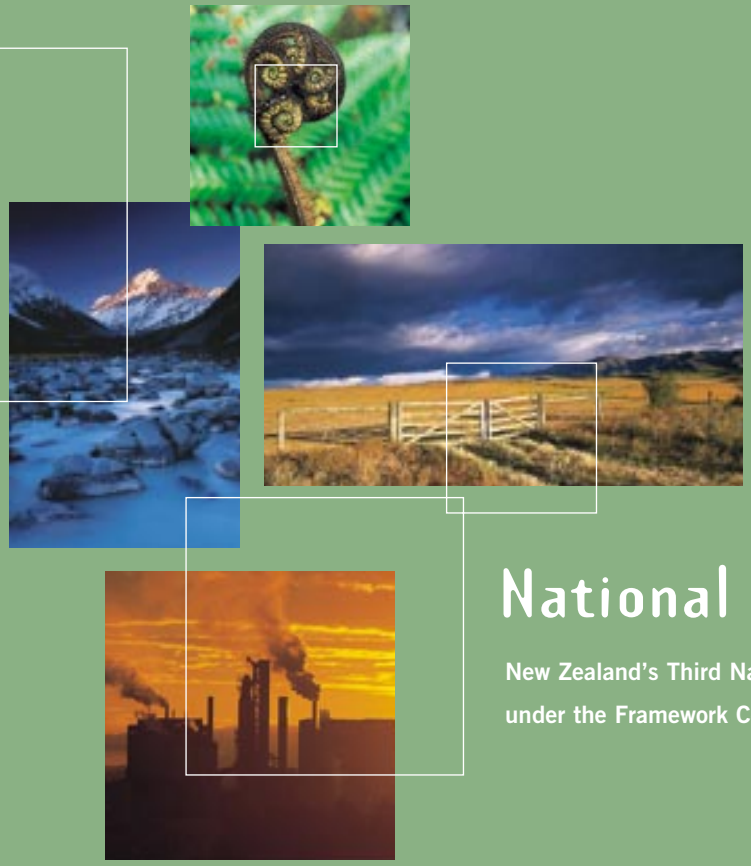

National Communication 2001

New Zealand's Third National Communication
under the Framework Convention on Climate Change

New Zealand Climate Change Programme
Te Hōtaka Rerekētanga Āhuarangi o Aotearoa

With the New Zealand Climate Change Programme

New Zealand Climate Change Programme
Te Hōtaka Rerekētanga Āhuarangi ō Aotearoa

National Communication 2001, New Zealand's Third National Communication under the Framework Convention on Climate Change

A report prepared by the Ministry for the Environment as part of the New Zealand Climate Change Programme.

Ministry for the Environment
Manatū Mō Te Taiao

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Disclaimer: This report has been prepared using the best current information available on greenhouse gas emissions and projections and the associated policy measures available. There are still many uncertainties associated with the collection of data and projection of future emissions and carbon sinks. On-going research could alter the projections made in this report.

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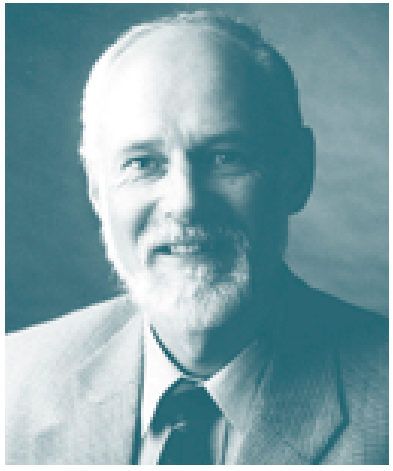
Foreword

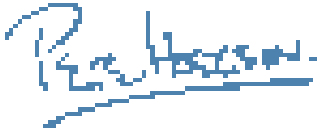


In May 2000 the Government announced its intention to join with most other developed nations and ratify the Kyoto Protocol by the time of the World Summit on Sustainable Development in September 2002. The 7th Conference of the Parties to the United Nations Framework Convention on Climate Change, held recently in Marrakech, Morocco, adopted decisions that allow the Kyoto Protocol to become 'operational'. This is a milestone in the international climate change process, and it means that we now have an agreement that can be ratified.

The timing of the publication of this third national communication occurs at around the same time as a number of decisions are being taken at the domestic level in areas directly connected or related to climate change. We are part way through a public consultation process on ratification of the Kyoto Protocol and associated domestic policy measures. The legislation required under New Zealand law to enable ratification is currently being drafted.

This third national communication provides an important update of New Zealand's response to our existing commitments under the Framework Convention on Climate Change. Meeting future commitments under the Kyoto Protocol will pose certain challenges for New Zealand because of our already high proportion of electricity from renewable sources (but we are aiming higher) and the high proportion of non-carbon dioxide emissions in our greenhouse gas inventory. We will be looking for innovative social and technological solutions, and believe that these solutions will create economic opportunities.

New Zealand is serious about climate change. In global terms our greenhouse gas emissions are small, but we are a country that derives much of its wealth from primary production, trade and the natural environment. Hence, our economy is vulnerable to the impacts of climate change on a global scale. If we want a stable climate in the future that preserves equity and opportunities for all nations, there must be a global response to reducing greenhouse gas emissions. New Zealand is prepared to be part of that response.



Hon Pete Hodgson
Convenor, Ministerial Group on Climate Change

Executive Summary

Introduction

This third national communication provides a "snapshot" of progress, to date, in New Zealand for both commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and also progress towards ratification of the Kyoto Protocol.

The New Zealand Government is committed to leadership on the issue of climate change. It has stated its intention to ratify the Kyoto Protocol, and has begun the process for ratification, which, under New Zealand law, requires legislation. Since the Prime Minister's announcement regarding ratification, domestic activity has been focused during most of 2000 and 2001 on the necessary domestic requirements for ratification. This has also included increased effort at the international level to ensure that the Kyoto Protocol rules and procedures are agreed before New Zealand completes the ratification process.

A Ministerial group was established in May 2000 to oversee the development and implementation of New Zealand's climate change action programme. The Ministerial Group on Climate Change is convened by the Minister responsible for Energy, Forestry, Small Business, and Research Science and Technology. The other members of the Ministerial Group are the Deputy Prime Minister and the Ministers of Finance, Foreign Affairs and Trade, Environment, Agriculture, Transport and Local Government. These ministers represent the core government agencies involved in the New Zealand Climate Change Programme.

Development of policy measures has for the most part been forward looking; that is what do we need to do before the beginning of the first commitment period of the Kyoto Protocol, and what measures will need to be in place during the commitment period?

New policy initiatives in particular are those relating to energy efficiency and conservation, highlighted with the passage of the Energy Efficiency and Conservation Act in 2000, and the release of the National Energy Efficiency and Conservation Strategy in 2001.

Inventory

New Zealand has developed an inventory of emissions and removals of the most significant greenhouse gases. The inventory is 1990-based and updated annually to monitor trends in emissions and removals, and to develop and evaluate the effectiveness of policy measures. The UNFCCC Common Reporting Format (CRF) was used for our inventory submissions to the UNFCCC in both 2000 and 2001.

The overall trend of New Zealand's greenhouse gas emissions from 1990 to 1999, as reported in April 2001, is that CO_2 has increased by 20 percent and N_2O by 5 percent; CH_4 has decreased by five percent, and HFCs, PFCs, and SF_6 as a whole have decreased by 47 percent (this is largely due to a sharp decline in PFC emissions). Table 1 compares emissions and removals in 1999 with 1990 data.

Table 1: Emissions and removals of greenhouse gases in New Zealand in 1990 and 1999 as reported in New Zealand's National Inventory Report 2001.

	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs	PFCs	SF_6
1990	25,399	-22,307	35,211	11,849	Negligible	603	2.87
1999	30,523	-23,245	33,594	12,397	210	74	33.2

All data is in Gigagrams of CO_2 equivalent.

New Zealand has been developing a carbon monitoring system over the last five years to fill the inventory gaps relating to soil carbon and indigenous forests and scrublands. In addition, resources continue to go into addressing the large uncertainties inherent in emissions from the agricultural sector.

New Zealand's inventory was reviewed in 2001 under the UNFCCC pilot of the technical review guidelines for greenhouse gas inventories. The reviews (in-country, desk, and centralised) have greatly assisted the focus on inventory improvement and introduction of inventory good practice.

Policies and measures

With agreement of the Kyoto Protocol in late 1997, and more recently, the Government's intention to ratify by September 2002, domestic effort has concentrated on the development of policies that will enable New Zealand to meet its Kyoto target.

The Government has agreed that broad coverage of greenhouse gases and sectors and cost-effective emission reductions opportunities will be required to meet New Zealand's commitments under the Kyoto Protocol. Policies will need to be developed that aim to establish broadly comparable incentives to reduce emissions across sectors. The Government has also identified five key criteria, in line with sustainable development, to guide the choice between different policy options: economic efficiency, equity, feasibility, environmental integrity and competitiveness.

Policies and measures for carbon dioxide emissions

Energy efficiency, conservation and renewables: The Government has agreed that energy efficiency, energy conservation, and use of renewable sources of energy will play a strong role in achieving CO_2 emissions reductions as part of New Zealand's domestic climate change policy response, especially in the period before 2008. The Energy Efficiency and Conservation Act (2000) and the National Energy Efficiency and Conservation Strategy (finalised in October 2001) are key platforms.

Negotiated greenhouse agreements: The industry voluntary agreement programme described in the second national communication concluded in 2000. The Government has agreed that Negotiated Greenhouse Agreements (NGAs) with major emitting industries aimed at limiting emissions of greenhouse gases, will form part of New Zealand's policy response in the period before 2008.

Transport sector: A number of measures aimed in part at containing the growth in greenhouse gas emissions from the transport sector are under development, including a New Zealand Transport Strategy, measures to encourage public transport, better charging and funding tools for road-making agencies, and measures to encourage greater co-operation between these agencies. In addition, a new system – patronage funding (based on actual patronage of public transport services) – has been implemented for the allocation of funding to public transport.

Policies and measures for protection and enhancement of sinks and reservoirs

New Zealand recognises the important role that forests play as sinks and reservoirs of greenhouse gases. As at 1 April 2000 there were 1.77 million hectares of sustainably managed planted forest in New Zealand. Over the period 1990 to 2000 new planting has averaged 55,000 hectares per annum. The best estimates of future average annual new planting is 40,000 until 2010, with a likely range of between 20,000 and 60,000 hectares per year. The design of a system that enables carbon accumulated in eligible forest sinks to be verified and traded is an important component of domestic climate change policy.

New Zealand has 6.2 million hectares of indigenous forests. Some 5.2 million hectares of indigenous forest are owned by the State, with the vast bulk of this State resource managed for its conservation values. Less than one percent 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 2000 the Government made a decision to end beech harvesting from indigenous production forests (around 93.5 thousand hectares) on the West Coast of the South Island due to their significant natural and conservation values. These forests are in the process of being transferred to the Department of Conservation. The remaining logging of rimu on Crown-managed land is due to end on 31 March 2002, which will mark the end of all indigenous forest logging on Crown-managed land.

The New Zealand Carbon Monitoring System, designed to track carbon changes in soils, indigenous forests and scrublands, should become operational over the next year.

Policies and measures for methane emissions from the agricultural sector

Methane emissions from agricultural sources in New Zealand are static as the result of policies being implemented for reasons other than climate change. For this reason, New Zealand has not, to date, adopted any direct policies to limit agricultural sources of methane. Research investment has increased, however. This research is aimed at reducing uncertainty in emissions sources and sinks and also investigating technical solutions to further reduce methane emissions from livestock. An experts' working group on methane has been established to advise on the most appropriate strategies for methane inventory improvement and on mitigation options for research.

Policies and measures for methane emissions from the waste sector

Methane emissions from the waste sector have been decreasing (in absolute terms as well as in the sector's relative share of total greenhouse gas emissions) in recent years despite increases in the volume of waste produced. This trend is expected to continue into the future.

Current climate change policy development has several options for managing the emissions from landfills, including the use of levies, emissions trading and project credits, with varying levels of government responsibility. All of these policy options are part of the current consultation round.

The National Waste Minimisation and Management Strategy aims to reduce the volume of waste being produced. It is expected to be publicly released March 2002.

Policies and measures for nitrous oxide emissions from the agricultural sector

The agricultural sector is responsible for most of New Zealand's emissions of nitrous oxide. As with methane from the agricultural sector, there has been an increase in research investment aimed at reducing uncertainty in nitrous oxide agricultural sources and sinks.

An expert committee (NzOnet) has also been set up specifically to advise on nitrous oxide inventory and mitigation strategies.

Policies and measures for other gases

Emissions of HFCs and PFCs from a range of source categories have been estimated.

Emissions of PFCs from New Zealand's single aluminium smelter (which are monitored under the Resource Management Act) have fallen significantly over the last two years with the introduction of improvements to the smelting process.

Emission projections and the effects of policy measures

By the middle of the first commitment period under the Kyoto Protocol, emissions of carbon dioxide, methane and nitrous oxide are projected to be about 37 percent, five percent and 36 percent respectively above 1990 levels using a medium (2.5 percent) GDP growth scenario for the energy and industrial process sector. Projections for methane and nitrous oxide are dominated by the agricultural sector. Although total livestock numbers are likely to continue to decrease, animal productivity is projected to increase which implies a corresponding increase in both methane and nitrous oxide emissions.

Total removals of carbon dioxide from the land-use change and forestry sector (planted forests) fluctuate on an annual basis, reflecting the amount of new planting together with the age class of the forests and the harvesting-replanting cycle. For the years 2000, 2010 and 2020, net removals are projected to be about 20,000, 10,000 and 17,000 Gg of carbon dioxide respectively. On a cumulative basis, New Zealand's planted forests are projected to remove 538.2 million tonnes of carbon dioxide over the period 1990 to 2020. Kyoto forests (those planted since 1990 are projected (at a planting rate of around 60,000 hectares per year from 2001) to remove 110 million tonnes of CO_2 from the atmosphere during the first commitment period.

Financial resources and transfer of technologys

The New Zealand Official Development Assistance (NZODA) bilateral schedule is dominated by direct assistance on a one-to-one, country-to-country basis, comprising in most cases a wide range of developmental projects and activities. Through this channel, New Zealand has supported a number of projects that are relevant to climate change.

Since 1997, the NZODA Pacific Initiative for the Environment (PIE) programme has funded projects in coral reef and integrated coastal management, and forestry, and has provided support for the Pacific Island Climate Change Assistance Programme (PICCAP) implemented by the South Pacific Regional Environment Programme (SPREP).

Vulnerability assessment, climate change impacts and adaptation measures

The impacts from climate change are of concern to New Zealand because of the size and importance (both economic and social) of the primary production sector. Furthermore, its low population density and related long-distance infrastructure, long coastline and varied geomorphology make it vulnerable to climate hazards.

A national review of climate change impacts research was completed in June 2001. This assessment updates the findings of the previous such exercise carried out in 1990. The new report summarised current projections of overall changes in bio-physical variables expected under two different global climate change scenarios, including sea-level rise and coastal erosion. It gives a description at a high level of the expected sectoral impacts for agriculture, health, natural ecosystems, urban environment and infrastructure, and examines the specific vulnerabilities of the indigenous Maori population and of New Zealand's Pacific Island neighbours. The report draws upon the broad range of on-going publicly funded research programmes, and makes extensive use an integrated, model-based system for evaluating the

effects of climate variability and change on the New Zealand environment (the CLIMPACTS programme).

The main impacts identified in the new report largely agree with those of the earlier report. However, some findings are now on a much firmer basis, and some general climate change projections have been modified based on the updated climate change scenarios.

Research and systematic observation

New Zealand has continued to promote and collaborate in research and systematic observations, as required by Articles 4 and 5 of the UNFCCC. Estimated central government expenditure on climate change related research and systematic observations for the 2000/01 financial year is NZ$21 million, an increase of NZ$4.6 million over the amount that was reported in the second national communication.

This expenditure has enabled climate observations to be maintained, new knowledge about climate change and its impacts in New Zealand and the southwest Pacific to be generated, and adaptation and mitigation options to be developed.

New Zealand made a substantial input to the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change, by supporting one scientist as a member of the IPCC Bureau and providing convening lead authors for three chapters and lead and contributing authors and review editors for several more chapters.

New Zealand has continued to build up an archive of systematic atmospheric, oceanic and terrestrial observations based on the monitoring activities described in the first and second national communications. Details of these observations are tabulated in the Global Climate Observing System report provided separately to the UNFCCC.

Education, training and public awareness

The Government, through the New Zealand Climate Change Programme, has increased its education, training and public awareness activities, including a number of published documents, newsletters and information sheets.

A structured education and public consultation programme is occurring as part of New Zealand's process for ratification of the Kyoto Protocol. In addition to documents, working papers and information sheets prepared for this consultation programme, a consultation kit has been prepared for use in schools. The consultation kit provides a forum for students and their families to get involved with the nationwide consultation process.

Photograph courtesy of NIWA/AgResearch

Chapter 1 Background

1.1 Earth's changing climate

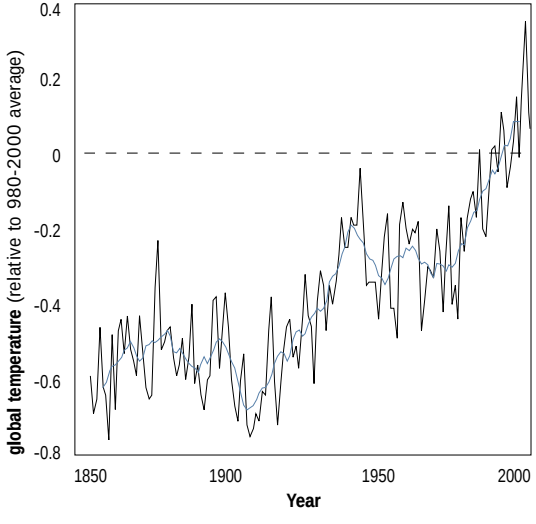
Our climate has undergone many changes over millions of years – from ice ages to tropical heat and back again. Natural changes have generally been gradual, allowing people and other species to adapt or migrate, although some prehistoric climate changes may have led to mass extinction of species.

Over the last 50 to 100 years, the process of change has sped up because of the growing build-up in the atmosphere of trace 'greenhouse' gases – carbon dioxide (CO_2), methane and nitrous oxide. These gases act like a blanket keeping the sun's warmth from escaping – making life on earth possible.

Because of human-caused emissions of these gases, their concentrations in the atmosphere have increased at unprecedented rates and the blanket is getting thicker. This produces an 'enhanced greenhouse effect' that is warming up the globe. The changes ahead of us will be much larger and will happen more quickly than any recent natural climate variations.

The effects are already measurable:

- the world's 10 warmest years have all been since 1983, seven of them since 1990
- the global mean temperature went up about 0.6ºC between 1861 and 2000
- sea levels went up about 10 to 20 cm between 1900 and 2000
- glaciers are retreating
- Arctic sea ice is thinning and reducing
- 1998 was the world's – and New Zealand's – hottest year since records began.



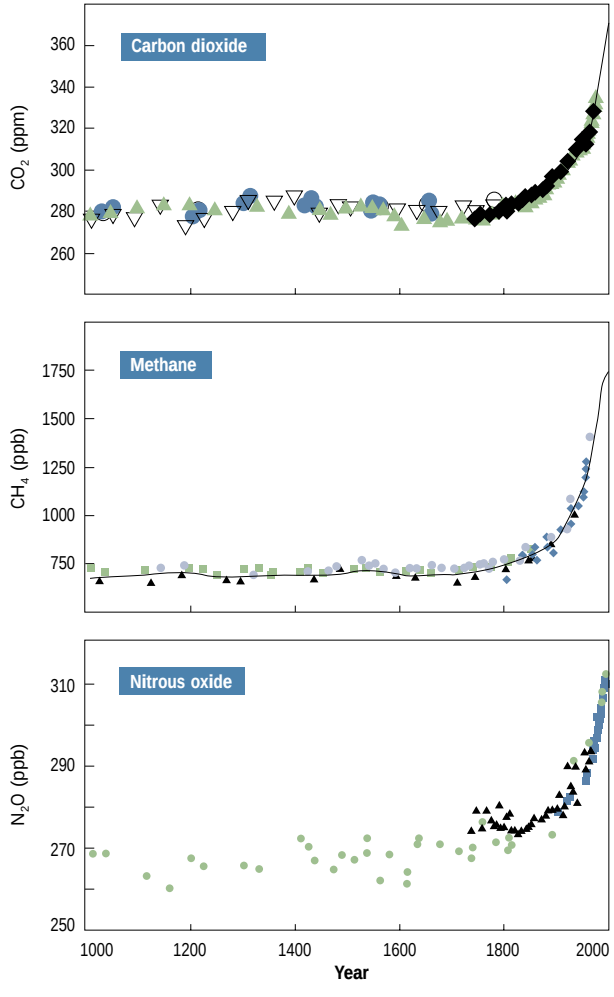


Figure 1 Human emissions have caused a strong rise in greenhouse gas concentrations over the past 100 years. This rise coincides with an increase in the global average temperature, and model studies find that most of the warming over the past 50 years is likely due to the increased greenhouse gases concentrations.

Source: Intergovernmental Panel on Climate Change, 2001

There has been debate in the past on whether humans were responsible for the observed climate change, or whether it was just a case of natural variability. Recent worldwide observations and complex climate models have produced new and stronger evidence that in most of the warming observed over the past 50 years is in fact due to human emissions of greenhouse gases. This finding by the Intergovernmental Panel on Climate Change was also supported by the American Academy of Sciences.

As the Earth's temperature continues to rise, the weather will become more extreme. Projections of future global temperature rises range from 1.4 to 5.8ºC over the next 100 years, depending on future greenhouse gas emissions. This will mean higher maximum and minimum temperatures, more hot days and heat waves, and fewer cold spells nearly everywhere. Rainfall patterns are likely to change, and the variability of rainfall is expected to increase. This will lead to more frequent rain in some mid and high latitude areas, but possible reductions in others. Large continental land areas will suffer from an increased risk of drought. Apart from gradual changes, extremely heavy rainfall could increase in severity and frequency. Tropical cyclone winds are likely to become more intense with heavier rainfall causing floods and property damage. Sea levels will continue to rise by between 10cm and 1m by 2100, eroding coastlines and flooding low-lying areas. Sea levels will continue to rise for many more centuries, even after atmospheric temperatures have reached a new stable level.

In some parts of the world, we can already see changes in response to the increasing temperatures, with shifts in the habitat range for some plants and animals, earlier flowering of trees and emergence of insects. Glaciers are receding worldwide, and seasonal snow and ice cover has reduced in northern high latitudes. The growing season in mid to high latitudes has extended by up to 11 days over the past 30 years.

Over the next 100 years, the expected rate of change in global average temperatures is likely to be larger than any natural variations in at least the past 10,000 years.

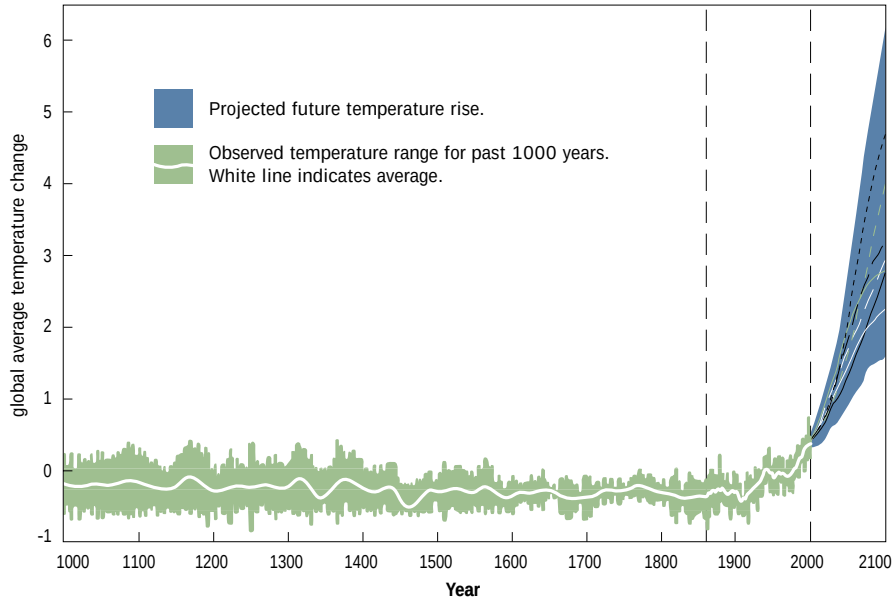


Figure 2 The projected future temperature rise can be compared with the temperatures over the past 1000 years or more, deduced from tree rings, corals, ice cores and bore holes. It shows that the changes over the next 100 years will be more rapid than any natural climate variations experienced in the past.

Source: Intergovernmental Panel on Climate Change, 2001

But the effect of global warming is more than just a rise in the world's temperature. Any changes in the global system have a flow-on effect. A warmer surface means more water vapour enters the atmosphere. This affects the complex systems controlling the Earth's climate and can radically change weather patterns.

Under continued climate change, water will become a more precious resource in many areas, especially in drier areas of the sub-tropics. Agricultural productivity will fall in tropical areas. Temperate regions may see a temporary increase, but even their production will decline if warming continues unchecked. More frequent incidences of climatic extremes, such as floods and droughts, will cause damage for agriculture and urban infrastructure in some places even where the average climate change has only a moderate effect.

Some natural habitats are highly vulnerable to a changing climate – particularly coral reefs and forests. Many areas will be lost. Floods due to rising sea levels and heavy storms could force millions of people from their homes. The threat from diseases such as dengue fever, malaria and cholera will increase. Water quality and supply will be affected.

In some areas agricultural productivity will temporarily increase, and some regions will benefit from increased average rainfall. Timber production could rise from appropriately managed forests. Warmer winters will mean fewer cold-related deaths in some areas and will reduce heating costs, but hotter summers will mean increased cooling costs. But heat waves will increase heat stress particularly for poor people without air conditioning in urban areas.

Increasing industrialisation over the past century is a major factor causing climate change – carbon dioxide is released by burning fossil fuels like coal, petrol and gas. They supply around 90 percent of the world's commercial energy needs. The carbon in these fuels, stored in the earth's crust over tens of thousands of years, is being released at a rapid pace.

Other greenhouse gases like methane and nitrous oxide come from:

- agricultural practices (rice cultivation or livestock farming)
- waste disposal
- industrial processes and industrial applications.

The effects are made worse by the destruction of much of the world's forests, which absorb CO_2 from the atmosphere.

Global energy use has increased nearly 70 percent since 1971 and is likely to rise at more than two percent annually for the next 15 years. This will raise greenhouse gas emissions about 50 percent above current levels, unless we increase energy efficiency and move away from fossil fuels. Developing nations account for more than three quarters of the world's population but consume only about one third of the world's energy and emit less than half of all human-created greenhouse gases. Despite continuing growth, in 30 years, per capita energy consumption and CO_2 emissions in the developing world are still likely to be much less than that of the industrialised world.

Developing countries will be worst affected by changing climate patterns. Many have land areas that are particularly sensitive to change and prone to floods or drought, and few resources to cope with negative impacts. Coastlines in poorer countries are more vulnerable to flooding – 49 of the 50 countries whose shore protection costs are likely to rise substantially are less developed countries.

Agriculture plays a larger part in the economies of developing countries which makes them more vulnerable to climate extremes, and poorer nutrition and health care will mean higher loss of life. Many developing countries are also less able to adapt quickly to changes in climate because of a lack of technology, education, infrastructure and money.

1.2 The international response

The United Nations Framework Convention on Climate Change

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

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

The treaty took effect on 21 March 1994. So far it has been signed and ratified by over 185 nations, including New Zealand.

Since 1990 the IPCC has produced two more assessment reports. As noted above, the Third Assessment Report in 2001 concludes that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities".

The UNFCCC sets out broad principles for change, recognising that it can be difficult to get consensus because all countries have different national circumstances. By establishing a framework of general principles and institutions, and by setting up a process through which governments can meet regularly, it gets things started.

It also encourages:

- scientific research on climate change
- sharing and exchange of environmentally sound technology and know-how
- education about the effects of climate change and how we must deal with it.

Taking into account national circumstances, all countries that ratify the UNFCCC are required to address climate change through greenhouse gas inventories, national or regional programmes and preparing for adaptation to the impacts of climate change.

The Kyoto Protocol

In 1995, the international community recognised that the UNFCCC alone was not enough to ensure that greenhouse gas levels would be reduced to safe levels. More urgent action was needed, and negotiations on a protocol began.

In 1997, the Kyoto Protocol to the Framework Convention on Climate Change was adopted. This Protocol builds on the concerns of the climate convention and makes new commitments that are more detailed and stronger. It sets out binding targets for countries to achieve within a set timeframe and suggests different ways that countries can reduce emissions. A total of 84 countries have signed the Protocol, and 42 have ratified, including one Party from Annex I.

The Kyoto Protocol will only come into force when enough countries have ratified it. This means that:

- at least 55 countries have ratified the Protocol and
- sufficient developed countries (the "Annex I" Parties) which account for 55 percent of the 1990 CO_2 emissions of developed countries have ratified the Protocol.

New Zealand signed the Kyoto Protocol in 1998 and the Government intends to ratify it by the time of the World Summit on Sustainable Development in September 2002.

Box 1 sets out the key elements of the Kyoto Protocol.

Since the adoption of the Kyoto Protocol in 1997, progress has been slow in finalising details of the rules and guidelines that countries need before they can ratify the Protocol. In particular, issues around the emissions trading and project mechanisms, sinks and compliance are critical. How these will work in practice has significant economic implications.

In addition, at the fourth meeting of the Parties (COP4) in Buenos Aires in 1998, it became clear that agreement on the Protocol rules needed to be done in conjunction with agreements related to UNFCCC commitments of developed countries relating to capacity building, technology transfer and financial assistance for developing countries.

The outcome of COP4 was the Buenos Aires Plan of Action, laying out a programme of ongoing work. The aim of the plan was to have final decisions on the rules and other elements of the Protocol by the sixth meeting of the Parties (COP6) in late 2000 at The Hague.

Although that meeting failed to reach a final decision, countries managed to come to a decision at a resumed session of COP6 in July 2001 in Bonn. The final legal text of rules and guidelines for the Protocol was adopted at COP 7 in Marrakech in November 2001.

Reporting requirements

Under the UNFCCC New Zealand is required to report its greenhouse gas inventory on an annual basis, and its national communication on a less frequent basis, the frequency being determined by the Conference of the Parties. The second national communication was submitted to the UNFCCC in 1997 and underwent an in-depth review by an international team from 31 August to 5 September 1998. The five person review team included experts from Indonesia, Japan and Poland, and two members of the UNFCCC secretariat, one of whom coordinated the review. The main findings of their report (FCCC/IDR.2/NZL), published in September 1999, are contained in Box 2.

This is New Zealand's third national communication and is based on the revised guidelines for national communications from Annex I Parties adopted at COP5 (FCCC/CP/1999/7). It updates much of the information in the second national communication. It also reports on New Zealand's progress towards meeting its UNFCCC commitments since the middle of 1997, and preparations for the entry into force of the Kyoto Protocol.

Box 1 Summary of key features of the Kyoto Protocol

- The greenhouse gases covered by the agreement are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride, taken in aggregate on a CO_2 equivalent basis.
- Legally binding emission constraints are set for countries listed in Annex B of the Protocol for the period 2008 – 2012. (Annex B[1] contains a list of developed countries and countries undergoing the process of transition to a market economy).
- Different percentage reductions relative to 1990 emissions are set for different countries, such that total emissions by Annex B countries are reduced by more than five percent. The calculated amount of emissions allowed a country is its initial 'assigned amount'. Any Party may use 1995 as the base year for HFCs, PFCs and SF_6 for the purposes of calculating its initial assigned amount.
- New Zealand's commitment is not to exceed 1990 emission levels, on average, during 2008 – 2012, or otherwise take responsibility through use of the mechanisms in the Kyoto Protocol.
- Parties shall take policies and measures in accordance with national circumstances and cooperate to enhance their effectiveness.
- 'Demonstrable progress' towards meeting the commitments under the Protocol is to be achieved by 2005.
- Forest sinks can be included but only as changes in forest carbon storage arising from certain actions (afforestation, reforestation and deforestation) taken since 1 January 1990. Parties will have credited/debited a quantity of 'assigned amount' equal to increases/decreases in carbon stock over 2008 – 2012 from these actions. Additional carbon storage activities undertaken since 1990 may also be used in the first commitment period (forest management, cropland management, grazing land management and revegetation).
- The Parties included in Annex B may participate in greenhouse gas emissions trading for the purposes of fulfiling their commitments under the Protocol. The Conference of the Parties completed the rules and guidelines for emissions trading at COP7 in November 2001.
- A 'joint implementation' mechanism is also established for trading 'credits' from project-based activities between Annex I Parties. The Conference of the Parties completed the rules and guidelines for joint implementation at COP7 in November 2001.
- A clean development mechanism (CDM) is defined. The CDM is designed to assist both Annex I and non-Annex I Parties by allowing certified emission reductions accruing from CDM projects to contribute to compliance by Annex I Parties. Certified emission reductions obtained from 2000 can be used to assist in achieving compliance in the first commitment period. The Conference of the Parties completed the rules and procedures for the CDM at COP7 in November 2001.
- Entry into force of the Protocol occurs when at least 55 countries, including developed countries representing at least 55 percent of developed country CO_2 emissions in 1990, have ratified it.
- Parties are to cooperate in research and promote systematic observation of the climate system, climate change impacts and responses.

[1] Annex B of the Kyoto Protocol is equivalent to Annex 1 of the UNFCCC

Box 2 In-depth review of New Zealand's second national communication

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

- the well reported greenhouse gas inventory data which was made transparent by the provision of methodological detail in annexes, separate additional information, detailed presentations, standard data tables and inventory overview tables
- the continuous efforts to improve inventory information including carbon estimates for indigenous forests, and reducing uncertainties relating to the quantification of methane and nitrous oxide emissions
- that information was reported on both implemented and planned policies and measures (in keeping with the reporting guidelines), but that it would be of use to provide more information on the relative importance of the identified measures
- the promotion of an economy-wide, cross-sectoral, least-cost approach
- the on-going reforms in the agricultural and forestry sector were expected to lead to an increased conversion of pastoral land to forest area
- that the reforms in the electricity sector are expected to prevent over-investment in new plants, encourage new investment in demand-side management and enhance the access of cogeneration and renewables to the grid
- the Government's commitment to improving energy efficiency through extension of funding (although at a reduced level) to the integrated energy efficiency strategy
- the importance of participation in the voluntary agreements programme for enhancing awareness and improving the quality of emissions data at the enterprise level, although the lack of penalties in the event of underachievement was noted
- there did not appear to be any explicit or effective policies to tackle emissions from the transport sector in spite of their large contribution to total emissions
- the approach to emissions reduction in the agricultural sector focussed on reducing uncertainties, and this was expected to lead at a future stage to the identification of mitigation measures in this sector
- the projections presented in the second national communication showed a considerable improvement over those in the first national communication in both scope and detail
- based on an overall assessment of the results from the sector projections it is unlikely that New Zealand will meet the UNFCCC stabilisation target at present levels of growth.

Chapter 2 New Zealand national circumstances

2.1 Geography

New Zealand consists of two large and a number of smaller islands located in the southwest Pacific Ocean between 33º and 55º 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 1,600 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.

Before human settlement about 75 percent of the country was forested. 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 percent of natural forest resource is state owned with the remainder being privately owned, half by Maori.

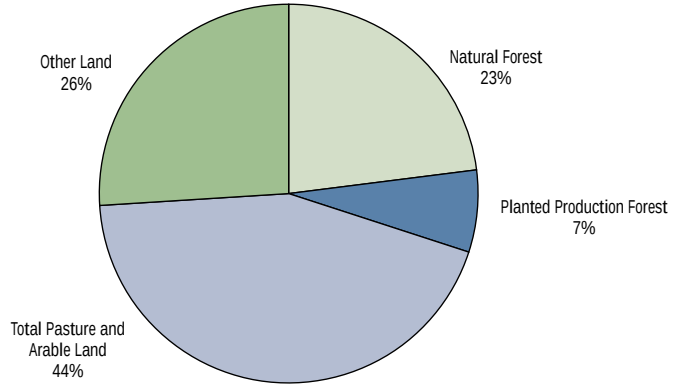


Figure 3 Land use in New Zealand

Source: 2000 New Zealand Forestry Statistics, Ministry of Agriculture and Forestry, 2001

Almost all the state-owned natural forest is in national parks, forest parks and other reserves, with only about 0.1 percent being managed for wood production. About 21 percent of the private natural forests have protective covenants under the Queen Elizabeth II Trust, the Nature Heritage Fund and Nga Whenua Rahu. Harvesting of timber on the remainder of private land is subject to the sustainable forest management provisions of the Forests Act 1949. Approximately 66,000 ha have approved plans and permits under these provisions. However, only a small percentage of these plans and permits are operative. Introduced animals, particularly the Australian brush tail possum, deer and goats, have caused significant damage to the quality of native forest. Much of the country supports managed ecosystems: pasture, production forests, and crop-land (Figure 3). The total area of farmland (pastoral, horticultural and arable land) is about 119,000 square kilometres or 44 percent of the national land area. The 1.77 million hectares (as assessed in March, 2000) of sustainably managed, non-indigenous planted forest provides more than 99 percent of New Zealand's wood production. The predominant forestry species is *Pinus radiata*.

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

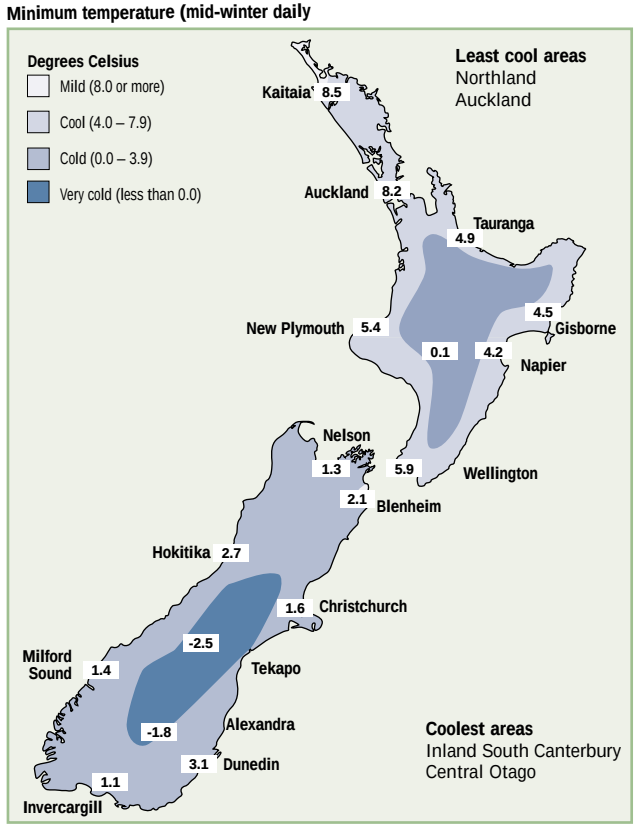
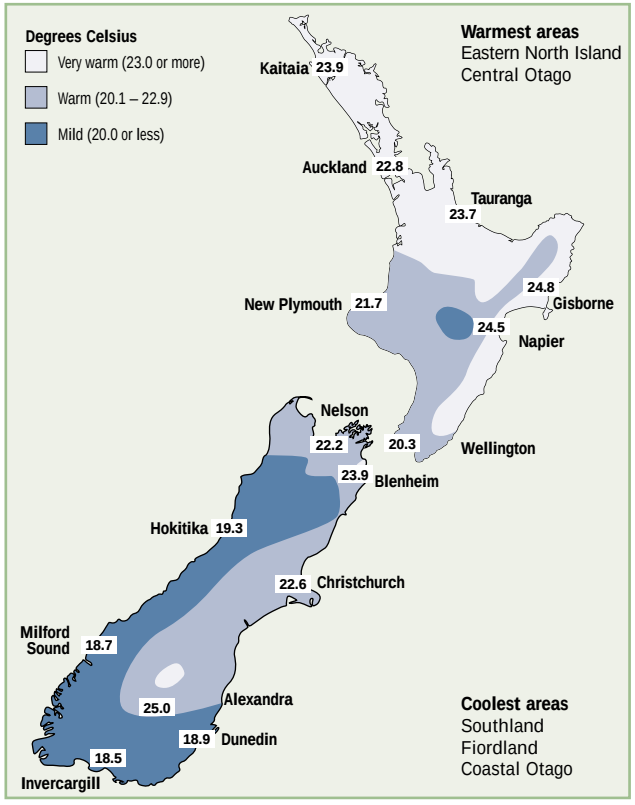


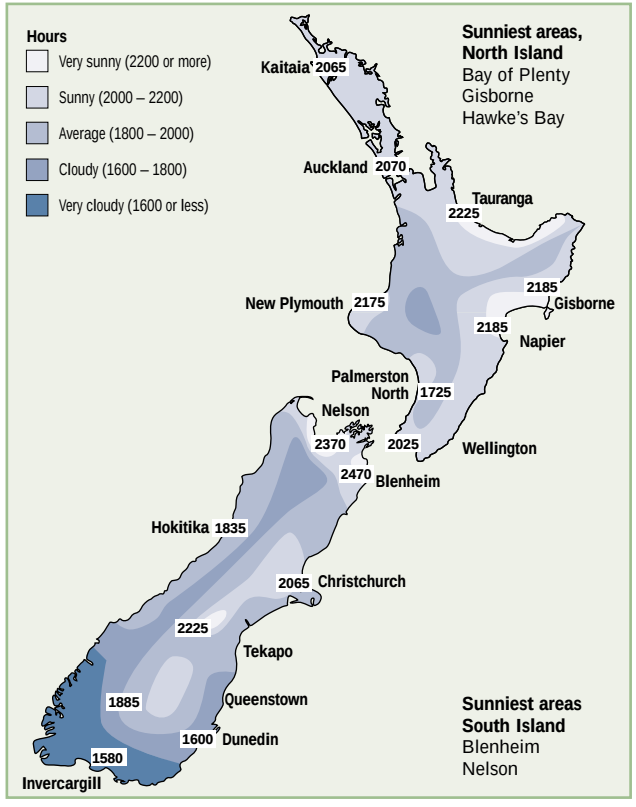
Figure 4 New Zealand climatic conditions

Source: NIWA, 1997; Department of Statistics, 1997

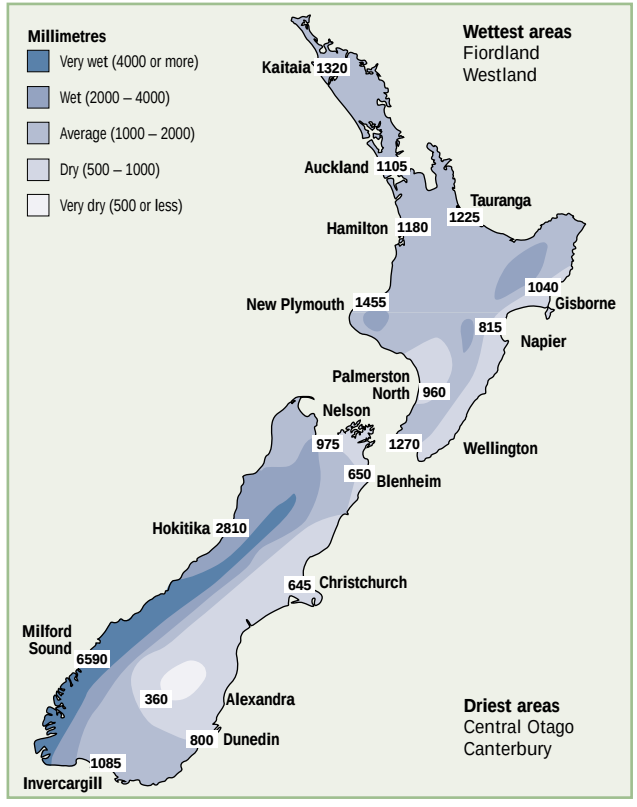
Maximum temperature (mid-summer daily average)



Sunshine hours (annual average)



Rainfall (annual average)



2.3 Population

New Zealand has a population of 3.79 million. This is expected to reach 3.96 million by the year 2005, and 4.22 million by 2020.

North Islanders outnumber South Islanders by three to one 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. Eighty-five percent 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: 11.8 percent of the population is over 65 years of age in 2000, as compared with 11.2 percent in 1991. The size of the average family has decreased to less than half of what it was in 1960.

New Zealand is a multi-racial society. While 74.5 percent are classified as being New Zealand European there are also people of Maori (14.5 percent), Pacific Islands Polynesian (5.6 percent), Indian (1.2 percent) and Chinese (2.2 percent) descent. New Zealand has strong links with the peoples of the South Pacific island nations. There is considerable movement of people between these island nations (for example, the Cook Islands, Niue, Western Samoa and Tokelau) and New Zealand.

Current projections (based on 1999 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 34 years in 1999 to 45 years in the mid-2040s.

2.4 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.

2.5 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. Members of Parliament are elected using mixed member proportional representation (MMP). 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 4.

2.6 The economy

New Zealand's small economy relies on overseas trade. New Zealand has adapted to a changing world so that Asia is now more dominant. Our largest merchandise export markets are Australia, USA and Japan. New Zealand has developed its agriculture and manufacturing industries to suit the needs of niche markets. This has meant that New Zealand has moved away from its dependence on dairy, meat and wool exports as forestry, horticulture, fishing, manufacturing and tourism have become more significant

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

In 1999, dairy exports were worth nearly NZ$3.9 billion, meat exports $2.8 billion, forest products $4.5 billion, fish exports $1.2 billion, fruit and vegetables $1.1 billion.

In the last 25 years, New Zealand 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, two 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.

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.

2.7 Agriculture

Agriculture is an important sector in the New Zealand economy. In 2001, New Zealand's total agricultural production is estimated to contribute 5.5 percent of the Gross Domestic Product (GDP). Industries associated with agriculture contribute another 10.7 percent of the GDP (Ministry of Agriculture, 2001).

New Zealand agriculture is based largely on pastoral systems that are inherently less energy intensive, 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 than most OECD countries. Livestock are grazed on pasture all year round, taking advantage of New Zealand's temperate climate and 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 of some species, particularly sheep (Figure 5). However, this decline has been partially offset by increases in dairy cattle and deer numbers. 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 farms are shown in Table 2. In general, the area of land in pasture is decreasing. The area of land in horticulture has not changed significantly between 1990 to 2000, although less land is in grain and more in nursery, vegetables and fruit. Farm forestry has increased significantly during the same period.

Table 2 Area of occupied land including agricultural land (000 hectares)

Land use at 30 June	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Grazing, Arable, Fodder and Fallow Land	13,857	14,083	13,911	13,945	13,536	13,520	13,265	-	-	13,863	-
Grain	189	-	180	176	-	167	171	-	-	212	-
Total land in Horticulture	88	91	90	95	104	124	123	-	-	-	129
Net Stocked Planted Production Forest	1,304	1,329	1,335	1,396	1,488	1,599	1,683	1,630	1,679	1,731	1,769
Other Land	2,240	1,948	1,965	1,900	1,749	1,335	1,475	-	-	1,221	-
Total Area of Farms	17,489	17,450	17,300	17,336	16,607	16,578	16,547	-	-	15,585	-

Livestock numbers. Based on August 2001 forecast round

June	Dairy	Beef	Deer	Goats	Sheep
1980	2,960,505	5,162,000	104,359	53	68,771,773
1985	3,321,385	4,613,000	319,908	427	67,853,625
1990	3,439,083	4,593,161	1,052,420	1,063	57,852,191
1991	3,426,981	4,670,567	1,256,042	793	55,161,645
1992	3,465,535	4,676,327	1,388,106	533	52,568,395
1993	3,546,012	4,757,962	1,319,825	353	50,298,359
1994	3,839,184	5,050,000	1,400,741	284	49,466,054
1995	4,089,817	5,182,508	1,393,690	256	48,816,271
1996	4,165,098	4,852,179	1,467,216	228	47,393,907
1997	4,256,000	4,806,000	1,667,052	215	46,834,000
1998	4,344,000	4,434,000	1,837,902	210	45,956,000
1999	4,316,409	4,643,705	2,009,035	186	45,679,891
2000	4,544,858	4,672,000	2,270,025	186	45,379,000

Figure 5 Total numbers of livestock on New Zealand farms, 1980 to 2000

Source: Ministry of Agriculture and Forestry, 2001

2.8 Forestry

New Zealand's planted forest estate is expanding, as is forestry's contribution to the New Zealand economy. The industry is based on sustainably managed, planted production forests. The forestry sector is estimated to contribute 4.5 percent of New Zealand's GDP.

Forests and other woodland cover 10.73 million hectares, or 40 percent of New Zealand's land area. Of this, 6.26 million hectares are indigenous, 1.77 million hectares are planted forests and 2.7 million hectares are shrublands. New planting rates since 1990 have been above the historic average of around 40,000 hectares per annum during the 1970s and 1980s. Over the period 1990 to 2000, new planting has averaged at about 55,000 hectares per annum. This has, however, fluctuated from a low of 15,000 hectares in 1992 to a high of 98,000 hectares in 1994. The best estimate of future average annual new planting is 40,000 until 2010 with a likely range of between 20,000 and 60,000 hectares per year.

The wood processing industry in New Zealand is well established. It currently consumes around 12.5 million cubic metres of wood annually, with the balance of the harvest (six million cubic metres) being exported as logs. Exports of forest products rank third in terms of commodity exports (behind dairy and meat). In 2001, forestry products exports accounted for 13 percent 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. Sixty-five percent of the planted forest estate is owned by 20 major organisations with the remaining 35 percent being owned by small companies, local government, partnerships, joint ventures and many thousands of farmers. In the long term, it is anticipated that up to half of the planted forest estate could be owned by small growers.

2.9 Energy

New Zealand is self-sufficient in electricity, gas and coal, and was 12 percent self-sufficient in oil in 2000. Figure 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 7.

New Zealand's electricity generation is dominated by renewable energy sources, with hydroelectric power (Figure 8) producing around 65 percent of annual electricity needs, depending on rainfall. Geothermal power contributes another six percent 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 70 percent of electricity generation is from renewable sources.

[1] *All data in this section are for March years.*

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 percent pa to 2000). 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 although new developments are likely to be affected by broader environmental considerations, particularly concerns about the damming or diverting of waterways.

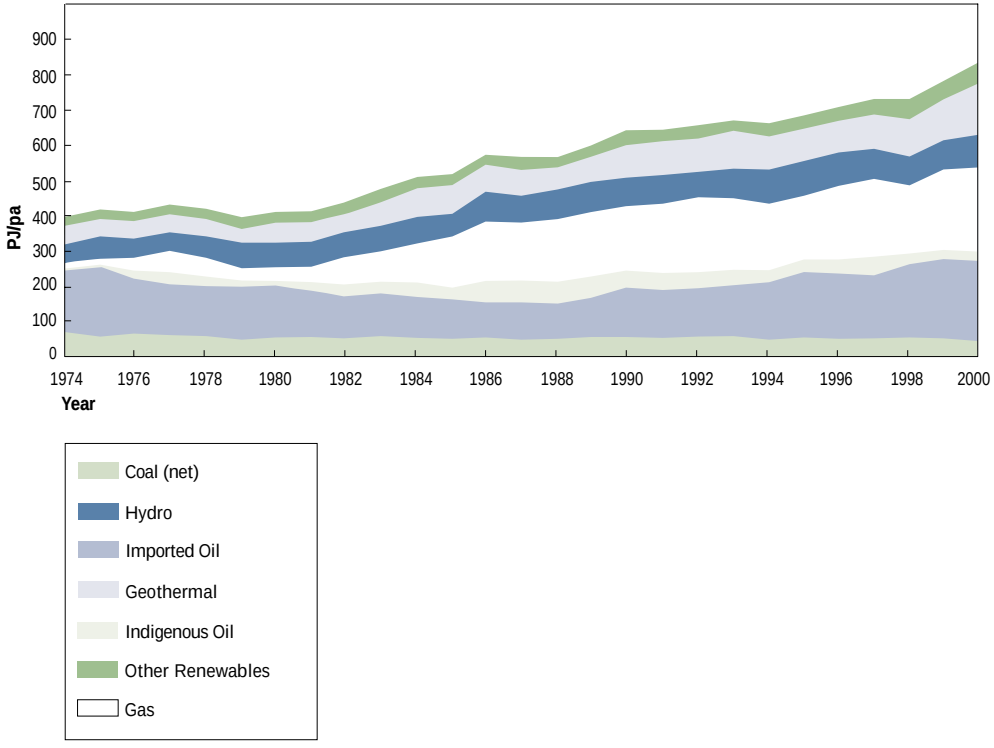


Figure 6 Primary energy supply in New Zealand, 1975 to 2000, petajoules per annum

Source: Ministry of Economic Development, 2001a

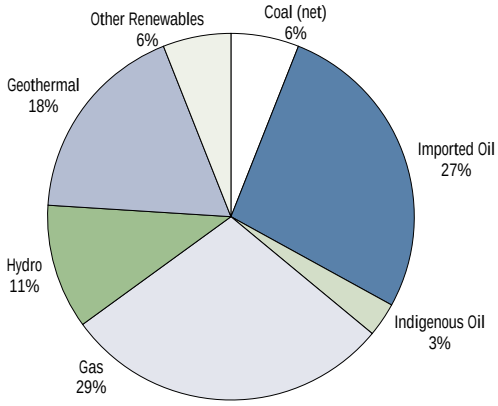


Figure 7 Consumption of energy in New Zealand by end use type 2001.

Source: Ministry of Economic Development, 2001a

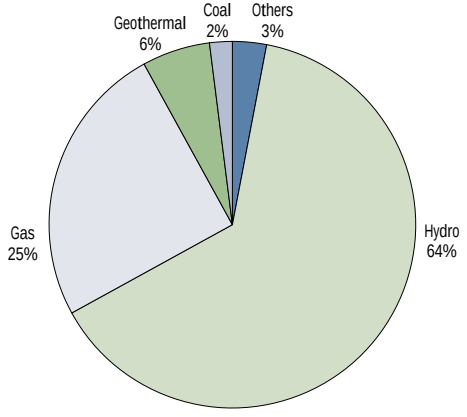


Figure 8 Electricity generation by fuel in New Zealand in 2001

Source: Ministry of Economic Development, 2001a

Crude oil and condensate production in 2000 was 74.95 Petajoules (PJ). This was equivalent to about 36 percent of total refinery intake. Known recoverable reserves are estimated to last another 11 to 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 (Figure 9).

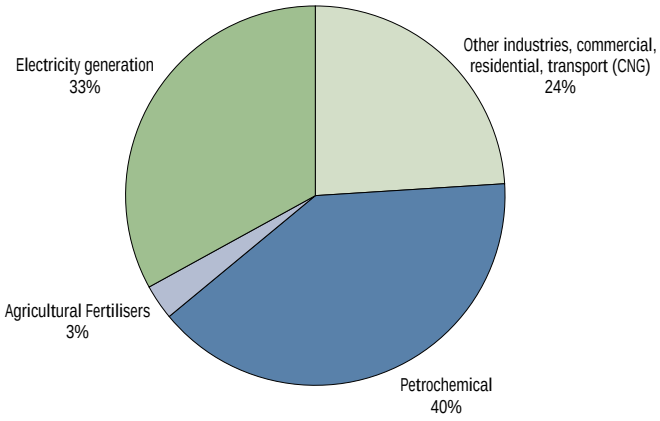


Figure 9 Natural gas by end use in New Zealand

Source: Ministry of Economic Development, 2001a

Coal production in 2001 was around 3.82 million tonnes. Around 54 percent was exported. The major end users of coal are basic metal manufacturing (31.4 percent), electricity generation including other manufacturing (20 percent), cogeneration (15 percent), and commercial (15 percent). New Zealand has recoverable reserves of coal estimated at 8.6 billion tonnes (one billion = 10^9).

2.10 Transport

The evolution of New Zealand's transport system has been characterised not only by the country's remoteness from many of its trading partners, but also by its relatively low population density. International air and telecommunication links have helped overcome the country's isolation, but there is still a heavy reliance on sea transport for overseas trade. Comprehensive railway and road networks have been established over difficult terrain and, taking into account the size of the population, the capital cost has been high. In recent years deregulation has brought major changes in the transport sector. The sector had been protected by legislation and by being wholly government-owned but is now on a more commercial footing.

Road transport

Capital investment in New Zealand's roading and road transport system exceeds that in all other forms of transport. There are about 91,800 km of formed roads and streets, and over 3.1 million motor vehicles. The road transport system has been largely deregulated since 1989.

At February 1999 there were 9,120 full-time persons engaged in the provision of road passenger transport, and 21,630 persons engaged in providing road freight transport. Table 3 shows the growth in total vehicles and private cars since 1995.

Transit New Zealand

Transit New Zealand, a Crown entity, is the state highway operator. It is responsible for representing the interests of New Zealanders in the planning and funding of the land transport system.

It is also responsible for the management, maintenance, and further development of the state highway network and reports to the Transit New Zealand Authority. This is an independent authority appointed by the government which operates much like a company board, directing overall policy and funding allocation.

Each year Transit New Zealand is required to prepare an annual work programme for the state highways and submit this to Transfund New Zealand for approval. This National State Highway programme is competitively assessed against applications for funding submitted by the nation's 74 territorial authorities.

Road facts

There are 74 national and provincial road controlling authorities that manage state highways and motorways in New Zealand. There are 15,962 km of urban roads and 65,508 km of rural roads and over 16,772 bridges.

Table 3 Licensed vehicles 1995 – 1999

As at 31 March	Total Vehicles	Private Cars
1995	2,487,727	1,647,134
1996	2,450,006	1,635,718
1997	2,457,116	1,675,301
1998	2,549,797	1,746,659
1999	2,668,536	1,831,118

Source: Land Transport Safety Authority

Railways

The New Zealand railways system has been through a period of transition from a government-owned and operated organisation to a commercially, privately owned business. In 1986 the then Railways Corporation became a state-owned enterprise and was renamed NZ Rail. NZ Rail was responsible for managing its resources on commercial lines and rationalising its operations. In 1993 NZ Rail was sold to the private sector and was renamed Tranz Rail. Tranz Rail is owned by a private consortium comprising Wisconsin Central Transportation Corporation, Berkshire Partners and Fay, Richwhite and Company. The consortium plays a key role in New Zealand's increasingly competitive transport market, operating rail, trucking and shipping services throughout its national network. In the 1998/99 financial year 12.9 million tonnes of freight was carried. Urban commuter services in Wellington and Auckland provide more than 10 million passenger trips a year. At 30 June 1999 Tranz Rail's track and rolling stock included 215 diesel, diesel/electric and electric locomotives, 6,004 freight wagons, 321 passenger carriages and commuter units, three rail ferries and plant and support equipment. Tranz Rail operates a railway network extending over 3,912 km.

Civil aviation

New Zealand is one of the most aviation-oriented nations in the world. In a population of just 3.8 million there are 9,040 pilots and 3,327 aircraft – one pilot for every 430 people and one aircraft for every 1,170 people.

During the 1998/99 year the airlines carried more than 4.7 million passengers on domestic services and 2.7 million arrived on international air carriers. The number of aircraft on the register decreased slightly this year from 3,405 to 3,327 due to efforts to remove disused aircraft from the register. The number of licensed aircraft engineers continues to increase, from 1,498 in 1998 to 1,547 in 1999.

Twenty-seven foreign airlines, including three cargo airlines, operate to New Zealand and six serve New Zealand on a code-share basis only. In addition, there are two New Zealand international scheduled airlines: Air New Zealand, and Freedom Air International which commenced services in 1995. The Tasman route is the busiest air route into New Zealand in both the volume of passengers carried and the number of airlines operating. Ten passenger airlines and four cargo airlines offer services between Australia and New Zealand. There were 1,623,720 overseas visitors to New Zealand in the year to September 1999.

Chapter 3 Inventory

3.1 Approach

New Zealand has developed an inventory of emissions and removals of the most significant greenhouse gases. The inventory is 1990-based and updated annually to monitor trends in emissions and removals, 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 emissions and removals of these gases for the IPCC categories of energy, industrial processes, solvent and other product use, agriculture, land-use change and forestry, and waste. New Zealand is unique in that it has a large proportion of methane and nitrous oxide in its inventory. This is due to New Zealand's heavy reliance on the agriculture sector where there are large numbers of livestock in comparison to the small human population. Methane and nitrous oxide emissions, almost entirely from agriculture, account for approximately 60 percent of New Zealand's inventory. Summary trends tables from New Zealand's 2001 Greenhouse Gas Inventory Report for years 1990 to 1999 can be found in Annex 1. Unless stated, all data in graphs and tables in this chapter have been taken from the New Zealand Greenhouse Gas Inventory 1990 – 1999, (Ministry for the Environment, 2001a).

In keeping with the reporting guidelines, emissions from international bunker fuels 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). Previous New Zealand inventories have only given potential, and not actual, emissions data for HFCs and PFCs (except for PFCs from aluminum smelting).

Table 4 presents a summarised inventory for 1999. Table 5 presents a summarised inventory from 1990 through to 1999. An overview is presented, followed by a detailed commentary on each category. Details of the full inventory, methodology, and techniques used for recording New Zealand's emissions and removals, can be found in the National Inventory Report 2001 (Ministry for the Environment, 2001a).

Table 4 1999 greenhouse gas summary table for New Zealand

(Table taken from the New Zealand Greenhouse Gas Inventory 1990 – 1999, Summary Table 2)

Greenhouse Gas Source and Sink	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Categories CO_2 equivalent (Gg)							
Total (Net Emissions)[1]	**8,407.03**	**33,596.20**	**12,392.09**	**209.86**	**74.47**	**33.32**	**54,712.96**
1. Energy	**27,656.38**	**1,138.54**	**241.33**				**29,036.26**
A. Fuel Combustion (Sectoral Approach)	26,984.14	223.19	241.33				27,448.67
1. Energy Industries	6,629.28	5.55	14.64				6,649.46
2. Manufacturing Industries and Construction	5,825.66	10.71	39.90				5,876.27
3. Transport	11,729.46	149.89	155.65				12,035.00
4. Other Sectors	2,799.74	57.05	31.15				2,887.94
5. Other	0.00	0.00	0.00				0.00
B. Fugitive Emissions from Fuels	672.24	915.35	0.00				1,587.59
1. Solid Fuels	0.00	543.10	0.00				543.10
2. Oil and Natural Gas	672.24	372.25	0.00				1,044.49
2. Industrial Processes	**2,869.04**	**2.31**	**0.00**	**209.86**	**74.47**	**33.32**	**3,188.99**
A. Mineral Products	634.90	0.00	0.00				634.90
B. Chemical Industry	191.33	2.31	0.00	0.00	0.00	0.00	193.64
C. Metal Production	2,042.81	0.00	0.00		74.47	2.87	2,120.15
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				0.00	0.00	0.00	0.00
F. Consumption of Halocarbons and SF_6				209.86	0.00	30.45	240.31
G. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Solvent and Other Product Use	**NE**		**0.00**				**0.00**
4. Agriculture	**0.00**	**29,727.18**	**11,989.87**				**41,717.05**
A. Enteric Fermentation		29,369.55					29,369.55
B. Manure Management		355.53	130.20				485.73
C. Rice Cultivation		0.00					0.00

Table 4 continued

Greenhouse Gas Source and Sink	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
D. Agricultural Soils		0.00	11,859.67				11,859.67
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		2.10	0.00				2.10
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[1]	**-22,118.39**	**119.18**	**12.09**				**-21,987.13**
6. Waste	**0.00**	**2,608.99**	**148.80**				**2,757.79**
A. Solid Waste Disposal on Land	NE	2,466.06					2,466.06
B. Wastewater Handling		142.93	148.80				291.73
C. Waste Incineration	NE	0.00	0.00				0.00
D. Other	0.00	0.00	0.00				0.00
Memo Items:							
International Bunkers	**2,912.29**	**2.85**	**17.85**				**2,933.00**
Aviation	1,959.18	0.91	9.64				1,969.73
Marine	953.11	1.95	8.21				963.26
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	**3,248.30**						**3,248.30**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. The signs for uptake are always (-) and for emissions (+).

Greenhouse Gas Source and Sink Categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry			**CO2 equivalent (Gg)**			
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-23,245.00	-23,245.00			-23,245.00
B. Forest and Grassland Conversion	1,126.61		1,126.61	119.18	12.09	1,257.88
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	0.00	0.00	0.00			0.00
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	1,126.61	-23,245.00	-22,118.39	119.18	12.09	-21,987.13
Total CO_2 Equivalent Emissions without Land-Use Change and Forestry						**76,700.09**

Table 5 1990 to 1999 inventory summary (all figures are in CO_2 equivalents.)

Table taken from the 1990 – 1999 Greenhouse Gas Inventory Report, April 2001, Trends Table 5.5)

Greenhouse Gas Emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Net CO_2 emissions/removals	3,761.52	5,401.34	9,345.38	10,660.24	11,363.29	10,899.56	11,605.78	11,996.64	7,865.11	8,404.74
CO_2 emissions (without LUCF)[1]	25,399.28	25,881.55	27,762.62	27,135.84	27,198.52	27,206.31	28,223.44	30,210.39	28,824.31	30,523.13
CH_4	35,211.16	34,477.67	33,857.33	33,896.31	34,104.78	34,143.65	34,102.93	33,493.83	33,557.54	33,593.81
N_2O	11,848.51	11,725.44	11,738.46	11,886.95	12,047.84	12,097.13	12,041.33	12,062.10	12,231.36	12,396.59
HFCs	0.00	0.00	6.76	16.12	43.21	103.20	169.99	144.20	247.30	209.86
PFCs	602.53	649.92	636.38	228.15	230.18	188.39	216.39	211.29	117.85	74.47
SF_6	2.87	2.87	2.87	2.87	26.77	18.88	27.72	28.92	31.79	33.22
Total (with net CO_2 emissions/removals)	**51,426.59**	**52,257.24**	**55,587.18**	**56,690.63**	**57,816.07**	**57,450.81**	**58,164.15**	**57,936.98**	**54,050.94**	**54,712.68**
Total (without CO_2 from LUCF)[1]	**73,064.35**	**72,737.45**	**74,004.42**	**73,166.23**	**73,651.30**	**73,757.56**	**74,781.81**	**76,150.73**	**75,010.14**	**76,831.07**

Greenhouse Gas Source and Sink	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Categories										
1. Energy	23,989.11	24,310.38	26,054.04	25,312.80	25,549.78	25,628.90	26,877.39	28,795.17	27,408.24	29,036.80
2. Industrial Processes	2,994.27	3,166.07	3,294.77	3,019.98	2,974.22	3,049.52	3,158.04	3,013.72	3,154.55	3,186.61
3. Solvent and Other Product Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Agriculture	42,850.89	42,012.01	41,528.17	41,629.37	41,895.85	41,903.37	41,546.86	41,320.87	41,520.54	41,719.61
5. Land-Use Change and Forestry[2]	-21,539.94	-20,390.15	-18,315.12	-16,344.92	-15,688.26	-16,164.86	-16,459.12	-18,040.34	-20,816.95	-21,987.12
6. Waste	3,132.26	3,158.93	3,025.32	3,073.41	3,084.49	3,033.88	3,040.97	2,847.56	2,784.56	2,756.79
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[1] *LUCF (Land-use Change and Forestry). The figures in this row do not include the CO_2 uptake from LUCF.*

[2] *Net emissions. These emissions are reported as (-) as it is the amount of CO_2 removed by LUCF. The "Net CO2 emissions/removals" figures are calculated by adding the LUCF figures for each year to the respective "CO_2 emissions (without LUCF)" figures.*

The overall trend of New Zealand's greenhouse gas emissions from 1990 to 1999, as reported in April 2001, is that CO_2 has increased by 20 percent, N_2O by five percent, CH4 has decreased by five percent, and HFCs, PFCs, and SF_6 as a whole have decreased by 47 percent. This final reduction is largely due to a sharp decline in PFC emissions. This is briefly discussed later in the chapter but a more detailed explanation is given in Chapter 6 "Policies and Measures". Total New Zealand 1999 greenhouse gas emissions are approximately five percent above 1990 levels.

International review of the New Zealand annual greenhouse gas inventory

The UNFCCC 5th Conference of the Parties (COP) requested in 1999 that the UNFCCC secretariat conduct for a trial period, individual reviews of greenhouse gas inventories for a limited number of Annex I Parties on a voluntary basis (FCCC/CP/1999/7; pp. 109 – 114). The review of greenhouse gas inventories will be an integral part of the Kyoto Protocol and is also an important component of the Framework Convention on Climate Change (FCCC Article 4, 2 (d)).

As part of the trial process, in 2001 New Zealand's greenhouse gas inventory was reviewed in three ways by the UNFCCC: a centralised review, a desk-top review and an in-country review.

The review concluded that New Zealand provided adequate information to the COP and that New Zealand's standard of reporting was generally consistent with IPCC and UNFCCC guidelines. However, the report noted that there was scope for further development and improvement in the New Zealand greenhouse gas inventory.

The expert review team (FCCC/WEB/IRI/(2)/2000/NZL) identified a number of issues where improvements need to be made, including that the reporting methodology needs to be moved to a higher tier level of assessment and some revision to current emission factors needed to be made.

The in-country review was particularly useful, as it provided a face-to-face discussion that allowed immediate clarification of issues. The interaction between New Zealand experts/scientists and the review team gave a stronger context for the New Zealand experts to relate the Common Reporting Format (CRF)/National Inventory Report (NIR) reporting process and purpose, and this has helped to strengthen our reporting process and focused our team towards the international requirements. The review was also beneficial to New Zealand in assisting with a prioritisation of work to be done on the inventory. This is particularly relevant as New Zealand has a small resource of experts; having an international team of experts helped identify areas we had overlooked. The review identified and raised issues particularly regarding key source categories and appropriate methodological approaches, as well as an ongoing need for internal peer review and quality assessment and quality control procedures with additional requirements to archive data and information. New Zealand has a unique greenhouse gas profile with emissions of non-CO_2 gases being greater than CO_2 (using Global Warming Potentials). We had already identified these agricultural sector gases as a priority area and the review reinforced the need for this.

The desktop review alerted us to: the importance of presenting information in a clear fashion in the National Inventory Report; the value of being unambiguous; and the importance of having all the relevant information included in a summary form. It was clear that there is a balance in the amount of information presented in the National Inventory Report between providing enough to enable the review team to conduct the review but not so much that the review team has difficulties getting through the information. The review reassured New Zealand about the quality of our current systems and strong capacity relative to resources to produce a robust and, for the most part, complete inventory.

3.2 National greenhouse gas emissions – overview

This third 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 understanding of New Zealand's contribution to radiative forcing from greenhouse gas emissions is arrived at using Global Warming Potentials (GWPs) and presented in Table 6. 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. Table 7 lists the GWPS used in compiling data for this report. Although the IPCC revised the GWPs in 2000, the 1995 GWPs are used for reporting purposes as per the UNFCCC guidelines for greenhouse gas inventory reporting (FCCC/CP/1999/7).

Table 6 Emissions and removals of greenhouse gases in New Zealand in 1990 and 1999 presented in CO_2 equivalents. All amounts are in gigagrams (Gg).

	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs	PFCs	SF_6
1990	25,399	-22,307	35,211	11,849	Negligible	603	2.87
1999	30,523	-23,245	33,594	12,397	210	74	33.22

Table 7 1995 IPCC GWP values based on the effects of greenhouse gases over a 100 year time horizon

Greenhouse gas	Chemical Formula	1995 IPCC GWP
Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	310
Hydrofluorocarbons (HFCs)		
HFC-32	CH_2F_2	650
HFC-125	C_2HF_5	2,800
HFC-134a	$C_2H_2F_4$ (CH_2 FCF_3)	1,300
HFC-152	$C_2H_2F_4$ (CH_3 CHF_2)	140
HFC-143a	$C_2H_3F_3$ (CF_3 CH_3)	3,800
HFC-227ea	C_3HF_7	2,900
Perfluorocarbons (PFCs)		
Perfluoromethane	CF_4	6,500
Perfluoroethane	C_2F_6	9,200
Perfluoropropane	C_2F_8	7,000
Sulphur hexafluoride	SF_6	23,900

Figure 10 illustrates the proportional effects of different greenhouse gases emitted in New Zealand in 1999, calculated using GWPs 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 however, CH_4 was responsible for 48 percent of the radiative forcing from greenhouse gases in 1990 and 44 percent in 1999. There has been a 47 percent decrease in HFC, PFC, and SF_6 emissions. This is mostly due to aluminium smelting improvements largely related to improvements in carbon consumption, better emission control systems and continuous improvements in cell stability.

Figure 11 illustrates, for gross emissions, the relative radiative forcing by source and by gas. Agriculture was responsible for almost 60 percent of the forcing in 1990 and 54 percent in 1999. However, future revisions of agricultural emissions based on new data may alter this proportion. Energy contributed about a 33 percent in 1990 and 38 percent in 1999. This rise is largely due to a 35 percent increase in transport emissions and a 50 percent increase in emissions from the thermal electricity sector. Waste sector emissions were below five percent of the total and decreased by about 12 percent. Although emissions from industrial processes retain the same proportion of the total emissions of around four percent between 1990 and 1999, they increased by six percent.

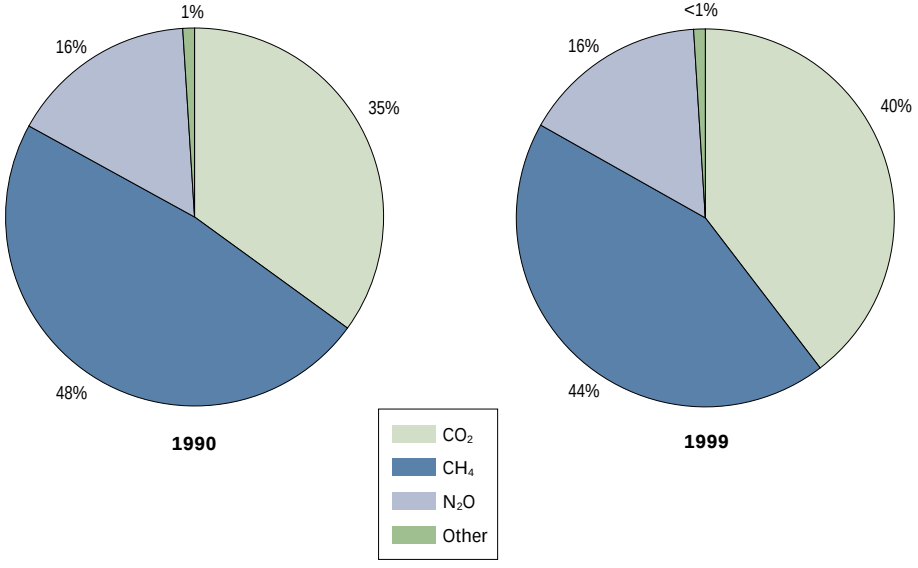


Figure 10 Pie charts showing relative radiative forcing for greenhouse gas emissions on a gross basis – shares by gas 1990 and 1999

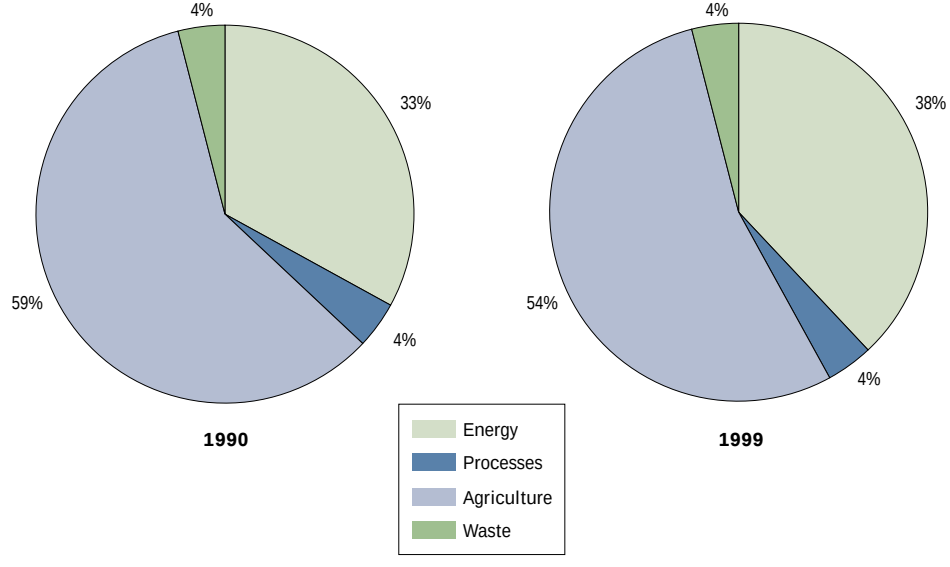


Figure 11 Gross relative radiative forcing – sectoral shares 1990

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 90 percent of total methane emissions in 1990. Almost 95 percent 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 only a small proportion of N_2O and is an almost insignificant source of CH_4 in New Zealand.

Around 90 percent of New Zealand's gross CO_2 emissions comes from energy, the remainder from industrial processes.

Energy and industrial processes together emitted 25,399 Gg CO_2 in 1990 rising to 30,523 Gg CO_2 in 1999, an increase of 20 percent. More detailed information on these emissions is covered in section 3.3 Energy sector emissions.

Land-use change and forestry absorption was 21,638 Gg CO_2 in 1990 and 22,118 Gg CO_2 in 1999. This takes into account the roughly 670 and 1000 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 603 Gg (in CO_2 equivalents) in 1990 and 74.47 Gg in 1999. The reason for such a significant fall in PFC emissions is given at the beginning of this chapter.

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 have grown. Their peak was in 1998 with 247 Gg (CO_2 equivalents). In 1999 actual emissions of HFCs and SF_6 were 210 Gg and 33 Gg respectively.

3.3 Energy sector emissions

Table 8 Summary of energy sector emissions for 1990 and 1999 (Gg).

Source Category	CO_2		CH_4		N_2O		NO_x		CO		NMVOCs	
	1990	1999	1990	1999	1990	1999	1990	1999	1990	1999	1990	1999
1. All Energy (Fuel Combustion + Fugitive)	**23,013**	**27,656**	**37.48**	**54.22**	**0.61**	**0.78**	**136,90**	**176.15**	**715.14**	**836.30**	**117.41**	**137.91**
A Fuel Combustion	**22,398**	**26,984**	**10.65**	**10.63**	**0.61**	**0.78**	**136.90**	**176.15**	**715.14**	**836.30**	**111.96**	**131.75**
Energy & Transformation Industries	6,080	6,629	0.26	0.26	0.03	0.05	**29.62**	23.86	**2.90**	2.77	**0.63**	0.52
Manufacturing Industries	4,812	5,826	0.41	0.51	0.12	0.13	**23.53**	35.93	**13.24**	15.21	**1.69**	1.95
Transport	8,660	11,729	7.21	7.14	0.37	0.50	69.08	98.59	618.02	734.92	99.88	120.62
Other Sectors	2,845	2,800	2.77	2.72	0.09	0.10	14.67	17.78	80.98	83.41	9.76	8.66
Other												
B Fugitive Fuel Emissions	**615**	**672**	**26.83**	**43.59**							**5.45**	**6.16**
Solid Fuels			11.83	25.86								
Oil and Natural Gas	615	672	15.00	17.73							5.45	6.16

Source: Ministry of Economic Development, 2001b

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, NOx, CO and NMVOCs. The energy inventory is reported in detail in an annual energy emissions report prepared by the Ministry of Economic Development (MED) that includes also CO_2 emissions from industrial processes. This MED report provides the basis for energy sector data in the national inventory (Ministry of Economic Development, 2000) and a summary of energy sector emissions for 1990 and 1999 is presented in Table 8.

Figure 12 shows 1990 and 1999 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 percent of energy CO_2 emissions in 1990 and 43 percent in 1999. (Using total CO_2 emissions, the transport sector accounted for 34 percent of emissions in 1990 and 38 percent in 1999).

Thermal electricity generation and other transformation activities (including gas used as fuel during oil refining and synthetic petrol production) accounted for 26 percent of the total for energy in 1990 and 24 percent in 1999. However, within that sub-sector, emissions from thermal electricity generation increased by 50 percent from 1990 to 1999 and there was a large decrease in emissions from other transformation activities.

Fuel combustion by industry and small combustion (which includes commercial/institutional, residential and agriculture/forestry sectors) accounted for 21 percent and 12 percent respectively in 1990, and 21 percent and 10 percent respectively in 1999. The remaining emissions (around three percent) came from fugitive fuel emissions.

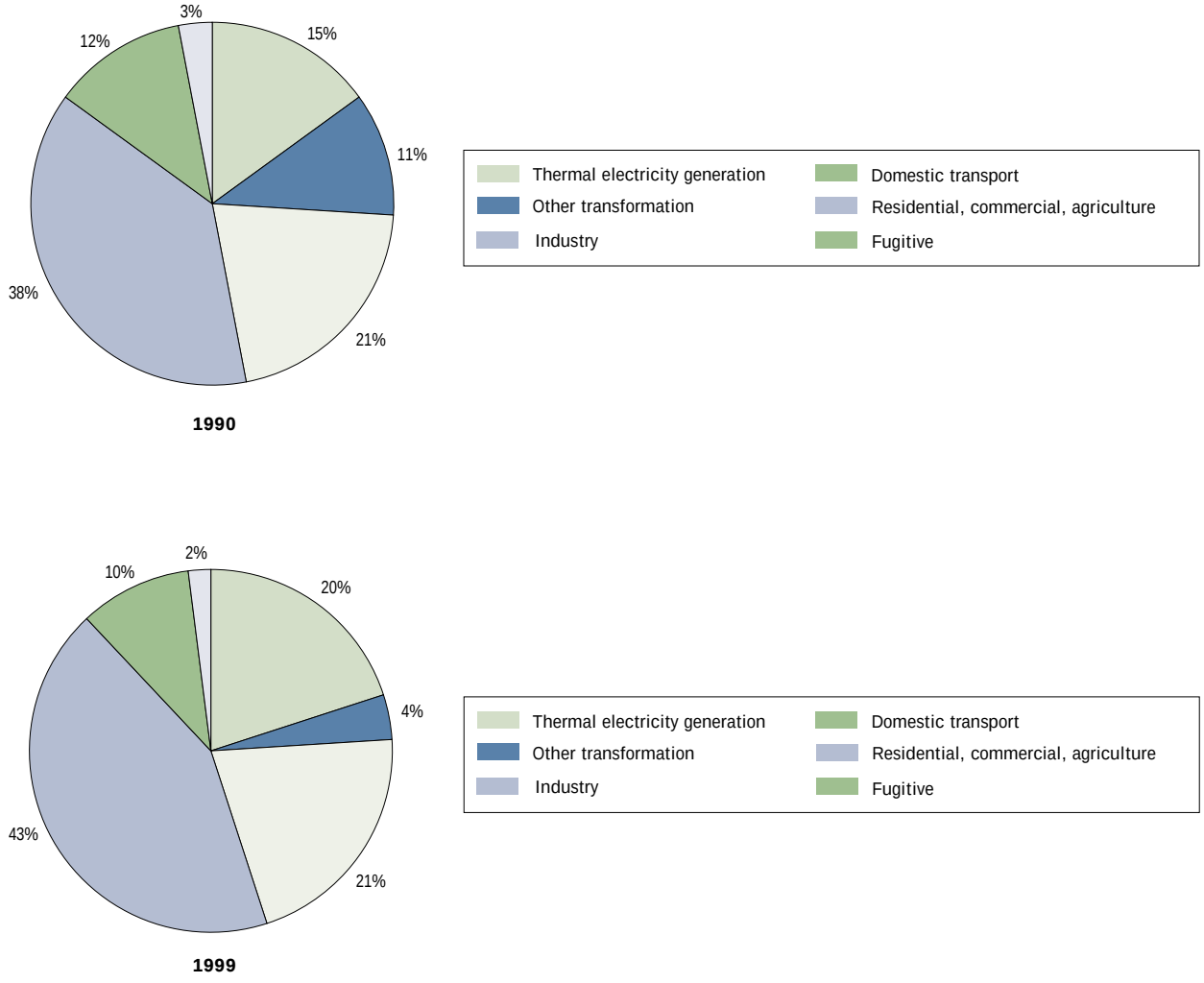


Figure 12 1990 and 1999 energy CO_2 emissions by sector

Source: Ministry of Economic Development, 2001b

Figure 13 shows 1990 and 1999 energy sector CO_2 emissions by fuel in New Zealand. In 1990, oil contributed 48 percent of total energy sector carbon dioxide, with the main source being the transport sector, which accounted for around 77 percent of all oil emissions. Gas and coal accounted for 36 percent and 14 percent respectively. Less than two percent of carbon dioxide emissions were derived from geothermal sources. In 1999, oil contributed 52 percent of total energy sector CO_2 emissions, with around 83 percent from transport. Gas and coal accounted for 36 percent and 11 percent respectively. About 1 percent of carbon dioxide emissions were derived from geothermal sources.

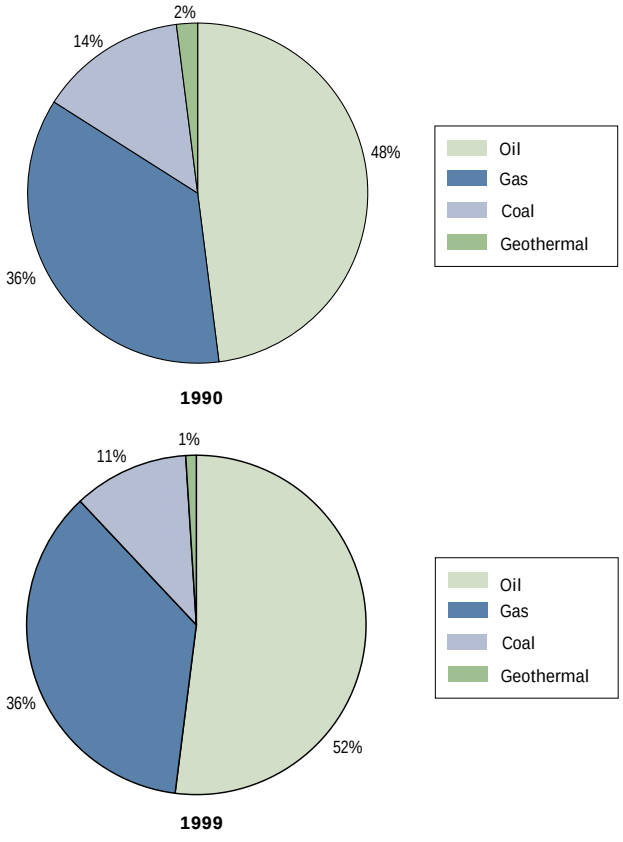


Figure 13 1990 and 1999 Energy CO_2 Emissions by Fuel

Source: Ministry of Economic Development, 2001b

Energy CO_2 emissions trends

Energy CO_2 emissions grew by 20 percent between 1990 and 1999, from 23,013 to 27,656 Gg CO_2. In this period, CO_2 emissions from transport, energy and thermal electricity generation grew faster than gross CO_2 emissions as a whole.

Domestic transport is the activity with the largest absolute (3,069 Gg more CO2 in 1999 compared to 1990) and proportional (35 percent) increases in CO_2 emissions over the period. This is largely due to a 172 percent increase in diesel use (PJ) for transport over the period (Ministry of Economic Development, 2001).

About two thirds of New Zealand's electricity generation is from hydroelectricity (and about six percent 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. Thermal electricity has the largest proportional increase.

The category with the largest absolute and proportional decrease in CO_2 emissions over the period 1990 – 1999 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.

Energy sector non-CO_2 emissions

Total energy emissions of CH4, NO_x, CO and NMVOCs have shown a general increase from 1990 to 1999, with the most significant increases occurring in the thermal electricity generation, manufacturing industries and transport sectors.

Table 9 gives details of energy sector non-CO_2 emissions, illustrating the influence of emissions from transport.

Table 9 Summary of non-CO_2 emissions from the energy sector 1990 and 1999

Gas (Gg)	1990	% from transport	1999	% from transport
NO_x	137	50	176	56
CO	715	86	836	88
NMVOC	117	85	138	87

Source: Ministry of Economic Development, 2001b

3.4 Industrial processes

Overall, greenhouse gas emissions from industrial processes increased by about six percent between 1990 and 1999 from 2,994 Gg to 3,187 Gg. However, there was a 20 percent increase in CO_2 emissions alone. Table 10 summarises CO_2 emissions from industrial processes in New Zealand for 1990 and 1999.

Table 11 gives total emissions in 1990 and 1999 of non-CO_2 greenhouse gases from industrial processes. Table 12 gives emissions in 1990 and 1999 of the precursor gases from industrial processes.

Table 10 CO_2 emissions from industrial processes 1990 and 1999 (Gg)

CO_2 from Industrial Processes	1990	1999
Total	**2,386**	**2,867**
Iron and Steel	1,328	1,508
Aluminium	458	535
Hydrogen	152	191
Cement	367	528
Lime	82	107

Source: Ministry of Economic Development, 2001b

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 2,867 Gg in 1999. This 20 percent increase from 1990 – 1999 is largely the result of continued growth in steel and cement production.

Table 11 Emission totals for non-CO_2 greenhouse gases from industrial processes for 1990 and 1999 in CO_2 equivalents (Gg)

Industrial Process Emissions	CH_4	N_2O	HFC	PFC	SF_6
Total for 1999 in Gg	2.31	nr	209.86	74.47	33.22
Total for 1990 in Gg	2.52	nr	neg	602.53	2.87

Source: Ministry for the Environment, 2001a

Table 12 Emission totals for precursor gases from industrial processes for 1990 and 1999 (Gg)

Industrial Processes Emissions	CO	NO_x	NMVOC	SO_2
Total for 1999 in Gg	4.39	7.03	9.59	12.79
Total for 1990 in Gg	0.86	2.25	16.73	16.31

Source: Ministry for the Environment, 2001a

Non-CO_2 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 1999 are the decrease in PFC and SO_2 emissions and the increase in HFC and SF_6 emissions.

3.5 Agriculture

Table 13 Agricultural emissions for 1990 and 1999 (Gg)

Agricultural Emissions	CH_4		N_2O		NO_x		CO	
	1990	1999	1990	1999	1990	1999	1990	1999
Total in Gg	**1,492.23**	**1,415.51**	**37.14**	**38.69**	**0.08**	**0.09**	**1 .87**	**2.13**
Enteric Fermentation	1,474.36	1,398.48						
Manure Management	17.78	16.93	0.33	0.42				
Agricultural Soils	0	0	36.81	38.27				
Field Burning of Agricultural Residues	0.09	0.10	0	0	0.08	0.09	1.87	2.13

Source: Ministry for the Environment, 2001a

Enteric Fermentation

Compared to its human population of approximately 3.8 million, New Zealand has large numbers of farm animals. For 1990, the Ministry of Agriculture and Forestry (MAF) report the following livestock numbers in Table 14.

Table 14 Livestock numbers (in 1000s)

Year	Sheep	Beef Cattle	Dairy Cattle	Deer	Goats
1990	56,528	4,622	3,419	1,021	911
1999	45,754	4,585	4,449	1,740	197

Source: Ministry for the Environment, 2001a

Note: This data was reported in the April 2001 submission of the Common Reporting Format to the UNFCCC. More recent (August 2001) livestock figures are reported in Chapter 2, Figure 5.

Table 14 shows a significant decline in sheep numbers of approximately 11 million from 1990 to 1999, with a relatively large increase in dairy cattle numbers over the same period. Methane production by ruminants (sheep, beef cattle, dairy cattle, goats, and deer) has been estimated at 1,492 Gg in 1990 and 1,415 Gg in 1999. Emissions from the agricultural sector follow the methodologies contained in the revised 1996 IPCC guidelines. New Zealand specific emission factors were used where possible.

Animal wastes

Methane emissions from animal wastes decreased from 18 Gg in 1990 to 16.9 Gg in 1999. Most animal waste decomposes aerobically on pasture in New Zealand.

Agricultural soils

Soil nitrous oxide

Nitrous oxide emissions from New Zealand soils have been estimated at 36.81 Gg in 1990 and 38.27 Gg in 1999, a four percent increase. However, they are expected to be five to 15 percent above 1990 levels by 2010 due to the greater use of nitrogen fertiliser and greater nitrogen intake from improved pastures with increased diary farm numbers and improved animal performance. The base 1990 level of nitrous oxide emissions from grazing livestock is also projected to be higher by approximately 25 percent due to use of new data on nitrogen excretion rates from New Zealand models rather than standard IPCC default values.

The nitrous oxide estimates (Table 15) have been derived using the IPCC 1996 revised 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. A recent national research programme has added to a database of national emissions factors for nitrous oxide and has shown a 10-fold range in emissions factors due to urine deposition.

Further research has suggested that IPCC default nitrogen input factors may be too low for New Zealand's grassland system. The work seeks to take into account increased nitrogen inputs due to increasing per animal performance since 1990 and higher nitrogen concentrations in the pasture due to a prevalence of legumes in New Zealand grazing systems. Further work is continuing to verify these findings.

Table 15 Nitrous oxide emissions from agricultural sources in gigagrams (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Nitrous oxide	37.14	36.74	36.75	37.20	37.66	37.79	37.59	37.63	38.18	38.69

Source: Ministry for the Environment, 2001a

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.

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 – 1999. Annual emissions in 1999 were on average: 0.10Gg CH_4; <0.00 Gg N_2O; 0.09Gg NO_x; and 2.13 Gg CO (based on IPCC default values (1996) and production data from the Ministry of Agriculture and Forestry).

3.6 Land-use change and forestry

For CO_2, apart from energy and industrial processes, the only category that could result in increased 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 large areas of forests 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 sequestration, and are netted into the 'land-use change and forestry' sink figure, which is 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 exotic planting was, until 1987, mainly by the State, New Zealand has very good records of commercial planting. Ninety percent of the forest is one species (Pinus radiata). Research in forestry (particularly by the Crown Research Institute, the New Zealand Forest Research Institute (NZFRI)) has been well developed over the past 30 to 40 years. This combination of factors means that New Zealand has been able to develop reliable carbon sequestration models and data.

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

- 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
- carbon lost through forest and scrubland wildfires and prescribed burning.

Soil carbon

Carbon stored in natural forests in 1990 has been estimated at 933 Mt C, while 527 Mt C was stored in the scrub and other woody mixed vegetation (Hall et al.,1998). Forest floor litter carbon is separately estimated as containing 570 Mt C for all natural vegetation, which includes both forest and scrub areas (Tate et al., 1997). These estimates are highly sensitive to both the accuracy of mapped areas and heterogeneity within mapped classes. Current (very provisional) estimates for soil carbon at soil depth intervals of 0-0.1, 0.1-0.3, and 0.3-1 m are 1208 Mt C, 1532 Mt C, and 1944 Mt C respectively. Some soil cells are still poorly represented in the database and additional fieldwork is being undertaken. There are a number of research programmes being funded through the Foundation for Research Science and Technology (FRST), which will improve the information base on carbon in New Zealand soils.

A 1990 baseline for soil carbon, which is 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, has been established and refined over the past four years using a dedicated funding source.

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, 1991. The soil carbon monitoring system will be expected to monitor this pool once the monitoring system is fully operational. Figure 14 depicts the pastoral land use and forest cover in New Zealand.

Pastoral Farm Types
- Dairying
- Dairy dry stock
- Grazing properties
- Primarily beef
- Deer farming
- Primarily sheep
- Mixed sheep and beef
- Other land

Forest Types
- Shrubland
- Planted forest
- Indigenous forest

Other Land Cover
- Urban Area
- Lakes
- Regional council boundaries

Figure 14 Pastoral land use and forest cover in New Zealand

Source: Ministry for the Environment, 2000

3.7 Waste

Landfill emissions have dropped between 1990 and 1999 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 16. Overall, nitrous oxide emissions from wastewater increased marginally from 0.44 Gg in 1990 to 0.48 Gg in 1999.

Table 16 Summary of waste sector methane emissions in gigagrams (Gg) for 1990 to 1999, 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	1996	1997	1998	1999
Landfills	136.5	137.7	131.1	133.3	133.6	131.1	131.2	121.9	118.9	117.4
Wastewater	6.2	6.2	6.3	6.4	6.5	6.6	6.7	6.7	6.8	6.8
Total	**142.7**	**143.9**	**137.4**	**139.7**	**140.1**	**137.7**	**137.9**	**128.7**	**125.7**	**124.2**

Source: Ministry for the Environment, 2001a

3.8 International bunkers

Fuels used in international transport are referred to as international bunker fuels. The emissions from this source are required under IPCC and UNFCCC 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 (Table 17) 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 2.6).

Table 17 International bunker emissions for 1990 and 1999 (Gg)

International Bunker Emissions	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1990 Total	**2,384**	**0.13**	**0.05**	**30.43**	**4.68**	**1.05**
Aviation	1,353	0.030	0.02	5.57	2.19	0.34
Marine	1,031	0.10	0.03	24.86	2.49	0.71
1999 Total	**2,912**	**0.13**	**0.06**	**30.70**	**5.43**	**1.14**
International Bunker Emissions	**CO_2**	**CH_4**	**N_2O**	**NO_x**	**CO**	**NMVOC**
Aviation	1,959	0.04	0.03	8.07	3.17	0.49
Marine	653	0.09	0.03	22.63	2.26	0.65

Source: Ministry of Economic Development, 2001b (Figures in italics from Ministry for the Environment, 2001a)

Between 1990 and 1999, 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.

3.9 Good Practice and Uncertainty Management

The IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000), has been introduced by the UNFCCC to reduce the uncertainties of the estimates in the inventory as far as practicable. These guidelines have been introduced with the purpose of improving the accuracy and clarity of the data submitted. Furthermore, good practice provides for the development of inventories that are transparent, consistent over time and subject to a range of other quality control features available to inventory agencies such that the uncertainties are gradually reduced. The importance of good practice is the fundamental association of the inventory data and eligibility to use the different mechanisms under the Kyoto Protocol to assist parties to meet their emissions reduction targets.

Practical implications

Only the direct greenhouse gases, at this time, are required to be examined. These are CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. The precursor gases such as CO, NO_x and NMVOCs are not included. Thus solvents and other product uses are not covered within the Good Practice Guidance. The Guidance also does not, at this stage, cover land-use change and forestry, although the IPCC has begun a process of developing good practice for this sector. The process of implementing good practice acts as a review of the current inventory construction, and New Zealand is undertaking this implementation while continuing national inventory preparation and developing the national system under Article 5.1 of the Kyoto Protocol.

The main focus of the Good Practice Guidance is in managing the uncertainties – the importance of this cannot be understated as current uncertainty values in the non-CO_2 gases in New Zealand's inventory is in the order of ±50 percent.

The Good Practice Guidance mirrors the IPCC National Greenhouse Gas Inventories Guidelines making the process convenient for cross-checking and clarity. Underpinning the quality control is an analysis of the key source categories. Key source categories analysis identifies the primary emissions from each sector of the inventory that represent the significant contributors to greenhouse gas emissions. For example, in the current inventory, nitrous oxide emissions from agricultural soils contribute 15.5 percent of total national greenhouse gas emissions, stated on a CO_2 equivalent-basis. However, the current uncertainty values for N_2O are at least ±50 percent. New Zealand recognises that the requirement for clear analysis and assessment in implementing good practice is a critical and necessary part of meeting the reporting requirements under the Kyoto Protocol.

3.10 Conclusion

Overall New Zealand's greenhouse gas emissions have increased by five percent since 1990. The most significant mover is CO_2, which has increased by 20 percent. This is largely due to a 50 percent increase in emissions from thermal electricity generation, and a 35 percent increase in emissions from domestic transport. On the whole, greenhouse gas emissions from industrial processes have increased by about six percent, but there has been a significant decline in PFC emissions largely due to improvements in aluminium smelting. CO_2 emissions from industrial processes, however, have increased by 20 percent.

Although CH_4 emissions, largely from agriculture, have declined by five percent since 1990, they are projected to rise between five and 15 percent by 2012 with a predicted rise in livestock numbers. Carbon sequestration from forestry has increased marginally since 1990, but this is likely to increase significantly if a carbon trading system enters the domestic and international markets. Finally, emissions from the waste sector declined marginally since 1990 with the increasing use of landfill gas for energy production.

Chapter 4 Policies and measures to reduce greenhouse gas emissions and to protect and enhance sinks

4.1 Introduction

New Zealand began its response to climate change in 1988 with the establishment of the New Zealand Climate Change Programme. New Zealand'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 New Zealand Climate Change Programme has the high level objectives of showing leadership on climate change (including ratification of the Kyoto Protocol), and meeting New Zealand's international commitments, including the ongoing commitments under the United Nations Framework Convention on Climate Change (UNFCCC).

Essential elements of the comprehensive approach to addressing climate change are:

- an international programme
- a science programme
- development and implementation of policies and measures
- business and economic development
- monitoring, reporting, review and compliance.

The Government has recognised that in order to minimise the risk of climate change to New Zealand and its Pacific neighbours, New Zealand needs to participate in the international effort to mitigate climate change and this requires a credible domestic programme to reduce greenhouse gas emissions and enhance sinks. The Government has agreed that New Zealand's domestic climate change policy should strive to achieve a practical programme to meet our international obligations and it has already taken a number of decisions regarding policy to address climate change. These decisions lay the foundation for on-going decision making by providing direction and likely sequencing and timing of domestic policy action.

A Ministerial group was established in May 2000 to oversee the development and implementation of New Zealand's climate change action programme. The Ministerial Group on Climate Change is convened by the Minster responsible for Energy, Forestry, Small Business, and Research Science and Technology. The other members of the Ministerial Group are the Deputy Prime Minister, and the Ministers of Finance, Foreign Affairs and Trade, Environment, Agriculture, Transport and Local Government. These Ministers represent the core government agencies involved in the New Zealand Climate Change Programme.

Through a steering group of officials coordinated by the Department of Prime Minister and Cabinet, advice is provided to Ministers. The agencies involved are:

- Department of Prime Minister and Cabinet
- Ministry for the Environment
- Ministry of Foreign Affairs and Trade
- The Treasury
- Ministry of Agriculture and Forestry
- Ministry of Economic Development (includes Energy)
- Te Puni Kokiri (Ministry of Maori Development)
- Ministry of Transport
- Ministry of Research, Science and Technology
- Energy Efficiency and Conservation Authority.

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

- policy measures being implemented to address CO_2 emissions including the development of Negotiated Greenhouse Agreements (NGAs) with industry, energy efficiency and renewable energy measures, including those recently approved as part of the National Energy Efficiency and Conservation Strategy (NEECS), and measures affecting the transport sector under a NEECS, and specific transport sector measures
- possible measures that could reduce CO_2 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 CH_4 emissions from both agricultural sources and from waste
- policy measures to limit N_2O emissions, in particular from the agricultural sector
- policy measures for non-CO_2 industrial process emissions.

This chapter also provides some information on the effects of the above policy measures. The detailed information on effects and projections is contained in Chapter 5 – Emission projections and the effects of policy measures.

4.2 The international context

Since the publication of New Zealand's second national communication in June 1997, and the completion of negotiations of the Kyoto Protocol in December 1997 at the third Conference of the Parties (COP3), New Zealand has continued to play an active part in international negotiations needed to define the rules and procedures under which the Kyoto Protocol will operate.

The Kyoto Protocol itself does not contain all the rules and guidelines which will be needed to make it operational, and COP4 set COP6 in 2000 as the deadline for taking decisions on these outstanding matters (including international emissions trading, joint implementation, the clean development mechanism, compliance, monitoring, reporting and review, and aspects of forest sinks). Thus 2000 was a very active year at the international level, and although agreement was very close at COP6 in The Hague in November 2000, the meeting was adjourned without final decisions being taken. At the resumed session of COP6 in Bonn in July 2001 political agreement was reached on key issues, and COP7 in November 2001 adopted the final decisions that in essence make the Kyoto Protocol ratifiable.

In May 2000, New Zealand's Prime Minister announced that the Government intended to ratify the Kyoto Protocol by June 2002, when the Rio+10 Earth Summit will meet[2] (10 years after the UNFCCC was originally signed). She said that wide consultation would contribute to the necessary development of policy and appropriate legislation. The Prime Minister also noted that although New Zealand's contribution to global climate change was relatively small, "we must lead by example and encourage other countries to participate actively".

Since the Prime Minister's announcement regarding ratification, domestic activity has been focussed on the necessary domestic requirements for ratification. This has also included increased effort at the international level to ensure that the Kyoto Protocol rules and procedures are agreed before New Zealand completes the ratification process.

[2] *The date of the World Summit on Sustainable Development has been moved to September 2002 and this is now the target date for New Zealand's ratification of the Kyoto Protocol.*

4.3 The science programme

Scientific research is integral to the development of New Zealand's policy response. The 2001 budget saw an increase in funding for climate change research. The funding will ensure that New Zealand's research into addressing climate change is aligned with government policy objectives. The Government has also signaled a re-focus in science and technology investment to better achieve specific climate change policy objectives through a framework that includes international collaboration, enhanced environmental understanding, greenhouse gas management and responses, environmental and societal impacts and responses, and economic opportunities from research, science and technology.

To achieve these objectives, attention is required to increase coordination of investment, encourage private sector investment and technology transfer, maintain the capability of skilled researchers in the medium to long term, and develop a framework within which the social policy objectives can be implemented.

Details of the contribution made by New Zealand to climate change research are covered in Chapter 8 on Research and systematic observation, and in the separate report regarding New Zealand's contribution to the Global Climate Observing System (GCOS). Where particular research issues relate to policy development, these are taken up in the relevant sections of this chapter.

4.4 Development and implementation of policies and measures

This section provides an update of the policies and measures described in the second national communication. The development and implementation of policies and measures has continued much along the same lines as described in that publication, but with agreement of the Kyoto Protocol, and more recently, the Government's decision to ratify, focus has shifted to the development of policies that will enable New Zealand to meet its Kyoto target.

A major effort was made during 1998 to advance climate change policy in New Zealand and in January 1999, the Government released for public submission, *Climate Change: Domestic Policy Options Statement*. This proposed options for meeting New Zealand's Kyoto Protocol target. The options focused on 'price signalling measures' (transferable tradable emissions permits or a carbon tax), and 'complementary measures' [i.e. complementary to the use of economic instruments] (e.g. energy efficiency and renewable energy). In November 1999, policy decisions were deferred by the Government until after COP6.

Under the New Zealand Climate Change Programme, the development of policies and measures can be broadly grouped as:

- price measures
- non-price measures
- pre-commitment period measures
- commitment period measures
- sectoral measures.

The Government has agreed that broad coverage of greenhouse gases and sectors and cost-effective emission reductions opportunities will be required to meet New Zealand's commitments under the Kyoto Protocol. Policies will need to be developed that aim to establish broadly comparable incentives to reduce emissions across sectors.

The Ministerial Group has indicated that it wishes the emphasis and priority in the domestic policy programme to be placed on non-price measures – such as energy efficiency measures and awareness raising – in the short term. The Government has also recognised that cross-sectoral and price measures will also be necessary since investment decisions will remain distorted until price signals better reflect the 'external cost' of carbon emissions.

4.5 Policy measures being implemented to address carbon dioxide emissions

Energy efficiency, energy conservation and renewables

The Government has agreed that energy efficiency, energy conservation, and use of renewable sources of energy will play a strong role in achieving CO_2 emissions reductions as part of New Zealand's domestic climate change policy response, especially in the period before 2008.

Energy Efficiency and Conservation Act

A cornerstone of New Zealand's approach to reducing CO_2 emissions from the energy sector is the Energy Efficiency and Conservation Act (2000). The Act had its origins as a private member's bill introduced to Parliament by the Green Party.

Energy Efficiency and Conservation Authority

The report of the international review of New Zealand's second national communication noted that government funding for the Energy Efficiency and Conservation Authority (EECA) had fallen.

EECA is now on a very sound footing with the Energy Efficiency and Conservation Act (2000) establishing EECA as a Crown entity. Under the Energy Efficiency and Conservation Act, EECA's function is to encourage, promote, and support energy efficiency, energy conservation, and the use of renewable sources of energy. EECA uses its influence to facilitate, encourage and, at times regulate to bring about changes in technology, management practices, and other behaviours consistent with its mandate.

New Zealand's second national communication contained a summary of EECA's operational programmes. An overview of EECA's current activities is provided in Box 3.

Box 3 EECA's activities during 2001/02

Cross sectoral

- Establish and implement a methodology to measure New Zealand's energy efficiency.
- Continue to gain a detailed understanding of New Zealand's energy efficiency performance and energy efficiency potential.
- Raise awareness of energy efficiency in general, and EECA, through a combination of activities.

Energy supply

- Develop and implement appropriate measures to promote greater uptake of renewable energy sources.
- Contribute to energy supply policy, including the gas sector review and Electricity Governance Board process.

Industry

- Provide technical support, as appropriate, for government in their development of Negotiated Greenhouse Agreements.
- Undertake 'business' commitment programmes with three target audiences, business (Energy Wise Companies), central (Government Energy Efficiency Leadership Programme) and local government (Energy Wise Councils) supported by a range of services including Crown loans and information services.
- Make energy management a mainstream practice through the development of a growth strategy addressing both demand for energy efficiency service and fostering a market to meet the demand.

Buildings and appliances

- Implement mandatory, minimum energy performance standards and mandatory labelling.
- Administer the Energy Saver Fund (ESF) to provide a range of domestic retrofitting projects – paying particular attention to particular target audiences and management of the funding to maintain continuity across financial years for service providers.
- Initiate a review of the recently enacted H1 (energy efficiency) elements of the Building Code and work with key elements of the new building industry code to raise awareness of energy efficiency.
- Continue research into current energy use patterns within homes and new research to start quantifying the health effects of energy efficiency measures.

Transport

- Implement and promote the fleet management guidelines.
- Undertake a review of current transport energy use patterns with a view to determining priorities for future transport activities.
- Develop proposals for fuel efficiency information for new and imported light vehicle purchasers – which may also include consideration of energy efficiency standards for light vehicles.
- Promote travel demand management proposals, including walking school buses and rideshare software.
- Begin to trial demand management initiatives being developed by others.

National Energy Efficiency and Conservation Strategy

Development of the National Energy Efficiency and Conservation Strategy is a requirement of the National Energy and Conservation Act. The Strategy was prepared jointly by EECA and the Ministry for the Environment over a period of 15 months, and was launched on 27 September 2001.

There was extensive consultation on what the Strategy should contain before the draft Strategy was released for public submissions at the end of March 2001. Over 330 submissions were received, the majority of which were supportive of the draft strategy. The Strategy includes measures that are already in place and being implemented. Regulatory based actions already taken include new energy efficiency requirements in the Building Code, agreement to the introduction of minimum energy performance standards and energy performance labelling for selected electricity using products. The Strategy is summarised below in Box 4.

The Strategy defines economy-wide targets for 2012 for energy efficiency and for the further development of renewable energy supplies. If these targets are achieved, energy sector CO_2 emissions are projected to be reduced by some 4.5 million tonnes per annum by 2012. This represents a 30-40 percent reduction on the 10 million tonnes per annum average excess CO_2 emissions anticipated in the first Kyoto commitment period under business as usual energy growth.

Box 4 Key elements of the National Energy Efficiency and Conservation Strategy

- Target of 20 percent improvement in energy efficiency by 2012. This target means roughly doubling the current rate of improvement in energy efficiency.
- Target to increase energy from renewable energy sources to provide a further 25 -55 PJ by 2012. This represents a 19 to 42 percent increase over current renewable energy. Further work to refine this target range and define implementation mechanisms is scheduled through to June 2002.
- There are five action plans outlining specific objectives, associated actions, measures, milestones, timeframes and responsibilities for each of the five Strategy sectors:
  - Central and local government: 15 percent energy efficiency improvement in five years, commit to adopting sustainable energy principles, introduce policies and actions to support economy-wide sustainable energy
  - Energy supply: increase renewable energy supply and develop industry base, improve efficiency in the energy sector, improve price signals to consumers
  - Industry: achieve international best practice in energy efficiency, maximise cost-effective use of renewable energy
  - Buildings and appliances: upgrade the energy efficiency rating of existing homes and commercial buildings, achieve best practice design in new buildings, improve appliance energy efficiency to best practice
  - Transport: Reduce energy use by reducing the need for travel, improve performance of the transport fleet, increase use of low energy transport options.
- Measures are aimed at behavioural change (to achieve energy conservation) and improving the energy efficiency of New Zealand's capital stock (investment decisions).
- Measures principally voluntary (such as market transformation processes, negotiated agreements), but include some regulation.
- Regulatory measures include minimum energy performance standards energy labelling and the New Zealand Building Code.
- Further government and third party funding needs have been signalled in the Strategy over the next five years to support initiatives, in particular for energy efficiency upgrading of domestic housing.

For details see website www.eeca.govt.nz

Negotiated greenhouse agreements

From 1995 to 2000, New Zealand had a voluntary agreement (VA) scheme with industrial emitters to limit greenhouse gas emissions. Key elements of the VA programme were described in New Zealand's second national communication. Individual agreements were signed from 1995 to 1998 focused on CO_2 emission reductions up until the end of 2000 and were targeted at energy intensive industries. VA participants were responsible for 47 percent of New Zealand's CO_2 emissions in the 1990 base year. The scheme also included one facilitating agreement for smaller scale coal users. Voluntary agreements were non-binding in nature, and designed to encourage economically feasible reductions in emission rates per unit of output.

The VA methodology essentially involved targets relative to a 1990 'base year equivalent', i.e. unchanged technologies and efficiencies. Although the final reconciliation for 2000 has yet to occur, up to the end of 1999 the signatories achieved total reductions of 1.5 million tonnes of CO_2 against the 1990 'base year equivalent' baseline.

The success of the VA scheme has encouraged industry and government to try and develop a successor programme for what will be called negotiated greenhouse agreements (NGAs) should they proceed. The exact nature of NGAs is under development, but following industry consultation late in 2001 and subsequent discussions, they are likely to have the following characteristics:

- involve an increased negotiation focus relative to VAs
- include a three-stage process: heads of agreement, generic development and the final negotiated agreement
- cover the period up to the end of 2007
- possibly involve more challenging targets than VAs, but this is conditional upon the incentives for participation, for example, exemption from a low level carbon charge if one is applied
- involve more binding commitments than VAs, with 'consequences' if targets are not achieved
- include flexibility elements, such as inclusion of off-site projects within a contractual trading framework to assist firms to accept meaningful targets and encourage wider abatement
- possibly cover a wider range of firms, but this will also be incentives framework driven
- aim to have some agreements in place early in 2003, as possible.

Transport sector

This section describes the various transport sector measures that have been adopted to address, in part, the growth in transport sector emissions as noted in Section 2.10.

The Government is developing a New Zealand Transport Strategy (NZTS) which will provide a clear high level statement of the Government's transport policy. The NZTS will address all modes and transport users. New Zealand's direction in transport policy will be structured around the concept of sustainable development and related social, economic and environmental objectives. The final NZTS will, through its action plan, identify ways in which transport can reduce its contribution to greenhouse gases.

The Government is investigating a number of measures to improve outcomes from the land transport system. Proposals are currently being considered to move the focus from road-making to a more integrated view. These include developing an NZTS, measures to encourage public transport, better charging and funding tools for road-making agencies, and measures to encourage greater co-operation between these agencies. The proposals include the possible establishment of specific funding streams for walking and cycling, and other land transport modes. In addition, a new system – patronage funding – has been implemented for the allocation of funding to public transport, which is based on actual patronage of public transport services. This is designed to reward innovations, which result in greater patronage. The Government is also developing a national rail policy, and is negotiating to purchase back the rail tracks in New Zealand's most populous city, Auckland, from the private sector. This is to ensure adequate access is maintained to the rail network for public transport services.

The NZTS is expected to complement and reinforce transport energy efficiency measures under the NEECS.

Transfund New Zealand, the agency that allocates most road-making funds, assesses road-making projects on their relative merits. This is done on the basis of cost benefit analysis carried out for each project. The cost benefit analysis process takes into account the likely effect of the proposed project on carbon dioxide emissions. Public transport and cycle-way works have been partly funded by government. In addition, projects providing alternatives to road-making will also be funded in circumstances where a project's viability outweighs that of a rival road-making project.

Funding for more energy efficient modes of transport has increased. Patronage funding has resulted in an increase in total public transport funding.

There is continuing speed limit education and improved enforcement. High intensity advertising and enforcement has contributed to the reduction of the incidence of drunk driving. This same approach is being used to reduce vehicle speeding. Enforcement mechanisms include speed cameras and a newly established highway patrol. The Government is currently developing a Road Safety Strategy to 2010. The Strategy will continue to have speed as a major focus, and is likely to have targets to improve the safety of pedestrians and cyclists.

The Ministry of Transport has developed and the Government has adopted the Vehicle Fleet Emissions Control Strategy (VFECS). The objective of the VFECS is to develop a rational and measured approach to assessing and managing the impact of vehicle emissions on local air quality. The VFECS includes a number of initiatives that, in combination, provide the most cost-effective approach to managing the impacts of vehicle emissions on local air quality in New Zealand. While the VFECS was developed to address local air quality issues, it is anticipated that some measures will also contribute to reducing greenhouse gas emissions from the land transport sector, as they support the progressive improvement in vehicle fuel efficiency across the national fleet.

The Ministry of Transport has commissioned the development of the Vehicle Fleet Fuel Model (VFFM). The VFFM is able to explain the sources of current carbon dioxide emissions from the road transport sector, project likely carbon dioxide emissions in the absence of policy interventions and identify the potential impact of possible policy interventions on carbon dioxide emissions. Modelling has shown that improvements in vehicle technology could lead to a considerable reduction in carbon dioxide emissions. Accordingly, the Government is currently investigating the viability of introducing vehicle efficiency standards for vehicles imported into New Zealand and a fuel consumption-labelling programme for vehicles.

Actions by local authorities also impact on the transport sector. Regional councils have land transport planning responsibilities under the Land Transport Act 1998 and the Resource Management Act 1991. 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 road-making proposals. This is enforced through the cost benefit analysis regime used by Transfund New Zealand (see above).

The Energy Efficiency and Conservation Authority (EECA) provides operational programmes and related policy advice designed to promote greater uptake of energy efficient travel options and technologies. The National Energy Efficiency and Conservation Strategy (as discussed previously)

includes a wide range of measures aimed at improving transport sector efficiency. One of the measures in the Strategy is a government inquiry into sustainable urban form. The intention of the inquiry is to develop more sustainable cities and transport systems, which could contribute to reductions in carbon dioxide emissions from vehicles.

4.6 Policy measures to protect and enhance carbon sinks and reservoirs

In 1990, New Zealand's planted forests (excluding soils) contained a total estimated carbon stock of 113,000 Gg. By the end of 2012 it is projected that this carbon pool will have grown to 143,000 Gg of carbon, due to an increase in forest area and growing stock. In the year 2000 these forests are estimated to have sequestered 6,200 Gg of carbon (24,200 Gg of CO2), by the end of 2012 carbon sequestration is projected to fall to 3,800 Gg of carbon due to a forecast increase in harvesting.

It is currently assumed that New Zealand's indigenous forests are a neutral carbon reservoir. The assumption that these indigenous forests are neither a carbon source nor a sink is unable to be tested until the results from the indigenous forest carbon monitoring system are available.

Commercial planted forests

New Zealand recognises the important role that forests play as sinks and reservoirs of greenhouse gases. As at 1 April 2000 there were 1.77 million hectares of sustainably-managed planted forest in New Zealand. These forests are planted with tree species introduced to New Zealand with the predominant species *Pinus radiata*. Government policies in the early 1990's created a more favourable environment for forestry investment. Economic reforms and general optimism over the market outlook have also contributed to planting levels. As reported in the second national communication, 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 seven percent) 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.

New Zealand has a 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 attractive. The most important factors are positive long-term market prospects, the current taxation regime, and the Government's commitment to removing unreasonable impediments to forestry and wood processing.

New planting rates since 1990 have been above the historic average of around 40,000 hectares per annum during the 1970's and 1980's. Over the period 1990 to 2000 new planting has averaged 55,000 hectares per annum. This has however, fluctuated from a low of 15,000 hectares in 1992 to a high of 98,000 hectares in 1994. In the year ended 2000, 40,000 hectares of new forest was established. The best estimates of future average annual new planting is 40,000 until 2010 with a likely range of between 20,000 and 60,000 hectares per year.

At current afforestation rates land availability is unlikely to be a constraint in the foreseeable future. Most planted forest expansion is taking place on rolling to steep hill country (Land Use Capability Classes 4 to 7, which comprised approximately 9.4 million hectares nationally in 1994).

It is estimated that planted forests removed 24,200 Gg carbon dioxide from the atmosphere in 2000. Based on new planting since 1990 and forecast average future new planting rate of 40,000 ha per year from 2001 to 2012 it is projected that forests planted since 1990 will sequester around 117,000 Gg of carbon dioxide over the five year Kyoto Protocol commitment period 2008 to 2012.

East Coast Forestry Project

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. In 1999 the Project was reviewed and the aim of the Project altered to plant 120,000 ha of the most erosion prone land on the East Coast. The Project was modified to reflect a greater concern regarding soil erosion and moved from a scheme supporting purely commercial forestry establishment to a land use sustainability project while still including commercial forestry, can also potentially include the potential for other forms of erosion control.

Government funding for this Project is available on a contestable basis to those proposing to establish vegetation for the control of erosion on land meeting the Project's criteria. It was estimated at the time the Project was developed that planting under the Project would absorb, in 2000, an amount equal to around three percent of New Zealand's carbon dioxide emissions in 1990.

While the planting rate has been below the initial target of 7,000 ha per annum it is anticipated that this planting rate will increase as local government regulation on sustainable land use is developed.

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 and will continue to be taken to discourage unsustainable management practices and to counteract mammalian pests.

Indigenous forests occupy 6.256 million ha of which 5.187 million ha are owned by the Crown. The vast bulk of the Crown resource is managed for its conservation values. It is comprised of 14 national parks and other conservation areas. The Crown owns 12,000 hectares with the cutting rights belonging to Waitutu Inc in perpetuity. A further 1.069 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. Less than 0.005% of New Zealand's total commercial wood production is from indigenous forests.

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 Nature 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 and 130,000 ha respectively of forest have been protected under these programmes. In addition, further provision has been made under the Resource Management Act 1991 for the protection of areas of significant indigenous vegetation.

In 2000 the Government made a decision to end harvesting from indigenous production forests on the West Coast of the South Island, managed by a Crown owned company Timberlands West Coast (TWC). These forests have been transferred to the Department of Conservation (DoC) due to their significant natural and conservation values. The area of forest involved was 130,000 hectares. The remaining logging of rimu on Crown managed land is due to end on 31 March 2002, which will mark the end of all indigenous forest logging on Crown managed land.

In 1993, the Government introduced an 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 forests. The amendment did not apply to either SILNA lands (that is land allocated to some Maori, individuals – not iwi), under the South Island Landless Natives Act 1906) or to land managed by Timberlands West Coast (the land that has since been transferred to DoC – see above). The amendment has virtually ended the unsustainable harvesting of private indigenous forest. TWC continued to unsustainably log rimu forest on the West Coast on Crown owned forest and this comprised of the bulk of the harvest for sawn timber in the 1990's. This is due to end soon. Less than two percent (this two percent is the SILNA land) of indigenous forest is now exempt from the requirement for sustainable management. The Government is committed to negotiating with the owners of these SILNA forests to bring them under sustainable management.

The New Zealand Forest Accord prohibits the clearance of mature and regenerating indigenous forest for plantation forestry. The Accord is a voluntary agreement between the NZ Forest Owners Association (NZFOA) whose members cover the bulk of the commercial planted forest estate. However, the NZFOA members were responsible for a lower proportion of new planting (on sites not previously plantation). A number of companies and small growers outside of NZFOA planted the rest – some of this was on Maori land. In 1999, 14 percent of new land planted into forestry had formerly been in scrub (scrublands). More marginal land is reverting to scrub and natural forest, especially since the removal of agricultural subsidies in the 1980's, than is being cleared for agricultural purposes.

A land tenure review programme that builds on previous programmes for retirement of grazing on degraded lands for water and soil conservation purposes, promises to contribute substantially to carbon sequestration in New Zealand in the future. The programme, managed by the Commissioner of Crown Lands and supported by the Department of Conservation, involves the voluntary retirement from productive use of around one million ha of indigenous grassland that is used unsustainably for pastoral farming. So far, 69,000 ha have been retired under the land tenure review programme. This land will be managed for conservation purposes and much of it is likely to revert to scrub and eventually forest. Vast areas of New Zealand's South Island were deforested by burning after Polynesian colonisation and the forest vegetation was replaced by native tussock grassland species. Although seed sources are scarce, substantial areas of this land are starting to develop scrub cover. The Department of Conservation is conducting research on the future management of these lands to assist building a robust policy response. Allowing reversion to indigenous forest is considered the most likely ecological end-point over substantial areas but it may be necessary to retain some land under grazing and/or fire management regimes to preserve current landscape character and satisfy public opinion.

Green Package funding has been used to develop a carbon monitoring system for indigenous forest and scrublands. An international review panel reviewed the proposed indigenous forest and scrub carbon monitoring system in 1999. The monitoring system will use remote sensing combined with ground-based plot measurements. New Zealand's first Land Cover Database (LCDB) was completed in 2000. This was based on the detailed classification of SPOT satellite imagery. A second LCDB is now beginning development, it will utilise Landsat 7 TM imagery captured during the New Zealand summer of 2001/02. This will provide a five-yearly check on afforestation, reforestation and deforestation. The first cycle of forest and scrub plot measurements is planned to start in late 2001 and is expected to be completed over a five year period. The carbon monitoring system is also expected to consolidate and standardise existing forest information currently held by various agencies.

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 carriers, and to improve the health and regenerative capacity of important indigenous plant communities, particularly forests.

Expenditure on pest (mainly possums) control for disease control purposes was $34.5 million in 2000/01. This will increase to an average of $53 million per year for the next 12 years. The current area under control for disease purposes is 4.3 m ha and this will increase to 8.4 m ha.

Expenditure increased by $1.9 million to $25.5 million in the year 2000/01 for wild animal control in indigenous forests and other ecosystems. In 2000/01, the Department of Conservation conducted a range of pest control activity to protect indigenous forests from animal browsing damage. The areas of land benefiting were: possums 742,000 ha, goats 2,358,000 ha and deer 527,000 ha. (These areas overlap in many localities.) Special biodiversity funding in 2000/01 allowed an additional 11,600 ha to benefit from possum control and 820,000 ha to benefit from goat control.

Increased funding has been provided for research to find new possum control methods, and for new bovine tuberculosis control methods. Research is underway to replace the use of toxins for pest control with biological control methods. Some advances have been made but the research is expensive and long-term. It involves genetic modification and other techniques that need public acceptance. The research includes the development of vector-carried immuno-contraceptives to diminish possum population growth rates. However, in the short to medium term, control will depend on conventional control (poisoning and trapping).

To coordinate scientific and technical advice to support the possum control programmes, the Government established a National Science Strategy (NSS) Committee for Possum and Bovine Tb Control in 1991. The Committee advises the Government on an overall science strategy, science priorities and science funding levels. In 2000/01, the Government spent NZ$14.1 million on possum research alone. The Government has funded research into biological control of possums as a means to a long-term control solution. Research has enabled more cost-effective methods to be adopted with a consequence that conventional controls have been extended over greater areas without significantly increasing the amount of poison being used.

A system to manage forest sinks

An important component of the Government's domestic climate change policy will be the design of a system that enables carbon accumulated in eligible forest sinks to be verified and traded.

In July 2001, the Government released a sinks information document. Its purpose was to inform readers of sink issues under the Kyoto Protocol. The Government intends to release a further discussion document following decisions on policy options for a system to manage forest sinks. These options will form the basis for consultation with stakeholders as the Government moves to ratify the Kyoto Protocol.

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 in New Zealand but compared to many countries forest fires only damage very small areas of forest each year. National Rural Fire Authority records show than in the seven year period 1990 to 1997 only 2,640 hectares of forest were burnt. This was likely to have been a mix of indigenous and planted forest.

Insect pests and pathogens have been recognised as a threat to New Zealand's forests for many years. 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 that occur at a rate of about ten per year. Few have significant impacts on forest health and New Zealand does not need to conduct insect and pathogen control in any of its indigenous forests.

In 1996, the white spotted tussock moth (*Orgyia thyellina*) was discovered in Auckland in the northern part of New Zealand's North Island. It was considered to be a significant potential pest of forests and horticultural crops and was eradicated. The result of this, and other recent pest incursions, is an increasing focus on biosecurity. The Government has signalled this priority by appointing a Minister of Biosecurity. In addition New Zealand is currently developing a long term Biosecurity Strategy.

Soil carbon

Green Package funding has been used to develop and to begin to implement a 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.

4.7 Policy measures to limit methane emissions

Overall, as a result of falling sheep numbers but rising dairy cattle and deer numbers, total methane emissions in New Zealand dropped slightly or were static over the period 1990 to 2000 in comparison to the 1990 baseline. However, it is projected that because of good product prices and therefore increasing animal numbers, and improving animal performance, future emissions will be above 1990 levels. 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.

Policy measures for methane emissions from the agricultural sector

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 static 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. Policy measures are being developed and consulted within the broader context of policy development as part of the Government's approach for ratification of the Kyoto Protocol.

The Government has, however, increased research investment, to reduce uncertainty in emissions sources and sinks, and to investigate technical solutions to further reduce methane emissions from livestock. The Government in the 2001 Budget announced additional research funding specifically to address methane mitigation in ruminants. Additionally the Government announced funding of $2.75 million dollars over four years to reduce uncertainties in the agricultural greenhouse gas inventory. This is administered by the Ministry of Agriculture and Forestry.

The policies and measures that have maintained 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 sheep numbers, but over recent years there has been an increase in dairy animal numbers and a substantial increase in deer numbers, resulting in total livestock units increasing again (table 22).

In addition, forest planting could also have important implications for methane emissions from livestock. Consistent levels of forestry planting on pastoral land are being maintained in New Zealand as a result of world price of timber and amendments in 1991 to the income tax laws, and other factors described in the previous section. 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. The level of stock unit displacement by forestry is estimated to have increased from 316

thousand stock units in 1989/1990 to a cumulative 2,553 thousand stock units in 1999/2000.

Some possible measures, such as feed additives to reduce emissions of methane from ruminants, would be difficult (and prohibitively expensive) to implement. This is because New Zealand's extensive sheep and beef systems (accounting for 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 (see table 21). 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 which will assist this type of quantification.

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 towards increased carrying capacities and to higher animal performance. These two factors are leading to increased methane emissions, although there may be confounding factors as intensification of agriculture will lead to improved forage quality which results in decreased methane emissions per unit of forage intake. Also there may be more efficient utilisation of forage for animal productivity as a result of intensive genetic breeding programmes.

The Government has also introduced the Sustainable Farming Fund, supporting farmer-initiated projects that lead to sustainable use of resources and sustainable productivity. The fund will provide $24 million over three years. Some of the projects have a direct link to improvement of animal productivity, and efficient use of farming input resources such as water and energy.

Reduction in subsidies – trade liberalisation

In New Zealand the policy that has had an 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 decrease in livestock numbers since 1990 reflecting the move away from surpluses to market demand production (table 18). Reduction or removal of subsidies reduces the incentive for over-production (table 19). Farmers in New Zealand now produce solely in response to demand in domestic and world markets. With good international prices there has been an increase in productivity and animal numbers without subsidy support.

Table 18 Livestock performance in New Zealand (1990 to 2000) (figures for 2000 are provisional).

Product	Season Ended	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Wool /sheep (kg Greasy)	30 June	5.1	5.3	5.4	4.9	5.7	5.8	5.5	5.8	5.7	5.5	5.6
Lambing %	30 June	96.6	100.4	105.7	95.4	102.5	107.3	104.3	111.9	117.3	113.6	114.9
Graded Lamb (kg/carcase)	30 Sept.	13.8	14.1	14.3	15.1	15.2	14.6	15.2	15.9	15.4	15.7	16.7
Graded Beef (kg carcase)	30 Sept.	237	240	233	248	250	244	242	254	241	240	245
Milksolids/cow (kg)	31 May	232	233	254	252	275	255	259	283	280	262	300

Sources: Statistics New Zealand, 2000; Ministry of Agriculture and Forestry, 2000

Table 19 Level of assistance to pastoral agriculture and total stock units (1990 to 2000) (figures for 2000 are provisional).

Level of Assistance to Pastoral Agriculture	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Produce Subsidy Equivalents % all products	4.0	4.0	3.0	3.0	3.0	NA	NA	3.0	1.0	2.0	NA
Total Stock Units (millions)	99.2	99.2	96.1	94.2	97.3	98.7	96.7	96.9	95.1	96.2	98.0

Sources: Statistics New Zealand, 2000; Ministry of Agriculture and Forestry, 2000

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.

Enteric methane emissions

The Ministry of Agriculture and Forestry and the Ministry for the Environment have established an experts working group on methane to advise on the most appropriate strategies for methane inventory improvement and mitigation options for research. The Ministry of Agriculture and Forestry has also commissioned studies to reassess the current inventory methodologies, in line with the recommendations of the international review of New Zealand Inventory conducted under the auspices of the UNFCCC. Reviews of international and national current and future potential methane emissions technologies have been carried out. A national software tool to assess the national impacts of methane and nitrous oxide technologies has also been developed.

Research is continuing into field assessment of enteric methane emissions using the SF_6 technique. Additional measurements of enteric methane from individual animals have added to the database on the dependence of methane emissions on animal diet, seasonality and individual animal conditions. Methane emissions from less digestible sub-tropical pastures (e.g. kikuyu) was higher in dairy cows than cows grazing ryegrass white clover pasture. Methane emissions were significantly reduced in sheep grazing the tannin-containing *Lotus corniculatus*. Exploitation of tannin containing forage species is being further investigated. This raises the prospect of devising pasture species and management strategies to lower enteric methane emissions.

Publication of earlier research has lead to the development of multiple regression equations relating methane emissions to a number of animal feed and performance parameters for a range of animal species. The range of animal performance parameters, animal age, feed quality is so far limited in scope and therefore the universality and robustness of the equations for use in national methane inventory estimates has yet to be assessed. Research is continuing in animal species and environmental circumstances not yet covered by past research.

New Zealand has funded research 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

Under New Zealand's extensive pastoral systems, the majority of animal waste is excreted onto pasture and is decomposed aerobically. There are also liquid-based systems where waste is decomposed anaerobically. This is largely from dairy shed effluent and is discharged into 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. Regional councils and local authorities, 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 three-four 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.

4.8 Policy measures for methane emissions from the waste sector

Landfill methane

The methane emissions from the waste sector have been decreasing (in absolute terms as well as the sector's relative share of total greenhouse gas emissions) in recent years despite increases in the volume of waste produced. This trend is expected to continue into the future. Contributing factors are likely to be:

- the improvements in landfill management, based on recently introduced (but non-mandatory at this report date) landfill guidelines
- increases in the use of methane recovery systems at larger landfills
- ongoing closure of smaller landfills and the general trend towards larger landfills that attempt to meet internationally defined best practise in terms of environmental effects
- probable effects from domestic climate change policy and the National Waste Minimisation and Management Strategy.

On the last point above, current climate change policy development poses several options for managing the emissions from landfills, including the use of levies, emissions trading and project credits, with varying levels of Government responsibility. All of these policy options are part of the current consultation round.

The National Waste Minimisation and Management Strategy aims to reduce the volume of waste being produced. It is expected to be publicly released March 2002. Part of the initial focus of Government attention in the strategy's implementation includes the organic waste stream due to its generation of leachate and methane when disposed of in landfills. The Strategy will have the following targets for this waste stream:

- by 2005 60% of garden wastes is diverted from landfill and by 2010, complete (more than 95 percent) diversion of garden wastes
- by 2015 complete diversion (more than 95 percent) of kitchen wastes from landfills
- by 2007 all sewage sludge disposed to landfill is appropriately treated.

The effect of these targets on the national greenhouse gas inventory has not been quantified.

One of the key objectives of this strategy is to reduce the amount of waste produced through better resource use, and design for re-use. Again, the effect of such objectives on the national greenhouse gas target has not been quantified. Improvements to production techniques will increase energy and resource efficiency, thereby assisting both the National Energy Efficiency and Conservation Strategy and the Climate Change Programme.

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 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.

4.9 Policy measures for nitrous oxide emissions

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. These programmes are funded under the new funding provided by Government to reduce uncertainty in the agricultural greenhouse gas national inventory.

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. Many regional council plans have placed limits on the maximum application of nitrogenous fertilisers, In addition, most councils are cautioning against over-use of fertilisers. Furthermore, 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 fertiliser industry has prepared a Code of Practice which will guide land users in the efficient use of fertilisers. The dairy industry has produced an Environmental Management System for New Zealand dairy farmers. Both are voluntary at this stage and include components on fertiliser, effluent, waste and soil management which will have outcomes related to agricultural greenhouse gas emissions.

Nitrous oxide inventory and mitigation

The approaches and schemes relevant to methane are also relevant to nitrous oxide in agriculture (e.g. the Sustainable Farming Fund) and additional Government support for addressing uncertainties in the nitrous oxide inventory. An expert committee (NzOnet) has also been set up to specifically advise on nitrous oxide inventory and mitigation strategies. The committee has been involved in a national series of trials to assess emissions factors for nitrous oxide from urine placed on different soils and evaluated under a standard methodological protocol. This research is essential to reduce the large uncertainty in the national emissions estimates which has high temporal and spatial variability.

The results from the first trial presented emissions factors that ranged from 0.6 percent of urine applied emitted as nitrous oxide on well drained soils to 3.3 percent of urine applied emitted as nitrous oxide on imperfectly drained soils respectively. However, the weighted average of emissions based on the national area of each of the soil drainage classes and their associated emissions factors gave a weighted national average emission factor of 0.94 percent which is similar to the currently used New Zealand specific default value of one percent. The calculations indicated that 35 percent, 36 percent and 29 percent of nitrous oxide emissions came from well, imperfectly and poorly drained soils respectively. Considering that poorly drained soils occupy only nine percent of the pasture area, yet accounts for one third of national emissions, in terms of cost effectiveness these are the soils that should most targeted with mitigation measures.

A recent study of the national distribution of nitrous oxide emissions indicated that the amount of nitrogen excreted onto New Zealand pastures may be significantly higher that the IPCC default values used in previous national inventory assessments. Increasing animal performance since 1990 will also result in increased nitrogen deposition onto pasture. Assessment of current mitigation technologies relevant to New Zealand and the potential national assessment of the impacts of these technologies has also been carried out.

Waste management systems

As described earlier in the methane section of this chapter under Animal waste management systems, the RMA is used to control water quality. Aerobic disposal systems are encouraged, resulting in lower emissions of nitrous oxide.

4.10 Other non-CO_2 greenhouse gases – PFCs, HFCs, SF_6

Using the methodology provided in the IPCC good practice guidance, New Zealand has estimated emissions of HFCs and PFCs from a range of source categories (e.g. aerosols, mobile air conditioning and stationary refrigeration – see Chapter 3). Gaining an understanding of the size of emissions is the first step in the policy development process. Although no particular policy is currently being advanced to address emissions of these gases, there is a growing level of awareness amongst users of these gases (e.g. the refrigeration industry) that measures aimed at limiting emissions are a possibility in the future as these gases are part of the Kyoto Protocol 'basket'. The Government in association with the Institute of Refrigeration, Heating and Air Conditioning Engineers (IRHACE) has developed a training scheme aimed at improving work practices that minimise refrigerant emissions and familiarisation of the Code of Practice in the use of these substances already developed by IHRACE.

Aluminium smelting

As already described in Chapter 3 on the greenhouse gas inventory there has been a significant reduction in PFC emissions from New Zealand's single aluminium smelter since 1990, with marked reductions over the past two years. This is largely related to improvements in carbon consumption, better emission control systems and continuous improvements in cell stability. Through the air discharge consent process under the RMA, 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. Energy efficiency is also a key driver for improvements in the smelting process which can lead to lower emissions.

4.11 Further policy development

New Zealand has begun the process that is required under domestic law to ratify the Kyoto Protocol by September 2002. This formal process of ratifying the Protocol requires legislation to allow New Zealand to ratify an international agreement, and put in place the policies by which New Zealand can meet its obligations under the Protocol.

Accordingly, the Government proposes to introduce a Climate Protection Bill in two stages to achieve the target of ratifying the Protocol by September 2002. The first Part, which will be passed by September 2002, will cover the minimum legal requirements for New Zealand to meet its international obligations under the Protocol. To enable ratification, Part I legislation

must provide the Crown with sufficient powers to ensure New Zealand is able to meet its compliance equation.

Thus, the legislation will include Crown powers to trade on the international market and to issue emission units into the Crown's registry account, formalisation of the arrangements for the national greenhouse gas inventory, and establishment of a national registry to record trading transactions.

The second Part of the legislation will set out what New Zealand actually intends to do to meet our obligations under the Protocol. The earlier parts of this chapter describe current policies, but the Government recognises that more are likely to be needed to ensure that New Zealand meets its obligations during the commitment period. Policies will be needed in the pre-2008 period in addition to those likely to be in effect during the first commitment period.

When making in-principle decisions on these further pre-2008 measures, it has been agreed that the Government will consider the following objectives:

- meeting Kyoto Protocol obligations at least cost to New Zealand
- encouraging other nations to act by demonstrating international leadership
- contributing to other environmental objectives and sustainable development generally
- recognising broader social concerns and objectives
- providing business opportunities and encouraging firms to innovate and 'learn by doing'
- ensuring that Treaty of Waitangi commitments are met.

The Government has decided that the specific objective for the 2008 – 2012 commitment period to limit greenhouse gas emissions should be to ensure achievement of New Zealand's Kyoto Protocol obligations in a manner that demonstrates environmental integrity and leadership while keeping as low as practicable the social and economic costs of measures to achieve those obligations.

The Government has also identified key criteria, or dimensions, to help guide the choice between different policy options. These dimensions are:

- **Economic efficiency**. Over the long term, what policies will minimise the cost and maximise the benefits to the economy as a whole, of meeting New Zealand's Kyoto Protocol obligations?
- **Equity**. How fair will policy measures be to different stakeholder groups?
- **Feasibility**. Can the option be carried out?
- **Environmental integrity**. How effective will a policy be in reducing global greenhouse gas emissions, compared to what the emissions would have been in the absence of the policy?
- **Competitiveness**. In an open trading economy like New Zealand, will the policy reduce the competitiveness of business?

The Government is considering a range of market-based policy instruments that, alone, or in combination, can serve the objective of setting up comparable incentives for the commitment period (or earlier). These include:

- Government retaining full responsibility for emissions
- charges on all emissions or activities leading to emissions (e.g. a carbon charge)
- domestic emissions trading
- levies on activities that are not directly related to emissions
- project based initiatives including project-based trading
- hybrids of the above, or the above plus other programmes
  e.g. Negotiated Greenhouse Agreements.

Negotiated Greenhouse Agreements during the commitment period are also an option.

Public consultation on ratification and policy options is taking place in two parts. The initial consultation round (mid-October to mid-December 2001) includes consultation on the implications of ratification for New Zealand (including the social, economic, environmental and cultural implications) and on the Part I of the legislation. At the same time, the Government is seeking feedback from the community on which of the policy options is best for New Zealand in which circumstances.

The second phase of consultation will take place in 2002, starting in March, and will include consultation on the preferred policy package for New Zealand (leading to the Climate Protection Bill: Part II, which the Government proposes to introduce to Parliament at a later time).

Chapter 5 Emission projections and the effects of policy measures

5.1 Summary of projections

Table 20 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	1999	2005	2010	2020
CO_2 emissions	25,399	27,207	30,523	32,485	34,779	44,654
CH_4 emissions	1676.7	1625.9	1599.7	1778.7	1770.5	
N_2O emissions	38.2	39.0	40.0		52.1	

Note: The CH4 projections from agriculture for 2010 are at the high end of the range. Projections of animal numbers beyond 2010 are too uncertain to include in the projections analysis.

Table 21 Summary of carbon dioxide removals in gigagrams (Gg) for 1990 and 1995, and projections from 2000 to 2020

Greenhouse Gas	1990	1995	1999	2005	2010	2020
CO_2 removals	-20,868	-15,429	-21,156	-14,491	-9,913	-16,878

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 22 Summary of policies and measures: energy and industry sector

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Estimate of Mitigation Impact, by Gas (for a particular year, not cumulative, in CO_2 equivalents)
National Energy Efficiency and Conservation Strategy	Promotion of energy efficiency and conservation	CO_2, CH_4, N_2O	Government programmes	Implemented	Energy Efficiency and Conservation Authority (EECA)	2008 – 2012 3- 4 Mt annually
Reduction in CO_2 emissions	Reduction in CO_2 emissions from energy and industry	CO_2	Negotiated Greenhouse Agreements	Planned	Central Government	2008 – 2012 1.5 Mt annually
Emissions price measures	Reduction of CO_2 emissions	CO_2	Carbon Taxation	Considered	Central Government	Charge: $15 / 2000: 0 Mt / 2010: 0.76 Mt / 2020: 3.0 5Mt
Vehicle Fleet Control Strategy	Air quality And GHG emissions	CO_2, CH_4, N_2O	Government programme	Planned	Ministry of Transport	$60 / 0 Mt / 5.08 Mt / 9.40 Mt No detailed projections on mitigation available at this stage

Table 23 Summary of policies and measures: industrial processes sector

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Estimate of Mitigation Impact, by Gas (for a particular year, not cumulative, in CO_2 equivalents)
Reduction of PFCs	Air quality and PFC reduction	PFCs	Resource consent condition	Implemented	Government regulation	2005: -0.057 Gg / 2010: -0.057 Gg / 2020: 0.057 Gg
Training and certification programme for refrigeration engineers	Correct handling of fluorocarbon refrigerants and reduction of emissions	HFCs	Government and Industry Training Initiative	Planned	Central Government (Ministry for the Environment) and the Institute of engineers Refrigeration, heating and Air conditioning	Unknown at this time

Table 24 Summary of policies and measures: agriculture sector

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Estimate of Mitigation Impact, by Gas (for a particular year, not cumulative, in CO_2 equivalents)
Research funding into methane mitigation	Reduce Ruminant methane emissions and enhanced animal production	CH_4	Science and Research Technology Investment	Implemented	Ministry of Agriculture and Forestry	Unknown at this time
Research funding into nitrous oxide mitigation	Reduce nitrous oxide emissions from soils and reduce nitrogen leaching to ground water	N_2O	Science and Research Technology Investment	Implemented	Ministry of Agriculture and Forestry	Unknown at this time
Animal Waste Management Systems	Water quality	CH_4 , N_2O	Local government regulation	Implemented	Local government	Estimates of reductions are difficult to quantify
Code of Practice for the Use of Fertilizer	Water quality and sustainable management	N_2O	Local government regulation	Implemented	Local government	Estimates of reductions are difficult to quantify
Reduction in agricultural subsidies	Agricultural reform	CH_4 and N_2O	Government regulation	Implemented	Central government	Estimates of reductions are difficult to quantify

Table 25 Summary of policies and measures: land-use change and forestry sector

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Forest expansion	New forest under sustainable management	CO_2 removals	Government regulations	Implemented	Central Government
East Coast Forestry Project	Erosion reduction and Forestry production	CO_2 removals	Government initiative	Implemented	Central Government
Indigenous Forest Protection	Protection and Conservation of native forests	CO_2 removals	Government initiative	Implemented	Central Government
Forest risk management	Reduction of forest fires	CO_2 mitigation	Government initiative	Implemented	Central Government

Table 26 Summary of policies and measures: waste sector

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Estimate of Mitigation Impact, by Gas (for a particular year, not cumulative, in CO_2 equivalents)
National Waste Minimisation and Management Strategy	Reduce volume of waste and enhanced methane recovery	CH_4	Government regulation	Adopted	Ministry for the Environment	Mitigation effects are not projected at the current time
Removal of methane in waste water	Water quality and methane capture	CH_4	Local government initiatives	Implemented	Local government	Mitigation effects are not projected at the current time

5.2 Introduction

This chapter reports on projections of CO_2 emissions from energy sources and industrial processes; CO_2 removals in the land use change and forestry sector; and other greenhouse gases. For CO_2 emissions, a 'business as usual' (BAU) 'with measures' projection has been developed in addition to 'with additional measures projections', which cover new likely policy initiatives. The projections present the sensitivity of CO_2 emissions and CO_2 removals to changes in the key variables, GDP growth rates and new planting rates respectively. 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 (on a BAU 'with measures' basis); agriculture; land use change and forestry; and waste.

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

Table 27 Summary of key variables and assumptions in the projections analysis

		1990	2000	2005	2010	2015	2020
World Coal Prices[1] (US$/tonne)		48.29	46.50	46.50	46.50	46.50	46.50
World Oil Prices[2] (US$/bbl)		20.47	26.17	20.00	21.00	22.00	23.00
Residential Energy Prices[3]	Electricity	31.67	38.06	44.40	50.75	57.09	63.43
(NZ$/GJ) – incl.GST	Petrol-Regular	32.8	30.50	27.25	27.02	27.42	27.82
	Gas	11.54	17.77	20.63	23.29	24.82	26.09
	Coal	13.51	13.00	13.00	13.00	13.00	13.00
Industrial/Commercial Energy	Electricity	43.61	24.58	28.68	32.77	36.87	40.97
Prices[3] (NZ$/GJ) – excl.GST	Diesel	15.64	17.07	13.96	13.78	14.10	14.42
	Gas	8.24	10.13	11.76	13.28	14.15	14.87
	Coal	6.25	6.02	6.02	6.02	6.02	6.02
GDP[4] (NZ$ millions)		79,443	104,720	119,868	135,620	153,441	173,605
Primary Energy Supply (PJ)		553	655	736	709	766	848

[1] Source: World Energy Outlook 2000, IEA. (Real 2000 Dollars/tonne).

[2] 1990 and 2000 prices are Dubai crude prices.

[3] Real (March year 2001) New Zealand Dollars.

[4] The GDP figures are in Real (1995/1996) New Zealand Dollars as reported by Statistics New Zealand.

In order to measure the effect of climate change related policies on CO_2 emissions, a 'business-as-usual' (BAU) projection of CO_2 emissions has been developed using an energy supply and demand model. This BAU scenario attempts to project the path that emissions would take if there were no government policies put in place to address the growth in CO_2 emissions.

As in the modelling analysis presented in the second 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 CO_2 emissions via 'with additional measures' modelling. CO_2 emissions have increased by 21.8 percent between 1990 and 2000 against a projection of 28 percent reported in the second national communication. The difference is primarily due to lower GDP growth than anticipated during the second half of the 1990s. Higher oil prices and lower realised and predicted exchange rates have also had significant effects in raising the price of liquid fuels.

The BAU and 'with measures' projection of CO_2 emissions from energy and industrial processes is shown in Table 28 with the percentage change in emissions relative to 1990 depicted in Figure 15 for the 2.5 percent GDP case.

Table 28 Actual and projected emissions from energy sources (Gg)

Greenhouse gas	1990	1995	1999	2005	2010	2015	2020
CO_2	23,011	24,470	27,656	30,697	31,773	35,434	41,019
CH_4	38	44	54	65	66	77	107
N_2O	0.6	0.7	0.8	0.9	0.9	1	1
NOx	137	158	176	191	191	212	242
CO	715	794	836	934	934	1,007	1,084
NMVOC	117	131	138	163	163	175	188

Source: Ministry of Economic Development, 2001c

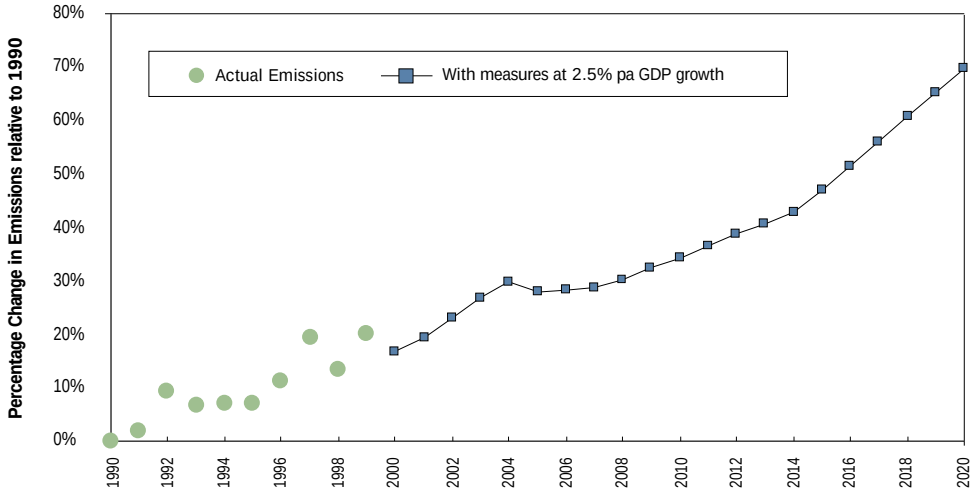


Figure 15 Energy and industrial process CO_2 emissions 1990 – 2020 'with measures' projections of CO_2 emissions at 2.5 percent GDP growth.

Source: Ministry of Economic Development, 2001c

Carbon dioxide emission projections in business-as-usual with measures

On the basis of the assumptions outlined in Annex 2, New Zealand's CO_2 emissions are expected, in BAU 'with measures' projections, to rise by about 22 percent over 1990 levels by 2000 and by 30 percent by 2005 (compared with 28 percent in 2000 and 46 percent in 2005 in the second national communication). In mass terms, this is an increase from 1990 – 2000 of about 6,000 Gg CO_2, and from 1990 – 2005 of about 7,000 Gg CO_2.

The updated BAU 'with measures' projections see CO_2 emissions from all sources increase from 2000 to 2020. Emissions from electricity generation are projected to increase at an average rate of almost six percent per annum (assuming average inflows for hydro generation), with coal and oil based emissions rising by one percent and 2.3 percent, whereas emissions from gas declines by 0.9 percent per annum respectively.

Oil will continue to be the largest single source of energy sector CO_2 emissions at 47.8 percent of the total in 2005 and 46.9 percent of the total in 2020 in the updated BAU scenario. The share of emissions attributable to gas falls significantly, and those attributable to coal show a slight fall in share over the projection period. The share of total CO_2 emissions from electricity generation is projected to rise from about 20 percent in 1999 to about 30 percent in 2020.

Reductions in source carbon dioxide emissions from policy measures

The reductions in source CO_2 emissions from the policy measures already in place can be estimated as the BAU 'with measures' projections. It is considered that the following policy measures have contributed significantly to the emissions, which would otherwise have been somewhat higher, although the individual contributions of these measures are not measurable.

- cross-sectoral policy measures
  - use of the RMA
  - energy sector reforms
  - NEECS and cooperative programmes
  - renewable energy measures
- specific sectoral policy measures to limit sources of CO_2
  - voluntary agreements with industry[4]
  - specific transport sector measures, including development of a vehicle fleet strategy
  - actions by local governments.

[4] Note that the CO_2 emissions 'avoided' as a result of Voluntary Agreements, referred to in Table 28, are measured against a different baseline to the BAU projection.

Voluntary agreements with industry

Voluntary agreements encompass those industries responsible for over 40 percent of New Zealand's total CO_2 emissions. Although CO_2 emissions for the economy as a whole are projected to be about 18 percent higher in 2000 relative to 1990, emissions for the voluntary agreement signatories as a group are only projected to increase by about nine percent.

Energy efficiency strategy

For the purpose of evaluating the impact on CO_2 emissions, the NEECS programmes can be grouped into 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, the 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.

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[5], 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 the Voluntary Agreements programme).

Government has funded EECA $30 million over five years. Programmes with 'hard quantifiable' benefits have cost around $12.5 m and achieved benefits of $59m (net present value $46.5m). Programmes with 'soft/indirect' benefits, such as the Energy-Wise Companies Campaign that has served over 700 businesses but where energy savings are subject to commercial confidentiality, are estimated to have produced benefits five to six times the programme costs. These benefits are summarised in Table 27.

[5] *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; that is, 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.*

Table 27 Summary of EECA cumulative benefits to 1999/2000

	'Hard Quantifiable' programmes[1] to 1999/2000	'Soft/Indirect' programmes[1] to 1999/2000	Total
Energy cost savings	$71 million	$135 to 185 million	**$206 to 256 million**
CO_2 emissions reductions	1.1 million tonnes	4.3 million tonnes	**5.4 million tonnes[2]**

Notes: [1] 'Hard quantifiable' programmes have fully documented savings. 'Soft/indirect' programmes involve a variety of actions by third parties with results that are self-reported or estimates.

[2] If the total is averaged over the period 1992 – 2000, or eight years, 5,400 kT = kT/year. If that amount was added to the 1999 national emissions data, one can estimate that without the EECA programmes New Zealand's total greenhouse gas emissions would have been 0.9% higher, and total CO_2 emissions 2.2% higher, in 1999.

Sources: EECA Annual Report for 1999/2000; Ministry for the Environment 2001, Table 10

In summary, the estimates of the overall CO_2 emissions reductions that have occurred as a result of the energy efficiency initiatives are, by nature, uncertain. These uncertainties 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.

Effect of policy measures on future emissions

This section presents the results based on 'with measures' BAU modelling for a 2.5 percent GDP growth rate and contrasts these with the BAU modelling results for alternative GDP growth rates of 1.5 percent and 3.5 percent growth rates. The updated relationships in the energy demand and supply model include more recent data up to the 2000 March year. The updated 'with measures' BAU projections are shown in Figure 16, together with projections for 'low' (2.5 percent per annum from 2005 onwards) and 'high' (3.5 percent per annum from 2005 onwards) GDP scenarios.

The key results of the three GDP scenarios are summarised below in Table 28 as percentage growth in gross CO_2 emissions from 1990 levels and the equivalent per annum growth rates.

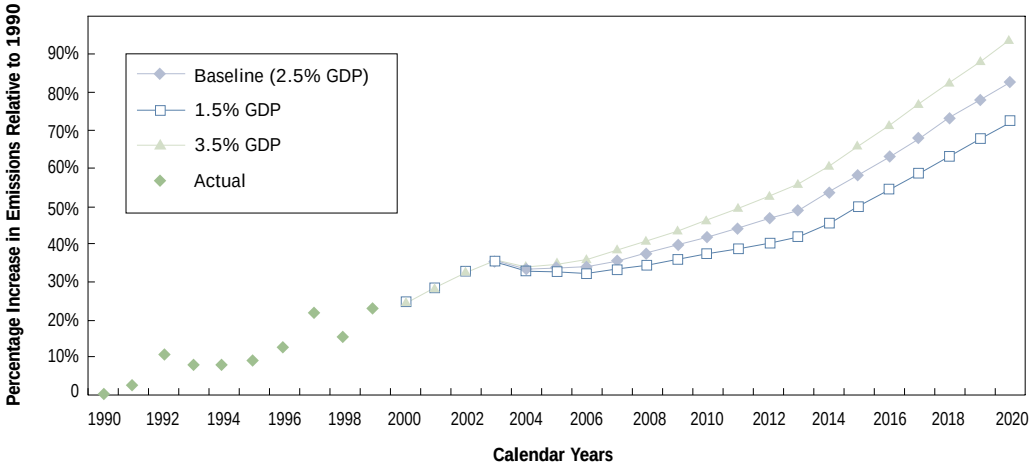


Figure 16: Energy and industrial process CO_2 emissions: baseline and alternative GDP growth rates

Source: Ministry of Economic Development, 2001c

Table 28 'With measures' BAU CO_2 emissions growth from 1990

	Low (1.5%) GDP Growth			Medium (2.5%) GDP Growth			High (3.5%) GDP Growth		
	2000	2010	2020	2000	2010	2020	2000	2010	2020
Growth from 1990	+22%	+34%	+65%	+22%	+38%	+75%	+22%	+42%	+85%
Equivalent per annum growth	+1.8%	+1.4%	+1.6%	+1.8%	+1.6%	+1.8%	+1.8%	+1.7%	+2.0%

Source: Ministry of Economic Development, 2001c

Analysis of the 'with measures' BAU energy projections suggests that over the 2000 to 2020 period, which includes the closure of the petrochemical plants, the energy multiplier could be around 0.2. That is, there will be, on average, a 0.2 percent change in energy consumption for every one percent change in GDP.

A significantly higher emissions multiplier of around 0.6[6] implies that the energy mix may be slightly more carbon intensive than has been the case historically. But over the 2010 to 2020 period after the anticipated closure of the petrochemical plants, this multiplier is close to 0.67. This is consistent with projections of a lower hydro share for electricity 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 for the entire projection period or for the sub-period of 2010 – 2020 is significantly lower than its average of around 1.5 for the 15 years up to 1995/96. The figures for 1994 – 2000 contain preliminary support for the projections. In the period 1994 – 2000, energy consumption increased by around 9.4 percent compared with a 20 percent increase in GDP in the same period, resulting in a multiplier of 0.45[7].

Lower economic growth, energy efficiency improvements, and an energy mix with lower gas supplies, 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 over the projection period.

Industrial process CO_2 emissions projections have been included in gross CO_2 emissions projections. Figure 17 presents projections for carbon dioxide emissions from industrial processes only. The historical data shows a steady increase in industrial process CO_2 emissions by about 20 percent (or additional 450 thousand tonnes of CO_2) over the ten year period from 1990 to 1999. The projections to 2020, suggest that industrial process emissions could be about 45 percent over 1990 levels (or another 550 thousand tonnes of CO_2 over the next 20 years to 2020 or about one Mt in total over the 30 year period).

The projections in emissions are based on historical growth in industrial process production (for example, for aluminium, cement, lime and hydrogen) extended at more conservative levels in the future and also according to information provided by the industries regarding capacity constraints with existing plants (for example, steel). The projections are, to some extent, uncertain as the removal or addition of blocks of production will have a significant impact on emissions.

[6]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).

[7]Primary energy supply increased by almost twice as much as GDP in the past 25 years. However, it increased by about the same rate as GDP over the past ten years.

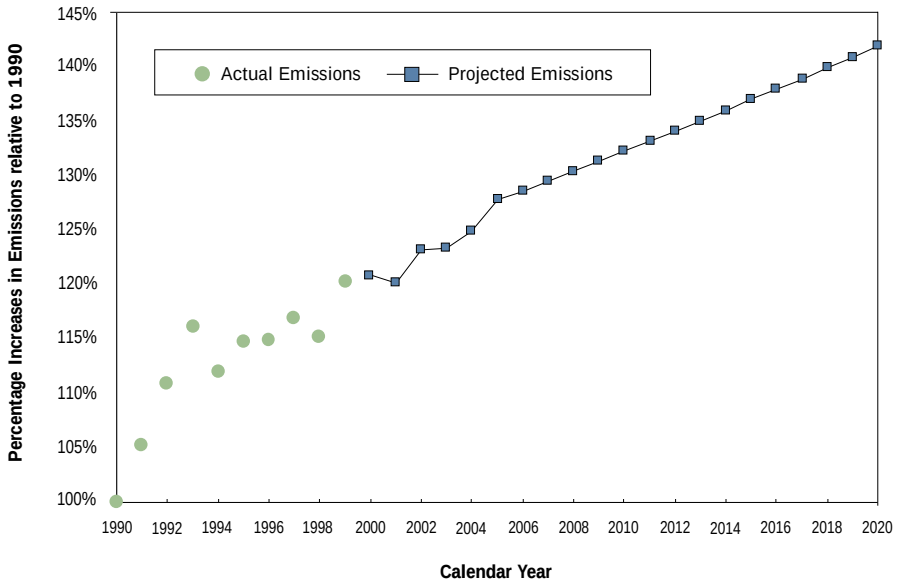


Figure 17 Industrial process CO_2 emissions 1990 to 2020 (2001 estimates)

Source: Ministry of Economic Development, 2001c

Effect of additional policy measures on future emissions

This section presents results based on 'with additional measures' modelling for a 2.5 percent GDP growth rate and contrasts these with the BAU with measures modelling results. The updated relationships in the energy demand and supply model include more recent data up to the 2000 March year.

Two sets of additional measures are included for modelling purposes:

1. Energy efficiency increases to reflect the effect of the National Energy Efficiency and Conservation Strategy. It is assumed for this modelling that the Strategy continues on to 2012 in its current form.

2. An emissions price on CO_2, representing the use of a price instrument (such as emissions trading or a carbon charge) in the Kyoto Protocol first commitment period from 2008 to 2012. It is assumed that the effect of the price instrument commences in 2005 through either forward emissions trading or introduction of a low-level carbon charge in preparation for the commitment period.

Energy efficiency increases under the NEECS

Projections of emissions with different energy efficiency uptake levels under the NEECS are shown in Figure 18. Two scenarios are modelled. The first assumes a one percent annual improvement in energy efficiency above the implicit Autonomous Energy Efficiency Improvement (AEEI) for all sectors. The second assumes a one percent annual improvement efficiency above AEEI for the transport sector, and 1.5 percent improvement in efficiency above AEEI for the residential, industrial and commercial sector. These figures are based on achieving the NEECS goal of a 20 percent improvement in energy efficiency by 2012.

The key results of the two energy efficiency improvement scenarios are summarised below in Table 29, as percentage growth in gross CO_2 emissions from 1990 levels and the equivalent per annum growth rates.

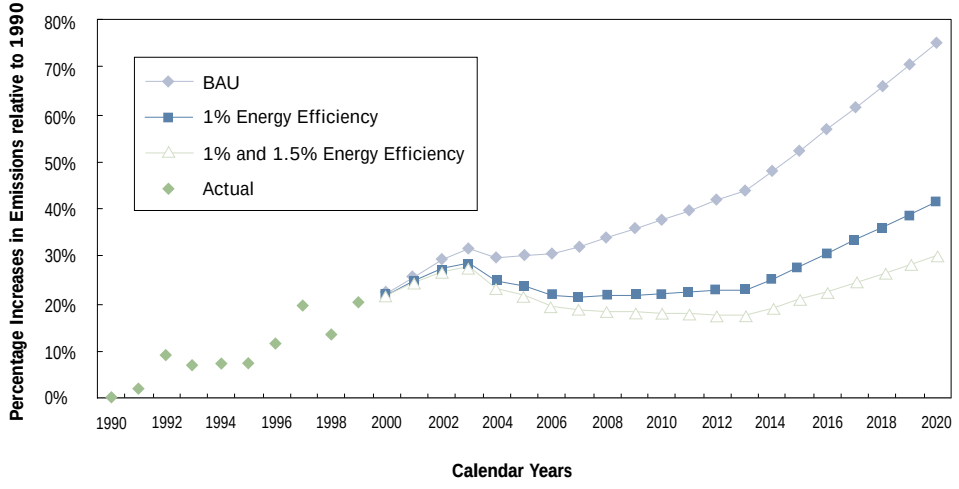


Figure 18 Energy and Industrial Process CO_2 Emissions 1990 – 2000 under alternative energy efficiency scenarios.

Source: Ministry of Economic Development, 2001c.

Table 29 CO_2 Emissions growth from 1990 under energy efficiency scenarios

	Business as usual			1% energy efficiency increase			1% and 1.5% energy efficiency increase		
	2000	2010	2020	2000	2010	2020	2000	2010	2020
Growth from 1990	22%	38%	75%	22%	22%	42%	30%	22%	18%
Equivalent per annum growth	1.8%	1.5%	1.8%	1.8%	1.0%	1.1%	1.8%	0.8%	0.8%

Source: Ministry of Economic Development, 2001c

Emissions prices under the Kyoto Protocol

At the time that this National Communication was being prepared, New Zealand had begun a public consultation process regarding ratification of the Kyoto Protocol, and possible policy measures that could be used to meet commitments under the Protocol in the event that it entered into force for New Zealand. Included in the policy options for consultation is the possibility of using an emissions price measure to manage commitment period emissions. Such measures could take the form of either emissions trading or a carbon charge.

Two scenarios have been modelled for the purpose of showing the effect of Kyoto commitment period emissions prices on carbon dioxide emissions from energy and industrial processes in New Zealand. Due to uncertainty surrounding the likely commitment period emissions prices, scenarios were modelled at NZ$15 per tonne of CO_2 and NZ$60 per tonne of CO_2. (At the time of writing, these equated to approximately US$6 and US$25 per tonne of CO_2 respectively.)

Figure 19 shows the expected changes in carbon dioxide emissions from energy and industrial processes under different emissions prices.

The key results of the two emissions price scenarios are summarised below in Table 30, as percentage growth in gross CO_2 emissions from 1990 levels and the equivalent per annum growth rates.

Figure 19 Energy and industrial process CO_2 emissions 1990 – 2020 under alternative emissions price scenarios

Source: Ministry of Economic Development, 2001c

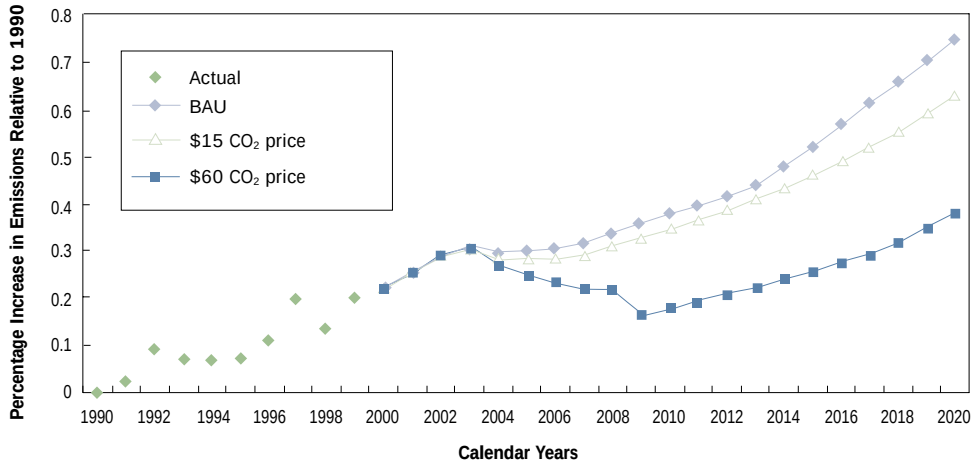


Table 30 CO_2 emissions growth from 1990 under emissions price scenarios

	Business as usual			NZ$15/ tonne CO_2			NZ$60 per tonne CO_2 2000		
	2000	2010	2020	2000	2010	2020	2000	2010	2020
Growth from 1990	22%	38%	75%	22%	35%	63%	22%	18%	38%
Equivalent per annum growth	1.8%	1.5%	1.8%	1.8%	1.4%	1.6%	1.8%	0.8%	1.0%

Source: Ministry of Economic Development, 2001c

5.4 Carbon dioxide removals from land use change and forestry

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

It is not possible to compile BAU projections for CO_2 emissions and removals from land use change and forestry. Chapter 4 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
- probably most importantly, changes to the taxation regime, which on average increased after-tax profitability by around seven percent.

In addition, a number of the measures described in Chapter 4 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 40,000 hectares per year from 2001. 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 20,000 hectares per year (Marshall et al., 2001). Based on the three scenarios for new planting, projected total removals of CO2 by planted forests (net of emissions from land use changes) are illustrated in Figure 20. CO_2 removals by planted forests, emissions from land use changes (and hence total CO_2 removals for the period 1990 – 2030, and intervening years, in the central scenario for new planting) are reported in Table 31.

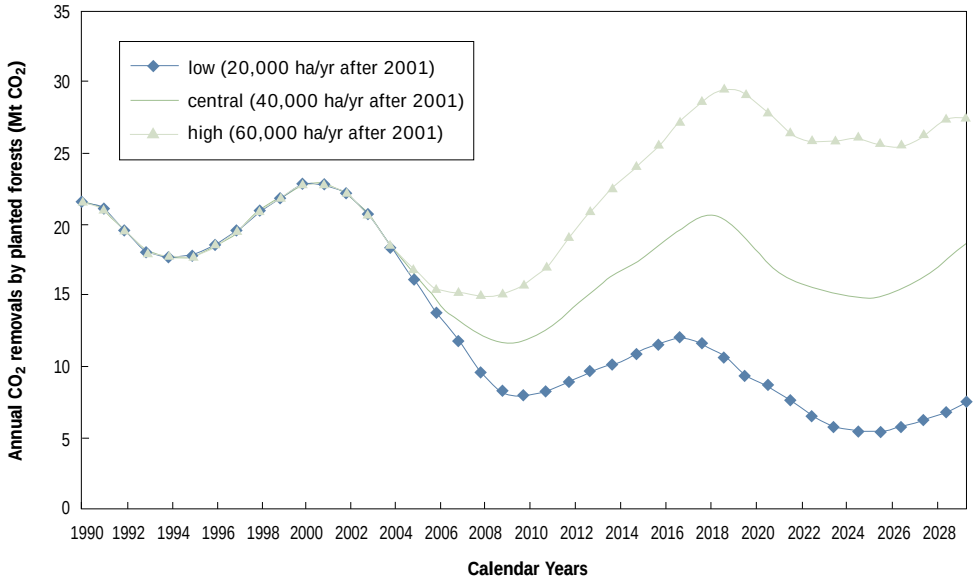


Figure 20 Projected annual total CO_2 removals by planted forests 1990 – 2030

Source: Marshall et al., 2001

Table 31 CO_2 Removals and emissions from land use change and forestry (central projection assuming new planting of 40,000 ha/yr from 2002)

	1990	1995	1999	2005	2010	2020
CO_2 removals	-22.3	-18.0	-23.2	-16.5	-11.9	-18.9
CO_2 emissions	1.4	2.6	2.1	1.9	1.9	1.9
Total removals	**-20.9**	**-15.4**	**-21.2**	**-14.5**	**-9.9**	**-16.9**

Source: Marshall et al, 2001

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. Figure 21 illustrates the cumulative total CO_2 stored in planted forest stocks compared with annual estimates of CO_2 removals.

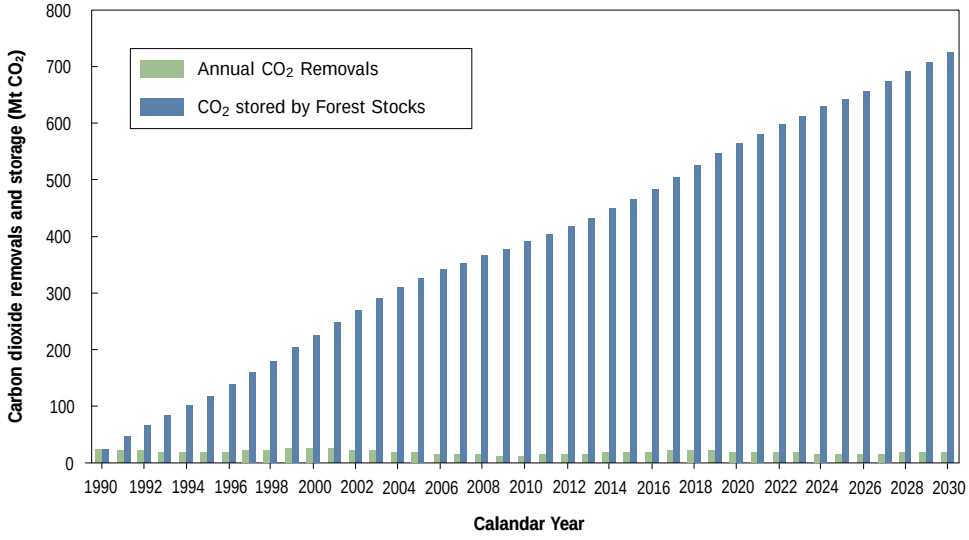


Figure 21 projected CO_2 storage in planted forest stocks compared with annual rates of CO_2 removals 1990 – 2030

Source: Marshall et al., 2001

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.

Projections of total increases in carbon stored Kyoto forests

New Zealand had approximately 600,000 hectares of Kyoto forests (i.e. forests planted after 1990) in 2001. Planting rates have been variable but have averaged approximately 50,000 hectares per annum. Forestry planting projections are in the range of between 20,000 to 60,000 hectares per annum from 2002 forward. At the assumed planting rate of around 40,000 hectares per annum after 2001, Kyoto forests are estimated to remove about 117 Mt CO_2 from the atmosphere over the first commitment period of the Kyoto Protocol. Figure 22 illustrates the carbon dioxide removed by New Zealand's Kyoto forests to the end of the first commitment period of the Kyoto Protocol (2008 to 2012). First and second rotations are included in this projection and the different planting scenarios as projected in the all forests projections presented.

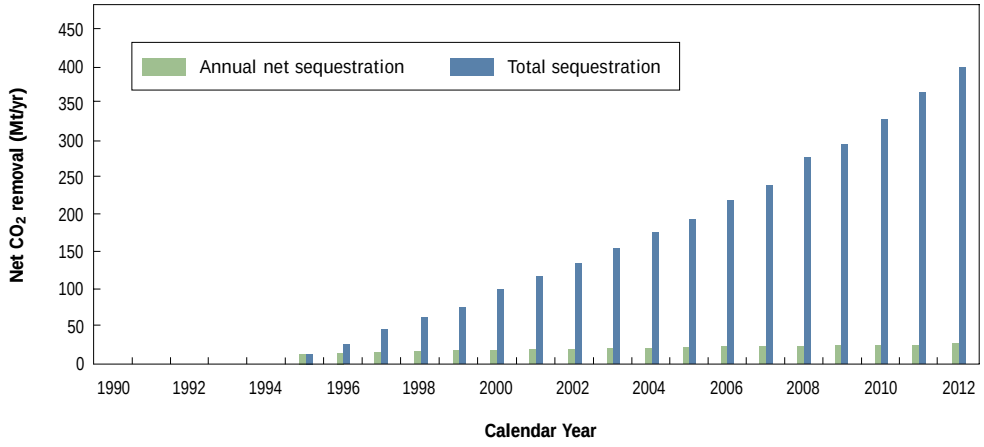


Figure 22 Projected annual total CO_2 removals by Kyoto forests 1990 – 2012

Source: Marshall et al., 2001

Cumulative carbon dioxide emissions and removals

A more accurate measure of New Zealand's total contribution to the atmospheric stock of CO_2 is to compare cumulative emissions of CO_2 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 975 Mt CO_2 as shown in Table 32. In total, planted forests, net of emissions from harvesting and other emissions from land use changes, are projected to increase in carbon storage by 538.2 Mt CO_2 over the period 1990 – 2020, as shown in Table 32. The projected removal of carbon dioxide from the atmosphere by planted forests over the total period 1990 – 2010 is estimated to mitigate, on average, 57 percent 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 23.

Table 32 Cumulative gross CO_2 emissions from energy and industrial sources and removals of CO_2 by planted forests (in Mt of CO_2)

	1990 – 1999	2000 – 2009	2010 – 2019
Cumulative Gross CO_2 Emissions[a]	278.577	321.147	374.858
Total CO_2 Removed and Stored in Planted Forests[b]	196.245	175.256	166.656
Percentage of Gross CO_2 Emissions Removed from the Atmosphere and Stored by Planted Forests	70.4%	54.6%	44.5%

Note: [a] BAU 'with measures' scenario, 2.5 percent GDP growth.

[b] Central projection, based on new planting rates of 40,000 ha/yr from 2002.

Source: Marshall et al., 2001

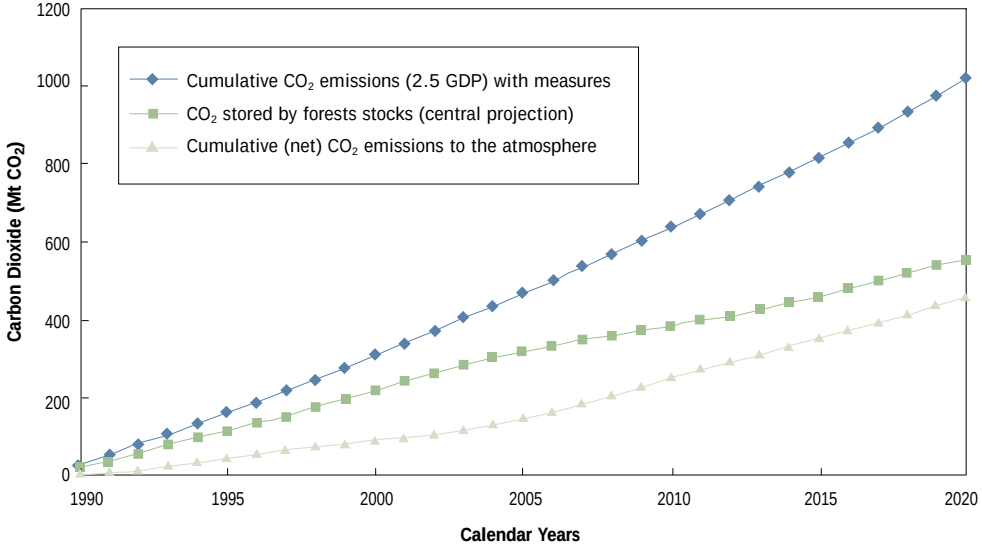


Figure 23 Cumulative gross CO_2 emissions from energy and industry, forest stocks and the resulting total cumulative (net) CO_2 emissions to the atmosphere

Source: Marshall et al., 2001

Table 32 and Figure 23 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. As can be seen in Figure 23, increases in forest stocks will offset increases in gross emissions for at least the next two decades, if projected rates of new planting are realised.

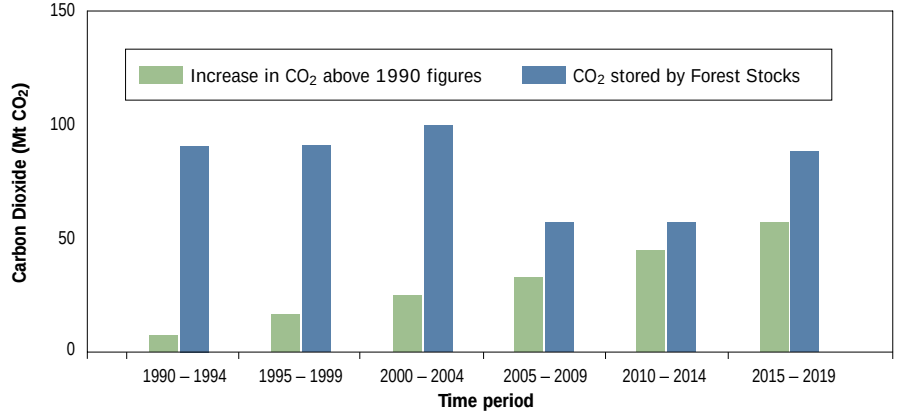


Figure 24 Five-yearly cumulative increases in gross CO_2 emissions above 1990 Level compared with CO_2 stored by planted forest stocks

Source: Marshall et al., 2001

5.5 Non-CO_2 greenhouse gases from energy sources

Projections of non-CO_2 greenhouse gases from energy sources have been carried out based on the energy outcomes from the energy demand and supply model under the BAU 'with measures' scenario.

Methane (CH_4)

CH_4 emissions from energy sources were 37.5 Gg in 1990 and rose to 54.2 Gg in 1999. At these levels, CH_4 emissions from energy sources comprise around three percent of economy-wide emissions.

Coal mining and post-mining activities comprise the largest component of CH_4 fugitive and CH_4 total emissions from energy sources. Coal's share of fugitive and total emissions were around 45 percent and 30 percent in the early 1990s and grew to over 60 percent and 50 percent

respectively in 1996, when increasing export demand for bituminous coal resulted in a higher level of underground mining activity. (Underground bituminous coal mining is the most CH_4 – intensive mode of mining activity). The share of CH_4 emissions from natural gas has fallen from 37 percent in 1990 to about 30 percent in 1999, mainly as a result of reduced gas flaring and declining use of compressed natural gas (CNG). The share from liquid fuels of around 16 percent in the early 1990s, has declined somewhat by the late 1990s in line with the growth in CH_4 emissions from coal and gas production and use in relation to transport fuels demand. The remaining CH_4 emissions arise from geothermal fugitive sources (around five percent) and biomass combustion (around four percent). Figure 25 shows CH_4 (and other non-CO_2 greenhouse gases) emissions from energy sources for 1990 – 1999 and the BAU 'with measures' projections from 2000 to 2020 at 2.5 percent GDP growth.

Nitrous oxide (N_2O)

Nitrous oxide emissions from energy sources (virtually all related to combustion) were between 0.6 and 0.8 Gg in the 1990s. Currently, around 73 percent of these N_2O emissions are from liquid fuels combustion, 15 percent from biomass and six percent each from coal and gas combustion.

Projections for nitrous oxide emissions are also shown in Figure 25. The projected increase in nitrous oxide emissions from 2000 is attributable to rising liquid fuel use, as a result of the rapid increase in the transport sector energy consumption and the lower fuel shares for gas at present compared to that reported in the second national communication.

Nitrogen oxides (NO_x)

Emissions of nitrogen oxides from energy sources have increased from 137 Gg in 1990 to 176 Gg in 1999. Virtually all NO_x emissions result from fuel combustion activities.

In 1999, around 65 percent was attributable to liquid fuels and 27 percent to gas, while coal accounted for about seven percent. Among the various sectors, domestic transport was responsible for 56 percent, 21 percent was from industry, and around 12 percent attributable to thermal electricity generation, of which 10 percent was from gas generation and two percent from 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. Some decline in nitrous oxide emissions post-2004 for two to three years is attributable to the decline in gas use by petrochemical plants, which is offset by rising transport fuels in subsequent years. The 'with measures' profiles are also shown in Figure 25.

Carbon monoxide (CO)

CO emissions from energy sources increased from 715 Gg in 1990 to 836 Gg in 1999, an average rate of increase of about 1.9 percent per year.

Around 90 percent of CO emissions from energy sources is from transport and around 95 percent of this is from petrol combustion. Thus, both the historical profile and projections closely follow the projected demand for petrol. This information is also shown in Figure 25.

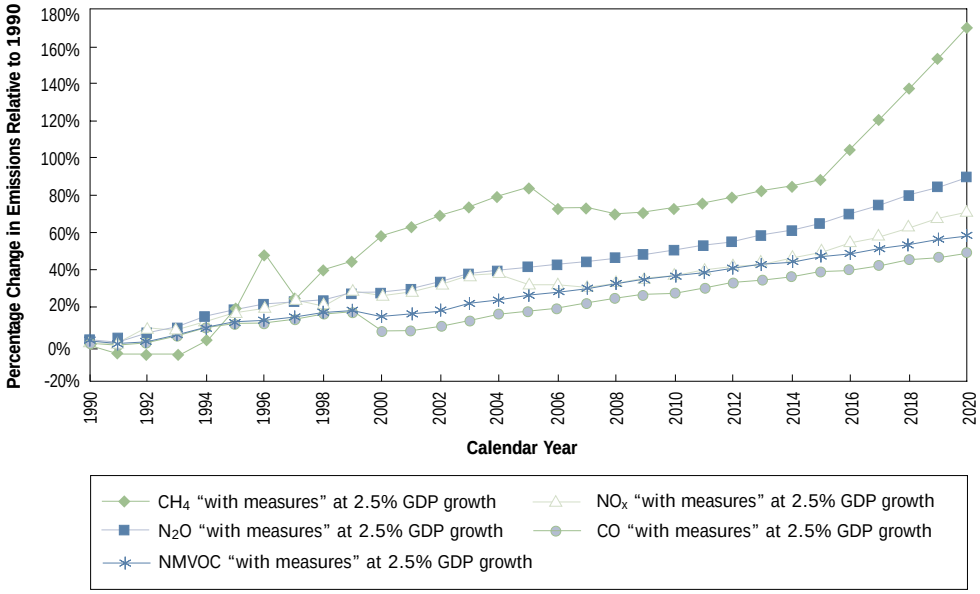


Figure 25 Non-CO_2 emissions from energy 1990 – 2020

Source: Ministry of Economic Development, 2001b

5.6 Industrial processing, solvent and other product use

CO_2 emissions from industrial processing have been included in Section 5.3 above (Projections for CO_2 from the energy sector and industrial processes).

Emissions of non-CO_2 greenhouse and precursor gases from industrial processing and solvent and other product use makes up a small part of New Zealand's total inventory. Emissions data for HFCs and PFCs has been estimated for 1990 to 1999 using the methodology provided by the IPCC good practice guidelines. At this stage, we have not developed any projections consistent with this methodology. Trend information to date indicates increases in HFCs and PFCs as replacements for ozone-depleting substances and decreases in PFCs from aluminium smelting.

Emissions of the other non-CO_2 gases from the industrial processing and solvent and other product use sectors are likely to continue to increase with continued economic growth.

5.7 Projections for emissions from the agricultural sector

Projected trends in methane emissions 2000 – 2012

Overall livestock numbers in New Zealand are projected to decline over the next 11 years. However, this decline is due to the large reduction in sheep populations projected over this period (from around 44 to 27 million). Dairy cattle are expected to increase in population from approximately 4.5 to 5.5 million. Beef cattle are projected to increase in numbers from approximately 5 million in 2001 to approximately 5.4 million in 2007 and then decline to around 5 million by the end of the first commitment period of the Kyoto Protocol (2012).

Table 33 Actual and projected methane emissions (CH_4 Gg) from livestock and their waste 1990 – 2012

	1990	1995	2000	2005	2008	2010	2012
Static	1471	1502	1520	1519	1475	1461	1461
Increasing	1471	1502	1533	1592	1575	1579	1595
%increase	0	2.1	3.3	3.3	0.3	0.7	0.7
% increase	0	2.1	4.2	8.2	7.1	7.3	8.4

Source: Ministry of Agriculture and Forestry, 2001

Projected methane emissions incorporate two possible scenarios. The results of these are presented in Table 34. The first considers no increase in methane emissions with enhanced animal productivity and the second considers enhanced emissions factors with increasing productivity.

Projected trends in nitrous oxide emissions to 2010

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; this has been partially offset by increases in some arable crops and increased fertiliser usage and application of waste effluent to land, showing an increase of 38 percent in direct soil emissions. Projections (Table 34) indicate that direct soil emissions will increase by up to 80 percent of 1990 levels by 2010 as there are no indications that fertiliser usage will decrease over this period. Recent research (Sherlock et al., 2001) using a New Zealand-devised nutrient balance model called OVERSEER indicates that nitrous oxide emissions will be in the range of 55.4 to 58.4 percent over 1990 levels. This research has to be further confirmed. However, the use of OVERSEER in this assessment of nitrous oxide emissions from soils showed emissions factors that were approximately 33 percent greater than the current IPCC emissions factors for the three major animal species in New Zealand. The two scenarios assume different possible animal numbers, where sheep numbers are 33 million in 2010a and 40 million in 2010b. Most recent Ministry of Agriculture and Forestry data indicate that sheep numbers will be in the order of 30 million in 2010.

Table 34 Projected nitrous oxide emissions from agricultural soils 1990 to 2010

	1990	1996	1999	2010a	2010b
% difference from 1990 (IPCC methodology)	0	34.6	35.0	36.4	38.3
% difference from 1990 (OVERSEER method)	0	49.6	50.0	55.4	58.4

Source: Sherlock et al., 2001

5.8 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 the 2000 projection. Table 35 shows projected non-CO_2 greenhouse gas emissions from land use changes.

Table 35 Emissions of non-CO_2 greenhouse gas from land use changes (Gg)

	1990	1995	2000	2005	2010	2020
Methane (CH_4)	4.233	6.122	5.618	5.168	5.618	5.618
Nitrous Oxide (N_2O)	0.029	0.043	0.039	0.039	0.039	0.039
Oxides of Nitrogen (NO_x)	1.083	1.522	1.399	1.399	1.399	1.399
Carbon Monoxide (CO)	37.044	53.572	49.247	49.247	49.247	49.247

Source: Marshall et al., 2001

5.8 Projections for waste sector emissions

Waste sector methane emissions (Table 36) show a 15 percent decrease from 1990 to 2000. Total methane emissions from waste are projected to fall to their lowest point in 2003. However, although there is a projected annual increase of 0.6 Gg from 2003, they are projected to remain below 1990 levels in the first commitment period of the Kyoto Protocol (2008 to 2012,) and through to 2020.

Table 36 Methane emissions (Gg CH_4) from waste in 1990 and 1995, and projections for 2000 – 2020

	1990	1995	2000	2005	2010	2020
Wastewater	6.16	6.58	6.80	6.90	6.90	7.1
Landfills	136.50	131.10	114.60	109.60	113.0	118.7
Total (Gg CH_4)	142.66	137.68	121.40	116.50	119.90	125.80

Source: SCS Wetherill Environmental, 1998

Wastewater

In the absence of policy measures, CH_4 emissions from wastewater are projected to increase with population over the next two decades.

Landfill methane

Net CH_4 emissions from landfills are projected to be below 1990 levels in first commitment period of the Kyoto Protocol (2008 to 2012). 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 where appropriate. However, further descriptions can be found in the National Inventory Report, April 2001. Figure 26 depicts 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).

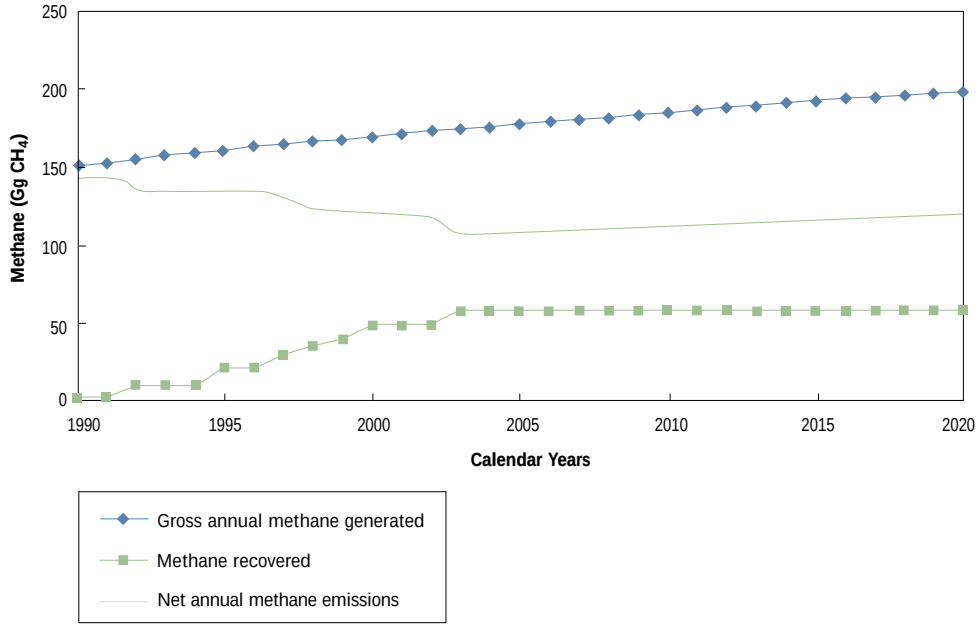


Figure 26 Gross methane generated, methane recovery, and net methane emissions

Source: SCS Wetherill Environmental, 1998.

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 currently 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.

The projections include an allowance for recovery of landfill gas, which has been estimated based on information from a review of available data and a survey of solid waste disposal systems (SWDS) that serve populations of over 20,000 people in New Zealand. The survey also requested information regarding the historical and estimated volume of solid waste received by each SWDS, and the coverage provided by the Landfill Gas control systems. 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.

5.9 International bunker emissions projections

International bunker emission projections as shown in Table 37, 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 percent above 1990 levels in 2020.

Table 37 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

Source: Ministry of Economic Development, 2001c

Chapter 6 Vulnerability assessment, climate change impacts and adaptation measures

6.1 Introduction and overview

Impacts of climate change are of concern to New Zealand because of its substantial primary production sector. Furthermore, its low population density and related long-distance infrastructure, long coastline and varied geomorphology make it vulnerable to climate hazards. Research and dissemination of findings on the impacts of climate change, vulnerability and adaptation options is therefore of high priority for New Zealand.

Overall, there have been three broad approaches aimed at identifying vulnerability of important sectors of the economy to the impacts of climate change, and exploring adaptation options.

Firstly, there have been government-led reviews of climate change impacts and vulnerability on a national or sector-specific basis. The Ministry for the Environment coordinated and published in June 2001 a national review of climate change impacts research, updating the findings of the previous such summary report carried out in 1990. The new report, Climate Change Impacts on New Zealand, summarises current projections of overall changes in biophysical variables expected under two different global climate change scenarios, including sea-level rise and coastal erosion, describes on a high level the expected sectoral impacts for agriculture, health, natural ecosystems, urban environment and infrastructure, and examines the specific vulnerabilities of the indigenous Maori population and New Zealand's Pacific Islands neighbours. It is predominantly based on peer-reviewed scientific publications of research carried out during the past decade.

The summary report is complemented by a series of more focused in-depth reports on climate change impacts on agriculture, human health and the coastal margins. These latter reports, published in August and September 2001 by the Ministry for the Environment, respond more directly to information needs of specific sectors.

Secondly, there is a range of on-going research programmes funded by the Foundation for Research, Science and Technology[8] (FRST) and carried out by a range of publicly owned and private research institutes. The studies are aimed at gaining a better understanding of projected climate changes and their impact on sector-specific production methods, infrastructure, and native ecosystems.

Research in this area includes:

- increasing understanding of New Zealand's past and present climate and its variability
- downscaling global climate model results to account for the New Zealand topography in future climate projections, and developing scenarios for rainfall and temperature changes
- increasing understanding of the responses of a range of plant and animal species to elevated temperature and CO_2 concentrations and changes in rainfall
- developing and refining crop models based on experimental work
- changing distribution of native and introduced plant species to changing climatic conditions
- developing soils models to increase understanding of the turnover of soil carbon.

Research is also carried out on linking projected climatic changes (temperature, rainfall, sea level) to impacts on essential other biophysical variables such as river flows and water catchments, and the impacts of altered UV-B, wind, temperature and rainfall patterns on buildings and urban infrastructure.

Recent research has also confirmed the influence of global ozone depletion and the Antarctic ozone hole on UV-B radiation levels in New Zealand, and the links between climate change and a potential delay in the projected recovery of the ozone layer over the next 50 years. New Zealand has a high rate of malignant skin cancers and concern about the impact of elevated UV-B radiation levels on public health is high. 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 human health continues to be given a high priority by the National Science Strategy Committee for Climate Change[9] (NSSCCC).

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 across regions and sectors. This has largely been achieved through a collaborative research effort that 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.

[8] The Foundation for Research Science and Technology (FRST) administers the Public Good Science and Technology Fund, which is the major source of government funding in the area of climate change research.

[9] The role of the National Science Strategy Committee for Climate Change is discussed in more detail in Chapter 8.

It is closely linked to a number of other research programmes that are focused on more specific in-depth understanding of various productive sectors. Its main advantages are the high level of collaboration between different research groups, its linking of climate models with species-specific growth models, and the user-friendly format that allows distribution to local government and industry level. The programme has continued to expand its coverage of sectors over recent years and similar applications have been developed for use in other countries, including Canada, Australia and several Pacific Island countries.

Chapter 8 on research and systematic observations contains more information on research on the impacts of climate change.

6.2 Scenarios of climate change and integrated impact assessment tools

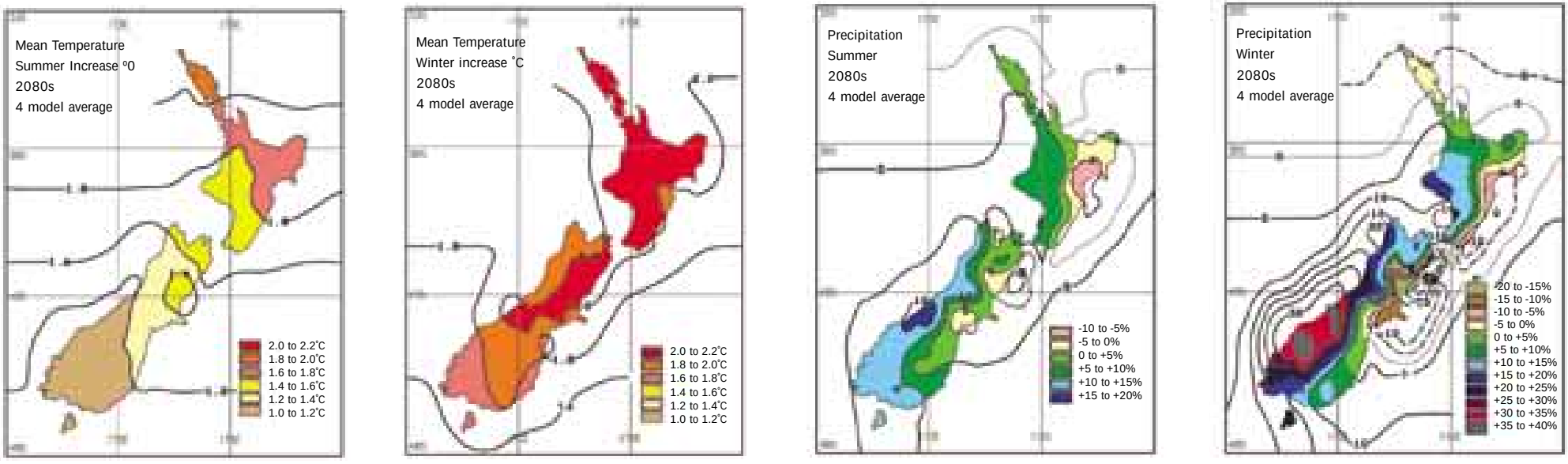
Assessment of climate change impacts in New Zealand is scenario based. The scenario approach is necessary because of the uncertainty of future greenhouse gas emission levels, differences between modelling results from different global climate models, and uncertainties arising from the downscaling of global model results to the local New Zealand scale. The most recent downscaled scenarios were developed by the National Institute of Water and Atmospheric Research (NIWA) by Mullan et al. (2001). These scenarios are based on transient model simulations by several international groups, assuming a one percent compound annual increase in CO_2 concentrations.

These new scenarios differ from earlier scenarios in that they are based on transient model simulations, leading to an increase rather than decrease of the average westerly air flow over the country, and a lesser local warming compared to the global average. Some of the earlier projections, particularly the likelihood for rainfall reductions in eastern areas, however, are retained in these updated scenarios. Uncertainty of the downscaled model results is still high, particularly in the area of regional rainfall projections. Table 38 gives the range of projections from several global models for different geographical regions in New Zealand, and Figure 27 graphically displays the averaged downscaled results from four different global climate models for temperature and average rainfall for the summer and winter seasons, for the average of the years 2070 to 2099.

Table 38 Projections from different geographical regions in New Zealand

Region	Temperature	Precipitation
Northland, Auckland	+1.0° to +2.8°C	-10% to 0%
Western North Island from Waikato to Wellington	+0.8° to +2.7°C	0% to +20%
Eastern North Island from Bay of Plenty to Wairarapa	+0.9° to +2.7°C	-20% to 0%
Nelson, Marlborough, to coastal Canterbury and Otago	+0.8° to +2.5°C	-20% to +5%
West Coast and Canterbury foothills	+0.6° to +2.5°C	+5% to +25%
Southland and inland Otago	+0.6° to +2.2°C	0% to +30%

Figure 27 Temperature and average rainfall, 2070 – 2099



Average summer and winter projected temperatures and rainfall for the 2070 to 2099 period, under a global greenhouse emission scenario similar to scenario one as defined in this report. Temperatures are expected to increase faster in the North Island than in the South Island, and faster in winter than in summer. Rainfall is projected to increase in the west of the country and decrease in the east, with changes being more pronounced in winter than in summer.

Source: Maps courtesy of NIWA, published in Ministry for the Environment, 2001b

Within the CLIMPACTS system, these patterns of regional climate change are scaled relative to modelled, 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, and using different scenarios derived from different global model results. 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 (for example, arable, horticulture, hill country farming)
- impact models for important agricultural sectors including: grasslands, arable crops, and fruit crops.

The CLIMPACTS programme has developed a range of different application scales for national, regional and site-specific impacts and adaptation assessments. 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 focused on the capacity for examining effects of mean changes in climate at the national scale. This has been refined, with the incorporation of time series of monthly and daily climate data and the development of capacities for analyses of extreme events (heat wave and extreme precipitation peaks) at both national and site-specific scales, using these time series data. At present, two regional-scale versions of the CLIMPACTS system have been developed for the Waikato and Canterbury regions and are in use by the representative regional councils.

The CLIMPACTS system has continued to expand over recent years in terms of the sectors and impacts it models, and the sophistication of its prediction methods and extreme events analysis. Its agricultural impacts prediction capability includes the spread of subtropical grasses and general pasture growth, growing conditions for several arable crops including maize and wheat, horticultural products such as kiwifruit and apples, and general growing conditions such as degree days, soil moisture and atmospheric water balance, and carbon balance in soils.

The system has recently been extended, using its open architecture, to predict changes in suitable habitats of several mosquito species capable of transmitting diseases such as Ross River virus and dengue fever. A further complexity layer has been added by incorporating the typical entrance points of these diseases vectors through shipping ports and airports, and social transmission conditions such as population density. Combined, these factors allow not only projection of changing suitability of habitats, but also estimations of changes in the establishment of risk vectors and eventual disease outbreak under current social and health care conditions.

Further expansion of the CLIMPACTS system is planned by adding an economic analysis layer to the biophysical impacts assessment, and by linking climatic and geographical factors determining greenhouse gas emissions from the agricultural sector with future climatic changes.

6.3 Expected impacts of climate change and sea-level rise

The Ministry for the Environment recently carried out a review of climate change impacts on New Zealand, using the updated climate change scenarios and additional sector-specific research carried out over the past decade since the last government-led impacts assessment. The main impacts identified in this report largely agree with those of the earlier report. However, some findings are now on a much firmer basis, and some general climate change projections have been modified based on the updated climate change scenarios.

Some of the overall effects identified include:

- temperatures in New Zealand are likely to increase faster in the North Island than in the South Island, but generally less than global average temperatures; changes are likely to be stronger in winter than in summer
- average westerly winds over New Zealand are likely to increase
- rainfall is projected to increase in the west of the country and decrease in many eastern regions, with greater changes in winter than in summer. However, the absolute magnitude of these changes is still uncertain and varies considerably depending on the global climate model used for scenario development

- most New Zealand glaciers will shrink at a faster rate than previously; snow lines are expected to rise; precipitation falling as rain rather than snow during winter will increase winter flows in many rivers originating from central mountain ranges
- eastern areas of New Zealand will suffer from an increased risk of drought as a result of increased evaporation and reduced average rainfall; at the same time, extremely heavy precipitation events could become up to four times more frequent by the year 2070, although it cannot be ruled out that no change will occur
- New Zealand sea levels are likely to rise at a rate similar to the global average (between 9 and 88cm by 2100 according to the Intergovernmental Panel on Climate Change, depending on emissions scenario and model assumptions), although decadal climate patterns are known to significantly influence local sea levels on shorter time scales; land-level rise under post-glacial rebound could reduce the relative sea-level rise by a small amount of 4cm per century
- 25 percent of New Zealand's coastline has advanced over the past century despite a local relative sea-level rise of about 17cm, 19 percent has retreated from erosion, and 56 percent has remained static; a further rise in sea levels is expected to lead to increased erosion rates
- changes in the severity and frequency of climatic extremes (that is, droughts and heavy rain) could have the greatest immediate impacts on key sectors such as agriculture and urban infrastructure;
- agriculture is likely to experience considerable benefits from extended growing seasons in the south and carbon fertilisation, as well as negative impacts from droughts and erosion, invasion of subtropical species and warmer winters leading to increased spread of some pests and diseases; the balance between benefits and costs will depend on regions, frequency of extreme events compared to average changes, and adaptation to changes
- potential negative impacts on human health from climate change have been identified in the spread of vector-borne diseases, heat waves, pollution of water supplies in rural areas, and a delay in the recovery of the ozone layer caused by stratospheric cooling; the latter would lead to continued high levels of ultraviolet radiation which are related to high skin cancer rates in New Zealand; some positive health effects are expected from warmer winters and related reduction in cold-related illnesses
- some native ecosystems may be put under additional pressure from climate change, with little ability of migration to adapt to changes because of the fragmented landscape; areas most at risk include dry lowland forests, some specific species with a limited climatic envelope, several freshwater species requiring cold conditions, and flow-on effects in predator/prey relationships following climate extremes
- urban areas will be put under pressure from increased risk of flooding and pressure on stormwater and drainage systems after heavy precipitation events; rising sea levels may result in 'coastal squeeze' in some settled areas requiring managed retreat or seashore protection;
- Maori lands and traditional food sources may be adversely affected, particularly in the northern North Island where Maori land is often of lower than average quality
- costs and benefits will not be spread evenly between different sectors of the economy, nor between different regions; a comprehensive economic assessment is not possible at this stage due to the large uncertainties of changes and their effects on different sectors, and because of the large exposure of the New Zealand economy to the changing international market
- adverse effects of climate change could be most severe for those parts of the environment and society that are already under pressure from other factors and least able to adjust.

Many of the assessments summarised above were derived from sector-specific application of CLIMPACTS system and additional specific research programmes. This integrated model system is consistent with the methods that are outlined in the IPCC guidelines for assessing climate change impacts and adaptations.

The most recent vulnerability assessment for agriculture in New Zealand under climate change scenarios identified the potential for a mixture of positive and negative impacts. There will likely be positive responses with arable crops such as maize and wheat where sufficient water for irrigation is available and soil nutrients sufficient to sustain enhanced growth. Responses may be more mixed for fruit crops such as kiwifruit, with some existing areas becoming climatically marginal due to warmer winters, but with windows of opportunity for cultivation in new areas. There will also be a southward shift of sub-tropical grass species with lower feed quality, counteracting an expected increase in pasture productivity under CO_2 fertilisation. Extension of the growing season in southern areas is likely to enhance the viability of the area for pastoral farming. The overall impacts of climate change effects on pasture-based industries (dairy, cattle, sheep) will depend on other changes in pasture composition under higher temperatures and enhanced CO_2 concentrations, changes in average rainfall and drought management, and occurrence of pests and diseases under warmer conditions. The Ministry for the Environment commissioned a summary report on potential climate change impacts on New Zealand agriculture, which forms the national basis for identification of key problem areas and adaptation options (Kenny et al., 2001).

A similar programme to CLIMPACTS has developed 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 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.

The coastal model is constrained, however, by its application of a limited number of model assumptions on coastal responses, and by the need for very extensive on-site data collection to allow a full incorporation of parameters such as wave action, sediment supply from ocean currents and coastal rivers, and beach structures. Because of the diversity of New Zealand coasts in terms of beach structure, wave action and sediment supply from oceans and rivers, no nation-wide coastal hazard assessment under sea-level rise scenarios has been carried out to date. The Ministry for the Environment commissioned in 2001 a comprehensive summary of the impacts of climate change on coastal margins, which identifies these factors and forms the basis for individual, site-specific hazard assessments to be carried out by local government, in particular district councils (Bell et al., 2001).

A detailed summary of likely impacts of climate change on human health is outlined in a further report commissioned by the Ministry for the Environment (Woodward et al., 2001).

6.4 Avoidance and mitigation of natural hazards arising from 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. To date, this continued uncertainty has made it difficult to mandate or implement specific actions at a national scale 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 formulating policy and developing strategic plans.

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. Further, the National Institute of Water and Atmospheric Research (NIWA) produces monthly climate forecasts with a time horizon of three months. These forecasts are primarily intended for the farming community but can also be of use to local government in managing water supplies.

In general, the avoidance or minimisation of risks from climate hazards in New Zealand falls into the domain of local government under the Resource Management Act 1991 (RMA). Climate change may result in more frequent occurrence of ‘unusual’ climate events, and greater extremes such as high rainfall and periods of drought. Coastal and low-lying land is particularly vulnerable to natural hazards resulting from climate change, with sea-level rise and coastal flooding being 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 and may require locally distinct management and adaptation methods.

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 or 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; for example, floods and severe storms.

Local authorities have the responsibility of planning for and mitigating coastal hazards. After extensive public consultation, the New Zealand Coastal Policy Statement (NZCPS) was prepared under the 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. The NZCPS is currently under review, and its update will reflect new scientific evidence on the magnitude and impacts of climate change on New Zealand's coasts. An overview on the assessment methods and mitigation strategies of coastal hazards connected with climate change are provided in the recent report published by the Ministry for the Environment referred to above (Bell et al., 2001).

Under the New Zealand approach to risk management, concrete actions to address and minimise impacts of climate change fall under the authority of territorial authorities (city and district councils). The formulation of clear national guidelines for managing climate-related risks for these territorial authorities, apart from the Coastal Policy Statement, has to date been limited by the absence of conclusive nation-wide projections for changes in the frequency of extreme events such as floods and droughts, and by uncertainty of sea-level rise projections and the influence of local overriding factors such as land subsidence. For this reason, specific implementation of risk management schemes and consideration of regional relevance of climate change impacts has largely been left to individual territorial authorities.

6.5 Avoidance and mitigation of other climate change impacts

A range of other potential negative impacts of climate change have been identified that do not fall under the authority of local government. These impacts and the consequent need for adaptation mechanisms mainly include risks to public health, changes to the primary production system, and impacts on natural ecosystems.

Health risks from the introduction of disease vectors are being addressed as part of New Zealand's biosecurity mechanisms, including the comprehensive Biosecurity Strategy, which is currently under development. Other potential health impacts from climate change are generally incorporated into on-going public health policies as they typically do not represent new threats, but rather a possible exacerbation of existing problems, such as clean water supply and direct impacts of heat waves, or a likely reduction in winter illnesses. However, with the exception of the introduction of disease vectors, other pressures on the public health system in many instances appear to outweigh the need for climate change-specific adaptation measures in the New Zealand context.

A number of research programmes provide specific information to define potential adaptation measures in the area of agriculture. These include investigating the response of various pasture and arable species to changes in temperature, CO_2 concentration and rainfall, and adaptive breeding of new cultivars (for example, kiwifruit with reduced winter chill requirements, drought resistant pastures, or high-quality subtropical pastures). Further adaptation measures are management of irrigation schemes and water supply systems, changing land-use in response to changing erosion and drought risk. Current impacts of climate variability, particularly droughts, have prompted the development of guidance material for farmers by the Ministry for Agriculture and Forestry (Ministry for Agriculture and Forestry, 1998). Adaptation to a potential increase in drought frequency and severity in eastern regions of New Zealand represents an important 'no-regrets' option in adjusting to uncertain climate change projections. The Ministry for the Environment has issued a guidance document on climate change impacts on agriculture which includes a list of short, medium and long term adaptation options as outlined above (Kenny et al., 2001).

To date there has been limited engagement by the private sector in addressing climate change impacts and adaptation measures.

The New Zealand Government recognises that collaboration between local and central government and the private sector is needed to adequately respond to the challenge of climate change impacts and to make best use of sector-specific knowledge. The National Science Strategy Committee for Climate Change[10] (NSSCCC), among other things, coordinates a range of workshops that focus on impacts and adaptation opportunities, and are aimed at achieving a greater interest and level of knowledge in the private sector on these matters.

Knowledge about the impacts of climate change on New Zealand native ecosystems is currently limited, and consequently adaptation options have received little attention in the management of the conservation estate. However, it is recognised that climate change will have impacts on biodiversity, and long-term management strategies are required to avoid additional species loss. The Ministry for the Environment has recently commissioned a report on the linkages between climate change and biodiversity (McGlone et al., 2001). The study acts as a national complement to the Technical Paper on Biodiversity and Climate Change which the Intergovernmental Panel on Climate Change has agreed to undertake at the request of the Convention on Biodiversity

[10] The role of the National Science Strategy Committee for Climate Change is discussed in more detail in Chapter 8 – Research and systematic Observations.

6.6 Future research

The National Science Strategy Committee for Climate Change has recently conducted an analysis of gaps in the understanding vulnerability and adaptation and where future effort could go (NSSCCC, 2001). The Committee concluded there was a particular need for:

- research relating to improving understanding and predictions of changes in storm and rainfall intensities and the resulting floods and erosion
- improved predictions on the frequency and intensity of droughts
- improved understanding on the connection between climate change and the ozone layer, and resulting UV-B radiation levels and their health impacts
- studies of the potential arrival of new pests, weeds and diseases vectors
- studies on the effects of climate change on the marine ecosystem and fisheries
- the establishment of a long-term sea-level monitoring programme.

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. Further detail about research recommendations in the specific areas of climate change impacts on coasts, agriculture and public health is provided in aforementioned sector-specific impacts reports. In future reports, these sector-specific research recommendations and their importance will be evaluated and incorporated into a national research strategy by the National Science Strategy Committee for Climate Change.

Chapter 7 Financial resources and transfer of technology

7.1 Contributions to the financial mechanism

The Global Environment Facility (GEF) is the international entity entrusted with the operation of the financial mechanism of the UNFCCC. New Zealand contributed NZ$8.31 million to the second replenishment of the GEF (GEF2), which covered the years 1998 – 2001.

Negotiations have begun on the third replenishment of the GEF (GEF3) for the period 2002 – 2005. These should be completed in early 2002. While the details are as yet undecided, it is likely that New Zealand's contribution to GEF3 will exceed the GEF2 contribution.

7.2 Actions to implement Articles 4.3, 4.4. and 4.5 of the UNFCCC

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 UNFCCC, and for adaptation assistance.

New Zealand is fulfiling its Article 4.3 commitments 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.

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

The New Zealand Official Development Assistance (NZODA) bilateral schedule is dominated by direct assistance on a one-to-one, country-to-country basis, comprising in most cases a wide range of developmental projects and activities. Through this channel, New Zealand has supported a number of projects relevant to climate change.

New Zealand also promotes the development of the South Pacific region as a whole with contributions to a number of regional and multilateral agencies including the South Pacific Forum Secretariat, the Forum Fisheries Agency, the Secretariat of the Pacific Community, the South Pacific Regional Environment Programme (SPREP), the South Pacific Applied Geoscience Commission (SOPAC), and the Pacific offices of UNIFEM and UNESCO. All these agencies are eligible for assistance from the NZODA Pacific Initiative for the Environment (PIE) programme, which evolved from the NZODA Environment Strategy for the South Pacific – a policy framework to address global environmental issues in the South Pacific region (1996). This strategy identified five main areas for assistance, which became five PIE categories, one of which is climate change. Since 1997, the PIE has funded projects in coral reef and integrated coastal management, forestry, and support for the Pacific Island Climate Change Assistance Programme (PICCAP) implemented by SPREP.

Mitigation

Energy efficiency and alternative energy

In 2000, New Zealand provided $350,000 to support the UN Alliance of Small Island States (AOSIS) Workshop on Climate Change, Energy and Preparations for the ninth session of the Commission on Sustainable Development (CSD9).

New Zealand is the major donor to a public-private partnership waste facility in Batangas Bay, Philippines, which will convert waste to electricity. New Zealand has provided a $400,000 grant to United Nations Development Programme's Project Development Facility and the Sustainable Project Management (SPM) Group since 1996, to assist in developing this project.

$295,000 was contributed to SPM to develop a Waste to Energy project in Samoa.

New Zealand has also allocated significant ODA resources to forest sector projects in a number of ASEAN and South Pacific countries.

Adaptation

New Zealand has provided assistance on integrated coastal management, which contributes to increasing the resilience of coastal systems to climate change.

Assistance to meteorological services in the Pacific has totalled $NZ1.92 million in the last five years.

Table 39 Financial contributions to the Global Environment Facility (GEF)

	Contribution (millions of US dollars)			
	1997	1998	1999	2000
Global Environment Facility	0.71	0.67	0.50	0.87

Table 40 Financial contributions to multilateral institutions and programmes

Institution or Programme	Contribution (millions of US dollars)			
	1997	1998	1999	2000
Multilateral institutions:				
1. World Bank Consultant Trust Fund	0.55	0.44	0.44	0.26
2. International Finance Corporation	0.46	0.21	0.21	0.18
3. Asian Development Bank	6.47	4.49	4.61	3.52
4. United Nations Development Programme	2.91	2.35	2.33	2.00
- Project Development Facility				
5. United Nations Environment Programme		0.05	0.01	
6. UNFCCC supplementary fund for participation		0.01		
Multilateral scientific, technological and training programmes:				
1. South Pacific Regional Environment Programme (SPREP)		1.45	0.56	0.02
2. Consultative Group on International Agricultural Research (CGIAR)		0.56	0.54	0.47
3. Commonwealth Science Council	0.13	0.10	0.11	0.13
4. International Fund for Agricultural Development (IFAD)	1.39		0.48	0.34

Table 41 Bilateral and regional financial contributions related to the implementation of the Convention, 1997 (millions of US dollars)

$US 1 = 1.5125 $NZ

	Mitigation						Adaptation		
Recipient country/region	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Capacity Building	Coastal zone management	Other vulnerability assessment
1. Philippines	0.02		0.90						
2. Papua New Guinea				0.48			0.24	0.18	
3. Tonga	0.01		0.34	0.31					
4. Vietnam			0.36	0.05					
5. Niue			0.18	0.16					
6. Indonesia	0.23			0.06			0.03		
7. Fiji			0.29	0.02					
8. Pacific region							0.25	0.03	0.02
9. China			0.10	0.20					
10. Vanuatu			0.09	0.19					
11. Samoa			0.12			0.01	0.08		
12. Nepal	0.03			0.10					
13. Tokelau	0.13								
14. Solomon Islands			0.06	0.02		0.02	0.02		
15. Cook Islands				0.03			0.05	0.02	
16. Kiribati								0.04	
17. Mongolia				0.04					
18. Kazakhstan				0.03					
19. Zimbabwe				0.03					

Table 42 Bilateral and regional financial contributions related to the implementation of the Convention, 1998 (millions of US dollars)

$US 1 = 1.8685 $NZ

	Mitigation						Adaptation		
Recipient country/region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity Building**	**Coastal zone management**	**Other vulnerability assessment**
1. Pacific region				0.01			0.95	0.19	
2. Papua New Guinea				0.42			0.50	0.13	
3. Philippines	0.02		0.70					0.06	
4. Vietnam			0.54	0.01					
5. China			0.24	0.17					
6. Tonga			0.25	0.07				0.01	0.02
7. Solomon Islands				0.31		0.01		0.01	
8. Vanuatu			0.06	0.15				0.01	
9. Cambodia			0.23						
10. Samoa				0.01			0.13	0.04	
11. Niue			0.06	0.07					
12. Kiribati								0.10	
13. Fiji			0.08	0.01				0.01	
14. Indonesia	0.05						0.04		
15. Tokelau	0.05								
16. Cook Islands				0.02			0.01		
17. Nepal	0.03								
18. India	0.03								
19. Africa region							0.02		
20. South Asia region	0.02								
21. Zimbabwe				0.01					
22. Laos			0.01						

Table 43: Bilateral and regional financial contributions related to the implementation of the Convention, 1999 (millions of US dollars)

$US 1 = 1.8917 $NZ

	Mitigation						Adaptation		
Recipient country/region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity Building**	**Coastal zone management**	**Other vulnerability assessment**
1. Pacific region				0.03			0.99	0.21	0.03
2. Philippines			0.93				0.02	0.02	
3. Papua New Guinea	0.01			0.35			0.35	0.09	
4. China			0.50	0.29					
5. Solomon Islands			0.01	0.26			0.01		
6. Vanuatu			0.07	0.14				0.01	
7. Tonga			0.16	0.02		0.01		0.01	
8. Niue			0.10	0.07		0.01		0.01	
9. Vietnam	0.14			0.03					
10. Samoa							0.11	0.01	
11. Cambodia			0.10						
12. Tokelau	0.09								
13. Africa region							0.09		
14. Nepal	0.08								
15. Fiji			0.02	0.02	0.04				
16. Sri Lanka	0.04			0.03					
17. Kiribati								0.04	
18. Indonesia	0.02						0.01		
19. Bhutan	0.03								
20. Zimbabwe				0.02					
21. South Asia region	0.01								

Table 44: Bilateral and regional financial contributions related to the implementation of the Convention, 2000 (millions of US dollars)

$US 1 = 2.2047 $NZ

	Mitigation						Adaptation		
Recipient country/region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity Building**	**Coastal zone management**	**Other vulnerability assessment**
1. Pacific region				0.27		0.03	1.42	0.02	
2. Papua New Guinea				0.24			0.50	0.01	
3. Philippines			0.30		0.11			0.06	
4. China			0.18	0.29					
5. Vietnam	0.10		0.22	0.02	0.02				
6. Indonesia	0.04						0.27		
7. Vanuatu			0.04	0.13					
8. Solomon Islands			0.02	0.13			0.01		
9. Tonga			0.09	0.06		0.01			
10. Niue	0.01		0.06	0.05					
11. Bhutan				0.10					
12. South Asia region				0.06					
13. Sri Lanka	0.01			0.05					
14. Cook Islands				0.01				0.04	
15. Eritrea								0.04	
16. India				0.04					
17. Africa region							0.02		
18. Samoa							0.02		
19. Kiribati								0.02	
20. South Africa								0.01	
21. Tokelau	0.01								
22. Nepal	0.01								

Table 45 Description of selected projects or programmes that promised practicable steps to facilitate and/or finance the transfer of, or access to, environmentally-sound technologies

Project/programme title:

Vulnerability and Adaptation Assessment Training Package

Purpose:

To build the capacity of Pacific Island Countries to conduct national or sub-national assessments of vulnerability and adaptation to climate change.

Recipient Country:	Sector	Total funding	Years in operation
Ten Pacific Island Countries	Environment	US$185,000	1998

Description:

The International Global Change Institute (IGCI) of Waikato University in collaboration with the Pacific Island Climate Change Assistance Programme (PICCAP), developed and delivered a standardised training package in vulnerability and adaptation assessment (based on the IPCC Technical Guidelines) to ten Pacific Island Countries (PICs). IGCI hosted the training course from June to October 1998.

The training course was subsequently transferred to the University of the South Pacific, where it is now offered as a credit course on an on-going basis. Major outputs of this training initiative have been national or sub-national assessments of vulnerability and adaptation to climate change. These have formed the basis of a major section of the PICs first National Communications. In-country support was provided for preparation of National Communications, including guidelines on the structure and content of the vulnerability and adaptation statements.

Indicate factors which led to project's success:

The robustness of the PICCAP design, executed by the South Pacific Regional Environment Programme (SPREP) is noteworthy. The PICs participants at the IGCI training became the PICCAP national focal points. Their network was pretty strong.

The transfer of the course to the University of the South Pacific as an on-going formal credit course ensured the sustainability of the project.

Technology transferred:

Adaptation guidelines for use in Pacific Island countries.

Impact on greenhouse gas emissions/sinks (optional):

(Not applicable)

Chapter 8 Research and systematic observations

8.1 Introduction

New Zealand has continued to promote and collaborate in research and systematic observations, as required by Articles 4 and 5 of the UNFCCC. Estimated central government expenditure on climate change related research and systematic observations for the 2000/01 financial year is NZ$21.0 million (NSSCCC, 2001), an increase of NZ$4.6 million over the amount reported in the second national communication (Ministry for the Environment, 1997). This expenditure was complemented by an estimated NZ$0.2 million expenditure by regional government, and NZ$2.3 million by the private sector.

Through this expenditure, climate observations have been maintained, new knowledge has been generated about climate change and its impacts in New Zealand and the southwest Pacific, and adaptation and mitigation options are being developed.

New Zealand made a substantial input to the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change, by supporting one scientist as a member of the IPCC Bureau and providing convening lead authors for three chapters and lead and contributing authors and review editors for several more chapters. Research groups participated in programmes and planning meetings of the World Climate Research Programme (WCRP), the International Geosphere Biosphere Programme (IGBP), and the Global Climate Observing System (GCOS). A workshop was hosted (with support from the Asia Pacific Network) to help meteorologists and scientists from Pacific Island Nations interpret trends and extremes in climate data. New Zealand led development of “The Island Climate Update”, a collaborative monthly paper and web publication which disseminates updates of current climate conditions and outlooks for the coming season to assist Pacific Island nations in adapting to climate variability and change.

8.2 General policy on and funding of research and systematic observations

Strategy for research and systematic observations

The National Science Strategy Committee for Climate Change (NSSCCC) was set up by the Government in 1991. Its terms of reference include developing, monitoring and updating a comprehensive strategy for climate change research that coordinates efforts between Crown Research Institutes , universities, government departments and the private sector. The NSSCCC provides advice to the Ministries for the Environment and for Research, Science and Technology, and the Foundation for Research Science and Technology (the main government research funding agency) on the research necessary to underpin the Government's climate change strategy, including its international obligations. The committee also provides advice on the establishment and maintenance of linkages with the IPCC process, and with international climate change research programmes including the World Climate Research Programme (WCRP) and the International Geosphere Biosphere Programme (IGBP).

The latest NSSCCC annual report (NSSCCC, 2001) outlines the NSSCCC vision, which is for New Zealanders to:

- be well informed on human modification of climate
- better understand uncertainties regarding the effects of climate variability and future climate change
- identify environmental technologies that will underpin contributions to New Zealand's Kyoto Protocol commitments
- participate effectively in managing and adapting to climate at national and international levels.

The NSSCCC report outlines research on processes, effects, responses and opportunities, and systematic observations required to achieve this vision. Specifically it provides an analysis of gaps in the current portfolio of research activities and points out opportunities to fill those gaps. It encourages integration of research across these categories to help policymakers make informed decisions. The importance of research on mitigation of greenhouse gas emissions is noted, particularly for lowering animal methane emissions and improving energy efficiency and transport. This research must be planned and timed to assist New Zealand to meet its Kyoto targets and likely post-Kyoto requirements.

The NSSCCC also notes that even if Kyoto targets are met internationally, and further greenhouse gas emission reductions are made through this century, significant climate changes are still likely. Thus strategies are required for adapting to inevitable climate change. To support development of

these strategies, the report identifies the need for research that provides a robust scientific understanding of the climate system, and of the regional and local sensitivities and vulnerabilities of natural, human and managed systems. It also notes the need for ongoing systematic observations to detect variations and changes in the climate system and the systems it affects, and the importance of international collaboration in scientific research and assessment.

Funding policies

The Foundation for Research, Science and Technology (FRST) has the main responsibility in funding climate change research from public investment. FRST's investment structure comprises a set of sector-based research strategies that provide overall direction for FRST's investment in research for that sector. Each strategy is further arranged into portfolios that relate to a specific desired outcome. For example, in the Animal-based Industries research strategy there exists a portfolio organised around environmental sustainability issues for the animal industry. Research within such a portfolio would contribute to mitigating the industry's effect on the environment including the production of greenhouse gases.

FRST also collates information on all research relevant to climate change conducted within all its portfolios for the purpose of analysing the contribution being made to New Zealand's climate change effort overall. This analysis is done with the NSSCCC using an evaluating and reporting framework developed as part of the NSSCCC's overall strategy for climate change research in New Zealand.

The current Minister of Research, Science and Technology has taken an initiative to increase research effort on mitigating greenhouse gas emissions so that New Zealand is better placed to meet its obligations under the Kyoto Protocol. In particular, the Minister is seeking a greater research effort on reducing methane and transport emissions, and enhancing energy efficiency, and expects that the relevant industries take action along with public research funding agencies. The Minister has formulated this initiative based on advice from the NSSCCC, and on input from various stakeholders, including other Ministers, government departments and industry.

In response, FRST developed a set of "Change Messages" for investment of Public Good Science and Technology (PGS&T) funds in climate change research. These messages emphasise increased research on greenhouse gas emissions in line with New Zealand's Kyoto Protocol commitments. Particular effort will be placed on increasing research effort toward reducing ruminant methane emissions and transport emissions, and enhancing energy efficiency. A reduction in effort is signalled in research on climate change that has less immediate relevance to New Zealand's Kyoto Protocol commitments.

FRST and the NSSCCC have identified a need for more direct climate change research investment by the private sector.

FRST will focus particularly on alignment of research with key stakeholder strategy development, increased attention to the human dimension so that effective mitigation and adaptation strategies can be developed, and increasing investment responsibility by the greenhouse gas-emitting sectors. FRST undertakes to maintain New Zealand's contribution to the global climate change research effort and policy initiatives through supporting research to understand the physical systems in this part of the world. FRST notes the need to maintain national research capacity to understand physical processes of climate change, and to expand research capability in human dimensions of climate change.

As well as advising FRST on research needs, the NSSCCC is currently consulting with officials, including the officials' Climate Change Steering Group, over improved procedures for identifying policy-relevant research gaps and opportunities that should be addressed directly by government departments.

Funding levels

Funding for climate change research and systematic observations in New Zealand is administered through several channels. The predominant channel for central government funding of strategic research is FRST. FRST purchases a portfolio of climate change research from various providers (Crown Research Institutes, universities and private organisations), guided by the funding policies outlined in the previous section. FRST funding also covers the archiving and part of the collection costs for systematic climate observations. Also, some government support for research in universities comes through Vote:Education. In addition, some climate research is supported by the Marsden fund, which supports excellent research and researchers and is not subject to government research priorities.

A further source of funding is direct funding from government departments. Such funding tends to be for shorter-term projects to meet needs for policy development. In addition, the contract for public weather forecasts and warnings administered by the Ministry of Transport covers routine upper air and surface weather observations that are also utilised for climate purposes. (These observations are forwarded to the National Institute of Water and Atmospheric Research for incorporation in the National Climate Database). New Zealand's 15 regional councils, which have primary responsibility for resource management, also undertake environmental monitoring, and fund some climate change research to help them develop regional policies.

Table 46 Estimated annual funding (New Zealand dollars) for climate change research and systematic observations

Funder	Estimated Annual Climate Change Research and Observation Funding
Central government research funds and universities (Breakdown: FRST $19.2M; Marsden $0.5M; universities $0.5M)	20,227,000
Central government operational department funds	809,000
Regional government	197,000
Private sector	2,294,000
Overall total	**23,527,000**

Note: Funding from the Foundation for Research, Science and Technology is for the year 2000/01. For all other agencies the funding is for 1999/2000.

Source: NSSCCC, 2001

Table 46 summarises the estimated annual funding for climate change related research and monitoring from the sources outlined above, as well as from the private sector. This table is based on information in the annual report for 2000 of the National Science Strategy Committee for Climate Research (NSSCCC, 2001). The NSSCCC breaks the NZ$23.5 million of total funding down into three categories: processes $12.0 million; effects $8.0 million; responses $7.5 million. A detailed list of the individual projects supported by the various funders listed in Table 46 is provided in Appendix 2 of the NSSCCC Annual Report (NSSCCC, 2001).

International exchange of data and information

New Zealand exchanges data and information with other countries in line with the policies of the World Meteorological Organisation. Appropriate real-time weather observations (which are also useful for climate modelling) are disseminated through standard WMO channels, and climate and greenhouse gas monitoring data is provided to appropriate World Data Centres.

New Zealand has identified some particular opportunities for the dissemination of real-time climate data through the Pacific, to provide up-to-date information on current climate conditions and seasonal outlooks to Pacific Island nations and help them deal with climate variability. This led to the establishment in July 2000 of the "Island Climate Update", a monthly paper and web publication produced by the National Institute of Water and Atmospheric Research (NIWA) in collaboration with organisations in Australia and the Islands, which receives funding support from several countries. NIWA also produces a similar monthly publication for New Zealand ("The Climate Update").

8.3 Research

A detailed listing of New Zealand climate change research projects, and an up-to-date bibliography of research publications, are provided in the Annual Report of the National Science Strategy Committee for Climate Change for the year 2000 (NSSCCC, 2001). Trends from New Zealand climate observations, research-based scenarios for future regional changes, and research results on impacts, vulnerability and adaptation have been compiled and assessed within the Australia and New Zealand chapter (Pittock and Wratt, 2001) of the Working Group II volume of the IPCC's Third Assessment Report. The Ministry for the Environment (2001) has published a report on climate change impacts on New Zealand, which synthesises relevant research results and includes a bibliography of key source material. Chapter 6 on vulnerability and adaptation measures contains more information on the content of this report.

Below is a summary of highlights, innovations and significant efforts made with regard to climate change research in New Zealand. More details are provided in the publications listed above.

Climate processes and climate system studies, including aleoclimate studies.

Atmospheric Chemistry: New experimental techniques are being developed to study the exchange of greenhouse gases between the atmosphere, ocean and biosphere. The first measurements of radiocarbon in CH_4 recovered from air in Antarctic firn (packed snow) allow the current fraction of methane related to fossil fuel activities to be compared with that produced 50 years ago. Isotope ratio measurements on CH_4 sampled from ships and aircraft travelling between New Zealand and Antarctica, and New Zealand and North America, coupled with atmospheric modelling, are improving estimates for tropical emissions of CH_4 and northern hemisphere emissions of CO.

Ocean-Atmosphere Gas Exchange: A 1999 international expedition (SOIREE) led by New Zealand scientists on the research vessel Tangaroa showed that releasing small amounts of iron into the 'iron-limited' Southern Ocean leads to rapid growth of algae, taking up CO_2 from the surface layers of the ocean. This research, which contributes to the Joint Global Oceans Flux Study (JGOFS) project of IGBP, was reported in the prestigious scientific journal *Nature*. SOIREE also showed that iron fertilisation enhances dimethyl sulphide emissions from marine ecosystems in the Southern Ocean, leading to small aerosol particles that may affect cloud properties and the radiation balance over the Southern Oceans.

Land-Atmosphere Interactions: National scale estimates of New Zealand's net carbon balance, based on measurements and modelling of exchanges of CO_2 between land and atmosphere, indicate our land systems are a net source of CO_2. Research is underway to better understand the effects of land-use changes, land management, and erosion, on soil carbon and its exchange with the atmosphere. This land-atmosphere interactions research underpins the development of an improved national carbon monitoring system for soil, forest and scrub, to be used for international reporting.

Research has been undertaken on the influence of variations in environmental factors, soil fertility and animal management on methane emissions. Initial work suggests some New Zealand indigenous forest soils are a sink for atmospheric CH_4.

A collaborative network of New Zealand researchers (NzOnet) has been established to perform research that will reduce the large national uncertainty in agricultural N_2O emissions, and progress is being made in estimating paddock-averaged N_2O fluxes.

Climatic Variability: Progress has been made on identifying climate variability and trends in New Zealand, the South-West Pacific and Antarctica, determining the reasons for these fluctuations, and analysing the implications for the future. 1998 was the warmest year in New Zealand since instrumental records began in the 1870s, and 1999 was the second warmest. The influence of El Niño on New Zealand climate has been shown to be modified by longer-term climate shifts caused by large-scale changes over the Pacific Basin (the Interdecadal Pacific Oscillation). New Zealand scientists have been active in planning meetings for CLIVAR (CLIVAR is the Climate Variability and Predictability project of the World Climate Research Programme).

Paleoclimate: Research has continued on using paleoclimate evidence from New Zealand, the surrounding ocean floor, and the Ross Dependency region in Antarctica, to contribute to the global picture of past climate changes. Research on sedimentary cores collected in the Tasman Sea and Southern Ocean (often under the international Ocean Drilling Programme – ODP) has identified major climate fluctuations such as ice ages, has shown that natural climate fluctuations have been more frequent in the past than was initially thought, and supports suggestions that many of these fluctuations were globally synchronous. The international Cape Roberts drilling programme, for which New Zealand provided much of the scientific planning and logistics, is developing new information on past fluctuations in Antarctic climate, sea level and ice cover. On the New Zealand mainland, studies of tree rings, speleothems, sediment cores and glacial history are providing further information on past climate variations, including information on the past occurrence of ENSO (El Niño Southern Oscillation) events and on synchronicity between Northern and Southern hemispheres. New Zealand results feed in to the PAGES (Past Global Changes) programme of the IGBP.

Modelling and prediction, including general circulation models

New Zealand 'climate modelling and prediction' research primarily addresses regional climate. This research has led to the publication of new climate scenarios for New Zealand, based on statistical downscaling from the results of recent transient global climate model runs available from the IPCC website.

An important infrastructure advance for New Zealand was the commissioning of NIWA's Cray supercomputer in 1999, providing much improved climate modelling capabilities. NIWA staff have installed the United Kingdom Meteorological Office's Unified Model (UM) on this computer, and are working to develop a regional climate modelling capability with the UM. This will be used both for improving understanding of current climate variability in this region, and for developing regional climate scenarios for the future. NIWA scientists also model atmospheric transport of greenhouse gases using global climate analyses, for use in the atmospheric chemistry research described earlier in this chapter, and are implementing atmospheric transport and chemistry modelling capabilities with the UM.

Research on the impacts of climate change

As mentioned earlier in this chapter, results from recent New Zealand impacts research were included in Chapter 12 (Pittock and Wratt, 2001) of the IPCC Working Group II contribution to the Third Assessment Report, and in the Ministry for the Environment's Impacts Report (Ministry for the Environment, 2001b). A further important assessment of climate change impacts on New Zealand, using the CLIMPACTS integrated assessment model, is in press (Warrick et al., 2001).

Hydrology: Work has begun on assessing the implications for soil moisture, river flows and drought of the latest New Zealand regional climate scenarios. An area of particular concern is the impact of climate change on irrigation resources, as water for irrigation is already in short supply during dry summers in various parts of the country. A need has been identified for more research on likely increases in the frequency of heavy rainfalls, and consequences for floods, landslides and erosion. Projections have been made of snowline and glacier retreat, and of changes in winter snowfall and spring thaw, and their implications considered for South Island river flows.

Coastal Effects and Fisheries: Research is underway on coastal hazards, and the implications for these of changes in sea level and other climate changes. These hazards are seen to be very location dependent, and quantitative impact assessments require local studies. Recent research indicates that climate variability has significantly influenced the stocks of various New Zealand fish species in the past, but knowledge is currently insufficient to predict the impacts of future climate changes. It is also thought that changes to the coastal marine environment in response to

climatic change could have significant implications for aquaculture, but research knowledge is still insufficient to allow reliable predictions of this.

Agriculture: Most New Zealand research over the last decade into climate change impacts on agriculture has concentrated on changes in average climate, showing a warmer climate could bring both benefits and risks to the farming sector. Recent experience has shown that climatic extremes (particularly drought) can have significant negative impacts on agricultural productivity in some regions, but the potential impact of possible future changes in heavy rainfall and of droughts in eastern regions has not yet been studied in detail.

Long-term, field-based experiments are being conducted to test the sensitivity of pasture communities to future changes in UV radiation, atmospheric CO_2 and climate variability and extremes. New crop-ecosystem models have been incorporated into the CLIMPACTS system over the past few years, and these have been used to study likely changes in pasture yield, the spread south of poorer quality sub-tropical grasses, changes in productivity and suitable areas for wheat and maize production, and implications for fruit production (apples and kiwifruit). These studies generally suggest the productivity of pastures and arable crops are likely to increase, provided sufficient water resources are available, that the pip and stonefruit industries are well-placed to adapt to the effects of warmer temperatures, and that changes may occur in which regions of New Zealand are most suitable for particular horticultural crops.

Plantation Forestry: A six-year research programme to investigate the impacts of elevated CO_2 concentrations on plantation forest ecosystems was recently completed, allowing improved predictions of the effects of elevated CO_2 on productivity and wood quality. Possible impacts of changes in rainfall and temperature on plantation forest growth, and on changes to fire risk and fungal disease, are being researched.

Natural Ecosystems: An ongoing study, which is examining relationships between forest composition and factors such as temperature, solar radiation, soil water stress, drying winds and geological substrate, is providing knowledge for assessing vulnerability to climate change. An ecosystem process model has been used to predict changes in long-term forest composition and biomass. Effects of elevated CO_2 level on the growth rate of some tree species, and on soil carbon storage have been examined. Research on freshwater ecosystems is also providing information to help assess possible climate change impacts.

Urban Environment, Transport and Energy: Research has been undertaken on the impact of expected changes in temperature on likely energy use for heating and cooling in households and businesses. Work has also been done on the likely impact of climate change on the magnitude and seasonality of water supply into South Island hydro-electricity storage lakes. It has been recognised that possible changes in the frequency and intensity of heavy rainfall and associated floods could have various urban impacts, and also impact on roads and bridges. More information on likely changes in climatic extremes is required (from the modelling and prediction research described earlier) to develop guidance in this area.

Health: Research is investigating both direct effects of changes in temperature on human health, and possible indirect effects (for example, establishment and spread of disease vectors). Recent studies include relationships between mortality and summer maximum temperatures, and risks of establishment and changes in climatically suitable areas for a mosquito that spreads dengue fever.

Maori: Little research has been carried out over the past decade specifically on the vulnerability of Maori to climate change. A number of issues have been identified in the recent Ministry for the Environment Climate Impacts report (Ministry for the Environment, 2001b), and the Foundation for Research, Science and Technology state they will give particular consideration to responding to Maori aspects, in their "change statement" for Global Environmental Processes and Change.

Socio-economic analysis, including impacts and response options

Research is underway on the impacts of climate variability on the New Zealand economy. This includes work on the economic impacts of recent droughts, and studies on the historical impact of climate variability on various sectors of New Zealand's GDP. Research has been undertaken on the economics of various greenhouse gas mitigation options, including the possible design of emissions trading schemes and their impact on implementation costs. Work is also being done on the viability and economic benefits of minimum energy performance standards.

Nevertheless, the Australia-New Zealand chapter of the IPCC Third Assessment Report (Pittock and Wratt, 2001) states that "comprehensive, quantitatively based cross-sectoral estimates of net Australasian costs of climate change impacts are not yet available".

Research and development on mitigation and adaptation technologies

Mitigation of Agricultural Greenhouse Gas Emissions: Research on ruminant methane emissions and their reduction is being given particular emphasis, given the relatively high contribution of methane to New Zealand's total greenhouse gas emissions. The research includes studies of microbial processes in the rumen of grazing sheep and cattle, and ways in which these might be influenced to reduce emissions, and research on the effect of pasture type on animal methane emissions. Nitrous oxide is another important emission from agricultural activities in New Zealand. Research by the NzOnet consortium (already mentioned under 'processes') to identify and quantify the various sources of agricultural emissions will indicate where farm management practices could be changed to reduce emissions.

Energy Efficiency and Renewables: Results are emerging from research on improving energy efficiency (particularly on thermal design of houses to reduce energy requirements for heating and cooling, on energy consumption by household appliances, and on reduced-energy street lighting systems). Research is also underway on development of ceramic fuel cells (in collaboration with Australia), solid-oxide fuel cells, and applications of superconductors.

Renewable energy research topics include resource assessments for wind energy, biofuels, and development of hydro power load controllers, small wood gasifiers, low-head hydro turbines and low-cost photovoltaic cells.

Transport: New Zealand transport research includes identifying greenhouse gas emissions from road transport, investigations of vehicle fleet emissions control strategies, and development and monitoring of ride-sharing. Work has also been undertaken on factors influencing decisions to travel by car or public transport.

Adaptation: So far in New Zealand, much less effort has gone into adaptation research than into work on processes, impacts and mitigation. However, research results have been used to develop climate update and seasonal outlook services, which help people adapt to climate variability. Some regional and district councils have commissioned work to assess and map climate extremes and hazards in their areas, often incorporating consideration of climate change.

These hazard and risk assessments, and some current research on how climate change might affect water demand and availability for agriculture, will help councils consider climate change issues when undertaking regional planning and making water allocation decisions. Likewise, CLIMPACTS research on likely impacts of climate change on agriculture, crops and horticulture provides a knowledge base for farmers considering adaptation through changed land uses, and for companies developing new crop cultivars.

8.4 Systematic observations

New Zealand has continued to build up an archive of systematic atmospheric, oceanic and terrestrial observations based on the monitoring activities described in the first and second national communications. Details of these observations are tabulated in the Global Climate Observing System report provided separately to the UNFCCC (Ministry for the Environment, 2001c).

Atmospheric observing systems

Programmes: There are two prime sources of New Zealand atmospheric observations relevant to climate change: the routine surface and upper air weather observations undertaken by the Meteorological Service of New Zealand, and dedicated climate observations and atmospheric constituent measurements undertaken by NIWA (the National Institute of Water and Atmospheric Research). NIWA is assisted by many voluntary observers, especially for rainfall monitoring. The Meteorological Service forwards its weather observations to NIWA, where they are archived in the National Climate Data Base along with NIWA's own measurements. The MetService and NIWA both play particular attention to quality control. NIWA's climate monitoring and archiving programme carries ISO9002 certification, and the Meteorological Service has ISO9001 certification.

Support: Funding for the core weather observations is from a Ministry of Transport contract to the Meteorological Service, with some extra observations funded out of commercial revenue. Dedicated climate observations are funded by a contract to NIWA from FRST, which recognises the climate database as a "database of national importance". Support for the climate database and monitoring has been at a constant dollar level for the past four years, and will be renegotiated by FRST in 2001 as part of their 'advancement' process for global environmental processes and change research. Atmospheric constituent measurements are also funded by FRST, as part of specific research programmes.

National Plans: NIWA's plans for the national climate network include continuing with gradual automation as finances permit, and NIWA staff regularly review the network in the light of user requirements. Planning for climate and atmospheric constituent measurements takes place as part of the FRST proposal and contracting process. Particular attention is paid to continuity of the 25-station reference climate network.

Availability and Exchange: NIWA is developing user-friendly web access to the national climate database, for implementation on a subscription basis during 2001. A subscription service to recent climate data and maps of interest to farmers has already been established. NIWA staff

answer data requests from both New Zealand and overseas. Arrangements and conditions for data provision are consistent with WMO Resolution 40(Cg-XII) on policy and practice for the exchange of meteorological and related data and products.

Appropriate weather observations are forwarded to other countries by the Meteorological Service in real time, through WMO (World Meteorological Organization) networks. New Zealand provides climate and greenhouse gas monitoring data to international data centres under the WMO / ICSU (International Council of Scientific Unions) programmes that comprise the Global Climate Observing System.

Weather and Climate Observations: New Zealand has nine stations providing data to international data centres as part of the Global Surface Network (GSN) of GCOS, and four stations which report as part of the Global Upper Air Network (GUAN). 208 stations provide[12] 9.00 a.m. climate observations to the national climate database, and 118 of these are automatic stations, which also provide information at other times of day. There are currently 654 stations providing daily rainfall information into the database. In addition, NIWA maintains satellite data archives for the New Zealand region of NOAA HRPT data (1992 – present), Global Geostationary Meteorological Satellite data products (August 1998 – present) and SeaStar SeaWiFS HRPT data (May 2000 – present).

Atmospheric Constituents: New Zealand has two stations providing atmospheric constituent data to international data centres as part of the Global Atmospheric Watch (GAW). Concentrations and isotope ratios in carbon dioxide, methane and nitrous oxide, as well as aerosol properties and non-methane hydrocarbons, are monitored at the Baring Head clean air monitoring station. Some of these gases are also monitored at two other sites, including one in the Antarctic. Surface ozone is monitored at seven stations (including one in Antarctica), column-integrated ozone concentrations are measured at two stations (including one in Antarctica), and a regular balloon-borne sampling programme for vertical profiles of ozone concentrations is operated at one station.

Ocean Observing Systems

There are 11 open-coast sea level monitoring gauges operating around the New Zealand coast, and 13 coastal stations at which sea surface temperatures are measured. In addition, 90-year tide gauge records are held for the ports of Auckland, Wellington, Lyttleton and Dunedin, and short records from several other ports. Since the 1980s, New Zealand has maintained a network of around seven drifting buoys in the Tasman Sea, and two subsurface floats under the ARGO programme. In collaboration with Australian and United States research institutions, NIWA (New Zealand) maintains three high resolution XBT (Expendable Bathythermograph) sections in the Tasman / Coral Sea area to monitor vertical ocean temperature profiles.

Ocean waves are routinely monitored at five sites around the New Zealand coast. Remote coastal video cameras have been installed for long-term monitoring of beach conditions and erosion at seven sites.

The Ministry of Fisheries contracts out regular surveys of various fish species, in order to set maximum allowable catch limits and quotas. The resulting data sets may also be relevant for assessing climate change impacts on fisheries.

Terrestrial observing systems

There are approximately 500 streamflow gauges in operation around New Zealand, and around 300 ground-water monitoring sites. End of summer snowline elevations and photographic images of 46 glaciers from special aircraft flights are available annually since 1979, and the terminus positions of key glaciers in the Southern Alps are available from 1800 to the present.

A soil carbon monitoring system for New Zealand has been developed. The national Land Cover Database (LCDB) developed using SPOT satellite imagery in 1995 is planned to be updated every five years. The National Vegetation Survey Databank (NVS) maintained by LandCare Research holds records from approximately 45,000 vegetation survey plots around New Zealand, including 12,000 permanent plots. In addition, Landcare Research maintains five New Zealand long-term ecological research and monitoring sites (LTER), and also monitors the presence or range of self-advective fungal and insect species.

The Ministry of Agriculture and Forestry maintains a planted forest cover database, and keeps records of carbon absorbed in new planting and lost through logging, fires and vegetation clearance.

Observing, data and monitoring system support for developing countries

The Meteorological Service, under a New Zealand government contract, provides general assistance to Kiribati, Tuvalu, Samoa, Tokelau, Tonga, Niue and the Cook Islands in ensuring that weather and climate observing systems run smoothly and the quality of the observations is maintained. Targeted New Zealand Overseas Development Aid programmes have covered training in technical maintenance and observing practices in the Cook Islands, Tuvalu and the Tokelaus. The Meteorological Service also administers the WMO trust fund, which supports upper air observations (part of GUAN) at Tuvalu, Kiribati and Penrhyn, and provides technical support regarding the operation of these stations.

[12] Of these 208 stations, 165 provide a sufficiently broad suite of climate measurements to be useful for national climate monitoring.

NIWA also assists meteorological services undertaking climate observations in the South West Pacific, through informal advice when requested, by backing up climate records from many of the islands in the New Zealand climate database, and by providing data from this database to them when requested. In early 2000, NIWA ran an APN (Asia-Pacific Network) workshop at which South West Pacific Islands countries shared their experience with climate monitoring, and reported on data availability and studies of climate trends. A further APN workshop is planned for November 2001, to help this group analyse their data for climate extremes. NIWA also hosted a CLIPS (Climate Information and Prediction Services) workshop for WMO Regional Association 5 in November 2000. As described earlier in this chapter, NIWA scientists work with staff from various organisations in the Pacific Islands and Australia, to produce the monthly Island Climate Update, which summarises recent climatic conditions and provides climate outlooks for the next three months.

Chapter 9 Education, training and public participation

9.1 General public information

Since New Zealand's second national communication climate change education and awareness has increased. This is reflected in the increased number of activities and published documents and newsletters from the New Zealand Climate Change Programme. As the Kyoto Protocol has become more certain, a more structured education and public participation programme is being designed. This chapter details New Zealand's efforts.

In 2001 the Ministry for the Environment produced the *Impacts Report*. This examines the likely impacts of climate change and global warming on New Zealand and up-dates the previous government-led assessment of climate change impacts carried out in 1990. The report concentrates on areas where new knowledge has been gained over the last decade.

Since March 2001 the Ministry for the Environment produces a newsletter titled *ClimateWise*. *ClimateWise* is distributed approximately monthly and brings together ideas from experts on climate change and New Zealand's policy response, along with information, news and views about New Zealand's climate change programme.

The Ministry for the Environment activated a climate change website **www.climatechange.govt.nz** in 2001. Along with other services, the site lists the government departments involved with the climate change programme, links to consultation and policy documents, basic climate change information and resources, key contacts, and links to other relevant websites.

The Ministry for the Environment is developing a climate change education and public awareness programme with 10 other government departments involved in the New Zealand Climate Change Programme. The purpose of the climate change education programme is to raise awareness of climate change by communicating and providing readily accessible information.

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

- *Climate change; Background information* (Ministry for the Environment, 2000)
- *Climate change: answers to frequently asked questions* (Ministry for the Environment, 2000)
- *Climate change: developing solutions* (Ministry for the Environment, 2000)
- *Global warming and climate change communication for Maori* (Ministry for the Environment, 2000)
- *Information update on climate change for Maori* (Ministry for the Environment, 2001)
- *Series of five Climate Change information sheets: More than global warming, Impacts on New Zealand, The international response, New Zealand's greenhouse gas emissions, and New Zealand's response so far* (Ministry for the Environment, 2001).

The Ministry of Agriculture and Forestry (MAF) have produced an information pack titled *Climate Change Agriculture and Forestry*. This provides basic information on what climate change is and the effects climate change, agriculture and forestry have on one another. It puts climate change into an international context and details the global response under the UNFCCC and Kyoto Protocol.

In 2001, The Royal Society hosted Dr Robert T. Watson, Chairman of the IPCC, to speak at a public workshop *"Climate Change: the IPCC Third assessment Report and the implication for New Zealand"*. His visit to New Zealand was made possible with the help of the Ministries of Foreign Affairs and Trade, and of Research, Science and Technology (MFAT and MORST).

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

9.2 Public participation

The New Zealand Government is currently undertaking national consultation on:

a) New Zealand ratifying the Kyoto Protocol

b) domestic policy options for New Zealand to meet its Kyoto Protocol target.

The consultation process began in mid-October 2001 with the release of a consultation paper and supporting material, and was followed by a series of meetings and forums for interested members of the public, Maori, local Government, and sector and industry groups during November. The Government intends the process to give as many New Zealanders as possible the opportunity to express their views on climate change. For more information on the consultation process, refer to the section on further policy development in Chapter 4.

There have been other opportunities for interest group input through the Government's climate change programme. In 1999, the Ministry for the Environment produced a consultation document *Climate Change Domestic Policy Options Statement* (Ministry for the Environment, 1999) to outline to New Zealanders the range of policy measures being considered by the Government, at that time, in response to our international commitments under the UNFCCC and the Kyoto Protocol.

The Ministry for the Environment, along with MAF, Te Puni Kokiri (TPK), and EECA, undertook pre-consultation rounds (hui) with indigenous Maori people in 2000 and 2001. The purpose of the pre-consultation rounds was to present the effects of climate change on Maori as resource owners, and to give Maori an opportunity to participate fully in the development of the Government's domestic climate change policy package.

In 2001 the Ministry for the Environment commissioned a survey on New Zealanders awareness of climate change. The survey of more than 750 New Zealanders aged 18 or over found that, while people did not know much about climate change, they did want to know more and were generally prepared to take steps to "do their bit" if government led the way.

In 2001 the Ministry for the Environment prepared a report called *The effects of low-level carbon charges* (Ministry for the Environment, 2001) for the Tax Review 2001 (a government initiated review to assess whether the architecture of the New Zealand tax system is adequate for today's needs). The purpose of the Ministry for the Environment report was to help identify the possible impacts of a carbon charge and the sensitivity of those impacts to interactions with other types of taxes.

The Ministry for Foreign Affairs and Trade, together with other key government departments, holds regular briefing meetings with business and environmental NGOs, before and after meetings under the UNFCCC.

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 pre-hearing meetings.

9.3 Material for schools

Students and teachers are a key audience for building awareness on climate change issues. Providing students with sound climate change knowledge that they then pass on to their parents/guardians, means that an effort in this area reaches a wide audience.

ClimateWise is sent out to schools, as is other relevant material, for example *Climate Change Impacts on New Zealand* (Ministry for the Environment, 2001b). Additionally, Dr Robert T. Watson visited a number of schools throughout the country and was interviewed by radio, television, and the print media during his visit to New Zealand.

In August 2001, the Ministry for the Environment assisted the Forest and Bird Protection Society of New Zealand (a non-governmental organisation or NGO) in constructing climate change material for an edition of their children's magazine, *Kiwi Conservation Club*. This was distributed to over 12,000 children and 900 primary and intermediate schools throughout New Zealand. The magazine is appropriate for years 7 – 13 year olds and the material is curriculum related.

In October 2001, the Ministry for the Environment, on behalf of the New Zealand Climate Change Programme, prepared a Climate Change Consultation Kit for schools to enable students and their teachers to gain a better understanding of climate change. This forms part of the national consultation on ratifying the Kyoto Protocol mentioned in Section 9.2 above. The Consultation Kit provides a forum for students and their families to get involved with the nationwide consultation process.

The Consultation Kit includes:

- five consultation documents for students and their families
- a feedback form (attached to the consultation document) for making a submission on ratifying the Kyoto Protocol
- one poster illustrating climate change and its effects.

9.4 Information, education and training for specialist groups

Immediately following COP6.5, New Zealand's Minister for Energy Pete Hodgson gave three public speeches on climate change issues and the Government's intention to ratify the Kyoto Protocol. A number of media statements regarding the outcome of COP 6.5 were also released. Private sector, NGO, and opposition members of Parliament who were part of the COP6 and COP6.5 delegations, took back to their organisations valuable feedback on climate change and the political response.

The Ministries for the Environment, of Economic Development, of Foreign Affairs and Trade, and of Agriculture and Forestry were involved with seminars that provided updates on the negotiation process and explained implications of various aspects of possible agreements. This included the implications of emissions trading, points of obligation, negotiated greenhouse agreements, carbon credits, and forest sinks.

In February 2001, the Ministry for the Environment, the Energy Efficiency and Conservation Authority (EECA), and the local government representative body, Local Government New Zealand, were involved in a series of 11 workshops to discuss climate change with council representatives. The workshops sought to raise awareness of climate change among local government politicians and officers and discuss the possible roles of local government in responding to climate change.

In 2001 EECA and the Ministry for the Environment produced a discussion document for consultation under the Energy Efficiency and Conservation Act 2000 titled *Proposed Implementation of Mandatory Energy Performance Standards and Labelling*. This document proposes regulations on energy efficiency performance and labelling.

In the same year, with the help of 10 other agencies, EECA produced a short video for educating businesses on how to be energy efficient in the workplace. The video is called *Cool Planet – Energy-wise tips for the office.*

EECA has for many years targeted a diverse array of markets with energy efficiency and renewable energy information, education and advice. This is a core activity for EECA, which was established as a legal entity under the Energy Efficiency and Conservation Act, 2000. Currently, programmes target the government (central and local), business and transport sectors. One of the requirements of the Energy Efficiency and Conservation Act is a National Energy Efficiency and Conservation Strategy (NEECS). This has been prepared by EECA in conjunction with the Ministry for the Environment – following an extensive consultation process involving government agencies, interest groups and members of the public. Refer to the Chapter 4 – Policies and measures to reduce greenhouse gas emissions and protect and enhance sinks for more information on NEECS.

In 2001, a resource document for Members of Parliament (MPs) called *The Greenhouse Effect and Climate Change* was produced by the Research and Analysis Branch of the Parliamentary Library, Wellington. This document was intended as a non-partisan resource for the MPs, who will need to consider legislation to be introduced by the Government in preparation for New Zealand ratifying the Kyoto Protocol by September 2002. The report brings together the key IPCC reports on climate change science and projections, New Zealand climate change data and projections, global and New Zealand emissions data, detail on carbon sinks, an overview of international agreements and the New Zealand policy response, and a summary of action options for central government, local government, and individuals.

Some regional and district councils have made significant mention of climate change and the Climate Change Education Programme in their newsletters and brochures.

9.5 Conclusion

The profile of climate change is growing in New Zealand since the Kyoto Protocol has become more certain. In 2001, climate change education and awareness has been a strong focus of the climate change action programme to engage with New Zealanders about the Government's decision-making process on ratifying the Kyoto Protocol.

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Abbreviations and acronyms

ASEAN	Association of South East Asian Nations
BAU	Business-as-usual
BPO	Best Practice Option
CFCs	Chlorofluorocarbons
CH_4	Methane
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COP	Conference of the Parties
ECNZ	Electricity Corporation of New Zealand
EECA	Energy Efficiency and Conservation Authority
EMCO	Electricity Market Company
EU	European Union
FRST	Foundation for Research, Science and Technology
GEF	Global Environmental Facility
GCOS	Global Climate Observing System
GCTE	Global Change and Terrestrial Ecosystems
Gg	Gigagrams
GIS	Geographic Information System
GRID	Global Resource Information Database
GWPs	Global Warming Potentials
HFCs	Hydrofluorocarbons
ICSU	International Council of Scientific Unions
IEA	International Energy Agency
IGBP	International Geosphere Biosphere Programme
IGNS	Institute of Geological and Nuclear Sciences
IPCC	Intergovernmental Panel on Climate Change
JGOFS	Joint Global Ocean Flux study
LPG	Liquidified Petroleum Gas
LTPS	Land Transport Pricing Study
NA	Not available
NDSC	Network for the Detection of Stratospheric Change
NEECS	National Energy Efficiency and Conservation Strategy
NEG	Negligible
NGOs	Non-governmental organisations
NIWA	National Institute of Water and Atmospheric Research
NLTS	National Land Transport Strategy
NMVOCs	Non-methane volatile organic compounds
NO_x	Oxides of Nitrogen
NSSCCC	National Science Strategy Committee on Climate Change
N_2O	Nitrous Oxide
NR	Not relevant
NZAS	New Zealand Aluminium Smelters Ltd
NZCPS	New Zealand Coastal Policy Statement
NZFRI	New Zealand Forest Research Institute
ODA	Official Development Assistance
OECD	Organisation of Economic Cooperation and Development
PICCAP	Pacific Island Climate Change Assistance Programme
PFCs	Perfluorocarbons
PGS&T	Public Good Science and Technology (fund)
PJ	Petajoules
PSE	Producer Subsidy Equivalents
RMA	Resource Management Act 1991
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SF_6	Sulphur Hexafluoride
SMF	Sustainable Management Fund
SOE	State Owned Enterprise
SO_2	Sulphur Dioxide
SPREP	South Pacific Regional Environment Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	World Climate Research Programme
WMO	World Meteorological Organisation

Annex 1 Summary of emissions and removals 1990 – 1999

Carbon Dioxide (CO_2) Emissions Trends – Sheet 1 of 5

Greenhouse Gas Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				(Gg)						
1. Energy	**23,012.93**	**23,370.79**	**25,116.02**	**24,365.43**	**24,527.01**	**24,469.78**	**25,481.65**	**27,583.49**	**26,069.09**	**27,656.38**
A. Fuel Combustion (Sectoral Approach)	22,397.74	22,670.33	24,448.65	23,734.92	23,846.54	23,842.03	24,808.79	26,823.53	25,399.15	26,984.14
1. Energy Industries	6,079.93	6,150.53	7,628.43	6,597.77	5,457.59	4,728.49	5,314.49	6,944.84	5,249.23	6,629.28
2. Manufacturing Industries and Construction	4,812.29	5,157.13	4,817.51	4,961.66	5,303.32	5,447.97	5,847.03	5,882.10	5,883.43	5,825.66
3. Transport	8,660.27	8,661.59	9,047.07	9,458.20	10,160.07	10,868.75	10,989.21	11,241.59	11,435.32	11,729.46
4. Other Sectors	2,845.25	2,701.08	2,955.64	2,717.29	2,925.56	2,796.82	2,658.06	2,755.00	2,831.17	2,799.74
5. Other										
B. Fugitive Emissions from Fuels	615.19	700.46	667.37	630.51	680.47	627.75	672.86	759.96	669.94	672.24
1. Solid Fuels										
2. Oil and Natural Gas										
2. Industrial Processes	**2,386.35**	**2,510.76**	**2,646.60**	**2,770.40**	**2,671.51**	**2,736.53**	**2,741.80**	**2,626.91**	**2,755.22**	**2,866.75**
A. Mineral Products	448.28	437.16	500.52	553.25	565.96	586.02	580.91	598.68	574.04	632.25
B. Chemical Industry	152.29	166.66	158.35	161.24	183.92	145.44	166.56	173.96	190.07	191.33
C. Metal Production	1,785.78	1,906.94	1,987.73	2,055.91	1,921.63	2,005.07	1,994.33	1,854.27	1,991.11	2,043.17
D. Other Production										
3. Solvent and Other Product Use										
4. Agriculture	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
5. Land-Use Change and Forestry	**-21,637.76**	**-20,480.21**	**-18,417.24**	**-16,475.60**	**-15,835.23**	**-16,306.75**	**-16,617.66**	**-18,213.76**	**-20,959.21**	**-22,118.39**
A. Changes in Forest and Other Woody Biomass Stocks	-22,307.00	-21,495.00	-20,003.00	-18,570.00	-18,166.00	-18,060.00	-18,548.00	-19,946.00	-21,831.00	-23,245.00
B. Forest and Grassland Conversion	669.24	1,014.79	1,585.76	2,094.40	2,330.77	1,753.25	1,930.34	1,732.24	871.79	1,126.61
C. Abandonment of Managed Lands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. CO2 Emissions and Removals from Soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Waste	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Emissions/Removals with LUCF	**3,761.52**	**5,401.34**	**9,345.38**	**10,660.24**	**11,363.29**	**10,899.56**	**11,605.78**	**11,996.64**	**7,865.11**	**8,404.74**
Total Emissions without LUCF	**25,399.28**	**25,881.55**	**27,762.62**	**27,135.84**	**27,198.52**	**27,206.31**	**28,223.44**	**30,210.39**	**28,824.31**	**30,523.13**
Memo Items:										
International Bunkers	**2,384.14**	**2,204.55**	**2,188.68**	**2,256.44**	**2,768.23**	**2,707.44**	**2,711.44**	**2,835.94**	**2,788.55**	**1,959.18**
Aviation	1,353.05	1,292.79	1,322.51	1,341.35	1,444.12	1,582.32	1,648.91	1,723.93	1,715.49	1,959.18
Marine	1,031.09	911.76	866.17	915.09	1,324.11	1,125.12	1,062.53	1,112.01	1,073.06	9.53.11
CO_2 Emissions from Biomass	**2,850.70**	**3,043.60**	**2,913.25**	**3,059.06**	**3,471.25**	**3,502.11**	**3,535.81**	**3,080.39**	**3,242.42**	**3,248.3**

Methane (CH_4) Emissions Trends – Sheet 2 of 5

Greenhouse Gas Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				(Gg)						
Total Emissions	**1,676.72**	**1,641.79**	**1,612.25**	**1,614.11**	**1,624.04**	**1,625.89**	**1,623.95**	**1,594.94**	**1,597.98**	**1,599.71**
1. Energy	37.48	35.59	35.22	35.37	38.37	44.42	55.54	46.48	52.55	54.22
A. Fuel Combustion (Sectoral Approach)	10.65	10.69	10.62	11.00	11.02	10.96	10.79	10.75	10.58	10.63
1. Energy Industries	0.26	0.28	0.32	0.29	0.24	0.20	0.22	0.27	0.20	0.26
2. Manufacturing Industries and Construction	0.41	0.45	0.42	0.42	0.49	0.51	0.54	0.49	0.49	0.51
3. Transport	7.21	7.24	7.27	7.28	7.27	7.31	7.15	7.13	7.08	7.14
4. Other Sectors	2.77	2.72	2.61	3.01	3.02	2.94	2.88	2.86	2.81	2.72
5. Other										
B. Fugitive Emissions from Fuels	26.83	24.90	24.60	24.37	27.35	33.46	44.75	35.73	41.97	43.59
1. Solid Fuels										25.86
2. Oil and Natural Gas										17.73
2. Industrial Processes	**0.12**	**0.12**	**0.10**	**0.12**	**0.12**	**0.12**	**0.10**	**0.11**	**0.11**	**0.11**
A. Mineral Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. Chemical Industry	0.12	0.12	0.10	0.12	0.12	0.12	0.10	0.11	0.11	0.11
C. Metal Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Solvent and Other Product Use										
4. Agriculture	**1,492.23**	**1,458.26**	**1,435.09**	**1,433.27**	**1,439.11**	**1,437.55**	**1,423.52**	**1,412.17**	**1,413.50**	**1,415.51**
A. Enteric Fermentation	1,474.36	1,440.76	1,417.83	1,416.00	1,421.76	1,420.22	1,406.37	1,395.17	1,396.49	1,398.48
B. Manure Management	17.78	17.42	17.17	17.17	17.25	17.23	17.05	16.90	16.91	16.93
C. Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Agricultural Soils	0.00	NE	0.00	NE	NE	NE	0.00	0.00	0.00	0.00
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10
G. Other	0.00	NE	NE	NE	NE	NE	NE	NE	NE	NE
5. Land-Use Change and Forestry	**4.23**	**3.89**	**4.42**	**5.65**	**6.35**	**6.12**	**6.92**	**7.52**	**6.15**	**5.68**
A. Changes in Forest and Other Woody Biomass Stocks	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Forest and Grassland Conversion	4.23	3.89	4.42	5.65	6.35	6.12	6.92	7.52	6.15	5.68
C. Abandonment of Managed Lands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. CO2 Emissions and Removals from Soil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Waste	**142.66**	**143.93**	**137.42**	**139.71**	**140.09**	**137.68**	**137.87**	**128.66**	**125.66**	**124.19**
A. Solid Waste Disposal on Land	136.50	137.70	131.10	133.30	133.60	131.10	131.20	121.90	118.90	117.43
B. Waste-water Handling	6.16	6.23	6.32	6.41	6.49	6.58	6.67	6.76	6.76	6.76
C. Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Memo Items										
International Bunkers	**0.13**	**0.12**	**0.12**	**0.12**	**0.16**	**0.15**	**0.14**	**0.15**	**0.14**	**0.13**
Aviation0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	
Marine	0.10	0.09	0.09	0.09	0.13	0.11	0.10	0.11	0.10	0.09

Nitrous Oxide (N_2O) Emission Trends – Sheet 3 of 5

Greenhouse Gas Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				(Gg)						
Total Emissions	**38.22**	**37.82**	**37.87**	**38.35**	**38.86**	**39.02**	**38.84**	**38.91**	**39.46**	**39.99**
1. Energy	**0.61**	**0.62**	**0.64**	**0.66**	**0.70**	**0.73**	**0.74**	**0.76**	**0.76**	**0.78**
A. Fuel Combustion (Sectoral Approach)	0.61	0.62	0.64	0.66	0.70	0.73	0.74	0.76	0.76	0.78
1. Energy Industries	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.05	0.04	0.05
2. Manufacturing Industries and Construction	0.12	0.13	0.12	0.13	0.14	0.14	0.14	0.13	0.13	0.13
3. Transport	0.37	0.37	0.39	0.40	0.43	0.46	0.47	0.48	0.49	0.50
4. Other Sectors	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10
5. Other										
B. Fugitive Emissions from Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Industrial Processes	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
3. Solvent and Other Product Use										
4. Agriculture	**37.14**	**36.74**	**36.75**	**37.20**	**37.66**	**37.79**	**37.59**	**37.63**	**38.18**	**38.69**
A. Enteric Fermentation										
B. Manure Management	0.33	0.33	0.34	0.36	0.39	0.40	0.41	0.41	0.35	0.42
C. Rice Cultivation										
D. Agricultural Soils	36.81	36.41	36.40	36.83	37.27	37.39	37.18	37.22	37.83	38.27
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Other	0.00	NE	NE	NE	NE	NE	NE	NE	NE	NE
5. Land-Use Change and Forestry	**0.03**	**0.03**	**0.03**	**0.04**	**0.04**	**0.04**	**0.04**	**0.05**	**0.04**	**0.04**
A. Changes in Forest and Other Woody Biomass Stocks	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Forest and Grassland Conversion	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.04	0.04
C. Abandonment of Managed Lands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. CO_2 Emissions and Removals from Soil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NO	NO	NO
6. Waste	**0.44**	**0.44**	**0.45**	**0.45**	**0.46**	**0.46**	**0.47**	**0.47**	**0.47**	**0.48**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	0.44	0.44	0.45	0.45	0.46	0.46	0.47	0.47	0.47	0.48
C. Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Memo Items										
International Bunkers	**0.05**	**0.05**	**0.04**	**0.05**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
Aviation	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Marine	0.03	0.03	0.02	0.03	0.04	0.03	0.03	0.03	0.03	0.03

HFCs, PFCs and SF_6 Emissions Trends – Sheet 4 of 5. All figures are in CO_2 equivalents.

Greenhouse Gas Source and Sink Categories	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					(Gg)						
Emissions of HFCs-CO_2 equivalent (Gg)		**0.00**	**0.00**	**6.76**	**16.12**	**43.21**	**103.20**	**169.99**	**144.20**	**247.30**	**209.86**
HFC-23		0	0	0	0	0	0	0	0		0
HFC-32		0	0	0	0	0	0.0004	0	0.0000	0.0000	0.0074
HFC-41		0	0	0	0	0	0	0	0		0
HFC-43-10mee		0	0	0	0	0	0	0	0		0
HFC-125		0	0	0	0	0.0012	0.0005	0.0067	0.0105	0.0095	0.0104
HFC-134		0	0	0	0	0	0	0	0		0
HFC-134a		0	0	0.0052	0.0124	0.0294	0.0548	0.0954	0.0609	0.1420	0.1027
HFC-152a		0	0	0	0	0.0004	0.0012	0.0004	0.0002	0.0004	0.0017
HFC-143		0	0	0	0	0	0	0	0		0
HFC-143a		0	0	0	0	0.0004	0.0079	0.0071	0.0093	0.0094	0.0110
HFC-227ea		0	0	0	0	0.0000	0.0000	0.0001	0.0001	0.00	0.0001
HFC-236fa		0	0	0	0	0	0	0	0		0
HFC-245ca		0	0	0	0	0	0	0	0		0
Emissions of PFCs-CO_2 equivalent (Gg)		**602.53**	**649.92**	**636.38**	**228.15**	**230.18**	**188.39**	**216.39**	**211.29**	**117.85**	**74.47**
CF_4		0.0801	0.0864	0.0846	0.0303	0.0306	0.0243	0.0243	0.0278	0.0083	0.0099
C_2F_6		0.0089	0.0096	0.0094	0.0034	0.0034	0.0027	0.0027	0.0031	0.0008	0.0011
C_3F_8							0.0008	0.0048	0.0003	0.01	
C_4F_{10}											
c-C_4F_8											
C_5F_{12}											
C_6F_{14}											
Emissions of SF_6-CO_2 equivalent (Gg)		**2.87**	**2.87**	**2.87**	**2.87**	**26.77**	**18.88**	**27.72**	**28.92**	**31.79**	**33.22**
SF_6		0.0001	0.0001	0.0001	0.0001	0.0011	0.0008	0.0012	0.0012	0.00	0.0014

[1] *New Zealand has not yet selected the base year for the fluorinated gases.*

Emission Trends (Summary) – Sheet 5 of 5. All figures are in CO_2 equivalents.

(Table taken from the 1990 – 1999 Greenhouse Gas Inventory Report, April 2001, Trends Table 5.5)

Greenhouse Gas Emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				(Gg)						
Net CO_2 emissions/removals	3,761.52	5,401.34	9,345.38	10,660.24	11,363.29	10,899.56	11,605.78	11,996.64	7,865.11	8,404.74
CO_2 emissions (without LUCF)[1]	25,399.28	25,881.55	27,762.62	27,135.84	27,198.52	27,206.31	28,223.44	30,210.39	28,824.31	30,523.13
CH_4	35,211.16	34,477.67	33,857.33	33,896.31	34,104.78	34,143.65	34,102.93	33,493.83	33,557.54	33,593.81
N_2O	11,848.51	11,725.44	11,738.46	11,886.95	12,047.84	12,097.13	12,041.33	12,062.10	12,231.36	12,396.59
HFCs	0.00	0.00	6.76	16.12	43.21	103.20	169.99	144.20	247.30	209.86
PFCs	602.53	649.92	636.38	228.15	230.18	188.39	216.39	211.29	117.85	74.47
SF_6	2.87	2.87	2.87	2.87	26.77	18.88	27.72	28.92	31.79	33.22
Total (with net CO_2 emissions/removals)	**51,426.59**	**52,257.24**	**55,587.18**	**56,690.63**	**57,816.07**	**57,450.81**	**58,164.15**	**57,936.98**	**54,050.94**	**54,712.68**
Total (without CO_2 from LUCF)[1]	73,064.35	72,737.45	74,004.42	73,166.23	73,651.30	73,757.56	74,781.81	76,150.73	75,010.14	76,831.07
Greenhouse Gas Source and Sink	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
CATEGORIES										
1. Energy	23,989.11	24,310.38	26,054.04	25,312.80	25,549.78	25,628.90	26,877.39	28,795.17	27,408.24	29,036.80
2. Industrial Processes	2,994.27	3,166.07	3,294.77	3,019.98	2,974.22	3,049.52	3,158.04	3,013.72	3,154.55	3,186.61
3. Solvent and Other Product Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Agriculture	42,850.89	42,012.01	41,528.17	41,629.37	41,895.85	41,903.37	41,546.86	41,320.87	41,520.54	41,719.61
5. Land-Use Change and Forestry[2]	-21,539.94	-20,390.15	-18,315.12	-16,344.92	-15,688.26	-16,164.86	-16,459.12	-18,040.34	-20,816.95	-21,987.12
6. Waste	3,132.26	3,158.93	3,025.32	3,073.41	3,084.49	3,033.88	3,040.97	2,847.56	2,784.56	2,756.79
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[1] LUCF (Land-use Change and Forestry). The figures in this row do not include the CO_2 uptake from LUCF.

[2] Net emissions. These emissions are reported as (-) as it is the amount of CO_2 removed by LUCF. The 'Net CO_2 emissions/removals' figures are calculated by adding the LUCF figures for each year to the respective 'CO_2 emissions (without LUCF)' figures.

Annex 2 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, Resources and Networks Branch, Ministry of Economic Development.

This work focuses primarily on energy supply and demand for the period 2001 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 modeled. 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.

Crude oil prices

The oil price path assumed is based on current import prices and exchange rates initially decreasing to US$19/bbl by 2003. Between 2004 and 2009, the price is US$20/bbl, then remaining at US$21/bbl between 2010 and 2014. The final six years of the projected period sees the price increase at a constant rate from US$22/bbl in 2015 to US$23/bbl by 2020. The 2020 projected price is close to both the IEA's World Energy Outlook 2000 and the US EIA's International Energy Outlook 2001, while the price path closely follows the US EIA's 'Reference case' scenario.

The past two years has seen the weekly average price for Dubai crude remain above US$20/bbl, and in November of 2000 peaked at US$31.61/bbl. This outlook assumes that after the world economy recovers from its present economic slump, the crude oil price will remain at or above the US$20/bbl mark. These projections are lower than those assumed in the second national communication, which was that the price would rise to US$25/bbl by 2005 and remain constant thereafter.

Coal prices

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$0.55 has been adopted for the years 2007 – 2020. Before then, a rate of NZ$1=US$0.44 is assumed for 2001, and this will increase at a constant rate from NZ$1=US$0.45 in 2002 to reach NZ$1=US$0.55 by 2007. This contrasts with the exchange rate used in the second national communication, which was constantly held at NZ$1=US$0.65 throughout the outlook period.

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 a fuel's entire 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 emission factors and constants are derived from detailed emission inventories.

While most emissions are from fuel combustion, the emission calculations also include 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 CO_2, CH_4 and NMVOCs 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 (Ministry of Commerce, 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).

Notes