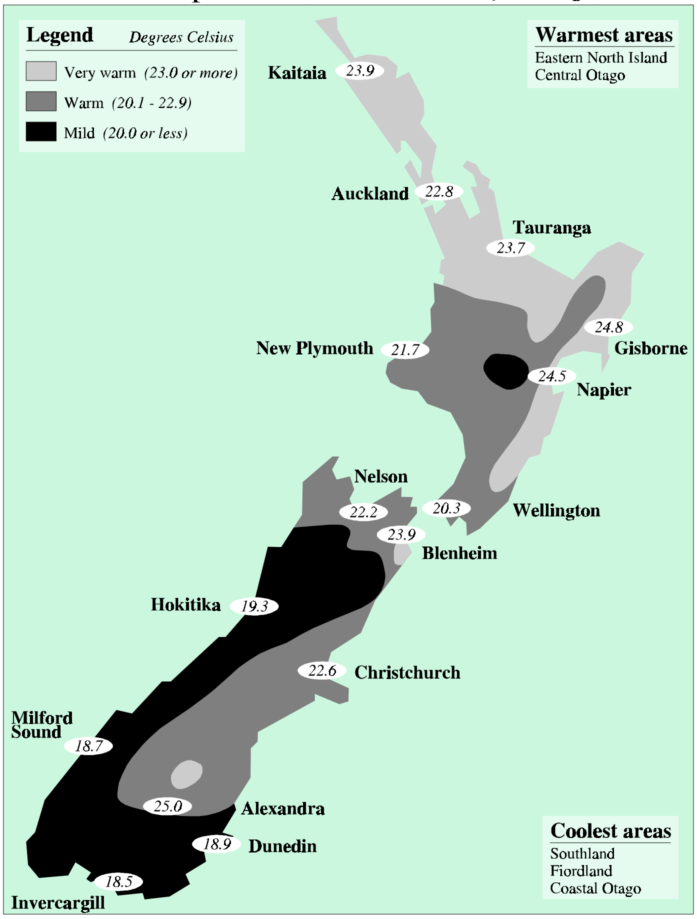
- its location in a latitude zone with prevailing westerly winds;
- the surrounding ocean;
- the mountain chains which modify the weather systems as they sweep eastward.

All these factors contribute to New Zealand having more variable weather compared to continental countries. Many parts of the country are affected by extremes of wind and rain, which, from time to time, cause considerable damage.

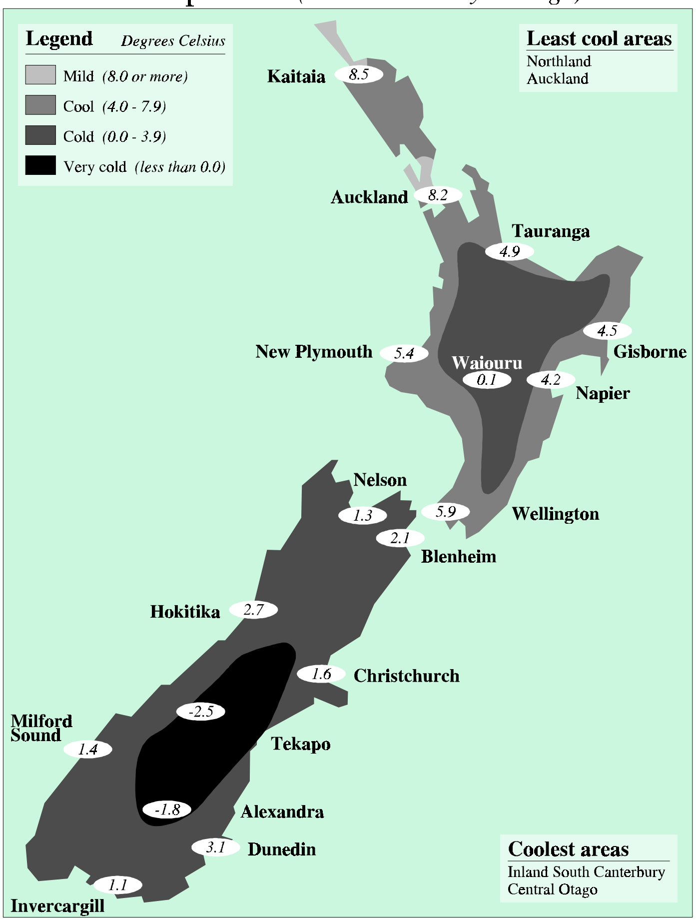
Figure 4.3 shows sunshine hours, rainfall, and maximum and minimum temperatures across the whole of New Zealand.

Figure 4.3: New Zealand weather. Source: NIWA, 1997; Department of Statistics, 1997

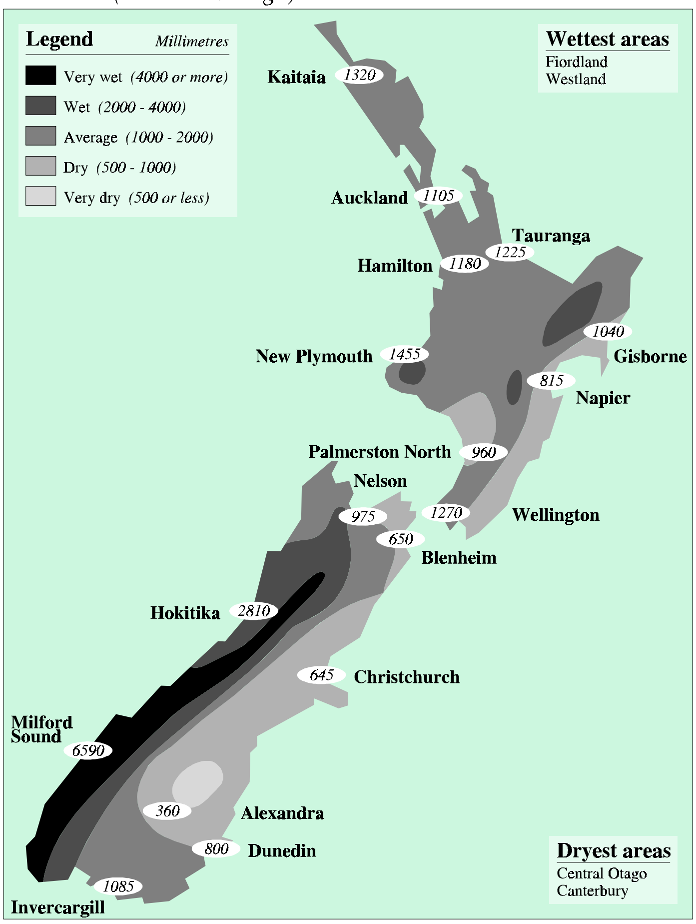
Maximum temperature *(mid-summer daily average)*



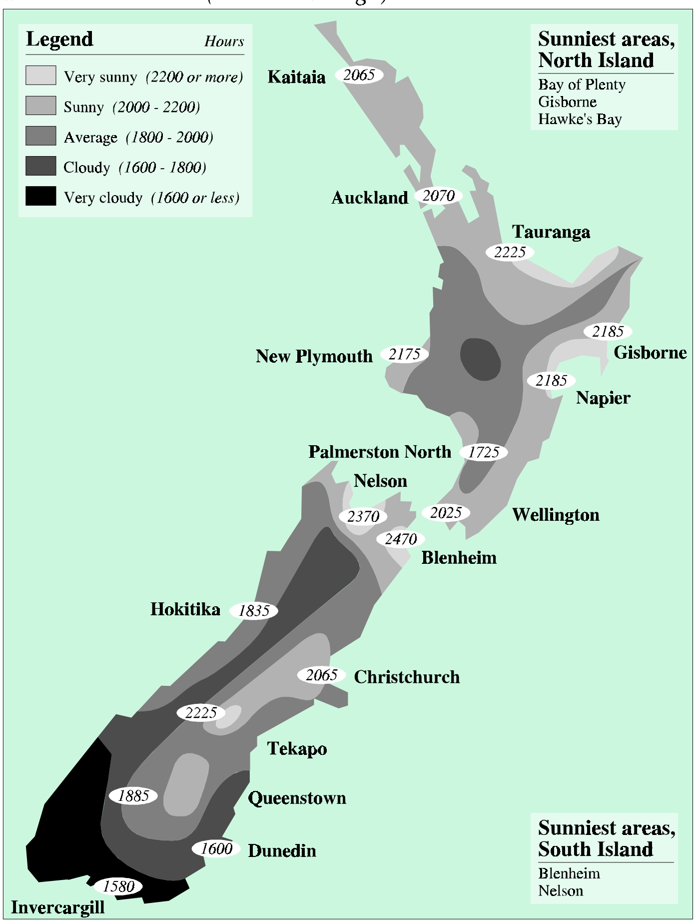
Minimum temperature *(mid-winter daily average)*



Rainfall *(annual average)*



Sunshine hours *(annual average)*



4.3 Population

New Zealand has a population of 3.66 million. This is expected to reach 3.75 million by the year 2000, and 4.22 million by 2020.

North Islanders outnumber South Islanders by 3 to 1 and there is a steady drift of people from the south to the north. Despite New Zealand's continued reliance on agricultural exports, more people are moving from the countryside into urban communities. 85% of New Zealanders live in towns and cities, and almost one-third of New Zealand's entire population lives in the greater Auckland area.

As in most other western countries the percentage of older people in the community is increasing; 16% of the population is over 60 years of age. At the same time the size of the average family has decreased to less than half of what it was in 1960. In 1995 the average birth rate was 2.04 births per woman, a number below the level required for the population to replace itself in the long run without migration. There are large swings in the external migration balance from one year to another. Net migration figures for 1991 to 1996 are positive with 1995 recording an increase of just under 30,000 people. In contrast, in 1989, almost 25,000 people left New Zealand on a permanent or long-term basis.

New Zealand is a multi-racial society. While 74.5% is classified as being New Zealand European there are people of Maori (12.7%), Pacific Island Polynesian (3.8%), Indian (0.8%), Chinese (1.1%), and of other European origin (4.6%) present. New Zealand has strong links with the peoples of the South Pacific island nations. There is considerable movement of people between these island nations (e.g. the Cook Islands, Niue, Western Samoa, and Tokelau) and New Zealand.

Current projections (based on 1991 figures) indicate that New Zealand's population will grow slowly and age steadily over the next three decades. There will be no profound changes to New Zealand's age structure with the two child family/minimal immigration scenario resulting in the median age of the population rising from 31.3 years (1991) to 39.7 years (2031).

4.4 Social Framework

The New Zealand population is predominantly urban. The bulk of the population live within a few kilometres of the coast, with estuarine systems playing an important part in the location of population centres. There are five cities with populations in excess of 100 000, and another 15 with populations between 20 000 and 100 000. About one million people in total live in towns of under 20 000 and in the rural hinterland.

Single, detached houses dominate the housing stock, with almost 75% of households owning their own home. The typical New Zealand house is single-storeyed and built from timber. In 1991 the average number of occupants per private dwelling was 2.8 as compared with 2.9 in 1986 and 3.2 in 1981 (see Table 4.1).

type	1986 Census Aggregate	Average	1991 Census Agggegate	Average
Permanent private dwelling				
Separate House	2 682 729	3.1	2 828 004	2.0
Two houses or flats joined together	215 418	2.1	220 434	2.0
Three or more flats/houses joined together ..	165 183	1.8	162 291	1.8
Flat/house attached to business or shop ..	22 446	2.7	24 225	2.6
Bach, crip, hut (not in a work camp)	12 285	2.1	14 073	2.0
Not specified	18 051	2.5	6 528	2.7
Total, permanent private dwellings.. ..	**3 116 112**	**2.9**	**3255 558**	**2.8**
Temporary, private dwellings..	22 893	2.2	13 314	1.9
Total, private dwellings	**3 139 005**	**2.9**	**3 268 872**	**2.8**
Non-private dwellings	168 081	23.5	166 080	21.5
Total occupied dwellings	**3 307 083**	**3.0**	**3 434 949**	**2.9**

Table 4.1: Number of occupants in occupied dwellings in New Zealand in 1991 compared with 1986 census data. Source: Department of Statistics, 1993

Housing densities are low, with the result that New Zealand cities and towns are unusually extensive with low population densities. The income distribution of households in New Zealand is shown in Table 4.2.

Annual Income				*Approximate equivalent weekly income*	*Number of households*	*Average weekly income per household*
$				**$**	(000)	**$**
Under 13,300	..	..	..	Under 255	114.0	162.50
13,300-18,799	..	..	..	255 to 361	116.5	311.50
18,800-22,899	..	..	..	361 to 439	111.6	396.80
22,900-28,799	..	..	..	439 to 552	116.7	491.50
28,800-36,199	..	..	..	552 to 694	114.9	626.10
36,200-44,199	..	..	..	694 to 848	115.2	768.30
44,200-53,299	..	..	..	848 to 1,022	114.2	929.70
53,300-67,399	..	..	..	1,022 to 1,293	113.9	1,145.70
67,400-87,099	..	..	..	1,293 to 1,670	114.4	1,451.60
87,100 or over	..	..	..	1,670 or over	115.1	2,588.90
Total	..	..	..		**1,146.6**	**887.60**

Table 4.2: Income distribution of New Zealand households, 1995-1996 as estimated by Household Economic Survey. Source: Statistics New Zealand, 1997.

4.5 Political and Decision Making Structure

New Zealand is a parliamentary democracy. There is one elected House of Representatives. The principal functions of Parliament are to enact laws, supervise the Government's administration, allocate tax income, provide a government, and redress grievances by way of petition. The New Zealand electoral system has recently changed, with Members of Parliament being elected using mixed member proportional representation (MMP) instead of the previous "first-past-the-post" system. New Zealand currently has a coalition government. The Government's financial year operates from 1 July to 30 June.

New Zealand has a system of local government that is largely independent of, but subordinate to, the central executive government. Local authorities fall into two main categories, namely regional and territorial authorities. They have their own sources of income independent of central government, the basic source being taxes on land and property.

Local authorities derive their functions and powers from a range of legislation, in particular the Resource Management Act 1991 (RMA). The RMA integrated the provisions of more than 75 earlier laws and is founded upon the principle of sustainable management of natural and physical resources. The use of the RMA to address climate change issues is covered in Chapter 6, section 6.3.5.

4.6 The Economy

New Zealand's economy is heavily dependent on its natural resources and exports. Although direct employment in primary industries is low (10.6%) and declining, agriculture, fishing, and forestry provide the basis for the processing and manufacturing industries.

New Zealand's leading export classes are dominated by agricultural, horticultural and forestry products. These account for about 66% of what is earned from the export of goods. Livestock farming is an integral part of the New Zealand economy. In 1995 dairy exports were worth nearly NZ $3.5 billion, wool exports exceeded $1.3 billion, fish exports $1.2 billion, fruit and vegetables $1.2 billion, while forest products came to $2.6 billion. Meat exports, meanwhile, were worth $2.7 billion.

In the last twenty years, New Zealand's has diversified both its markets and its range of products. Although Australia, the European Union (EU), Asia and the United States of America still account for the majority of New Zealand's overseas trade, important trading links with other regions such as Latin America have been developed.

Although generally regarded as an agricultural nation, New Zealand does have some heavy industry including two steel works, an aluminium smelter, a synthetic petrol plant, cement works, and pulp and paper mills. There are also dairy factories and meat processing works throughout the country. It also has a range of sophisticated and diverse export-oriented manufacturing sectors including plastics, packaging, whiteware and engineering.

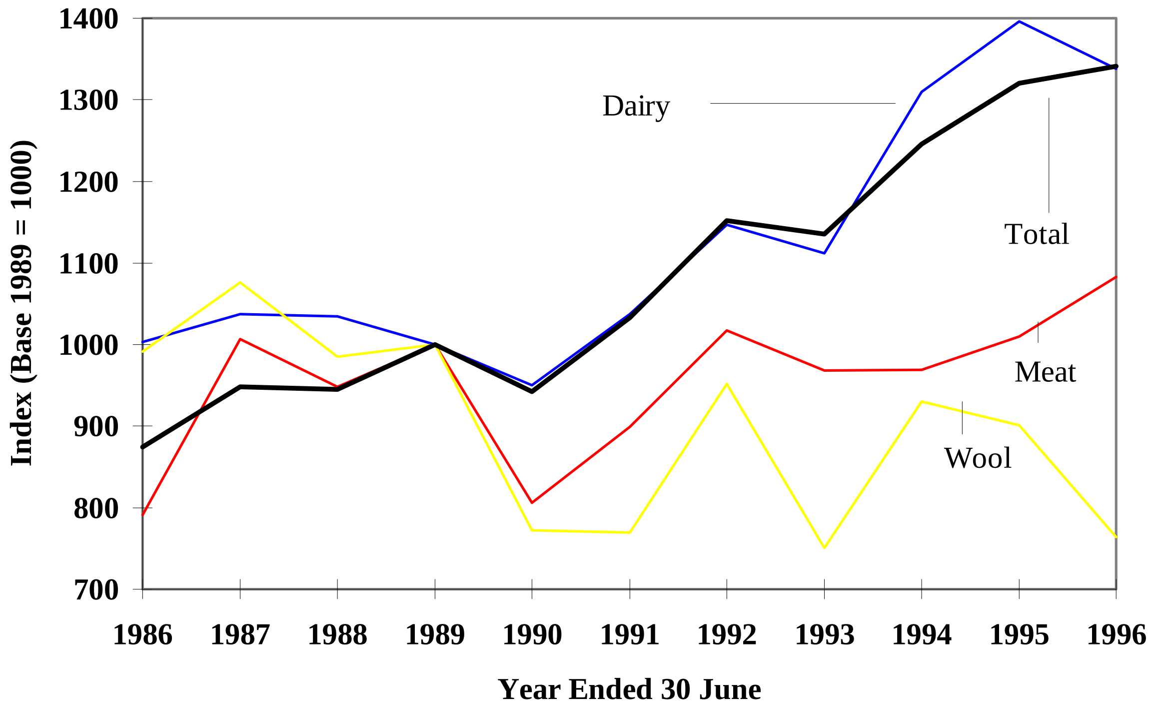


Figure 4.4: New Zealand export volume index, 1986 to 1996.
Source: Statistics New Zealand, 1997

The New Zealand economy has undergone major restructuring during the last decade, designed to foster the development of an open, competitive, and resilient economy. An extensive agenda of macro- and microeconomic reforms has allowed the price system to emerge as the dominant signal for investment, production, and consumption decisions.

The major changes implemented include removal of controls on prices, interest rates, and wages; introducing a flexible exchange rate regime; giving the central bank (the Reserve Bank) independence to maintain price stability; extensive taxation reform aimed at reducing marginal rates and broadening the base; removal of agricultural subsidies and price supports; removal of quantitative import controls and ongoing tariff reductions; deregulation of oil, banking, electricity and transport markets; reform of labour market regulation; privatisation of State-Owned Enterprises (SOEs); and wide-ranging public sector structural and financial management reforms.

A number of these reforms have a limited, but not quantified, impact on carbon dioxide emissions. Examples include the application of the consumption tax (Goods and Services Tax or GST) on all domestic and industrial fuels, removal of incentives and subsidies on the mining of coal and gas, and the reform of the energy sector.

4.7 Agriculture

Agriculture is an important sector in the New Zealand economy. In 1995 New Zealand’s total agricultural production is estimated to contribute 5.2% (Statistics New Zealand, 1996; Ministry of Agriculture, 1995) of the Gross Domestic Product (GDP). Industries associated with agriculture contribute another 10.2% (Statistics New Zealand, 1996; Ministry of Agriculture, 1995) of the GDP.

New Zealand agriculture is based largely on pastoral systems that are energy efficient. Compared with the agriculture sectors of North Asia, Europe and North America, New Zealand agriculture utilises more extensive grazing systems, with substantially less reliance on fertilisers and energy inputs. Livestock are grazed on pasture all year round, taking advantage of New Zealand’s temperate climate and improved grassland.

Since 1984, Government financial support for New Zealand agriculture has been almost totally removed. Farm income levels are now entirely dependent on international prices and are therefore vulnerable to the world market fluctuations and barriers to trade, as well as climatic risks. The agricultural sector now reacts swiftly to market pressures. This has resulted in some significant benefits to the environment including the reduction in livestock numbers resulting in lower methane emissions from ruminants. In addition, the clearance of natural forest has largely ceased, and some pastoral land is reverting back to scrubland and forest.

Changes in different types of land use on farm are shown in Table 4.3. In general, the area of land in pasture is decreasing. The area of land in horticulture has not changed significantly between 1990 to 1995 although less land is in grain and more in nursery, vegetables, and fruit. Farm forestry has increased significantly during the same period.

Table 4.3: Area of Occupied Land including agricultural land (000 hectares)

Land use at 30 June	1990	1991	1992	1993	1994	1995
Grasslands, Lucerne, Tussock and Danthonia	13,624	13,540	13,517	13,769	13,356	13,351
Grain	189	175	180	176	173	169
Nursery, Vegetables, Fruit	88	90	90	94	104	124
Plantations of Exotic Trees	1,304	1,329	1,335	1,396	1,488	1,599
Other Land on holdings	2,284	2,315	2,178	1,900	1,306	1,335
Total area of farms	17,489	17,450	17,300	17,336	16,607	16,578

Source: Statistics New Zealand 1995; Situation Outlook New Zealand Agriculture, MAF, 1995.

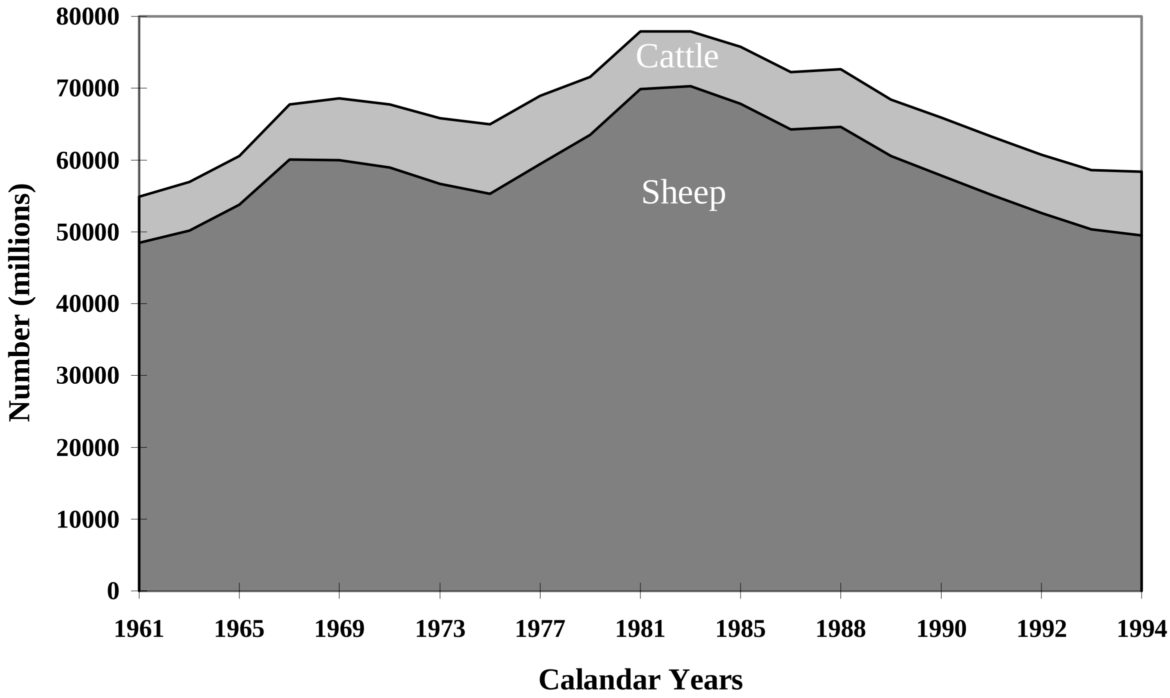


Figure 4.5: Total numbers of livestock on New Zealand farms, 1961 to 1994
Source: Statistics New Zealand, 1996

4.8 Forestry

New Zealand's planted forest estate is expanding, as is forestry's contribution to the New Zealand economy. The industry is based on a sustainably managed, planted production forests. The forestry sector is estimated to contribute 5.3% of New Zealand's Gross Domestic Product. The current value of the planted forest estate is in the range of NZ$15 billion and is increasing at a rate of up to NZ$0.5 billion per annum.

Forests cover 7.9 million hectares, or 29% of New Zealand's land area. Of this, 6.4 million hectares are indigenous and 1.5 million hectares are planted forests. Recent years have seen an increase in new planting and future increases are estimated at approximately 70,000 hectares per year up to 2000 and 55,000 hectares from 2001.

The wood processing industry in New Zealand is well established. It consumes around 12 million cubic metres of wood annually, with the balance of the harvest (5 million cubic metres) being exported as logs. Forestry products exports rank third in terms of commodity exports

(behind dairy and meat). In 1996, forestry products exports accounted for 12% of New Zealand's total exports.

New Zealand planted forest ownership has undergone considerable change since 1990 with the sale of cutting rights to much of the State's planted forests. Seventy percent of the planted forest estate is owned by 10 major organisations with the remaining 30% being owned by small companies, local government, partnerships, joint ventures and many thousands of farmers. In the future, it is anticipated that nearly half of the planted forest estate will be owned by small growers.

4.9 Energy

New Zealand is self-sufficient in electricity, gas and coal, and was 36% self-sufficient in oil in 1996. Figure 4.6 shows the trends in New Zealand's primary energy sources since 1974[1] The consumption of energy by end use type is given in Figure 4.7.

New Zealand's electricity generation is dominated by renewable energy sources, with hydroelectric power (see Figure 4.8) producing around 70-80% of annual electricity needs, depending on rainfall. Geothermal power contributes another 6% with smaller contributions from other renewable sources such as wind and cogeneration using wood. The balance is made up by fossil fuel generation, using mostly natural gas (but occasionally some coal). On average about 80% of electricity generation is from renewable sources.

At present New Zealand has adequate generating capacity to meet its electricity requirements. With the electricity market reforms of recent years, a diverse range of new entrants have committed themselves to the development of additional generating capacity to meet growing demand (growth projected to average 2.3% pa to 2000). Around 700 MW of new capacity has been committed to be on stream before 2000, with up to another 500 MW under consideration. The new committed capacity is mainly gas and wood cogeneration, geothermal, and gas combined cycle generation with smaller amounts of wind and biomass generation. Significant enhancements to the existing hydroelectric system are also likely in the foreseeable future while new developments are likely to be affected by broader environmental considerations, particularly concerns about the damming or diverting of waterways.

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1 All data in this section are for March years.

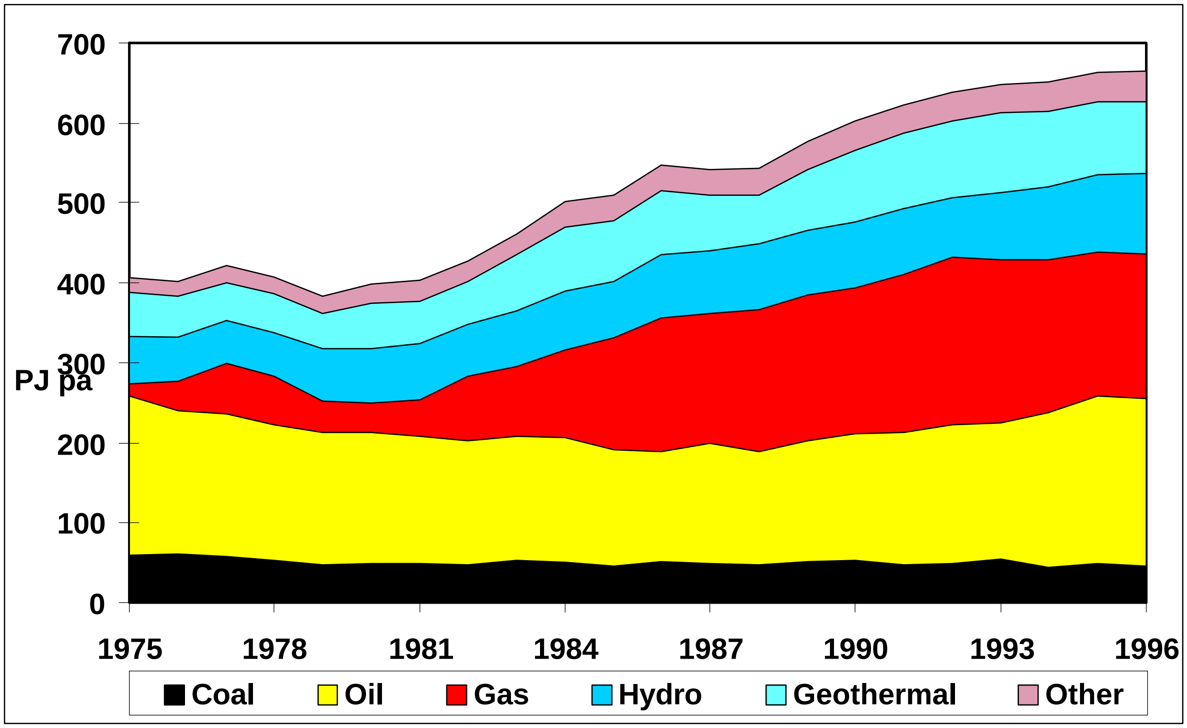

Figure 4.6: Primary energy supply in New Zealand, 1975 to 1996, petajoules per annum.
Source: Ministry of Commerce, 1997

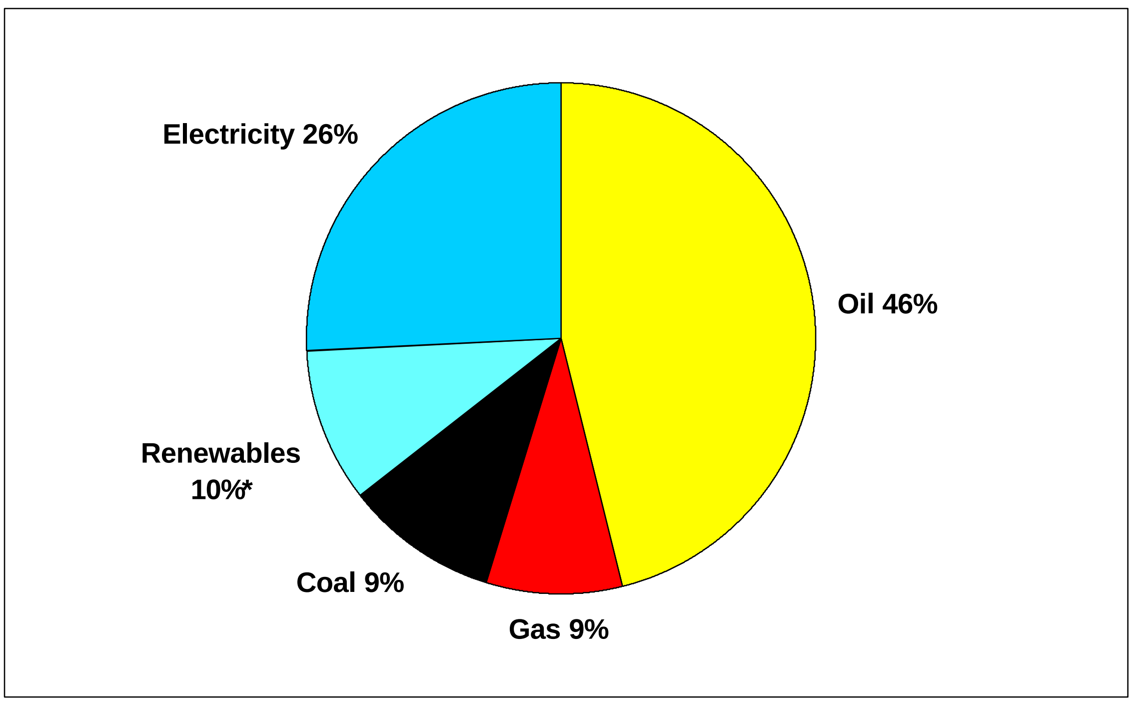

Figure 4.7: Consumption of energy in New Zealand by end use type, 1996.
Source: Ministry of Commerce, 1997

* Direct use of wood and geothermal

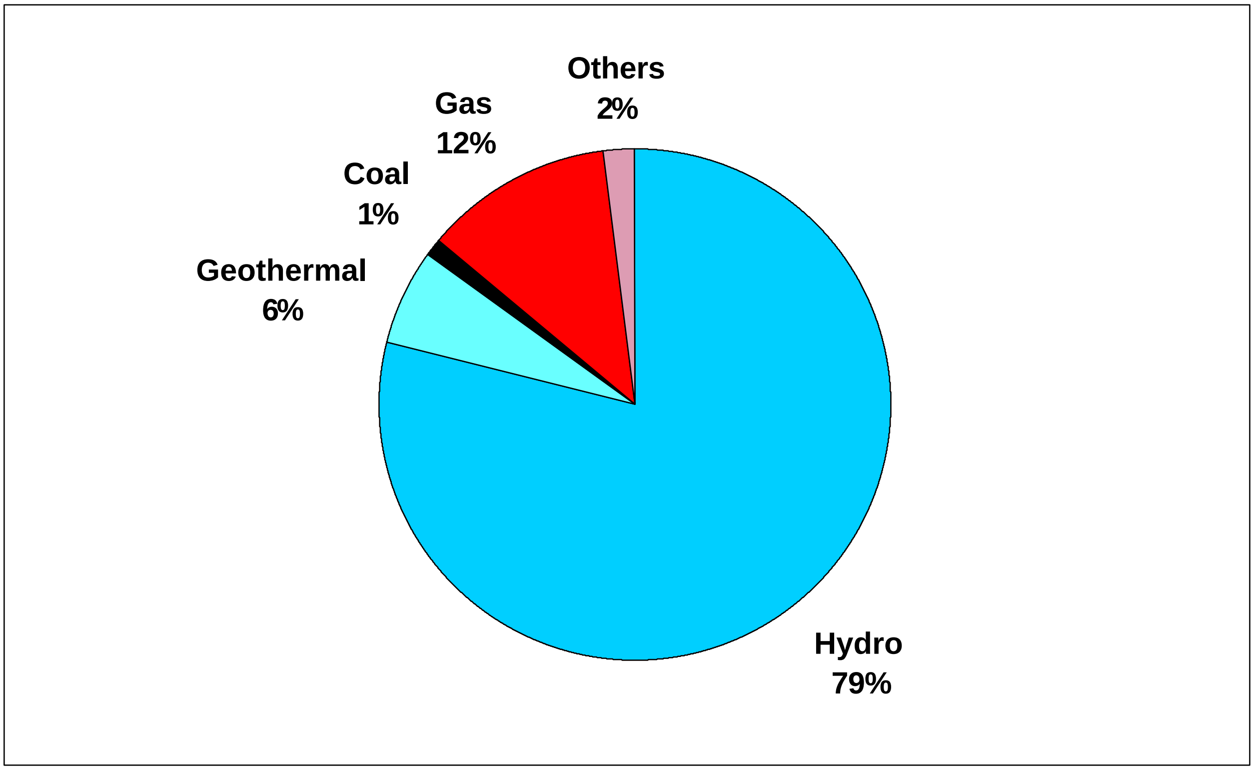

Figure 4.8: Electricity generation by fuel in New Zealand, 1996.
Source: Ministry of Commerce, 1997

Crude oil and condensate production in 1996 was 68.8 Petajoules (PJ). This was equivalent to about 35% of total refinery intake. Known recoverable reserves are estimated to last another 11-12 years at current rates of extraction.

Modelling suggests that if no new discoveries of natural gas are made, current reserves will last until about 2014 (18 years) in a greatly reduced market. This compares to around 14 years of supply at current levels of use if no new discoveries are made. The New Zealand natural gas market is dominated by feedstock users (see Figure 4.9).

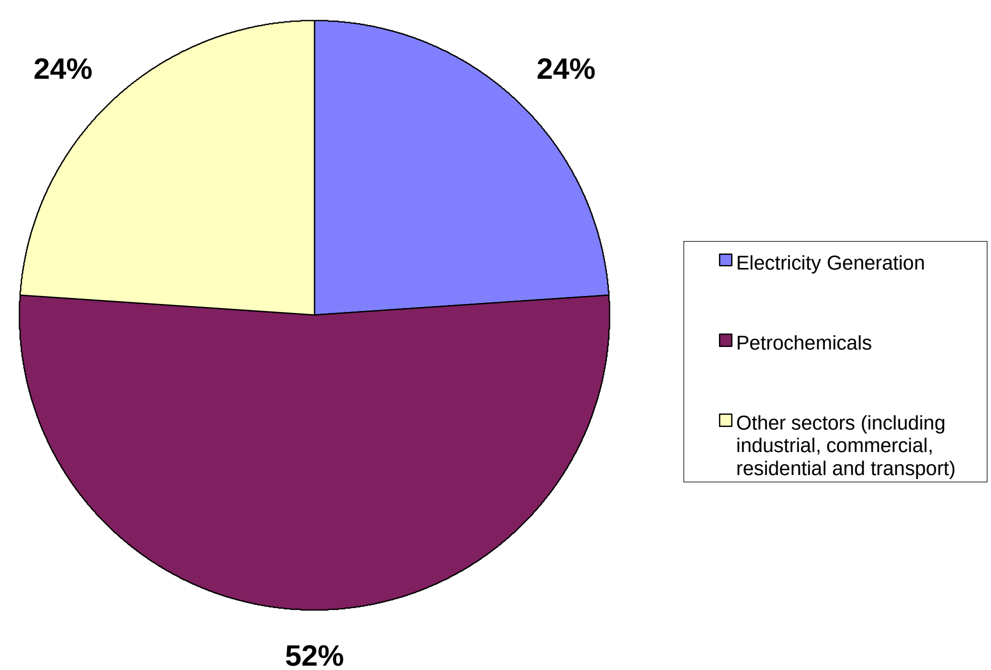

Figure 4.9: 1996 natural gas by end use in New Zealand. Source: Ministry of Commerce, 1997

Coal production in 1996 was around 3.25 million tonnes. Around 39% was exported. Of the 53 mines in operation during 1995, 42 were opencast mines and were responsible for 81% of total production. The major end users of coal are basic metal manufacturing (33%), electricity generation including other manufacturing (33%), cogeneration (15%), and commercial (15%). New Zealand has recoverable reserves of coal estimated at 8.6 billion tonnes (one billion = 10^9).

4.10 Transport

The nature of New Zealand's transport system has been influenced by the spread of the small population over two islands with a combined length of 2,000 kilometres. There are about 94,000 km of road. Unsealed roads make up 40% of the network but account for only 3% of vehicle kilometres travelled. There are about 4,000 kilometres of railway track. New Zealand's remoteness from many of its trading partners has required extensive use of shipping and, more recently, air transport.

In the year ended March 1996, the transport sector consumed 39% of New Zealand's total consumer energy[1]. Of this 72% was used for passenger movement, and 28% for freight. Private cars consumed 60.2% of the transport sector's energy use; road freight 26.2% and domestic air transport 9.2%. Buses accounted for 2.0% of energy use; rail freight 1.2%, coastal shipping 0.9% and passenger rail 0.2%.

Energy use in the transport sector increased 23.7% between 1991 and 1996 (from 133.8 Petajoules (PJ) to 165.5PJ). Growth in energy use was uneven across fuel types: petrol and diesel use increased 9.6 and 84.3% respectively. Aviation fuel use increased by 30.0%. CNG use in the transport sector fell by 44.1% during the same period.
The low density and dispersed nature of the New Zealand population has created a significant dependence on private passenger vehicles as a mode of daily travel. Approximately 1.8 million passenger cars are registered to individuals in New Zealand. The number of motor vehicles per household is shown in Table 4.4. The average age of the vehicle stock is currently about 10 years and the expected life of a vehicle is 15-20 years. About 2% of the passenger vehicle fleet operates on LPG and CNG. Total passenger travel increased by 6.1% between 1991 and 1995; private cars accounted for 85% of this increase.

In recent years there has been a progressive increase in the percentage of diesel-fuelled vehicles, with an increased proportion of cars and light goods service vehicles operating on diesel. Diesel vehicles make up approximately 2% of the light vehicle fleet. In addition the majority of heavy vehicles are diesel-powered. Total freight carried increased by 1.1% between 1991 and 1995. In 1995, 58% of freight was carried by road, 30% by coastal shipping and 12% by rail.
Domestic air transport accounted for nearly 6% of passenger movement in 1995. This form of transport is accounting for an increased market share of total passenger kilometres travelled, gaining against the private car. The energy intensity of air transport has increased, reflecting a fall in the average passenger load factor, associated with the introduction of domestic air transport competition.

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1 Total consumer energy refers to energy delivered to the end user (e.g. factory or household). It is measured at the consumer metering point, and does not include energy losses at the point of extraction, conversion or transmissions.

Number of Motor Vehicles[a]	*1986 Census* *Households*	*Percentage of total*[b]	*1991 Census* *Households*	*Percentage of total*	*Intercensal percentage change*
0	142 593	13.4	143 232	12.4	0.4
1	525 048	49.4	538 227	46.7	2.5
2	302 415	28.4	356 814	31.0	18.0
3	69 525	6.5	84 537	7.3	21.6
4	17 334	1.6	21 411	1.9	23.5
5 or more	6 177	0.6	8 097	0.7	31.1
Not specified	25 509	...	25 347	...	-0.6
Total	**1 088 598**	**100.0**	**1 177 665**	**100.0**	**8.2**

Notes a: includes cars, station-wagons, vans, trucks, and other vehicles used on public roads (excludes motorcycles and scooters). Business vehicles if available for private use are also included.
b: Calculated on specified cases only.

Table 4.10 Household transport in New Zealand, 1991 compared with 1986 census data.
Source: Department of Statistics, 1993

Given current pricing structures, low population density and dispersed centres of population, it is difficult to provide a comprehensive public transport system with frequent services in smaller centres throughout the country. However, the large urban centres generally have public transport systems that carry commuters to and from work, and children to and from school. In most places public transport carries a small proportion of total commuters.

In the 1980s and 1990s, much of New Zealand’s transport sector was deregulated and state ownership was relinquished. This restructuring and change in ownership allows the transport sector to respond to change in market demand or technology more efficiently than previously.

Chapter 5: Inventory

5.1 Approach

New Zealand has developed an inventory of emissions and sinks of the most significant greenhouse gases. The inventory is 1990-based and updated annually to monitor trends in emissions and sinks, and develop and evaluate the effectiveness of policy measures.

The inventory focuses on carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), other nitrogen oxides (NO_X) and carbon monoxide (CO). National data is provided for sources and sinks of these gases for the IPCC categories of energy, industrial processes, solvent and other product use, agriculture, land use change and forestry, and waste. In keeping with the IPCC guidelines, emissions from international bunkers are treated separately. New information is also available for the emissions of perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphurhexafluoride (SF_6), sulphur dioxide (SO_2) and non-methane volatile organic compounds (NMVOCs) which have not been included in New Zealand's greenhouse gas inventories previously.

Tables 5.1 and 5.2 present summarised inventories for 1990 and 1995 respectively. Full inventory data is presented in Annexes 7 to 12, with methodologies described in Annexes 2 to 6, noting where these differ from those developed by the IPCC. An overview is presented, followed by a detailed commentary on each category.

Table 5.1: 1990 Inventory summary. All data is presented in gigagrams (Gg).

Greenhouse Gas Source / Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total emissions and removals	**25,475**	**-20,571**	**1,706.0**	**17.5**	**113.4**	**703.9**	**178.9**	**neg**	**0.089**	**0.023**	**16.3**
All Energy	23,089		32.4	2.6	109.9	655.5	137.0				ne
Industrial Processes	2,38		0.1	nr	2.3	0.9	16.7	neg	0.089	0.023	16.3
Solvents & Other Product Use							25.2				
Agriculture			1,513.4	14.9	0.2	3.8					
Land Use Change & Forestry	net	-20,571	5.0	neg	1.1	43.7					
Waste			155.1	ne							
International Bunkers Total	**2,41**		**0.2**	**0.05**	**27.0**	**5.6**	**3.7**				**ne**

Notes: neg = negligible; ne = not estimated; nr = not reported; net = emissions netted into removals figure

Table 5.2: 1995 Inventory summary. All data is presented in gigagrams (Gg).

Greenhouse Gas Source / Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total emissions and removals	**27,368**	**-13,490**	**1,634.9**	**16.6**	**133.6**	**797.2**	**200.6**	**0.141**	**0.029**	**0.183**	**20.8**
All Energy	24,63		35.0	2.5	129.1	724.8	153.7				ne
Industrial Processes	2,73		0.1	nr	2.7	1.1	18.9	0.141	0.029	0.183	20.8
Solvents & Other Product Use							28.0				
Agriculture			1,460.4	14.1	0.2	4.0					
Land Use Change & Forestry	net	-13,490	7.7	neg	1.7	67.3					
Waste			131.8	ne							
International Bunkers Total	**2,73**		**0.25**	**0.06**	**30.4**	**6.0**	**4.1**				**ne**

Note: neg = negligible; ne = not estimated; nr = not reported; net = emissions netted into removals figure

5.2 National greenhouse gas emissions - overview

This second national communication reports on emissions of all greenhouse gases and removals of CO_2. For New Zealand, CO_2 emissions through scrub clearing and on-site burning of scrub and forests are netted in CO_2 removals under land use change and forestry, so gross CO_2 emissions refers to CO_2 emissions from energy and industrial processes. There are no non-CO_2 sinks reported, thus there is no difference between gross and net CH_4, N_2O, NO_X, CO and other gas emissions.

An overall sense of New Zealand's contribution to radiative forcing from greenhouse gas emissions is arrived at using Global Warming Potentials (GWPs) and presented in Table 5.3. GWPs present the radiative forcing impacts of greenhouse gases relative to CO_2. For example, using 1995 IPCC figures over a 100 year time horizon, one kilogram of CH_4 has the same impact as 21 kilograms of CO_2. In other words, CH_4 is 21 times more powerful as a greenhouse gas than CO_2. There are uncertainties in GWPs of typically ± 35%, thus data derived using GWPs should be regarded as indicative only. The data in Table 5.3, and in Figures 5.1 and 5.2, should be regarded as indicative only, given the uncertainties in the GWPs themselves, and taking into account that reported emissions of HFCs and SF_6 are potential rather than actual emissions.

Table 5.3: Emissions and removals of greenhouse gases in New Zealand in 1990 and 1995 presented in carbon dioxide equivalent form using 100 year Global Warming Potentials[a] (GWPs). All amounts are in gigagrams (Gg).

	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs	PFCs	SF_6
1990	25,475	-20,571	35,868	14,880	negligible	585	478[b]
1995	27,368	-13,490	34,335	14,446	182[b]	195	4,302[b]

Notes: a IPCC 1995 Global Warming Potentials (GWPs) are CO_2 = 1, CH_4 = 21, N_2O = 310, HFC 134a = 1300, PFCs (CF_4) = 6500, and SF_6 = 23900.

b Reported emissions of HFCs and SF_6 are potential rather than actual emissions. Release of most of these gases to the atmosphere is likely to take place over a number of years, rather than all occur in the year of importation.

Figure 5.1 illustrates the proportional effects of different greenhouse gases emitted in New Zealand in 1990 and 1995, calculated using global warming potentials for a 100 year time horizon. For most developed countries, CO_2 is the most important greenhouse gas in terms of its contribution to increased radiative forcing. For New Zealand CH_4 was responsible for 46% of the radiative forcing from greenhouse gases in 1990 and 44% in 1995.

Figure 5.2 illustrates, for gross emissions, the relative radiative forcing by source. Agriculture was responsible for almost 60% of the forcing in 1990 and 55% in 1995 (illustrating the reduction in agricultural sector emissions), while energy contributed about a third in both years. Waste emissions were below 5% with industrial processes growing from 4% to 9% from 1990 to 1995.

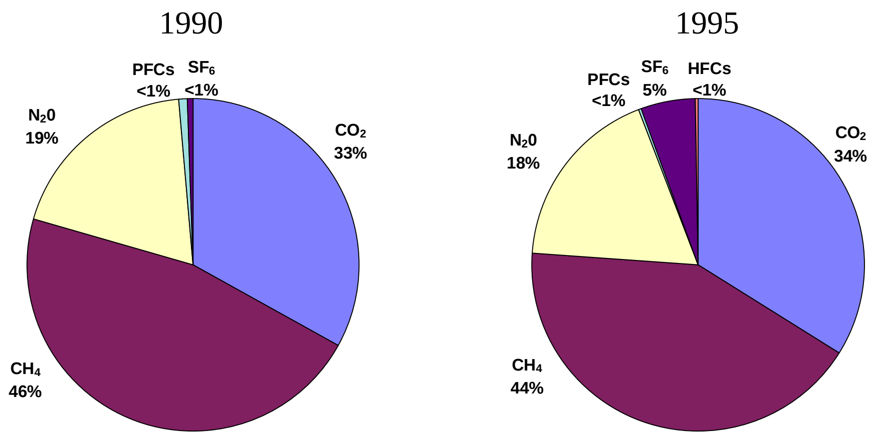

Figure 5.1: Relative radiative forcing for greenhouse gas emissions on a gross basis - Shares by gas 1990 and 1995

Notes:
1. PFCs are largely from aluminium smelting and are CF_4 and C_2F_6 in the ratio 10:1. Therefore the Global Warming Potential (GWP) for CF_4 has been used.
2. 74% of the HFC emissions are HFC 134a, hence the choice of GWP for HFCs.
3. IPCC 100 year Global Warming Potentials have been used (IPCC 1995):

CH_4 = 21, N_2O = 310, CF_4 = 6500, HFC 134a = 1300, SF_6 = 23900

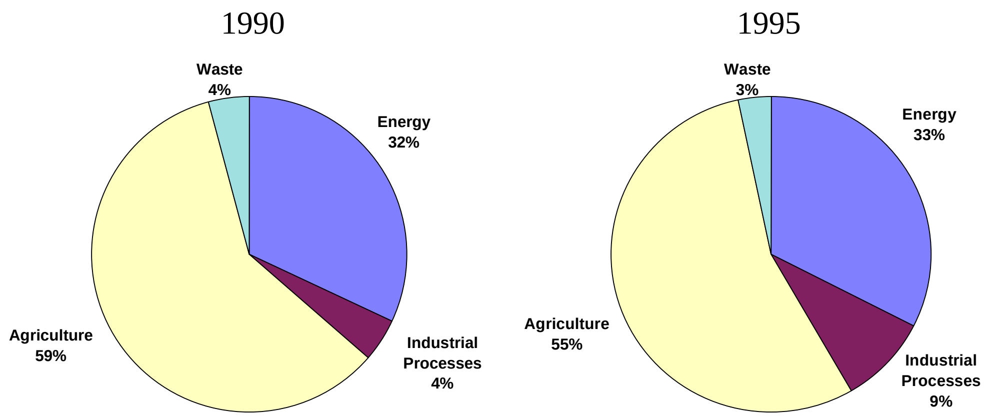

Figure 5.2: Gross Relative Radiative Forcing - Sectoral Shares 1990

Notes:
1. PFCs are largely from aluminium smelting and are CF_4 and C_2F_6 in the ratio 10:1. Therefore the Global Warming Potential (GWP) for CF_4 has been used.
2. 74% of the HFC emissions are HFC 134a, hence the choice of GWP for HFCs.
3. IPCC 100 year Global Warming Potentials have been used (IPCC 1995):

CH_4 = 21, N_2O = 310, CF_4 = 6500, HFC 134a = 1300, SF_6 = 23900

New Zealand’s inventory is dominated by emissions from the agricultural sector, the main source of both CH_4 and N_2O. Enteric fermentation by ruminants accounted for around 85% of total methane emissions in 1990. Almost 95% of New Zealand’s total N_2O emissions come from agricultural soils.

Energy is the main source of CO_2, NO_X and CO emissions, but generates a small proportion of N_2O and is an almost insignificant source of CH_4 in New Zealand. Around 90% of New Zealand’s gross CO_2 emissions comes from energy, the remainder from industrial processes. Energy and industrial processes together emitted 25,475 Gg CO_2 in 1990 rising to 27,368 Gg CO_2 in 1995, an increase of 7.4%. NO_X emissions from energy were 110 Gg in 1990, with over 60% from transport and the remainder from other fuel combustion. Of the 656 Gg of CO emitted in 1990, 94% was from the transport sector and 5% from fuel use by industry. Energy emitted also 137 Gg of NMVOCs in 1990, 95% of which was from transport.

Land use change and forestry absorption was 20,571 Gg CO_2 in 1990 and 13,490 Gg CO_2 in 1995. This takes into account the roughly 1,500 and 2,300 Gg CO_2 respectively, emitted through scrub clearing and scrub and forest fires.

The most significant emission from industrial processes is CO_2. However, small emissions of other greenhouse gases and precursors occur in this sector. Perfluorocarbons (PFCs) emissions were estimated to have been 0.089 Gg in 1990 and 0.029 Gg in 1995. Hydrofluorocarbons (HFCs) are imported into New Zealand. In 1990 HFC emissions were negligible. As increasing amounts of HFCs have been imported into New Zealand (as replacements for ozone depleting substances), HFC emissions will grow. In 1995 estimated potential emissions of HFCs and SF_6 were 0.14 Gg and 0.18 Gg respectively.

5.3 Energy Sector Emissions

Table 5.4: Summary of energy sector emissions for 1990 and 1995, (Gg).

Source Category	**CO_2**		**CH_4**		**N_2O**		**NO_x**		**CO**		**NMVOCs**	
	1990	1995	1990	1995	1990	1995	1990	1995	1990	1995	1990	1995
1. All Energy (Fuel Combustion + Fugitive)	**23,089**	**24,631**	**32.355**	**35.022**	**2.620**	**2.494**	**109.90**	**129.10**	**655.5**	**724.8**	**136.969**	**153.702**
A Fuel Combustion	**22,474**	**24,004**	**7.812**	**7.962**	**2.620**	**2.494**	**109.90**	**129.10**	**655.5**	**724.8**	**136.969**	**153.702**
Energy & Transformation Industries	6079	4741	0.112	0.073	0.928	0.709	20.80	16.72	2.2	1.5	0.628	0.443
Industry	4766	5416	0.437	0.480	0.729	0.794	14.60	15.90	32.5	33.1	1.678	1.811
Transport	8748	10983	7.120	7.269	0.362	0.455	69.10	91.16	618.0	687.5	130.269	147.042
Small combustion	2766	2775	0.140	0.137	0.582	0.520	5.00	4.99	2.8	2.6	4.371	4.387
Other	115	89	0.003	0.002	0.019	0.015	0.40	0.30	0.1	0.1	0.024	0.018
B Fugitive Fuel Emissions	**615**	**627**	**24.543**	**27.060**								
Oil and Natural Gas Systems	258	260	10.215	7.743								
Coal Mining			11.829	16.721								
Geothermal	357	367	2.499	2.596								

5.3.1 Energy Sector CO_2 emissions

Energy emissions are calculated using the IPCC default methodology, except where this has been improved upon using New Zealand specific data. Estimates are made of CO_2, CH_4, N_2O, NO_X, CO and NMVOCs. The energy inventory is reported in detail

in the annual energy emissions report[1] (Ministry of Commerce, 1996), which includes also CO_2 emissions from industrial processes.

Figure 5.4 shows 1990 emissions of CO_2 from energy. The largest single source of CO_2 emissions in New Zealand is the transport sector which accounted for 38% of energy CO_2 emissions in 1990 and 45% in 1995. (Using total CO_2 emissions, the transport sector accounted for 34% of emissions in 1990 and 40% in 1995). Thermal electricity generation and other transformation activities (including gas used as fuel during oil refining and synthetic petrol production) accounted for 26% of the total for energy in 1990 and 19% in 1995. Fuel combustion by industry, and small combustion (which includes commercial/institutional, residential and agriculture/forestry sectors) accounted for 21% and 12% respectively in 1990, and 22% and 11% respectively in 1995. The remaining emissions (around 3%) came from fugitive fuel emissions, and other sources.

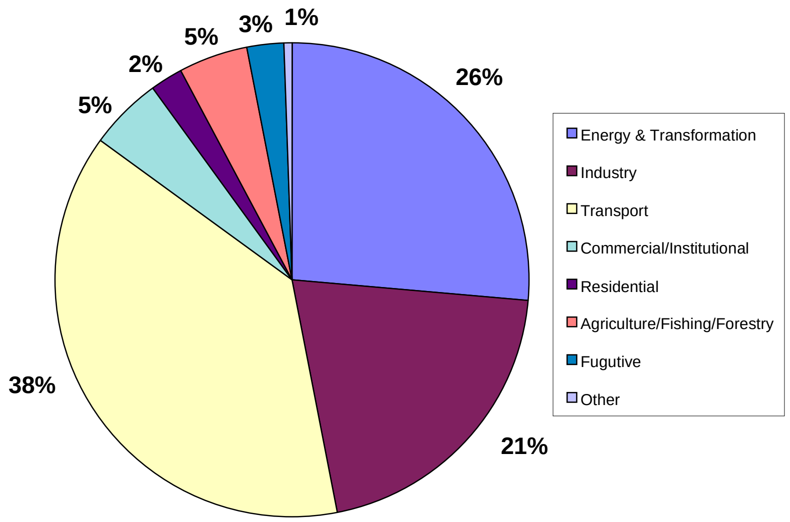

Figure 5.4: 1990 Energy CO_2 Emissions by Sector. Source: Ministry of Commerce, 1997

Figure 5.5 shows 1990 energy sector CO_2 emissions by fuel in New Zealand. Oil contributed 48% of total energy sector carbon dioxide, with the main source being the transport sector which accounted for around 77% of all oil emissions. Gas and coal accounted for 36% and 14% respectively. Less than 2% of carbon dioxide emissions was derived from geothermal sources.

[1] The publication "Energy Greenhouse Gas Emissions 1990-1995", does not include the estimates of emissions of non methane volatile organic compounds included in this second national communication. A detailed inventory of that gas will be included in the next edition, for 1990-1996, to be published in May 1997.

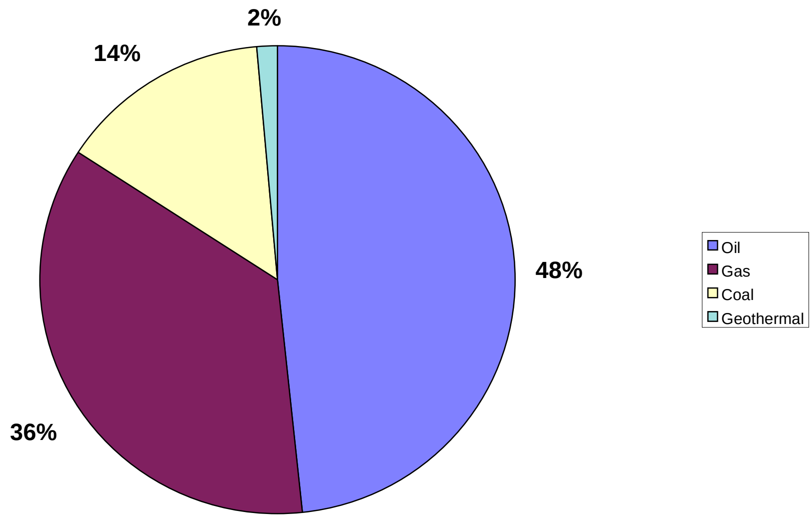

Figure 5.5: 1990 Energy CO_2 Emissions by Fuel. Source: Ministry of Commerce, 1997

5.3.2 Energy CO_2 emissions trends

Energy CO_2 emissions grew by 6.7% from 1990-1995, from 23,089 to 24,631 Gg CO_2. In this period CO_2 emissions from transport, industry and industrial processes grew faster than gross CO_2 emissions as a whole.

Domestic transport is the activity with the largest absolute (2,235 Gg more CO_2 in 1995 compared to 1990) and proportional (26%) increases in CO_2 emissions over the period, mostly due to a 96% increase in diesel use for transport over the period.

About three-quarters of New Zealand's electricity generation is from hydro (and about 6% from geothermal), with fossil fuel thermal stations on the margin. Electricity emissions therefore fluctuate depending on rainfall. High inflows in 1995 resulted in a decrease in CO_2 from electricity generation relative to 1990, which was a more average year for rainfall.

The category with the largest absolute and proportional decrease in CO_2 emissions over the period 1990-1995 is "other transformation". This was mainly due to decreased synthetic petrol production by Methanex New Zealand Limited, which chose to increase its methanol output, leading to offsetting increases in emissions from industry.

5.3.3 Energy sector non-CO_2 emissions

Total *energy* emissions of CH_4, NO_x, CO and NMVOCs have shown a general increase from 1990 to 1995, with the most significant increases occurring in the transport sector. N_2O emissions show a slight decrease in the same period.

5.4 Industrial Processes

Table 5.5 summarises CO_2 emissions from industrial processes in New Zealand for 1990 and 1995. Table 5.6 summarises non-CO_2 emissions from industrial processes for 1990, with Table 5.7 giving total emissions in 1990 and 1995 of non-CO_2 gases from industrial processes for the purposes of comparison.

Table 5.5: CO_2 emissions from industrial processes 1990 and 1995 (Gg).

CO_2 from Industrial Processes	**1990**	**1995**
Total	**2,386**	**2,737**
Iron and Steel	1,328	1,535
Aluminium	458	470
Hydrogen	152	145
Cement	367	503
Lime	82	83

CO_2 is emitted in the chemical processes associated with steel, aluminium, hydrogen, cement and lime production (in addition to any CO_2 emissions from fuel combustion, included above as energy emissions). These industrial process CO_2 emissions amount to a total of 2,386 Gg of CO_2 in 1990 and 2,737 Gg in 1995. The almost 15% increase from 1990-1995 is largely the result of growth in steel and cement production.

Table 5.6: Industrial process non-CO_2 emissions for 1990 of gas (Gg).

Source Category	**CO**	**CH_4**	**N_2O**	**NO_x**	**NMVOC**	**HFC**	**PFC**	**SF_6**	**SO_2**
Total 1990 in Gg	**0.86**	**0.12**	**nr**	**2.25**	**16.73**	**0.00**	**0.09**	**0.02**	**16.31**
Iron and Steel	0.42			0.88					0.67
Aluminium							0.09		5.96
Fertiliser Production									8.85
Ammonia/Urea		0.12							
Cement	0.44			1.38					0.81
Lime									<0.01
Asphalt and Bitumen					6.60				0.01
Glass					0.26				
Pulp and Paper					0.15				
Food and Drink					9.71				
Halocarbons and SF_6						neg		0.02	

Table 5.7 : Emission totals for non-CO_2 emissions from industrial processes for 1990 and 1995 (Gg).

Industrial Process Emissions	**CO**	**CH_4**	**N_2O**	**NO_x**	**NMVOC**	**HFC**	**PFC**	**SF_6**	**SO_2**
Total for 1995 in Gg	**1.12**	**0.12**	**nr**	**2.66**	**18.89**	**0.14**	**0.03**	**0.18**	**20.77**
Total for 1990 in Gg	**0.86**	**0.12**	**nr**	**2.25**	**16.73**	**neg**	**0.09**	**0.02**	**16.31**

Non-CO2 emissions from industrial processes make a relatively minor contribution to New Zealand's greenhouse gas inventory. The most significant differences between the data for 1990 and that for 1995 is the decrease in PFC emissions and the increase in HFC, SF_6 and SO_2 emissions. However, reported emissions of HFCs and SF_6 are potential rather than actual emissions. Release of most of these gases is likely to take place over a number of years, rather than all occur in the year of importation.

5.5 Agriculture

Table 5.8: Agricultural emissions for 1990 and 1995 (Gg)

Agricultural Emissions	**CH_4**		**N_2O**		**NO_x**		**CO**	
	1990	1995	1990	1995	1990	1995	1990	1995
Total in Gg	**1,513.47**	**1,460.43**	**44.87**	**44.10**	**0.16**	**0.16**	**3.80**	**4.03**
Enteric Fermentation	1,495.27	1,442.7						
Manure Management	18.02	17.52						
Agricultural Soils	ne	ne	44.87	44.10				
Field Burning of Agricultural Residues	0.18	0.19	0.01	0.01	0.16	0.16	3.80	4.03

5.5.1 Enteric Fermentation

Compared to its human population, New Zealand has large numbers of farm animals. For 1990, the Ministry of Agriculture and Fisheries report animal numbers at an estimated 57.8 million sheep, 4.6 million beef cattle, 3.4 million dairy cattle, 1.0 million deer, and 1.1 million goats. In 1995, animal numbers were estimated at 48.8 million sheep, 5.2 million beef cattle, 4.1 million dairy cattle, 1.2 million deer and 0.4 million goats. Notably, sheep numbers have declined by approximately 9 million from 1990 to 1995, with a small increase in total cattle numbers over the same period.

The methodology used to estimate methane production by ruminants in New Zealand is described in Annex 2. Methane production by ruminants (sheep, beef cattle, dairy cattle, goats, and deer) has been estimated at 1,495 Gg in 1990 and 1,443 Gg in 1995.

5.5.2 Animal Wastes

The reported methane emissions from manure management are an estimated maximum. This figure is 18 Gg in 1990 and 17.5 Gg in 1995. Included in this total are emission maxima from ruminant faecal deposits on pasture, plus emissions from feedlots, and pig and poultry waste. Annex 2 describes how the estimates were arrived at. Figure 5.6 shows methane emissions from ruminants and their waste from 1990 to 1995.

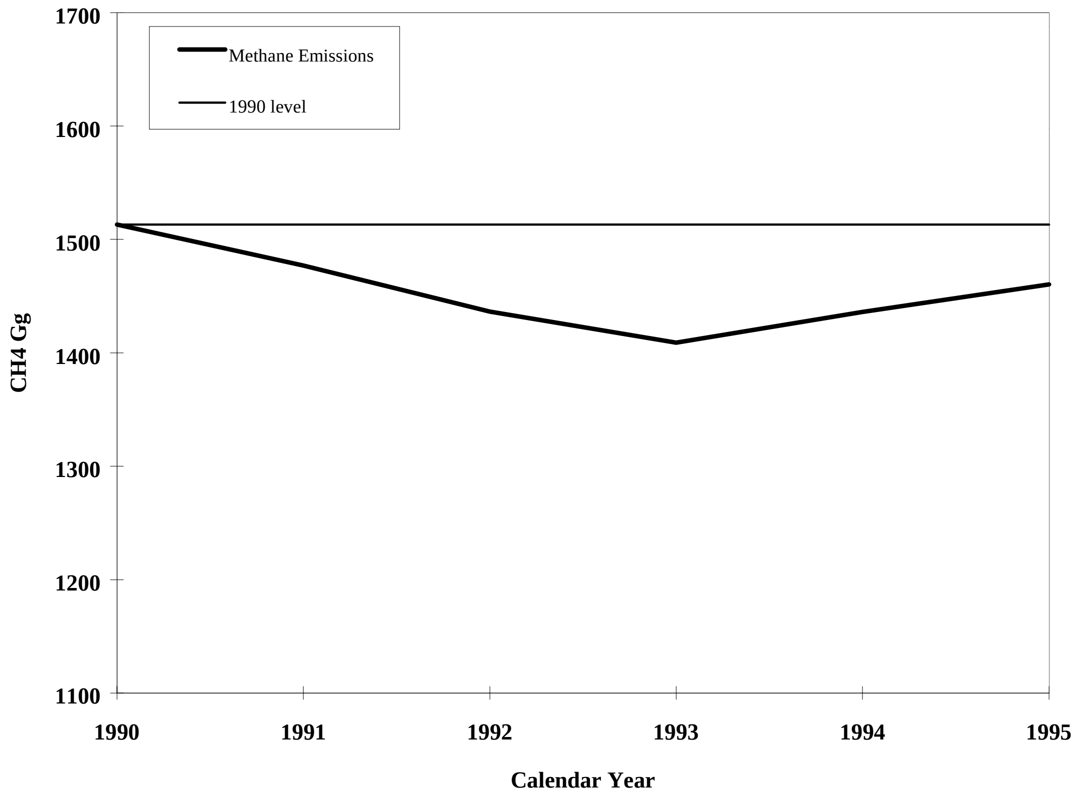

Figure 5.6: Methane emissions from ruminants and their wastes 1990 to 1995.

5.5.3 Agricultural Soils

Soil Carbon

The inventory table does not contain any estimates of carbon loss/gain in New Zealand soils either from agricultural soils, or from soil carbon changes as a result of grassland conversion or the abandonment of managed lands. Total soil carbon in New Zealand to a depth of 1 metre is estimated at 4262 ± 190 Mt (Tate *et al.*, 1993). There are a number of research programmes being funded through the Public Good Science Fund (PGSF - refer to Chapter 10 for more details) which will improve the information base on carbon in New Zealand soils. Green Package funding (refer to Section 6.1.2) is being used to establish a 1990 baseline for soil carbon, which will be a first step in establishing a national system for quantifying changes in soil carbon storage and the contribution of soils to New Zealand's greenhouse gas emissions.

Soils under pasture do not tend to be disturbed by normal New Zealand pastoral agriculture practice (i.e. soils used for pasture are generally not ploughed), and these soils are believed to be in carbon balance. Land used for cropping and horticulture is, however, cultivated annually, and there are large tracts of severely eroded land. Soils under first rotation planted forests are likely to be in balance, although soil carbon may increase in inorganic soils such as sand over successive rotations. Extensive soil disturbance associated with forest harvest is discouraged under the Resource Management Act (see Section 6.3.5).

Soil Nitrous Oxide

Nitrous oxide emissions from New Zealand soils have been estimated at 44.87 Gg in 1990 and 44.10 Gg in 1995, a 2% decrease.

The first national communication presented nitrous oxide emissions from soil as a range, mainly as a result of differing climatic and soil conditions in the North and South Islands of New Zealand. The most recent estimates (quoted above) have been done using the IPCC 1995 default methodology and include emissions from synthetic fertilisers, animal wastes, animal waste management systems, nitrogen leaching and run-off, and human sewage. Although New Zealand emissions factors were applied where these were known, the resulting estimates are still considered to be highly uncertain. Annex 4 outlines the approach taken.

Table 5.9 Nitrous oxide emissions from agricultural sources in gigagrams (Gg).

	1990	1991	1992	1993	1994	1995
Nitrous oxide	44.87	42.96	42.96	43.14	43.51	44.10

Nitrous oxide emissions from agricultural soils in New Zealand generally do not come from the application of nitrogenous fertiliser, although there has been a slight increase in nitrous oxide emissions from fertiliser since 1990. The predominant use of legume-based pastures makes fertiliser nitrogen a relatively small consideration for nitrous oxide emissions compared to the complex interaction between soil type and climatological factors such as rainfall and temperature. Grazing animals can locally enhance nitrous oxide emissions via urine deposited on the soil, and through hoof traffic causing surface damage and poor aeration in wet soils.

5.5.4 Field Burning of Agricultural Residues

Emissions from field burning of agricultural residues from crops, such as barley, wheat and maize, are negligible for New Zealand and, as production levels are relatively constant, do not vary significantly over the period 1990-1995. Annual emissions over the period 1990-1995 were on average: 0.18 Gg CH_4; 0.004 Gg N_2O; 0.16 Gg NO_x; and, 3.9 Gg CO (based on IPCC default values (1995) and production data from the Ministry of Agriculture).

5.6 Land Use Change and Forestry

For CO_2, apart from energy and industrial processes, the only category that could result in emissions for New Zealand is "land use change and forestry". Under IPCC Guidelines, this category covers total emissions and removals from changes in forest and other woody biomass stocks, forest and grassland conversion, and the abandonment of managed lands. In New Zealand, because the area of planted forest is increasing, and because the planted forest estate contains a large number of trees that are yet to reach maturity, the planted forest is absorbing carbon from the atmosphere and therefore acts as a "sink". On-site burning, and forest and grassland conversion, results in some emissions of CO_2, but these are smaller in magnitude than the sink, and are netted into the "land use change and forestry" sink figure, and reported as negative emissions in the tables that follow.

Major planting of exotic forests began in the 1920s. The amount of planting has fluctuated widely since then. As most exotic planting was, until recently, mainly by the State, New Zealand has very good records of commercial planting. Planting is basically (90%) of one species (*Pinus radiata*). Research in forestry (particularly by the government body, the New Zealand Forest Research Institute (NZFRI)) has been well developed, over many years. This combination of factors means that New Zealand has been able to develop very reliable carbon sequestration models and data.

New Zealand has developed a method (Hollinger *et al*., 1993; Wakelin and Te Morenga, 1996) to quantify carbon sequestration by managed forests based on calculating a 'carbon inventory' at two points in time and identifying the difference. This difference represents the net sequestration or emission of carbon for this period. Carbon dioxide sequestered by New Zealand forests in the calendar year 1990 is estimated at 20,571 Gg. The methodology is described in more detail in Annex 5.

The estimation of the total amount of carbon dioxide sequestered by New Zealand forests in any one year takes into account:

- the amount of carbon sequestered by planted forests;
- the amount of carbon lost through the harvesting of planted forests;
- carbon lost through the logging of indigenous forests;
- carbon lost through the clearance of scrublands for forest planting; and
- carbon lost through forest and scrubland wildfires and prescribed burning.

Carbon dioxide and other greenhouse gas emissions from Land Use Changes and Forests are reported in Table 5.10. The figures given for removals include sequestration by planted forests, emissions at harvest from planted forests and harvest emissions from indigenous forests. Emissions figures are for scrub clearing for new forest planting, wildfires and prescribed burning.

Table 5.10: CO_2 and Other Greenhouse Gas Removals and Emissions from Land Use Changes and Forests (Gg)

	1990	1991	1992	1993	1994	1995
CO_2 removals[1]	-22,057	-20,931	-19,585	-17,796	-16,750	-15,766
CO_2 emissions	1,486	1,303	1,414	1,661	2,041	2,276
Total CO_2 removals[1]	-20,571	-19,628	-18,171	-16,135	-14,709	-13,490
CH_4 emissions	4.99	4.39	4.81	6.02	7.13	7.69
N_2O emissions	0.03	0.03	0.03	0.03	0.04	0.05
NO_x emissions	1.12	0.99	1.08	1.35	1.60	1.73
CO emissions	43.67	38.42	42.11	52.69	62.44	67.32

Note: 1. As per IPCC guidelines, removals are reported as a negative emission.
Currently the IPCC methodology assumes that emissions of CO_2 occur at the time of harvest. This is an obvious simplification. Although a large proportion of carbon is emitted shortly after harvest from on-site slash and short-lived products, where harvested wood ends up in long-lived wood products the carbon may remain in storage for long periods of time. Therefore, New Zealand's inventory of CO_2 removals by planted forests includes the potential emissions from harvest, as opposed to actual emissions in New Zealand.

No estimates are available of the net level of vegetation clearance for land uses other than forest. Reversion to scrubland of marginally economic hill pastures, mainly in the North Island, has been particularly evident since the restructuring of the New Zealand economy saw agricultural assistance to farmers fall from an average 25% of the value of agricultural production in the period 1979-86, to 3% in 1992. Thus it is probable that more land is reverting to scrubland cover than is being cleared of such vegetation.

Estimates for emissions from or the amount of absorption occurring in indigenous forests are not available. The reported carbon dioxide emissions inventory does however, include harvesting and wildfires in indigenous forests. Carbon in indigenous forests is discussed in Chapter 6, Section 6.5.2.

5.7 Waste

Table 5.11: Summary of waste sector methane emissions in gigagrams (Gg) for 1990 to 1995, covering emissions from solid waste disposal in landfills, and from wastewater.

Waste Sector	**Methane emissions per year in Gg**					
	1990	**1991**	**1992**	**1993**	**1994**	**1995**
Landfills	150.80	152.26	147.43	144.40	137.33	127.37
Wastewater	4.26	4.27	4.28	4.28	4.29	4.30
Total	**155.06**	**156.53**	**151.71**	**148.68**	**141.62**	**131.67**

5.7.1 Landfills

Population density and distribution, waste volume estimates, and waste stream composition were used, together with the IPCC Phase II methodology (IPCC, 1996), to calculate methane emissions from New Zealand municipal landfills. Landfill emissions have dropped between 1990 to 1995 because of the increased use of landfill gas for energy production. Annual emissions of methane from solid waste disposal in landfills are reported in Table 5.11.

5.7.2 Wastewater

Previous inventories have included an estimated methane emission from primary production processing, with emissions coming from both wastewater and landfilled waste. An approach which combines both the IPCC methodology for wastewater emissions together with New Zealand specific information (as outlined in Annex 6) has since been applied producing estimates for methane emissions from wastewater considerably less than the maximum potential reported in the first national communication. Annual wastewater methane emissions are reported in Table 5.11.

Nitrous oxide emissions from the meat processing industry are estimated at 0.6 Gg (Brown and Cooper, 1992). As other primary production processing industries have nitrous oxide emission potential, total emissions are likely to be higher.

5.8 International Bunkers

Fuels used in international transport are referred to as international bunker fuels. The emissions from this source are required under IPCC guidelines to be reported separately, and so are not included in the aggregations elsewhere in this report. The fuels used in international transport are diesel, fuel oil and aviation fuel.

Emissions from international aviation and marine bunkers reflect New Zealand's geographic location, the long sea and air routes to destinations for passengers and freight, and the country's reliance on export trade (see Section 4.6).

Table 5.13: International bunker emissions for 1990 and 1995 (Gg)

International Bunker Emissions	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1990 Total	**2,413**	**0.225**	**0.055**	**26.96**	**5.56**	**3.72**
Aviation	1,367	0.030	0.021	5.49	2.27	0.95
Marine	1,046	0.195	0.033	21.47	3.29	2.77
1995 Total	**2,736**	**0.246**	**0.060**	**30.42**	**5.95**	**4.11**
Aviation	1,601	0.035	0.025	6.43	2.66	1.11
Marine	1,135	0.211	0.035	23.99	3.30	3.00

Between 1990 and 1995, international bunker emissions (other than of CH_4) increased relatively faster than energy emissions, reflecting growth in international transport use, but not as fast as land transport emissions.

Chapter 6: Policies and Measures to Limit Emissions and Protect and Enhance Sinks and Reservoirs

6.1 Introduction

New Zealand began its response to climate change in 1988 with the establishment of the New Zealand Climate Change Programme. The Government's policy responses have since been brought together with the on-going development of a comprehensive strategy on climate change which aims to address sources of all greenhouse gases and to protect and enhance sinks and reservoirs. The shape of further international commitments by New Zealand and the possible development of international policy measures arising as an outcome of the Berlin Mandate process will be a key influence on further domestic policy development in New Zealand.

Climate change policy development in New Zealand is coordinated by the Ministry for the Environment. There is a steering group of officials from the Ministry for the Environment, the Ministry of Foreign Affairs and Trade, the Ministry of Commerce, and the Treasury. Other agencies involved are the ministries of Agriculture, Forestry, Transport, and Research, Science and Technology, and the Energy Efficiency and Conservation Authority (EECA). The various agencies have responsibilities for contributing to the policy development process, for inventory data collection, and for implementing policy. In particular, the Ministry of Commerce coordinates the voluntary agreements programme, and EECA implements the Energy Efficiency Strategy, and provides technical support to the voluntary agreements programme.

Policy measures in this chapter are described on a gas-by-gas basis and cover:

- policy measures being implemented to address carbon dioxide emissions including voluntary agreements with industry, legislative and regulatory reform in the energy sector, energy efficiency measures, renewable energy measures, use of the Resource Management Act, and specific transport sector measures;
- possible measures that could reduce carbon dioxide emissions, including a low-level carbon charge, and/or a domestic emissions trading regime;
- policy measures to enhance and protect carbon sinks and reservoirs including commercial planted forests, indigenous forests and soil carbon;
- policy measures to limit methane emissions from both agricultural sources and from waste;
- policy measures to limit nitrous oxide emissions, in particular from the agricultural sector; and
- policy measures for non-CO_2 industrial process emissions.

This chapter also provides some information on the effects of the above policy measures, but the detailed information on effects and projections is contained in Chapter 7.

6.1.1 Framework Convention on Climate Change

New Zealand was an active participant in the negotiation of the Framework Convention on Climate Change (FCCC). It was among the countries that signed the convention at the Earth Summit in June 1992. New Zealand ratified the FCCC on 18 September 1993, becoming the 34th Party to the Convention. It was therefore one of the 50 ratifications necessary to bring

the FCCC into force. As a developed country Party, New Zealand accepts the particular obligations this involves, including:

(a) the need to adopt policies and measures to limit emissions of greenhouse gases and to protect and enhance its greenhouse gas sinks and reservoirs;

(b) a responsibility to report detailed information on its policies and measures, as well as projected emissions by sources and removals by sinks, in keeping with the timeframes identified in the FCCC;

(c) the commitment to provide new and additional financial resources to assist developing countries to fulfil their commitments on the basis outlined in the FCCC;

(d) the need to support research into climate change; and

(e) the requirement to promote public awareness and education.

New Zealand has continued to play an active part in the subsidiary bodies of the FCCC which were established at COP1. The permanent subsidiary bodies are the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI). COP1 also established two “ad hoc” subsidiary bodies, the Ad Hoc Group on Article 13 (AG13) and the Ad Hoc Group on the Berlin Mandate (AGBM). AG13 is looking at establishing a multilateral consultative process for the resolution of questions regarding the implementation of the FCCC. The AGBM is negotiating strengthened commitments for developed country Parties (and other Parties included in Annex I) to the FCCC, for the period after 2000.

New Zealand has participated actively in the Berlin Mandate process and also made written submissions for consideration of the AGBM. New Zealand has consistently advocated that targets for emissions reduction should be realistic, achievable and consistent with the principles of cost-effectiveness and lowest possible cost outlined in the FCCC.

6.1.2 The comprehensive strategy on climate change

The first package of measures specifically aimed at reducing carbon dioxide emissions was announced in June 1992.

Expecting to ratify the FCCC later in 1993, the Government announced in May 1993 it would develop a comprehensive strategy on climate change. This strategy aims, over time, to incorporate a range of policies and measures to address sources and sinks of all greenhouse gases (apart from those covered by the Montreal Protocol) and to help New Zealand adapt to the impacts of climate change. A number of policies and measures have already been agreed to and are being implemented. Further measures will be added incrementally. This will be done in step with scientific and technological developments and the development of appropriate policy measures, including any international measures arising from the international negotiation process. The further development of commitments under the FCCC, including the outcome of the Berlin Mandate negotiations, will be an important factor for future policy development.

The Government, in deciding to develop the comprehensive strategy, also established a clear domestic carbon dioxide target, consistent with New Zealand’s commitments under the FCCC. New Zealand’s current carbon dioxide objective is to return net carbon dioxide emissions to their 1990 level by 2000 and to maintain them at that level thereafter. The approach to meeting this objective includes policies to reduce gross emissions together with policies to protect and enhance forest sinks and reservoirs.

New Zealand is currently investigating policies and measures for non-CO_2 greenhouse gases. The lack of data on emission sources and sinks and the effects of policies to address emissions including costs is being improved through research. Better information will assist in the identification of least cost options for addressing emissions of these gases.

Additional funding has been made available to government departments through a Budget Green Package. Announced in the 1996/97 budget, the Green Package funding of over NZ$110 million over three years, is assisting the Government achieve its environmental and conservation objectives, including addressing the risks of climate change. The climate change policy areas benefiting from this funding are non-CO_2 greenhouse gases (NZ$0.57 million), carbon in soils (NZ$0.9 million), carbon in indigenous forests and scrublands[1] (NZ$1.0 million), pest and weed control in areas with high conservation value under threat (NZ$20 million) and new methods of possum control (NZ$6.25 million). Specific items of the Green Package are covered in the appropriate sections in this chapter.

6.2 Policy measures being implemented to address carbon dioxide

In July 1994, the Government announced a policy package to address carbon dioxide emissions. The package was expected to achieve a target of stabilising net emissions of carbon dioxide at 1990 levels by 2000. It was expected that the stabilisation target would be achieved, for any GDP growth rate, by a 20 percent reduction in gross emissions growth below a 'business as usual' (BAU) emissions scenario, with the remaining 80 percent from absorption by the expanding area of planted forest sinks. In other words, the policy aims at an overall reduction in the rate of emissions growth.

Under the 1994 policy package, the reduction in emissions growth comes from voluntary agreements, energy efficiency measures, and energy sector reforms. Initiatives in other sectors also contribute to achievement of the target. The policy also provided for the Government to introduce a low level carbon charge if, by mid-1997, it assessed that the policy measures proved to be insufficient to achieve stabilisation of net carbon dioxide emissions at 1990 levels by 2000. However, the Government announced in March, 1997, that any decision on a carbon charge will be deferred until early 1998. By this time the Berlin Mandate process will have clarified international expectations, and multilateral instruments, such as an international emissions trading regime, may be available to assist New Zealand meet any new commitments at least cost.

6.3 Policy measures being implemented to address carbon dioxide emissions

6.3.1 Voluntary agreements with industry

In July 1994, as part of the CO_2 Policy Package, the Government announced a programme of voluntary agreements. The Government is encouraging a broad range of business sector groups and companies to enter into voluntary agreements to reduce their emissions of carbon dioxide. These agreements encourage companies to lower emissions (both energy and process) or improve their emission rate by any economically feasible means. Voluntary agreements require companies or sector groups to specify the amounts of CO_2 that they will

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[1] Scrublands (also known as seral vegetation) are generally areas of mixed species woody vegetation, generally less than 3-4m in height, with a biomass density ranging from 70-110 t/ha (biomass estimates based on Tate *et al.*, 1993). If left relatively undisturbed over time, scrublands may lead to the regeneration of indigenous forest, depending on species composition and other factors.

avoid emitting as a result of improvements or alterations in current practices over the period 1990-2000. These amounts of CO_2 avoided are defined either as total tonnes of CO_2 saved from specific projects, or in terms of expected CO_2 per unit of production in 2000 compared with either actual base year figures (usually 1990), or base-year equivalent projected figures for 2000.[2]

The use of voluntary agreements recognises the major role of business in reducing New Zealand's emissions of greenhouse gases. They provide a means of encouraging industry to consider carbon dioxide emissions when making decisions affecting the type and level of energy use.

The Ministry of Commerce has coordinated the development and negotiation of voluntary agreements. After wide consultation with industry, government agencies and environment non-governmental organisations (NGOs), technical guidelines for voluntary agreements were issued in February 1995 (Box 6.1). The current system is designed to impose the maximum rigour, consistent with the absence of government subsidies and the need to minimise company compliance costs.

Box 6.1: Summary of Technical Guidelines for Voluntary Agreements

The basic framework for a voluntary agreement provides for an industry to:

- identify CO_2 emission abatement achieved or planned over the period 1990-2000, to coincide with the Government's stabilisation objective;
- establish 1990 base year data for CO_2 emissions;
- identify a target or outturn to be reached in the year 2000;
- identify the major activities carried out or to be undertaken to achieve the year 2000 target;
- identify periodic intermediate targets;
- commit to making an annual report to the Ministry of Commerce on progress towards the year 2000 target; and
- accept independent validation (by EECA) of the 1990 base year data and of subsequent data and the annual reports.
- CO_2 abatement may be identified by calculating changes in emission intensity, changes relative to a base year equivalent method or the actual tonnes of CO_2 saved by specific projects.

The agreements are not legally binding, and there is no penalty for under-achievement. There is an expectation that they will be renegotiated if annual reporting shows a major variation from what was expected to be achieved. The evidence from companies so far is that they have been conservative in setting their target for the year 2000, and that several are likely to achieve greater abatement than they have targeted.

[2] This last formulation is recommended in the Technical Guidelines and is essentially the same as Canada's methodology. The abatement calculation using this methodology involves comparing the targets with a Base Year Equivalent (BYE) for 2000, which estimates the emission rate if technologies and efficiencies were to remain unchanged at base year levels (usually 1990).

Negotiations have focused on the major industry and energy transformation sectors that together account for over 40% of total CO_2 emissions - steel, oil refining, methanol and synthetic gasoline production, electricity generation, aluminium smelting, cement, oil and gas production and distribution, pulp and paper, dairy processing, meat processing, wood panel production and coal production.

Additionally, other smaller businesses have also opted to join the process, including those involved in urea production, glass manufacturing and plaster board production. The range of participants is expected to continue to expand.

The Government has approved a variation on voluntary agreements called Facilitating Agreements. These allow the voluntary agreements to penetrate into more dispersed sectors with multiple small units, where an industry association or similar body is willing to act as an intermediary. An example is the Coal Research Association which is negotiating for small coal users to sign agreements. It is not expected that there will be large numbers of facilitating agreements or that the volumes of CO_2 involved will materially affect New Zealand's total position.

As at the end of January 1997, 21 Voluntary Agreements, including one Facilitating Agreement, have been signed. A summary of the Voluntary Agreements is given in Table 6.1.

Table 6.1: CO_2 emissions reduction as identified in voluntary agreements.

Company/Sector	**Target CO_2 reduction**[1.]
ACI New Zealand Glass Manufacturers	16.5%
BHP New Zealand Steel	13.2%
Carter Holt Harvey	45.5%
The Cement Industry	12.0%
Comalco New Zealand	4.0%
Petrochem	28.0%
Winstone Wallboards	21.0%
Electricity Corporation of New Zealand	874 kt
Methanex New Zealand Ltd	5.5%
Lincoln University	15.1%
Canterbury Brewery	18.3%
Skellerup Industries Ltd	52.9%
STAR Services Ltd	33.4%
University of Canterbury	3.7%
Websters Hydrated Lime	27.6%
New Zealand Sugar Co Ltd	13%
Shell Todd Oil Services Ltd	10%
New Zealand Refining Ltd	10%
Coal Corporation Ltd	22.77%
NZ Co-op Dairy Co Ltd	21.5%[2.]

Notes: 1. In most cases, per unit of production 1990 to 2000.
2. Dairy production only. The voluntary agreement has a target for the milk collection fleet also.

6.3.2 Legislative and regulatory reform in the energy sector

As reported in New Zealand's first national communication, new legislation was enacted in 1992 as a key part of the Government's energy sector reforms. This legislation provides, among other things, a regulatory framework to facilitate the development of competitive gas and electricity markets. Price controls on gas have also been removed.

The main objective of the reforms has been to improve the sector's efficiency, in both the production and use of energy, for the overall benefit of the economy. This includes recognition of the role played by clear market incentives in the adoption of energy efficiency practices. These legislative changes do not in themselves ensure that energy efficiency will be promoted but, instead, set the scene for this to happen where commercially viable prospects exist. Over time, the energy sector reforms are expected to provide a significant boost to improving the economy's efficient use of energy.

Energy companies are now free to compete in energy supply. A competitive response by electricity and gas retailers could be expected to include the promotion of energy efficiency because customers are likely to prefer suppliers offering energy services packages. Under competitive pressure, suppliers will need to strive to meet their customers' needs for energy services.

The Government has also moved to introduce competition in the electricity generation industry. As of February 1996, the Electricity Corporation of New Zealand (ECNZ) has been split into two competing state-owned enterprises: ECNZ and Contact Energy Limited. The reduction of ECNZ's market dominance is expected to ensure that prices move over time to reflect the marginal costs of supplying electricity (rather than average pricing) and will therefore mean that energy efficiency and renewable energy projects can more fairly compete with new investment proposals. A set of special restraints will apply until ECNZ's market share falls below 45 percent. These include a cap on ECNZ building new capacity and a requirement for ECNZ to "ring-fence", i.e. to separate operational/financial control, any new capacity it builds. The cap precludes ECNZ from providing more than 50 percent of new generating capacity. ECNZ may, however, invest in cogeneration and non-traditional renewable energy plants outside the cap and this may encourage investment in renewables such as wind. The ring-fencing restraint means that ECNZ may not cross-subsidise its new generation capacity and is required to achieve a proper commercial return on its assets. The combined effect of these regulatory measures is expected to provide an environment which is more encouraging for energy efficiency and renewables.

A self-regulated wholesale electricity market has been operating since October 1996. In addition to promoting overall economic efficiency, the wholesale electricity market is expected to encourage energy conservation, energy efficiency and renewables by:

- having spot market prices which more accurately signal the real time supply and demand situation: high prices when supply is tight will encourage demand reductions;
- allowing demand-side bids into the spot market: the ability of wholesale buyers to indicate to the spot market that they are willing to shed load when the price reaches a certain level will encourage economically efficient load management;
- providing long-term contracts and a contract trading market which will facilitate trading and improve the longer term price signals of the value of reductions in demand;

- having open access to the pool and grid, which will encourage development of renewables such as wind by providing access to a wide market and backup supply.

The Electricity Market Company (EMCO) which administers the wholesale electricity market has recently established a special industry working group to investigate and make recommendations to foster greater competition from demand side alternatives (such as energy efficiency schemes) to electricity generation.

Despite the potential for New Zealand's competitive energy market reforms to enhance the uptake of cost-effective energy efficiency and new renewables, the benefits of competition may be slow to reach some market segments, notably household customers and small commercial accounts in the electricity sector. It is recognised that in practice these small electricity consumers may remain effectively the captive customers of their incumbent suppliers, at least until the cost of the metering and communication equipment necessary for competitive supply reaches viable levels. The Ministry of Commerce has recently commissioned a study to identify and provide recommendations to address barriers to competition in the market for small consumers.

Consequently, as part of its reform package in mid-1995 which ushered in the competitive wholesale electricity market, the Government also introduced a competitively tendered source of funding for energy efficiency installations in the residential sector - the Energy Saver Fund.

The Energy Saver Fund, has as its primary objective, the achievement of cost-effective improvements in end-use residential energy efficiency. It also seeks, as secondary objectives, to foster the development of sustainable commercial energy efficiency activities, and to especially promote energy savings in areas where commercial provision of energy efficiency services is currently particularly unlikely to occur (such as in low income tenanted properties). The Government decided to allocate funding of up to $18 million over five years to the Energy Saver Fund. Current allocations are $1.85 million in 1996/97, $4 million in 1997/98 and, subject to the outcome of a review, $5 million in each of 1998/99 and 1999/2000. The Energy Saver Fund is administered by the Energy Efficiency and Conservation Authority (EECA). The Energy Saver Fund complements EECA's other activities which are further described in Section 6.3.3.

The development of a more competitive environment in the gas sector will encourage greater efficiency in the use of gas. There are some encouraging developments in this regard.

Regulations requiring information disclosure for the gas industry will be implemented shortly. These will help the development of wholesale competition. At the retail level, gas-to-gas competition is insignificant. Natural gas faces some localised competition from landfill gas, but in the main, the principal competitor is electricity.

A recent court decision re-assigning the rights to half of a major gas field has raised the likelihood of new entry into the wholesale market, which is currently dominated by a single company. This vertically integrated corporation also owns most of New Zealand's high pressure gas transmission pipeline network, access to which will be an important determinant of the development of competition. The information disclosure regulations, which will include information about pipeline capacity will assist in this regard. The industry is moving to self-regulate better access to pipelines through a voluntary industry body called Gas House.

6.3.3 Energy efficiency measures

As reported in New Zealand's first national communication, the Government established the Energy Efficiency and Conservation Authority (EECA) in 1992 as an independent agency

charged with determining and implementing practical measures for achieving greater energy efficiency in New Zealand. Box 6.2 provides an overview of EECA.

Box 6.2: Overview of EECA

EECA was established in October 1992 with an annual operating budget of just over $2 million. It is governed by a Board which reports directly to the Minister of Energy. In 1996/97 EECA has an operating budget of some $6 million. The functions of EECA, as defined in its Terms of Reference, are as follows:

- To develop, implement and promote strategies for energy conservation;
- To advise the Government and the New Zealand energy industry on matters relating to the development, implementation and promotion of those conservation strategies; and
- To monitor known energy sources, their use, and the investigation of potential sources and applications, together with the economic, social and environmental impacts, in both the short and longer term.

EECA’s terms of reference are broad enough to encompass a focus on efficiency and conservation in any aspect of energy production, supply and use. In practice, however, EECA’s activities are focused mainly in two areas: end-use energy efficiency, and the development of non-traditional renewable energy resources. The decision to focus efforts in these areas followed a period of extensive analysis during 1993 and the early part of 1994 on the barriers to improved energy efficiency and conservation, the opportunities to make improvements, the incentives for the private sector to realise the potential gains, and the appropriate role of a government agency within the field.

Building on this analysis, the Government’s Energy Efficiency Strategy was announced in June 1994, as detailed in New Zealand’s first national communication. It contains a range of practical measures aimed at increasing efficiency in selected end-uses of energy across all sectors of the economy (including the household sector), and the promotion and facilitation of the development of non-traditional renewable energy resources. This Strategy (albeit with some minor alterations), in combination with the “core” functions of information provision, policy advice, and the collation and evaluation of end-use data, has continued to provide the basis of EECA’s activities since 1994. Significant recent additions are:

- the administration of technical aspects of the Government’s Voluntary Agreements with industry for limiting carbon dioxide emissions, and
- the administration of the Energy Saver Fund (established as part of the Government’s reforms to the wholesale electricity market).

EECA’s operational programmes are outlined in Box 6.3.

As announced in the 1994 CO_2 Policy Package, an assessment was made in 1995 to determine whether the Energy Efficiency Strategy should be enhanced. It was confirmed that the Strategy would be expected to reduce gross carbon dioxide emissions by around one percent of projected emissions in 2000, or around 300 Gg. It was decided it would be premature to consider enhancing the Energy Efficiency Strategy before the initial three years of programme funding had run its course. Further information on programme performance to date can be found in Chapter 7.

Box 6.3: EECA's operational programmes

In addition to its functions of policy development and energy efficiency monitoring, EECA has a wide range of operational programmes centred around the delivery of Government's 10 point Energy Efficiency Strategy, announced in June 1994. Some of the programmes span more than one sector, while others are aimed more particularly at specific sectors of the economy. They are described briefly below:

Cross sectoral initiatives

- Building Code energy efficiency provisions
  - New mandatory energy efficiency provisions have been drafted for inclusion in the proposed revision of the Building Code. Both new residential and new commercial buildings are covered.
- Minimum energy performance standards (MEPs)
  - Government has approved the development of mandatory MEPs for fluorescent lamps and ballasts, as well as domestic storage water heaters.
- Partnerships
  - A number of energy efficiency initiatives have been undertaken jointly with other parties including the "Energy-Wise Contractors Campaign" and joint initiatives with both schools and hospitals.
- Information provision and seminars
  - EECA produces a wide range of technical and management oriented publications, as well as conducting seminars aimed at improving skills and knowledge in the energy efficiency area.
- Technology demonstration
  - Activities in this area assist the development of the market for new products and services by demonstrating their technical and economic performance.

Sector-specific programmes

- Residential sector initiatives including:
  - establishment and administration of the Energy Saver Fund which provides a pool of finance, of up to $18 million over a 5 year period, for household energy efficiency measures aimed at "kick starting" residential energy efficiency activities;
  - pilot community schemes; and
  - raising awareness and gaining commitment to improving the energy efficiency of water heating and appliances (including labelling and endorsement of energy efficient water heaters).
- Commercial and industrial sector initiatives including:
  - the Energy-Wise Companies Campaign (with 650 signed up members to date) which secures management commitment to improving energy efficiency through a charter of energy efficiency principles, priorities and actions;
  - the Energy-Wise Practice Programme aimed at raising awareness and increasing skills in the energy efficiency area; and
  - activities focussed on equipment suppliers and consumers aimed at improving the uptake of energy efficient lighting, energy efficient motors and drives, and energy efficient office equipment.
- Transport sector initiatives including:
  - investigations into the costs and benefits of a vehicle emissions testing regime;
  - commercial driver education (and in particular the development of appropriate resource materials); and
  - the demonstration of an original equipment manufacture CNG vehicle.
- Initiatives aimed at facilitating the development of non-traditional renewable energy forms, including:
  - facilitating renewable energy industry associations and networks;
  - the development of renewable energy planning guidelines; and
  - advice on the priorities for application of public good research funding.
- Public sector initiatives including:
  - administration of the Crown Energy Efficiency Loan Scheme;
  - the Government Energy Efficiency Leadership Programme; and
  - advice and advocacy on energy efficiency to local government, addressing land use, transport, and air quality planning issues, as well as their in house use of energy.

6.3.4 Renewable energy measures

New Zealand has a set of climatic, geographic and other conditions which are favourable for many specific renewable energy applications. The country has abundant resources of wind, rainfall and sunshine. It has a long coastline, many steep rivers and streams and elevated lakes. The climate and soils are favourable for agriculture and there is land available for energy crops and forestry.

New Zealand has made considerable progress towards making renewable energy a significant and permanent part of the nation's mix of energy resources. Hydro generation increased from 54 to 100 PJ from 1974 to 1996, an increase of over 80 percent. Geothermal energy supply increased by 70 percent over the same period. The use of other renewables, principally biomass in the form of wood, has increased by over 100 percent in the last 20 years.

While the use of fossil fuels has steadily increased as well, renewable energy has held its position as a major contributor to New Zealand's energy supply. In 1996, renewable energy provided 34 percent of New Zealand's total consumer energy demand of 435 PJ, and approximately 80 percent of New Zealand's electricity generation. Nearly all (97 percent) of this renewable energy comes from "traditional" sources, mainly hydro development, but also firewood in homes and wood processing wastes in industry, and geothermal development. The remaining 3 percent is from a diverse range of energy sources: wind, industrial waste, landfill gas and biogas.

<u>Research on non-traditional renewable energy sources</u>

New and emerging sources of energy (especially wind power, solar power and biomass) continue to receive prominent and increasing attention in the energy research strategy for New Zealand's Public Good Science Fund (PGSF). Research funding for these non-traditional renewable sources is scheduled to almost double over the period 1996/97 to 2000/01 as shown in Table 6.2.

Table 6.2: Funding trends for energy research to 2000/01 ($000s) Source: Foundation for Research, Science and Technology, 1996.

Topic Area	Funding (000s of dollars)					
	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
Fossil fuels	1,080	1,130	1,232	1,334	1,443	1,560
Geothermal and hydro	1,421	1,449	1,522	1,595	1,672	1,755
New and emerging	966	1,068	1,255	1,441	1,639	1,852
Utilisation	1,386	1,529	1,792	2,053	2,331	2,632
Total	**4,800**	**5,177**	**5,802**	**6,423**	**7,085**	**7,800**

Note: Totals may not sum precisely due to rounding and technical adjustments in the Science Priorities Statement.

These funding trends continue the strong encouragement given in the previous strategy to research in the New and Emerging and Utilisation topics. Smaller increases are proposed for Fossil Fuels and Geothermal and Hydro, which remain important areas for research. The Utilisation topic is focussed especially at increasing the end-use efficiency and conservation of energy.

Projects currently being funded in the New and Emerging area include: renewable woody biomass as a sustainable energy source, solar energy conversion and applications, and turbulence and wind energy.

A major study of new and emerging renewable energy opportunities in New Zealand conducted jointly by EECA and the Centre for Advanced Engineering was published in 1996 (Energy Efficiency and Conservation Authority and the Centre for Advanced Engineering, 1996). The report outlines the present state of the technology, economic viability and environmental impact of implementing various types of “non-traditional” renewable energy in New Zealand.

Measures to increase renewable energy use

Government policy on facilitating the development of cost-effective renewable energy, consistent with its wider energy policy framework is set out in the Renewable Energy: Framework Policy Statement of 1993 (Ministry of Commerce, 1993).

The legislative and regulatory reforms in the energy sector have stressed open access to transmission facilities, improved pricing signals and competitive incentives in the electricity and gas markets. This provides improved access to markets by new electricity generators using renewable sources.

During 1996, New Zealand’s first commercial wind farm (Hau Nui) with a total installed capacity of 3.5 MW, was commissioned by Wairarapa Electricity. The wind farm adds to the existing ECNZ 225 kW Wind Turbine Generator installed four years ago in Wellington. Together with various smaller turbines installed in New Zealand, the total grid connected installed wind turbine capacity is estimated to be 4 MW. Energy companies and other developers have or are currently investigating specific wind power proposals amounting to about 150 to 200 MW. Several power companies have already secured land for wind farm developments. Many future wind farms will be similar in size to the 3.5 MW Hau Nui project although there will be exceptions (for example the 65 MW proposed development near Palmerston North).

The commissioning of New Zealand's first wind farm allows concerned parties to experience an operational wind farm first hand. It is believed that this will help to alleviate any perceived negative effects of wind farms.

EECA has been examining additional measures to assist the development of renewable energy, consistent with the Government's policy framework. Two volumes of planning guidelines - one relating to wind generation, the other to small scale hydro schemes - have been published (Energy Efficiency and Conservation Authority, 1996a; Energy Efficiency and Conservation Authority, 1996b) to assist developers and local authorities with consent applications under the Resource Management Act. Two other issues under review which may influence the uptake of renewable energy: a draft Australian/New Zealand standard for Acoustics - The Assessment of Noise from Wind Turbine Generators, is currently being reviewed following a period of public consultation and comment, and a consortium of major wind farm developers has applied for the Inland Revenue Department to review the tax depreciation regime applying to wind turbine generators.

Two new renewable energy industry groupings have also been established - the New Zealand Wind Energy Association and the Bioenergy Network of New Zealand. These networks seek to foster the development of cost-effective renewable energy opportunities in conjunction with existing networks such as the Solar Industries Association.

Private Sector Initiatives

There is a range of private sector and other parties whose decisions and actions directly foster the uptake of energy efficiency and renewable energy. Typically their actions are commercially motivated by one or more of the following influences:

- energy sector reforms;
- pressures for international cost competitiveness on business;
- voluntary industry CO_2 emission reduction agreements;
- the Government's energy efficiency strategy;
- the availability of new, more energy efficient technologies; and
- advances in renewable energy technologies.

There is some evidence of increasing activity and focus on energy efficiency by the private sector and other organisations. A brief outline of some of their activities is set out below.

Energy supply companies

There is evidence of an increasing provision of broader energy services (including advice on energy efficiency, and third party financing techniques such as shared savings contracts) to larger industrial consumers by energy supply companies, particularly in the electricity and gas sectors. This is probably a consequence of the energy sector reforms, which are also leading to more interest and investment in upstream energy generation by retail companies. Some of these projects are renewable energy developments such as New Zealand's first commercial wind farm (Hau Nui) described earlier.

There has also been significant development of cogeneration projects in the last two to three years. Over 170 MW have been commissioned in that period, with about 100 MW to be commissioned in the remainder of 1997, and approximately 150 MW actively being proposed. The main feedstock is gas, but with significant amounts of wood waste, kiln waste and coal cogeneration.

Equipment suppliers

Entrepreneurial activity by suppliers of equipment such as energy efficient fluorescent lighting and electronic ballasts, electric induction motors, variable speed drives, heat pumps, solar thermal water heating systems, efficient whiteware appliances, building energy management systems, energy monitoring and targeting systems, and new electro-technologies are already contributing to the diffusion of new, energy efficient technologies. In addition, an energy management industry is beginning to develop in New Zealand, supported by new organisations such as the Energy Management Association.

Industrial energy consumers

There is evidence of continuing energy efficiency gains by a significant number of industrial energy users, assisted by the Government's CO_2 voluntary agreements, and EECA's programmes. The inaugural round of EECA's Energy-Wise Companies Awards has provided a number of examples of companies which have made gains in the region of 10-20 percent in annual energy cost savings during the 1995/96 year. It is recognised that there is still a significant way to go in achieving best international practice in energy management processes among industry.

Commercial building developers, owners and tenants

As with industrial energy consumers, there is increasing evidence of significant energy efficiency gains (again in the order of 20 percent) being made by commercial building owners and tenants, and an increased focus on energy management by building managers. However, ongoing, systematic integration of these activities remains patchy.

There is also some anecdotal evidence of increased emphasis being placed on high quality building design with more desirable working conditions, with less impact on the environment and lower operating cost structures. There is however, room for considerable progress in this area.

Local government

Local government is not only a significant energy user in its own right (with approximately NZ$80 million in energy costs per annum), it also devises and implements policies which impact on land use, transport planning and the patterns of industrial development. (The role of councils with respect to these issues is covered in the following section on the Use of the Resource Management Act). In the latter context, the United Nations Agenda 21 places special responsibilities on communities to develop more sustainable energy use at a local level.

Local government's degree of implementation of energy management practices and the promotion of sustainable energy at a community level is variable within New Zealand. Some councils have embarked on a range of energy management activities which are already resulting in substantial energy cost savings, and improved living conditions for tenants of council-owned flats. Approximately thirty councils are also members of the Energy-Wise Companies Campaign.

6.3.5 Use of the Resource Management Act

The Resource Management Act 1991 (RMA) provides the basis for local and regional governments' response to climate change through granting resource consents and developing plans and policies. The Act integrated provisions of more than 75 earlier laws and is founded on the concept of "sustainable management" of natural and physical resources.

'Sustainable management' under the RMA is defined as "managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well being and for their health and safety while–

(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment."

The RMA is set up to primarily deal with the local environmental effects of activities. There are some difficulties in dealing with greenhouse gases at a regional level, particularly as climate change is a national/global issue. Greenhouse gases are however regarded as contaminants under the Act and local authorities in New Zealand are currently:

- dealing with resource consents with significant carbon dioxide implications by undertaking early consultation with applicants, encouraging the use of the best means practicable to reduce proposed carbon dioxide emissions, ensuring that emissions are monitored and that any voluntary offsets are recorded;
- basing decisions as to emission reductions on a 'no regrets' approach and decisions as to mitigating the potential impacts of climate change on a 'precautionary' approach; and
- considering greenhouse gas emissions and sinks in the preparation of their regional policies and plans.

Local authorities are required under the RMA to develop policy statements and plans for their areas. These policies and plans have the potential to address the issue of how emissions of greenhouse gases are to be dealt with. Regional policy statements have covered:

- the promotion of renewable energy, especially planning for the environmental effects of renewable sources of energy, including wind, solar, micro-hydro, and biogas;
- the promotion of efficient energy use and energy conservation;
- the availability of water for future hydro power production;
- setting air quality standards; and
- the promotion of energy efficiency through appropriate urban design, subdivision pattern and lot orientation, and promotion of public transport systems.

The first national communication reported the participation of the Government in several Air Discharge Permit applications where significant carbon dioxide and other greenhouse gas emissions have been involved. The RMA has provided opportunities, prior to the consent application being made, for applicants to be encouraged to consider alternatives and adopt the best means practicable to reduce greenhouse gas emissions.

The conditions attached to the consents have included:

- the adoption of the best practicable option[3] (BPO), for example, regarding the efficiency of fuel burning. Some conditions have required the use of appropriate technology when it becomes available;
- the provision of information on emissions, which may require an independent audit;
- reporting on technological advances for the reduction or mitigation of emissions and any energy efficiency measures the consent holder has adopted; and
- review clauses for two or five years on the basis of changes in Government policy.

The Act also allows for resource consent applications involving matters of ‘national significance’ to be ‘called in’ for consideration by the Minister for the Environment. Such consent applications include any relating to proposals that would affect the country’s ability to achieve its targets for carbon dioxide emissions. Decisions on such consent applications are made by central government rather than the local authority. The procedure involves a board of inquiry reporting to the Minister for the Environment, with the Minister’s decision being subject to appeal.

In December 1993, the Minister for the Environment called in the application for an air discharge permit for the proposed 400 MW Taranaki Combined Cycle power station. The power station would discharge up to 1.5 million tonnes of carbon dioxide a year running at full capacity (around 5% of total 1993 carbon dioxide emissions, or 4% of projected total carbon dioxide emissions for 2000). Because of its national significance, it was decided to deal with the application at a national rather than a regional level.

A Board of Inquiry was convened, which in due course made recommendations to the Minister (Board of Inquiry, 1995). Responding to these recommendations, the Minister for the Environment granted the resource consent application subject to much more stringent conditions than those typical to such applications as described above. The conditions require the consent holder to fully avoid, remedy or mitigate CO_2 emissions from the power station that are additional to the CO_2 emissions from the electricity generation system prior to the commissioning of the station (Ministry for the Environment, 1995).

Although there have been several more consent applications for power stations since the Taranaki Combined Cycle consent, councils have chosen not to use the Taranaki Combined Cycle consent conditions, of imposing a condition requiring immediate mitigation, as a precedent. Instead conditions have been attached to review the need for a mitigation requirement two years after commissioning, dependent on the development of the Government’s climate change policy.

6.3.6 Specific transport sector measures

The following transport sector measures have been adopted to address, in part, the growth in transport sector emissions noted in Section 5.3.1.

- Transfund New Zealand, the agency which allocates most roading funds, assesses roading projects on their relative merits. This is done on the basis of cost benefit analysis carried

[3] “Best practicable option” means, in this case, the best method for preventing or minimising the adverse effects of the discharged contaminant on the environment, having regard to the method’s comparative financial and environmental implications and the current state of technological knowledge.

out for each project. The cost benefit analysis process takes into account the likely effect of the proposed project on CO_2 emissions. Public transport and cycle-way works have been partly funded by Government. In addition, projects providing alternatives to roading will also be funded in circumstances where a project's viability outweighs that of a rival roading project. An industry working group has been established to advise Transfund on implementation of this provision. Their recommendations on the type of evaluation procedures to adopt are expected soon. As an interim measure, Transfund is using a shadow price of $30 per tonne of carbon dioxide in its roading cost benefit assessments.

- There is to be further speed limit education and improved enforcement**.** High intensity advertising and enforcement has reduced the incidence of drunk driving. This same approach will be used in 1997/98 to reduce vehicle speeds. The New Zealand open road speed limit is 100 kilometres per hour (km/h). Mid-winter open road speeds average about 105 km/h. There is a target to reduce this to 102 km/h by 2001. Enforcement mechanisms include speed cameras, which are also being trialed as hidden cameras in parts of the country.

- The Ministry of Transport is currently developing a Light Vehicle Fleet Emissions Control Strategy. Its intention is to manage the impacts and structure of New Zealand's vehicle fleet. The objective of the Strategy is to recommend the most cost-effective policy responses, appropriate for New Zealand conditions, for mitigating the local effects of vehicle emissions. Secondary outcomes can be expected that reduce CO_2 and other greenhouse gas emissions. The draft strategy will be presented to the Government in mid-1997.

- A Heavy Vehicle Fleet Emissions Control Strategy is being developed and will follow the same process as, and be complementary to, the Light Vehicle Fleet Strategy.

- A full Land Transport Pricing Study (LTPS) is being undertaken. The LTPS seeks to identify the full costs of the roading system (including external costs), to identify the costs that should fall on individual road users, and to make appropriate policy proposals to Government. The Ministry of Transport in consultation with Transit New Zealand, the Ministry for the Environment, the Treasury, the Ministry of Commerce, the Energy Efficiency and Conservation Authority, and other government agencies, has released the Land Transport Pricing Study: Environmental Externalities report. This report puts a range of figures around the likely social cost of the CO_2 emissions from transport in New Zealand. Due to the fact that very limited monitoring of road transport environmental impacts has been undertaken, the figures presented in the report are preliminary. Submissions on this report are being analysed, and a position paper will be released analysing the results of the submissions process and presenting a future programme of work for environmental externalities. It is likely that this position paper will be released in mid 1997.

- The Ministry of Transport is currently developing a National Land Transport Strategy (NLTS) in consultation with other government departments, local government, transport industry representatives, and community groups at national, regional and local levels. The purpose of the Strategy is to set goals and objectives for the transport sector over the next twenty years. The draft NLTS will be presented to the Government in mid 1998. The environmental effects of land transport including carbon dioxide are being discussed as part of the Strategy's development.

- The Ministry of Transport is scheduled to begin work on a Vehicle Fleet Fuel Efficiency Study in 1998. The objective of the project is to determine the opportunity in the road transport sector for reducing fuel consumption, and hence CO_2 emissions, on a marginal cost basis, and evaluate the relative effectiveness of strategies for doing so.

- Actions by local authorities also pertain to the transport sector. Regional Councils have land transport planning responsibilities under the Land Transport Act 1993. These include the preparation of Regional Land Transport Strategies which take into account regional transport needs, safety, cost, and environmental considerations. As part of their Strategy, regional councils determine the role of the various forms of transport within their region, including public passenger transport services and cycling. Most local authorities are aware of the need to consider carbon dioxide emissions in evaluating new roading proposals. This is enforced through the cost benefit analysis regime used by Transfund New Zealand (see above), and is included in the development of the National Land Transport Strategy (also covered above).

6.4 Further Domestic and International Policy Initiatives

The Government will be actively monitoring progress on emission reductions under the measures outlined above. Further domestic policy responses will be informed by international policy developments. New Zealand recognises that meeting commitments for the post 2000 period is unlikely to be "least cost" if left solely to unilateral national policies. It will be necessary to explore cost-effective multilateral policy responses that reduce differences in abatement costs between countries as well as reducing the overall costs of meeting any agreed targets.

6.4.1 Contribution of the Working Group on CO_2 Policy

The Working Group on CO_2 Policy was established by the Government in August 1995 to examine more broadly the use of alternative economic instruments and other measures for cost-effectively achieving New Zealand's carbon dioxide target, while minimising the impact on output and growth in the economy. The Working Group was also asked to address the overlap between the Resource Management Act (RMA) and the Government's commitments under the FCCC arising from the outcome of the Taranaki Combined Cycle power station air discharge consent application described in Section 6.3.5.

The Working Group consisted of experts from the private sector, environment non-governmental organisations and government agencies. It produced a discussion document (Climate Change and CO_2 Policy - A Durable Response) in June 1996 containing, among other things, the following conclusions:

- approaches to reducing CO_2 emissions should be least cost, preserve maximum flexibility in terms of responses, be part of a global response, and be durable both domestically and internationally;

- if the Government wishes to move further toward its existing policy target, or move beyond it in future, then an economic instrument (carbon charges or tradeable carbon certificates (TCCs[4])) provides the least cost means of reducing emissions. Including both

[4] The instrument proposed by the Working Group on CO_2 Policy is a tradeable carbon certificate (TCC) scheme (including both emissions and absorption of CO_2 capped with an optional carbon charge to manage volatility and overall cost to the economy).

emissions and absorption would maximise the opportunities for least cost abatement responses;

- a nationally-legislated economic instrument, operated at a level sufficient to meet FCCC commitments, would remove the rationale for declining or attaching conditions to a consent in respect of CO_2, or any rationale for a National Policy Statement under the RMA;
- specific subsidies or regulatory interventions will not, in general, provide a least-cost or durable response to reducing CO_2 emissions;
- the Government should improve the measurement of carbon storage, particularly in indigenous forests;
- a decision should be made by 2000 on settings and timing of implementation of the TCC scheme, based on Annex I countries [sic] moving to the introduction of measures of comparable marginal cost. This would not be before the conclusion of the Berlin Mandate negotiations;
- New Zealand should continue with the current policy, in the interim, but any carbon charge should not be increased beyond a low-level prior to the introduction of the TCC scheme.

After the discussion document was released by the Minister for the Environment, a public consultation process was held which included public meetings, meetings with sector groups, and the opportunity to make written submissions. The report of the Working Group on CO_2 Policy has made a valuable contribution to policy development and will inform future policy work. The submissions together with the Working Group's response to the points raised in these submissions will be published in May 1997.

6.4.2 Future policy options: economic instruments

The 1994 policy package provided for the introduction of a low-level carbon charge in December 1997, if by mid 1997 the Government assessed the existing policy measures to be insufficient to achieve the target to which it committed. As stated in Section 6.2, in March 1997, the Government announced that any decision regarding implementation of a carbon charge will be deferred until, after the outcome of the Berlin Mandate negotiations is known and has been assessed with respect to future policy development needs.

Following the outcomes of the Third Conference of the Parties (COP3) under the FCCC in Kyoto in December 1997, New Zealand will address the policy implications of future commitments. The introduction of a carbon charge remains a policy option open to New Zealand to meet new targets, and other policy instruments, including domestic emissions trading, will be available. Participation in an international trading regime may also be an option.

Other existing policy measures will continue, including design work on a possible carbon charge. A working paper on the design of a low-level carbon charge was released in April 1997. Work will also commence on the design of a domestic emissions trading regime in 1997. Linkages with proposals to develop practical options for the implementation of an international emissions trading system will be examined concurrently with domestic initiatives. To this end, New Zealand is participating in a number of international forums which are examining options for cost-effective international responses to support the objectives of the Convention. Such forums include those supported by the OECD and IEA, such as the Annex I Expert Group on the FCCC and the OECD Forum on Climate Change, as

well as a number of events and activities hosted by other agencies and national institutions with a focus on international responses to climate change.

6.5 Policy measures to protect and enhance carbon sinks and reservoirs

In 2000, New Zealand's planted forests are projected to remove 18,944 Gg of carbon dioxide from the atmosphere. This annual carbon absorption level arises from new forest planting and also because the biomass of existing planted forests is increasing. Carbon stored in natural and planted forests in New Zealand is at least 100 times greater than the net annual carbon absorption level. The forests are therefore a substantial carbon reservoir as well as a significant carbon sink, assuming new planting rates are maintained and that the planted forest estate continues to expand.

6.5.1 Commercial planted forests

New Zealand recognises the important role that forests can play as sinks and reservoirs of greenhouse gases. In March 1995, there were 1.5 million hectares of sustainably-managed planted forest. The predominant non-indigenous species is *Pinus radiata*. Recent Government policies have created a more favourable environment for forestry investment. Economic reforms and optimism over the market outlook have also contributed to high planting levels. Government policies which have contributed to forest expansion include:

- a return to tax deductibility in the year of expenditure for forest growing costs (which has enhanced profitability by around 7%) with the aim of establishing a taxation regime which adequately reflects the long-term nature of forestry investment;
- introduction of a 'qualifying company' regime which gives investors limited liability while being treated as individuals for tax purposes. By forming a partnership of qualifying companies, an unlimited number of individuals can invest in a project under the regime. (Earlier legislation which treated investors as individuals for tax purposes did not provide limited liability and restricted the number of individuals to 25 per partnership.);
- abolition of lease duty on forestry rights (planting rights granted by a landowner to a forestry investor);
- amendment to the forestry rights legislation to allow forestry rights to be granted over land which has no Certificate of Title, thereby improving opportunities for forestry, particularly on Maori-owned land;
- the Resource Management Act 1991 which has the potential to reduce planning controls on sustainable forestry as a land use; and
- the $12 million spent by the Ministry of Forestry in the three years to June 1996 together with $1.25 million by TRADENZ over the same period to fill information gaps in the operation of the market. Forestry facilitation services included sector and market advice and information, investment, productivity and market promotion and the development of sector and market strategies.

New Zealand has a sustainable forest resource which is a crop rather than a product of a natural ecosystem. This provides flexibility to manipulate the crop through management. Productivity and quality gains have also resulted from New Zealand's strongly developed forestry research and development capability.

Strong investment in forestry is based on many factors working in combination to make it an attractive investment. The most important factors are strong long-term market prospects, the current taxation regime, and the Government's commitment to removing unreasonable impediments to forestry and wood processing. Although there are some potential constraints on new planting investment, the balance is in favour of continued high levels of new planting.

New planting rates since 1990 have been well above the historical average of 40,000 hectares per annum during the 1970s and 1980s. The provisional figure for new planting in 1996 is 70,900 hectares and 77,800 for 1997. It is expected that new planting will not reach the previously estimated average of 100,000 hectares each year until 2000. Best estimates of new planting up until 2000 are 70,000 hectares each year. From 2001, best estimates are for approximately 55,000 hectares of new planting each year. Land availability is unlikely to be a constraint under current market conditions until at least the second quarter of the next century.

The projected removal of 18,944 Gg carbon dioxide from the atmosphere in 2000 is based on an average new planting rate of 70,000 ha per year from 1997 and 55,000 ha per year from 2001, and employs a three year rolling average to even out annual peaks and troughs. An allowance has been made for carbon lost through forest fires and clearance of scrubland for forest planting (2,116 Gg carbon dioxide). In total over the decade of the 1990s, planted forest stocks are expected to remove around 160,000 Gg carbon dioxide due to growth in the existing forest and expansion of the forest area.

<u>East Coast forestry project</u>

In 1992, the Government established the East Coast Forestry Project which aims to facilitate the planting of 200,000 hectares of commercially productive forest over the next 28 years on eroding and erodable land in the East Coast region of the North Island. Government funding is available on a contestable basis to those proposing to establish and manage forest on land meeting the scheme's criteria.

Carbon sink attributes were an important consideration leading to the introduction of the project. It was estimated at the time that planting under the project would absorb, in 2000, an amount equal to around 3% of New Zealand's carbon dioxide emissions in 1990.

The planting rate was below the target of 7,000 ha per annum in the first three years of the project but reached this level in 1996. It is anticipated that this planting rate will continue for the foreseeable future. This is included in the expected new planting rate of 70,000 ha/year from 1998 to 2000 and 55,000 ha/year beyond 2000.

6.5.2 Indigenous forests

New Zealand indigenous forests represent a considerable reservoir of carbon. Approximately 95 percent of the total carbon in all forests in New Zealand is stored in indigenous forests. It is not known whether this reservoir is expanding or shrinking, i.e. whether it is a sink or a source, but work is underway to monitor changes in indigenous forests. In order to protect this reservoir, steps have will continue to be taken to discourage unsustainable management practices and to counteract pests and diseases.

Indigenous forests occupy 6.2 million ha. Some 4.9 million ha are owned by the State. The vast bulk of the State resource is managed for its conservation values. It is comprised of 14 national parks, 18 forest parks, and a network of other reserves. Only 164,000 hectares are managed for wood production. A further 1.3 million ha of natural forest is privately owned, half by Maori, with 124,000 hectares of this considered to be commercially viable for wood

production under current market conditions. Only about 1% of New Zealand's total commercial wood production is from indigenous forests. However the Government has made a commitment to encourage the planting of native trees on a commercial basis and to protect the property rights of those who do so.

In recent years, there have been a number of Government measures aimed at protecting and conserving New Zealand's indigenous forests. In 1990, the Government introduced the Forest Heritage Fund and Nga Whenua Rahui. These provide financial assistance to landowners to enter into voluntary forest protection agreements with the Government. Over 176,000 ha of forest have been protected under the programmes. In addition, further provision has been made under the Resource Management Act for the protection of areas of significant indigenous vegetation.

In 1993, the Government introduced a major amendment to the Forests Act with the purpose of promoting sustainable indigenous forest management. The amendment introduced indigenous timber milling and exporting controls with a requirement for sustainable forest management plans for private and Crown forests. The amendment has virtually ended the unsustainable harvesting of all indigenous forest. Less than two percent of indigenous forest is exempt from the requirement for sustainable management. The Government is committed to negotiating with the owners of these forests to bring them under sustainable management.

The New Zealand Forest Accord prohibits the clearance of mature and regenerating indigenous forest for planted forestry. The Accord is a voluntary agreement covering 95 percent of the commercial planted forest estate. In 1993, 16 percent of new land planted into forestry had formerly been in scrub (scrublands). It is assumed that, with the removal of agricultural subsidies, more land is reverting to scrub than is being cleared for agricultural purposes.

Green Package funding has been made available for monitoring carbon in indigenous forests and scrublands, (together with funding from the Ministry of Forestry to include planted forests). The monitoring system is likely to make extensive use of sophisticated remote sensing techniques, such as satellite imagery, combined with ground-based verification. This will provide a check on afforestation, reforestation, and deforestation. Green Package funding for improving information on the carbon stored in indigenous forests also includes consolidation and standardisation of existing forest information currently held by various agencies. The indigenous forest component of the Green Package amounts to $1 million over three years.

The Government, through the Animal Health Board and the Department of Conservation, has greatly increased the effort and expenditure on controlling the country's major mammal pest, the Australian brush-tailed possum (*Trichosurus vulpecula*). The objectives of this programme are to minimise the risk to domestic stock of any diseases for which possums are believed to be responsible, and to improve the health and regenerative capacity of important indigenous plant communities, particularly forests.

Expenditure has increased by $4.1 million to $19.5 million in the 1995/96 year for wild animal control in indigenous forests. This enables 1.3 million hectares of 'at risk' indigenous forest to be covered. Pigs, deer, goats and possums, all introduced (exotic) species are targeted by the programme. Longer-term possum control, and control of other pest animals such as deer and goats over the whole country is likely to depend heavily on the development of new methods of sustainable control. Green Package funding has also been made available which is in various ways targeted at possums. Increased funding has been provided for pest

and weed control in indigenous forests, research to find new possum control methods, and for bovine tuberculosis control (where possums contribute to the spread of the disease).

To underpin the need for robust and coordinated scientific and technical advice to support the possum control programmes, the Government established a National Science Strategy Committee for Possum and Bovine Tb Control in 1991. The committee is charged with advising the Government on an overall science strategy, science priorities and science funding levels. In 1996/97, the Government spent NZ$8.3 million on possum research alone. The NSS Committee has advised the Government on the importance of research into biological control of possums as a means to a long-term control solution. However, in the short-term, research into more efficient means of conventional control (poisoning and trapping) has been supported.

6.5.3 Forest risk management

New Zealand is concerned to ensure that a ‘risk averse’ approach is taken to management of the national forest estate. Fire is a potential hazard, but the New Zealand Fire Service records show that only 2,644 ha of forest were burnt between 1986 and 1995. This was likely to have been a mix of indigenous and planted forest. If it was all exotic forest area, it would account for approximately 0.17% of the national planted forest estate.

Insect pests and pathogens have been recognised as a threat to New Zealand’s forests for many years. Well developed quarantine and forest health surveillance systems are in place to minimise the risk. Tested emergency procedures are also in place to enable eradication or containment of pest introductions which occur at a rate of about ten per year. Few have significant impacts on forest health.

In 1996, the white spotted tussock moth (*Orgyia thyellina*) was discovered in Auckland in the northern part of New Zealand’s North Island. It is a potential pest of forests and horticultural crops and an eradication campaign has been implemented. It is too early to determine whether the moth has been eradicated but there is commitment to pursuing this goal. The result of this, and other recent pest incursions, is an increasing focus on biosecurity. The Government has signalled this priority by appointing, for the first time, a Minister of Biosecurity.

Genetic tree improvement is offsetting growth rate losses from disease. Any decline in forest vigour that might occur as a result of pest introductions would be reflected in calculations of carbon sequestration by forests.

6.5.4 Soil carbon

Approximately $0.9 million over three years has been made available under the Green Package to develop and implement a comprehensive monitoring programme for carbon storage within New Zealand’s soils. The programme will focus on quantifying soil, climate and land use interactions that result in changes in soil carbon, together with the development of an effective information management system on the carbon storage capability of these soils in response to changes in patterns of land use. The soil carbon programme is being constructed in conjunction with the work on the indigenous forest and scrubland monitoring programme as part of an integrated approach to monitoring influences on the terrestrial carbon cycle in New Zealand.

6.6 Policy measures to limit methane emissions

Overall, as a result of falling animal numbers, total methane emissions in New Zealand are dropping and are projected to be below 1990 levels in 2000. Technological solutions

currently being researched show promise for reducing ruminant methane, but application is limited in the short-term. There is further potential for reducing methane emissions from landfills and wastewater.

6.6.1 Policy measures for methane emissions from agricultural sources

Reductions in agricultural greenhouse gas emissions worldwide are generally a side effect of on-going agricultural policy reforms and, in countries like New Zealand, the adoption of more sustainable agricultural practices.

As emissions of methane from agricultural sources in New Zealand are dropping as the result of policies being implemented for reasons other than climate change, New Zealand, to date, has not adopted any direct policies to limit agricultural sources of methane. It has, however, increased research investment, including Green Package funding, to reduce uncertainty in emissions sources and sinks, and to investigate technical solutions to further reduce methane emissions from livestock. These research programmes are listed in Annex 2.

The policies and measures that have reduced methane (and nitrous oxide) emissions from agricultural sources in New Zealand include the removal of agricultural production subsidies, (undertaken mainly for financial and economic reasons). This has resulted in decreased total livestock numbers. In addition, forest planting could also have important implications for methane emissions from livestock. Significantly increased levels of forestry planting are being undertaken in New Zealand as a result of increases in the world price of timber and amendments in 1991 to the income tax laws, and other factors described in the previous section. According to statistics collected by the Ministry of Forestry, of the 98,000 hectares planted in 1994, 49% was on improved pasture and 39% on unimproved pasture. If planting rates are sustained, as expected, it is likely that livestock will continue to be displaced by the trees being planted on pasture land.

Some possible measures, such as feed additives to reduce emissions of methane from ruminants, would be difficult (and prohibitively expensive) to implement under New Zealand's extensive pastoral systems where 75 percent of the livestock derive nourishment from fresh pasture without individual management on a daily or even weekly basis.

Productivity Programmes

Programmes to improve agricultural productivity, such as improving the reproductive performance of animals, can reduce methane emissions. In New Zealand, research and implementation of productivity improvement programmes have resulted in some productivity increases for beef, sheep, and dairy farming. This allows a reduction in livestock numbers for a set level of output. Quantifying how these changes in productivity affect methane emissions is difficult without base data on methane emissions for each animal type, under each type of pasture system. Research is underway (see Annex 2) which will assist this type of quantification. It is likely that in New Zealand there has been a reduction in methane emissions as a result of productivity increases from 1990 to 1995, and that further reductions will be made the future. At this stage, potential future reductions from productivity are not quantifiable.

Improving livestock performance can increase methane emissions if the total number of animals increases with new productivity gains. However, in New Zealand there has been no increase in the overall livestock numbers with productivity gains made. The trend has generally been to lower carrying capacities and higher animal performance.

Table 6.3: Livestock Performance in New Zealand 1990 to 1995

Product	Season Ended	1990	1991	1992	1993	1994	1995 (Provisional)
Total Wool per sheep wintered (kg greasy)	30 June	5.1	5.3	5.4	4.9	5.7	5.8
Lambing percentage*	30 June	96.6	100.4	105.7	95.4	108.2	104.8
Export Lamb (kg/carcase)	30 Sept	13.7	13.9	14.1	15.0	15.4	14.8
Export Beef (kg/carcase)	30 Sept	243.6	246.7	251.6	252.2	262.9	65.5
Milksolids/cow at factory (kg)	31 May	218.0	220.0	241.0	239.0	262.0	248.0

Sources: Statistics New Zealand, 1996; Ministry of Agriculture, 1995.

Reduction in subsidies - Trade liberalisation

In New Zealand the policy that has had the most profound effect on greenhouse gas emissions from agricultural sources is the withdrawal of agricultural support measures. Since agricultural support was removed in New Zealand there has been a significant decrease in livestock numbers reflecting the move away from surpluses to market demand production. Reduction or removal of subsidies reduces the incentive for over-production. Farmers in New Zealand now produce solely in response to demand in domestic and world markets.

Table 6.4: Level of assistance to pastoral agriculture and total stock units 1985-1995 (years ended December).

Levels of Assistance (Pastoral Agriculture)	1986-1988 average	1990-1992 average	1993	1994 (Provisional)	1995 (Provisional)
Producer Subsidy Equivalents (%) of all products	18.0	4.0	3.0	3.0	4.0
Total Stock Units (million)	101.0	99.2	96.3	99.2	95.6

Sources: Statistics New Zealand, 1996; Ministry of Agriculture, 1995.

Note: Producer Subsidy Equivalents (PSE) measure the value of transfers from domestic consumers and taxpayers to farmers and are comprised mainly of research and border control and quarantine costs. In this table the PSE is expressed as the percentage of the value of agricultural output that comes, firstly from government subsidies and, secondly, the extent that domestic prices are higher than world prices due to government interventions in markets and trade.

Modifying enteric bacteria.

New Zealand has funded a research programme (see Annex 2) that looks at the potential for lowering ruminant methane emissions through manipulation of enteric bacteria. It is not at present possible to quantify the potential outcomes of the programme.

Animal waste management systems

Policies and measures dealing with methane emissions from animal waste management systems are covered in the following section on methane emissions from waste.

6.6.2 Policy measures for methane emissions from waste

Under the Sustainable Management Fund (SMF), which was established in July 1995 to provide practical support for the achievement of the Government's environmental management priorities, the current objectives in the waste management area, across all sectors, are:

- to obtain better information on waste to enable people to make informed decisions on waste management;
- to minimise the adverse environmental effects of waste; and

- the promotion of cleaner production to achieve sustainable production processes.

The SMF, which is administered by the Ministry for the Environment, has allocated in excess of NZ$1.5 million to waste management projects in the 1996/97 financial year including such projects as:

- waste analysis surveys;
- cleaner production programmes, including producing guidelines for industry sectors;
- dairy shed wastewater treatment and effluent management; and
- assessment of landfill gas.

The total cost of the projects is in excess of NZ$2.5 million as the proponents provide a significant proportion of the funding themselves.

Animal waste management systems

Under New Zealand's extensive pastoral systems, the majority of animal waste is decomposed aerobically. There are also liquid-based systems where waste is decomposed anaerobically, for example dairy shed effluent ponds.

In New Zealand, under the Resource Management Act 1991 (RMA), much of the emphasis for the treatment of dairy shed effluent comes from the City, Regional or District Councils and is done for water quality reasons. Councils, under the RMA, are charged with the control of water quality including the discharge of contaminants into water such as post-treatment dairy shed effluent.

There are many ways to treat dairy shed effluent in ponds and influence the level of methane emissions from these systems. Land disposal of treated or untreated dairy shed wastewater is encouraged by Regional Councils as a treatment/disposal/re-use solution, which, when well-managed, avoids contamination of surface waterways. The land disposal method, if effluent is not stored for more than 3-4 days, encourages the aerobic breakdown of the waste, which results in lower emissions of methane (and nitrous oxide) than in other systems such as the two pond systems.

Landfill Methane

Methane emissions from landfills are expected to be below 1990 levels in 2000. Projections show them increasing again after 2000 (in response to population increase), but remaining below 1990 levels in 2020.

The Government has adopted a Waste Management Policy, which encourages a 'waste-generator-pays' approach, and use of the Waste Management Hierarchy, which encourages reduction, reuse, recycling and recovery before final disposal. The effect of this is likely to be a gradual minimisation of waste requiring residual disposal. This, in turn, will have an effect on the amount of greenhouse gases produced from disposal processes. Cleaner production initiatives and waste audits should also see a minimisation of waste and changes in waste composition affecting the final production of greenhouse gases.

Landfill Guidelines have been produced which recommend the use of a 'bioreactor' design (wet) landfill which aims to treat waste to make it stable. Over the short-term more methane may be produced, but this methane will be more accessible to capture or flaring.

Composting of green wastes is also becoming more prevalent and composting facilities are likely to be set up in many areas. The intention is to divert waste from landfills. However,

other changes, including the greater use of landfills for treatment of sewage sludges, could offset some of the gains from waste minimisation and composting activities.

If all the methane from municipal landfills were to be emitted to the atmosphere, there would be a projected increase of around 10% over 1990 levels by 2000. However, between 1990 and 2000, there will be an increase in the recovery of landfill methane for the production of energy. In 2000, between 40 and 65 Gg of landfill methane is expected to be utilized for the production of energy.

There is an increasing recognition by landfill operators of the need to plan for the capture of landfill gas, partly because of best practice under Odour Management Guidelines. There is also a growing awareness of the economic potential for energy recovery or direct end-use of landfill gas where urban centres and infrastructure are relatively close by.

The Government will continue to promote cleaner production and waste minimisation initiatives and improved landfill management which will reduce greenhouse gas emissions. This is likely to balance the changes in the waste stream composition and any increase in waste generation associated with an increase in economic activity and population.

Methane from wastewater

Methane emissions from wastewater are a small part of New Zealand's total methane emissions. However, several local authorities already extract methane from wastewater treatment plants and use it for generating electricity, heating boilers and heating digesters. In some instances the methane is flared. Some of the industrial emitters are extracting methane from wastewater treatment systems and using it as an energy source. Others are examining the considerable potential for using methane from this source.

6.7 Policy measures to limit nitrous oxide emissions

6.7.1 Policies and measures for nitrous oxide emissions from agricultural-related sources

The agricultural sector is responsible for most of New Zealand's emissions of nitrous oxide. Consequently, research investment to reduce uncertainty in agricultural sources and sinks has been increased. In Annex 4, detailing nitrous oxide methodology, research programmes aimed at reducing uncertainties in emissions and sinks are listed. These programmes are partially funded under the Green Package.

Fertiliser use

Regional and District Councils, under the Resource Management Act 1991 (RMA), can introduce rules for the application of fertiliser for water quality reasons. As yet, few rules have been introduced to restrict fertiliser application. However, some councils are cautioning against over-use of fertilisers. In addition, the removal of subsidies (as outlined in the agricultural methane section) encourages efficient production because farmers aim to minimise production costs in order to maximise profit. For example, without subsidies, farmers have no incentive to use excessive amounts of fertiliser as the cost of the fertiliser will reduce their profits.

The New Zealand fertiliser industry is currently preparing a Code of Practice for the use of fertiliser, which will guide land users in the efficient use of fertilisers.

Waste management systems

As described earlier in the methane section of this chapter under Animal waste management

systems, the Resource Management Act is used to control water quality. Aerobic disposal systems are encouraged, resulting in lower emissions of nitrous oxide.

6.8 Policy measures for non-CO_2 industrial process emissions

New Zealand has begun to collect data on emissions of non-CO_2 greenhouse gases and precursors from industrial processes and solvent use. This was a previous gap in New Zealand's greenhouse gas inventory. Under the Green Package, data has been collected on emissions of CH_4, NO_x, CO, NMVOCs, HFCs, PFCs, SF_6, and SO_2 (Royds Consulting, 1997). With the exception of PFCs, where policy has already been implemented as described below, analysis of policy options is at an early stage.

6.8.1 Perfluorocarbons (PFCs)

New Zealand Aluminium Smelters Ltd (NZAS) has, through changes in process control procedures, significantly reduced PFC emissions from its aluminium smelter since 1987. Through the air discharge consent process under the Resource Management Act, conditions have been put in place with respect to the discharge of both PFCs and carbon dioxide from the smelter. These conditions ensure monitoring of emissions, minimising emissions, and minimising the adverse effects of these emissions on the environment. The conditions also allow the consent authority to review conditions at specified intervals to ensure that the best practicable technical option is being used to minimise emissions and their adverse effects.

It is expected that these air discharge consent conditions will keep PFC emissions from the aluminium smelter at or below 1990 levels.

Chapter 7: Emission projections and the effects of policy measures

7.1 Summary of projections

Table 7.1: Summary of actual emissions of carbon dioxide, methane and nitrous oxide in gigagrams (Gg) for 1990 and 1995, and projections from 2000 to 2020.

Greenhouse Gas	1990	1995	2000	2005	2010	2020
CO_2 emissions	25,475	27,368	31,080	33,570	36,310	43,560
CH_4 emissions	1,706.0	1,634.9	1,541.5	1,552.0	1,573.8	1,604.0
N_2O emissions	47.5	46.7	46.0	45.6	45.7	45.7
Note:Projections for nitrous oxide from the agricultural sources (the largest contributor) are projected forward at 2000 levels as the data is considered to be too uncertain to do otherwise.						

Table 7.2: Summary of carbon dioxide removals in gigagrams (Gg) for 1990 and 1995, and projections from 2000 to 2020.

Greenhouse Gas	1990	1995	2000	2005	2010	2020
CO_2 removals	-20,571	-13,490	-18,944	-20,807	-21,208	-31,654
Note:The projections include an allowance for emissions from land use changes: wild fires and prescribed burning, and the clearing of scrub for planted forestry.						

Table 7.3: Summary of actual emissions of nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphurhexafluoride (SF_6) and sulphur dioxide (SO_2) in gigagrams (Gg) for 1990 and 1995, and projections for 2000 to 2020. SO_2 is from *industrial processes* only.

Greenhouse Gas	1990	1995	2000	2005	2010	2020
NO_x	113.7	133.6	153.9	170.8	186.4	225.4
CO	703.9	797.3	853.6	930.4	1,015.5	1,231.9
NMVOCs	178.9	200.6	216.2	238.1	264.4	326.4
HFCs	neg	0.141	0.164	0.190	0.220	0.295
PFCs	0.089	0.029	0.034	0.035	0.035	0.037
SF_6	0.023	0.183	0.212	0.246	0.285	0.383
SO_2	16.305	20.770	31.609	34.873	38.864	47.991

7.2 Introduction

This chapter reports on projections of: CO_2 emissions from energy sources and industrial processes; CO_2 removals by land use changes and forests; and other greenhouse gases. For CO_2 emissions, both a 'business as usual' (BAU) and "with measures" projection have been developed. The sensitivity of CO_2 emissions and CO_2 removals to changes in the key variables, GDP growth rates and new planting rates respectively, are presented. CO_2 emissions and removals are also presented in terms of cumulative total emissions to the atmosphere.

Projections for emissions of non-CO_2 greenhouse gases are given for the following sectors: energy and industrial processes, on both a BAU and "with measures" basis; agriculture; land use change and forests; and waste.

7.3 Projections for carbon dioxide from the energy sector and industrial processes

To assist in deciding on and measuring the effect of policies related to carbon dioxide emissions, a ‘business-as-usual’ (BAU) projection of carbon dioxide emissions has been developed using an energy supply and demand model. This BAU scenario attempts to project the path which emissions would have taken, and would take if there had been no government policies put in place since 1990 to address the growth in carbon dioxide emissions. In contrast to the modelling analysis presented in the first national communication, the analysis here includes updates for realised data for key (exogenous) determinants of energy supply and demand such as GDP, oil prices and exchange rates. Estimates have also been made as to the effects of policy measures in reducing sources of carbon dioxide emissions via “with measures” modelling, rather than estimates based on analysis of individual measures.

Based on the BAU, carbon dioxide emissions are expected to rise by 28% (2.5% pa) between 1990 and 2000 if GDP growth averages 3% between 1995 and 2000. This contrasts against a projection of 21.6% reported in the first national communication. The increase is primarily due to higher GDP growth than anticipated in the three years to 1995. Lower oil prices and higher realised and predicted exchange rates have also had significant effects in lowering the price of liquid fuels. Further description of energy sector trends for carbon dioxide emissions is given in Section 7.2.

The “with measures” projection of CO_2 emissions from energy and industrial processes is shown in Figure 7.2 for the 3% GDP case. The “policy inclusive” projection is for an increase in emissions of 22% (2% pa) by 2000 compared with an increase of 28% (2.5% pa) under the BAU scenario. Thus policy measures are estimated to reduce the growth in energy CO_2 emissions by about 21.5% below the “business-as-usual” growth path by 2000.

Table 7.4: Actual and projected emissions from energy sources (Gg)

Greenhouse gas	1990	1995	2000	2005	2010	2020
CO_2	23,176	25,059	28,141	30,389	33,057	39,820
CH_4	32	35	33	34	36	39
N_2O	2.5	2.6	2.9	2.5	2.6	2.8
NO_x	110	129	149	166	182	220
CO	656	725	792	870	861	1176
NMVOC	139	148	165	182	201	247

Energy and Industrial Process CO_2 Emissions 1990 - 2020

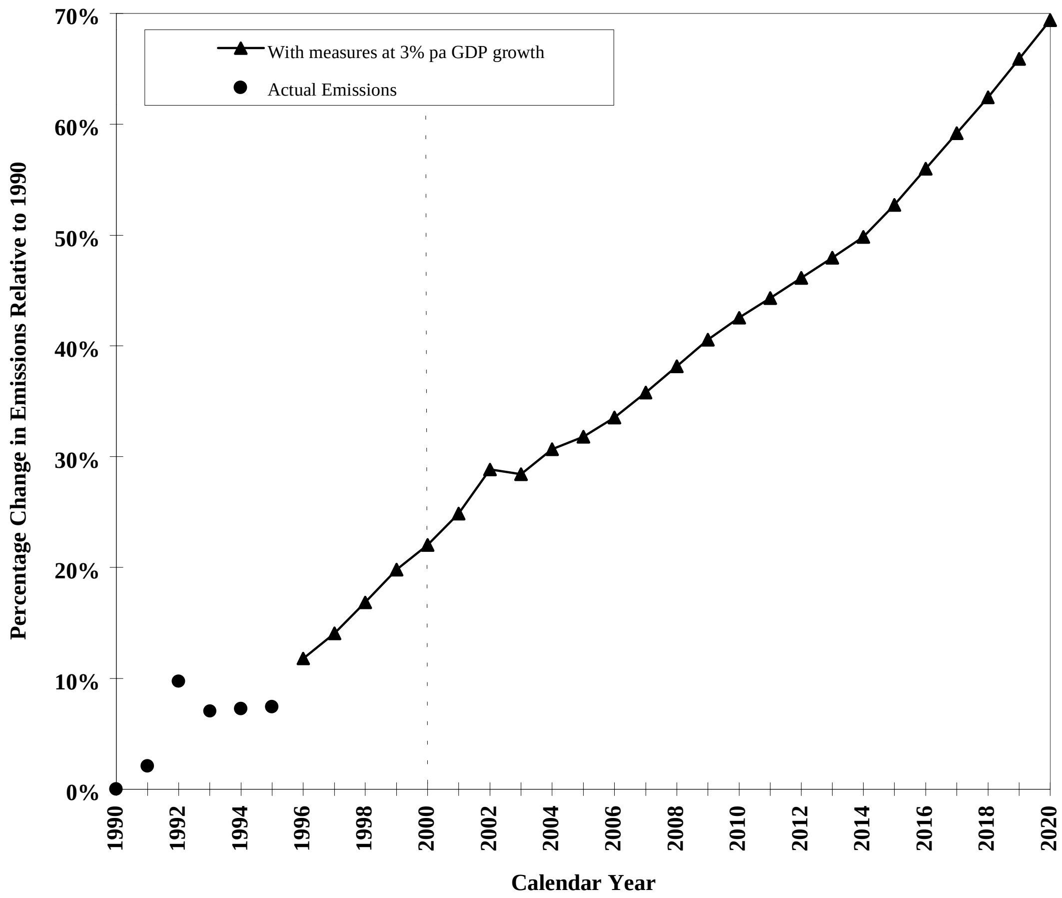

Figure 7.1 With Measures projections of CO_2 emissions at 3% GDP growth. Source: Ministry of Commerce, 1997.

7.3.1 Carbon dioxide emission projections in the absence of policy ("Business-as-usual") measures

On the basis of the assumptions outlined in Annex 1, New Zealand's CO_2 emissions are expected in BAU projections to rise by about 28% over 1990 levels by 2000 and by 46% by 2005 (compared with 20% in 2000 and 37% in 2005 in the first national communication). In mass terms, this is an increase from 1990 - 2000 of about 7,000 Gg CO_2, and from 1990 - 2005 of about 11,500 Gg CO_2.

The updated BAU sees CO_2 emissions from all sources increase from 1990 to 2000. Emissions from electricity generation are projected to increase at an average rate of 5% per annum (assuming average inflows for hydro generation), with coal, oil and gas rising by 1.9%, 2.2% and 1.4% per annum respectively.

Oil will continue to be the largest single source of energy sector CO_2 emissions at 46.2% of the total in 2000 in the updated BAU. Gas and coal CO_2 emissions also experience slight falls in share over the projection period. The share of total CO_2 emissions from electricity generation is projected to rise from 15.9% to 20.3% over the same period.

7.3.2 Reductions in source carbon dioxide emissions from policy measures

The reductions in source CO_2 emissions from the policy measures being implemented can be estimated as the difference between the “with measures” and BAU projections. This difference is about 20% of 1990 to 2000 growth, and about 25% of 1990 to 2020 growth as presented in Table 7.5. However, the difference may not all be attributable to the effects of policy measures: other effects may be captured, such as any recent acceleration in the change of consumer preferences or technological uptake, that has occurred for other reasons. Nevertheless, it is considered that the following policy measures will have contributed significantly to the difference, although their individual contributions are not measurable on a comparable basis to the difference between the BAU and “with measures” projections. Estimates of CO_2 reductions should therefore be treated with caution.

- Cross-sectoral policy measures
  - Use of the Resource Management Act
  - Energy sector reforms
  - Energy Efficiency Strategy and cooperative programmes
  - Renewable energy measures
- Specific sectoral policy measures to limit sources of CO_2
  - Voluntary agreements with industry[1]
  - Development of a vehicle fleet strategy
  - Specific transport sector measures
  - Actions by local authorities

Voluntary agreements with industry

The key result from the voluntary agreements is that they encompass those industries responsible for over 40% of New Zealand’s total CO_2 emissions. Although CO_2 emissions for the economy as a whole are projected to be 22% higher in 2000 relative to 1990, emissions for the voluntary agreement signatories as a group are only projected to increase by about 9%.

Energy Efficiency Strategy

For the purpose of evaluating the impact on CO_2 emissions, the Energy Efficiency Strategy programmes can be grouped into the two "clusters". The first cluster includes those programmes that exert a direct influence on known and identifiable energy consumers. Examples include the Energy Saver Fund, Crown Energy Efficiency Loan Scheme, and the proposed minimum energy performance standards regime (MEPS) and building code energy efficiency provisions. The other cluster of programmes - the majority - exert an indirect influence on specific markets and areas of activity to make energy efficiency a more pervasive feature.

[1] Note that the CO_2 emissions “avoided” as a result of Voluntary Agreements, referred to in Table 6.1, are measured against a different baseline to the BAU projection.

As a general rule, the direct influence programmes allow estimates to be made of the potential energy savings, and hence potential CO_2 emissions reductions[2], provided that the measures enter into force as anticipated. It is more difficult to predict the potential impact of the indirect market influence programmes because of the inevitable difficulties in distinguishing the impacts that are directly attributable to the programme from those that may have been subject to other influences (such as greater competition in energy markets or the effect of Voluntary Agreements for CO_2 reduction). The indirect market facilitation programmes, and significant achievements to date, are outlined in Box 7.1

An ongoing programme evaluation strategy focusing on the development and measurement of appropriate performance indicators. Preliminary estimates of the effect of the direct influence cluster of activities are outlined below in Box 7.2.

Box 7.1 Progress on Indirect Market Influence Programmes

Significant achievements, to date, for indirect market facilitation programmes are outlined below:

- Reporting to date on the **Energy-Wise Companies Campaign** and the **Energy-Wise Practice** programme, indicates improvement in the level of energy management activity within a significant proportion of member companies.
- Information and training on energy efficiency is promoted through: bi-monthly publication of **Energy Wise News** (circulation 15,000); **seminars**; and, the distribution of a secondary schools **curriculum resource kit** ("Precious Joules").
- The **Government Energy Efficiency Leadership Programme** has contributed to a reduction in energy expenditures within the state sector by fostering the development of departmental energy management plans, encouraging energy cost accountability, and annual monitoring of energy management performance outcomes.
- In the industrial and commercial sectors the **office equipment programme** has generated a strong response, with more than 20 percent of New Zealand's personal computers being fitted with internal "switch-off" devices. Energy savings are estimated to exceed $2 million per annum, with associated CO_2 emissions reductions in excess of 12.5 Gg per year.

In summary, estimates of the overall CO_2 emissions reductions that will occur as a result of the Energy Efficiency Strategy are, by nature, uncertain. These arise primarily out of the need to make assumptions about exogenous factors and the ability to influence behaviour, and leverage activity, from other players through the market-facilitation programmes which dominate the strategy. The programmes which make up the Strategy have all been designed, developed and commenced operation in the last three years. Estimates of their impact on CO_2 emissions are not yet available. Consequently, it is necessary at this stage, to rely predominantly on estimates made in advance of full programme implementation.

With these uncertainties in mind, it is considered premature to revisit the estimate in the first national communication that, overall, the Government's Energy Efficiency Strategy is likely to achieve a reduction of around 300 Gg of CO_2 emissions in the

[2] Estimates of CO_2 reductions are based on an engineering analysis of the technical potential based on certain assumptions (notably, assumed energy efficiency uptake rates based on full implementation of the programmes) and may not capture behavioural responses, i.e. income and substitution effects. This is one reason why estimates for individual programmes are not comparable with the BAU and "with measures" projections based on econometric modelling of energy supply and demand.

year 2000 compared to what they otherwise would have been. The estimate will be revised as new information becomes available.

Box 7.2[3] Preliminary Estimates for Significant Direct Influence Activities to date

- The **Energy Saver Fund** is being implemented. More than $4.2 million has been allocated to 40 projects. The total average cost of projected energy savings from these projects is less than 4 cents per kWh, with a cost to government of approximately 2.15 cents per kWh. The associated CO_2 emissions reductions are estimated to exceed 120 Gg over the lifetime of the projects.
- Revisions to the **Building Code energy efficiency provisions** have been submitted to the Minister of Internal Affairs for approval. The three energy efficiency Standards which support the proposed revisions have been published and are available for use as voluntary standards, until incorporated into the Building Code. In the first year, the potential reductions in CO_2 emissions are assessed as being in the order of 13 Gg and are expected to increase over time, with each year's additional new buildings.
- The **Crown Energy Efficiency Loan Scheme** is estimated to be achieving annual savings in energy costs to central and local government of $3 million as well as reducing CO_2 emissions by 18 Gg per year.
- Analysis of mandatory **Minimum Energy Performance Standards** (MEPS) has been carried out. For the three types of equipment (fluorescent lamps and ballasts, and domestic electric water storage heaters) which legislation is currently being developed, it is estimated that over one million tonnes of CO_2 could be saved, in total, over the first 15 years following introduction of the standards.

7.3.3 Effect of policy measures on future emissions

This section presents some results based on "with measures" modelling and contrasts these with the BAU modelling results. The key difference between the "with measures" version of the model and the BAU model is that the former contains energy demand relationships which are somewhat updated from the BAU relationships. The updated relationships include more recent data and capture some of the effects since 1993 of energy market reforms, greenhouse gas mitigation policies implemented and changes in consumer behaviour. The updated "with measures" projections are shown in Figure 7.2 together with projections for "low" (3% per annum to 2000 then 2% ongoing) and "high" (4% per annum ongoing) GDP scenarios.

The key results of the three GDP scenarios are summarised below in Table 7.5, as percentage growth in gross CO_2 emissions from 1990 levels and the equivalent per annum growth rates. Table 7.5 summarises the comparable "Business as usual" or "in the absence of policy" scenarios. Tables 7.5 and 7.6 compare the results of the BAU and "with measures" projections.

[3] Refer to footnote 2 (previous page).

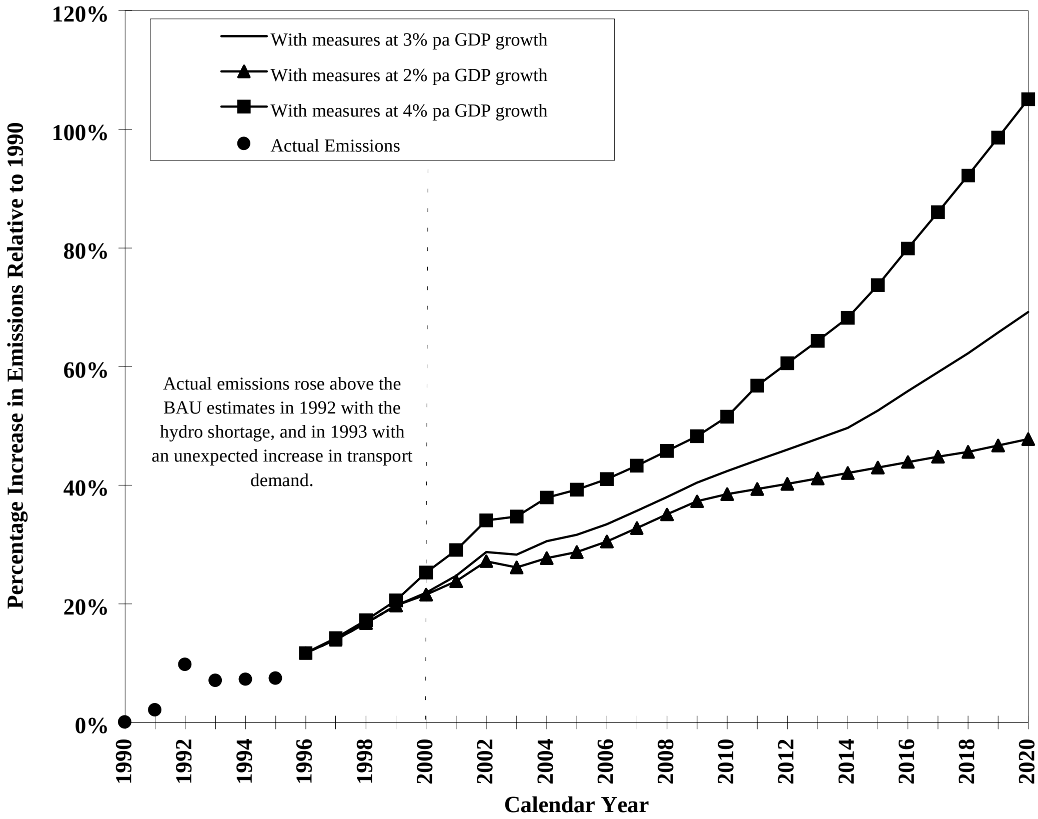

Figure 7.2: Energy and Industrial Process CO_2 Emissions 1990 - 2020. 1997 "with measures" Scenarios.

Table 7.5: "With measures" CO_2 Emissions Growth from 1990.

	Low (2%) GDP growth			Medium (3%) GDP growth			High (4%) GDP growth		
	2000	2010	2020	2000	2010	2020	2000	2010	2020
Growth from 1990	+22%	+38%	+50%	+22%	+42%	+71%	+25%	+52%	+105%
Equivalent per annum growth	+2.0%	+1.5%	+1.3%	+2.0%	+1.8%	+1.8%	+2.3%	+2.1%	+2.4%

Table 7.6: "BAU" CO_2 Emissions Growth from 1990.

	Low (2%) GDP growth			Medium (3%) GDP growth			High (4%) GDP growth		
	2000	2010	2020	2000	2010	2020	2000	2010	2020
Growth from 1990	+28%	+44%	+71%	+28%	+55%	+94%	+31%	+74%	+131%
Equivalent per annum growth	+2.5%	+1.8%	+1.8%	+2.5%	+2.2%	+2.2%	+2.7%	+2.8%	+2.8%

Analysis of the “with measures” energy projections suggests that the longer term *energy* multiplier is around 0.5. That is, there will be, on average, a 0.5% change in energy consumption for every 1% change in GDP. A somewhat higher *emissions* multiplier of around 0.6[4] from the same analysis implies that the energy mix may be slightly more carbon intensive than has been the case historically. This is consistent with projections of a lower electricity share for hydro generation and also consistent with the eventual replacement of most gas-fired thermal generation by coal-fired sources toward the end of the outlook period, under current assumptions about reserves of natural gas.

The projected (consumer) energy multiplier of around 0.5 is significantly lower than its average of around 1.5 for the last 15 years up to 1995/96. The figures for 1993-1996 contain preliminary support for the projections. In the period 1993-1996, energy consumption increased by around 8.3% compared with a 15% increase in GDP in the same period, resulting in a multiplier of 0.55[5].

Continued economic growth, energy efficiency improvements, and a higher quality energy mix together with increasing competition in the energy sector, are expected to be the main drivers of a lowering of energy intensity, and thus carbon intensity, in the economy in the next few years.

Industrial process CO_2 has been included in the above projections for gross CO_2 emissions. Figure 7.3 presents projections for carbon dioxide emissions from industrial processes only. The data shows a steady increase in emissions to around 2003, followed by a reduced rate of increase through to the end of the projection period. Although the projections are based on information provided by the industries, the projections are uncertain as the removal or addition of blocks of production will have a significant impact on emissions.

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[4]The concept of an emissions multiplier is simply an extension of the energy multiplier concept, both of which are similar to income elasticities (where the increase in energy usage is expressed as a fraction of the increase in GDP). The figure of 0.6 is based on the scenarios analysed for the projections and is discussed further in the Discussion Document of the Working Group on CO_2 Policy (Working Group on CO_2 Policy, 1996).

[5]Primary energy supply has increased by around 1.6 times GDP in the last 15 years. However, it has increased by a total of only 3% in the last three years.

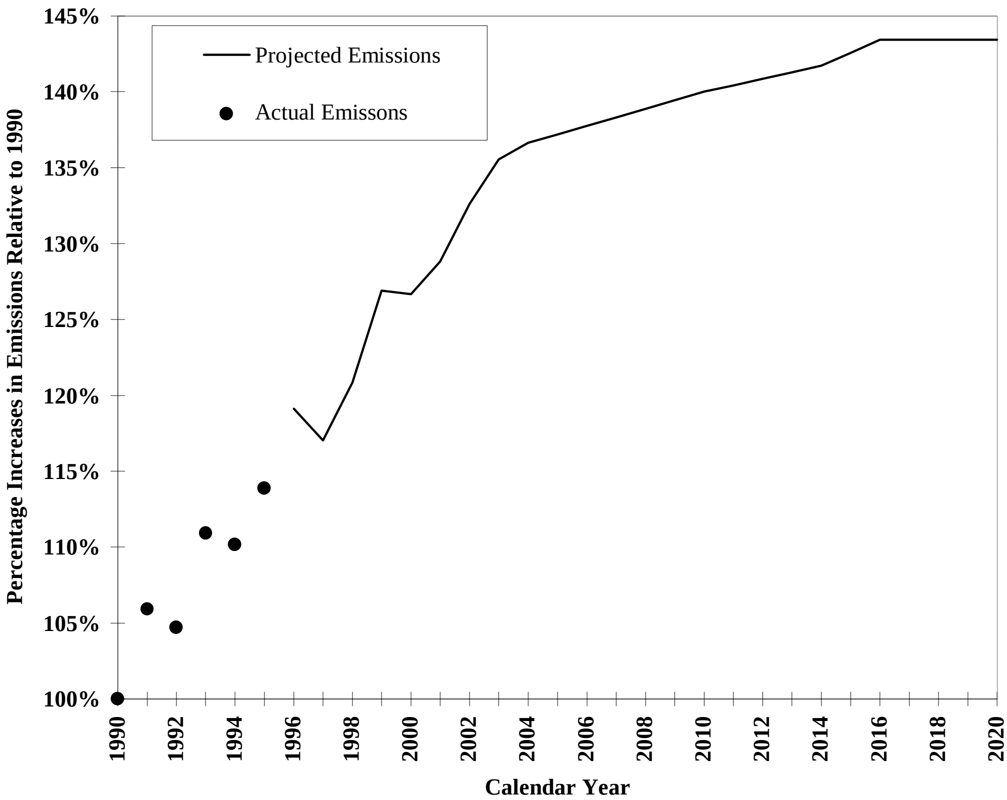

Figure 7.3: Industrial Process CO_2 Emissions 1990 - 2020. 1997 estimates.

7.4 Carbon Dioxide Removals from Land Use Changes and Forests

7.4.1 Projections of total increases in carbon stored in planted forest sinks and reservoirs

For CO_2 emissions and removals from land use changes and forests it is not possible to compile BAU projections. Chapter 6 discusses in detail specific policies and measures to enhance sinks and protect reservoirs. It is likely though, that the main factors affecting the increase in current and projected new planting rates, above the historical levels of the 1970s and 80s, are:

- increases in world log prices in the early part of the 1990s;
- removal of agricultural subsidies and reform of land use controls; and,
- probably most importantly, changes to the taxation regime, which on average increased after tax profitability by around 7%.

In addition, a number of the measures described in Chapter 6 aim to protect sinks and reservoirs, particularly indigenous forests. Measures aimed at protecting and sustainably managing indigenous forest reservoirs have contributed to the reduction in emissions from harvest in these forests. The trend toward increasing new forest planting on former pastoral land and the Forest Accord, which voluntarily banned the

clearing of mature and regenerating indigenous forest for planted forestry, may also contribute to a decrease in emissions from scrub clearing in the future, although no allowance has been made for any such decrease in the projections.

The central projection for CO_2 removals by planted forests is based on the best estimate for new forest planting of 70,000 hectares per year from 1998 to 2000, with 55,000 hectares per year from 2001 onward. The projections include an allowance for emissions from land use changes: wildfires and prescribed burning and the clearing of scrub for planted forestry. Upper and lower projections for new planting are within the range of plus or minus 20-35,000 hectares per year. By comparison, the historical planting rate during the 1980s was 42,000 hectares per year. Interestingly, the lower estimate for new forest planting in the future is, by coincidence, similar to the historical average planting rate in the 1980s (but should not be interpreted as a BAU scenario). Annex 5 discusses the methodology for CO_2 sequestration by planted forests and emissions from land use changes in more detail and the basis for projections of new planting rates.

Based on the three scenarios for new planting, projected total removals of CO_2 by planted forests (net of emissions from land use changes) are illustrated in Figure 7.4. CO_2 removals by planted forests, emissions from land use changes (and hence total CO_2 removals for the period 1990 - 2020, and intervening years, in the central scenario for new planting) are reported in Table 7.6.

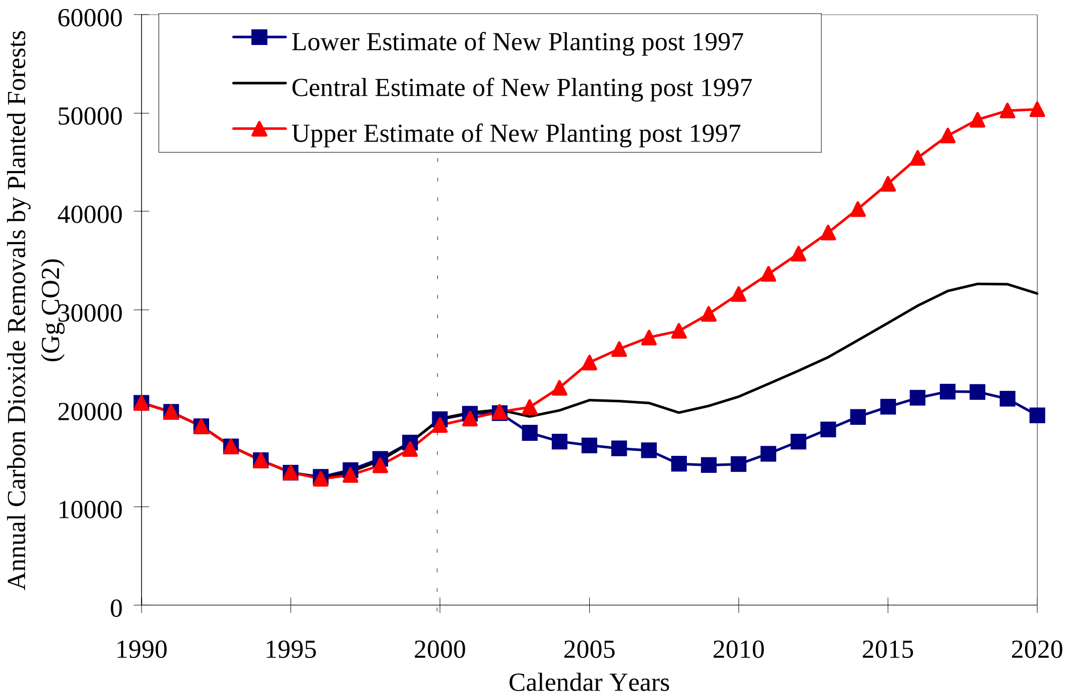

Figure 7.4 Projected Annual Total CO_2 Removals by Planted Forests 1990 - 2020. Source: Ministry for the Environment, 1997

Table 7.7: CO_2 Removals and emissions from land use changes and forests (central projection assuming new planting of 70,000 ha/yr to 2000 and 55,000 ha/yr from 2001)

	1990	1995	2000	2005	2010	2020
CO_2 removals	-22,057	-15,770	-20,921	-22,790	-23,103	-33,552
CO_2 emissions	1,486	2,276	2,622	2,682	2,675	
Total removals	**-20,571**	**-13,490**	**-18,944**	**-20,807**	**-21,208**	**-31,654**

Measuring and comparing annual total removals of carbon dioxide by planted forests can, however, provide a misleading picture of the underlying changes and processes involved in meeting commitments to protect and enhance sinks and reservoirs. This is because measuring the relative change in annual removals neglects the magnitude and direction of total carbon storage in the intervening period. For instance, CO_2 removals in 2000 are projected to be 18,944 Gg CO_2, while CO_2 removals in 1990 were 20,571 Gg CO_2. Thus, the annual rate of CO_2 removal has slowed, even though, the total biomass of planted forests increased over the decade by some 50 million tonnes of carbon. Or viewed another way, 179 million tonnes of carbon dioxide were removed from the atmosphere and stored as carbon in the trees. Figure 7.5 illustrates the cumulative total CO_2 stored in planted forest stocks compared with annual estimates of CO_2 removals.

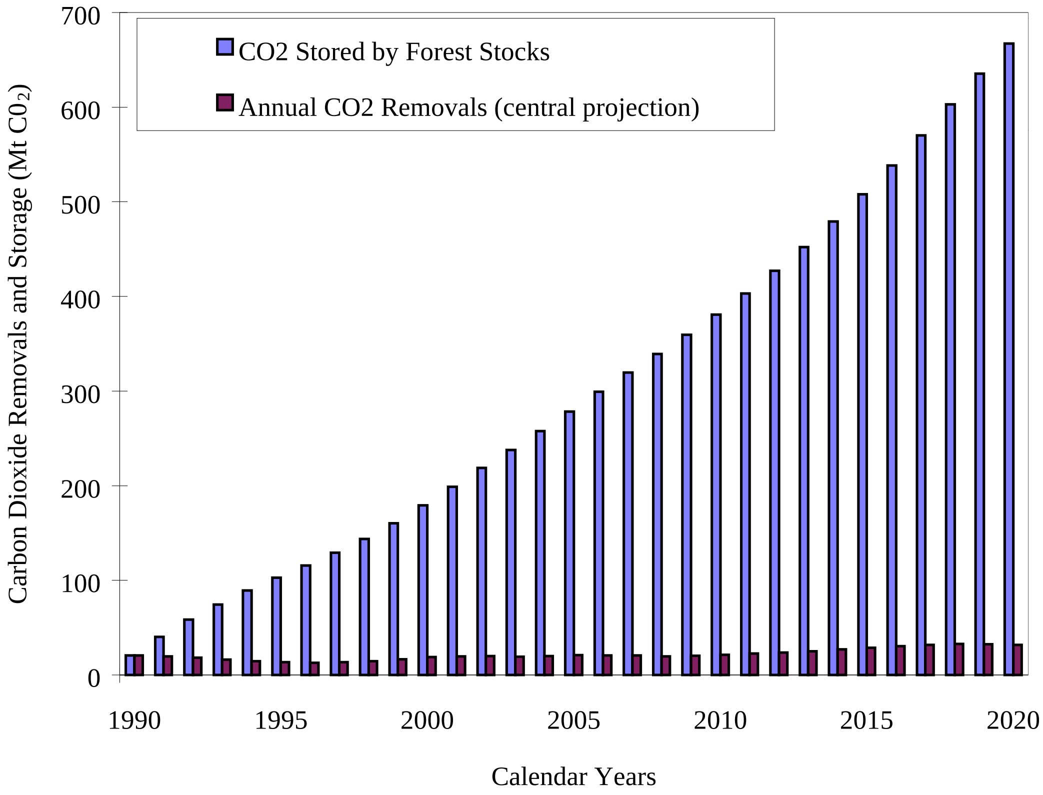

Figure 7.5: Projected CO_2 Storage in Planted Forest Stocks compared with Annual Rates of CO_2 Removals 1990 - 2000. Source: Ministry for the Environment, 1997

Focussing exclusively on the relative annual changes in CO_2 removals and comparing these to CO_2 emissions ignores the significant increase in carbon storage and gives the appearance that New Zealand's net emissions have increased by an order of magnitude over this decade.

7.4.2 Cumulative Carbon Dioxide Emissions and Removals

A more accurate measure of New Zealand's total contribution to the atmospheric stock of carbon dioxide is to compare cumulative emissions of carbon dioxide with the increase in planted forest stocks in the same timeframe, which, when subtracted, give the cumulative net emissions to the atmosphere attributable to New Zealand.

Cumulative emissions are based on the addition of annual inventories and projected emissions for energy and industrial processes. Cumulative emissions over the period 1990 - 2020 from energy and industrial processes are expected to total 1,003.6 Mt CO_2 as shown in Table 7.8. In total, planted forests, net of emissions from harvesting and other emissions from land use changes, are projected to increase in carbon storage by 635.4 Mt CO_2 over the period 1990 - 2020, as shown in Table 7.8. The projected removal of carbon dioxide from the atmosphere by planted forests over the total period 1990 - 2010 is estimated to mitigate, on average, 63% of total gross carbon dioxide emissions from energy sources and industrial processes over the same period. Projections of cumulative gross CO_2 emissions, total increases in planted forest stocks (CO_2 removals less harvest and land use change emissions) and total cumulative (net) CO_2 emissions to the atmosphere are illustrated in Figure 7.6.

Table 7.8: Cumulative Gross CO_2 Emissions from Energy and Industrial Sources and Removals of CO_2 by Planted Forests (in Gg of CO_2)

	1990 - 1999	2000 - 2009	2010 - 2019
Cumulative Gross CO_2 Emissions[a]	279,685	334,921	389,020
Total CO_2 Removed and Stored in Planted Forests[b]	160,350	199,168	275,870
Percentage of Gross CO_2 Emissions Removed from the Atmosphere and Stored by Planted Forests	57%	60%	71%

Note: a BAU “with measures” scenario, 3% GDP growth
b Central projection, based on new planting rates of 70,000 ha/yr from 1998 to 2000 and 55,000 ha/yr from 2001

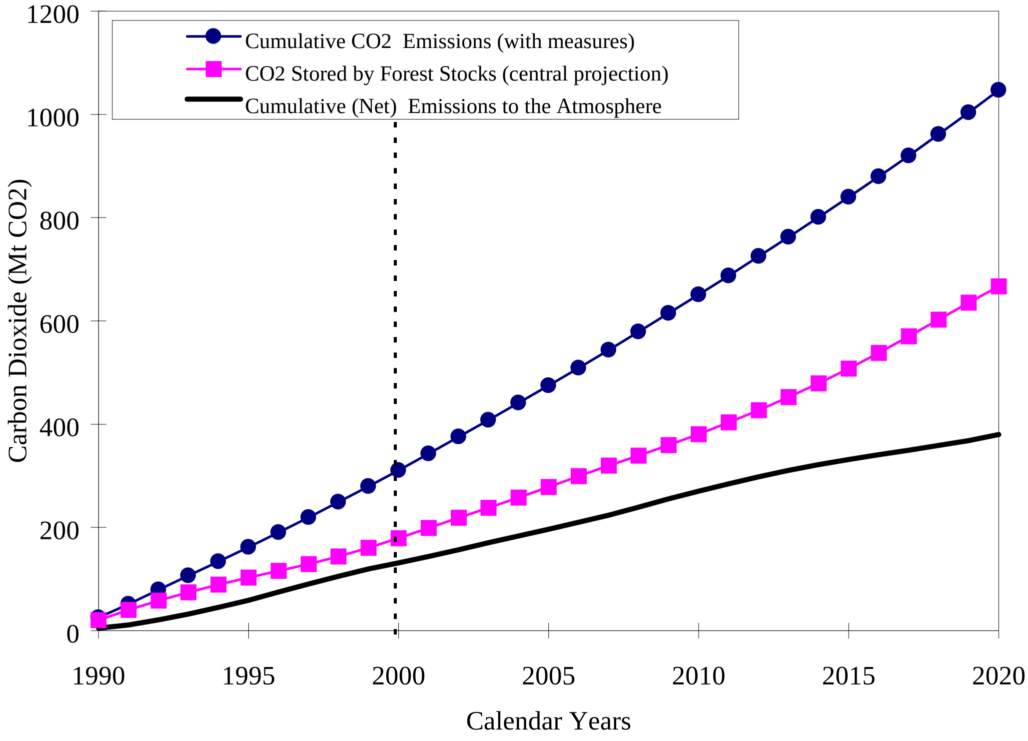

Figure 7.6: Cumulative gross CO_2 emissions, forest stocks and total cumulative (net) CO_2 emissions to the atmosphere. Source: Ministry for the Environment, 1997

Table 7.8 and Figure 7.6 indicate that the increase in forest stocks will remove around two thirds of New Zealand total gross CO_2 emissions from energy sources and industrial processes from the atmosphere. However, even these illustrations do not convey the magnitude of mitigation of increases in gross CO_2 emissions over the period 1990 - 2020, through the growth increments in forest stocks. As can be seen in Figure 7.7, increases in forest stocks will more than offset increases in gross emissions for at least the next two decades, if projected rates of new planting are realised.

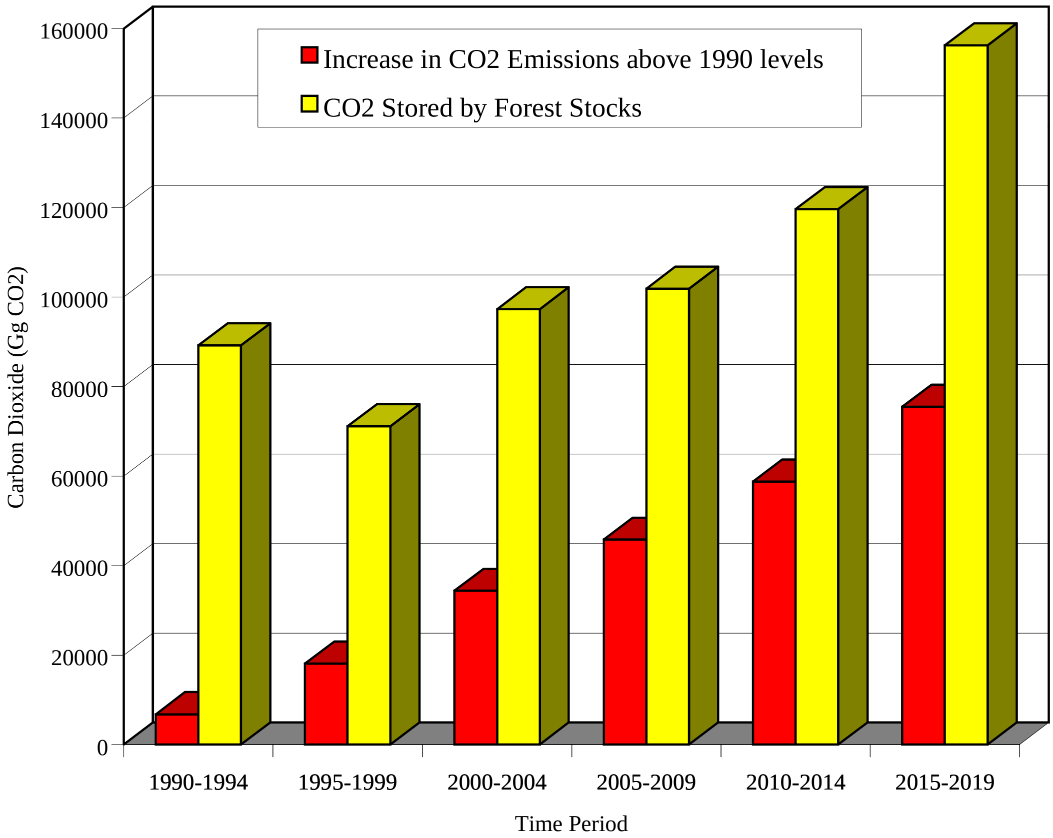

Figure 7.7: Five-yearly Cumulative Increases in Gross CO_2 Emissions Above 1990 Levels Compared with CO_2 Stored by Planted Forest Stocks. Source: Ministry for the Environment, 1997.

7.5 Non-CO2 Greenhouse Gases from Energy Sources

Analysis has been extended to enable projections for non-CO_2 greenhouse gases from energy sources to be made. The basis of this analysis is the same scenarios and cases as for the CO_2 from energy sources analysis.

7.5.1 Methane (CH_4)

Methane emissions from energy sources were 32.4 Gg in 1990 but fell below 30 Gg for the next three years. Emissions did not rise above the 1990 level until 1995 when it increased by around 14% over the 1994 level to 35 Gg. At these levels, methane emissions from energy sources comprise around 1.5% of economy-wide emissions.

Coal production activities comprise the largest component of CH_4 emissions from energy sources. Coal's share has been around 38% for all of the 1990s except for 1995 when coal's emissions rose by over a third and its share rose to 48% when increasing export demand resulted in a higher level of underground mining than previously. (Under ground mining is the most CH_4-intensive mode of mining). Gas's share of methane emissions has fallen from 37% in 1990 to 25% in 1995 mainly as a result of reduced gas flaring and declining use of compressed natural gas (CNG). Liquid fuels' share of around 20% has risen in line with transport fuels demand. The balance of methane emissions is from geothermal sources (around 8%) and biofuels

(around 1%). Figure 7.8 shows methane emissions from energy sources for 1990-1995 and the "with measures" projections at 3% GDP growth.

7.5.2 Nitrous Oxide (N_2O)

Nitrous oxide emissions from energy sources have been between 2.5 and 3 Gg in the 1990s.

Currently, around 40% of emissions are from gas combustion, 30% from liquid fuels, 25% from coal combustion and the balance of around 5% from biofuels.

Projections for nitrous oxide emissions are shown in Figure 7.8. The projected decline from 1999 is from declining gas use, initially from reduced use in electricity generation then, more dramatically, as the petrochemicals industries close down as the Maui gas field depletes. The declining projected trend reverses when this reduction in gas use is complete and increases in emissions from liquid fuels and coal use dominate.

7.5.3 Nitrogen Oxides (NO_x)

Emissions of nitrogen oxides from energy sources have increased from 110 Gg in 1990 to 129 Gg in 1995. Virtually all NO_x emissions result from fuel combustion activities.

In 1995, around 71% was attributable to transport fuels, 12% was from industry, and around 11% to thermal electricity generation of which 8.5% was from gas generation and 2% coal generation.

The projections for NO_x emissions from energy sources are therefore dominated by projected growth of transport fuels with a smaller contribution from increased thermal electricity generation. The "with measures" profiles are shown in Figure 7.8.

7.5.4 Carbon Monoxide (CO)

Carbon monoxide emissions from energy sources increased from 656 Gg in 1990 to 725 Gg in 1995, an average rate of increase of 2% pa.

Around 95% of emissions from energy sources is from transport and around 95% of this is from petrol combustion. Thus both the historical profile and projections closely follow the projected demand for petrol. This information is shown in Figure 7.8.

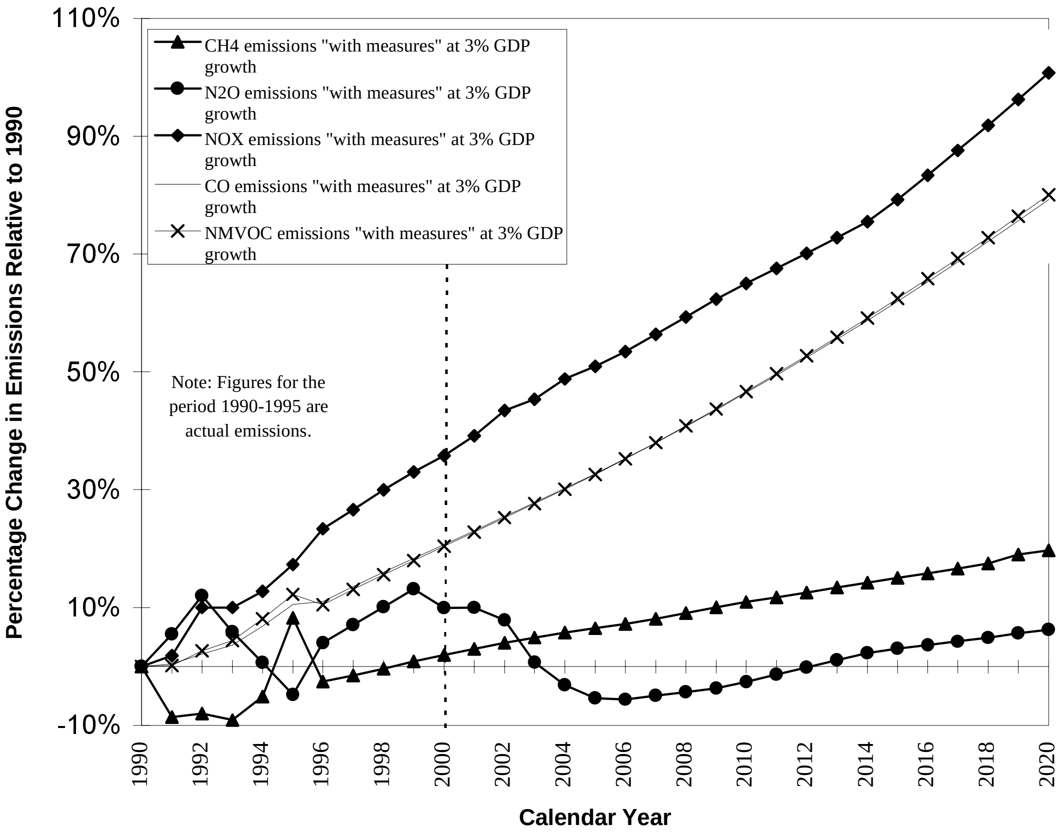

Figure 7.8: Non CO_2 emissions from energy 1990 - 2000. 1997 estimates.

7.6 Industrial processing and solvent use

Carbon dioxide emissions from industrial processing have been included in section 7.3 above (Projections for carbon dioxide from the energy sector and industrial processes).

Table 7.9 Projected emissions in gigagrams (Gg) of non-CO_2 greenhouse gases from industrial processes and solvent use from 2000 to 2020.

	1990	1995	2000	2005	2010	2020
CH_4	0.120	0.120	0.168	0.168	0.168	0.168
N_2O	nr	nr				
NO_x	2.252	2.659	2.885	3.344	3.571	2.984
CO	0.860	1.123	1.168	1.337	1.455	1.409
NMVOC - processes	16.729	18.890	21.898	23.580	27.335	36.736
NMVOC - solvents	25.232	28.040	29.925	32.300	35.711	43.114
HFCs	neg	0.141	0.164	0.190	0.220	0.295
PFCs	0.089	0.029	0.034	0.035	0.035	0.037
SF_6	0.023	0.183	0.212	0.246	0.285	0.383
SO_2	16.305	20.770	31.609	34.873	38.864	47.991

Note: Emissions for the years 1990 and 1995 are included for comparison.
nr = not reported by New Zealand industry

Projections for the emissions of non-CO_2 greenhouse gases from industrial processes and solvent use have been made on the basis of either information supplied by the companies involved (for example PFCs from aluminium smelting), an assumed 3% growth per year, or in some cases a Ministry of Commerce industry specific model.

There are no policy measures in place to address the emissions of non-CO_2 greenhouse gases from industrial processes, except for those that apply to PFC emissions from aluminium smelting. Most of this group of gases show a steady increase from 1990 through to the end of the projection period. The exception is PFCs. PFCs from aluminium smelting show a significant decrease in 2000 compared to emissions earlier in the decade. However, some of this decrease is offset by a small but steady increase in PFCs (namely PFC R218 or C_3F_8) from 1995 onwards. In total, however, PFC emissions are projected to remain below 1990 levels at least until 2020.

Projections of HFC and SF_6 emissions are made on the basis of potential rather than actual emissions. Release of most of these gases to the atmosphere is likely to take place over a number of years, rather than all occur in the year of importation. As PFC projections are dominated by emissions from aluminium smelting, they will more closely reflect ‘actual’ rather than ‘potential’ emissions.

7.7 Projections for emissions from the agricultural sector

7.7.1 Projected trends in methane emissions 1996-2020

Overall, it is expected that total livestock numbers in New Zealand will continue to decrease. This is due to a number of factors, including anticipated low prices for beef and sheep meat and the increase in pasture land being used for planted forests. Details of the assumptions used for the projections have been included in Annex 3.

Table 7.10: Projected methane emissions from livestock and their waste 1996 - 2000

	1990	1996	1997	1998	1999	2000
Methane emissions (Gg)	1,513	1,412	1,390	1,393	1,391	1,391
% change compared to 1990	0	-7%	-8%	-8%	-8%	-8%

Projected methane emissions do not incorporate any potential methane emission reductions from productivity increases as the relationship has not been accurately quantified. It is likely that further increases in productivity will result in further methane emission reductions. Projected methane emissions for ruminants and their waste for the period 2001 to 2020 is shown in Figure 7.9, showing an increasing trend in emissions from 2000, although still being well below 1990 levels in 2020.

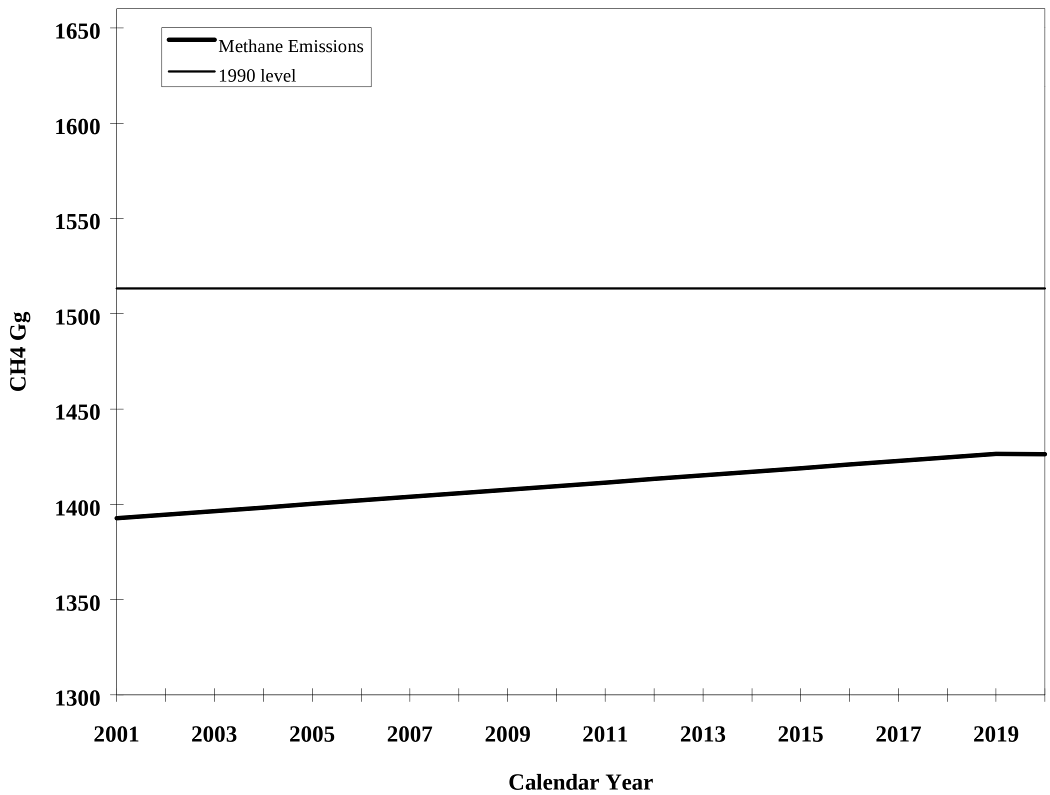

Figure 7.9: Projected methane emissions from ruminants and their wastes 2001 to 2020. Source: Ministry of Agriculture, 1997

7.7.2 Nitrous oxide emissions

There is still a great deal of uncertainty surrounding the various sources of, and sinks for, nitrous oxide. The decrease in livestock numbers has resulted in lower emissions from livestock waste. However, this has been partially offset by increases in some arable crops and, for some years, increased fertiliser usage.

The quantity of fertilisers sold in 1995 started to decrease, reversing an upward trend that began in 1991. Sales peaked in 1994 at about the levels of the early 1980s, when fertiliser subsidies were still in place. The decrease in fertiliser usage in 1995 was largely attributable to declining sheep and beef farm income.

<u>Projected trends in nitrous oxide emissions 1996-2000</u>

The decrease in livestock numbers is expected to continue, resulting in lower nitrous oxide emissions.

The current outlook for sheep and beef farming in New Zealand is not optimistic. Increases in fertiliser usage are therefore unlikely.

Table 7.11: Projected nitrous oxide emissions from agricultural 1996 - 2000

	1990	1996	1997	1998	1999	2000
Nitrous oxide (Gg)	44.87	43.45	43.11	43.16	43.10	43.05
% change compared to 1990	0%	-4%	-4%	-4%	-4%	-4%

Projections for nitrous oxide emissions from the agricultural sector have not been extended past 2000. These projections could be done, but the resulting information would be almost meaningless as a result of uncertainties in existing inventory data.

7.8 Projections for Land Use Change and Forestry Non-CO_2 Greenhouse gas Emissions

Emissions of non-CO_2 greenhouse gases arise from wildfires and prescribed burning. Prescribed burning includes a portion of the area of scrub cleared for new forest planting. Emissions are projected on the basis of the previous 10 year average for the area burnt in wildfires and prescribed burning, and the fraction of new forest planting where fire is used to remove any on-site scrub prior to planting. Predictably, given the above assumptions, emissions are projected to remain relatively constant beyond 2005. Table 7.12 shows projected non-CO_2 greenhouse gas emissions from land use changes.

Table 7.12: Emissions of non-CO_2 greenhouse gas from land use changes (Gg)

	1990	**1995**	**2000**	**2005**	**2010**	**2020**
Methane (CH_4)	4.985	7.686	6.302	6.078	6.045	6.058
Nitrous Oxide (N_2O)	0.031	0.048	0.039	0.038	0.037	0.038
Oxides of Nitrogen (NO_x)	1.119	1.725	1.415	1.364	1.357	1.360
Carbon Monoxide (CO)	43.669	67.323	55.203	53.218	52.948	53.066

7.9 Projections for Waste Sector Emissions

Waste sector methane emissions show an 18% decrease from 1990 to 1995. Total methane emissions from waste are projected to remain below 1990 levels in 2000, to begin increasing after 2000, but still be below 1990 levels in 2020.

Table 7.13: Methane emissions from waste in 1990 and 1995, and projections for 2000 - 2020.

	1990	1995	2000	2005	2010	2020
Wastewater	4.26	4.30	4.34	4.37	4.40	4.44
Landfills	150.80	127.37	106.86	112.85	117.63	126.06
Total (Gg CH_4)	**155.06**	**131.67**	**111.20**	**117.22**	**122.03**	**130.50**

7.9.1 Wastewater

In the absence of policy measures, methane emissions from wastewater are projected to increase with population over the next two decades. Methodology for wastewater emission calculations is described in Annex 6.

7.9.2 Landfill Methane

Methane emissions from landfills are expected to be below 1990 levels in 2000. They are expected to increase again after 2000 (in response to population increase), but are projected to remain below 1990 levels in 2020. Landfill methane emission calculations were carried out using the methodology described in the IPCC 1996 Revised Guidelines. Complete inventory data and details of the assumptions used are contained in Annex 14. Figure 7.10 shows gross methane generated, recovery of methane, and net methane emissions to the atmosphere (after allowance for some oxidation of the methane generated by surface layer micro-organisms).

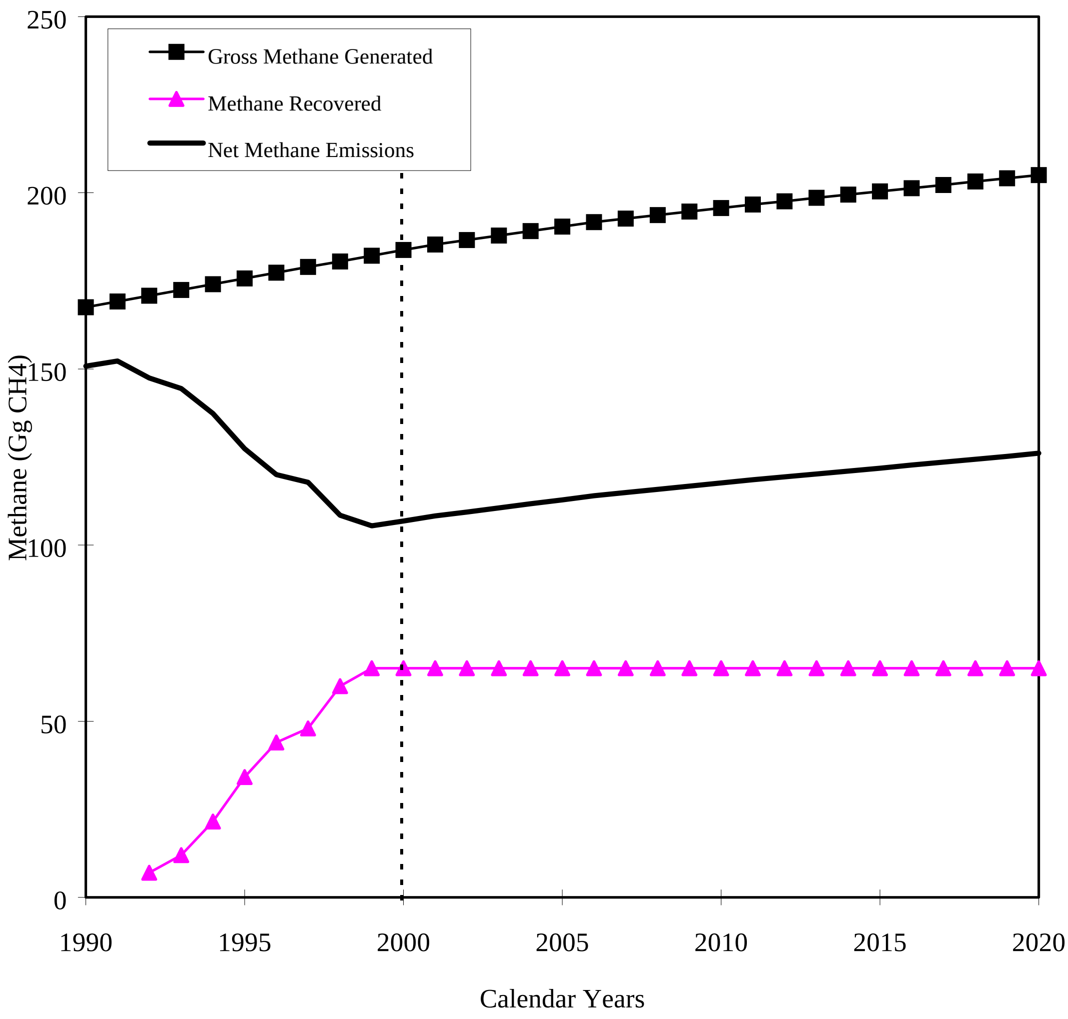

Figure 7.10: Gross methane generated, methane recovery, and net methane emissions. Source: Ministry for the Environment, 1997.

While it is known that waste management policies are changing the type and reducing the quantity of rubbish received at landfills, quantified data on paper recycling or the diversion of organic waste to composting programmes is not available. Waste management policies, however, are addressing the task of acquiring further data on landfill management practices, waste stream composition, and waste generation data for urban and rural populations.

Included in the projections is an allowance for recovery of landfill gas, although only existing or currently planned landfill gas systems have been included. Energy market reforms, in particular in the natural gas customers, combined with further experience with landfill gas capture and management technologies, are likely to increase gas recovery rates. The availability of urban centres or large commercial power and heat consumers, in the case of direct end-use, will greatly influence the pattern of development and economics of landfill gas recovery. A small number of commercial organisations and local governments are currently utilising landfill gas for direct end-use and for electricity generation.

7.10 International bunker emissions projections

International bunker emission projections as shown in Table 7.14, show increasing emissions across all gases, with aviation emissions projected to double from 1990 to 2020. Emissions from marine bunker fuels are projected to increase much more slowly, being 15% above 1990 levels in 2020.

Table 7.14: Projections in gigagrams (Gg) of emissions from international bunkers for the period 2000 to 2020.

	1990	2000	2005	2010	2020
CO_2 Total	**2,413**	**2,654**	**3,378**	**3,251**	**3,967**
air	1,367	1,681	1,914	2,174	2,775
marine	1,046	973	1,464	1,077	1,192
CH_4 Total	**0.225**	**0.218**	**0.233**	**0.249**	**0.283**
air	0.030	0.037	0.042	0.048	0.061
marine	0.195	0.181	0.191	0.201	0.222
N_2O Total	**0.055**	**0.055**	**0.060**	**0.066**	**0.078**
air	0.021	0.025	0.028	0.032	0.041
marine	0.033	0.031	0.032	0.034	0.038
NO_X Total	**26.96**	**26.72**	**28.73**	**30.84**	**35.62**
air	5.49	6.75	7.69	8.73	11.14
marine	21.47	19.97	21.04	22.11	24.48
CO Total	**5.56**	**5.85**	**6.40**	**8.84**	**8.36**
air	2.27	2.79	3.18	3.61	4.61
marine	3.29	3.06	3.22	5.23	3.75
NMVOCs Total	**3.72**	**3.75**	**4.05**	**4.36**	**5.09**
air	0.95	1.17	1.33	1.51	1.93
marine	2.77	2.58	2.72	2.85	3.16

Note: 1990 data is included for comparison.

Chapter 8: Vulnerability and Adaptation Measures

8.1 Introduction

Within New Zealand there have been three broad approaches aimed at identifying vulnerability of important sectors of the economy to climate change.

Firstly, there have been national reviews, largely based on the judgement of sectoral experts. New Zealand's first national communication under the FCCC largely drew from the work of the New Zealand Climate Change Programme Impacts Working Group in 1989 and 1990. The Impacts Working Group comprised 40 experts who drew on the expertise of a network of over 300 people spanning all economic sectors. This study provided a comprehensive assessment of the possible impacts of climate change in New Zealand.

Secondly, there are on-going research programmes funded by the Foundation for Research, Science and Technology[1] (FRST), aimed at a number of outcomes which include: increasing understanding of New Zealand's climate and how this may change in the future; increasing understanding of the underlying responses to the environment of a range of plant and animal species, including responses to elevated temperature and CO_2; development and refinement of crop models based on experimental work; development of soils models to increase understanding of the turnover of soil carbon. Uncertainties about the impact of increased UV-B on New Zealand plants, especially those of economic importance, adds another dimension to possible impacts of changes in other climatic variables on these plants. Consequently, research into the impacts of increased UV-B on plants (and on human health) is given a high priority by the National Science Strategy Committee for Climate Change[2] (NSSCCC). Some research programmes are already underway in this area including the effects of UV-B on the economically important white clover and the effects of UV radiation on New Zealand indigenous and exotic plants.

Thirdly, there are FRST-funded research programmes aimed at integrating existing knowledge, models and data in order to enhance the ***capacity*** for assessing vulnerability and adaptation to climate change within New Zealand. This has largely been achieved through a collaborative research effort which is aimed at the development of an integrated, model-based system for evaluating the effects of climate variability and change on the New Zealand environment (the CLIMPACTS programme). The system is being developed through an interdisciplinary research programme involving scientists from five Crown Research Institutes and two universities. It is closely linked to a number of other research programmes with a climate change theme that are focussed on more in-depth understanding of environmental sensitivities within specific economic sectors. In addition to this programme there is also a new, recently funded, programme aimed at development of an integrated system for use in coastal zone management.

8.2 Scenarios of climate change and development of assessment tools

Assessment of climate change impacts in New Zealand is scenario based. Two scenarios of climate and sea level change for New Zealand were developed for use by the Impacts Working Group in 1989 and 1990. More recent scenarios have been developed for the CLIMPACTS research programme and for an Australia-New Zealand conference on climate change. In both cases a

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[1] The Foundation for Research Science and Technology (FRST) administers the Public Good Science Fund which is the major source of government research funding.

[2] The role of the National Science Strategy Committee for Climate Change is discussed in more detail in Chapter 10 - Research and Systematic Observations.

statistical downscaling method was used to infer local-scale changes from GCM model output. These were provided for use within the CLIMPACTS system in the form of standardised patterns of change (i.e. the changes in temperature and precipitation expressed as the change per 1ºC global temperature change). In general these indicate a temperature increase over New Zealand of approximately 1ºC per 1ºC of global warming. Changes in precipitation are of the order of ±10% with a tendency for decreased rainfall in central and eastern New Zealand and increased rainfall in northern and southern regions.

Within the CLIMPACTS system these patterns of regional climate change are scaled by time-dependent global temperature changes. These are derived from a simple climate model, MAGICC (Model for the Assessment of Greenhouse Gas Induced Climate Change), and enable users to examine the effects of a wide range of emissions scenarios with different levels of radiative forcing. The main advantage of this system is that it provides a high degree of flexibility in terms of the scenarios that can be evaluated. It is readily updated to reflect the latest findings of the IPCC and allows comprehensive evaluation of environmental sensitivities for selected sectors. Thus it is of direct benefit to New Zealand policy makers and environmental managers.

One of the significant features of CLIMPACTS is the flexibility to generate a wide range of scenarios. This *scenario generator* is integrally linked with a number of other key components which include:

- monthly climate data (temperature, rainfall, and solar radiation) for 1951-80, interpolated to a 0.05º lat/long grid.
- time series of monthly climate data for maximum and minimum temperature (68 sites), rainfall (100 sites) and sunshine hours (35 sites) and time series of daily weather data for 15 sites.
- a land use capability database, which allows the user to conduct spatial analyses for specific land use types (e.g. arable, horticulture, hill country farming).
- impact models for important agricultural sectors including: grasslands, arable crops, and fruit crops.

The overall research strategy is aimed at developing applications for a number of time and space scales. The main scales are: national (0.05º lat/long grid; monthly climate normals) ; regional council (0.01º lat/long grid; time series of monthly and daily climate data); site-specific (time series of monthly and daily climate data). Outputs are aimed at a number of potential users, including central government, local authorities, industry, and modellers.

Initial development of CLIMPACTS focussed on the capacity for examining effects of mean changes in climate at the national scale. This has been refined recently with the incorporation of time series of monthly and daily climate data and the development of capacities for analyses of risk at both national and site-specific scales, using these time series data. In future this work will be refined further with a focus on additional sectoral models (including, it is hoped, water resource models) and development of applications at the regional council scale. Future development includes capacity for evaluating land-use change and socio-economic effects. This is beyond the scope of the current research programme.

While the focus with CLIMPACTS has been the development of the system itself (i.e. development of the capacity for integrated assessment), there have also been some applications of the system. These have been, in general, aimed at developing methods for evaluating environmental sensitivities, including identification of thresholds of critical change, and for quantifying uncertainties. At the national scale it is possible to examine spatial changes in regions that are suitable for different crops. By generating a time series of scenarios (from 1990 up to 2100) it is

also possible to examine rates and thresholds of critical change. At the site scale it is possible to examine changes in risk in relation to user-defined tolerance thresholds. This will be developed further to enable evaluation of effects of changes in climate variability.

8.3 Expected impacts of climate and sea-level change

The Impacts Working Group of 1989 and 1990 produced a report that gave a comprehensive summary of expert judgement of expected impacts of climate and sea-level change for a wide range of sectors in New Zealand. The main findings of this report remain largely unchanged. Some of the overall effects identified in this report are:

- warming is expected to be similar for both North and South Island but winter temperatures may rise faster than summer temperatures in more southern parts of the country;
- average westerly winds over New Zealand may decrease, particularly in the winter;
- whilst rainfall might decrease, summer rainfall might increase in western and northern parts of both Islands (predictions of likely changes in rainfall are still quite uncertain);
- most New Zealand glaciers will shrink at a faster rate than previously;
- seasonal snow storage in the South Island will decrease, with increased flows in winter and decreased flows in summer likely for large snow-fed rivers;
- New Zealand sea levels are likely to rise by between 7 and 17 cm by the year 2025 and between 17 and 35 cm by the year 2050.
- changes in the severity and frequency of climatic extremes could have the greatest immediate impacts;
- costs and benefits will not be spread evenly between different sectors of the economy, nor between different regions;
- there will be the capacity for surprise given the large uncertainties that still exist in the state of knowledge of climate change and its effects;
- Maori lands and traditional food sources may be adversely affected, particularly in the north of North Island;
- adverse effects of climate change could be most severe for those parts of the environment and society that are least able to adjust.

The recent development of the CLIMPACTS system has provided a significant enhancement of the capacity for assessing vulnerability and adaptation to climate change in New Zealand. This integrated model system is consistent with the methods that are outlined in the IPCC guidelines for assessing climate change impacts and adaptations.

Preliminary applications, using the various methods for assessment, have identified the potential for variable responses between different agricultural sectors. There will likely be positive responses with arable crops such as maize, with increased opportunities for this crop. There may be mixed responses for fruit crops such as kiwifruit with some existing areas becoming climatically marginal, but with windows of opportunity for cultivation in new areas. There will also be a southward shift of sub-tropical grass species, which may on balance have adverse effects on the very important dairy industry and other pasture based industries.

A similar programme to CLIMPACTS has begun recently to develop an integrated model system for application in coastal zone management in New Zealand. The overall goal of this interdisciplinary

programme (Coastal Hazard Assessment for Management and Planning) is to determine, within a spatial context relevant for long-term strategic planning and management, the effects of erosion and storm-surge flooding on the natural and human systems of the coastal zone. The model-based system will simulate erosion and storm-surge flood events and their consequent impacts on the coastal zone over time. The purpose is to examine the *sensitivity* of the coastal systems to various model parameters and their uncertainties, and to evaluate the benefits and costs of hazard mitigation options for sandy beach and dune coasts. It will explicitly allow for examination of the effects of uncertainties in future climate and sea level change over the planning horizon.

8.4 Actions taken to adapt to the impacts of climate change

While on-going research will lead to a greater understanding of the possible impacts of climate change on specific sectors there are still large uncertainties. This continued uncertainty makes it difficult to implement specific actions aimed at adaptation to climate change. However it is recognised as important that policy makers at both national and local level, and decision makers within industry groups, take account of the possible effects of climate change in their policy formulation and development of strategic plans. Research programmes such as CLIMPACTS have an important role in this process

There are a number of research programmes which provide information to help prepare for possible future adaptation measures. These include investigating the biological control of plant diseases, plant pathogen ecology and disease management, grassland genetic resources and white clover improvement, and biosecurity issues.

Within the agricultural sector, there are a range of adaptation measures that can be taken including: new varieties, use of irrigation, altered nutrient levels. Changing land use is another important consideration. For such measures to be explicitly considered, a close liaison between scientists and user groups, such as local authorities and industry, is required. This process of consultation has begun for a number of sectors, most notably for the coastal zone.

8.5 Adaptation to possible sea level rise

After extensive public consultation the New Zealand Coastal Policy Statement (NZCPS) was prepared under the Resource Management Act (RMA) in 1994. This policy statement is to guide local authorities in their day-to-day management of the coastal environment.

The NZCPS has provided a structure for adaptive response to sea level rise as part of the national strategic planning framework. The NZCPS requires recognition of the potential impacts of likely changes in sea level, including the need to avoid development in areas prone to inundation or accelerated erosion; protecting human life; essential facilities and economic activities; and ensuring that the integrity of natural systems and their buffers is not unduly affected.

8.6 Avoidance and mitigation of natural hazards

Climate change may result in more frequent occurrence of ‘unusual’ climate events, and greater extremes such as high rainfall, severe winds, and periods of drought. Coastal and low-lying land is particularly vulnerable to natural hazards resulting from climate change. Sea level rise is the most obvious. Planning to reduce the adverse effects of natural hazards is particularly important at local government level because the hazards usually have localised effects.

Local authorities have a stake in avoiding, minimising, and mitigating the costs and effects of natural hazards because:

- they are responsible for providing services and utilities necessary for the wellbeing of communities;
- they are responsible for the avoidance and mitigation of natural hazards through plans and rules under the RMA;
- they can be liable for loss of damage to private property in specific circumstances.
- they have responsibility for 'civil defence' including the planning and organisation necessary for public safety during events beyond the capability of regular emergency services e.g. floods and severe storms.

MetService, the State Owned Enterprise (SOE) responsible for weather forecasting in New Zealand, is under contract to the Government to provide storm warnings and warnings of high rainfall events to the New Zealand public, as well as maintain its routine weather forecasting duties.

8.7 Future research

The National Science Strategy Committee for Climate Change[3] (NSSCCC) has recently conducted (NSSCCC, 1996) an analysis of gaps in the understanding vulnerability and adaptation and where future effort could go. The Committee concluded there was a need for:

- better validated economy-wide models to test the economic impact of public policy;
- research in New Zealand into pests and diseases of biological systems and human health; and
- climate change research related to economic plants and biological systems.

These conclusions have been drawn to the attention of the Foundation for Research, Science and Technology, government departments and other funders, and all providers of research on climate change.

[3] The role of the National Science Strategy Committee for Climate Change is discussed in more detail in Chapter 10 - Research and Systematic Observations.

Chapter 9: Finance and technology

9.1 Contributions to the financial mechanism

The Global Environment Facility (GEF) is the international entity entrusted with the operation of the financial mechanism of the FCCC on an interim basis. For the 1994-97 replenishment, New Zealand's contribution was NZ$10.4 million (SDR 4 million). Only half of this amount is an assessed share. The remainder is a supplementary contribution. On a per capita basis, this contribution is one of the largest made to the first operational phase of the GEF.

Negotiations are about to begin on the second replenishment of the GEF for the period 1998-2001. These should be completed in early 1998. At this point an indication of New Zealand's contribution is not possible.

9.2 Actions to implement Articles 4.3, 4.4 and 4.5 of the FCCC

Articles 4.3, 4.4 and 4.5 relate to the commitments of developed country Parties (Annex II Parties) regarding financial resources and technology transfer to enable developing country Parties to implement the provisions of the FCCC, and for adaptation assistance.

New Zealand is fulfilling its Article 4.3 commitment at this point through its contribution to the GEF.

New Zealand recognises the need to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects (Article 4.4).

New Zealand has a particular concern about the possible implications of climate change for the small island developing states. They make little contribution to the problem of climate change, yet stand to be among the first to suffer the consequences.

9.3 Financial resources provided through bilateral, regional, and other multilateral channels

New Zealand values regional approaches to development and environmental issues and its Official Development Assistance (ODA) programme has a strong regional component. New Zealand contributes to a number of regional development cooperation organisations, including the South Pacific Forum Secretariat, and the South Pacific Regional Environment Programme (SPREP).

In September 1996, the Minister of Foreign Affairs and Trade approved a new NZODA strategy for dealing with global environmental issues in the South Pacific. This strategy identified five main areas for assistance, one of which is climate change. Through its multilateral, regional, and bilateral programme, New Zealand has supported a number of projects which are relevant to the problem of climate change. The approach taken by the new strategy is to complement and add to existing programmes in the South Pacific. It targets coral reef and integrated coastal management as potential areas for assistance. The strategy has established a consultative process that will get underway in early 1997

to determine a programme of action. Implementation of the programme of action will involve new funding to this area of NZODA.

9.3.1 Mitigation

Energy efficiency and alternative energy

New Zealand has provided ongoing funding to a project administered by the South Pacific Forum (a grouping of South Pacific independent and self-governing countries) aimed at reducing Pacific developing country dependence on petrol, in particular through the increased use of alternative fuels. The 1996/97 allocation was NZ$375,000.

In 1995/96 New Zealand contributed NZ$420,000 to a project organised by the Association of South East Asian Nations (ASEAN) to increase the use of natural gas in the transport sector. In the same financial year, New Zealand also provided NZ$54,000 for an ongoing geothermal power project in Indonesia; the 1996/97 allocation for this project is NZ$220,000. The New Zealand ODA programme also allocates in excess of NZ$1 million annually on an ongoing basis to support study at the Geothermal Institute at Auckland University New Zealand. In 1997, for example, 24 students from developing countries are participating in this programme, with the majority of those students from the Asian region. The Institute teaches a diploma course in geothermal resource management

New Zealand has allocated significant ODA resources to forest sector projects for some time and supports forest programmes in a number of Asian and South Pacific countries. Assistance has taken several forms: policy and technical advice, assistance in forest conservation and the creation of national parks, assistance in afforestation and planted forestry projects, and assistance in monitoring. New Zealand provided NZ$5,165,000 for forestry and conservation related projects in 1995/96. The 1996/97 allocation is NZ$6,050,000.

9.3.2 Adaptation

New Zealand recognises the special difficulties climate change poses for developing island countries and has supported a number of projects that will help countries deal with them. These include the development of meteorological services and coastal zone management programmes which will assist responses to the increased erosion and sea level changes that climate change could cause. The total expenditure on projects relating to meteorological services and coastal management programmes (both bilateral and through the South Pacific Regional Environment Programme) was NZ$1,272,900 in 1995/96. The 1996/97 allocation is NZ$791,450.

9.4 Contributions to the trust fund for supplementary activities under the UNFCCC process

In addition to contributing its assessed share to the trust fund for the core budget of the FCCC in both 1995 and 1996, in 1995 New Zealand also contributed NZ$32,000 (US$21,000) to the trust fund for supplementary activities under the FCCC process.

Chapter 10: Research and systematic observations

10.1 Introduction

In 1991, the Government established the National Science Strategy Committee for Climate Change (NSSCCC) to develop a comprehensive strategy for climate change research. This specifically includes the identification of priority research and gaps in the climate change research agenda, coordination of research efforts, and identification of the appropriate overall level of funding for climate change research. The NSSCCC has a responsibility to establish and maintain linkages with researchers and end users of the research across a broad spectrum, from the fundamental understanding of climate change processes, through to predictions, scenarios and options analysis critical for climate change policy response. The NSSCCC also has a role in providing advice on the establishment and maintenance of linkages within the international climate change programme. An annual report, the most recent covering 1995/1996, is provided to the Minister of Research, Science and Technology (Royal Society of New Zealand, 1996a), and the recommendations in this report are taken into account in the setting of priorities for Public Good Science Fund (PGSF) expenditure.

New Zealand has continued to promote and collaborate in research and systematic observations, as required by Articles 4 and 5 of the FCCC. Estimated public expenditure on research and systematic observations for the 1996/97 financial year is NZ$16.4 million (US$10.4 million), an increase of NZ$1.2 million over the amount that was reported in the first national communication (Ministry for the Environment, 1994a). Goals for this research, as identified by the NSSCCC (Royal Society of New Zealand, 1996b), include reducing uncertainties about climate change and its impacts, and improving understanding of the range of possible responses. New Zealand is located in a large data-sparse region of the south-west Pacific, so observations of atmosphere and ocean climate and of greenhouse gases are an important contribution to global and regional monitoring of climate variability and change.

New Zealand scientists and institutions have continued their collaboration in international research and monitoring programmes, including those of the International Geosphere Biosphere Programme (IGBP) and the World Climate Research Programme (WCRP). New Zealand contributed to the Second Assessment Report of the Intergovernmental Panel on Climate Change, with two scientists taking lead authorship responsibility and many others contributing to the report and reviewing it.

A detailed listing of New Zealand climate change research projects, and an up-to-date bibliography of research publications, are provided in the 1995/96 annual report (Royal Society of New Zealand, 1996a) of the government-appointed NSSCCC. An extensive overview of New Zealand and Australian research on climate science, impacts and response options is provided in the proceedings of the Greenhouse í94 Conference (Bouma *et al*., 1996), which was held in Wellington in October 1994. Further information on New Zealand research results, together with implications for New Zealand of the 1995 IPCC Assessment, are documented in the proceedings of a workshop organised by the Royal Society of New Zealand in April 1996 (Braddock, 1996).

10.2 Research on the impacts of climate change

10.2.1 Agriculture, Forestry and Ecosystems

Programmes are in place to address the sensitivity to climate variability and change of pastures, horticultural and arable crops, indigenous and managed forests, terrestrial and coastal ecosystems, and Antarctic penguin populations. The CLIMPACTS programme (as detailed in Chapter 8) is integrating information and data from various sector-oriented science programmes into a computer model for integrated climate impact assessments of New Zealand agriculture, horticulture, grassland and soils. The model includes a global climate component, regional modules for generating climate scenarios, and modules for biophysical impact analyses.

The research into effects of climate change is being conducted in several different sector-oriented research programmes. The consistent theme in this research effort is to quantify the effects of climate, CO_2, and UV radiation on underlying biological growth processes, and to incorporate this information into improved predictive models. Effects of climate change on greenhouse gas emissions are also being investigated in soils, and managed and indigenous ecosystems.

First-order impact analyses were conducted for New Zealand pastoral agriculture in 1990; these were primarily qualitative statements about expected changes based on expert knowledge. Since that time specialised experiments have been initiated to examine effects of UV-B radiation, CO_2, and climate variability, on pasture growth and nutritive value, and consequent animal production. New Zealand improved pastures are comprised primarily of two temperate forage species (*Lolium perenne* and *Trifolium repens*), with a strong reliance on symbiotic nitrogen fixation, making this a unique system in global pastoral agriculture. A combination of laboratory and field-based experimentation, coupled to mathematical models, is being used for this research. Important components of this research are the examination of the spread of undesirable subtropical grass species into the temperate pastures, and identification of options for addressing climate change impact issues in future forage crop breeding efforts. An experimental programme is in progress examining the effects of elevated CO_2 and UV-B radiation on native and exotic tree species (especially *Pinus radiata*). Climate effects on fruit, cereals and other grain crops are also being investigated to develop improved functions for predictive mathematical models.

New Zealand programmes on grasslands, wheat, and forest ecosystems are recognised as important core contributions to the Global Change and Terrestrial Ecosystems (GCTE) programme of the International Geosphere Biosphere Programme (IGBP).

The NSSCCC has concluded that gaps remain in climate change research related to economic plants and biological systems, and into pests and diseases of biological systems.

10.2.2 Human health

Health effects research includes assessment of factors affecting vulnerability to climate change, such as crowding, food insecurity, local environmental degradation, and

perturbed ecosystems, which are highly relevant to the Pacific region. Investigations are also underway into relationships between health outcomes (mortality and morbidity) and climatic factors in New Zealand and the South Pacific over recent decades. Predictive models of health impacts of climate change are being developed, drawing on the above work and in collaboration with the CLIMPACTS programme.

10.2.3 Terrestrial and coastal impacts, and sea level

Current terrestrial impacts research includes the response of snow and glaciers to climate change, and the relationship between climate and landslides. Research is also underway on assessing coastal hazards related to climate change, on the role of wind in generating storm surge and damaging waves, and on the break-up of sea ice around Antarctica.

The NSSCCC has indicated the need for more fundamental physical monitoring and research on coastal processes around New Zealand, which is required to underpin coastal impact modelling.

10.3 Modelling and prediction, including Global Circulation Models (GCMs)

Facilities have now been developed to run global and regional climate models in New Zealand, to examine regional climate variability, seasonal climate forecasting, and climate change. New Zealand scientists have also made extended collaborative visits to climate modelling groups at the CSIRO Division of Atmospheric Research in Australia and the Hadley Centre in the United Kingdom, to work on model validation and applications in the South West Pacific. Work has also commenced on hydrodynamic modelling of the ocean region surrounding New Zealand.

Research is underway on using both mesoscale (high resolution) meteorological models and statistical techniques to simulate local climate and climate changes for the New Zealand and South West Pacific region, by downscaling from global circulation model results. The ability of mesoscale models to simulate the strong spatial gradients in rainfall occurring during the flow of moist air over mountains is being tested within the collaborative Southern Alps Experiment (SALPEX).

Revised climate change scenarios have been developed for New Zealand (Whetton *et al*., 1996) and published in the proceedings of the Greenhouse ë94 Conference.

10.4 Climate process and climate system studies

10.4.1 Climate Variability, Trends and Predictability

A programme focusing on the causes and predictability of climate variations in the New Zealand region commenced in 1995. This programme is closely linked to the goals of the CLIVAR project within the World Climate Research Programme.

Climate trends since the 1860's have been studied using instrumental data, glacier records, and tree ring data. Climate variations further back into the Holocene period have been investigated using evidence of glacier changes, pollen analyses, sediment studies, and deep sea cores, and compared with Northern Hemisphere information. A

collaborative international drilling programme at Cape Roberts is testing theories about past climate and ice extent in Antarctica.

10.4.2 Trace Gases and Atmospheric Chemistry.

New Zealand's emissions of methane and nitrous oxide are relatively large on a per-capita basis, because of the large agricultural component of the economy. Research to establish agricultural methane emissions includes measurements on individual animals, micrometeorological measurements of methane fluxes over stock paddocks, and regional flux estimates from aircraft vertical profile measurements. Work is in progress on nitrous oxide fluxes from various agricultural activities and land uses including pasture. The role in carbon dioxide uptake or release to the atmosphere of New Zealand's indigenous and planted forests, including the role of the underlying soils, is a further important area of current research.

Detailed isotopic studies of methane and carbon monoxide samples from New Zealand, the Pacific and Antarctica are being used to address global sources, transport, chemical transformations, and sinks of greenhouse gases, including the role of tropical biomass burning. Research is in progress to better understand the chemistry and dynamics influencing ozone concentrations, particularly in the stratosphere over the region from New Zealand south to Antarctica.

The NSSCCC considers gaps remain in studies of greenhouse gas emissions, particularly on sources, sinks, and mitigation options for ruminant methane emissions and nitrous oxide. The NSSCCC recommends that coordinated national research on greenhouse gas emissions should include more work on indigenous forests as sinks of greenhouse gases (including the effect of possums and other animal pests), as well as on refining New Zealand's methane and nitrous oxide inventory.

10.4.3 Aerosols and Clouds

Clouds affect the amount of solar radiation warming the earth's surface, and in the New Zealand region their formation is dependent on marine aerosols and subsequent physics and chemistry in clean air.

New Zealand participated in the first aerosol characterisation experiment (ACE-1) of the International Global Atmospheric Chemistry project, investigating the relationships between cloud condensation nuclei and dimethyl sulphide in the South Tasman Sea. New Zealand also collaborates with other countries to remotely sense aerosols in the upper atmosphere over Lauder (in southern New Zealand) and the Ross Dependency (Antarctica), and to understand their behaviour and their influences in atmospheric chemistry.

The SALPEX field campaign over the Southern Alps in October/November 1996 gathered data on cloud microphysical properties and atmospheric conditions. This will be used in the international GEWEX cloud system study (GCSS) to test ways of simulating cloud development near mountainous areas in Global Circulation Models.

10.4.4 Ocean Processes, and Ocean-Atmosphere Exchange

The first systematic studies of oceanic sinks of carbon dioxide and sources of dimethyl sulphide (a precursor of cloud condensation nuclei) in the New Zealand region have commenced, as part of a major new ocean-atmosphere research programme. This programme includes collaborative research with Australia on the ocean carbon cycle. Research is also underway on the role of the marine biosphere in sequestering carbon dioxide, through studies of phytoplankton production in subantarctic and subtropical waters and the subtropical convergence zone. This work contributes to the Joint Global Ocean Flux study (JGOFS) of the IGBP. Research continues on the ocean circulation and its variability in the South West Pacific, linked to WOCE (the World Ocean Circulation Experiment - a component of the WCRP).

10.4.5 Land - Atmosphere Interactions

Research is continuing on processes which govern the fluxes of moisture, energy, and greenhouse gases between various surfaces (grassland, forests) and the atmosphere. The processes through which mountains affect regional climate (precipitation, temperature, and wind) are being studied within the SALPEX research programme.

10.5 Data collection, monitoring and systematic observation, including data banks

New Zealand monitoring and observation activities relevant to climate change are still much as outlined in the first national communication. Continuing activities originally reported in the first national communication are listed below, along with newer initiatives:

- **Climate monitoring**: Climate and weather observations from New Zealand, and from the South Pacific Islands, are archived by the National Institute of Water and Atmospheric Research (NIWA), in a database accessible to registered users over the internet. The archive includes data from a 21 station New Zealand reference climate network as a small subset.
- **Oceans**: NIWA is monitoring sea surface temperatures at coastal sites using *in situ* temperature recorders, and sea surface temperature using satellites.
- **Greenhouse gases and aerosols:** NIWA measures concentrations and isotope ratios in carbon dioxide, methane, and carbon monoxide, as well as aerosol properties and non-methane hydrocarbons, at the Baring Head clean air monitoring station. The carbon dioxide data are submitted to World Meteorological Organization (WMO) databases, and information on other chemical species is maintained by NIWA.
- **Stratospheric ozone and ultraviolet radiation:** The NIWA research station at Lauder in Otago is the mid-latitude Southern Hemisphere site of the Network for the Detection of Stratospheric Change (NDSC). Measurements include stratospheric ozone and oxides of nitrogen, stratospheric aerosols, other gases relevant to ozone chemistry, and detailed spectral measurements of surface UV radiation. NIWA makes similar measurements at the interim Antarctic NDSC station which it operates near Scott Base, and (in collaboration with France) monitors stratospheric ozone and nitrogen dioxide at Kiribati near the Equator. Industrial Research Ltd monitors

erythemal (sunburning) UV radiation at 5 sites around New Zealand using UV-B radiometers, and makes the data available on request.

- **Sea level**: The Navy Hydrographic Office holds 90-year tide gauge records from the ports of Auckland, Wellington, Lyttelton, and Dunedin, as well as short records from several other ports, and supplies information on request. NIWA is installing open coast sea level gauges at six sites around New Zealand.

  The NSSCCC has identified a need for clarification of responsibilities for sea level monitoring, and for protecting and archiving sea level data collected by various organizations.

- **Hydrology**: NIWA operates almost 300 river flow and lake level measuring sites throughout New Zealand. The Institute of Geological and Nuclear Sciences (IGNS) carries out an annual survey of snowlines and the positions of glacial snouts, and provides data to the World Glacier Monitoring Service in Switzerland.

- **Terrestrial landscapes and ecosystems:** Landcare Research maintains five New Zealand long-term ecological research and monitoring sites, and also monitors erosion, plant species population and vegetation patterns, at a number of other mainland and offshore sites. This monitoring includes the use of satellite remote sensing and Geographic Information System (GIS) techniques. National information on land resources, soils, and vegetative cover is archived in databanks held by Landcare Research. Landcare research also monitors the presence or range of self-advective fungal and insect species.

  Funding has been made available to develop and implement a comprehensive monitoring programme and information management system for carbon storage within New Zealand's soils and indigenous forests.

- **Forests:** The Ministry of Forestry maintains a planted forest cover database, and keeps records of carbon absorbed in new planting and lost through logging, fires and vegetation clearance using methodology developed by the Forest Research Institute. An indigenous forest cover database is maintained by Landcare Research, and current programmes include work on the decline and sustainability of forest ecosystems, carbon dynamics, and climate impacts. Work has commenced to consolidate and standardise existing forest information held by various agencies.

- **Antarctica:** NIWA monitors climate, stratospheric ozone, and stratospheric trace gases near Scott Base, and holds climate records from field expeditions. The International Centre for Antarctic Information and Research (ICAIR) in Christchurch develops and maintains databases of Antarctic information. It also establishes and maintains Antarctic and Southern Ocean environmental databases relevant to UNEP, as part of the UNEP GRID (Global Resource Information Database) network. ICAIR has been selected by the Scientific Committee on Antarctic Research (SCAR) and the Council of Managers of National Antarctic Programs (COMNAP) to host the Antarctic Master Directory of the proposed Antarctic Data Directory System (ADDS).

10.6 Socio-economic analysis, including both the impacts of climate change and response options

Research and analysis on the economic implications of various possible economic instruments for stabilising carbon dioxide emissions has continued. Research has also been undertaken on the carbon dioxide effects of possible changes to land transport pricing, and on the response of regional councils to carbon dioxide emissions. Research will be undertaken during 1997 on the possible impacts on the New Zealand economy of future emission reduction options.

The NSSCCC supports work on the development or modification for New Zealand conditions of economy-wide models, to enable testing of the economic impact of public policy options. It also recommends research on international market issues associated with potential global climate changes and their effect on New Zealand agricultural exports.

The CLIMPACTS project as detailed in Chapter 8, and discussed above under Impacts Research, will improve the basis for estimating the costs or benefits to New Zealand of climate change impacts under a range of credible future emissions and climate scenarios.

10.7 Technology research and development

Measurements are underway of the quantities of methane released by individual sheep grazing in the field, and on examining the factors leading to the unexpectedly large variations between animals. This may possibly lead to natural methods for lowering methane emissions from New Zealand sheep. Research is also in progress on the methanogenic bacteria in New Zealand pasture-grazing ruminants, and on other rumen bacteria (acetogens) which convert hydrogen to acetate rather than methane. If acetogens could outcompete methanogens for hydrogen they might lower ruminant methane emissions.

In the energy sector, research into the use of exotic forests as energy sources, either via recovery of waste materials or through purpose grown crops is gaining momentum. Research also continues on strategies for carbon storage in forests. Applied research is underway into novel means of converting biomass into fuels. Research is also continuing on New Zealand wind and solar energy resources.

New Zealand research has led to a commercial prototype of a very energy-efficient refinement of the Sterling engine. Research is also continuing on efficient energy use in domestic buildings. The aluminium industry has a major research and development effort in improving energy efficiency, the coal industry is researching carbon dioxide emission reduction, and the dairy industry has projects on methane and carbon dioxide emissions.

10.8 International programmes

Involvement in international climate research and monitoring programmes is essential for New Zealand. The complex global processes which govern the climate can only be understood through such collaboration. The contribution of various research activities in New Zealand to components of the International Geosphere Biosphere Programme, and

the World Climate Research Programme have been mentioned already under the appropriate research headings. New Zealand has a national IGBP committee under the aegis of the Royal Society, and several New Zealanders serve on scientific committees for IGBP projects. The substantial contribution of New Zealand scientists to authorship and review of parts of the IPCC Second Scientific Assessment have also been mentioned.

Other international climate science consortiums in which New Zealand participates include the Global Environment Research Programme (a tripartite arrangement between New Zealand, Australia and the United Kingdom to foster scientific collaboration), the climate change working group of the Valdivia Group (Argentina, Australia, Chile, New Zealand, South Africa and Uraguay), and the Asia-Pacific Network (coordinated by Japan). Outside of these networks there are many bilateral collaborations on climate science between individual scientists or research institutions.

New Zealand provides climate and greenhouse gas monitoring data to international data centres under the WMO/ICSU (International Council of Scientific Unions) programmes which comprise the Global Climate Observing System (GCOS). New Zealand operates the Southern Hemisphere mid-latitude station of the Network for the Detection of Stratospheric Change (NDSC), and the interim Antarctic NDSC station.

10.9 Capacity building in developing countries

New Zealand’s efforts to assist with capacity building are predominantly focussed on small Pacific Island nations, which have particular concerns about the potential impacts of sea level rise. New Zealand provides financial, training and technical support to assist meteorological services in several of these countries. New Zealand scientists have collaborated with appropriate individuals from Pacific Island nations through the South Pacific Regional Environment Programme (SPREP), to assist with comprehensive regional assessment of the vulnerability of these countries to the impacts of global climate change and accelerated sea-level rise and development of national policy responses consistent with scientific knowledge. The proposal for a Pacific Climate Change Assistance Programme (PCAP), which has now been approved for funding by the Global Environment Facility (GEF), was developed with assistance from New Zealand scientists. This programme targets capacity building in Pacific Island countries.

University scientists have worked with Bangladesh experts, to assess implications of climate change and sea level rise for that nation. Through the Valdivia Climate Change Working Group New Zealand is helping to develop plans for collaborative research and capacity building within several Southern Hemisphere developing countries.

Chapter 11: Education, training and public participation

11.1 General public information

In 1991, the Ministry for the Environment produced a pamphlet "Climate Change – Exhausting the Future" (Ministry for the Environment, 1991) explaining the science, likely impacts, and responses individuals might make to reduce emissions. This was updated in 1993.

In addition the Ministry for the Environment produced posters and accompanying material on climate change in 1991 and 1994. Material produced for World Environment Day in 1989 ("So you want to save the World") and 1992 ("Take the Green Road") encouraged individuals and communities to take actions which among other things reduced greenhouse gas emissions.

The Ministry for the Environment has also produced reports and general information sheets on climate change science, monitoring and possible impacts for New Zealand. Examples are:

- Climate Change: Impacts on New Zealand. Implications for the Environment, Economy and Society. (Ministry for the Environment, 1990a);
- Climate Change: A Review of Impacts on New Zealand. (Ministry for the Environment, 1990b);
- Climate Change: The Consensus and The Debate. (Wratt *et al*., 1991); and
- A Climate Change Monitoring Network. (Ministry for the Environment, 1993).

Local government also has a public education function through newsletters, community development, local publicity material, healthy cities promotions, and seeking to encourage community and individual responsibility in energy use, recycling, and driving habits. Many local authorities are active in promoting recycling, public transport use, support for local facilities and activities, and sustainable land use planning.

The Ministry for the Environment organised a seminar in September 1994 to communicate the details of the "Government's CO_2 Policy Package" to a wide audience including local government, environmental groups, industry, and members of the public.

Following the release of the IPCC Second Assessment Report, the National Science Strategy Committee for Climate Change, together with the Royal Society of New Zealand's Climate Committee, hosted a workshop "Climate Change: IPCC'95 and Beyond" in March 1996. Participants in the workshop included advisors to local and central government, industry representatives, scientists and members of the public. The workshop was organised to enable the results of the IPCC work to be presented authoritatively, to bring them to the attention of New Zealanders and to enable discussions of their relevance to New Zealand and the South Pacific islands.

The NSSCCC/Royal Society has also hosted several meetings where visiting scientists have presented information on various aspects of climate change science. The invitation list for these meetings includes government agencies, scientists, and interested members of the public.

This second national communication (as did the first national communication) also serves to provide information on climate change and policy response to members of the public.

11.2 Material for schools

Much of the material produced for the general public has been provided to schools. Specific information for schools was produced to accompany the 1994 climate change poster. EECA has produced material specifically for schools, including a secondary schools curriculum resource kit called ‘Precious Joules’.

11.3 Information, education and training for specialist groups

The Ministry for the Environment has provided local government with advice and information on climate change. This has included the publications “Information for the Guidance of Local Authorities in Addressing Climate Change” (Allen, 1993) and “Waste and the Resource Management Act” (Ministry for the Environment, 1994b).

EECA has been extensively involved in information, training and promotion about energy efficiency, as outlined in Chapter 7, including seminars and workshops, and a regular publication with a circulation of over 15,000.

Regional and District Councils are also educating and working with sectoral interests within their areas to limit and minimise greenhouse gas emissions. For example, applicants for resource consents are being encouraged by councils to consider the following issues in the design of their proposals:

- consumer education identifying practical ways in which the burning of fossil fuels can be reduced;
- encouragement of greater efficiency in production and use of energy from fossil fuels;
- encouragement of a transfer to technologies which do not produce greenhouse gases or produce reduced levels, including types of agricultural production and agricultural technologies;
- account taken of efforts to enhance sinks and reservoirs of greenhouse gases.

11.4 Public participation

There have been opportunities for interest group input throughout the Government’s climate change policy development programme. In 1990, a discussion document on policy options was released accompanied by considerable publicity inviting any interested party to make a submission. The discussion documents were provided free of charge to any person or group who requested them. Meetings were held with industry and environmental and professional groups. In addition a three day hui (meeting) was held with Maori people to discuss climate change science, impacts, and responses.

In 1991 a scoping paper “Developing a Strategy to Reduce Carbon Dioxide Emissions” was circulated. This was produced by the Ministries for the Environment, Commerce, and Transport and circulated widely. Submissions on this contributed to the policy development leading to the Carbon Dioxide Reduction Action Plan in 1992.

A further round of consultation occurred in 1994 leading up to the Government’s decision on the package of policy measures it would adopt to reduce carbon dioxide emissions. A consultation document was sent to industry, local authorities, environmental groups and any others who requested a copy. Submissions were received which contributed to the advice officials provided to ministers. Meetings were also held with a number of key organisations.

The Working Group on CO_2 Policy produced a discussion document “Climate Change and CO_2 Policy - A Durable Response” in June 1996. A series of consultation meetings were held in conjunction with a written submission process. A total of 187 submissions were

received from a diverse range of industries, regional and local governments and environmental and community groups and individuals. The submissions, together with the Working Group's response to the points made in these submissions will be published in June 1997. The Working Group's report and public submissions on it will help to shape future policy development.

A working paper on the design of a carbon charge was publicly released in April 1997. Although no formal consultation process has been designed, public reaction to the document will be considered in the development of the carbon charge policy. Public release of a working paper on emissions trading is also planned for later in 1997.

The Ministry of Foreign Affairs and Trade, together with other key government departments, holds regular briefing meetings with business and environmental non-government organisations (NGOs), before and after meetings under the FCCC.

The Ministry for the Environment holds regular meetings with environmental NGOs, professional bodies, and local government and industry leaders. Each group meets six times a year. The issue of climate change is almost always on the agenda.

The Ministry of Commerce holds regular meetings with the Greenhouse Policy Coalition, a group of business representatives with an interest in climate change policy development, and other business and interest groups on a more ad hoc basis.

Local government also provides consultation opportunities on resource consents, and public input into plan preparation. Under the RMA, any person has the opportunity to make a submission when a resource consent, plan, or policy statement is notified. Those making submissions can also participate at hearings and prehearing meetings.

11.5 International activities

New Zealand has participated in the Asia-Pacific Seminar on Climate Change series which is hosted by the Government of Japan. These seminars provide an opportunity for the countries of the Asia-Pacific region to exchange information on climate change, particularly in relation to reporting requirements under the FCCC.

LIST OF ANNEXES;

ANNEX 1

Modelling methodology and assumptions used in the energy and industrial process greenhouse gas emissions projections

Greenhouse gas emission projections from energy, and CO_2 emission projections from industrial processes, are provided through the modelling work of the Energy Modelling and Statistics Unit, Energy and Resources Division of the Ministry of Commerce.

This work focuses primarily on energy supply and demand for the period 1995 to 2020, balancing supply and demand for energy in New Zealand through prices using the market clearing assumption. All sectors of the New Zealand economy are modelled, but from an energy supply and demand perspective only, so it is a partial rather than general equilibrium approach.

The model used is a hybrid top-down/bottom-up model, its sectoral demand sub-models chosen to make best use of available data. Econometric sub-models of energy demand are estimated for the residential, other industrial and commercial, and diesel and petrol land transport sectors, using historical data. Energy demand for petrochemicals, basic metals, forestry processing, and other transport sectors are projected based on industry information quantitative sub-models.

Energy prices

Energy prices are the main mechanism through which the interaction between energy demand and supply is modelled. The future availability of indigenous energy resources and the associated costs with bringing these, and internationally sourced fuels, to consumers, significantly influences future patterns of energy pricing and, as a consequence, energy consumption.

Crude oil and coal prices are exogenous variables in the modelling. They are assumed to be determined by international markets. Gas and electricity prices are, however, determined by allowing for the interaction of demand and supply on a national level.

<u>Crude oil prices</u>

The oil price path assumed is based on current import prices and exchange rates, with prices increasing at 5% pa real to 2000, 2% pa to 2005 and constant thereafter. These assumptions lead to an oil price path that is similar but not identical to the IEA's "capacity constraints" scenario price path in their 1996 "World Energy Outlook".

Recent prices were somewhat lower than the $US22 per barrel assumed in the first national communication, having been between $US17 and $US20 between 1993 and 1995. This outlook assumes that crude oil prices will rise to slightly over $US22 per barrel by 2000 and to about $US25 in real terms by 2005 and remain constant thereafter. These projections contrast with $US27 and $US30 in 2000 and 2005 respectively assumed in the first national communication.

<u>Coal prices</u>

The price of internationally traded coal is widely expected to experience little growth in the period up to 2000 and in the longer term. The current outlook of a constant real price of $3.70/GJ is unchanged from the previous outlook.

Electricity prices

The average wholesale electricity price is currently higher than the short run marginal cost of generation. Electricity prices are assumed to move towards the long-run marginal cost of supply as existing generation capacity is used up and new, more expensive, generation capacity is built. It is projected that the short-run marginal cost will surpass the average wholesale price after around 2000.

It is assumed that the transmission and distribution components of final electricity prices will fall as the largely fixed costs are spread over greater demand. The impact of tariff rebalancing will continue to reduce commercial and industrial electricity prices and increase domestic electricity prices, albeit at lower rates of change than in recent years.

Electricity prices and the price and availability of new generation capacity are little changed from the previous outlook.

Gas prices

At present New Zealand enjoys indigenous supplies of gas at relatively low prices. As currently known gas reserves near depletion, the growing scarcity will cause the gas to be traded from lower value to higher value uses. It has been assumed that there will continue to be new oil and gas discoveries, though new gas discoveries are not expected to be large enough or cheap enough to maintain the current level of supply.

As a result wholesale gas prices are expected to rise following the anticipated depletion of the Maui field around 2005. Post Maui, wholesale gas prices rise more slowly reflecting the availability of new gas reserves. Residential gas prices are assumed to remain constant until around 2000 then rise gradually over the rest of the outlook period. As with electricity, transmission and distribution unit costs are expected to fall with growth in reticulated demand.

Exchange rate

An exchange rate of NZ$1=US$0.65 has been adopted throughout the outlook period with 0.554 and 0.615 for 1993-94 and 1994-95 respectively. This contrasts with a rate of 0.53 in the first national communication which impacts quite significantly on the price of crude oil, but, on the other hand, does not impact significantly on the final price of oil products due to the magnitudes of other cost components.

Socio-economic assumptions

Beyond energy prices and resource availability, and the price and availability of alternative electricity generation technologies, the key modelled determinants of energy demand and supply are the socio-economic inputs of economic growth, real disposable income and population.

Economic growth

Real GDP growth of 4.8% for 1993-94 and 3.6% for 1994-95 was assumed in the first national communication. Actual growth rates of 5.5% and 6% were realised which means that the economy was around 3.2% larger at 31 March 1995 than previously assumed. An annual growth rate of 3% has been adopted for the remainder of the outlook period with 2%

(after 2000) and 4% (throughout) profiles being used as scenarios to illustrate some possible bounds. This is consistent with the current predictions of most economic forecasters.

Real disposable income

The assumptions on real disposable income (RDI) are based on the New Zealand Institute of Economic Research (NZIER) publication “Quarterly Predictions - September 1996”. RDI growth is estimated to have been 3.4% and 1.6% in the 1993-94 and 1994-95 years respectively with 2.8% per annum assumed thereafter for the 3% GDP scenarios. The revised track is lower than that previously used.

Population

Forecasts of population growth were taken from Statistics New Zealand. Based on medium fertility and medium mortality assumptions and on annual net migration inflows of 5000, New Zealand’s population growth is expected to grow from 3.45 million in 1990 to 3.75 million in 2000 and 4.45 million in 2020. These forecasts are marginally higher than those used in the First National Communication.

Greenhouse Gas Emissions

Greenhouse gas emissions of CO_2, CH_4 , N_2O, CO and NMVOCs are calculated directly from modelled energy use, by multiplying energy quantities by specific emission factors (the average amount of gas released during a particular type of combustion, per energy content of the fuel).

The emission factors for CO_2 assume that all a fuel’s carbon content is released as CO_2 during combustion. For non-CO_2 emissions, projections are relatively less certain because, while based on the same energy use, there are larger uncertainties in their emission factors. Where emission factors are unknown or inappropriate, constants are used. These emissions factors and constants are derived from detailed emissions inventories.

While most emissions are from fuel combustion, the emissions calculations include also fugitive emissions resulting from the leakage or loss of gases, such as during natural gas flaring and processing, gas transmission and distribution, and methane emissions from coal mining. Only carbon dioxide and methane result from fugitive emissions.

For CO_2, and to a lesser extent for the other gases, the emissions sub-models estimate quantities by fuel and by sector, allowing both fuel and sectoral shares to be assessed.

Further information

The “with measures” projections reported in this second national communication have been reported also in energy supply and demand terms in the Ministry of Commerce’s *Energy Outlook* February 1997 (Eng and Taylor, 1997), and in CO_2 emissions terms in the discussion document produced by the Working Group on CO_2 Policy (Working Group on CO_2 Policy, 1996).

References

Eng, G. and Taylor, M., 1997: Energy Outlook, Ministry of Commerce, Wellington, New Zealand, February 1997.

Working Group on CO_2 Policy, 1996

New Zealand Institute of Economic Research (NZIER) publication “Quarterly Predictions - September 1996

ANNEX 2

Methane (CH_4) emissions methodology for ruminants and their waste

The IPCC default methodologies were not followed to obtain estimates for methane emissions from ruminants and their waste. Instead a mathematical model of rumen digestion interfaced with estimates of livestock numbers was used as outlined below.

Method for obtaining New Zealand ruminant numbers.

Until 1990 the New Zealand Department of Statistics (now called Statistics New Zealand) conducted annual agricultural censuses. By questionnaire, farmers were asked to supply a wide range of information including the area of their holding, land sales and acquisitions, land use, usage of fertiliser, type, age, sex and fertility of livestock.

In 1991, 1992 and 1993 surveys of those farms contributing around 95% of estimated value of agricultural output were conducted using questionnaires.

In 1994 a full annual agricultural census covering all farm sizes was conducted using questionnaires.

NZ now conducts a full agricultural census every four years with the intervening years being covered by surveys.

In years when small farms are not surveyed their production is estimated on the basis of their last census return. Adjustments are made to the main variables on the basis of trends identifiable on the surveyed farms.

The statistics used by Ulyatt (1991) for the calculation of methane production by NZ ruminants were provisional and this inventory contains the actual statistics for 1990. This changes the 1990 methane emission from ruminants and their waste from 1,500 Gg to 1,513 Gg.

Calculation of methane production by New Zealand Ruminants

Estimation of enteric methane production by New Zealand ruminants - Introduction

Methane production by ruminants in New Zealand (sheep, beef cattle, dairy cattle, goats and deer) was estimated by Ulyatt 1991 using a mathematical model of rumen digestion (Baldwin et al., 1987) interfaced with estimates of livestock numbers. Input required by the model was diet composition and feed intake.

New Zealand was divided into four climatic regions. Each region (north, east, central and south) was classified into improved, unimproved and tussock grasslands, and livestock were allocated to these in line with acceptable stocking rates. Models of livestock movements within a year were developed for each animal and land class.

Food dry matter intake for each class of livestock was calculated from estimates of feed requirements and diet digestibilities. The model takes account of age classes of animals. For example, the methane emission factor for sheep reflects not only an adult sheep but the methane emitted from a lamb during its brief life.

Total methane production from ruminants in New Zealand was estimated to be 1,500 Gg per year, each animal species contributing the following to the total: 58.4% sheep, 20.7% beef cattle, 17.7% dairy cattle, 2.0% deer and 1.2% goats. There was considerable seasonal variation in methane production in the order spring>summer>autumn>winter.

Calculation of methane production

Animal data from the New Zealand Department of Statistics 30 June 1990 (opening numbers and estimates for the 1990/91 production season) census was used. For all but deer and goats, animals were classified into breeding stock and other livestock. As the model data were used in 1991, the livestock number estimates for the 1990/91 production seasons have since been refined.

A model which described the movements of animals within a year was constructed for each animal type on each vegetation class for each of New Zealand's geographical regions. Movements included transfers due to birth, slaughter and age. This would allow calculation of per head methane emission rate which could be applied to single year statistic such as June 1990.

Food dry matter intakes (DMI) of the various classes of animals were derived on a monthly basis using the equation:

$$DMI = R/NV$$

Metabolisable energy (ME) requirement allowances for maintenance, growth, pregnancy or lactation were calculated for New Zealand conditions for sheep and cattle (Ulyatt et al., 1980), deer (Fennessy and Millighan, 1987) and goats (McCall and Lambert 1987). The feed requirements, R (MJME/d), of every class of animal were obtained by assuming average liveweight change curves for mature females or liveweight gain curves for growing and fattening stock (Scott et al., 1980). Nutritive values, NV (MJME/kg DM), were either taken from published values (e.g Ulyatt et al., 1980) or estimated from diet digestibility.

The mathematical model used to predict methane production in the rumen (Baldwin et al., 1977: Murphy et al. 1986; Baldwin et al., 1987) is based on known stoichiometries of food degradation and microbial growth. The relatively large number of components specified in the diet is necessary because either they produce unique stoichiometrics or affect the physico-chemical milieu in the rumen. A test set of data, in which methane output was measured from animals fed a wide range of diets of different composition, was taken from the literature. The model was used to predict methane production from these diets and the two sets of data compared. The comparison showed that there was bias in the model predictions: predictions were high at low observed methane and low at high observed methane values. However, the methane production values generated by the model for New Zealand diets fell in the narrow range of 0.09 to 0.11 MJ per MJ digestible energy, the region where the model predictions are most accurate.

Total ruminant methane was calculated to be 1.50 Tg. The breakdown according to per animal type is shown below;

Table ( ) Ulyatt (1991) breakdown of methane emissions per animal type.

Animal type	No. of animals (A)	CH_4 production 1990/91 (Gg) (B)	kg CH_4 per head per year = (B/A x 10^6)
Dairy	3,463,802	266.1	76.8
Sheep	57,852,192	876.2	15.1
Beef	4,600,703	310.4	67.5
Deer	976,290	29.9	30.6
Goats	1,062,900	17.5	16.5
Total		1,500.1[1]	

Source: Ulyatt 1991

Verification of methane emissions from Ruminants.

During 1994 & 1995, research has been conducted to measure actual methane emissions from ruminant livestock grazing under pastoral conditions in the Manawatu region of New Zealand. These trials deployed a new tracer technique, sulphur hexafluoride, SF_6, to measure emissions directly from grazing ruminants.

Another study has been commissioned with two long-term objectives, one is to provide a scientific basis for assessing New Zealand's anthropogenic emissions of methane (CH_4), a potent greenhouse gas; and the other to provide a basis for investigating both the improved nutritional performance of New Zealand ruminants and a reduction in microbial methane production.

Preliminary results for 40 days of cow methane samples have shown emissions ranged from 229-313 g CH_4/cow/day with a herd mean of 262.8 ± 9.6. This equates to approximately 95 kg CH_4 per head per year. This is more than originally estimated by Ulyatt 1991.

For sheep, mean methane emissions of 20.4 g/day was found. Over a year, this equates to 7.4 kg CH_4 per head per year. This is substantially lower than originally estimated by Ulyatt 1991.

The results from the actual measurement of methane emissions field trials have not been used in producing this inventory. The results come from only one group of animals, at one site, grazing one pasture type, at one particular time of the year and therefore are not as comprehensive as the original (Ulyatt 1991) model at this stage.

Field trials are now underway to measure methane emissions from ruminants for the following categories;

* hill country summer pasture with sheep (Manawatu);
* subtropical grass dominant pasture with dairy cattle (Bay of Plenty); and
* improved pasture (Manawatu) in the autumn.

<u>Methane emissions from ruminants and the effect of the surrounding ecosystem.</u>

Over the next two years, several research organisations will be conducting studies to determine what happens to ruminant methane emissions in the surrounding ecosystem. The study will monitor three levels (ground, biosphere and atmosphere) for methane emissions from ruminants. This will provide information on the amount of methane from ruminants absorbed by the surrounding environment and released into the atmosphere.

<u>Evaluation of difference in methane emissions</u>

In the 1995/96 study of ruminant methane emissions, large differences in methane emissions were found between individual sheep at the same feed intake level. Researchers intend to first screen a large number of sheep to establish groups of high and low emitters. These groups will be monitored over time to determine whether the difference is genetically determined or of environmental origin. Following this, experiments would be conducted to determine whether the effect is of microbial origin.

Emissions of methane production from animal waste deposited on New Zealand pastures

<u>Estimation of maximum methane emissions from ruminant animal wastes deposited on New Zealand pasture.</u>

Animal wastes are principally composed of organic matter. When this matter decomposes in an anaerobic environment it produces methane. In general, most animal waste decomposes aerobically on pasture. Field measurements in Australia indicate that only a small proportion (approximately 1%) of the waste from cattle in the field decomposes anaerobically (Williams 1992)

From estimates of intake and diet digestibilities (Ulyatt et al 1991), it is estimated that the combined faecal output (% total) from sheep (57.2%), goats (0.7%), deer (2.0%), dairy cattle (17.0%) and beef cattle (23.2%) is approximately 16 million tonnes dry weight per annum (Joblin et al. 1994). Extrapolation from the quantity of methane produced from sheep faeces in vitro, suggest that the maximum methane capacity of faeces in New Zealand pastures was approximately 18.0 Gg for 1990. Actual methane production is probably much less than this due to aerobic decomopsition, but there are no data in New Zealand available from which to determine this.

Estimation of maximum methane emissions from animal wastes from feedlots, pig and poultry wastes

Estimates of the maximum methane emissions from other animal wastes, including feedlots, pig and poultry wastes are estimated at <100Gg. The actual emissions from this source are expected to be substantially lower than the maximum.

References

Joblin, K.N. and Waghorn, G.C., 1994: Estimates of methane production from animal waste deposited in New Zealand Pastures. Unpublished report for the Ministry of Agriculture and Fisheries and the Ministry for the Environment. New Zealand Pastoral Agriculture Research Institute Ltd. (AgResearch), Grasslands, Palmerston North.

Ulyatt, M.J., Betteridge, K., Knapp, J. and Baldwin, R.L., 1991: Methane production by New Zealand ruminants. DSIR Grasslands, Private Bag, Palmerston North. Global Change: Impacts on agriculture and forestry. Proceedings of the Royal Society of New Zealand Conference. Royal Society Bulletin 30.

ANNEX 3

Methodology for projecting agriculture methane emissions post 2000.

The NZ Ministry of Agriculture (MAF) estimates are based on developments in prices, overseas markets and trading conditions. The major factors influencing agricultural production in New Zealand are international prices through changes in exchange rates and changes in overseas markets. The rate of progress in meeting GATT commitments for agricultural reform will impact on New Zealand's production levels. Commodity specific impacts are incorporated in the projections out to 2000, as far as these are known.

Commodity prices are separately projected using a variety of models and incorporate specific macroeconomic assumptions of exchange, inflation and world growth rates. The latter are supplied by Treasury for each current economic situation (CES) round. Projected prices for pastoral products are key input assumptions in a pastoral supply response model used to project sheep, beef and dairy stock numbers and production. At this stage, a separate model is used for deer.

In running the pastoral model, projections are adjusted for factors not specifically included in the model's equations. These include land use conversions from sheep and beef farming to dairy, deer and forestry, and productivity improvements in animal performance. Dairy conversions are based on information received from dairy companies together with MAF projections out to 2000. Deer conversions are based on the results of the deer model. Forestry area expansion affecting farm land use is derived from a model with adjustments for new planting estimates prepared by the Ministry of Forestry. MAF would be more conservative than the latter with respect to long term expansion of forestry.

While it is possible to expand the direct modelling out to 2020, constraints dictated the simpler approach of extrapolation out from 2000. The direct modelling alternative would amount to little more than fine tuning because of the uncertainties facing projecting out beyond 2000. The World Bank regularly provides long term projections for 2000 and 2005 for major world commodities, of which beef and timber would be the only ones of interest to MAF.

<u>Caution on use of projected figures.</u>

Projections out to 2020 can only be considered as approximate trends. There is formidable uncertainty in the underlying assumptions even beyond the next 2-3 years. Fundamentally, this derives from international and national factors that determine or influence farm level prices. Changes in the latter, change the supply response.

Farm level prices are a major determinant of supply response. Agricultural commodity prices have exhibited a long run decline in real terms, which has led to greater efficiency and a lower input costs, or extensification of, farming in New Zealand. The focus on inflation control by the Reserve Bank in recent years may have reinforced this trend. However, given the right price signals, there is latent capacity to expand sheep and beef production. This is indicative from the expansion of dairy and deer farming in recent years. New entrants into dairy are primarily larger scale operators.

As a trading nation, New Zealand still faces difficulties as a consequence of continued government intervention in our main export markets. The potential benefits to New Zealand from the recent GATT round are encouraging, but the larger benefits associated with a move to multilateral free trade are dependent upon the acceptance of further reforms in the next WTO round for which negotiations on agriculture are scheduled to begin in 1999. Any subsequent trade liberalisation of the economies of major trading partners should enhance real prices at the farm level. Thus there is more likely to be upside risk to the livestock numbers projected out to 2020.

ANNEX 4

Agricultural nitrous oxide methodology

Emissions of nitrous oxide

New Zealand's nitrous oxide inventory contains a number of gaps and uncertainties. Therefore, the IPCC default methodology approach was used.

As noted in the 1995 IPCC default methodology for nitrous oxide, individual countries may wish to substitute their own appropriate coefficients and emissions factors, with the explanation of changes to be outlined. The IPCC default values have not been used because of New Zealand studies show different values and these are more appropriate to use in calculating New Zealand nitrous oxide emissions . Table == sets out the IPCC default values together with the values from the New Zealand studies. The origin of the New Zealand values is briefly described below.

	IPCC default value	New Zealand value
Leaching	0.3	0.15
Pasture emissions	0.2	0.01
Animal excretion emissions factors	variable factors	variable factors

Table ==: Comparison of IPCC default values and values from New Zealand studies used for the calculation of nitrous oxide emissions from soils.

Leaching

The IPCC default value for nitrous oxide emissions from leaching has not been used because data on nitrate concentration has been obtained for several systems in New Zealand. Each study had a system that had animals grazing during the experiment period and where applicable, the application of fertiliser. Measurement of nitrogen leaching (Ledgard et al 1996, Heng et al 1991) from both animals and fertiliser application, generally have not exceeded 15% of total nitrogen input.

Emission factors from pasture

The revised emission factor for pasture application of animal wastes comes from a combination of the results of two New Zealand studies on nitrous oxide emissions.

North Island field studies

In New Zealand, nitrous oxide emissions from grazed pastures, where no nitrogen fertiliser was applied, were measured at four sites for a two year period by Carran (1995). Sites differed in drainage class and N cycle characteristics. At two intensively farmed sites on Karianga silt loam, which is poorly drained, daily emissions ranged from 0 to 100g N per hectare per day and annual emission was in the range of 3-5 kg N_2O-N per hectare. Emissions at low fertility hillside site were very low and an annual emission of 0.5kg N_2O-N

per year, or less was indicated. The highly fertile hillside site also showed low emission values, but there were slightly higher than the low fertility hillside site.

In the New Zealand context, this suggest that very low rates of N_2O emissions (0.5kg N per hectare per year or less) could be expected from the low fertility hill lands which occupy much of the agricultural core of the North Island. Emissions of 3-5 kg N_2O per hectare per year are likely in the situations that are strongly predisposed to emission reactions. These will be confined to the relatively small areas of intensively farmed land with poor drainage and a positive water balance.

South Island field studies.

In the South Island area of Canterbury, direct measurements of annual nitrous oxide fluxes from urine-affected, urine unaffected and ploughed intensive grassland (used for rotational cropping-grazing system) were taken over one year by Sherlock (1995).

A soil cover technique was used to collect gas samples in the field. Daily nitrous oxide losses averaged over a year for the background emissions, the spring and autumn ploughing events and the summer, autumn, winter and spring urine applications were 0.7, 1.5, 1.3, 1.2, 5.1, 2.7 and 3.7 g N_2O-N per hectare per day respectively. Compared to the background emissions, the ploughing events resulted in twice the nitrous oxide emissions, and the urine-affected areas emitted approximately 1.5 to 7 times more nitrous oxide. Nitrogen lost as N_2O-N from the applied nitrogen in the urine patched amounted to 0.08, 0.37, 0.20 and 0.27% for the summer, autumn, winter, and spring applications respectively (Sherlock et al. 1992). The emissions from urine-unaffected and urine-affected pasture were substantially lower than previously estimated (Sherlock et al 1992).

Both field studies show very low nitrous oxide emission levels for the majority of New Zealand farming systems. Therefore, a default value of 0.01 recognises the range found in New Zealand studies.

Emission factors for animal excretion.

On the basis of a limited dataset, studies in New Zealand (MacRae and Ulyatt, 1974 and Ulyatt 1996) based on relatively N-rich diets, information on N content of dietary intake, and its throughput to urine and to faeces, were used to derive excretion factors from N intake and pathways. The excretion factors are in reasonable agreement for non-dairy cattle and for deer. But the default excretion factor for dairy cattle, goats and sheep is too high. Also an adjustment like in the case of methane emission factor for sheep, was made for lambs not captured in the New Zealand stock numbers.

Verification of nitrous oxide emissions from agricultural sources.

There are currently two programmes underway to get a better understanding of nitrous oxide emission sources and sinks in New Zealand. The first project looks at using a Geographical Information System (GIS) model to estimate emissions from New Zealand using available and to be gathered datasets.

The second programme will study New Zealand's net N_2O emissions from soils, and the factors influencing these emissions, with measurements taken from several representative ecosystems.

References.

Carran, R.A., Theobald, P.W. and Evans, J.P: 1995 "Emission of Nitrous Oxide from some Grazed Pasture Soils in New Zealand" Australian Journal of Soil Research 33, 341-52.

Heng, L.K, White, R.E, Bolan, N.S, Scotter, D.R: 1991 " Leaching losses of major nutrients from a mole-drained soil under pasture.". New Zealand Journal of Agricultural Research Vol 34: 325 - 334.

Ledgard, S.F, Clark, D.A, Sprosen, M.S, Brier, G.J. and Nemaia, E.K.K; 1996 "Nitrogen losses from grazed dairy pasture, as affected by nitrogen fertiliser". Proceedings of the New Zealand Grassland Association 57: 21-25 (1996).

MacRae, J.C. and Ulyatt, M.J. 1974: Quantitative digestion of fresh herbage by sheep. The sites of digestion of some nitrogenous constituents. Journal of Agricultural Science, Cam.82, 309-319.

Sherlock, R.R, Muller, C. and Williams, P.H.: 1995 "Direct field measurements of annual nitrous oxide emissions from urine-affected and urine un-affected pasture in Canterbury. In press.

Ulyatt, M.J. 1996 pers comm.

ANNEX 5

Land Use Change and Forestry: Methodology and assumptions

This annex reports on the methodology and assumptions for modelling carbon sequestration (CO_2 removal), primarily by planted forests, for inventories and projections. The methodology for inventories and projections of CO_2 and other greenhouse gases emissions from land use changes, which include wildfire and controlled burning and scrub clearance for new forest planting, are also discussed.

Methodology for Carbon Sequestration

Comparability with the Intergovernmental Panel on Climate Change (IPCC) guidelines2 require the use of a national *forest estate model* where the overall change in forest biomass, and therefore carbon, is reported3.

The forest estate model includes biomass increases from growth and losses, mainly from harvesting. Currently the IPCC methodology assumes that emissions of CO_2 occur at the time of harvest. This is an obvious simplification. Although a large proportion of carbon is emitted shortly after harvest from on-site slash and short-lived products, where harvested wood ends up in long-lived wood products the carbon may remain in storage for long periods of time. Wood that is subsequently exported also removes carbon from New Zealand, while imports would introduce carbon. There is, however, no agreement yet internationally on an accepted methodology for calculating changes in carbon stored in wood products. Therefore, New Zealand's inventory of emissions and sequestration by woody biomass, in terms of harvest emissions and hence net carbon uptake or removal, reports potential emissions from harvested wood, as opposed to actual emissions in New Zealand. This is clearly an anomaly in the current inventory methodology.

The total biomass of New Zealand's planted forests is relatively simple to measure. Stands are almost exclusively single species and single aged. Radiata pine comprises 90 percent of planted forests and Douglas fir a further 5 percent. A long history of forest management and research has enabled relatively accurate and detailed growth modelling to be developed. Provided accurate data on forest area, age and location can be maintained, reasonably precise estimates of carbon absorption can be determined.

The forest estate method is based on determining forest biomass at one point in time and using a model to estimate carbon levels at different points of time in the future. The difference between years represents the estimated carbon absorption or emission for the period.

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2 IPCC. 1995. Greenhouse Gas Inventory Reporting Instructions. IPCC Guidelines for National Greenhouse Gas Inventories.

3 For further information on the forest estate model and sequestration calculations, see Wakelin and Te Morenga, 1995. Carbon Sequestration by Plantation Forests (Calculations revised at June 1995), and also, Wakelin and Te Morenga, 1996. Carbon Sequestration by Plantation Forests (Calculations revised at December 1996), both reports published by the New Zealand Forest Research Institute, Rotorua. See also, Hollinger, Maclaren, Beets and Turland. 1993. 'Carbon Sequestration by New Zealand's Plantation Forests'. *New Zealand Journal of Forestry Science* Vol 23(2), pp 194-208.

The estate-based modelling approach involves assigning areas by age class in the existing forest to an aggregate yield table4. A forest estate model (FOLPI5) is then used to "time-shift" the national forest estate forwards and backwards in time, in order to represent the changes that occur in the national forest estate as a result of forest growth and silvicultural management.

FOLPI is a linear programming model that optimises the management of the forest estate in all time periods according to a number of constraints and objective functions, in relation to the above activities. The total change in biomass is converted to carbon on the basis of the known relationships contained in the CARBON version of DRYMAT (a biomass allocation model). The estate-based model, therefore, simulates the change in biomass, and hence carbon stored, in the forest estate over time as the age class composition and forest make-up changes. National estimates are based on the National Exotic Forest Description (NEFD) database, scaled to represent all of the plantation forest resource. Box 1 describes the (simplified) steps in the calculations.

Box 1. Simplified Steps in Calculating Carbon Sequestration by Planted Forests

The total standing volume of stemwood is used to estimate biomass which is then converted to stored carbon. This calculation is done as follows:

1. The physical make-up of the forest is determined to obtain an estimate of the area of land in each age class and 'crop-type'. A 'crop-type' is an aggregate of stands6 that possess similar properties, including species, site quality, management regime, and territorial location.
2. Appropriate yield tables are used for each crop-type to convert area and age class7 information into total stemwood volume8. Such yield tables have been developed by the New Zealand Forest Research Institute (NZFRI) for a large variety of predominant crop-types within New Zealand.
On a national scale, New Zealand uses one crop-type which represents the entire national planted forest estate. The yield table used for this single national crop-type is developed from the area weighted yields of the individual crop-types held within the National Exotic Forest Description.
3. Stemwood volume is converted to oven-dry weight of stemwood by multiplying by the average wood density factor.
4. Oven-dry weight of stemwood biomass is converted to total biomass oven-dry weight since carbon is stored not only in the stemwood, but also in the bark, branches, foliage, cones, stumps, roots, forest floor litter and in understorey species. The NZFRI computer model CARBON/DRYMAT has been used to estimate the oven-dry weight of non-stem biomass in *Pinus radiata* stands over a rotation. The model is based on forest biomass studies which provide data on the effects of tree age, spacing, and site fertility on stand development parameters.

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4 The aggregate yield table is based on an area weighted average of the four main silvicultural regimes classified in the NEFD: Intensively tended with, and without, production thinning; and Minimum tended with, and without, production thinning. The four main silvicultural regimes are themselves aggregate yield tables based on an area weighted average of the 10 wood growing regions, which reflect differences in growth rates because of locational or site quality factors.

5 Garcia, O, 1984. FOLPI, a forestry-oriented linear programming interpreter, in Nagumo H et al (Ed) Proceedings IUFRO Symposium on Forest Management, Planning and Managerial Economics, University of Tokyo.

6 In New Zealand, a "stand" is an area of standing trees that is relatively uniform in species, age, and management regime. A "forest" may consist of hundreds or thousands of individual stands.

7 Stands can be classified according to the age of their component trees. In New Zealand, records are usually adequate to enable stands to be aged to within one year. For example, a manager could say that a forest contains 500 ha of trees in the 31-year age class.

8 In addition to the trunk or bole, trees contain wood in the branches, stumps and roots, but this is not generally commercially useful. Therefore, methods have been developed for the accurate volumetric calculation of the wood (including or excluding the bark) from the height of the stump (nominally 0.3 m above ground) to the tip of the main stem. This is the "total stemwood". "Merchantable stemwood" is the total stemwood less logging waste, and is often 85% of total stemwood.

5. The total biomass oven-dry weight is summed for all age classes, crop-types and growth regions, and converted to the weight of carbon. The fractional carbon content of dry woody biomass varies, but a value of 0.5 has been used in New Zealand for carbon inventory calculations to date.

In summary, as a simple approximation, forest carbon uptake (or emissions) can be calculated by:

U= V.r.a. 0.5

where U = forest carbon uptake (tonnes C/ha)

V = change in wood volume from one specified point in time to another (m^3)

r = average wood density (oven-dry tonnes/m^3)

a = a dimensionless factor that relates oven-dry weight of stem volume to oven-dry weight of stemwood plus tree components

0.5 = the fractional carbon content of the biomass

Conversion factors will change from year to year depending on changes in age-class composition, regional location, crop-type, etc.

For natural forests insufficient data are available to complete a full inventory. New Zealand is currently reporting carbon emissions from scrub clearance for new forest planting, wildfire and controlled burning, and unsustainable harvesting of natural forest. However, there are no reliable estimates of emissions and sinks for other aspects of land use change and forestry such as reversion on marginal or abandoned land, scrub clearance for agriculture, changes in carbon stored in indigenous forests and soil carbon. The absence of data with respect to changes in carbon stored in indigenous forests and soil carbon is being addressed, as described in Chapter 5.

Refinements in the Methodology for Calculating Sequestration

Sequestration estimates calculated by the New Zealand Forest Research Institute have been revised and improved twice since New Zealand's First National Communication. There are three main types of revisions: refinements in the modelling methodology; improved data describing the existing forest estate; and, revised estimates of new planting in the future (the primary assumption underlying projections).

The models which converts the forest estate inventory data into total biomass, and hence carbon, have been revised following recent research. Ministry of Forestry data describing the existing forest estate has also been substantially updated. Compared with the 1994 models used for New Zealand's First National Communication, the following changes have occurred[9]:

- The most recent NEFD area estimates for each age class (as at 1 April 1995) have been used.
- The models have been updated to 1 April 1997 with the most recent estimates of new planting, restocking and harvesting.
- The CARBON model (which is an updated version of the DRYMAT model so that in addition to biomass allocation it also converts biomass to carbon) has been modified to run for more that one rotation, so that emissions from the decay of harvest residues are accounted for in second and subsequent rotations. Harvest residues left on-site decay over

9 Detailed discussion of the changes and their impact on sequestration estimates are given in Wakelin and Te Morenga, 1996. Carbon Sequestration by Plantation Forests (Calculations revised at December 1996), a contract report for the Ministry of Forestry and Ministry for the Environment, New Zealand Forest Research Institute, Rotorua.

12-15 years following the year of felling, this can mean that replanted forests are initially net emitters of CO_2. This means that the stem volume to stand carbon ratios are calculated differently to account for harvest residues, as only the merchantable stem is (assumed) to result in an instantaneous emission at harvest.

- The CARBON model estimates of stand carbon have been revised and now start at age zero.
- The most recent NEFD yield tables (1995) have been used.
- It is assumed that there is a one year lag between harvesting and replanting operations
- The model solutions are driven toward a target rotation age (28 years), rather than using a minimum allowable age for harvesting.

The main factors resulting in the revised level of sequestration reported for 1990 and beyond are the new area and yield tables and the treatment of harvest residues. While changes in the modelling methodology also affect projections of future sequestration, the most important factor for sequestration projections is the rate of new planting.

Uncertainty in Carbon Sequestration Estimates

Attempts have been made to quantify the precision of carbon sequestration estimates. While levels of precision are known for the DRYMAT/CARBON calculations10 for wood density (±3%), carbon allocation (±15%) and carbon content (±5%), it is difficult to quantify errors due to modelling assumptions. Taking the root mean squares of the above error terms, the proportional error in carbon sequestration estimates is likely to be at least ±16%. The level of uncertainty could be higher depending on the errors in the NEFD area and yield data bases. The national total planted area from the latest NEFD area data is thought to be accurate to within 3%11 and yield tables are assumed to be accurate to within 5%. Sensitivity analysis, where the model was run using the above accuracy estimates for the area and yield and applying the proportional error term of ±16% for DRYMAT/CARBON calculations, indicates that the precision of national carbon sequestration estimates could be in the order of ±25%.

Sequestration Projections and New Planting Assumptions

Projections of carbon sequestration by planted forests are particularly sensitive to new planting rates. In 1994, the view of the Ministry of Forestry was that new planting would average 100,000 hectares per annum (±50 percent) in the medium to long term. A recent survey by NZFRI suggests that this was probably optimistic.

In 1995 The Ministry of Forestry and the Ministry for the Environment commissioned NZFRI to carry out a survey of new planting intentions over the next 5 years and the decade 2000 - 201012. The results of this survey, which the NZFRI regard as conservative, estimate that the average planting rate over this period will be in the region of 70,000 hectares per annum to 2000 and 55,000 hectares from 2001 onward. Upper and lower bounds of this survey estimate are in the range of plus or minus 20-30,000 hectares per annum. This is substantially lower than previously projected, although the central rate is still significantly higher than the

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10 Hollinger, Maclaren, Beets and Turland. 1993. ‘Carbon Sequestration by New Zealand's Plantation Forests’. *New Zealand Journal of Forestry Science* Vol 23(2), pp 194-208.
11 Ministry of Forestry, 1996. A National Exotic Forest Description as at 1 April 1995. Ministry of Forestry, Wellington.
12 Glass, B (1996) *Survey of new land planting intentions for exotic forests in New Zealand and analysis of factors influencing past afforestation trends.* Contract report for the Ministry for the Environment and the Ministry of Forestry, New Zealand Forest Research Institute, Rotorua. January 1996.

historical average of 42,000 hectares per annum during the 1980s. Table XX gives the new planting rates used for projections from 1998 onwards and actual planting rates for comparison.

Table XX. New Land Planting Rates for Forestry (hectares)

Year	New Planting Rates	
1980-1989	42000	(annual average)
1990	22500	
1991	15800	
1992	15400	
1993	50200	
1994	61600	
1995	98200	
1996	73900	provisional
1997	81500	provisional
1998 - 2000	70000	projected (range 45000 - 90000)
2001 onward	55000	projected (range 35000 - 90000)

Source: NEFD, Ministry of Forestry and NZFRI

Emissions from Land Use Change

Emissions from wildfires and controlled burning are based on fire report returns collected by the National Rural Fire Authority on the area of scrub and forest burnt. It is assumed that indigenous forest is the main forest types burnt for the purpose of converting biomass loss to emissions of CO_2 and other greenhouse gases. For projections, the previous 10 year average of area burnt is used.

The figures do not include any allowance for forest or scrub cleared for agriculture, although it assumed that the removal of agricultural subsidies is resulting in the reversion of marginal land to scrub, rather than scrub clearance.

Scrub cleared for forestry is based on the assumption that 20 percent of new forest planting is on land where the previous landcover was predominantly mixed scrub. Actual data is used for 1993-1995 which records that 16% of new planting was on land previously covered in scrub13. It is assumed that 50 percent of scrub cleared for forestry is left to decay on-site with the remainder burnt, also on-site.

13 Ministry of Forestry Statistics.

ANNEX 6

Methodology for estimating methane emissions from wastewater.

The IPCC Guidelines were used as a guide. However, in order to more accurately reflect methane emissions from wastewater in New Zealand, an alternative method was developed (Savage, 1996) and is described below.

In the New Zealand situation, where there are no constraints on the availability of land, oxidation ponds are the most frequently used for wastewater treatment. This contrasts with many other developed countries where compact, high technology means of waste treatment are employed. The anaerobic handling systems employed in New Zealand are: anaerobic ponds, facultative ponds, septic tanks, Imhoff tanks and anaerobic sludge digesters.

The domestic/commercial and industrial division in the IPCC Guidelines has been kept. The domestic/commercial part of the calculation includes anything discharged to the local sewerage system, i.e. waste from private houses, waste from businesses, and trade waste from industries that have a permit to discharge to the sewer. The industrial part of the calculation covers only industrial waste treated by the industry itself.

Wastewater treatment plants are operated throughout New Zealand by district or city councils. Data on handling systems in plant with aerobic environments was collected, together with information on the general treatment types at each plant, and the influent BOD. Where the influent BOD information was not know, a theoretical BOD was calculated based on population. An average BOD value for New Zealand of 100 grams per person per day (includes trade waste) was used (Hauber, 1995).

Best estimates (based on literature sources and national wastewater experts) of BOD undergoing anaerobic treatment and methane released to the atmosphere for each treatment handling system are as shown in the following table:

Anaerobic handling system	**Percentage BOD removed anaerobically in system**
Anaerobic lagoon	70%
Facultative pond	25%
Septic tank	70%
Imhoff tank	70% of 30% BOD removed to sludge layer

In most cases the influent BOD into the actual anaerobic handling system, as opposed to the influent BOD of the plant as a whole, was not known and required an estimate. Best estimates (based on literature sources and national wastewater experts) of the BOD removed by the systems preceding the anaerobic system are shown in the following table:

Treatment stage	**Percentage BOD removed in stage**
Off-site pretreatment	10%
On-site pretreatement	10%
Primary	20%
Secondary	20%
Tertiary	20%

The original New Zealand study was done using 1995 data, and produced the following results:

Methane from domestic/commercial sources	0.86 ± 0.43 Gg
Methane from industrial sources	3.44 ± 0.69 Gg
Total	4.30 ± 1.12 Gg

The primary driver of methane emissions from wastewater (apart from the treatment system used), in the domestic/commercial sector is population. Using the 1995 results and a population of 3.5 million, methane emissions from the domestic/commercial sector are 0.245 kg per capita. This figure, together with population figures, was used to do a back calculations for 1990 through to 1994. Similarly, the per capita emission has been applied together with projections of population growth, to produce projections of methane emissions from wastewater. Methane from industrial sources is shown as being constant, allowing for any expansion in this sector as the result of economic growth to be cancelled out by increasing uptake in technologies which would reduce emissions.

	1990	1991	1992	1993	1994	1995	2000	2005	2010	2020
Domestic/commercial	0.82	0.83	0.84	0.84	0.85	0.86	0.90	0.93	0.96	1.22
Industrial	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44
Total (Gg CH_4)	**4.26**	**4.27**	**4.28**	**4.28**	**4.29**	**4.30**	**4.34**	**4.37**	**4.40**	**4.55**

References

Hauber, G. 1995: Wastewater treatment in New Zealand: Evaluation of 1992/93 Performance Data - ORGD. Water and Wastes in New Zealand, Auckland, May 1995.

Savage, E. 1996: Methane emissions from wastewater in New Zealand. Unpublished report prepared for the Ministry for the Environment as part of MA(Applied), Victoria University of Wellington.

ANNEX 7: Greenhouse gas inventory, 1990

All data is presented in gigagrams (Gg)

Short Summary Report for New Zealand's Greenhouse Gas Inventory, 1990

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**25,476**	**-20,569**	**1,706.00[illegible]**	**47.524**	**113.419**	**703.856**	**178.930**	**neg**	**0.089**	**0.023**	**16.305**
1 All Energy (Fuel Combustion and Fugitive)	**23,089**		**32.362**	**2.620**	**109.890**	**655.530**	**136.969**				
A Fuel Combustion	22,474		7.812	2.620	109.890	655.530	139.969				
B Fugutive Emissions from Fuels	615		24.155								
2 Industrial Processes	**2,387**		**0.120**		**2.252**	**0.860**	**16.729**	**neg**	**0.089**	**0.023**	**16.305**
3 Solvent and Other Product Use							**25.232**				
4 Agriculture			**1,513.450**	**44.874**	**0.157**	**3.796**					
5 Land Use Change and Forestry		**-20,569**	**4.990**	**0.030**	**1.120**	**43.670**					
6 Waste			**155.080**								
7 Other											
International Bunkers	**2,413**		**0.225**	**0.053**	**26.960**	**5.560**	**3.720**				

Summary Report for New Zealand's Greenhouse Gas Inventory, 1990

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**25,476**	**-20,569**	**1,706.00[illegible]**	**47.524**	**113.419**	**703.856**	**178.930**	**neg**	**0.089**	**0.023**	**16.305**
1 All Energy (Fuel Combustion and Fugitive)	**23,089**		**32.362**	**2.620**	**109.890**	**655.530**	**136.969**				
A Fuel Combustion	22,474		7.812	2.620	109.890	655.530	139.969				
1 Energy & Transformation Industries	6,079		0.112	0.928	20.790	2.180	0.628				
2 Industry (ISIC)	4,766		0.437	0.729	14.590	32.460	1.678				
3 Transport	8,748		7.120	0.362	69.080	618.020	130.269				
4 Small Combustion	2,766		0.140	0.582	5.040	2.760	4.370				
5 Other	115		0.003	0.019	0.390	0.110	0.024				
B Fugutive Emissions from Fuels	615		24.155								
1 Solid Fuels			11.830								
2 Oil, Natural Gas & Geothermal	615		12.720								
2 Industrial Processes	**2,387**		**0.120**		**2.252**	**0.860**	**16.729**	**neg**	**0.089**	**0.023**	**16.305**
3 Solvent and Other Product Use							**25.232**				
4 Agriculture			**1,513.450**	**44.874**	**0.157**	**3.796**					
A Enteric Fermentation			1,495.251								
B Manure Management			18.018								
D Agricultural Soils	ne			44.870							
F Field Burning of Agricultural Residues			0.181	0.004	0.157	3.796					
G Other											
5 Land Use Change and Forestry		**-20,569**	**4.990**	**0.030**	**1.120**	**43.670**					
A Changes in Forest Stocks		-22,055									
B Forest and Grassland Conversion	1,486		4.990	0.030	1.120	43.670					
C Abandonment of Managed Lands		ne									
G Other											
6 Waste			**155.080**								
A Solid Waste Disposal on Land			150.800								
B Wastewater Treatment			4.280								
C Waste Incineration											
7 Other											
International Bunkers	**2,413**		**0.225**	**0.053**	**26.960**	**5.560**	**3.720**				
A Air	1,367		0.03	0.020	5.490	2.270	0.950				
B Marine	1,046		0.195	0.033	21.470	3.290	2.770				

Standard Data Table 1

Energy: 1A Fuel Combustion Activites (Sheet 2) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C = B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A Fuel Combustion Activities	**298.8**	**22,474**	**7.812**	**2.620**	**109.89**	**655.53**	**136.97**	**75.2**	**0.026**	**0.0088**	**0.37**	**2.19**	**0.458**
Liquid	**165.1**	**11,163**	**5.679**	**0.725**	**73.16**	**616.80**	**133.16**	**67.6**	**0.034**	**0.0044**	**0.44**	**3.74**	**0.806**
Petrol	91.0	6,057	5.083	0.301	40.80	598.29	123.06	66.6	0.056	0.0033	0.45	6.58	1.353
Diesel	46.3	3,181	0.361	0.278	20.02	11.82	6.57	68.7	0.008	0.0060	0.43	0.26	0.143
Fuel Oil	7.8	576	0.056	0.076	7.19	0.21	0.82	73.6	0.007	0.0097	0.92	0.03	0.105
Aviation Fuels	12.3	843	0.019	0.032	3.26	1.32	0.58	68.7	0.002	0.0026	0.27	0.11	0.047
LPG	5.1	308	0.153	0.019	1.49	5.12	2.12	60.4	0.030	0.0038	0.29	1.00	0.415
Asphalt	2.6	190	0.007	0.020	0.39	0.04	0.01	74.0	0.003	0.0077	0.15	0.01	0.005
Unspecified	0.1	7	0.000	0.001	0.02	0.00	0.00	72.9	0.003	0.0077	0.15	0.01	0.005
Solid	**35.7**	**3,291**	**0.128**	**0.697**	**12.02**	**4.34**	**1.95**						
Coal	35.7	3,291	0.128	0.697	12.02	4.34	1.95	92.2	0.004	0.0195	0.34	0.12	0.055
Gas	**77.2**	**8,020**	**1.709**	**1.084**	**22.44**	**4.68**	**0.87**	**103.8**	**0.022**	**0.0140**	**0.29**	**0.06**	**0.011**
Natural Gas	64.9	7,307	0.166	1.047	20.94	2.78	0.82	112.6	0.003	0.0161	0.32	0.04	0.013
Refinery Gas	9.6	571	0.013	0.029	0.58	0.14	0.04	59.3	0.001	0.0030	0.06	0.02	0.005
CNG	2.7	143	1.531	0.008	0.92	1.75	0.01	52.8	0.567	0.0028	0.34	0.65	0.005
Biofuels	**20.8**		**0.296**	**0.114**	**2.27**	**29.72**	0.99		**0.014**	**0.0055**	**0.11**	**1.43**	**0.048**

Energy: 1A Fuel Combustion Activites (Sheet 3) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 Energy and Transformation Industries	**74.6**	**6,079**	**0.112**	**0.928**	**20.79**	**2.18**	**0.63**	**81.5**	**0.00151**	**0.0124**	**0.28**	**0.029**	**0.0084**
Liquid	**3.1**	**224**	**0.008**	**0.023**	**0.45**	**0.04**	**0.01**						
Petrol	0.1	7	0.000	0.000	0.01	0.00	0.00	66.6	0.00003	0.0033	0.07	0.014	0.00475
Diesel	0.1	6	0.000	0.000	0.01	0.00	0.00	68.7	0.00003	0.0033	0.07	0.014	0.00475
Fuel Oil	0.3	21	0.001	0.002	0.05	0.00	0.00	71.7	0.00260	0.0079	0.16	0.014	0.00475
Aviation Fuels	2.6	190	0.007	0.020	0.39	0.04	0.01	74.0	0.00280	0.0077	0.15	0.014	0.00475
Solid	**5.3**	**491**	**0.003**	**0.004**	**2.31**	**0.07**	**0.03**						
Coal	5.3	491	0.003	0.004	2.31	0.07	0.03	93.0	0.00060	0.0008	0.44	0.013	0.00475
Gas	**66.2**	**5,364**	**0.101**	**0.901**	**18.02**	**2.07**	**0.59**						
Natural Gas	56.6	4,793	0.089	0.872	17.45	1.93	0.54	84.7	0.00157	0.0154	0.31	0.034	0.0096
Refinery Gas	9.6	571	0.013	0.029	0.58	0.14	0.04	59.3	0.00130	0.0030	0.06	0.015	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 4) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 a Electricity and Heat Production	62.1	3,518	0.01	0.68	15.91	1.03	0.28						
1 A 1 a i Electricity Generation	62.1	3,518	0.01	0.68	15.91	1.03	0.28						
Public Generation	62.1	3,518	0.01	0.68	15.91	1.03	0.28						
Liquid	**0.2**	**15**	**0.00**	**0.00**	**0.02**	**0.00**	0.00						
Motor Gasoline	0.1	7	0.00	0.00	0.01	0.00	0.00	66.6	0.00003	0.00330	0.065	0.014	0.00475
Diesel	0.1	6	0.00	0.00	0.01	0.00	0.00	68.7	0.00003	0.00330	0.065	0.014	0.00475
Fuel Oil	0.03	2	0.00	0.00	0.01	0.00	0.00	73.6	0.00070	0.00960	0.191	0.014	0.00475
Solid	**5.28**	**491**	**0.0032**	**0.004**	**2.31**	**0.07**	0.03						
Sub-bituminous Coal	5.28	491	0.0032	0.004	2.31	0.07	0.03	92.99	0.00060	0.0008	0.438	0.013	0.00475
Gas	**56.60**	**3,012**	**0.005**	**0.679**	**13.58**	**0.96**	0.25						
Natural Gas	56.60	3,012	0.005	0.679	13.58	0.96	0.25	53.2	0.00009	0.012	0.24	0.017	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 5) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 b Petroleum Refining	22.1	780	0.020	0.051	1.01	0.18	0.06						
Liquid	2.83	209	0.008	0.022	0.43	0.04	0.01						
Fuel Oil	0.27	19	0.001	0.002	0.04	0.00	0.00	71.5	0.0028	0.0077	0.153	0.014	0.00475
Asphalt	2.57	190	0.007	0.020	0.39	0.04	0.01	74.0	0.0028	0.0077	0.153	0.014	0.00475
Gas	9.64	571	0.013	0.029	0.58	0.14	0.04						
Refinery Gas	9.64	571	0.013	0.029	0.58	0.14	0.04	59.3	0.0013	0.003	0.060	0.015	0.0045
Natural Gas	0.00	0	0.000	0.000	0.00	0.00	0.00						

Energy: 1A Fuel Combustion Activites (Sheet 6) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 c Solid Fuel Transformation and Other Energy Industries		1,780	0.084	0.193	3.86	0.97	0.29						
1 A 1 c i Solid Fuel Transformation		0	0	0	0	0	0						
1 A 1 c ii Other Energy Industries		1,780	0.084	0.19	3.86	0.97	0.29						
Gas		1,780	0.084	0.193	3.86	0.97	0.29						
Synthetic Petrol													
Natural Gas		1,495	0.079	0.18	3.62	0.91	0.27						
Oil & Gas Extraction													
Natural Gas		286	0.005	0.01	0.24	0.06	0.02						

Energy: 1A Fuel Combustion Activites (Sheet 7) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 2 Industry	105.0	4,766	0.437	0.729	14.59	32.46	1.68						
Gas	52.3	2,076	0.068	0.157	3.14	0.78	0.24	39.7	0.0013	0.0030	0.060	0.015	0.005
Methanol													
Natural Gas		380											
Urea													
Natural Gas		149											
Other Industry													
Natural Gas		1,547											
Liquid	10.6	733	0.030	0.082	1.62	0.15	0.05	69.0	0.0028	0.0077	0.153	0.014	0.00475
Petrol	0.7	46	0.002	0.005	0.11	0.01	0.00	66.6	0.0028	0.0077	0.153	0.014	0.00475
Diesel	6.6	452	0.018	0.051	1.01	0.09	0.03	68.7	0.0028	0.0077	0.153	0.014	0.00475
Fuel Oil	2.2	162	0.006	0.017	0.34	0.03	0.01	73.7	0.0028	0.0077	0.153	0.014	0.00475
Aviation Fuels	0.2	17	0.001	0.002	0.04	0.00	0.00	68.7	0.0028	0.0077	0.153	0.014	0.00475
LPG	0.8	48	0.002	0.006	0.12	0.01	0.00	60.4	0.0028	0.0077	0.153	0.014	0.00475
Other	0.1	7	0.000	0.001	0.02	0.00	0.00	72.9	0.0028	0.0077	0.153	0.014	0.00475
Solid	21.3	1,958	0.043	0.377	7.56	1.81	0.40						
Coal	21.3	1,958	0.043	0.377	7.56	1.81	0.40	92.1	0.0020	0.018	0.356	0.085	0.019
Biofuels	20.8	NE	0.296	0.114	2.27	29.72	0.99		0.01425	0.00546	0.10925	1.4288	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 8) - Detailed Technology Based Calculation

Source and Sink Categoriies	**Activity Data**	**Emissions Estimates**						**Aggregate Emission Factors**					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Transport	**130.8**	**8,748**	**7.120**	**0.362**	**69.08**	**618.02**	130.27						
Liquid	**128.1**	**8,605**	**5.589**	**0.354**	**68.16**	**616.27**	130.26						
Petrol	86.0	5,724	5.1	0.26	40.14	598.22	122.48	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	23.7	1,628	0.3	0.07	17.02	11.49	4.50	68.7	0.013	0.00297	0.718	0.485	0.19
Fuel Oil	3.3	240	0.0	0.01	6.49	0.14	0.62	73.7	0.0136	0.00177	1.995	0.044	0.19
Aviation Fuels	11.5	789	0.0	0.01	3.17	1.31	0.55	68.7	0.0015	0.00108	0.276	0.114	0.0475
LPG	3.7	223	0.1	0.01	1.34	5.11	2.11	60.4	0.04	0.0028	0.361	1.38	0.57
Gas	**2.7**	**143**	**1.5**	**0.01**	**0.92**	**1.75**	0.01						
CNG	2.7	143	1.5	0.01	0.92	1.75	0.01	52.8	0.567	0.0028	0.342	0.648	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 9) - Detailed Technology Based Calculation

Source and Sink Categoriies	**Activity Data**	**Emissions Estimates**						**Aggregate Emission Factors**					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 a Civil Aviation	31.4	2,156	0.05	0.03	8.66	3.58	1.49						
1 A 3 a i International Aviation (International Bunkers)	19.9	1,367	0.03	0.02	5.49	2.27	0.95						
Aviation Fuels	19.9	1,367	0.03	0.02	5.49	2.27	0.95	68.7	0.0015	0.00108	0.276	0.114	0.0475
1 A 3 a ii Domestic	11.5	789	0.02	0.01	3.17	1.31	0.55						
Aviation Fuels	11.5	789	0.02	0.01	3.17	1.31	0.55	68.7	0.0015	0.00108	0.276	0.114	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 10) - Detailed Technology Based Calculation

Source and Sink Categoriies	**Activity Data**	**Emissions Estimates**						**Aggregate Emission Factors**					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Road & Marine Transportation	119.3	7,958	7.10	0.35	65.91	616.71	129.72						
Liquid	116.6	7,816	5.57	0.34	64.99	614.96	129.71						
Petrol	86.0	5,724	5.07	0.26	40.14	598.22	122.48	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	23.7	1,628	0.31	0.07	17.02	11.49	4.50	68.7	0.013	0.00297	0.718	0.485	0.19
Fuel Oil	3.3	240	0.04	0.01	6.49	0.14	0.62	73.7	0.0136	0.00177	1.995	0.044	0.19
LPG	3.7	223	0.15	0.01	1.34	5.11	2.11	60.4	0.04	0.0028	0.361	1.38	0.57
Gas	2.7	143	1.53	0.01	0.92	1.75	0.01						
CNG	2.7	143	1.53	0.01	0.92	1.75	0.01	52.8	0.567	0.0028	0.342	0.648	0.0045
1 A 3 d i International Marine	14.6	1,046	0.195	0.033	21.47	3.29	2.77						
Diesel	6.0	412	0.078	0.018	4.31	2.91	1.14	68.7	0.0130	0.00297	0.718	0.485	0.190
Marine	8.6	634	0.117	0.015	17.16	0.38	1.63	73.7	0.0136	0.00177	1.995	0.044	0.190

Energy: 1A Fuel Combustion Activites (Sheet 11) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 Small Combustion	39.5	2,766	0.140	0.582	5.04	2.76	4.37						
Liquid	23.3	1,601	0.052	0.267	2.93	0.33	2.83						
Petrol	4.2	280	0.009	0.040	0.55	0.06	0.57	66.6	0.0023	0.0095	0.130	0.014	0.136
Diesel	15.9	1,095	0.034	0.156	1.99	0.23	2.03	68.7	0.0022	0.0098	0.125	0.014	0.128
Fuel Oil	2.1	152	0.005	0.051	0.31	0.03	0.19	73.7	0.0022	0.0245	0.150	0.015	0.094
Aviation Fuels	0.5	37	0.001	0.017	0.05	0.01	0.03	68.7	0.0020	0.0320	0.089	0.015	0.058
LPG	0.6	36	0.003	0.003	0.03	0.01	0.00	60.4	0.0043	0.0045	0.050	0.013	0.005
Solid	7.9	727	0.079	0.297	1.76	2.35	1.50						
Coal	7.9	727	0.079	0.297	1.76	2.35	1.50	92.1	0.01	0.038	0.22	0.30	0.190
Gas	8.3	438	0.009	0.018	0.35	0.07	0.04						
CNG	8.3	438	0.009	0.018	0.35	0.07	0.04	52.8	0.0011	0.0022	0.043	0.0088	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 12) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 a Commercial / Institutional	16.7	1,183	0.057	0.418	1.77	1.01	0.94						
Liquid	7.19	495	0.005	0.146	0.52	0.11	0.03						
Petrol	1.05	70	0.001	0.016	0.06	0.02	0.00	66.6	0.0006	0.0149	0.061	0.015	0.00475
Diesel	4.72	325	0.003	0.070	0.29	0.07	0.02	68.7	0.0006	0.0149	0.061	0.015	0.00475
Fuel Oil	0.95	70	0.001	0.042	0.14	0.02	0.00	73.7	0.0015	0.0442	0.147	0.016	0.00475
Aviation Fuels	0.36	25	0.001	0.016	0.02	0.01	0.00	68.7	0.0015	0.0442	0.061	0.015	0.00475
LPG	0.10	6	0.000	0.001	0.01	0.00	0.00	60.4	0.0006	0.0149	0.061	0.015	0.00475
Solid	4.7	429	0.047	0.261	1.04	0.86	0.89						
Coal	4.7	429	0.047	0.261	1.04	0.86	0.89	92.1	0.01	0.0561	0.224	0.185	0.19
Gas	4.9	259	0.005	0.011	0.21	0.04	0.02						
Natural Gas	4.9	259	0.005	0.011	0.21	0.04	0.02	52.8	0.0011	0.0022	0.043	0.0086	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 13) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 b Residential	7.2	515.0	0.039	0.044	0.88	1.53	0.63						
Liquid	0.6	37.8	0.003	0.001	0.03	0.01	0.00						
Petrol	0.0	0.8	0.000	0.000	0.00	0.00	6E-05	66.6	0.005	0.0024	0.048	0.012	0.00475
Diesel	0.1	5.9	0.000	0.000	0.00	0.00	4E-04	68.7	0.005	0.0024	0.048	0.012	0.00475
Fuel Oil	0.0	0.0	0.000	0.000	0.00	0.00	4E-07	73.7	0.005	0.0024	0.048	0.012	0.00475
Aviation Fuels	0.0	0.9	0.000	0.000	0.00	0.00	6E-05	68.7	0.005	0.0024	0.048	0.012	0.00475
LPG	0.5	30.2	0.003	0.001	0.02	0.01	2E-03	60.4	0.005	0.0024	0.048	0.012	0.00475
Solid	3.2	298.0	0.032	0.036	0.71	1.49	6E-01						
Coal	3.2	298.0	0.032	0.036	0.71	1.49	6E-01	92.1	0.01	0.011	0.22	0.46	0.19
Gas	3.4	180.0	0.003	0.007	0.14	0.03	2E-02						
Natural Gas	3.4	180.0	0.003	0.007	0.14	0.03	2E-02	52.8	0.001	0.0021	0.042	0.009	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 14) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 c Agriculture / Forestry / Fishing	15.6	1,067	0.044	0.120	2.38	0.22	2.80						
Liquid	15.6	1,067	0.044	0.120	2.38	0.22	2.80						
Petrol	3.1	209	0.009	0.024	0.48	0.04	0.57	66.6	0.0028	0.0077	0.153	0.014	0.181
Diesel	11.1	764	0.031	0.086	1.70	0.16	2.01	68.7	0.0028	0.0077	0.153	0.014	0.181
Fuel Oil	1.1	82	0.003	0.009	0.17	0.02	0.19	73.7	0.0028	0.0077	0.153	0.014	0.169
Aviation Fuels	0.2	11	0.000	0.001	0.03	0.00	0.03	68.7	0.0028	0.0077	0.153	0.014	0.178

Energy: 1A Fuel Combustion Activites (Sheet 15) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 5 Other	1.2	115	0.003	0.019	0.39	0.11	0.02						
Solid													
Coal	1.2	115	0.003	0.019	0.39	0.11	0.02	92.1	0.0023	0.0156	0.313	0.088	0.019

Standard Data Table 1

Energy: 1B1 Fugitive Emissions from Fuels (Coal Mining)

Source and Sink Categories		Activity Data Production (Mt) A	Methane Emissions (Gg) B	Emission Factor (Gg/Mt) C = B/A
1 B 1	**Solid Fuels**	**2.59**	**11.83**	
1 B 1 a	Coal Mining			
1 B 1 a i	Underground Mines			
	Underground Activities	0.57	9.23	16.10
	Post-Mining Activities	0.57	0.92	1.60
1 B 1 a ii	Surface Mines			
	Surface Activities	2.01	1.55	0.77
	Post-Mining Activities	2.01	0.13	0.067
1 B 1 b	Solid Fuel Transformation			
1 B 1 c	Other			

Energy: 1B2 Fugitive Emissions from Fuels (Oil and Natural Gas)

Source and Sink Categories			Activity Data	Emissions Estimates			Aggregate Emission Factors		
			Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
1 B 2 a	**Oil**								
	i	Exploration	NE						
	ii	Production of Crude Oil	NE						
	iii	Transport of Crude Oil	NE						
	iv	Refining/Storage	NE						
	v	Distribution of Oil Products	NE						
	vi	Other	NE						
1 B 2 b	**Natural Gas**								
	i	Production/Processing				NE			
	ii	Transmission/Distribution	40.3	7.63	1.2	NE	0.189	0.0302	
	iii	Other Leakage				NE			
1 B 2 c	**Venting and Flaring**								
	i	Oil				NE			
	ii	Natural Gas				NE			
	iii	Combined	6.1	2.59	257.0	NE	0.421	41.800	

Energy: 1B2 Fugitive Emissions from Fuels (Geothermal)

Source and Sink Categories	Activity Data	Emissions Estimates			Aggregate Emission Factors		
	Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
Geothermal	76.8	2.499	357.0	NE	0.033	4.7	

Standard Data Table 2
Industrial Processes 1990

Source and Sink Categories	Activity Data A Production Quantity (kt)	Methane Emissions B Full mass of Pollutant (Gg) CO_2	Aggregate Emission Factors C Tonne of Pollutant per tonne of Product (t/t) CO_2
A Iron and Steel	694.0	1,328.0	1.900
B Non-Ferrous Metals			
Aluminium	264.0	458.0	1.734
Other			
C Inorganic Chemicals (excepting solvent use)			
Hydrogen	21.0	152.0	7.100
D Non-Metallic Products			
Cement	719.0	367.0	0.510
Lime	114.0	82.0	0.720

Standard Data Table 2
Non CO_2 Emissons from Industrial Processes 1990

Source and Sink Categories	Activity Data A Production Quantity (kt)	Emission Estimates B Full Mass of Pollutants (Gg) Tonnes x 1000								
		CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2
A Iron and Steel	693.3000	0.4232			0.8756					0.6662
B Non Ferrous Metals										
Aluminium Production	264.0830							0.0888		5.9600
Other										
C Inorganic Chemicals (excepting solvent use)										
Nitric Acid										
Fertiliser Production	894.0000									8.8506
Other	171.0830		0.1198							
D Organic Chemicals										
Adipic Acid										
Other										
E Non-Metallic Mineral Products										
Cement	823.2930	0.4369			1.3761					0.8114
Lime	108.3590	0.0000								0.0040
Other	167.7047					6.8625				0.0132
F Other (ISIC)	6,966.8956					9.8663	neg		0.0231	
Grand Total		**0.8601**	**0.1198**		**2.2517**	**16.7288**	**neg**	**0.0888**	**0.0231**	**16.3054**

Source and Sink Categories	Aggregate Emission Factors C Tonne of Pollutant per Tonne of Product (t / t)								
	CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2
A Iron and Steel	0.00061			0.00126					0.00096
B Non Ferrous Metals									
Aluminium Production							0.00034		0.02257
Other									
C Inorganic Chemicals (excepting solvent use)									
Nitric Acid									
Fertiliser Production									0.00990
Other		0.00070							
D Organic Chemicals									
Adipic Acid									
Other									
E Non-Metallic Mineral Products									
Cement	0.00053			0.00167					0.00099
Lime	0.00000			0.00000					0.00004
Other					0.04092				0.00008
F Other (ISIC)				0.00000	0.00142				
Grand Total									

Standard Data Table 3
Solvent and Other Product Use 1990

Source and Sink Categories	Activity Data A Quantity Consumed (kt)	Emissions Estimates B Full Mass of Pollutant (Gg)			Aggregate Emission Estimates C Tonne of Pollutant per Tonne of Product (t / t) C = B / A		
		N_2O	HFC	NMVOC	N_2O	HFC	NMVOC
A Paint Application	44.17			13.4088			0.3035
B Degreasing and Dry Cleaning	0.76			0.7607			1.0000
C Chemical Products Manufacture / Processing							
D Other	11.06			11.0624			1.0000
Total				**25.2319**			

Standard Data Table 4
Agriculture: 4A & 4B Enteric Fermentation and Manure Management 1990

Source and Sink Categories	Activity Data A	Emission Estimates B		Aggregate Emission Factor C	
	Number of Animals	Enteric Fermentation	Manure Management	Enteric Fermentation	Manure Management
	(1000)*	(Gg CH4)		(kg CH4 per head per year) C = (B/A) X 1000	
Totals	**67,925.357**	**1,495.273**	**18.018**		
Cattle					
a Dairy	3,440.815	264.255	3.059	76.8	0.889
b Non-Dairy	4,593.160	310.038	4.175	67.5	0.909
Sheep	57,852.192	873.568	10.298	15.1	0.178
Goats	1,062.900	17.538	0.126	16.5	0.119
Deer	976.290	29.874	0.360	30.6	0.369
Total ruminant emission for 1995 is 1,513.291 Gg					

Standard Data Table
1990 New Zealand N_2O Emissions Calculated with the PHASE II Methodolgy

Source and Sink Categories	Emission Estimates (kg N_20 - N)
Total	**28,553,364**
Direct Soil Emissions	**2,821,563**
Synthetic Fertilizers	1,278,438
Animal Wastes	464,404
Biological N2 Fixation	45,574
Crop Residue	203,147
Cultivated Histosols	830,000
Animal Production	**15,784,420**
Animals	0
Animals Waste Management Systems	15,784,420
Indirect Emissions	**9,947,381**
Atmospheric Deposition	3,328,452
Nitrogen Leaching and Runoff	6,413,437
Human Sewage	205,492
Note: 28,553 tonnes N_2O - N is equivalent to 44,870 tonnes N_2O or 44.87 Gg	

Detailed information on the calculations and emission factors used is in Annex 4.

Greenhouse gas emissions from field burning of agricultural residues
All Cereals

Year	Total Biomass Burned (Gg dm)	Carbon Fraction	Total Carbon Release (Gg C)	Total Nitrogen (Gg N)	GHG Emissions (Gg)				GHG Agregate Emission factors (kg / t dm)			
					CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
1990	58.1	0.46673	27.1	0.40	0.181	3.796	0.004	0.157	3.112	65.342	0.075	2.707

Detailed calculations are in Annex 13.

Standard Data Table 5

Land Use Change and Forestry: 5A (Sheet 1) Changes in Forest and Other Woody Biomass Stocks - Annual Growth Increment 1990

Source and Sink Categories			Activity Data	Uptake Estimates	Aggregate Uptake Factor
Sector Specific Data (units) Land Type			Area of Forest/Biomass Stocks (kha)	Total Carbon Uptake Increment (Gg C)	Carbon Uptake Factor (t C/ha)
Temperate Forests	Plantations (specify type)	Pinus Radiata	1,264.28[1]	- 8,839	7.0[2]

Notes: 1 The figure for the area of forest stocks is for plantation forests.
2 This factor will also vary from year to year as the average age and hence growth rates of the planted forest estate changes.
All figures are reported as three year averages with the base year in the middle.

Land Use Change and Forestry: 5A (Sheet 2) Changes in Forest and Other Woody Biomass Stocks - Annual Harvest 1990

Source and Sink Categories	Activity Data	Carbon Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units)	Amount of Biomass Removed (kt dm)	Carbon Emission/Removal Estimates (Gg C)	Carbon Emission Factors (t C/t dm)
Total Biomass Removed in Commercial Harvest	5,648	2,824	0.5
Traditional Fuelwood Consumed			
Total Other Wood Use			
Total Biomass Consumption	**5,648**	**2,824**	

Note: 1 The figure given includes roundwood removals from both plantation and native forests and post harvest slash

Land Use Change and Forestry: 5A (Sheet 3) Changes in Forest and Other Woody Biomass Stocks - Net CO_2 Emissions/Removals 1990

Source and Sink Categories	Emission/Uptake C (Gg)	Emissions/Removals CO_2 (Gg)
Total Annual Growth Increment	-8,839	-32,410
Total Annual Harvest	2,824	10,355
Net Emissions (+) or Removals (-)	**-6,015**	**-22,055**

Land Use Change and Forestry: 5B (Sheet 1) Forest and Grassland Conversion - CO_2 Release from Burning Aboveground Biomass 1990

Source and Sink Categories			Activity Data				Emission Estimates		Aggregate Emission Factors	
Sector Specific Data (units) Land Type			Area Converted Annually (kha)	Annual Loss of Biomass (kt dm)	Quantity of Biomass Burned (on and off-site) (kt dm)		Quantity of C Released[1] (kt C)		Carbon Fraction of Biomass Burned	
					On Site	Off Site	On Site	Off Site	On Site	Off Site
Temperate Forests	Evergreen	Primary[2] Secondary	0.32	215.8	215.8	NA	97.1	NA	0.5	NA
Other (specify): Mixed Scrub[3]			5.11	408.9	408.9	NA	184.0	NA	0.5	NA
Total C Released							281.1	NA		
Total of On Site and Off Site C Released							281.1			
Total CO_2 Released							1031.0			

Notes: 1 Quantity of Biomass burned is adjusted for the portion of carbon in biomass that remains on-site as charcoal (10% of biomass carbon).
2 Includes burning (from natural and anthropogenic causes) of Native Forests and Plantation Forests (ie. mixed primary/secondary and plantation).
3 Includes burning (from natural and anthropogenic causes) of mixed scrub and prescribed burning of scrub cleared for Plantation Forestry.
All figures are reported as three year averages with the base year in the middle. See Annex 5 for further details.
NA = Not Applicable

Land Use Change and Forestry: 5B (Sheet 2) Forest and Grassland Conversion - Release of Non-CO_2 GHG from On-Site Burning of Forests 1990

Source and Sink Categories	Activity Data		Emissions Estimates				Aggregate Emission Ratios			
Sector Specific Data (units) Land Type	Carbon Release (Gg)	Nitrogen Release (Gg)	Emissions Estimates (Gg)				Aggregate Emission Ratios			
			CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
On Site Burning of Forests	281.13	2.81	4.985	43.669	0.031	1.119	0.160	0.140	0.011	0.398

Land Use Change and Forestry: 5B (Sheet 3) Forest and Grassland Conversion - CO_2 Release from Decay of Aboveground Biomass 1990

Source and Sink Categories			Activity Data			Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units) Land Type			5-Year Average Area Converted[1] (kha/yr)	5-Year Average Annual Loss of Biomass (kt dm/yr)	Average Quantity of Biomass to Decay (kt dm)	Carbon Released from Decay (kt C)	Carbon Fraction of Aboveground Biomass
Temperate Forests	Evergreen	Primary[2] Secondary					
Other (specify): Mixed Scrub			3.101[2]	248	248	124	0.5
Total C Released from Decay						124	
Total CO_2 Released from Decay						455	

Note: 1 Figures are given as previous five year average.
2 Only includes the area of mixed scrub cleared for plantation forestry that is left to decay (approximately 50% of toal area converted), the remainder is burned and is included under 5B Sheet 1.

Land Use Change and Forestry: 5B (Sheet 4) Forest and Grassland Conversion - Soil Carbon Release 1990

Soil carbon is not estimated as it is assumed to remain in balance or increase slightly from the conversion of pastoral land and mixed scrub to first rotation plantation forestry. No data is currently available on whether other forms of conversion may be occurring which result in a release of soil carbon.

Land Use Change and Forestry: 5B (Sheet 5) Forest and Grassland Conversion - Total CO_2 Emissions 1990

Category	Emissions (Gg)
CO_2 Release from Burning of Aboveground Biomass	1,031
CO_2 from Decay of Aboveground Biomass	455
CO_2 from Soil Carbon Release	ne
Total	1,486
Note: ne = Not Estimated	

Land Use Change and Forestry: 5C (Sheet 1-3) Abandonment of Managed Lands 1990

Not Estimated. No data is currently available on the extent of abandoned managed lands on a national basis. It is known however that considerable regeneration is occurring in some areas, but these have yet to be quantified.

Standard Data Table 6: Waste

Detailed information and calculations for waste sector emissions are in Annex 6 for wastewater, and Annex 14 for landfills. Emissions from landfills are calculated using the Phase II Guidelines.

Waste sector methane in Gg	1990
Total	**155.08**
Landfills	150.80
Wastewater	4.28

ANNEX 8: Greenhouse gas inventory, 1991

All data is presented in gigagrams (Gg)

Short Summary Report for New Zealand's Greenhouse Gas Inventory, 1991

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**26,007**	**-19,630**	**1,668.569**	**45.753**	**115.841**	**702.473**	**176.214**	**neg**	**0.096**	**0.021**	**17.080**
1 All Energy (Fuel Combustion and Fugitive)	**23,497**		**30.496**	**2.762**	**112.370**	**659.370**	**137.200**				
A Fuel Combustion	22,796		8.779	2.762	112.370	659.370	137.200				
B Fugutive Emissions from Fuels	701		21.717								
2 Industrial Processes	**2,510**		**0.120**		**2.331**	**0.934**	**15.902**	**neg**	**0.096**	**0.021**	**17.080**
3 Solvent and Other Product Use							**23.112**				
4 Agriculture			**1,477.027**	**42.964**	**0.155**	**3.749**					
5 Land Use Change and Forestry		**-19,630**	**4.386**	**0.027**	**0.985**	**38.420**					
6 Waste			**156.540**								
7 Other											
International Bunkers	**2,223**		**0.201**	**0.051**	**22.550**	**5.650**	**3.350**				

Summary Report for New Zealand's Greenhouse Gas Inventory, 1991

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**26,007**	**-19,630**	**1,668.569**	**45.753**	**115.841**	**702.473**	**176.214**	**neg**	**0.096**	**0.021**	**17.080**
1 All Energy (Fuel Combustion and Fugitive)	**23,497**		**30.496**	**2.762**	**112.370**	**659.370**	**137.200**				
A Fuel Combustion	22,796		8.779	2.762	112.370	659.370	137.200				
1 Energy & Transformation Industries	6,151		0.980	1.044	21.920	2.200	0.620				
2 Industry (ISIC)	5,073		0.474	0.765	15.310	34.890	1.800				
3 Transport	8,749		7.185	0.365	69.770	619.380	130.700				
4 Small Combustion	2,640		0.135	0.557	4.750	2.730	4.040				
5 Other	183		0.005	0.031	0.620	0.170	0.040				
B Fugutive Emissions from Fuels	701		21.717								
1 Solid Fuels			10.580								
2 Oil, Natural Gas & Geothermal	701		11.137								
2 Industrial Processes	**2,510**		**0.120**		**2.331**	**0.934**	**15.902**	**neg**	**0.096**	**0.021**	**17.080**
3 Solvent and Other Product Use							**23.112**				
4 Agriculture			**1,477.027**	**42.964**	**0.155**	**3.749**					
A Enteric Fermentation			1,459.223								
B Manure Management			17.625								
D Agricultural Soils	ne			42.960							
F Field Burning of Agricultural Residues			0.179	0.004	0.155	3.749					
G Other											
5 Land Use Change and Forestry		**-19,630**	**4.386**	**0.027**	**0.985**	**38.420**					
A Changes in Forest Stocks		-20,933									
B Forest and Grassland Conversion	1,303		4.386	0.027	0.985	38.420					
C Abandonment of Managed Lands		ne									
G Other											
6 Waste			**156.540**								
A Solid Waste Disposal on Land			152.260								
B Wastewater Treatment			4.280								
C Waste Incineration											
7 Other											
International Bunkers	**2,223**		**0.201**	**0.051**	**22.550**	**5.650**	**3.350**				
A Air	1,305		0.030	0.020	5.240	2.170	0.900				
B Marine	918		0.171	0.031	17.310	3.480	2.450				

Standard Data Table 1

Energy: 1A Fuel Combustion Activites (Sheet 2) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A Fuel Combustion Activities	308.0	22,795	7.861	2.763	112.37	659.38	137.20	74.0	0.026	0.0090	0.36	2.14	0.445
Liquid	162.8	11,004	5.702	0.701	73.49	618.12	133.25	67.6	0.035	0.0043	0.45	3.80	0.809
Petrol	90.4	6,021	5.086	0.295	40.76	598.82	123.12	66.6	0.056	0.0033	0.45	6.62	1.358
Diesel	46.5	3,194	0.377	0.274	20.90	12.54	6.64	68.7	0.008	0.0059	0.45	0.27	0.139
Fuel Oil	7.2	530	0.054	0.066	7.05	0.20	0.76	73.8	0.008	0.0092	0.98	0.03	0.102
Aviation Fuels	10.3	708	0.016	0.022	2.76	1.12	0.49	68.7	0.002	0.0022	0.27	0.11	0.047
LPG	5.5	332	0.162	0.021	1.58	5.40	2.23	60.4	0.029	0.0038	0.29	0.98	0.406
Asphalt	2.8	211	0.008	0.022	0.43	0.04	0.01	74.8	0.003	0.0077	0.15	0.01	0.005
Unspecified	0.1	7	0.000	0.001	0.02	0.00	0.00	72.9	0.003	0.0077	0.15	0.01	0.005
Solid	33.0	3,042	0.126	0.698	10.83	4.31	1.94						
Coal	33.0	3,042	0.126	0.698	10.83	4.31	1.94	92.2	0.004	0.0211	0.33	0.13	0.059
Gas	89.8	8,750	1.714	1.242	25.61	4.93	0.94	97.6	0.019	0.0139	0.29	0.06	0.011
Natural Gas	77.6	8,045	0.171	1.207	24.13	3.05	0.89	103.7	0.002	0.0156	0.31	0.04	0.011
Refinery Gas	9.5	562	0.012	0.028	0.56	0.14	0.04	60.3	0.001	0.0030	0.06	0.02	0.005
CNG	2.7	143	1.531	0.008	0.92	1.75	0.01	52.8	0.567	0.0028	0.34	0.65	0.005
Biofuels	22.4		0.319	0.122	2.44	32.01	1.06		0.014	0.0054	0.11	1.43	0.048

Energy: 1A Fuel Combustion Activites (Sheet 3) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 Energy and Transformation Industries	84.1	6,150	0.098	1.044	21.92	2.20	0.62	73.3	0.00117	0.0124	0.26	0.026	0.0074
Liquid	3.0	227	0.008	0.023	0.45	0.04	0.01						
Petrol	0.1	5	0.000	0.000	0.01	0.00	0.00	66.6	0.00003	0.0033	0.07	0.014	0.00475
Diesel	0.1	6	0.000	0.000	0.01	0.00	0.00	68.7	0.00003	0.0033	0.07	0.014	0.00475
Fuel Oil	0.1	4	0.000	0.000	0.01	0.00	0.00	88.3	0.00255	0.0079	0.16	0.014	0.00475
Aviation Fuels	2.8	211	0.008	0.022	0.43	0.04	0.01	74.8	0.00280	0.0077	0.15	0.014	0.00475
Solid	2.5	229	0.001	0.002	1.08	0.03	0.01						
Coal	2.5	229	0.001	0.002	1.08	0.03	0.01	93.0	0.00060	0.0008	0.44	0.013	0.00475
Gas	78.6	5,695	0.089	1.020	20.40	2.13	0.60						
Natural Gas	69.1	5,133	0.077	0.992	19.84	1.99	0.55	74.3	0.00111	0.0144	0.29	0.029	0.0080
Refinery Gas	9.5	562	0.012	0.028	0.56	0.14	0.04	60.3	0.00130	0.0030	0.06	0.015	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 4) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 a Electricity and Heat Production	71.7	3,911	0.01	0.83	17.67	1.21	0.32						
1 A 1 a i Electricity Generation	71.7	3,911	0.01	0.83	17.67	1.21	0.32						
Public Generation	71.7	3,911	0.01	0.83	17.67	1.21	0.32						
Liquid	0.2	12	0.00	0.00	0.01	0.00	0.00						
Motor Gasoline	0.1	5	0.00	0.00	0.01	0.00	0.00	66.6	0.00003	0.00330	0.065	0.014	0.00475
Diesel	0.1	6	0.00	0.00	0.01	0.00	0.00	68.7	0.00003	0.00330	0.065	0.014	0.00475
Fuel Oil	0.01	0	0.00	0.00	0.00	0.00	0.00	73.6	0.00070	0.00960	0.191	0.014	0.00475
Solid	2.46	229	0.0015	0.002	1.08	0.03	0.01						
Sub-bituminous Coal	2.46	229	0.0015	0.002	1.08	0.03	0.01	92.99	0.00060	0.0008	0.438	0.013	0.00475
Gas	69.1	3,671	0.006	0.829	16.58	1.17	0.31						
Natural Gas	69.1	3,671	0.006	0.83	16.58	1.17	0.31	53.1	0.0001	0.012	0.24	0.017	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 5) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 b Petroleum Refining	21.80	777	0.020	0.050	1.00	0.18	0.06						
Liquid	2.87	215	0.008	0.022	0.44	0.04	0.01						
Fuel Oil	0.04	4	0.000	0.000	0.01	0.00	0.00	90.3	0.0028	0.0077	0.153	0.014	0.00475
Asphalt	2.82	211	0.008	0.022	0.43	0.04	0.01	74.8	0.0028	0.0077	0.153	0.014	0.00475
Gas	9.47	562	0.012	0.028	0.56	0.14	0.04						
Refinery Gas	9.47	562	0.012	0.028	0.56	0.14	0.04	60.3	0.0013	0.003	0.060	0.015	0.0045
Natural Gas	0.00	0	0.000	0.000	0.00	0.00	0.00						0.0045

Energy: 1A Fuel Combustion Activites (Sheet 6) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 c Solid Fuel Transformation and Other Energy Industries		1,462	0.070	0.163	3.25	0.81	0.24						
1 A 1 c i Solid Fuel Transformation		0	0	0	0	0	0.00						
1 A 1 c ii Other Energy Industries		1,462	0.070	0.16	3.25	0.81	0.24						
Gas		1,462	0.070	0.163	3.25	0.81	0.24						
Synthetic Petrol													
Natural Gas		1,196	0.065	0.15	3.02	0.75	0.23						
Oil & Gas Extraction													
Natural Gas		266	0.005	0.01	0.24	0.06	0.02						

Energy: 1A Fuel Combustion Activites (Sheet 7) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 2 Industry	118.8	5,073	0.474	0.765	15.31	34.89	1.80						
Gas	65.5	2,464	0.085	0.196	3.93	0.98	0.29						
Methanol													
Natural Gas		762											
Urea													
Natural Gas		149											
Other Industry													
Natural Gas		1,552											
Liquid	10.2	706	0.029	0.079	1.57	0.14	0.05	69.0	0.0028	0.0077	0.153	0.014	0.00475
Petrol	0.5	36	0.002	0.004	0.08	0.01	0.00	66.6	0.0028	0.0077	0.153	0.014	0.00475
Diesel	6.2	428	0.017	0.048	0.95	0.09	0.03	68.7	0.0028	0.0077	0.153	0.014	0.00475
Fuel Oil	2.3	166	0.006	0.017	0.35	0.03	0.01	73.7	0.0028	0.0077	0.153	0.014	0.00475
Aviation Fuels	0.2	15	0.001	0.002	0.03	0.00	0.00	68.7	0.0028	0.0077	0.153	0.014	0.00475
LPG	0.9	54	0.003	0.007	0.14	0.01	0.00	60.4	0.0028	0.0077	0.153	0.014	0.00475
Other	0.1	7	0.000	0.001	0.02	0.00	0.00	72.9	0.0028	0.0077	0.153	0.014	0.00475
Solid	20.7	1,903	0.041	0.368	7.38	1.76	0.39						
Coal	20.7	1,903	0.041	0.368	7.38	1.76	0.39	92.1	0.0020	0.018	0.357	0.085	0.019
Biofuels	22.4		0.319	0.122	2.44	32.01	1.06		0.014	0.005	0.109	1.429	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 8) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Transport	130.8	8,749	7.149	0.365	69.77	619.38	130.70						
Liquid	128.1	8,607	5.618	0.358	68.85	617.63	130.69						
Petrol	86.0	5,729	5.1	0.256	40.18	598.75	122.59	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	25.2	1,734	0.3	0.075	18.12	12.24	4.79	68.7	0.013	0.00297	0.718	0.485	0.19
Fuel Oil	3.2	238	0.0	0.006	6.45	0.14	0.61	73.7	0.0136	0.00177	1.995	0.044	0.19
Aviation Fuels	9.7	669	0.0	0.011	2.69	1.11	0.46	68.7	0.0015	0.00108	0.276	0.114	0.0475
LPG	3.9	236	0.2	0.011	1.41	5.38	2.22	60.4	0.04	0.0028	0.361	1.38	0.57
Gas	2.7	143	1.5	0.008	0.92	1.75	0.01						
CNG	2.7	143	1.5	0.008	0.92	1.75	0.01	52.8	0.567	0.0028	0.342	0.648	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 9) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 a Civil Aviation													
1 A 3 a i International Aviation (International Bunkers)	19.0	1,305	0.03	0.02	5.24	2.17	0.90						
Aviation Fuels	19.0	1,305	0.03	0.02	5.24	2.17	0.90	68.7	0.0015	0.00108	0.276	0.114	0.0475
1 A 3 a ii Domestic	9.7	669	0.01	0.01	2.69	1.11	0.46						
Aviation Fuels	9.7	669	0.01	0.01	2.69	1.11	0.46	68.7	0.0015	0.00108	0.276	0.114	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 10) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Road & Marine Transportation	121.1	8,080	7.13	0.35	67.08	618.27	130.23						
Liquid	118.4	7,937	5.60	0.35	66.16	616.52	130.22						
Petrol	86.0	5,729	5.08	0.26	40.18	598.75	122.59	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	25.2	1,734	0.33	0.07	18.12	12.24	4.79	68.7	0.013	0.00297	0.718	0.485	0.19
Fuel Oil	3.2	238	0.04	0.01	6.45	0.14	0.61	73.7	0.0136	0.00177	1.995	0.044	0.19
LPG	3.9	236	0.16	0.01	1.41	5.38	2.22	60.4	0.04	0.0028	0.361	1.38	0.57
Gas	2.7	143	1.53	0.01	0.92	1.75	0.01						
CNG	2.7	143	1.53	0.01	0.92	1.75	0.01	52.8	0.567	0.0028	0.342	0.648	0.0045
1 A 3 d i International Marine	12.9	918	0.171	0.031	17.31	3.48	2.45						
Diesel	6.6	453	0.086	0.020	4.74	3.20	1.25	68.7	0.0130	0.00297	0.718	0.485	0.190
Marine	6.3	464	0.086	0.011	12.57	0.28	1.20	73.7	0.0136	0.00177	1.995	0.044	0.190

Energy: 1A Fuel Combustion Activites (Sheet 11) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 Small Combustion	37.8	2,640	0.135	0.557	4.75	2.73	4.04						
Liquid	21.4	1,464	0.047	0.242	2.63	0.31	2.50						
Petrol	3.8	250	0.009	0.035	0.49	0.05	0.52	66.6	0.0023	0.0094	0.131	0.014	0.130
Diesel	15.0	1,027	0.031	0.151	1.82	0.21	1.81	68.7	0.0021	0.0101	0.122	0.014	0.112
Fuel Oil	1.6	121	0.004	0.043	0.25	0.02	0.14	73.7	0.0021	0.0262	0.150	0.015	0.070
Aviation Fuels	0.4	24	0.001	0.010	0.03	0.01	0.03	68.7	0.0021	0.0288	0.097	0.015	0.068
LPG	0.7	42	0.003	0.003	0.03	0.01	0.00	60.4	0.0044	0.0042	0.050	0.012	0.005
Solid	7.9	727	0.079	0.297	1.76	2.35	1.50						
Coal	7.9	727	0.079	0.297	1.76	2.35	1.50	92.1	0.01	0.038	0.22	0.30	0.19
Gas	8.5	449	0.009	0.018	0.36	0.07	0.04						
CNG	8.5	449	0.009	0.018	0.36	0.07	0.04	52.8	0.0011	0.0022	0.043	0.0088	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 12) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 a Commercial / Institutional	16.5	1,169	0.057	0.406	1.75	1.01	0.94						
Liquid	6.99	482	0.005	0.134	0.50	0.11	0.03						
Petrol	0.88	58	0.001	0.013	0.05	0.01	0.00	66.6	0.0006	0.0149	0.061	0.015	0.00475
Diesel	4.98	342	0.003	0.074	0.30	0.07	0.02	68.7	0.0006	0.0149	0.061	0.015	0.00475
Fuel Oil	0.83	61	0.001	0.037	0.12	0.01	0.00	73.7	0.0015	0.0442	0.147	0.016	0.00475
Aviation Fuels	0.20	14	0.000	0.009	0.01	0.00	0.00	68.7	0.0015	0.0442	0.061	0.015	0.00475
LPG	0.10	6	0.000	0.001	0.01	0.00	0.00	60.4	0.0006	0.0149	0.061	0.015	0.00475
Solid	4.7	429	0.047	0.261	1.04	0.86	0.89						
Coal	4.7	429	0.047	0.261	1.04	0.86	0.89	92.1	0.01	0.0561	0.224	0.185	0.19
Gas	4.9	259	0.005	0.011	0.21	0.04	0.02						
Natural Gas	4.9	259	0.005	0.011	0.21	0.04	0.02	52.8	0.0011	0.0022	0.043	0.0086	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 13) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 b Residential	7.5	530	0.039	0.045	0.90	1.53	0.63						
Liquid	0.7	42.4	0.003	0.002	0.03	0.01	0.00						
Petrol	0.0	0.8	0.000	0.000	0.00	0.00	0.00	66.6	0.005	0.0024	0.048	0.012	0.00475
Diesel	0.1	4.8	0.000	0.000	0.00	0.00	0.00	68.7	0.005	0.0024	0.048	0.012	0.00475
Fuel Oil	0.0	0.1	0.000	0.000	0.00	0.00	0.00	73.7	0.005	0.0024	0.048	0.012	0.00475
Aviation Fuels	0.0	0.5	0.000	0.000	0.00	0.00	0.00	68.7	0.005	0.0024	0.048	0.012	0.00475
LPG	0.6	36.2	0.003	0.001	0.03	0.01	0.00	60.4	0.005	0.0024	0.048	0.012	0.00475
Solid	3.2	298	0.032	0.036	0.71	1.49	0.61						
Coal	3.2	298	0.032	0.036	0.71	1.49	0.61	92.1	0.01	0.011	0.22	0.46	0.19
Gas	3.6	190	0.004	0.008	0.15	0.03	0.02						
Natural Gas	3.6	190	0.004	0.008	0.15	0.03	0.02	52.8	0.001	0.0021	0.042	0.009	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 14) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 c Agriculture / Forestry / Fishing	13.7	940	0.038	0.106	2.10	0.19	2.46						
Liquid	13.7	940	0.038	0.106	2.10	0.19	2.46						
Petrol	2.9	191	0.008	0.022	0.44	0.04	0.52	66.6	0.0028	0.0077	0.153	0.014	0.165
Diesel	9.9	680	0.028	0.076	1.52	0.14	1.79	68.7	0.0028	0.0077	0.153	0.014	0.161
Fuel Oil	0.8	60	0.002	0.006	0.12	0.01	0.13	73.7	0.0028	0.0077	0.153	0.014	0.118
Aviation Fuels	0.1	10	0.000	0.001	0.02	0.00	0.02	68.7	0.0028	0.0077	0.153	0.014	0.149
LPG	0.0	0	0.000	0.000	0.00	0.00							

Energy: 1A Fuel Combustion Activites (Sheet 15) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 5 Other	2.0	183	0.005	0.031	0.62	0.17	0.04						
Solid													
Coal	2.0	183	0.005	0.031	0.62	0.17	0.04	92.1	0.0023	0.0156	0.313	0.088	0.019

IPCC Standard Data Tables 1991

Standard Data Table 1

Energy: 1B1 Fugitive Emissions from Fuels (Coal Mining)

Source and Sink Categories		Activity Data Production (Mt) A	Methane Emissions (Gg) B	Emission Factor (Gg/Mt) C = B/A
1 B 1	**Solid Fuels**	**2.68**	**10.58**	
1 B 1 a	Coal Mining			
1 B 1 a i	Underground Mines			
	Underground Activities	0.47	7.97	17.0
	Post-Mining Activities	0.47	0.75	1.6
1 B 1 a ii	Surface Mines			
	Surface Activities	2.22	1.71	0.77
	Post-Mining Activities	2.22	0.15	0.067
1 B 1 b	Solid Fuel Transformation			
1 B 1 c	Other			

Energy: 1B2 Fugitive Emissions from Fuels (Oil and Natural Gas)

Source and Sink Categories		Activity Data	Emissions Estimates			Aggregate Emission Factors		
		Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
1 B 2 a	**Oil**							
i	Exploration	NE						
ii	Production of Crude Oil	NE						
iii	Transport of Crude Oil	NE						
iv	Refining/Storage	NE						
v	Distribution of Oil Products	NE						
vi	Other	NE						
1 B 2 b	**Natural Gas**							
i	Production/Processing				NE			
ii	Transmission/Distribution	40.7	7.66	1.07	NE	0.188	0.0264	
iii	Other Leakage				NE			
1 B 2 c	**Venting and Flaring**							
i	Oil				NE			
ii	Natural Gas				NE			
iii	Combined	8.9	1.03	348	NE	0.116	39.1	

Energy: 1B2 Fugitive Emissions from Fuels (Geothermal)

Source and Sink Categories	Activity Data	Emissions Estimates			Aggregate Emission Factors		
	Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
Geothermal	82.1	2.447	351.0	NE	0.030	4.3	

Standard Data Table 2
Industrial Processes 1991

Source and Sink Categories	Activity Data A Production Quantity (kt)	Methane Emissions B Full mass of Pollutant (Gg) CO_2	Aggregate Emission Factors C Tonne of Pollutant per tonne of Product (t/t) CO_2
A Iron and Steel	752.0	1,452.0	1.900
B Non-Ferrous Metals			
Aluminium	263.0	455.0	1.734
Other			
C Inorganic Chemicals (excepting solvent use)			
Hydrogen	24.0	166.0	7.000
D Non-Metallic Products			
Cement	673.0	343.0	0.510
Lime	131.0	94.0	0.720

Non CO_2 Emissions from Industrial Processes 1991

Source and Sink Categories	Activity Data A Production Quantity (kt)	Emission Estimates B Full Mass of Pollutants (Gg) Tonnes x 1000								
		CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2
A Iron and Steel	750.7000	0.4533			0.9530					0.7253
B Non Ferrous Metals										
Aluminium Production	262.4120							0.0956		5.7300
Other										
C Inorganic Chemicals (excepting solvent use)										
Nitric Acid										
Fertiliser Production	994.0000									9.8406
Other	171.0130		0.1197							
D Organic Chemicals										
Adipic Acid										
Other										
E Non-Metallic Mineral Products										
Cement	807.1880	0.4411			1.3581					0.7688
Lime	129.7450	0.0397			0.0198					0.0046
Other	143.9442	0.0000			0.0000	5.4275				0.0103
F Other (ISIC)	7,893.6210				0.0000	10.4744	neg		0.0214	0.0000
Grand Total		**0.9341**	**0.1197**		**2.3309**	**15.9020**	**neg**	**0.0956**	**0.0214**	**17.0797**

Source and Sink Categories	Aggregate Emission Factors C Tonne of Pollutant per Tonne of Product (t / t)								
	CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2
A Iron and Steel	0.00060			0.00127					0.00097
B Non Ferrous Metals									
Aluminium Production							0.00036		0.02184
Other									
C Inorganic Chemicals (excepting solvent use)									
Nitric Acid									
Fertiliser Production									0.0099
Other		0.00070							
D Organic Chemicals									
Adipic Acid									
Other									
E Non-Metallic Mineral Products									
Cement	0.00055			0.00168					0.00095
Lime	0.00030			0.00015					0.00004
Other	0.00000				0.03771				0.00007
F Other (ISIC)				0.00000	0.00133				0.00000
Grand Total									

Standard Data Table 3
Solvent and Other Product Use 1991

Source and Sink Categories	Activity Data A Quantity Consumed (kt)	Emissions Estimates B Full Mass of Pollutant (Gg)			Aggregate Emission Estimates C Tonne of Pollutant per Tonne of Product (t / t) C = B / A		
		N_2O	HFC	NMVOC	N_2O	HFC	NMVOC
A Paint Application	44.17			13.6665			0.3094
B Degreasing and Dry Cleaning	0.76			0.6827			0.8974
C Chemical Products Manufacture / Processing							
D Other	11.06			8.7622			0.7921
Total				**23.1115**			

Standard Data Table 4
Agriculture: 4A & 4B Enteric Fermentation and Manure Management 1991

Source and Sink Categories	Activity Data A	Emission Estimates B		Aggregate Emission Factor C	
	Number of Animals	Enteric Fermentation	Manure Management	Enteric Fermentation	Manure Management
	(1000)*	(Gg CH4)		(kg CH4 per head per year) C = (B/A) X 1000	
Totals	**65,183.719**	**1,459.223**	**17.625**		
Cattle					
a Dairy	3,429.427	263.380	3.049	76.8	0.889
b Non-Dairy	4,670.569	315.263	4.246	67.5	0.909
Sheep	55,161.643	832.941	9.819	15.1	0.178
Goats	792.577	13.076	0.094	16.5	0.119
Deer	1,129.503	34.563	0.417	30.6	0.369
Total ruminant emission for 1995 is 1,476.848 Gg					

1991 New Zealand N_2O Emissions Calculated with the PHASE II Methodolgy

Source and Sink Categories	Emission Estimates (kg N_20 - N)
Total	**27,338,406**
Direct Soil Emissions	**2,652,320**
Synthetic Fertilizers	1,116,059
Animal Wastes	461,006
Biological N2 Fixation	51,338
Crop Residue	193,918
Cultivated Histosols	830,000
Animal Production	**14,794,239**
Animals	0
Animals Waste Management Systems	14,794,239
Indirect Emissions	**9,891,847**
Atmospheric Deposition	3,316,761
Nitrogen Leaching and Runoff	6,369,594
Human Sewage	205,492
Note: 27,338 tonnes N_2O - N is equivalent to 42,960 tonnes N_2O or 42.96 Gg	

Detailed information on the calculations and emission factors used is in Annex 4.

Greenhouse gas emissions from field burning of agricultural residues
All Cereals

Year	Total Biomass Burned (Gg dm)	Carbon Fraction	Total Carbon Release (Gg C)	Total Nitrogen (Gg N)	GHG Emissions (Gg)				GHG Agregate Emission factors (kg / t dm)			
					CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
1991	57.3	0.46742	26.8	0.39	0.179	3.749	0.004	0.155	3.116	65.438	0.075	2.699

Detailed calculations are in Annex 13.

Standard Data Table 5

Land Use Change and Forestry: 5A (Sheet 1) Changes in Forest and Other Woody Biomass Stocks - Annual Growth Increment 1991

Source and Sink Categories			Activity Data	Uptake Estimates	Aggregate Uptake Factor
Sector Specific Data (units) Land Type			Area of Forest/Biomass Stocks (kha)	Total Carbon Uptake Increment (Gg C)	Carbon Uptake Factor (t C/ha)
Temperate Forests	Plantations (specify type)	Pinus Radiata	1,29513[1]	- 8,748	6.8[2]

Notes: 1 The figure for the area of forest stocks is for plantation forests.
2 This factor will also vary from year to year as the average and hence growth rates of the planted forest estate changes.
All figures are reported as three year averages with the base year in the middle.

Land Use Change and Forestry: 5A (Sheet 2) Changes in Forest and Other Woody Biomass Stocks - Annual Harvest 1991

Source and Sink Categories	Activity Data	Carbon Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units)	Amount of Biomass Removed (kt dm)	Carbon Emission/Removal Estimates (Gg C)	Carbon Emission Factors (t C/t dm)
Total Biomass Removed in Commercial Harvest	6,079	3,039	0.5
Traditional Fuelwood Consumed			
Total Other Wood Use			
Total Biomass Consumption	**6,079**	**3,039**	

Note: 1 The figure given includes roundwood removals from both plantation and native forests and post harvest slash

Land Use Change and Forestry: 5A (Sheet 3) Changes in Forest and Other Woody Biomass Stocks - Net CO_2 Emissions/Removals 1991

Source and Sink Categories	Emission/Uptake C (Gg)	Emissions/Removals CO_2 (Gg)
Total Annual Growth Increment	-8,748	-32,076
Total Annual Harvest	3,039	11,143
Net Emissions (+) or Removals (-)	**-5,709**	**-20,933**

Land Use Change and Forestry: 5B (Sheet 1) Forest and Grassland Conversion - CO_2 Release from Burning Aboveground Biomass 1991

Source and Sink Categories			Activity Data				Emission Estimates		Aggregate Emission Factors	
Sector Specific Data (units) Land Type			Area Converted Annually (kha)	Annual Loss of Biomass (kt dm)	Quantity of Biomass Burned (on and off-site) (kt dm)		Quantity of C Released[1] (kt C)		Carbon Fraction of Biomass Burned	
					On Site	Off Site	On Site	Off Site	On Site	Off Site
Temperate Forests	Evergreen	Primary[2] Secondary	0.21	137.8	137.8	NA	62.0	NA	0.5	NA
Other (specify): Mixed Scrub[3]			5.15	411.8	411.8	NA	185.3	NA	0.5	NA
Total C Released							247.3	NA		
Total of On Site and Off Site C Released							247.3			
Total CO_2 Released							907.0			

Notes: 1 Quantity of Biomass burned is adjusted for the portion of carbon in biomass that remains on-site as charcoal (10% of biomass carbon).
2 Includes burning (from natural and anthropogenic causes) of Native Forests and Plantation Forests (ie. mixed primary/secondary and plantation).
3 Includes burning (from natural and anthropogenic causes) of mixed scrub and prescribed burning of scrub cleared for Plantation Forestry.
All figures are reported as three year averages with the base year in the middle. See Annex 5 for further details.
NA = Not Applicable

Land Use Change and Forestry: 5B (Sheet 2) Forest and Grassland Conversion - Release of Non-CO_2 GHG from On-Site Burning of Forests 1991

Source and Sink Categories	Activity Data		Emissions Estimates				Aggregate Emission Ratios			
Sector Specific Data (units) Land Type	Carbon Release (Gg)	Nitrogen Release (Gg)	Emissions Estimates (Gg)				Aggregate Emission Ratios			
			CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
On Site Burning of Forests	247.34	2.47	4.386	38.420	0.027	0.985	0.160	0.140	0.011	0.398

Land Use Change and Forestry: 5B (Sheet 3) Forest and Grassland Conversion - CO_2 Release from Decay of Aboveground Biomass 1991

Source and Sink Categories			Activity Data			Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units) Land Type			5-Year Average Area Converted[1] (kha/yr)	5-Year Average Annual Loss of Biomass (kt dm/yr)	Average Quantity of Biomass to Decay (kt dm)	Carbon Released from Decay (kt C)	Carbon Fraction of Aboveground Biomass
Temperate Forests	Evergreen	Primary[2]					
		Secondary					
Other (specify): Mixed Scrub			2.701[2]	216	216	108	0.5
Total C Released from Decay						108	
Total CO_2 Released from Decay						396	

Note: 1 Figures are given as previous five year average.
2 Only includes the area of mixed scrub cleared for plantation forestry that is left to decay (approximately 50% of toal area converted), the remainder is burned and is included under 5B Sheet 1.

Land Use Change and Forestry: 5B (Sheet 4) Forest and Grassland Conversion - Soil Carbon Release 1991

Soil carbon is not estimated as it is assumed to remain in balance or increase slightly from the conversion of pastoral land and mixed scrub to first rotation plantation forestry. No data is currently available on whether other forms of conversion may be occurring which result in a release of soil carbon.

Land Use Change and Forestry: 5B (Sheet 5) Forest and Grassland Conversion - Total CO_2 Emissions 1991

Category	Emissions (Gg)
CO_2 Release from Burning of Aboveground Biomass	907.0
CO_2 from Decay of Aboveground Biomass	396
CO_2 from Soil Carbon Release	ne
Total	1,303
Note: ne = Not Estimated	

Land Use Change and Forestry: 5C (Sheet 1-3) Abandonment of Managed Lands 1991

Not Estimated. No data is currently available on the extent of abandoned managed lands on a national basis. It is known however that considerable regeneration is occurring in some areas, but these have yet to be quantified.

Standard Data Table 6: Waste

Detailed information and calculations for waste sector emissions are in Annex 6 for wastewater, and Annex 14 for landfills. Emissions from landfills are calculated using the Phase II Guidelines.

Waste sector methane in Gg	**1991**
Total	**156.54**
Landfills	152.26
Wastewater	4.28

ANNEX 9: Greenhouse gas inventory, 1992

All data is presented in gigagrams (Gg)

Short Summary Report for New Zealand's Greenhouse Gas Inventory, 1992

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**27,954**	**-18,173**	**16,23.034**	**45.929**	**125.046**	**716.836**	**186.746**	**neg**	**0.094**	**0.007**	**18.406**
1 All Energy (Fuel Combustion and Fugitive)	**25,309**		**29.755**	**2.935**	**121.350**	**669.950**	**140.541**				
A Fuel Combustion	24,641		7.897	2.935	121.350	669.950	140.541				
B Fugutive Emissions from Fuels	668		21.858								
2 Industrial Processes	**2,645**		**0.103**		**2.461**	**0.974**	**19.782**	**neg**	**0.094**	**0.007**	**18.406**
3 Solvent and Other Product Use							**26.423**				
4 Agriculture			**1,436.659**	**42.964**	**0.156**	**3.804**					
5 Land Use Change and Forestry		**-18,173**	**4.807**	**0.030**	**1.079**	**42.108**					
6 Waste			**151.710**								
7 Other											
International Bunkers	**2,215**		**0.192**	**0.048**	**23.590**	**4.870**	**3.250**				

Summary Report for New Zealand's Greenhouse Gas Inventory, 1992

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**27,954**	**-18,173**	**16,23.034**	**45.929**	**125.046**	**716.836**	**186.746**	**neg**	**0.094**	**0.007**	**18.406**
1 All Energy (Fuel Combustion and Fugitive)	**25,309**		**29.755**	**2.935**	**121.350**	**669.950**	**140.541**				
A Fuel Combustion	24,641		7.897	2.935	121.350	669.950	140.541				
1 Energy & Transformation Industries	7,628		0.119	1.171	27.550	2.590	0.740				
2 Industry (ISIC)	4,880		0.448	0.738	14.760	32.890	1.700				
3 Transport	9,138		7.185	0.383	73.670	631.660	133.680				
4 Small Combustion	2,989		0.145	0.642	5.350	2.800	4.420				
5 Other	6			0.001	0.020	0.010	0.001				
B Fugutive Emissions from Fuels	668		21.858								
1 Solid Fuels			10.910								
2 Oil, Natural Gas & Geothermal	668		10.948								
2 Industrial Processes	**2,645**		**0.103**		**2.461**	**0.974**	**19.782**	**neg**	**0.094**	**0.007**	**18.406**
3 Solvent and Other Product Use							**26.423**				
4 Agriculture			**1,436.659**	**42.964**	**0.156**	**3.804**					
A Enteric Fermentation			1,419.305								
B Manure Management			17.173								
D Agricultural Soils	ne			42.960							
F Field Burning of Agricultural Residues			0.181	0.004	0.156	3.804					
G Other											
5 Land Use Change and Forestry		**-18,173**	**4.807**	**0.030**	**1.079**	**42.108**					
A Changes in Forest Stocks		-19,587									
B Forest and Grassland Conversion	1,414		4.807	0.030	1.079	42.108					
C Abandonment of Managed Lands		ne									
G Other											
6 Waste			**151.710**								
A Solid Waste Disposal on Land			147.430								
B Wastewater Treatment			4.280								
C Waste Incineration											
7 Other											
International Bunkers	**2,215**		**0.192**	**0.048**	**23.590**	**4.870**	**3.250**				
A Air	1,340		0.029	0.021	5.380	2.220	0.930				
B Marine	875		0.163	0.027	18.210	2.650	2.320				

Standard Data Table 1

Energy: 1A Fuel Combustion Activites (Sheet 2) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A Fuel Combustion Activities	331.2	24,641	7.898	2.934	121.34	669.95	140.55	79.5	0.024	0.0089	0.39	2.16	0.453
Liquid	176.7	11,964	5.865	0.831	78.59	630.65	136.63	67.7	0.033	0.0047	0.44	3.57	0.773
Petrol	92.9	6,186	5.173	0.312	41.53	608.87	125.12	66.6	0.056	0.0034	0.45	6.56	1.347
Diesel	53.9	3,706	0.443	0.309	24.61	14.86	7.87	68.7	0.008	0.0057	0.46	0.28	0.146
Fuel Oil	11.3	832	0.060	0.142	7.74	0.26	0.83	73.5	0.005	0.0125	0.68	0.02	0.073
Aviation Fuels	10.2	700	0.016	0.026	2.69	1.08	0.50	68.7	0.002	0.0025	0.26	0.11	0.049
LPG	5.8	350	0.166	0.022	1.64	5.54	2.29	60.4	0.029	0.0038	0.28	0.96	0.395
Asphalt	2.5	183	0.007	0.019	0.38	0.03	0.01	73.7	0.003	0.0077	0.15	0.01	0.005
Unspecified	0.1	7	0.000	0.001	0.02	0.00	0.00	72.9	0.003	0.0077	0.15	0.01	0.005
Solid	37.7	3,483	0.124	0.664	13.27	4.17	1.93						
Coal	37.7	3,483	0.124	0.664	13.27	4.17	1.93	92.3	0.003	0.0176	0.35	0.11	0.051
Gas	95.6	9,194	1.607	1.323	27.18	4.97	0.99	96.2	0.017	0.0138	0.28	0.05	0.010
Natural Gas	83.7	8,500	0.178	1.288	25.76	3.21	0.94	101.6	0.002	0.0154	0.31	0.04	0.011
Refinery Gas	9.4	562	0.012	0.028	0.57	0.14	0.04	59.7	0.001	0.0030	0.06	0.02	0.005
CNG	2.5	132	1.418	0.007	0.86	1.62	0.01	52.8	0.567	0.0028	0.34	0.65	0.005
Biofuels	21.1		0.301	0.115	2.30	30.15	1.00		0.014	0.0055	0.11	1.43	0.048

Energy: 1A Fuel Combustion Activites (Sheet 3) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 Energy and Transformation Industries	99.5	7,628	0.119	1.171	27.55	2.59	0.74	76.6	0.00119	0.0118	0.28	0.026	0.0075
Liquid	5.6	407	0.010	0.044	0.88	0.08	0.03						
Petrol	0.1	4	0.000	0.000	0.00	0.00	0.00	66.6	0.00003	0.0033	0.07	0.014	0.00475
Diesel	0.6	39	0.000	0.002	0.04	0.01	0.00	68.7	0.00003	0.0033	0.07	0.014	0.00475
Fuel Oil	2.5	181	0.003	0.023	0.46	0.03	0.01	72.8	0.00111	0.0092	0.18	0.014	0.00475
Aviation Fuels	2.5	183	0.007	0.019	0.38	0.03	0.01	73.7	0.00280	0.0077	0.15	0.014	0.00475
Solid	9.8	913	0.006	0.008	4.30	0.13	0.05						
Coal	9.8	913	0.006	0.008	4.30	0.13	0.05	93.0	0.00060	0.0008	0.44	0.013	0.00475
Gas	84.1	6,307	0.103	1.119	22.37	2.38	0.67						
Natural Gas	74.7	5,745	0.091	1.090	21.81	2.24	0.63	76.9	0.00122	0.0146	0.29	0.030	0.0084
Refinery Gas	9.4	562	0.012	0.028	0.57	0.14	0.04	59.7	0.00130	0.0030	0.06	0.015	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 4) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 a Electricity and Heat Production	87.1	5,065	0.01	0.93	22.65	1.43	0.40						
1 A 1 a i Electricity Generation	87.1	5,065	0.01	0.93	22.65	1.43	0.40						
Public Generation	87.1	5,065	0.01	0.93	22.65	1.43	0.40						
Liquid	2.6	190	0.00	0.02	0.42	0.04	0.01						
Motor Gasoline	0.1	4	0.00	0.00	0.00	0.00	0.00	66.6	0.00003	0.00330	0.065	0.014	0.00475
Diesel	0.6	39	0.00	0.00	0.04	0.01	0.00	68.7	0.00003	0.00330	0.065	0.014	0.00475
Fuel Oil	2.00	147	0.00	0.02	0.38	0.03	0.01	73.6	0.00070	0.00960	0.191	0.014	0.00475
Solid	9.82	913	0.0059	0.008	4.30	0.13	0.05						
Sub-bituminous Coal	9.82	913	0.0059	0.008	4.30	0.13	0.05	92.99	0.00060	0.0008	0.438	0.013	0.00475
Gas	74.70	3,961	0.007	0.896	17.93	1.27	0.34						
Natural Gas	74.70	3,961	0.007	0.90	17.93	1.27	0.34	53.0	0.0001	0.012	0.24	0.017	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 5) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 b Petroleum Refining	21.8	779	0.021	0.051	1.02	0.18	0.06						
Liquid	2.97	217	0.008	0.023	0.45	0.04	0.01						
Fuel Oil	0.49	34	0.001	0.004	0.07	0.01	0.00	69.8	0.0028	0.0077	0.153	0.014	0.00475
Asphalt	2.48	183	0.007	0.019	0.38	0.03	0.01	73.7	0.0028	0.0077	0.153	0.014	0.00475
Gas	9.42	562	0.012	0.028	0.57	0.14	0.04						
Refinery Gas	9.42	562	0.012	0.028	0.57	0.14	0.04	59.7	0.0013	0.003	0.060	0.015	0.0045
Natural Gas	0.00	0	0.000	0.000	0.00	0.00	0.00						

Energy: 1A Fuel Combustion Activites (Sheet 6) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 c Solid Fuel Transformation and Other Energy Industries		1,784	0.084	0.194	3.88	0.97	1.29						
1 A 1 c i Solid Fuel Transformation		0	0	0	0	0	1.00						
1 A 1 c ii Other Energy Industries		1,784	0.084	0.19	3.88	0.97	0.29						
Gas		1,784	0.084	0.194	3.88	0.97	0.29						
Synthetic Petrol													
Natural Gas		1,495	0.079	0.18	3.62	0.91	0.27						
Oil & Gas Extraction		289	0.006	0.01	0.26	0.06	0.02						
Natural Gas													

Energy: 1A Fuel Combustion Activites (Sheet 7) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 2 Industry	111.6	4,880	0.449	0.738	14.76	32.89	1.70						
Gas	59.5	2,279	0.077	0.178	3.57	0.89	0.27						
Methanol													
Natural Gas		585											
Urea													
Natural Gas		137											
Other Industry													
Natural Gas		1,558											
Liquid	11.1	763	0.031	0.085	1.70	0.16	0.05	68.8	0.0028	0.0077	0.153	0.014	0.00475
Petrol	1.2	82	0.003	0.010	0.19	0.02	0.01	66.6	0.0028	0.0077	0.153	0.014	0.00475
Diesel	6.2	424	0.017	0.048	0.95	0.09	0.03	68.7	0.0028	0.0077	0.153	0.014	0.00475
Fuel Oil	2.3	173	0.007	0.018	0.36	0.03	0.01	73.7	0.0028	0.0077	0.153	0.014	0.00475
Aviation Fuels	0.2	16	0.001	0.002	0.04	0.00	0.00	68.7	0.0028	0.0077	0.153	0.014	0.00475
LPG	1.0	60	0.003	0.008	0.15	0.01	0.00	60.4	0.0028	0.0077	0.153	0.014	0.00475
Other	0.1	7	0.000	0.001	0.02	0.00	0.00	72.9	0.0028	0.0077	0.153	0.014	0.00475
Solid	19.9	1,837	0.039	0.359	7.19	1.69	0.38						
Coal	19.9	1,837	0.039	0.359	7.19	1.69	0.38	92.1	0.00197	0.018	0.36	0.085	0.019
Biofuels	21.1		0.301	0.115	2.30	30.15	1.00		0.014	0.005	0.109	1.429	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 8) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ)					
								C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Transport	136.5	9,138	7.185	0.383	73.67	631.66	133.68						
Liquid	134.0	9,006	5.768	0.376	72.81	630.04	133.67						
Petrol	87.5	5,826	5.2	0.3	40.85	608.79	124.65	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	29.9	2,056	0.4	0.1	21.49	14.52	5.69	68.7	0.013	0.00297	0.718	0.485	0.19
Fuel Oil	3.2	238	0.0	0.0	6.43	0.14	0.61	73.7	0.0136	0.00177	1.995	0.044	0.19
Aviation Fuels	9.4	645	0.0	0.0	2.59	1.07	0.45	68.7	0.0015	0.00108	0.276	0.114	0.0475
LPG	4.0	242	0.2	0.0	1.44	5.52	2.28	60.4	0.04	0.0028	0.361	1.38	0.57
Gas	2.5	132	1.4	0.0	0.86	1.62	0.01						
CNG	2.5	132	1.4	0.0	0.86	1.62	0.01	52.8	0.567	0.0028	0.342	0.648	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 9) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ)					
								C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 a Civil Aviation													
1 A 3 a i International Aviation (International Bunkers)	19.5	1,340	0.029	0.021	5.38	2.22	0.93						
Aviation Fuels	19.5	1,340	0.029	0.021	5.38	2.22	0.93	68.7	0.0015	0.00108	0.276	0.114	**0.0475**
1 A 3 a ii Domestic	9.4	645	0.014	0.010	2.59	1.07	0.45						
Aviation Fuels	9.4	645	0.014	0.010	2.59	1.07	0.45	68.7	0.0015	0.00108	0.276	0.114	**0.0475**

Energy: 1A Fuel Combustion Activites (Sheet 10) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ)					
								C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Road & Marine Transportation	127.1	8,493	7.17	0.37	71.07	630.59	133.24						
Liquid	124.6	8,361	5.75	0.37	70.22	628.97	133.23						
Petrol	87.5	5,826	5.16	0.26	40.85	608.79	124.65	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	29.9	2,056	0.39	0.09	21.49	14.52	5.69	68.7	0.013	0.00297	0.718	0.485	0.19
Fuel Oil	3.2	238	0.04	0.01	6.43	0.14	0.61	73.7	0.0136	0.00177	1.995	0.044	0.19
LPG	4.0	242	0.16	0.01	1.44	5.52	2.28	60.4	0.04	0.0028	0.361	1.38	0.57
Gas	2.5	132	1.42	0.01	0.86	1.62	0.01						
CNG	2.5	132	1.42	0.01	0.86	1.62	0.01	52.8	0.567	0.0028	0.342	0.648	0.0045
1 A 3 d i International Marine	12.2	875	0.163	0.027	18.21	2.65	2.32						
Diesel	4.8	330	0.062	0.014	3.45	2.33	0.91	68.7	0.0130	0.00297	0.718	0.485	0.19
Marine	7.4	545	0.101	0.013	14.76	0.33	1.41	73.7	0.0136	0.00177	1.995	0.044	0.19

Energy: 1A Fuel Combustion Activites (Sheet 11) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 Small Combustion	42.9	2,989	0.145	0.642	5.35	2.80	4.42						
Liquid	26.0	1,787	0.057	0.325	3.21	0.37	2.88						
Petrol	4.1	274	0.008	0.042	0.49	0.06	0.47	66.6	0.0020	0.0102	0.118	0.014	0.115
Diesel	17.3	1,186	0.037	0.171	2.13	0.25	2.15	68.7	0.0021	0.0099	0.124	0.014	0.125
Fuel Oil	3.3	240	0.007	0.095	0.49	0.05	0.19	73.7	0.0020	0.0292	0.149	0.015	0.060
Aviation Fuels	0.6	39	0.001	0.014	0.06	0.01	0.05	68.7	0.0023	0.0247	0.107	0.014	0.095
LPG	0.8	48	0.004	0.003	0.04	0.01	0.00	60.4	0.0045	0.0040	0.050	0.012	0.005
Solid	7.9	727	0.079	0.297	1.76	2.35	1.50						
Coal	7.9	727	0.079	0.297	1.76	2.35	1.50	92.1	0.0100	0.038	0.22	0.30	0.19
Gas	9.0	475	0.009	0.019	0.38	0.08	0.04						
CNG	9.0	475	0.009	0.019	0.38	0.08	0.04	52.8	0.0011	0.0022	0.043	0.0088	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 12) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 a Commercial / Institutional	18.7	1,321	0.059	0.472	1.98	1.04	0.95						
Liquid	9.14	633	0.007	0.200	0.72	0.14	0.04						
Petrol	1.49	99	0.001	0.022	0.09	0.02	0.007061	66.6	0.0006	0.0149	0.061	0.015	0.00475
Diesel	5.36	368	0.003	0.080	0.33	0.08	0.025471	68.7	0.0006	0.0149	0.061	0.015	0.00475
Fuel Oil	1.92	142	0.003	0.085	0.28	0.03	0.009137	73.7	0.0015	0.0442	0.147	0.016	0.00475
Aviation Fuels	0.26	18	0.000	0.012	0.02	0.00	0.001251	68.7	0.0015	0.0442	0.061	0.015	0.00475
LPG	0.10	6	0.000	0.001	0.01	0.00	0.000475	60.4	0.0006	0.0149	0.061	0.015	0.00475
Solid	4.7	429	0.047	0.261	1.04	0.86	0.89						
Coal	4.7	429	0.047	0.261	1.04	0.86	1	92.1	0.01	0.0561	0.224	0.185	0.19
Gas	4.9	259	0.005	0.011	0.21	0.04	0.02						
Natural Gas	4.9	259	0.005	0.011	0.21	0.04	0	52.8	0.0011	0.0022	0.043	0.0086	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 13) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 b Residential	8.2	571	0.041	0.046	0.93	1.54	0.64						
Liquid	0.9	56.4	0.005	0.002	0.04	0.01	0.00						
Petrol	0.1	3.6	0.000	0.000	0.00	0.00	0.00026	66.6	0.005	0.0024	0.048	0.012	0.00475
Diesel	0.1	9.4	0.001	0.000	0.01	0.00	0.000647	68.7	0.005	0.0024	0.048	0.012	0.00475
Fuel Oil	0.0	0.1	0.000	0.000	0.00	0.00	6.34E-06	73.7	0.005	0.0024	0.048	0.012	0.00475
Aviation Fuels	0.0	1.1	0.000	0.000	0.00	0.00	7.33E-05	68.7	0.005	0.0024	0.048	0.012	0.00475
LPG	0.7	42.3	0.004	0.002	0.03	0.01	0.003325	60.4	0.005	0.0024	0.048	0.012	0.00475
Solid	3.2	298	0.032	0.036	0.71	1.49	0.61						
Coal	3.2	298	0.032	0.036	0.71	1.49	1	92.1	0.01	0.011	0.22	0.46	0.19
Gas	4.1	216	0.004	0.009	0.17	0.04	0.02						
Natural Gas	4.1	216	0.004	0.009	0.17	0.04	0	52.8	0.001	0.0021	0.042	0.009	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 14) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 c Agriculture / Forestry / Fishing	16.0	1,097	0.045	0.123	2.44	0.22	2.83						
Liquid	16.0	1,097	0.045	0.123	2.44	0.22	2.83						
Petrol	2.6	171	0.007	0.020	0.39	0.04	0.47	66.6	0.0028	0.0077	0.153	0.014	0.181
Diesel	11.8	808	0.033	0.091	1.80	0.16	2.13	68.7	0.0028	0.0077	0.153	0.014	0.181
Fuel Oil	1.3	98	0.004	0.010	0.20	0.02	0.19	73.7	0.0028	0.0077	0.153	0.014	0.139
Aviation Fuels	0.3	19	0.001	0.002	0.04	0.00	0.05	68.7	0.0028	0.0077	0.153	0.014	0.183

Energy: 1A Fuel Combustion Activites (Sheet 15) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 5 Other	0.1	6	0.000	0.001	0.02	0.01	0.001						
Solid													
Coal	0.1	6	0.000	0.001	0.02	0.01	0.001	92.1	0.0023	0.0156	0.313	0.088	**0.019**

IPCC Standard Data Tables 1992

Standard Data Table 1

Energy: 1B1 Fugitive Emissions from Fuels (Coal Mining)

	Source and Sink Categories	Activity Data Production (Mt) A	Methane Emissions (Gg) B	Emission Factor (Gg/Mt) C = B/A
1 B 1	**Solid Fuels**	2.95	10.91	
1 B 1 a	Coal Mining			
1 B 1 a i	Underground Mines			
	Underground Activities	0.46	8.10	17.600
	Post-Mining Activities	0.46	0.73	1.600
1 B 1 a ii	Surface Mines			
	Surface Activities	2.49	1.92	0.770
	Post-Mining Activities	2.49	0.17	0.067
1 B 1 b	Solid Fuel Transformation			
1 B 1 c	Other			

Energy: 1B2 Fugitive Emissions from Fuels (Oil and Natural Gas)

Source and Sink Categories			Activity Data	Emissions Estimates			Aggregate Emission Factors		
			Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
1 B 2 a	**Oil**								
	i	Exploration	NE						
	ii	Production of Crude Oil	NE						
	iii	Transport of Crude Oil	NE						
	iv	Refining/Storage	NE						
	v	Distribution of Oil Products	NE						
	vi	Other	NE						
1 B 2 b	**Natural Gas**								
	i	Production/Processing				NE			
	ii	Transmission/Distribution	41.0	7.68	1.06	NE	0.187	0.0258	
	iii	Other Leakage				NE			
1 B 2 c	**Venting and Flaring**								
	i	Oil				NE			
	ii	Natural Gas				NE			
	iii	Combined	8.9	0.78	311	NE	0.088	34.9	

Energy: 1B2 Fugitive Emissions from Fuels (Geothermal)

Source and Sink Categories	Activity Data	Emissions Estimates			Aggregate Emission Factors		
	Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
Geothermal	81.1	2.488	355.0	NE	0.031	4.4	

Standard Data Table 2
Industrial Processes 1992

Source and Sink Categories	Activity Data A Production Quantity (kt)	Methane Emissions B Full mass of Pollutant (Gg) CO_2	Aggregate Emission Factors C Tonne of Pollutant per tonne of Product (t/t) CO_2
A Iron and Steel	755.0	1,564.0	2.100
B Non-Ferrous Metals			
Aluminium	244.0	423.0	1.733
Other			
C Inorganic Chemicals (excepting solvent use)			
Hydrogen	23.0	158.0	6.900
D Non-Metallic Products			
Cement	795.0	405.0	0.510
Lime	132.0	95.0	0.720

Non CO_2 Emissions from Industrial Processes 1992

Source and Sink Categories	Activity Data A Production Quantity (kt)	Emission Estimates B Full Mass of Pollutants (Gg) Tonnes x 1000								
		CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2
A Iron and Steel	755.2000	0.4593			0.9555					0.7270
B Non Ferrous Metals										
Aluminium Production	244.4230							0.0936		5.1500
Other										
C Inorganic Chemicals (excepting solvent use)										
Nitric Acid										
Fertiliser Production	1,178.0000									11.6622
Other	146.9590		0.1029							
D Organic Chemicals										
Adipic Acid										
Other										
E Non-Metallic Mineral Products										
Cement	886.0540	0.4866			1.4914					0.8454
Lime	124.9720	0.0283			0.0142					0.0045
Other	202.4010	0.0000			0.0000	8.9336				0.0173
F Other (ISIC)	7,947.0214					10.8480	neg	0.0000	0.0066	0.0000
Grand Total		**0.9742**	**0.1029**		**2.4610**	**19.7816**	neg	**0.0936**	**0.0066**	**18.4064**

Source and Sink Categories	Aggregate Emission Factors C Tonne of Pollutant per Tonne of Product (t / t)								
	CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2
A Iron and Steel	0.00061			0.00127					0.00096
B Non Ferrous Metals									
Aluminium Production							0.00038		0.02107
Other									
C Inorganic Chemicals (excepting solvent use)									
Nitric Acid									
Fertiliser Production									0.00990
Other		0.00070							
D Organic Chemicals									
Adipic Acid									
Other									
E Non-Metallic Mineral Products									
Cement	0.00055			0.00168					0.00095
Lime	0.00023			0.00011					0.00004
Other	0.00000				0.04414				0.00009
F Other (ISIC)					0.00137				0.00000
Grand Total									

Standard Data Table 3
Solvent and Other Product Use 1992

Source and Sink Categories	Activity Data A Quantity Consumed (kt)	Emissions Estimates B Full Mass of Pollutant (Gg)			Aggregate Emission Estimates C Tonne of Pollutant per Tonne of Product (t / t) C = B / A		
		N_2O	HFC	NMVOC	N_2O	HFC	NMVOC
A Paint Application	47.44			13.9169			0.2933
B Degreasing and Dry Cleaning	0.76			1.2536			1.6478
C Chemical Products Manufacture / Processing							
D Other	11.06			11.2529			1.0172
Total				**26.4234**			

Standard Data Table 4
Agriculture: 4A & 4B Enteric Fermentation and Manure Management 1992

Source and Sink Categories	Activity Data A	Emission Estimates B		Aggregate Emission Factor C	
	Number of Animals	Enteric Fermentation	Manure Management	Enteric Fermentation	Manure Management
	(1000)*	(Gg CH4)		(kg CH4 per head per year) C = (B/A) X 1000	
Totals	**62,380.753**	**1,419.305**	**17.173**		
Cattle					
a Dairy	3,467.824	266.329	3.083	76.8	0.889
b Non-Dairy	4,676.497	315.664	4.251	67.5	0.909
Sheep	52,568.393	793.783	9.357	15.1	0.178
Goats	532.797	8.791	0.063	16.5	0.119
Deer	1,135.242	34.738	0.419	30.6	0.369
Total ruminant emission for 1995 is 1,436.478 Gg					

1992 New Zealand N_2O Emissions Calculated with the PHASE II Methodolgy

Source and Sink Categories	Emission Estimates (kg N_20 - N)
Total	**27,338,138**
Direct Soil Emissions	**2,931,182**
Synthetic Fertilizers	1,392,126
Animal Wastes	464,653
Biological N2 Fixation	60,371
Crop Residue	184,033
Cultivated Histosols	830,000
Animal Production	**14,418,567**
Animals	0
Animals Waste Management Systems	14,418,567
Indirect Emissions	**9,988,389**
Atmospheric Deposition	3,336,638
Nitrogen Leaching and Runoff	6,444,133
Human Sewage	207,618
Note: 27,338 tonnes N_2O - N is equivalent to 42,960 tonnes N_2O or 42.96 Gg	

Detailed information on the calculations and emission factors used is in Annex 4.

Greenhouse gas emissions from field burning of agricultural residues
All Cereals

Year	Production June Years (Gg Crop)	Production Annual (Gg Crop)	Production 3 Year Average (Gg Crop)	Total Biomass Burned (Gg dm)	Quantity of Carbon Released (Gg C)	Total Nitrogen Release (Gg N)
1992	191.04	205.2	206.7	20.1	9.7	0.12

Detailed calculations are in Annex 13.

Standard Data Table 5

Land Use Change and Forestry: 5A (Sheet 1) Changes in Forest and Other Woody Biomass Stocks - Annual Growth Increment 1992

Source and Sink Categories			Activity Data	Uptake Estimates	Aggregate Uptake Factor
Sector Specific Data (units) Land Type			Area of Forest/Biomass Stocks (kha)	Total Carbon Uptake Increment (Gg C)	Carbon Uptake Factor (t C/ha)
Temperate Forests	Plantations (specify type)	Pinus Radiata	1,337.13[1]	-8,498	6.4[2]

Notes: 1 The figure for the area of forest stocks is for plantation forests.
2 This factor will also vary from year to year as the average age and hence growth rates of the planted forest estate changes.
All figures are reported as three year averages with the base year in the middle.

Land Use Change and Forestry: 5A (Sheet 2) Changes in Forest and Other Woody Biomass Stocks - Annual Harvest 1992

Source and Sink Categories	Activity Data	Carbon Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units)	Amount of Biomass Removed (kt dm)	Carbon Emission/Removal Estimates (Gg C)	Carbon Emission Factors (t C/t dm)
Total Biomass Removed in Commercial Harvest	6,313	3,156	0.5
Traditional Fuelwood Consumed			
Total Other Wood Use			
Total Biomass Consumption	**6,313**	**3,156**	

Note: 1 The figure given includes roundwood removals from both plantation and native forests and post harvest slash

Land Use Change and Forestry: 5A (Sheet 3) Changes in Forest and Other Woody Biomass Stocks - Net CO_2 Emissions/Removals 1992

Source and Sink Categories	Emission/Uptake C (Gg)	Emissions/Removals CO_2 (Gg)
Total Annual Growth Increment	-8,498	-31,159
Total Annual Harvest	3,156	11,572
Net Emissions (+) or Removals (-)	**-5,342**	**-19,587**

Land Use Change and Forestry: 5B (Sheet 1) Forest and Grassland Conversion - CO_2 Release from Burning Aboveground Biomass 1992

Source and Sink Categories			Activity Data				Emission Estimates		Aggregate Emission Factors	
Sector Specific Data (units) Land Type			Area Converted Annually (kha)	Annual Loss of Biomass (kt dm)	Quantity of Biomass Burned (on and off-site) (kt dm)		Quantity of C Released[1] (kt C)		Carbon Fraction of Biomass Burned	
					On Site	Off Site	On Site	Off Site	On Site	Off Site
Temperate Forests	Evergreen	Primary[2] Secondary	0.17	110.1	110.1	NA	49.5	NA	0.5	NA
Other (specify): Mixed Scrub[3]			6.15	492.3	492.3	NA	221.6	NA	0.5	NA
Total C Released							271.1	NA		
Total of On Site and Off Site C Released							271.1			
Total CO_2 Released							994.0			

Notes: 1 Quantity of Biomass burned is adjusted for the portion of carbon in biomass that remains on-site as charcoal (10% of biomass carbon).
2 Includes burning (from natural and anthropogenic causes) of Native Forests and Plantation Forests (ie. mixed primary/secondary and plantation).
3 Includes burning (from natural and anthropogenic causes) of mixed scrub and prescribed burning of scrub cleared for Plantation Forestry.
All figures are reported as three year averages with the base year in the middle. See Annex 5 for further details.
NA = Not Applicable

Land Use Change and Forestry: 5B (Sheet 2) Forest and Grassland Conversion - Release of Non-CO_2 GHG from On-Site Burning of Forests 1992

Source and Sink Categories	Activity Data		Emissions Estimates				Aggregate Emission Ratios			
Sector Specific Data (units) Land Type	Carbon Release (Gg)	Nitrogen Release (Gg)	Emissions Estimates (Gg)				Aggregate Emission Ratios			
			CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
On Site Burning of Forests	271.08	2.71	4.807	42.108	0.030	1.079	0.160	0.140	0.011	0.398

Land Use Change and Forestry: 5B (Sheet 3) Forest and Grassland Conversion - CO_2 Release from Decay of Aboveground Biomass 1992

Source and Sink Categories			Activity Data			Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units) Land Type			5-Year Average Area Converted[1] (kha/yr)	5-Year Average Annual Loss of Biomass (kt dm/yr)	Average Quantity of Biomass to Decay (kt dm)	Carbon Released from Decay (kt C)	Carbon Fraction of Aboveground Biomass
Temperate Forests	Evergreen	Primary[2] Secondary					
Other (specify): Mixed Scrub			2.864[2]	229	229	115	0.5
Total C Released from Decay						115	
Total CO_2 Released from Decay						420	

Note: 1 Figures are given as previous five year average.
2 Only includes the area of mixed scrub cleared for plantation forestry that is left to decay (approximately 50% of toal area converted), the remainder is burned and is included under 5B Sheet 1.

Land Use Change and Forestry: 5B (Sheet 4) Forest and Grassland Conversion - Soil Carbon Release 1992

Soil carbon is not estimated as it is assumed to remain in balance or increase slightly from the conversion of pastoral land and mixed scrub to first rotation plantation forestry. No data is currently available on whether other forms of conversion may be occurring which result in a release of soil carbon.

Land Use Change and Forestry: 5B (Sheet 5) Forest and Grassland Conversion - Total CO_2 Emissions 1992

Category	Emissions (Gg)
CO_2 Release from Burning of Aboveground Biomass	994.0
CO_2 from Decay of Aboveground Biomass	420
CO_2 from Soil Carbon Release	ne
Total	1,414
Note: ne = Not Estimated	

Land Use Change and Forestry: 5C (Sheet 1-3) Abandonment of Managed Lands 1992

Not Estimated. No data is currently available on the extent of abandoned managed lands on a national basis. It is known however that considerable regeneration is occurring in some areas, but these have yet to be quantified.

Standard Data Table 6: Waste

Detailed information and calculations for waste sector emissions are in Annex 6 for wastewater, and Annex 14 for landfills. Emissions from landfills are calculated using the Phase II Guidelines.

Waste sector methane in Gg	1992
Total	**151.71**
Landfills	147.43
Wastewater	4.28

ANNEX 10: Greenhouse gas inventory, 1993

All data is presented in gigagrams (Gg)

Short Summary Report for New Zealand's Greenhouse Gas Inventory, 1993

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**27,276**	**-16,136**	**1,593.408**	**45.955**	**125.324**	**737.478**	**188.250**	**0.008**	**0.100**	**0.023**	**21.890**
1 All Energy (Fuel Combustion and Fugitive)	**24,506**		**29.393**	**2.774**	**121.270**	**679.750**	**142.980**				
A Fuel Combustion	23,875		7.897	2.774	121.270	679.750	142.980				
B Fugutive Emissions from Fuels	631		21.496								
2 Industrial Processes	**2,770**		**0.116**		**2.543**	**1.067**	**18.446**	**0.008**	**0.100**	**0.023**	**21.890**
3 Solvent and Other Product Use							**26.824**				
4 Agriculture			**1,409.204**	**43.144**	**0.161**	**3.975**					
5 Land Use Change and Forestry		**-16,136**	**6.015**	**0.037**	**1.350**	**52.686**					
6 Waste			**148.680**								
7 Other											
International Bunkers	**2,280**		**0.203**	**0.048**	**25.170**	**4.890**	**3.390**				

Summary Report for New Zealand's Greenhouse Gas Inventory, 1993

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**27,276**	**-16,136**	**1,593.408**	**45.955**	**125.324**	**737.478**	**188.250**	**0.008**	**0.100**	**0.023**	**21.890**
1 All Energy (Fuel Combustion and Fugitive)	**24,506**		**29.393**	**2.774**	**121.270**	**679.750**	**142.980**				
A Fuel Combustion	23,875		7.897	2.774	121.270	679.750	142.980				
1 Energy & Transformation Industries	6,598		0.110	1.070	23.420	2.340	0.670				
2 Industry (ISIC)	4,923		0.454	0.755	15.110	33.450	1.750				
3 Transport	9,554		7.186	0.400	77.410	641.050	136.100				
4 Small Combustion	2,700		0.144	0.532	4.990	2.810	4.440				
5 Other	100		0.003	0.017	0.340	0.100	0.020				
B Fugutive Emissions from Fuels	631		21.496								
1 Solid Fuels			11.090								
2 Oil, Natural Gas & Geothermal	631		10.406								
2 Industrial Processes	**2,770**		**0.116**		**2.543**	**1.067**	**18.446**	**0.008**	**0.100**	**0.023**	**21.890**
3 Solvent and Other Product Use							**26.824**				
4 Agriculture			**1,409.204**	**43.144**	**0.161**	**3.975**					
A Enteric Fermentation			1,392.141								
B Manure Management			16.874								
D Agricultural Soils	ne			43.140							
F Field Burning of Agricultural Residues			0.189	0.004	0.161	3.975					
G Other											
5 Land Use Change and Forestry		**-16,136**	**6.015**	**0.037**	**1.350**	**52.686**					
A Changes in Forest Stocks		-17,798									
B Forest and Grassland Conversion	1,662		6.015	0.037	1.350	52.686					
C Abandonment of Managed Lands		ne									
G Other											
6 Waste			**148.680**								
A Solid Waste Disposal on Land			144.400								
B Wastewater Treatment			4.280								
C Waste Incineration											
7 Other											
International Bunkers	**2,280**		**0.203**	**0.048**	**25.170**	**4.890**	**3.390**				
A Air	1,353		0.030	0.020	5.440	2.250	0.940				
B Marine	927		0.173	0.028	19.730	2.640	2.450				

Standard Data Table 1

Energy: 1A Fuel Combustion Activites (Sheet 2) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A Fuel Combustion Activities	**321.6**	**23,875**	**7.897**	**2.774**	**121.27**	**679.75**	**142.97**	**74.2**	**0.025**	**0.0086**	**0.38**	**2.11**	**0.444**
Liquid	**174.5**	**11,800**	**5.982**	**0.697**	**81.38**	**640.05**	**138.99**	**67.6**	**0.034**	**0.0040**	**0.47**	**3.67**	**0.797**
Petrol	92.2	6,137	5.229	0.296	41.80	615.86	126.52	66.6	0.057	0.0032	0.45	6.68	1.373
Diesel	55.2	3,792	0.499	0.282	27.60	16.97	8.75	68.7	0.009	0.0051	0.50	0.31	0.159
Fuel Oil	8.2	603	0.057	0.050	7.09	0.21	0.81	73.7	0.007	0.0062	0.87	0.03	0.099
Aviation Fuels	10.8	739	0.017	0.029	2.85	1.16	0.50	68.7	0.002	0.0027	0.26	0.11	0.047
LPG	6.0	362	0.174	0.023	1.71	5.82	2.40	60.4	0.029	0.0038	0.28	0.97	0.400
Asphalt	2.1	158	0.006	0.016	0.32	0.03	0.01	75.1	0.003	0.0077	0.15	0.01	0.005
Unspecified	0.1	7	0.000	0.001	0.02	0.00	0.00	72.9	0.003	0.0077	0.15	0.01	0.005
Solid	**35.2**	**3,260**	**0.129**	**0.708**	**11.87**	**4.40**	**2.00**						
Coal	35.2	3,260	0.129	0.708	11.87	4.40	2.00	92.6	0.004	0.0201	0.34	0.12	0.057
Gas	**90.6**	**8,816**	**1.481**	**1.252**	**25.68**	**4.72**	**0.96**	**97.4**	**0.016**	**0.0138**	**0.28**	**0.05**	**0.011**
Natural Gas	78.6	8,126	0.176	1.216	24.32	3.10	0.91	103.4	0.002	0.0155	0.31	0.04	0.012
Refinery Gas	9.6	570	0.013	0.029	0.58	0.14	0.04	59.1	0.001	0.0030	0.06	0.02	0.005
CNG	2.3	120	1.293	0.006	0.78	1.48	0.01	52.5	0.567	0.0028	0.34	0.65	0.005
Biofuels	**21.4**		**0.305**	**0.117**	**2.33**	**30.58**	**1.02**		**0.014**	**0.0055**	**0.11**	**1.43**	**0.048**

Energy: 1A Fuel Combustion Activites (Sheet 3) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 Energy and Transformation Industries	87.3	6,598	0.110	1.070	23.42	2.34	0.67	75.6	0.00126	0.0123	0.27	0.027	0.0076
Liquid	3.7	275	0.010	0.028	0.56	0.05	0.02						
Petrol	0.0	2	0.000	0.000	0.00	0.00	0.00	66.6	0.00003	0.0033	0.07	0.014	0.00475
Diesel	0.1	4	0.000	0.000	0.00	0.00	0.00	68.7	0.00003	0.0033	0.07	0.014	0.00475
Fuel Oil	1.5	111	0.004	0.012	0.23	0.02	0.01	73.7	0.00280	0.0077	0.15	0.014	0.00475
Aviation Fuels	2.1	158	0.006	0.016	0.32	0.03	0.01	75.1	0.00280	0.0077	0.15	0.014	0.00475
Solid	4.8	446	0.003	0.004	2.10	0.06	0.02						
Coal	4.8	446	0.003	0.004	2.10	0.06	0.02	93.0	0.00060	0.0008	0.44	0.013	0.00475
Gas	78.8	5,877	0.097	1.038	20.76	2.22	0.63						
Natural Gas	69.1	5,307	0.085	1.009	20.18	2.08	0.58	76.8	0.00123	0.0146	0.29	0.030	0.0084
Refinery Gas	9.6	570	0.013	0.029	0.58	0.14	0.04	59.1	0.00130	0.0030	0.06	0.015	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 4) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 a Electricity and Heat Production	73.9	4,099	0.01	0.83	18.66	1.24	0.33						
1 A 1 a i Electricity Generation	73.9	4,099	0.01	0.83	18.66	1.24	0.33						
Public Generation	73.9	4,099	0.01	0.83	18.66	1.24	0.33						
Liquid	0.1	6	0.00	0.00	0.01	0.00	0.00						
Motor Gasoline	0.0	2	0.00	0.00	0.00	0.00	0.00	66.6	0.00003	0.00330	0.065	0.014	0.00475
Diesel	0.1	4	0.00	0.00	0.00	0.00	0.00	68.7	0.00003	0.00330	0.065	0.014	0.00475
Fuel Oil	0.00	0	0.00	0.00	0.00	0.00	0.00	73.6	0.00070	0.00960	0.191	0.014	0.00475
Solid	4.79	446	0.0029	0.004	2.10	0.06	0.02						
Sub-bituminous Coal	4.79	446	0.0029	0.004	2.10	0.06	0.02	92.99	0.00060	0.0008	0.438	0.013	0.00475
Gas	68.98	3,647	0.006	0.828	16.56	1.17	0.31						
Natural Gas	68.98	3,647	0.006	0.83	16.56	1.17	0.31	52.9	0.0001	0.012	0.24	0.017	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 5) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 b Petroleum Refining	23.2	847	0.023	0.057	1.14	0.20	0.06						
Liquid	3.61	269	0.010	0.028	0.55	0.05	0.02						
Fuel Oil	1.51	111	0.004	0.012	0.23	0.02	0.01	73.7	0.0028	0.0077	0.153	0.014	0.00475
Asphalt	2.11	158	0.006	0.016	0.32	0.03	0.01	75.1	0.0028	0.0077	0.153	0.014	0.00475
Gas	9.79	578	0.013	0.029	0.59	0.15	0.04						
Refinery Gas	9.65	570	0.013	0.029	0.58	0.14	0.04	59.1	0.0013	0.003	0.06	0.015	0.0045
Natural Gas	0.14	8	0.000	0.000	0.01	0.00	0.00	57.1	0.0013	0.003	0.06	0.015	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 6) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 c Solid Fuel Transformation and Other Energy Industries		1,652	0.078	0.181	3.62	0.90	1.27						
1 A 1 c i Solid Fuel Transformation		0	0	0	0	0	1.00						
1 A 1 c ii Other Energy Industries		1,652	0.078	0.18	3.62	0.90	0.27						
Gas		1,652	0.078	0.181	3.62	0.90	0.27						
Synthetic Petrol													
Natural Gas		1,380	0.073	0.17	3.36	0.84	0.25						
Oil & Gas Extraction													
Natural Gas		272	0.006	0.01	0.26	0.06	0.02						

Energy: 1A Fuel Combustion Activites (Sheet 7) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 2 Industry	114.2	4,923	0.454	0.755	15.11	33.45	1.75						
Gas	62.2	2,322	0.081	0.187	3.73	0.93	0.28						
Methanol													
Natural Gas		682											
Urea													
Natural Gas		143											
Other Industry													
Natural Gas		1,497											
Liquid	9.3	639	0.026	0.072	1.42	0.13	0.04	68.7	0.0028	0.0077	0.153	0.014	0.00475
Petrol	0.4	27	0.001	0.003	0.06	0.01	0.00	66.6	0.0028	0.0077	0.153	0.014	0.00475
Diesel	5.7	394	0.016	0.044	0.88	0.08	0.03	68.7	0.0028	0.0077	0.153	0.014	0.00475
Fuel Oil	1.8	135	0.005	0.014	0.28	0.03	0.01	73.7	0.0028	0.0077	0.153	0.014	0.00475
Aviation Fuels	0.2	15	0.001	0.002	0.03	0.00	0.00	68.7	0.0028	0.0077	0.153	0.014	0.00475
LPG	1.0	60	0.003	0.008	0.15	0.01	0.00	60.4	0.0028	0.0077	0.153	0.014	0.00475
Other	0.1	7	0.000	0.001	0.02	0.00	0.00	72.9	0.0028	0.0077	0.153	0.014	0.00475
Solid	21.3	1,962	0.042	0.380	7.62	1.81	0.40						
Coal	21.3	1,962	0.042	0.380	7.62	1.81	0.40	92.1	0.0020	0.0178	0.358	0.085	0.019
Biofuels	21.4		0.305	0.117	2.33	30.58	1.02		0.0142	0.0055	0.109	1.429	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 8) - Detailed Technology Based Calculation

Source and Sink Categoriies	**Activity Data**	**Emissions Estimates**						**Aggregate Emission Factors**					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Transport	142.6	9,554	7.186	0.400	77.41	641.05	136.10						
Liquid	140.30	9,434	5.894	0.393	76.63	639.57	136.09						
Petrol	88.48	5,893	5.2	0.3	41.32	615.81	126.08	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	34.39	2,363	0.4	0.1	24.69	16.68	6.53	68.7	0.0130	0.00297	0.718	0.485	0.19
Fuel Oil	3.17	234	0.0	0.0	6.32	0.14	0.60	73.7	0.0136	0.00177	1.995	0.044	0.19
Aviation Fuels	10.06	691	0.0	0.0	2.78	1.15	0.48	68.7	0.0015	0.00108	0.276	0.114	0.0475
LPG	4.20	254	0.2	0.0	1.52	5.80	2.39	60.4	0.040	0.00280	0.361	1.38	0.57
Gas	2.28	120	1.3	0.0	0.78	1.48	0.01						
CNG	2.28	120	1.3	0.0	0.78	1.48	0.01	52.5	0.567	0.0028	0.342	0.648	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 9) - Detailed Technology Based Calculation

Source and Sink Categoriies	**Activity Data**	**Emissions Estimates**						**Aggregate Emission Factors**					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 a Civil Aviation													
1 A 3 a i International Aviation (International Bunkers)	19.7	1,353	0.03	0.02	5.44	2.25	0.94						
Aviation Fuels	19.7	1,353	0.03	0.02	5.44	2.25	0.94	68.7	0.0015	0.00108	0.276	0.114	**0.0475**
1 A 3 a ii Domestic	10.06	691	0.02	0.01	2.78	1.15	0.48						
Aviation Fuels	10.06	691	0.02	0.01	2.78	1.15	0.48	68.7	0.0015	0.00108	0.276	0.114	**0.0475**

Energy: 1A Fuel Combustion Activites (Sheet 10) - Detailed Technology Based Calculation

Source and Sink Categoriies	**Activity Data**	**Emissions Estimates**						**Aggregate Emission Factors**					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Road & Marine Transportation	132.5	8,862	7.17	0.39	74.63	639.90	135.62						
Liquid	130.2	8,743	5.88	0.38	73.85	638.42	135.61						
Petrol	88.5	5,893	5.22	0.26	41.32	615.81	126.08	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	34.4	2,363	0.45	0.10	24.69	16.68	6.53	68.7	0.013	0.00297	0.718	0.485	0.19
Fuel Oil	3.2	234	0.04	0.01	6.32	0.14	0.60	73.7	0.0136	0.00177	1.995	0.044	0.19
LPG	4.2	254	0.17	0.01	1.52	5.80	2.39	60.4	0.04	0.0028	0.361	1.38	0.57
Gas	2.28	120	1.29	0.01	0.78	1.48	0.01						
CNG	2.28	120	1.29	0.01	0.78	1.48	0.01	52.5	0.567	0.0028	0.342	0.648	0.0045
1 A 3 d i International Marine	12.9	927	0.173	0.028	19.73	2.64	2.45						
Diesel	4.7	323	0.061	0.014	3.37	2.28	0.89	68.7	0.0130	0.00297	0.718	0.485	0.190
Marine	8.2	604	0.112	0.015	16.36	0.36	1.56	73.7	0.0136	0.00177	1.995	0.044	0.190

Energy: 1A Fuel Combustion Activites (Sheet 11) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 Small Combustion	38.7	2,700	0.144	0.532	4.99	2.81	4.44						
Liquid	21.2	1,451	0.052	0.204	2.77	0.30	2.84						
Petrol	3.2	215	0.007	0.030	0.42	0.05	0.43	66.6	0.0023	0.0094	0.129	0.014	0.134
Diesel	15.0	1,031	0.036	0.135	2.02	0.21	2.19	68.7	0.0024	0.0090	0.135	0.014	0.146
Fuel Oil	1.7	123	0.004	0.019	0.26	0.02	0.19	73.7	0.0027	0.0115	0.152	0.014	0.114
Aviation Fuels	0.5	33	0.001	0.016	0.04	0.01	0.02	68.7	0.0019	0.0341	0.083	0.015	0.047
LPG	0.8	48	0.004	0.003	0.04	0.01	0.00	60.4	0.0045	0.0040	0.050	0.012	0.005
Solid	8.0	752	0.082	0.307	1.82	2.43	1.55						
Coal	8.0	752	0.082	0.307	1.82	2.43	1.55	93.9	0.0102	0.038	0.23	0.30	0.19
Gas	9.5	497	0.010	0.020	0.40	0.08	0.04						
CNG	9.5	497	0.010	0.020	0.40	0.08	0.04	52.279	0.0011	0.0022	0.043	0.0088	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 12) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 a Commercial / Institutional	14.1	1,007	0.057	0.360	1.58	1.00	0.96						
Liquid	4.26	291	0.003	0.079	0.27	0.06	0.02						
Petrol	0.80	53	0.000	0.012	0.05	0.01	0.00	66.6	0.0006	0.0149	0.061	0.015	0.00475
Diesel	2.83	195	0.002	0.042	0.17	0.04	0.01	68.7	0.0006	0.0149	0.061	0.015	0.00475
Fuel Oil	0.17	13	0.000	0.008	0.03	0.00	0.00	73.7	0.0015	0.0442	0.147	0.016	0.00475
Aviation Fuels	0.35	24	0.001	0.015	0.02	0.01	0.00	68.7	0.0015	0.0442	0.061	0.015	0.00475
LPG	0.10	6	0.000	0.001	0.01	0.00	0.00	60.4	0.0006	0.0149	0.061	0.015	0.00475
Solid	4.7	444	0.048	0.270	1.08	0.89	0.92						
Coal	4.7	444	0.048	0.270	1.08	0.89	0.92	95.3	0.01034	0.05802	0.23168	0.19134	0.197
Gas	5.2	273	0.006	0.011	0.22	0.04	0.02						
Natural Gas	5.2	273	0.006	0.011	0.22	0.04	0.02	52.5	0.0011	0.0022	0.043	0.0086	

Energy: 1A Fuel Combustion Activites (Sheet 13) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 b Residential	8.5	588	0.042	0.048	0.96	1.59	0.66						
Liquid	0.9	55.9	0.004	0.002	0.04	0.01	0.00						
Petrol	0.1	3.4	0.000	0.000	0.00	0.00	0.00	66.6	0.005	0.0024	0.048	0.012	0.00475
Diesel	0.1	9.3	0.001	0.000	0.01	0.00	0.00	68.7	0.005	0.0024	0.048	0.012	0.00475
Fuel Oil	0.0	0.1	0.000	0.000	0.00	0.00	0.00	73.7	0.005	0.0024	0.048	0.012	0.00475
Aviation Fuels	0.0	0.9	0.000	0.000	0.00	0.00	0.00	68.7	0.005	0.0024	0.048	0.012	0.00475
LPG	0.7	42.3	0.004	0.002	0.03	0.01	0.00	60.4	0.005	0.0024	0.048	0.012	0.00475
Solid	3.3	308	0.033	0.037	0.74	1.54	0.64						
Coal	3.3	308	0.033	0.037	0.74	1.54	0.64	92.1	0.01	0.011	0.220	0.460	0.190
Gas	4.3	224	0.004	0.009	0.18	0.04	0.02						
Natural Gas	4.3	224	0.004	0.009	0.18	0.04	0.02	52.0116	0.001	0.0021	0.042	0.009	0.00446

Energy: 1A Fuel Combustion Activites (Sheet 14) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 c Agriculture / Forestry / Fishing	16.0	1,104	0.045	0.124	2.45	0.22	2.82						
Liquid	16.0	1,104	0.045	0.124	2.45	0.22	2.82						
Petrol	2.4	158	0.007	0.018	0.36	0.03	0.43	66.6	0.0028	0.0077	0.153	0.014	0.181
Diesel	12.0	827	0.034	0.093	1.84	0.17	2.18	68.7	0.0028	0.0077	0.153	0.014	0.181
Fuel Oil	1.5	111	0.004	0.012	0.23	0.02	0.19	73.7	0.0028	0.0077	0.153	0.014	0.126
Aviation Fuels	0.1	8	0.000	0.001	0.02	0.00	0.02	68.7	0.0028	0.0077	0.153	0.014	0.177
LPG	0.0	0	0.000	0.000	0.00	0.00	0.00						

Energy: 1A Fuel Combustion Activites (Sheet 15) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 5 Other	1.1	100	0.003	0.017	0.34	0.10	0.02						
Solid													
Coal	1.1	100	0.003	0.017	0.34	0.10	0.02	92.1	0.0023	0.0156	0.313	0.088	**0.019**

Standard Data Table 1

Energy: 1B1 Fugitive Emissions from Fuels (Coal Mining)

Source and Sink Categories		Activity Data Production (Mt) A	Methane Emissions (Gg) B	Emission Factor (Gg/Mt) C = B/A
1 B 1	**Solid Fuels**	3.10	11.09	
1 B 1 a	Coal Mining			
1 B 1 a i	Underground Mines			
	Underground Activities	0.43	8.16	18.900
	Post-Mining Activities	0.43	0.69	1.600
1 B 1 a ii	Surface Mines			
	Surface Activities	2.67	2.06	0.770
	Post-Mining Activities	2.67	0.18	0.067
1 B 1 b	Solid Fuel Transformation			
1 B 1 c	Other			

Energy: 1B2 Fugitive Emissions from Fuels (Oil and Natural Gas)

Source and Sink Categories			Activity Data	Emissions Estimates			Aggregate Emission Factors		
			Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
1 B 2 a	**Oil**								
	i	Exploration	NE						
	ii	Production of Crude Oil	NE						
	iii	Transport of Crude Oil	NE						
	iv	Refining/Storage	NE						
	v	Distribution of Oil Products	NE						
	vi	Other	NE						
1 B 2 b	**Natural Gas**								
	i	Production/Processing				NE			
	ii	Transmission/Distribution	40.3	7.23	0.8	NE	0.180	0.0206	
	iii	Other Leakage				NE			
1 B 2 c	**Venting and Flaring**								
	i	Oil				NE			
	ii	Natural Gas				NE			
	iii	Combined	7.9	0.68	271.00	NE	0.087	34.3	

Energy: 1B2 Fugitive Emissions from Fuels (Geothermal)

Source and Sink Categories	Activity Data	Emissions Estimates			Aggregate Emission Factors		
	Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
Geothermal	85.75	2.496	359.0	NE	0.029	4.2	

Standard Data Table 2
Industrial Processes 1993

Source and Sink Categories	Activity Data A Production Quantity (kt)	Methane Emissions B Full mass of Pollutant (Gg) CO_2	Aggregate Emission Factors C Tonne of Pollutant per tonne of Product (t/t) CO_2
A Iron and Steel	840.0	1,589.0	1.900
B Non-Ferrous Metals			
Aluminium	270.0	467.0	1.731
Other			
C Inorganic Chemicals (excepting solvent use)			
Hydrogen	25.0	161.0	6.600
D Non-Metallic Products			
Cement	904.0	461.0	0.510
Lime	128.0	92.0	0.720

Non CO_2 Emissions from Industrial Processes 1993

Source and Sink Categories	Activity Data A Production Quantity (kt)	Emission Estimates B Full Mass of Pollutants (Gg) Tonnes x 1000									Aggregate Emission Factors C Tonne of Pollutant per Tonne of Product (t / t)								
		CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2	CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2
A Iron and Steel	812.4000	0.5423			0.9793					0.7434	0.00067			0.00121					0.00092
B Non Ferrous Metals																			
Aluminium Production	269.5000							0.0999		5.8400							0.00037		0.02167
Other																			
C Inorganic Chemicals (excepting solvent use)																			
Nitric Acid																			
Fertiliser Production	1,450.0000									14.3550									0.00990
Other	165.1350		0.1156									0.00070							
D Organic Chemicals																			
Adipic Acid																			
Other																			
E Non-Metallic Mineral Products																			
Cement	927.8290	0.4932			1.5480					0.9333	0.00053			0.00167					0.00101
Lime	120.7730	0.0312			0.0156					0.0044	0.00026			0.00013					0.00004
Other	175.3084	0.0000			0.0000	7.3147				0.0141	0.00000				0.04172				0.00008
F Other (ISIC)	7,655.3649	0.0000			0.0000	11.1317	0.0075	0.0000	0.0234	0.0000	0.00000			0.00000	0.00145				0.00000
Grand Total		**1.0667**	**0.1156**		**2.5428**	**18.4464**	**0.0075**	**0.0999**	**0.0234**	**21.8901**									

Standard Data Table 3
Solvent and Other Product Use 1993

Source and Sink Categories	Activity Data A Quantity Consumed (kt)	Emissions Estimates B Full Mass of Pollutant (Gg)			Aggregate Emission Estimates C Tonne of Pollutant per Tonne of Product (t / t) C = B / A		
		N_2O	HFC	NMVOC	N_2O	HFC	NMVOC
A Paint Application	44.17			14.1674			0.3200
B Degreasing and Dry Cleaning	0.76			0.4032			0.5300
C Chemical Products Manufacture / Processing							
D Other	11.06			12.2530			1.1076
Total				**26.8236**			

Standard Data Table 4
Agriculture: 4A & 4B Enteric Fermentation and Manure Management 1993

Source and Sink Categories	Activity Data A	Emission Estimates B		Aggregate Emission Factor C	
	Number of Animals	Enteric Fermentation	Manure Management	Enteric Fermentation	Manure Management
	(1000)*	(Gg CH4)		(kg CH4 per head per year) C = (B/A) X 1000	
Totals	**60,037.800**	**1,392.141**	**16.874**		
Cattle					
a Dairy	3,550.140	272.651	3.156	76.8	0.889
b Non-Dairy	4,757.962	321.162	4.325	67.5	0.909
Sheep	50,298.361	759.505	8.953	15.1	0.178
Goats	352.858	5.822	0.042	16.5	0.119
Deer	1,078.479	33.001	0.398	30.6	0.369
Total ruminant emission for 1995 is 1,409.015 Gg					

1993 New Zealand N_2O Emissions Calculated with the PHASE II Methodolgy

Source and Sink Categories	Emission Estimates (kg N_20 - N)
Total	**27,454,707**
Direct Soil Emissions	**3,201,490**
Synthetic Fertilizers	1,656,824
Animal Wastes	470,531
Biological N2 Fixation	51,215
Crop Residue	192,920
Cultivated Histosols	830,000
Animal Production	**14,171,955**
Animals	0
Animals Waste Management Systems	14,171,955
Indirect Emissions	**10,081,262**
Atmospheric Deposition	3,355,696
Nitrogen Leaching and Runoff	6,515,601
Human Sewage	209,965
Note: 27,455 tonnes N_2O - N is equivalent to 43,143 tonnes N_2O or 43.14 Gg	

Detailed information on the calculations and emission factors used is in Annex 4.

Greenhouse gas emissions from field burning of agricultural residues
All Cereals

Year	Total Biomass Burned	Carbon Fraction	Total Carbon Release	Total Nitrogen	GHG Emissions (Gg)				GHG Agregate Emission factors (kg / t dm)			
	(Gg dm)		(Gg C)	(Gg N)	CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
1993	60.6	0.46834	28.4	0.41	0.189	3.975	0.004	0.161	3.122	65.567	0.074	2.662

Detailed calculation are in Annex 13.

Standard Data Table 5

Land Use Change and Forestry: 5A (Sheet 1) Changes in Forest and Other Woody Biomass Stocks - Annual Growth Increment 1993

Source and Sink Categories			Activity Data	Uptake Estimates	Aggregate Uptake Factor
Sector Specific Data (units) Land Type			Area of Forest/Biomass Stocks (kha)	Total Carbon Uptake Increment (Gg C)	Carbon Uptake Factor (t C/ha)
Temperate Forests	Plantations (specify type)	Pinus Radiata	1,400.96[1]	-8,153	5.8[2]

Notes: 1 The figure for the area of forest stocks is for plantation forests.
2 This factor will also vary from year to year as the average age and hence growth rates of the planted forest estate changes.
All figures are reported as three year averages with the base year in the middle.

Land Use Change and Forestry: 5A (Sheet 2) Changes in Forest and Other Woody Biomass Stocks - Annual Harvest 1993

Source and Sink Categories	Activity Data	Carbon Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units)	Amount of Biomass Removed (kt dm)	Carbon Emission/Removal Estimates (Gg C)	Carbon Emission Factors (t C/t dm)
Total Biomass Removed in Commercial Harvest	6,599	3,299	0.5
Traditional Fuelwood Consumed			
Total Other Wood Use			
Total Biomass Consumption	**6,599**	**3,299**	

Note: 1 The figure given includes roundwood removals from both plantation and native forests and post harvest slash

Land Use Change and Forestry: 5A (Sheet 3) Changes in Forest and Other Woody Biomass Stocks - Net CO_2 Emissions/Removals 1993

Source and Sink Categories	Emission/Uptake C (Gg)	Emissions/Removals CO_2 (Gg)
Total Annual Growth Increment	-8,153	-29,894
Total Annual Harvest	3,299	12,096
Net Emissions (+) or Removals (-)	**-4,854**	**-17,798**

Land Use Change and Forestry: 5B (Sheet 1) Forest and Grassland Conversion - CO_2 Release from Burning Aboveground Biomass 1993

Source and Sink Categories			Activity Data				Emission Estimates		Aggregate Emission Factors	
Sector Specific Data (units) Land Type			Area Converted Annually (kha)	Annual Loss of Biomass (kt dm)	Quantity of Biomass Burned (on and off-site) (kt dm)		Quantity of C Released[1] (kt C)		Carbon Fraction of Biomass Burned	
					On Site	Off Site	On Site	Off Site	On Site	Off Site
Temperate Forests	Evergreen	Primary[2] Secondary	0.24	158.8	158.8	NA	71.5	NA	0.5	NA
Other (specify): Mixed Scrub[3]			7.44	594.9	594.9	NA	267.7	NA	0.5	NA
Total C Released							339.2	NA		
Total of On Site and Off Site C Released							339.2			
Total CO_2 Released							1,244			

Notes: 1 Quantity of Biomass burned is adjusted for the portion of carbon in biomass that remains on-site as charcoal (10% of biomass carbon).
2 Includes burning (from natural and anthropogenic causes) of Native Forests and Plantation Forests (ie. mixed primary/secondary and plantation).
3 Includes burning (from natural and anthropogenic causes) of mixed scrub and prescribed burning of scrub cleared for Plantation Forestry.
All figures are reported as three year averages with the base year in the middle. See Annex 5 for further details.
NA = Not Applicable

Land Use Change and Forestry: 5B (Sheet 2) Forest and Grassland Conversion - Release of Non-CO_2 GHG from On-Site Burning of Forests 1993

Source and Sink Categories	Activity Data		Emissions Estimates				Aggregate Emission Ratios			
Sector Specific Data (units) Land Type	Carbon Release (Gg)	Nitrogen Release (Gg)	Emissions Estimates (Gg)				Aggregate Emission Ratios			
			CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
On Site Burning of Forests	339.18	3.39	6.015	52.686	0.037	1.350	0.160	0.140	0.011	0.398

Land Use Change and Forestry: 5B (Sheet 3) Forest and Grassland Conversion - CO_2 Release from Decay of Aboveground Biomass 1993

Source and Sink Categories			Activity Data			Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units) Land Type			5-Year Average Area Converted[1] (kha/yr)	5-Year Average Annual Loss of Biomass (kt dm/yr)	Average Quantity of Biomass to Decay (kt dm)	Carbon Released from Decay (kt C)	Carbon Fraction of Aboveground Biomass
Temperate Forests	Evergreen	Primary[2] Secondary					
Other (specify): Mixed Scrub			2.847[2]	228	228	114	0.5
Total C Released from Decay						114	
Total CO_2 Released from Decay						418	

Note: 1 Figures are given as previous five year average.
2 Only includes the area of mixed scrub cleared for plantation forestry that is left to decay (approximately 50% of toal area converted), the remainder is burned and is included under 5B Sheet 1.

Land Use Change and Forestry: 5B (Sheet 4) Forest and Grassland Conversion - Soil Carbon Release 1993

Soil carbon is not estimated as it is assumed to remain in balance or increase slightly from the conversion of pastoral land and mixed scrub to first rotation plantation forestry. No data is currently available on whether other forms of conversion may be occurring which result in a release of soil carbon.

Land Use Change and Forestry: 5B (Sheet 5) Forest and Grassland Conversion - Total CO_2 Emissions 1993

Category	Emissions (Gg)
CO_2 Release from Burning of Aboveground Biomass	1,244
CO_2 from Decay of Aboveground Biomass	418
CO_2 from Soil Carbon Release	ne
Total	1,662
Note: ne = Not Estimated	

Land Use Change and Forestry: 5C (Sheet 1-3) Abandonment of Managed Lands 1993

Not Estimated. No data is currently available on the extent of abandoned managed lands on a national basis. It is known however that considerable regeneration is occurring in some areas, but these have yet to be quantified.

Standard Data Table 6: Waste

Detailed information and calculations for waste sector emissions are in Annex 6 for wastewater, and Annex 14 for landfills. Emissions from landfills are calculated using the Phase II Guidelines.

Waste sector methane in Gg	1993
Total	**148.68**
Landfills	144.40
Wastewater	4.28

ANNEX 11: Greenhouse gas inventory, 1994

All data is presented in gigagrams (Gg)

Short Summary Report for New Zealand's Greenhouse Gas Inventory, 1994

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**27,326**	**-14,708**	**1,615.735**	**46.197**	**128.371**	**768.464**	**194.700**	**0.064**	**0.034**	**0.184**	**21.930**
1 All Energy (Fuel Combustion and Fugitive)	**24,655**		**30.682**	**2.638**	**124.100**	**700.920**	**148.060**				
A Fuel Combustion	23,975		7.875	2.638	124.100	700.920	148.060				
B Fugutive Emissions from Fuels	680		22.807								
2 Industrial Processes	**2,671**		**0.121**		**2.508**	**1.083**	**19.231**	**0.064**	**0.034**	**0.184**	**21.930**
3 Solvent and Other Product Use							**27.409**				
4 Agriculture			**1,436.184**	**43.515**	**0.163**	**4.025**					
5 Land Use Change and Forestry		**-14,708**	**7.128**	**0.044**	**1.600**	**62.436**					
6 Waste			**141.620**								
7 Other											
International Bunkers	**2,793**		**0.281**	**0.064**	**34.270**	**6.240**	**4.540**				

Summary Report for New Zealand's Greenhouse Gas Inventory, 1994

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**27,326**	**-14,708**	**1,615.735**	**46.197**	**128.371**	**768.464**	**194.700**	**0.064**	**0.034**	**0.184**	**21.930**
1 All Energy (Fuel Combustion and Fugitive)	**24,655**		**30.682**	**2.638**	**124.100**	**700.920**	**148.060**				
A Fuel Combustion	23,975		7.875	2.638	124.100	700.920	148.060				
1 Energy & Transformation Industries	5,457		0.091	0.854	18.830	1.910	0.540				
2 Industry (ISIC)	5,247		0.464	0.779	15.580	33.000	1.770				
3 Transport	10,263		7.175	0.425	84.210	663.150	141.320				
4 Small Combustion	2,912		0.143	0.564	5.150	2.770	4.410				
5 Other	96		0.002	0.016	0.330	0.090	0.020				
B Fugutive Emissions from Fuels	680		22.807								
1 Solid Fuels			12.400								
2 Oil, Natural Gas & Geothermal	680		10.407								
2 Industrial Processes	**2,671**		**0.121**		**2.508**	**1.083**	**19.231**	**0.064**	**0.034**	**0.184**	**21.930**
3 Solvent and Other Product Use							**27.409**				
4 Agriculture			**1,436.184**	**43.515**	**0.163**	**4.025**					
A Enteric Fermentation			1,418.791								
B Manure Management			17.201								
D Agricultural Soils	ne			43.510							
F Field Burning of Agricultural Residues			0.192	0.005	0.163	4.025					
G Other											
5 Land Use Change and Forestry		**-14,708**	**7.128**	**0.044**	**1.600**	**62.436**					
A Changes in Forest Stocks		-16,749									
B Forest and Grassland Conversion	2,041		7.128	0.044	1.600	62.436					
C Abandonment of Managed Lands		ne									
G Other											
6 Waste			**141.620**								
A Solid Waste Disposal on Land			137.330								
B Wastewater Treatment			4.290								
C Waste Incineration											
7 Other											
International Bunkers	**2,793**		**0.281**	**0.064**	**34.270**	**6.240**	**4.540**				
A Air	1,456		0.032	0.023	5.850	2.420	1.010				
B Marine	1,337		0.249	0.041	28.420	3.820	3.530				

Standard Data Table 1

Energy: 1A Fuel Combustion Activites (Sheet 2) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A Fuel Combustion Activities	320.3	23,975	7.876	2.637	124.11	700.92	148.06	80.1	0.025	0.0082	0.41	2.34	0.495
Liquid	187.8	12,702	6.226	0.761	88.45	662.49	144.24	67.6	0.033	0.0041	0.47	3.53	0.768
Petrol	97.5	6,496	5.397	0.345	43.25	635.66	130.54	66.6	0.055	0.0035	0.44	6.52	1.338
Diesel	61.1	4,196	0.564	0.309	31.17	19.33	9.69	68.7	0.009	0.0051	0.51	0.32	0.159
Fuel Oil	8.8	648	0.067	0.052	8.61	0.24	0.99	73.8	0.008	0.0059	0.98	0.03	0.113
Aviation Fuels	12.8	877	0.020	0.020	3.46	1.41	0.61	68.7	0.002	0.0016	0.27	0.11	0.048
LPG	6.0	362	0.174	0.023	1.71	5.82	2.40	60.4	0.029	0.0038	0.28	0.97	0.400
Asphalt	1.6	122	0.005	0.013	0.25	0.02	0.01	74.3	0.003	0.0077	0.15	0.01	0.005
Unspecified	0.0	0	0.000	0.000	0.00	0.00	0.00						
Solid	33.6	3,095	0.124	0.681	11.23	4.22	1.92						
Coal	33.6	3,095	0.124	0.681	11.23	4.22	1.92	92.2	0.004	0.0203	0.33	0.13	0.057
Gas	77.9	8,178	1.227	1.081	22.14	4.20	0.90	105.0	0.016	0.0139	0.28	0.05	0.012
Natural Gas	65.6	7,480	0.175	1.044	20.88	2.86	0.84	114.0	0.003	0.0159	0.32	0.04	0.013
Refinery Gas	10.4	602	0.014	0.031	0.63	0.16	0.05	57.7	0.001	0.0030	0.06	0.02	0.005
CNG	1.8	96	1.038	0.005	0.63	1.19	0.01	52.3	0.567	0.0028	0.34	0.65	0.005
Biofuels	21.0		0.299	0.115	2.29	30.01	1.00		0.014	0.0055	0.11	1.43	0.048

Energy: 1A Fuel Combustion Activites (Sheet 3) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 Energy and Transformation Industries	72.7	5,457	0.091	0.854	18.83	1.91	0.54	75.1	0.00126	0.0117	0.26	0.026	0.0075
Liquid	2.3	168	0.006	0.017	0.34	0.03	0.01						
Petrol	0.0	1	0.000	0.000	0.00	0.00	0.00	66.6	0.00003	0.0033	0.07	0.014	0.00475
Diesel	0.0	2	0.000	0.000	0.00	0.00	0.00	68.7	0.00003	0.0033	0.07	0.014	0.00475
Fuel Oil	0.6	43	0.002	0.004	0.09	0.01	0.00	74.7	0.00280	0.0077	0.15	0.014	0.00475
Aviation Fuels	1.6	122	0.005	0.013	0.25	0.02	0.01	74.3	0.00280	0.0077	0.15	0.014	0.00475
Solid	4.2	389	0.003	0.003	1.83	0.05	0.02						
Coal	4.2	389	0.003	0.003	1.83	0.05	0.02	93.0	0.00060	0.0008	0.44	0.013	0.00475
Gas	66.3	4,901	0.083	0.833	16.66	1.82	0.51						
Natural Gas	55.8	4,299	0.069	0.802	16.03	1.67	0.47	77.0	0.00124	0.0144	0.29	0.030	0.0084
Refinery Gas	10.4	602	0.014	0.031	0.63	0.16	0.05	57.7	0.00130	0.0030	0.06	0.015	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 4) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 a Electricity and Heat Production	58.7	3,265	0.007	0.657	14.91	0.98	0.27						
1 A 1 a i Electricity Generation	58.7	3,265	0.007	0.657	14.91	0.98	0.27						
Public Generation	58.7	3,265	0.007	0.657	14.91	0.98	0.27						
Liquid	0.0	3	0.000	0.000	0.00	0.00	0.00						
Motor Gasoline	0.0	1	0.000	0.000	0.00	0.00	0.00	66.6	0.00003	0.00330	0.065	0.014	0.00475
Diesel	0.0	2	0.000	0.000	0.00	0.00	0.00	68.7	0.00003	0.00330	0.065	0.014	0.00475
Fuel Oil	0.00	0	0.000	0.000	0.00	0.00	0.00	73.6	0.00070	0.00960	0.191	0.014	0.00475
Solid	4.18	389	0.0025	0.003	1.83	0.05	0.02						
Sub-bituminous Coal	4.18	389	0.0025	0.003	1.83	0.05	0.02	92.99	0.0006	0.0008	0.438	0.013	0.00475
Gas	54.48	2,874	0.005	0.654	13.08	0.93	0.25						
Natural Gas	54.48	2,874	0.005	0.65	13.08	0.93	0.25	52.7	0.0001	0.0120	0.240	0.017	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 5) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 b Petroleum Refining	25.8	839	0.022	0.052	1.05	0.21	0.06						
Liquid	2.22	165	0.006	0.017	0.34	0.03	0.01						
Fuel Oil	0.58	43	0.002	0.004	0.09	0.01	0.00	74.7	0.0028	0.0077	0.153	0.014	0.00475
Asphalt	1.64	122	0.005	0.013	0.25	0.02	0.01	74.3	0.0028	0.0077	0.153	0.014	0.00475
Gas	11.79	674	0.015	0.035	0.71	0.18	0.05						
Refinery Gas	10.44	602	0.014	0.031	0.63	0.16	0.05	57.7	0.0013	0.003	0.06	0.015	0.0045
Natural Gas	1.35	72	0.002	0.004	0.08	0.02	0.01	53.2	0.0013	0.003	0.06	0.015	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 6) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 c Solid Fuel Transformation and Other Energy Industries		1,353	0.062	0.144	2.88	0.72	1.22						
1 A 1 c i Solid Fuel Transformation		0	0	0	0	0	1.00						
1 A 1 c ii Other Energy Industries		1,353	0.062	0.14	2.88	0.72	0.22						
Gas		1,353	0.062	0.144	2.88	0.72	0.22						
Synthetic Petrol													
Natural Gas		1,075	0.056	0.13	2.59	0.65	0.19						
Oil & Gas Extraction													
Natural Gas		278	0.006	0.01	0.29	0.07	0.02						

Energy: 1A Fuel Combustion Activites (Sheet 7) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 2 Industry	125.4	5,247	0.464	0.779	15.58	33.00	1.77						
Gas	73.9	2,669	0.096	0.222	4.43	1.11	0.33						
Methanol													
Natural Gas		981											
Urea													
Natural Gas		145											
Other Industry													
Natural Gas		1,543											
Liquid	10.0	690	0.028	0.077	1.53	0.14	0.05	69.0	0.0028	0.0077	0.153	0.014	0.00475
Petrol	0.3	21	0.001	0.002	0.05	0.00	0.00	66.6	0.0028	0.0077	0.153	0.014	0.00475
Diesel	6.1	422	0.017	0.047	0.94	0.09	0.03	68.7	0.0028	0.0077	0.153	0.014	0.00475
Fuel Oil	2.3	173	0.007	0.018	0.36	0.03	0.01	73.7	0.0028	0.0077	0.153	0.014	0.00475
Aviation Fuels	0.2	15	0.001	0.002	0.03	0.00	0.00	68.7	0.0028	0.0077	0.153	0.014	0.00475
LPG	1.0	60	0.003	0.008	0.15	0.01	0.00	60.4	0.0028	0.0077	0.153	0.014	0.00475
Other	0.0	0	0.000	0.000	0.00	0.00	0.00						
Solid	20.5	1,887	0.041	0.365	7.33	1.74	0.39						
Coal	20.5	1,887	0.041	0.365	7.33	1.74	0.39	92.1	0.0020	0.018	0.360	0.085	0.019
Biofuels	21.0		0.299	0.115	2.29	30.01	1.00		0.0142	0.0055	0.109	1.429	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 8) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Transport	152.8	10,263	7.175	0.425	84.21	663.15	141.32						
Liquid	151.0	10,167	6.138	0.420	83.59	661.96	141.31						
Petrol	91.32	6,082	5.4	0.3	42.65	635.57	130.13	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	39.21	2,694	0.5	0.1	28.15	19.02	7.45	68.7	0.0130	0.00297	0.718	0.485	0.19
Fuel Oil	3.94	291	0.1	0.0	7.87	0.17	0.75	73.7	0.0136	0.00177	1.995	0.044	0.19
Aviation Fuels	12.33	847	0.0	0.0	3.40	1.41	0.59	68.7	0.0015	0.00108	0.276	0.114	0.0475
LPG	4.20	254	0.2	0.0	1.52	5.80	2.39	60.4	0.040	0.0028	0.361	1.38	0.57
Gas	1.83	96	1.0	0.0	0.63	1.19	0.01						
CNG	1.83	96	1.0	0.0	0.63	1.19	0.01	52.3	0.567	0.0028	0.342	0.648	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 9) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 a Civil Aviation													
1 A 3 a i International Aviation (International Bunkers)	21.2	1,456	0.032	0.023	5.85	2.42	1.01						
Aviation Fuels	21.2	1,456	0.032	0.023	5.85	2.42	1.01	68.7	0.0015	0.00108	0.276	0.114	0.0475
1 A 3 a ii Domestic	12.3	847	0.02	0.01	3.40	1.41	0.59						
Aviation Fuels	12.3	847	0.02	0.01	3.40	1.41	0.59	68.7	0.0015	0.00108	0.276	0.114	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 10) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Road & Marine Transportation	140.5	9,416	7.16	0.41	80.81	661.74	140.73						
Liquid	138.7	9,320	6.12	0.41	80.19	660.56	140.72						
Petrol	91.3	6,082	5.39	0.27	42.65	635.57	130.13	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	39.2	2,694	0.51	0.12	28.15	19.02	7.45	68.7	0.013	0.00297	0.718	0.485	0.19
Fuel Oil	3.9	291	0.05	0.01	7.87	0.17	0.75	73.7	0.0136	0.00177	1.995	0.044	0.19
LPG	4.2	254	0.17	0.01	1.52	5.80	2.39	60.4	0.04	0.0028	0.361	1.38	0.57
Gas	1.83	96	1.04	0.01	0.63	1.19	0.01						
CNG	1.83	96	1.04	0.01	0.63	1.19	0.01	52.3	0.567	0.0028	0.342	0.648	0.0045
1 A 3 d i International Marine	18.6	1,337	0.249	0.041	28.42	3.82	3.53						
Diesel	6.8	467	0.088	0.020	4.88	3.30	1.29	68.7	0.0130	0.00297	0.718	0.485	0.190
Marine	11.8	870	0.160	0.021	23.54	0.52	2.24	73.7	0.0136	0.00177	1.995	0.044	0.190

Energy: 1A Fuel Combustion Activites (Sheet 11) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 Small Combustion	42.2	2,912	0.143	0.564	5.15	2.77	4.41						
Liquid	24.5	1,676	0.054	0.247	2.99	0.35	2.88						
Petrol	5.9	393	0.009	0.072	0.56	0.09	0.41	66.6	0.00144	0.01215	0.09516	0.01461	0.070
Diesel	15.7	1,079	0.037	0.145	2.07	0.22	2.21	68.7	0.00234	0.00923	0.13211	0.0142	0.141
Fuel Oil	1.9	141	0.005	0.022	0.29	0.03	0.23	73.7	0.00266	0.01154	0.15232	0.01421	0.118
Aviation Fuels	0.2	15	0.001	0.005	0.02	0.00	0.02	68.7	0.00233	0.02359	0.10744	0.01435	0.093
LPG	0.8	48	0.004	0.003	0.04	0.01	0.00	60.4	0.00445	0.00396	0.04963	0.01238	0.005
Solid	7.9	723	0.079	0.295	1.75	2.34	1.49						
Coal	7.9	723	0.079	0.295	1.75	2.34	1.49	92.1	0.01	0.03761	0.22236	0.29772	0.19
Gas	9.8	513	0.010	0.021	0.42	0.09	0.04						
CNG	9.8	513	0.010	0.021	0.42	0.09	0.04	52.3	0.00106	0.00216	0.04255	0.00878	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 12) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 a Commercial / Institutional	17.5	1,217	0.057	0.392	1.75	1.02	0.94						
Liquid	7.50	508	0.005	0.121	0.47	0.11	0.04						
Petrol	3.67	244	0.002	0.055	0.22	0.05	0.02	66.6	0.0006	0.0149	0.061	0.015	0.00475
Diesel	3.43	236	0.002	0.051	0.21	0.05	0.02	68.7	0.0006	0.0149	0.061	0.015	0.00475
Fuel Oil	0.20	15	0.000	0.009	0.03	0.00	0.00	73.7	0.0015	0.0442	0.147	0.016	0.00475
Aviation Fuels	0.10	7	0.000	0.004	0.01	0.00	0.00	68.7	0.0015	0.0442	0.061	0.015	0.00475
LPG	0.10	6	0.000	0.001	0.01	0.00	0.00	60.4	0.0006	0.0149	0.061	0.015	0.00475
Solid	4.6	427	0.046	0.260	1.04	0.86	0.88						
Coal	4.6	427	0.046	0.260	1.04	0.86	0.88	92.1	0.01	0.0561	0.224	0.185	0.19
Gas	5.4	282	0.006	0.012	0.23	0.05	0.02						
Natural Gas	5.4	282	0.006	0.012	0.23	0.05	0.02	52.3	0.0011	0.0022	0.043	0.0086	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 13) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 b Residential	8.5	580	0.041	0.047	0.93	1.53	0.64						
Liquid	0.9	53.4	0.004	0.002	0.04	0.01	0.00						
Petrol	0.0	2.3	0.000	0.000	0.00	0.00	0.00	66.6	0.005	0.0024	0.048	0.012	0.00475
Diesel	0.1	8.1	0.001	0.000	0.01	0.00	0.00	68.7	0.005	0.0024	0.048	0.012	0.00475
Fuel Oil	0.0	0.1	0.000	0.000	0.00	0.00	0.00	73.7	0.005	0.0024	0.048	0.012	0.00475
Aviation Fuels	0.0	0.7	0.000	0.000	0.00	0.00	0.00	68.7	0.005	0.0024	0.048	0.012	0.00475
LPG	0.7	42.3	0.004	0.002	0.03	0.01	0.00	60.4	0.005	0.0024	0.048	0.012	0.00475
Solid	3.2	296	0.032	0.035	0.71	1.48	0.61						
Coal	3.2	296	0.032	0.035	0.71	1.48	0.61	92.1	0.01	0.011	0.22	0.46	0.19
Gas	4.4	230	0.004	0.009	0.18	0.04	0.02						
Natural Gas	4.4	230	0.004	0.009	0.18	0.04	0.02	52.3	0.001	0.0021	0.042	0.009	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 14) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 c Agriculture / Forestry / Fishing	16.2	1,115	0.045	0.125	2.48	0.23	2.84						
Liquid	16.2	1,115	0.045	0.125	2.48	0.23	2.84						
Petrol	2.2	146	0.006	0.017	0.34	0.03	0.40	66.6	0.0028	0.0077	0.153	0.014	0.181
Diesel	12.2	835	0.034	0.094	1.86	0.17	2.20	68.7	0.0028	0.0077	0.153	0.014	0.181
Fuel Oil	1.7	126	0.005	0.013	0.26	0.02	0.23	73.7	0.0028	0.0077	0.153	0.014	0.131
Aviation Fuels	0.1	8	0.000	0.001	0.02	0.00	0.02	68.7	0.0028	0.0077	0.153	0.014	0.178
LPG	0.0	0	0.000	0.000	0.00	0.00	0.00						

Energy: 1A Fuel Combustion Activites (Sheet 15) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 5 Other	1.0	96	0.002	0.016	0.33	0.09	0.02						
Solid													
Coal	1.0	96	0.002	0.016	0.33	0.09	0.02	92.1	0.0023	0.0156	0.313	0.088	**0.019**

Standard Data Table 1

Energy: 1B1 Fugitive Emissions from Fuels (Coal Mining)

Source and Sink Categories		Activity Data Production (Mt) A	Methane Emissions (Gg) B	Emission Factor (Gg/Mt) C = B/A
1 B 1	**Solid Fuels**	2.92	12.40	
1 B 1 a	Coal Mining			
1 B 1 a i	Underground Mines			
	Underground Activities	0.51	9.57	18.700
	Post-Mining Activities	0.51	0.82	1.600
1 B 1 a ii	Surface Mines			
	Surface Activities	2.41	1.85	0.770
	Post-Mining Activities	2.41	0.16	0.067
1 B 1 b	Solid Fuel Transformation			
1 B 1 c	Other			

Energy: 1B2 Fugitive Emissions from Fuels (Oil and Natural Gas)

Source and Sink Categories			Activity Data	Emissions Estimates			Aggregate Emission Factors		
			Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
1 B 2 a	**Oil**								
	i	Exploration	NE						
	ii	Production of Crude Oil	NE						
	iii	Transport of Crude Oil	NE						
	iv	Refining/Storage	NE						
	v	Distribution of Oil Products	NE						
	vi	Other	NE						
1 B 2 b	**Natural Gas**								
	i	Production/Processing				NE			
	ii	Transmission/Distribution	41.1	6.96	0.72	NE	0.169	0.0174	
	iii	Other Leakage				NE			
1 B 2 c	**Venting and Flaring**								
	i	Oil				NE			
	ii	Natural Gas				NE			
	iii	Combined	9.0	0.87	314.00	NE	0.097	34.9	

Energy: 1B2 Fugitive Emissions from Fuels (Geothermal)

Source and Sink Categories	Activity Data	Emissions Estimates			Aggregate Emission Factors		
	Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
Geothermal	81.1	2.577	365.0	NE	0.032	4.5	

Standard Data Table 2
Industrial Processes 1994

Source and Sink Categories	Activity Data A Production Quantity (kt)	Methane Emissions B Full mass of Pollutant (Gg) CO_2	Aggregate Emission Factors C Tonne of Pollutant per tonne of Product (t/t) CO_2
A Iron and Steel	805.0	1,454.0	1.800
B Non-Ferrous Metals			
Aluminium	270.0	468.0	1.730
Other			
C Inorganic Chemicals (excepting solvent use)			
Hydrogen	28.0	183.0	6.500
D Non-Metallic Products			
Cement	954.0	487.0	0.510
Lime	110.0	79.0	0.720

Non CO_2 Emissions from Industrial Processes 1994

Source and Sink Categories	Activity Data A Production Quantity (kt)	Emission Estimates B Full Mass of Pollutants (Gg) Tonnes x 1000									Aggregate Emission Factors C Tonne of Pollutant per Tonne of Product (t / t)								
		CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2	CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2
A Iron and Steel	761.9000	0.5191			0.9079					0.6887	0.00068			0.00119					0.00090
B Non Ferrous Metals																			
Aluminium Production	270.3700							0.0337		5.9000							0.00012		0.02182
Other																			
C Inorganic Chemicals (excepting solvent use)																			
Nitric Acid																			
Fertiliser Production	1,456.0000									14.4144									0.00990
Other	172.2230		0.1206									0.00070							
D Organic Chemicals																			
Adipic Acid																			
Other																			
E Non-Metallic Mineral Products																			
Cement	938.0340	0.5210			1.5788					0.9081	0.00056			0.00168					0.00097
Lime	98.3710	0.0425			0.0212					0.0036	0.00043			0.00022					0.00004
Other	182.1397	0.0000			0.0000	7.7183				0.0149	0.00000				0.04238				0.00008
F Other (ISIC)	7,941.6692	0.0000			0.0000	11.5126	0.0635	0.0000	0.1841	0.0000	0.00000			0.00000	0.00145				0.00000
Grand Total		**1.0827**	**0.1206**		**2.5079**	**19.2309**	**0.0635**	**0.0337**	**0.1841**	**21.9297**									

Standard Data Table 3
Solvent and Other Product Use 1994

Source and Sink Categories	Activity Data A Quantity Consumed (kt)	Emissions Estimates B Full Mass of Pollutant (Gg)			Aggregate Emission Estimates C Tonne of Pollutant per Tonne of Product (t / t) C = B / A		
		N_2O	HFC	NMVOC	N_2O	HFC	NMVOC
A Paint Application	44.17			14.4178			0.3300
B Degreasing and Dry Cleaning	0.76			0.6052			0.7955
C Chemical Products Manufacture / Processing							
D Other	11.06			12.3861			1.1197
Total				**27.4090**			

Standard Data Table 4
Agriculture: 4A & 4B Enteric Fermentation and Manure Management 1994

Source and Sink Categories	Activity Data A	Emission Estimates B		Aggregate Emission Factor C	
	Number of Animals	Enteric Fermentation	Manure Management	Enteric Fermentation	Manure Management
	(1000)*	(Gg CH4)		(kg CH4 per head per year) C = (B/A) X 1000	
Totals	**60,241.000**	**1,418.791**	**17.201**		
Cattle					
a Dairy	3,775.000	289.920	3.356	76.8	0.889
b Non-Dairy	4,906.000	331.155	4.460	67.5	0.909
Sheep	49,980.000	754.698	8.896	15.1	0.178
Goats	378.000	6.237	0.045	16.5	0.119
Deer	1,202.000	36.781	0.444	30.6	0.369

Total ruminant emission for 1995 is 1,435.992 Gg

Note: * Ruminant numbers based on expected numbers.

1994 New Zealand N_2O Emissions Calculated with the PHASE II Methodolgy

Source and Sink Categories	Emission Estimates (kg N_20 - N)
Total	**27,687,692**
Direct Soil Emissions	**3,230,908**
Synthetic Fertilizers	1,656,824
Animal Wastes	498,500
Biological N2 Fixation	46,958
Crop Residue	198,626
Cultivated Histosols	830,000
Animal Production	**14,372,400**
Animals	0
Animals Waste Management Systems	14,372,400
Indirect Emissions	**10,084,384**
Atmospheric Deposition	3,355,696
Nitrogen Leaching and Runoff	6,515,601
Human Sewage	213,087

Note: 27,688 tonnes N_2O - N is equivalent to 43,509 tonnes N_2O or 43.51 Gg

Detailed information on the calculations and emission factors used is in Annex 4.

Greenhouse gas emissions from field burning of agricultural residues
All Cereals

Year	Total Biomass Burned (Gg dm)	Carbon Fraction	Total Carbon Release (Gg C)	Total Nitrogen (Gg N)	GHG Emissions (Gg)				GHG Agregate Emission factors (kg / t dm)			
					CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
1994	61.3	0.46899	28.7	0.41	0.192	4.025	0.005	0.163	3.127	65.659	0.074	2.662

Detailed calculations are in Annex 13

Standard Data Table 5

Land Use Change and Forestry: 5A (Sheet 1) Changes in Forest and Other Woody Biomass Stocks - Annual Growth Increment 1994

Source and Sink Categories			Activity Data	Uptake Estimates	Aggregate Uptake Factor
Sector Specific Data (units) Land Type			Area of Forest/Biomass Stocks (kha)	Total Carbon Uptake Increment (Gg C)	Carbon Uptake Factor (t C/ha)
Temperate Forests	Plantations (specify type)	Pinus Radiata	1,476.24[1]	-8,042	5.4[2]

Notes: 1 The figure for the area of forest stocks is for plantation forests.
2 This factor will also vary from year to year as the average age and hence growth rates of the planted forest estate changes..
All figures are reported as three year averages with the base year in the middle.

Land Use Change and Forestry: 5A (Sheet 2) Changes in Forest and Other Woody Biomass Stocks - Annual Harvest 1994

Source and Sink Categories	Activity Data	Carbon Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units)	Amount of Biomass Removed (kt dm)	Carbon Emission/Removal Estimates (Gg C)	Carbon Emission Factors (t C/t dm)
Total Biomass Removed in Commercial Harvest	6,948	3,474	0.5
Traditional Fuelwood Consumed			
Total Other Wood Use			
Total Biomass Consumption	**6,948**	**3,474**	

Note: 1 The figure given includes roundwood removals from both plantation and native forests and post harvest slash

Land Use Change and Forestry: 5A (Sheet 3) Changes in Forest and Other Woody Biomass Stocks - Net CO_2 Emissions/Removals 1994

Source and Sink Categories	Emission/Uptake C (Gg)	Emissions/Removals CO_2 (Gg)
Total Annual Growth Increment	-8,042	-29,487
Total Annual Harvest	3,474	12,738
Net Emissions (+) or Removals (-)	**-4,568**	**-16,749**

Land Use Change and Forestry: 5B (Sheet 1) Forest and Grassland Conversion - CO_2 Release from Burning Aboveground Biomass 1994

Source and Sink Categories			Activity Data				Emission Estimates		Aggregate Emission Factors	
Sector Specific Data (units) Land Type			Area Converted Annually (kha)	Annual Loss of Biomass (kt dm)	Quantity of Biomass Burned (on and off-site) (kt dm)		Quantity of C Released[1] (kt C)		Carbon Fraction of Biomass Burned	
					On Site	Off Site	On Site	Off Site	On Site	Off Site
Temperate Forests	Evergreen	Primary[2] Secondary	0.31	209.1	209.1	NA	94.1	NA	0.5	NA
Other (specify): Mixed Scrub[3]			8.55	684.1	684.1	NA	307.9	NA	0.5	NA
Total C Released							401.9	NA		
Total of On Site and Off Site C Released							401.9			
Total CO_2 Released							1,474			

Notes: 1 Quantity of Biomass burned is adjusted for the portion of carbon in biomass that remains on-site as charcoal (10% of biomass carbon).
2 Includes burning (from natural and anthropogenic causes) of Native Forests and Plantation Forests (ie. mixed primary/secondary and plantation).
3 Includes burning (from natural and anthropogenic causes) of mixed scrub and prescribed burning of scrub cleared for Plantation Forestry.
All figures are reported as three year averages with the base year in the middle. See Annex 5 for further details.
NA = Not Applicable

Land Use Change and Forestry: 5B (Sheet 2) Forest and Grassland Conversion - Release of Non-CO_2 GHG from On-Site Burning of Forests 1994

Source and Sink Categories	Activity Data		Emissions Estimates				Aggregate Emission Ratios			
Sector Specific Data (units) Land Type	Carbon Release (Gg)	Nitrogen Release (Gg)	Emissions Estimates (Gg)				Aggregate Emission Ratios			
			CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
On Site Burning of Forests	401.95	4.02	7.128	62.436	0.044	1.600	0.160	0.140	0.011	0.398

Land Use Change and Forestry: 5B (Sheet 3) Forest and Grassland Conversion - CO_2 Release from Decay of Aboveground Biomass 1994

Source and Sink Categories			Activity Data			Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units) Land Type			5-Year Average Area Converted[1] (kha/yr)	5-Year Average Annual Loss of Biomass (kt dm/yr)	Average Quantity of Biomass to Decay (kt dm)	Carbon Released from Decay (kt C)	Carbon Fraction of Aboveground Biomass
Temperate Forests	Evergreen	Primary[2] Secondary					
Other (specify): Mixed Scrub			3.866[2]	309	309	155	0.5
Total C Released from Decay						155	
Total CO_2 Released from Decay						567	

Note: 1 Figures are given as previous five year average.
2 Only includes the area of mixed scrub cleared for plantation forestry that is left to decay (approximately 50% of toal area converted), the remainder is burned and is included under 5B Sheet 1.

Land Use Change and Forestry: 5B (Sheet 4) Forest and Grassland Conversion - Soil Carbon Release 1994

Soil carbon is not estimated as it is assumed to remain in balance or increase slightly from the conversion of pastoral land and mixed scrub to first rotation plantation forestry. No data is currently available on whether other forms of conversion may be occurring which result in a release of soil carbon.

Land Use Change and Forestry: 5B (Sheet 5) Forest and Grassland Conversion - Total CO_2 Emissions 1994

Category	Emissions (Gg)
CO_2 Release from Burning of Aboveground Biomass	1,474
CO_2 from Decay of Aboveground Biomass	567
CO_2 from Soil Carbon Release	ne
Total	2,041
Note: ne = Not Estimated	

Land Use Change and Forestry: 5C (Sheet 1-3) Abandonment of Managed Lands 1994

Not Estimated. No data is currently available on the extent of abandoned managed lands on a national basis. It is known however that considerable regeneration is occurring in some areas, but these have yet to be quantified.

Standard Data Table 6: Waste

Detailed information and calculations for waste sector emissions are in Annex 6 for wastewater, and Annex 14 for landfills. Emissions from landfills are calculated using the Phase II Guidelines.

Waste sector methane in Gg	1994
Total	**141.62**
Landfills	137.33
Wastewater	4.29

ANNEX 12: Greenhouse gas inventory, 1995

All data is presented in gigagrams (Gg)

Short Summary Report for New Zealand's Greenhouse Gas Inventory, 1995

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**27,367**	**-13,487**	**1,634.924**	**46.658**	**133.656**	**797.266**	**200.634**	**0.141**	**0.029**	**0.183**	**20.770**
1 All Energy (Fuel Combustion and Fugitive)	**24,631**		**35.017**	**2.493**	**129.070**	**724.770**	**153.704**				
A Fuel Combustion	24,004		7.961	2.493	129.070	724.770	153.704				
B Fugutive Emissions from Fuels	627		27.056								
2 Industrial Processes	**2,736**		**0.119**		**2.692**	**1.144**	**18.890**	**0.141**	**0.029**	**0.183**	**20.770**
3 Solvent and Other Product Use							**28.040**				
4 Agriculture			**1,460.228**	**44.115**	**0.164**	**4.032**					
5 Land Use Change and Forestry		**-13,487**	**7.690**	**0.050**	**1.730**	**67.320**					
6 Waste			**131.670**								
7 Other											
International Bunkers	**2,736**		**0.246**	**0.060**	**30.420**	**5.960**	**4.110**				

Summary Report for New Zealand's Greenhouse Gas Inventory, 1995

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	HFCs	PFCs	SF_6	SO_2
Total National Emissions and Removals	**27,367**	**-13,487**	**1,634.924**	**46.658**	**133.656**	**797.266**	**200.634**	**0.141**	**0.029**	**0.183**	**20.770**
1 All Energy (Fuel Combustion and Fugitive)	**24,631**		**35.017**	**2.493**	**129.070**	**724.770**	**153.704**				
A Fuel Combustion	24,004		7.961	2.493	129.070	724.770	153.704				
1 Energy & Transformation Industries	4,741		0.073	0.709	16.720	1.540	0.443				
2 Industry (ISIC)	5,416		0.480	0.794	15.900	33.070	1.811				
3 Transport	10,983		7.269	0.455	91.160	687.510	147.042				
4 Small Combustion	2,775		0.137	0.520	4.990	2.570	4.390				
5 Other	89		0.002	0.015	0.300	0.080	0.018				
B Fugutive Emissions from Fuels	627		27.056								
1 Solid Fuels			16.720								
2 Oil, Natural Gas & Geothermal	627		10.336								
2 Industrial Processes	**2,736**		**0.119**		**2.692**	**1.144**	**18.890**	**0.141**	**0.029**	**0.183**	**20.770**
3 Solvent and Other Product Use							**28.040**				
4 Agriculture			**1,460.228**	**44.115**	**0.164**	**4.032**					
A Enteric Fermentation			1,442.724								
B Manure Management			17.512								
D Agricultural Soils	ne			44.110							
F Field Burning of Agricultural Residues			0.192	0.005	0.164	4.032					
G Other											
5 Land Use Change and Forestry		**-13,487**	**7.690**	**0.050**	**1.730**	**67.320**					
A Changes in Forest Stocks		-15,763									
B Forest and Grassland Conversion	2,276		7.690	0.050	1.730	67.320					
C Abandonment of Managed Lands		ne									
G Other											
6 Waste			**131.670**								
A Solid Waste Disposal on Land			127.370								
B Wastewater Treatment			4.300								
C Waste Incineration											
7 Other											
International Bunkers	**2,736**		**0.246**	**0.060**	**30.420**	**5.960**	**4.110**				
A Air	1,601		0.035	0.025	6.430	2.660	1.110				
B Marine	1,135		0.211	0.035	23.990	3.300	3.300				

IPCC Standard Data Tables 1995

Standard Data Table 1

Energy: 1A Fuel Combustion Activites (Sheet 2) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A Fuel Combustion Activities	**319.7**	**24,004**	**7.962**	**2.494**	**129.07**	**724.78**	**153.70**	**75.1**	**0.025**	**0.0078**	**0.40**	**2.27**	**0.481**
Liquid	**199.2**	**13,491**	**6.507**	**0.786**	**95.75**	**687.06**	**150.07**	**67.7**	**0.033**	**0.0039**	**0.48**	**3.45**	**0.753**
Petrol	98.7	6,573	5.573	0.328	44.53	656.61	134.80	66.6	0.056	0.0033	0.45	6.65	1.366
Diesel	69.6	4,781	0.662	0.341	36.60	22.89	11.23	68.7	0.010	0.0049	0.53	0.33	0.161
Fuel Oil	9.0	664	0.069	0.052	8.93	0.25	1.00	73.5	0.008	0.0058	0.99	0.03	0.110
Aviation Fuels	13.3	911	0.021	0.022	3.58	1.45	0.63	68.7	0.002	0.0016	0.27	0.11	0.047
LPG	6.0	362	0.174	0.023	1.71	5.82	2.40	60.4	0.029	0.0038	0.28	0.97	0.400
Asphalt	2.7	201	0.008	0.021	0.41	0.04	0.01	74.6	0.003	0.0077	0.15	0.01	0.005
Unspecified	0.0	0	0.000	0.000	0.00	0.00	0.00						
Solid	**33.0**	**3,048**	**0.115**	**0.627**	**11.28**	**3.91**	**1.78**						
Coal	33.0	3,048	0.115	0.627	11.28	3.91	1.78	92.3	0.003	0.0181	0.33	0.11	0.054
Gas	**66.2**	**7,465**	**1.041**	**0.966**	**19.75**	**3.80**	**0.84**	**112.7**	**0.016**	**0.0146**	**0.30**	**0.06**	**0.013**
Natural Gas	56.1	6,890	0.173	0.936	18.71	2.70	0.80	122.8	0.003	0.0167	0.33	0.05	0.014
Refinery Gas	8.6	495	0.011	0.026	0.51	0.13	0.04	57.7	0.001	0.0030	0.06	0.02	0.005
CNG	1.5	79	0.856	0.004	0.52	0.98	0.01	52.5	0.567	0.0028	0.34	0.65	0.005
Biofuels	21.2		0.299	0.115	2.29	30.00	1.01		0.014	0.0054	0.11	1.41	0.048

Energy: 1A Fuel Combustion Activites (Sheet 3) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 Energy and Transformation Industries	64.9	4,741	0.073	0.709	16.72	1.54	0.44	73.0	0.00113	0.0109	0.26	0.024	0.0068
Liquid	3.7	271	0.010	0.028	0.56	0.05	0.02						
Petrol	0.0	1	0.000	0.000	0.00	0.00	0.00	66.6	0.00003	0.0033	0.07	0.014	0.00475
Diesel	0.0	2	0.000	0.000	0.00	0.00	0.00	68.7	0.00003	0.0033	0.07	0.014	0.00475
Fuel Oil	0.9	67	0.003	0.007	0.14	0.01	0.00	72.0	0.00279	0.0077	0.15	0.014	0.00475
Aviation Fuels	2.7	201	0.008	0.021	0.41	0.04	0.01	74.6	0.00280	0.0077	0.15	0.014	0.00475
Solid	6.0	561	0.004	0.005	2.64	0.08	0.03						
Coal	6.0	561	0.004	0.005	2.64	0.08	0.03	93.0	0.00060	0.0008	0.44	0.013	0.00475
Gas	55.2	3,910	0.059	0.676	13.52	1.41	0.40						
Natural Gas	46.6	3,415	0.048	0.650	13.01	1.29	0.36	73.2	0.00103	0.0139	0.28	0.028	0.0077
Refinery Gas	8.6	495	0.011	0.026	0.51	0.13	0.04	57.7	0.00130	0.0030	0.06	0.015	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 4) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 a Electricity and Heat Production	51.8	2,965	0.008	0.553	13.61	0.86	0.23						
1 A 1 a i Electricity Generation	51.8	2,965	0.008	0.553	13.61	0.86	0.23						
Public Generation	51.8	2,965	0.008	0.553	13.61	0.86	0.23						
Liquid	0.0	3	0.000	0.000	0.00	0.00	0.00						
Motor Gasoline	0.0	1	0.000	0.000	0.00	0.00	0.00	66.6	0.00003	0.00330	0.065	0.014	0.00475
Diesel	0.0	2	0.000	0.000	0.00	0.00	0.00	68.7	0.00003	0.00330	0.065	0.014	0.00475
Fuel Oil	0.0	0	0.000	0.000	0.00	0.00	0.00	73.6	0.00070	0.00960	0.191	0.014	0.00475
Solid	6.03	561	0.0036	0.005	2.64	0.08	0.03						
Sub-bituminous Coal	6.03	561	0.0036	0.005	2.64	0.08	0.03	92.99	0.0006	0.0008	0.438	0.013	0.00475
Gas	45.70	2,401	0.004	0.548	10.97	0.78	0.21						
Natural Gas	45.70	2,401	0.004	0.548	10.97	0.78	0.21	52.5	0.0001	0.0120	0.240	0.017	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 5) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 b Petroleum Refining	22.7	814	0.023	0.056	1.13	0.19	0.06						
Liquid	3.62	268	0.010	0.028	0.55	0.05	0.02						
Fuel Oil	0.93	67	0.003	0.007	0.14	0.01	0.00	72.0	0.0028	0.0077	0.153	0.014	0.00475
Asphalt	2.69	201	0.008	0.021	0.41	0.04	0.01	74.6	0.0028	0.0077	0.153	0.014	0.00475
Gas	9.52	546	0.012	0.029	0.57	0.14	0.04						
Refinery Gas	8.58	495	0.011	0.026	0.51	0.13	0.04	57.7	0.0013	0.003	0.06	0.015	0.0045
Natural Gas	0.93	51	0.001	0.003	0.06	0.01	0.00	54.6	0.0013	0.003	0.06	0.015	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 6) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 1 c Solid Fuel Transformation and Other Energy Industries		962	0.043	0.099	1.98	0.50	1.15						
1 A 1 c i Solid Fuel Transformation		0	0	0	0	0	1.00						
1 A 1 c ii Other Energy Industries		962	0.043	0.099	1.98	0.50	0.15						
Gas		962	0.043	0.099	1.98	0.50	0.15						
Synthetic Petrol													
Natural Gas		666	0.037	0.085	1.70	0.43	0.13						
Oil & Gas Extraction													
Natural Gas		296	0.006	0.014	0.28	0.07	0.02						

Standard Data Table 1 (note that it's not updated yet)

Energy: 1A Fuel Combustion Activites (Sheet 7) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fule	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 2 Industry	126.1	5,416	0.480	0.794	15.90	33.07	1.81						
Gas	75.8	2,978	0.115	0.265	5.30	1.33	0.40						
Methanol													
Natural Gas		1,249											
Urea													
Natural Gas		157											
Other Industry													
Natural Gas		1,571											
Liquid	10.2	704	0.029	0.079	1.56	0.14	0.05	68.9	0.0028	0.0077	0.153	0.014	0.00475
Petrol	0.2	16	0.001	0.002	0.04	0.00	0.00	66.6	0.0028	0.0077	0.153	0.014	0.00475
Diesel	6.5	443	0.018	0.050	0.99	0.09	0.03	68.7	0.0028	0.0077	0.153	0.014	0.00475
Fuel Oil	2.2	159	0.006	0.017	0.33	0.03	0.01	73.7	0.0028	0.0077	0.153	0.014	0.00475
Aviation Fuels	0.4	25	0.001	0.003	0.06	0.01	0.00	68.7	0.0028	0.0077	0.153	0.014	0.00475
LPG	1.0	60	0.003	0.008	0.15	0.01	0.00	60.4	0.0028	0.0077	0.153	0.014	0.00475
Other	0.0	0	0.000	0.000	0.00	0.00	0.00						
Solid	18.8	1,734	0.037	0.336	6.74	1.60	0.36						
Coal	18.8	1,734	0.037	0.336	6.74	1.60	0.36	92.1	0.0020	0.018	0.36	0.085	0.019
Biofuels	21.2		0.299	0.115	2.29	30.00	1.01		0.0141	0.005	0.108	1.414	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 8) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Transport	163.3	10,983	7.269	0.455	91.16	687.51	147.04						
Liquid	161.8	10,904	6.413	0.451	90.64	686.53	147.04						
Petrol	94.33	6,283	5.6	0.3	44.05	656.55	134.42	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	46.52	3,196	0.6	0.1	33.40	22.56	8.84	68.7	0.0130	0.00297	0.718	0.485	0.19
Fuel Oil	4.10	302	0.1	0.0	8.18	0.18	0.78	73.7	0.0136	0.00177	1.995	0.044	0.19
Aviation Fuels	12.66	870	0.0	0.0	3.49	1.44	0.60	68.7	0.0015	0.00108	0.276	0.114	0.0475
LPG	4.2	254	0.2	0.0	1.52	5.80	2.39	60.4	0.040	0.0028	0.361	1.38	0.57
Gas	1.51	79	0.9	0.0	0.52	0.98	0.01						
CNG	1.51	79	0.9	0.0	0.52	0.98	0.01	52.5	0.567	0.0028	0.342	0.648	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 9) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 a Civil Aviation													
1 A 3 a i International Aviation (International Bunkers)	23.3	1,601	0.035	0.025	6.43	2.66	1.11						
Aviation Fuels	23.3	1,601	0.035	0.025	6.43	2.66	1.11	68.7	0.0015	0.00108	0.276	0.114	0.0475
1 A 3 a ii Domestic	12.66	870	0.019	0.014	3.49	1.44	0.60						
Aviation Fuels	12.66	870	0.019	0.014	3.49	1.44	0.60	68.7	0.0015	0.00108	0.276	0.114	0.0475

Energy: 1A Fuel Combustion Activites (Sheet 10) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 3 Road & Marine Transportation	150.7	10,113	7.25	0.44	87.67	686.07	146.44						
Liquid	149.2	10,034	6.39	0.44	87.15	685.09	146.43						
Petrol	94.3	6,283	5.57	0.28	44.05	656.55	134.42	66.6	0.059	0.00297	0.467	6.96	1.425
Diesel	46.5	3,196	0.60	0.14	33.40	22.56	8.84	68.7	0.013	0.00297	0.718	0.485	0.19
Fuel Oil	4.1	302	0.06	0.01	8.18	0.18	0.78	73.7	0.0136	0.00177	1.995	0.044	0.19
LPG	4.2	254	0.17	0.01	1.52	5.80	2.39	60.4	0.04	0.0028	0.361	1.38	0.57
Gas	1.51	79	0.86	0.00	0.52	0.98	0.01						
CNG	1.51	79	0.86	0.00	0.52	0.98	0.01	52.5	0.567	0.0028	0.342	0.648	0.0045
1 A 3 d i International Marine	15.8	1,135	0.211	0.035	23.99	3.30	3.00						
Diesel	5.9	405	0.077	0.018	4.24	2.86	1.12	68.7	0.0130	0.00297	0.718	0.485	0.190
Marine	9.9	730	0.135	0.018	19.75	0.44	1.88	73.7	0.0136	0.00177	1.995	0.044	0.190

Energy: 1A Fuel Combustion Activites (Sheet 11) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 Small Combustion	40.3	2,775	0.137	0.520	4.99	2.57	4.39						
Liquid	23.6	1,612	0.055	0.228	2.98	0.33	2.97						
Petrol	4.1	273	0.007	0.046	0.44	0.06	0.38	66.6	0.00172	0.01123	0.10687	0.01448	0.093
Diesel	16.6	1,140	0.039	0.153	2.21	0.24	2.36	68.7	0.00234	0.00921	0.13294	0.0142	0.142
Fuel Oil	1.8	135	0.005	0.021	0.28	0.03	0.20	73.7	0.00271	0.01151	0.15018	0.01417	0.110
Aviation Fuels	0.2	16	0.001	0.005	0.03	0.00	0.02	68.7	0.00235	0.02236	0.11202	0.01434	0.099
LPG	0.8	48	0.004	0.003	0.04	0.01	0.00	60.4	0.00445	0.00396	0.04963	0.01238	0.00475
Solid	7.2	665	0.072	0.271	1.60	2.15	1.37						
Coal	7.2	665	0.072	0.271	1.60	2.15	1.37	92.1	0.01	0.03761	0.22236	0.29772	0.19
Gas	9.5	498	0.010	0.020	0.40	0.08	0.04						
CNG	9.5	498	0.010	0.020	0.40	0.08	0.04	52.5	0.00106	0.00216	0.04257	0.00877	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 12) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 a Commercial / Institutional	15.6	1,080	0.052	0.348	1.57	0.92	0.86						
Liquid	5.95	405	0.004	0.097	0.38	0.09	0.03						
Petrol	2.03	135	0.001	0.030	0.12	0.03	0.01	66.6	0.0006	0.0149	0.061	0.015	0.00475
Diesel	3.53	243	0.002	0.053	0.22	0.05	0.02	68.7	0.0006	0.0149	0.061	0.015	0.00475
Fuel Oil	0.20	15	0.000	0.009	0.03	0.00	0.00	73.7	0.0015	0.0442	0.147	0.016	0.00475
Aviation Fuels	0.09	6	0.000	0.004	0.01	0.00	0.00	68.7	0.0015	0.0442	0.061	0.015	0.00475
LPG	0.10	6	0.000	0.001	0.01	0.00	0.00	60.4	0.0006	0.0149	0.061	0.015	0.00475
Solid	4.3	392	0.043	0.239	0.95	0.79	0.81						
Coal	4.3	392	0.043	0.239	0.95	0.79	0.81	92.1	0.01	0.0561	0.224	0.185	0.19
Gas	5.4	284	0.006	0.012	0.23	0.05	0.02						
Natural Gas	5.4	284	0.006	0.012	0.23	0.05	0.02	52.5	0.0011	0.0022	0.043	0.0086	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 13) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 b Residential	7.9	540	0.038	0.043	0.86	1.41	0.59						
Liquid	0.84	52	0.004	0.002	0.04	0.01	0.00						
Petrol	0.02	2	0.000	0.000	0.00	0.00	0.00	66.6	0.005	0.0024	0.048	0.012	0.00475
Diesel	0.08	5	0.000	0.000	0.00	0.00	0.00	68.7	0.005	0.0024	0.048	0.012	0.00475
Fuel Oil	0.04	3	0.000	0.000	0.00	0.00	0.00	73.7	0.005	0.0024	0.048	0.012	0.00475
Aviation Fuels	0.01	1	0.000	0.000	0.00	0.00	0.00	68.7	0.005	0.0024	0.048	0.012	0.00475
LPG	0.70	42	0.004	0.002	0.03	0.01	0.00	60.4	0.005	0.0024	0.048	0.012	0.00475
Solid	3.0	272	0.030	0.033	0.65	1.36	0.56						
Coal	3.0	272	0.030	0.033	0.65	1.36	0.56	92.1	0.01	0.011	0.22	0.46	0.19
Gas	4.09	215	0.004	0.009	0.17	0.04	0.02						
Natural Gas	4.09	215	0.004	0.009	0.17	0.04	0.02	52.5	0.001	0.0021	0.042	0.009	0.0045

Energy: 1A Fuel Combustion Activites (Sheet 14) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 4 c Agriculture / Forestry / Fishing	16.76	1,155	0.047	0.129	2.56	0.23	2.94						
Liquid	16.76	1,155	0.047	0.129	2.56	0.23	2.94						
Petrol	2.05	136	0.006	0.016	0.31	0.03	0.37	66.6	0.0028	0.0077	0.153	0.014	0.181
Diesel	12.99	892	0.036	0.100	1.99	0.18	2.35	68.7	0.0028	0.0077	0.153	0.014	0.181
Fuel Oil	1.60	118	0.004	0.012	0.24	0.02	0.20	73.7	0.0028	0.0077	0.153	0.014	0.125
Aviation Fuels	0.13	9	0.000	0.001	0.02	0.00	0.02	68.7	0.0028	0.0077	0.153	0.014	0.173
LPG	0.00	0	0.000	0.000	0.00	0.00	0.00						

Energy: 1A Fuel Combustion Activites (Sheet 15) - Detailed Technology Based Calculation

Source and Sink Categoriies	Activity Data	Emissions Estimates						Aggregate Emission Factors					
Sector Specific Data by Fuel	A Consumption	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/TJ) C= B/A					
	(PJ)	CO_2	CH_4	N_2O	NOx	CO	NMVOC	CO_2	CH_4	N_2O	NOx	CO	NMVOC
1 A 5 Other	1.0	89	0.002	0.015	0.30	0.08	0.02						
Solid													
Coal	1.0	89	0.002	0.015	0.30	0.08	0.02	92.1	0.0023	0.0156	0.313	0.088	**0.019**

Standard Data Table 1

Energy: 1B1 Fugitive Emissions from Fuels (Coal Mining)

Source and Sink Categories	Activity Data Production (Mt) A	Methane Emissions (Gg) B	Emission Factor (Gg/Mt) C = B/A
1 B 1 Solid Fuels	3.17	16.72	
1 B 1 a Coal Mining			
1 B 1 a i Underground Mines			
Underground Activities	0.66	13.57	20.600
Post-Mining Activities	0.66	1.05	1.600
1 B 1 a ii Surface Mines			
Surface Activities	2.51	1.93	0.770
Post-Mining Activities	2.51	0.17	0.067
1 B 1 b Solid Fuel Transformation			
1 B 1 c Other			

Energy: 1B2 Fugitive Emissions from Fuels (Oil and Natural Gas)

Source and Sink Categories	Activity Data	Emissions Estimates			Aggregate Emission Factors		
	Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
1 B 2 a Oil							
i Exploration	NE						
ii Production of Crude Oil	NE						
iii Transport of Crude Oil	NE						
iv Refining/Storage	NE						
v Distribution of Oil Products	NE						
vi Other	NE						
1 B 2 b Natural Gas							
i Production/Processing				NE			
ii Transmission/Distribution	40.9	7.22	0.65	NE	0.176	0.0159	
iii Other Leakage				NE			
1 B 2 c Venting and Flaring							
i Oil				NE			
ii Natural Gas				NE			
iii Combined	8.1	0.52	259.00	NE	0.0645	31.9	

Energy: 1B2 Fugitive Emissions from Fuels (Geothermal)

Source and Sink Categories	Activity Data	Emissions Estimates			Aggregate Emission Factors		
	Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (kg/GJ)	CO_2 (kg/GJ)	NMVOC (kg/GJ)
Geothermal	78.94	2.596	367.0	NE	0.033	4.7	

Standard Data Table 2
Industrial Processes 1995

Source and Sink Categories	Activity Data A Production Quantity (kt)	Methane Emissions B Full mass of Pollutant (Gg) CO_2	Aggregate Emission Factors C Tonne of Pollutant per tonne of Product (t/t) CO_2
A Iron and Steel	845.0	1,535.0	1.800
B Non-Ferrous Metals			
Aluminium	272.0	470.0	1.730
Other			
C Inorganic Chemicals (excepting solvent use)			
Hydrogen	23.0	145.0	6.200
D Non-Metallic Products			
Cement	987.0	503.0	0.510
Lime	115.0	83.0	0.720

Non CO_2 Emissions from Industrial Processes 1995

Source and Sink Categories	Activity Data A Production Quantity (kt)	Emission Estimates B Full Mass of Pollutants (Gg) Tonnes x 1000									Aggregate Emission Factors C Tonne of Pollutant per Tonne of Product (t / t)								
		CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2	CO	CH_4	N_2O	NO_X	NMVOC	HFC	PFC	SF_6	SO_2
A Iron and Steel	845.0000	0.5660			1.0166					0.7717	0.00067			0.00120					0.00091
B Non Ferrous Metals																			
Aluminium Production	271.5470							0.0268		6.4700							0.00010		0.02383
Other																			
C Inorganic Chemicals (excepting solvent use)																			
Nitric Acid																			
Fertiliser Production	1,266.0000									12.5334									0.00990
Other	170.6830		0.1195									0.00070							
D Organic Chemicals																			
Adipic Acid																			
Other																			
E Non-Metallic Mineral Products																			
Cement	988.7580	0.5436			1.6588					0.9775	0.00055			0.00168					0.00099
Lime	110.1290	0.0340			0.0170					0.0040	0.00031			0.00015					0.00004
Other	169.0751	0.0000			0.0000	6.9780				0.0134	0.00000				0.04127				0.00008
F Other (ISIC)	8,262.0621	0.0000			0.0000	11.9117	0.1411	0.0022 0	0.1828	0.0000	0.00000			0.00000	0.00144		0.00000		0.00000
Grand Total		**1.1436**	**0.1195**		**2.6924**	**18.8897**	**0.1411**	**0.0290**	**0.1828**	**20.7700**									

Standard Data Table 3
Solvent and Other Product Use 1995

Source and Sink Categories	Activity Data A Quantity Consumed (kt)	Emissions Estimates B Full Mass of Pollutant (Gg)			Aggregate Emission Estimates C Tonne of Pollutant per Tonne of Product (t / t) C = B / A		
		N_2O	HFC	NMVOC	N_2O	HFC	NMVOC
A Paint Application	44.17			14.6682			0.3300
B Degreasing and Dry Cleaning	0.76			0.8200			1.0779
C Chemical Products Manufacture / Processing				N/A			
D Other	11.06			12.5520			1.1346
Total				**28.0402**			

Standard Data Table 4
Agriculture: 4A & 4B Enteric Fermentation and Manure Management 1995

Source and Sink Categories	Activity Data A	Emission Estimates B		Aggregate Emission Factor C	
	Number of Animals	Enteric Fermentation	Manure Management	Enteric Fermentation	Manure Management
	(1000)*	(Gg CH4)		(kg CH4 per head per year) C = (B/A) X 1000	
Totals		**1,442.724**	**17.516**		
Cattle					
a Dairy	4,090.00	314.112	3.636	76.8	0.889
b Non-Dairy	5,183.00	349.853	4.711	67.5	0.909
Sheep	48,816.00	737.122	8.689	15.1	0.178
Goats	337.00	5.560	0.040	16.5	0.119
Deer	1,179.00	36.077	0.435	30.6	0.369

Total ruminant emission for 1995 is 1,460.240 Gg

Note: * Ruminant numbers based on expected numbers.

1995 New Zealand N_2O Emissions Calculated with the PHASE II Methodolgy

Source and Sink Categories	Emission Estimates (kg N_20 - N)
Total	**28,062,666**
Direct Soil Emissions	**3,239,752**
Synthetic Fertilizers	1,656,824
Animal Wastes	532,060
Biological N2 Fixation	43,028
Crop Residue	177,839
Cultivated Histosols	830,000
Animal Production	**14,734,640**
Animals	0
Animals Waste Management Systems	14,734,640
Indirect Emissions	**10,088,274**
Atmospheric Deposition	3,355,696
Nitrogen Leaching and Runoff	6,515,601
Human Sewage	216,976

Note: 28,063 tonnes N_2O - N is equivalent to 44,098 tonnes N_2O or 44.10 Gg

Detailed information on the calculations and emission factors used is in Annex 4.

Greenhouse gas emissions from field burning of agricultural residues
All Cereals

Year	Total Biomass Burned (Gg dm)	Carbon Fraction	Total Carbon Release (Gg C)	Total Nitrogen (Gg N)	GHG Emissions (Gg)				GHG Agregate Emission factors (kg / t dm)			
					CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
1995	61.3	0.46943	28.8	0.41	0.192	4.032	0.005	0.164	3.130	65.720	0.074	2.671

Note that the figure for 1995 is provisional

Detailed calculations are in Annex 13.

Standard Data Table 5

Land Use Change and Forestry: 5A (Sheet 1) Changes in Forest and Other Woody Biomass Stocks - Annual Growth Increment 1995

Source and Sink Categories			Activity Data	Uptake Estimates	Aggregate Uptake Factor
Sector Specific Data (units) Land Type			Area of Forest/Biomass Stocks (kha)	Total Carbon Uptake Increment (Gg C)	Carbon Uptake Factor (t C/ha)
Temperate Forests	Plantations (specify type)	Pinus Radiata	1,557.04[1]	-7,977	5.1[2]

Notes: 1 The figure for the area of forest stocks is for plantation forests.
2 This factor will also vary from year to year as the average age and hence growth rates of the planted forest estate changes.
All figures are reported as three year averages with the base year in the middle.

Land Use Change and Forestry: 5A (Sheet 2) Changes in Forest and Other Woody Biomass Stocks - Annual Harvest 1995

Source and Sink Categories	Activity Data	Carbon Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units)	Amount of Biomass Removed (kt dm)	Carbon Emission/Removal Estimates (Gg C)	Carbon Emission Factors (t C/t dm)
Total Biomass Removed in Commercial Harvest	7,355	3,678	0.5
Traditional Fuelwood Consumed			
Total Other Wood Use			
Total Biomass Consumption	**7,355**	**3,678**	

Note: 1 The figure given includes roundwood removals from both plantation and native forests and post harvest slash

Land Use Change and Forestry: 5A (Sheet 3) Changes in Forest and Other Woody Biomass Stocks - Net CO_2 Emissions/Removals 1995

Source and Sink Categories	Emission/Uptake C (Gg)	Emissions/Removals CO_2 (Gg)
Total Annual Growth Increment	-7,977	-29,249
Total Annual Harvest	3,678	13,486
Net Emissions (+) or Removals (-)	**-4,299**	**-15,763**

Land Use Change and Forestry: 5B (Sheet 1) Forest and Grassland Conversion - CO_2 Release from Burning Aboveground Biomass 1995

Source and Sink Categories			Activity Data				Emission Estimates		Aggregate Emission Factors	
Sector Specific Data (units) Land Type			Area Converted Annually (kha)	Annual Loss of Biomass (kt dm)	Quantity of Biomass Burned (on and off-site) (kt dm)		Quantity of C Released[1] (kt C)		Carbon Fraction of Biomass Burned	
					On Site	Off Site	On Site	Off Site	On Site	Off Site
Temperate Forests	Evergreen	Primary[2] Secondary	0.36	237.6	237.6	NA	106.9	NA	0.5	NA
Other (specify): Mixed Scrub[3]			9.07	725.5	725.5	NA	326.5	NA	0.5	NA
Total C Released							433.4	NA		
Total of On Site and Off Site C Released							433.4			
Total CO_2 Released							1,589			

Notes: 1 Quantity of Biomass Burned is adjusted for the portion of carbon in biomass that remains on-site as charcoal (10% of biomass carbon).
2 Includes burning (from natural and anthropogenic causes) of Native Forests and Plantation Forests (ie. mixed primary/secondary and plantation).
3 Includes burning (from natural and anthropogenic causes) of mixed scrub and prescribed burning of scrub cleared for Plantation Forestry.
All figures are reported as three year averages with the base year in the middle. See Annex 5 for further details.
NA = Not Applicable

Land Use Change and Forestry: 5B (Sheet 2) Forest and Grassland Conversion - Release of Non-CO_2 GHG from On-Site Burning of Forests 1995

Source and Sink Categories	Activity Data		Emissions Estimates				Aggregate Emission Ratios			
Sector Specific Data (units) Land Type	Carbon Release (Gg)	Nitrogen Release (Gg)	Emissions Estimates (Gg)				Aggregate Emission Ratios			
			CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
On Site Burning of Forests	433.41	4.33	7.686	67.323	0.048	1.725	0.160	0.140	0.011	0.398

Land Use Change and Forestry: 5B (Sheet 3) Forest and Grassland Conversion - CO_2 Release from Decay of Aboveground Biomass 1995

Source and Sink Categories			Activity Data			Emission Estimates	Aggregate Emission Factors
Sector Specific Data (units) Land Type			5-Year Average Area Converted[1] (kha/yr)	5-Year Average Annual Loss of Biomass (kt dm/yr)	Average Quantity of Biomass to Decay (kt dm)	Carbon Released from Decay (kt C)	Carbon Fraction of Aboveground Biomass
Temperate Forests	Evergreen	Primary[2] Secondary					
Other (specify): Mixed Scrub			4.684[2]	375	375	187	0.5
Total C Released from Decay						187	
Total CO_2 Released from Decay						687	

Note: 1 Figures are given as previous five year average.
2 Only includes the area of mixed scrub cleared for plantation forestry that is left to decay (approximately 50% of toal area converted), the remainder is burned and is included under 5B Sheet 1.

Land Use Change and Forestry: 5B (Sheet 4) Forest and Grassland Conversion - Soil Carbon Release 1995

Soil carbon is not estimated as it is assumed to remain in balance or increase slightly from the conversion of pastoral land and mixed scrub to first rotation plantation forestry. No data is currently available on whether other forms of conversion may be occurring which result in a release of soil carbon.

Land Use Change and Forestry: 5B (Sheet 5) Forest and Grassland Conversion - Total CO_2 Emissions 1995

Category	Emissions (Gg)
CO_2 Release from Burning of Aboveground Biomass	1,589
CO_2 from Decay of Aboveground Biomass	687
CO_2 from Soil Carbon Release	ne
Total	2,276
Note: ne = Not Estimated	

Land Use Change and Forestry: 5C (Sheet 1-3) Abandonment of Managed Lands 1995

Not Estimated. No data is currently available on the extent of abandoned managed lands on a national basis. It is known however that considerable regeneration is occurring in some areas, but these have yet to be quantified.

Standard Data Table 6: Waste

Detailed information and calculations for waste sector emissions are in Annex 6 for wastewater, and Annex 14 for landfills. Emissions from landfills are calculated using the Phase II Guidelines.

Waste sector methane in Gg	1995
Total	**131.67**
Landfills	127.37
Wastewater	4.30

ANNEX 13: Detailed calculations for emissions from the field burning of agricultural residues

IPCC Standard Data Table 4

Agriculture: 4F Field Burning of Agricultural Residues

CropType: Barley

Year	Production June Years (Gg Crop)	Production Annual (Gg Crop)	Production 3 Year Average (Gg Crop)	Total Biomass Burned (Gg dm)	Quantity of Carbon Released (Gg C)	Total Nitrogen Release (Gg N)
1988	356.06	341.5				
1989	326.85	380.9	377.9	33.9	15.47	0.23
1990	434.86	408.5	387.0	34.7	15.84	0.24
1991	382.04	350.4	365.9	32.8	14.98	0.22
1992	318.79	354.2	362.8	32.5	14.85	0.22
1993	389.52	392.5	372.1	33.4	15.23	0.23
1994	395.48	349.1	357.8	32.1	14.65	0.22
1995	302.80	340.4	343.4	30.8	14.06	0.21
1996	378.00					

Crop Type: Wheat

Year	Production June Years (Gg Crop)	Production Annual (Gg Crop)	Production 3 Year Average (Gg Crop)	Total Biomass Burned (Gg dm)	Quantity of Carbon Released (Gg C)	Total Nitrogen Release (Gg N)
1988	205.98	170.5				
1989	134.99	161.5	169.5	16.5	8.0	0.10
1990	188.05	184.4	179.0	17.4	8.4	0.10
1991	180.69	185.9	190.3	18.5	9.0	0.11
1992	191.04	205.2	206.7	20.1	9.7	0.12
1993	219.41	230.6	227.5	22.1	10.7	0.13
1994	241.85	243.5	242.0	23.5	11.4	0.14
1995	245.17	250.2	248.0	24.1	11.7	0.14
1996	255.32					

Crop Type: Maize

Year	Production June Years (Gg Crop)	Production Annual (Gg Crop)	Production 3 Year Average (Gg Crop)	Total Biomass Burned (Gg dm)	Quantity of Carbon Released (Gg C)	Total Nitrogen Release (Gg N)
1988	136.94	137.8				
1989	138.69	150.2	152.7	5.5	2.6	0.05
1990	161.65	172.5	167.2	6.0	2.8	0.06
1991	183.39	173.6	167.1	6.0	2.8	0.06
1992	163.84	148.5	152.1	5.5	2.6	0.05
1993	133.07	137.9	144.0	5.2	2.4	0.05
1994	142.77	151.8	159.1	5.7	2.7	0.05
1995	160.80	195.0	180.3	6.5	3.1	0.06
1996	229.19					

All Cereals

Year	Total Biomass Burned (Gg dm)	Carbon Fraction	Total Carbon Release (Gg C)	Total Nitrogen (Gg N)	GHG Emissions (Gg)				GHG Agregate Emission factors (kg / t dm)			
					CH_4	CO	N_2O	NO_X	CH_4	CO	N_2O	NO_X
1989	55.8	0.46653	26.0	0.38	0.174	3.646	0.004	0.151	3.110	65.314	0.075	2.704
1990	58.1	0.46673	27.1	0.40	0.181	3.796	0.004	0.157	3.112	65.342	0.075	2.707
1991	57.3	0.46742	26.8	0.39	0.179	3.749	0.004	0.155	3.116	65.438	0.075	2.699
1992	58.1	0.46793	27.2	0.39	0.181	3.804	0.004	0.156	3.120	65.510	0.074	2.679
1993	60.6	0.46834	28.4	0.41	0.189	3.975	0.004	0.161	3.122	65.567	0.074	2.662
1994	61.3	0.46899	28.7	0.41	0.192	4.025	0.005	0.163	3.127	65.659	0.074	2.662
1995	61.3	0.46943	28.8	0.41	0.192	4.032	0.005	0.164	3.130	65.720	0.074	2.671

Note that the figure for 1995 is provisional

ANNEX 14: Detailed calculations for methane from solid waste disposal

IPCC Standard Data Table 6: CH4 from Solid Waste Disposal

Landfill Methane Generation (tonnes)

Year	MSW to SWD	MCF	DOC to SWD	Carbon in Biogas	Biogas C as CH_4	CH_4 in Biogas	Gross Annual GH_4 Generated (Gg)	Recovered Methane	Net Annual CH_4 Emissions (Gg)	Net Annual CH_4 Emissions (Gg)	Aggregate Emission Factor
1990	2472710	2373802	456957	228478	125663	167551	167.55		167.55	150.80	0.3667
1991	2496686	2396819	461388	230694	126882	169175	169.18		169.18	152.26	0.3667
1992	2520884	2420049	465859	232930	128111	170815	170.82	7000	163.82	147.43	0.3667
1993	2545008	2443208	470317	235159	129337	172450	172.45	12000	160.45	144.40	0.3667
1994	2569132	2466367	474776	237388	130563	174084	174.08	21500	152.58	137.33	0.3667
1995	2593256	2489526	479234	239617	131789	175719	175.72	34200	141.52	127.37	0.3667
1996	2617454	2512756	483705	241853	133019	177359	177.36	44000	133.36	120.02	0.3667
1997	2640912	2535276	488041	244020	134211	178948	178.95	48000	130.95	117.85	0.3667
1998	2664444	2557866	492389	246195	135407	180543	180.54	60000	120.54	108.49	0.3667
1999	2687976	2580457	496738	248369	136603	182137	182.14	65000	117.14	105.42	0.3667
2000	2711508	2603048	501087	250543	137799	183732	183.73	65000	118.73	106.86	0.3667
2001	2734966	2625567	505422	252711	138991	185321	185.32	65000	120.32	108.29	0.3667
2002	2753462	2643324	508840	254420	139931	186575	186.57	65000	121.57	109.42	0.3667
2003	2772100	2661216	512284	256142	140878	187838	187.84	65000	122.84	110.55	0.3667
2004	2790882	2679246	515755	257877	141833	189110	189.11	65000	124.11	111.70	0.3667
2005	2809808	2697415	519252	259626	142794	190393	190.39	65000	125.39	112.85	0.3667
2006	2828946	2715788	522789	261395	143767	191689	191.69	65000	126.69	114.02	0.3667
2007	2843611	2729867	525499	262750	144512	192683	192.68	65000	127.68	114.91	0.3667
2008	2858370	2744035	528227	264113	145262	193683	193.68	65000	128.68	115.81	0.3667
2009	2873222	2758294	530972	265486	146017	194690	194.69	65000	129.69	116.72	0.3667
2010	2888170	2772643	533734	266867	146777	195702	195.70	65000	130.70	117.63	0.3667
2011	2903168	2787041	536505	268253	147539	196719	196.72	65000	131.72	118.55	0.3667
2012	2916571	2799908	538982	269491	148220	197627	197.63	65000	132.63	119.36	0.3667
2013	2930055	2812853	541474	270737	148905	198541	198.54	65000	133.54	120.19	0.3667
2014	2943622	2825877	543981	271991	149595	199460	199.46	65000	134.46	121.01	0.3667
2015	2957271	2838981	546504	273252	150289	200385	200.38	65000	135.38	121.85	0.3667
2016	2971026	2852185	549046	274523	150988	201317	201.32	65000	136.32	122.69	0.3667
2017	2984728	2865339	551578	275789	151684	202245	202.25	65000	137.25	123.52	0.3667
2018	2998512	2878572	554125	277063	152384	203179	203.18	65000	138.18	124.36	0.3667
2019	3012380	2891885	556688	278344	153089	204119	204.12	65000	139.12	125.21	0.3667
2020	3026332	2905279	559266	279633	153798	205064	205.06	65000	140.06	126.06	0.3667

Fraction MSW to SWD		**1.0**	**Stream**	**% of MSW**	**% DOC**
Site Type	%	MCF	Paper	30%	40%
Managed	90%	1.0	Garden	10%	17%
Unmanaged - deep	10%	0.8	Food	15%	15%
Unmanaged - shallow	10%	0.6	Wood	7%	30%
Weighted MCF		**0.96**	Textiles	3%	40%
% DOC Degraded		**0.5**	**Weighted DOC**		**0.19**
Biogas as Methane		**0.55**	**Oxidation Correction**		**0.10**

Note: MSW = Municipal Solid Waste
SWD = Solid Waste Disposal
DOC = Degradable Organic Disposal
MCF = Methane Correction Factor.
Landfill Sites are classified as:Managed, Unmanaged - deep (>5m), and Unmanaged - shallow (<5m).
Aggregate Emission Factor (before Recovery) = (1000*Gross CH4 Gen/DOC to SWD)
Methodology based on Phase II IPCC Guidelines (1996)

Projected National Emissions of Methane from Landfills 1990 - 2010

Population Projections (thousands)

Year	North Island		South Island		National Total	
	Base	% growth	Base	% growth	Base	% growth
1990	2491.8		849.7		3341.5	
1991	2520.5	1.15	853.4	0.44	3373.9	1.0
1992	2549.5	1.15	857.1	0.43	3406.6	1.0
1993	2578.5	1.14	860.7	0.42	3439.2	1.0
1994	2607.4	1.12	864.4	0.43	3471.8	0.9
1995	2636.4	1.11	868.0	0.42	3504.4	0.9
1996	2665.4	1.10	871.7	0.43	3537.1	0.9
1997	2693.5	1.05	875.3	0.41	3568.8	0.9
1998	2721.7	1.05	878.9	0.41	3600.6	0.9
1999	2749.8	1.03	882.6	0.42	3632.4	0.9
2000	2778.0	1.03	886.2	0.41	3664.2	0.9
2001	2806.1	1.01	889.8	0.41	3695.9	0.9
2002	2829.0	0.82	891.9	0.23	3720.9	0.7
2003	2852.1	0.82	893.9	0.23	3746.1	0.7
2004	2875.4	0.82	896.0	0.23	3771.5	0.7
2005	2898.9	0.82	898.1	0.23	3797.0	0.7
2006	2922.7	0.82	900.2	0.23	3822.9	0.7
2007	2941.9	0.66	900.8	0.07	3842.7	0.5
2008	2961.2	0.66	901.5	0.07	3862.7	0.5
2009	2980.6	0.66	902.1	0.07	3882.7	0.5
2010	3000.2	0.66	902.7	0.07	3902.9	0.5
2011	3019.8	0.65	903.4	0.07	3923.2	0.5
2012	3038.1	0.61	903.2	-0.02	3941.3	0.5
2013	3056.5	0.61	903.1	-0.02	3959.5	0.5
2014	3074.9	0.61	902.9	-0.02	3977.9	0.5
2015	3093.5	0.61	902.8	-0.02	3996.3	0.5
2016	3112.3	0.61	902.6	-0.02	4014.9	0.5
2017	3131.0	0.60	902.4	-0.02	4033.4	0.5
2018	3149.8	0.60	902.3	-0.02	4052.0	0.5
2019	3168.7	0.60	902.1	-0.02	4070.8	0.5
2020	3187.7	0.60	902.0	-0.02	4089.6	0.5

Projected Waste production (tonnes)

Year	North Island	South Island	National Total
1990	1843932	628778	2472710
1991	1865170	631516	2496686
1992	1886630	634254	2520884
1993	1908090	636918	2545008
1994	1929476	639656	2569132
1995	1950936	642320	2593256
1996	1972396	645058	2617454
1997	1993190	647722	2640912
1998	2014058	650386	2664444
1999	2034852	653124	2687976
2000	2055720	655788	2711508
2001	2076514	658452	2734966
2002	2093479	659983	2753462
2003	2110583	661517	2772100
2004	2127826	663055	2790882
2005	2145211	664597	2809808
2006	2162798	666148	2828946
2007	2176997	666614	2843611
2008	2191289	667081	2858370
2009	2205675	667548	2873222
2010	2220155	668015	2888170
2011	2234652	668516	2903168
2012	2248172	668399	2916571
2013	2261773	668282	2930055
2014	2275457	668165	2943622
2015	2289223	668048	2957271
2016	2303102	667924	2971026
2017	2316921	667807	2984728
2018	2330822	667690	2998512
2019	2344807	667573	3012380
2020	2358876	667457	3026332

Urban	85%	MSW kg / cap	800
Rural	15%	MSW kg / cap	400