New Zealand's Sixth National Communication

under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

newzealand.govt.nz

Acknowledgements

Key contributors

Ministry for the Environment

Dylan Muggeridge (Project Leader National Communication, Projections)

Alice Ryan (Executive summary, National circumstances)

Olia Glade (Greenhouse gas inventory)

Tanya Roth (Policies and measures)

Fionna Cumming (Vulnerability assessment, impacts and adaptation, Education, training and public awareness)

Dan Zwartz (Research and systematic observations)

Ministry of Foreign Affairs and Trade

Andrea Stewart, Roger Dungan (Financial resources and technology transfer)

NIWA

Jochen Schmidt (Report on the Global Climate Observing System)

Technical Contributors

Simon Wear, Craig Elvidge, Anna Morris, Christine McNeight, Josh Fyfe, Nigel Searles, Warren Gray, Sarah Metwell, Nathan Young, Cary Milkop, Michael Smith, Kennie Tsui, Julie Knauf, Sonia Petrie, Helen Plume, Anna De Raadt, Peter Ettema, Sheree De Malmanche, Marianne Lukkien, Rosalind Dawson, Craig McKendry, Pauline Doherty, Jess Thorn, Erin Morriss, Tom Baragwanath, Caroline Parlane, Jennie Wattie, Ted Jamieson, Carly Soo, Gerry O'Neill, Karen Wong, Dana Peterson, Jonathan Dallaston**,** Steven Cox, Nicole Kirkham, Samuel Thornton, Matthew Smith, Stephen Walter, Siobhan Bakker, Angela Bell, Andrea Byrom, Frances Graham, Tammy Hambling, Victoria Jollands, Jonathan Jull, Te Raumawhitu Kupenga, Judy Lawrence, Anna Broadhurst, Adrian Lill, Mary Livingstone, Reece Martin, Torrey McDonnell, Alison Stringer, Claudia Boyles, Sarah McRae, Richard Nottage, Irene Parminter, Gerald Rys, Edward Schofield, Trecia Smith, Frances Sullivan, Kirsty Van Reenen, Richard Ward, Ivana Cortesini, Michelle Dow, Suzi Kerr, Ann Smith, Moya McConnell, Adrian Macey, Andy Reisinger, Tim Naish, Kristen Price, Karen Quinn, Stuart Badger, Iain McGlinchy, Julia Thevessen, Ian Turney, Climate Change Directors Group, Reporting Governance Group.

This document may be cited as *New Zealand's Sixth National Communication under the United Nations Framework Convention on Climate Change and Kyoto Protocol,* Ministry for the Environment, 2013.

Cover image and Chapter 4 image courtesy of Scott Muggeridge. Chapter 2 image courtesy of Alice Ryan, Chapter 3 image courtesy of Stirling Smidt, images for Chapters 6 and 9 are courtesy of Fionna Cumming, Chapter 7 image courtesy of Tim Adams, Chapter 8 image courtesy of New Zealand Agricultural Greenhouse Gas Research Centre.

ISBN (print) 978-0-478-41231-4

ISBN (electronic) 978-0-478-41232-1

ME 1137

Published by the Ministry for the Environment, December 2013

Foreword

Addressing climate change is the great challenge of our age. All nations are affected so we must all play our part. It is a truly global issue, requiring global engagement and a global solution.

In publishing this 6th National Communication on Climate Change New Zealand is not just fulfilling its obligations under the United Nations Framework Convention on Climate Change, we are doing it in a spirit of transparency. We support reporting transparently, as that will increase awareness of the issues we face and reveal the common ground on which lasting and binding agreements can be built.

This Communication shows that New Zealand is taking responsibility for its emissions and is committed to doing its fair share to address climate change. We have set an unconditional 2020 net emissions target. We are engaging internationally in pursuit of binding agreements, through applying our skills in science and innovation to reduce agricultural emissions. We are focussing aid programmes to help our Pacific neighbours adapt to climate change and move to a renewable energy future – for example Tokelau has converted to 100% solar electricity. We are taking a range of actions to reduce our domestic emissions.

The Communication highlights that our emissions profile is unique for a developed country: nearly half our greenhouse gas emissions come from agriculture and these are largely dictated by genetics and production volumes; we have one of the highest proportions of renewable energy in the world; and we have a low population density that makes economies of scale difficult. The emissions reduction opportunities available to other nations through conversion to renewables, mass public transit, and energy efficiency in industry have already been done or have far less scope in New Zealand.

It also provides a snapshot of potential future emissions. These projections have been developed using the best possible information but, like all long term projections, they are not predictions and inherently have large uncertainties. They show the carbon capture by New Zealand's plantation forests at a cyclic low, due to the impact of the harvest cycle. Projections beyond 2030 show our forests becoming a significant carbon sink again as they grow. The projections also don't take into account the impact of emissions reductions from research efforts, such as the Global Research Alliance on Agricultural Greenhouse Gases that New Zealand is leading and which involves about 40 countries.

I expect that these projections will change as the effects of international negotiations flow through to markets and policy settings. But it is a binding agreement that we need. Such an agreement needs to be flexible in its mechanisms, reducing emissions while catering for individual countries' circumstances, and allowing them to play to their strengths. Such an agreement could provide the ambitious targets and wide participation we need for a truly effective global response to the challenge of climate change.

The Honourable Tim Groser

Minister for Climate Change Issues

Contents

Tables

Figures

Abbreviations

ANDRILL:	Antarctic Geological Drilling
APEC:	Asia–Pacific Economic Cooperation
CCILG:	Climate Change Iwi Leaders Group
CCS:	carbon capture and storage
CEMARS:	Certified Emissions Management and Reduction Scheme
CFC:	chlorofluorocarbon
CH_4:	methane
CMIP3:	Coupled Model Intercomparison Project Phase 3
CMIP5:	Coupled Model Intercomparison Project Phase 5
CMP:	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
CO:	carbon monoxide
CO_2:	carbon dioxide
CO_2-e:	carbon dioxide equivalent
CRF:	common reporting format
CRI:	Crown Research Institute
DCD:	dicyandiamide
E3:	Equipment Energy Efficiency
ECV:	essential climate variable
EECA:	Energy Efficiency and Conservation Authority
FACE:	Free Air CO_2 Enrichment
GAW:	Global Atmosphere Watch
GCMP:	GCOS climate monitoring principles
GCOS:	Global Climate Observing System
GDP:	gross domestic product
GEF :	Global Environment Facility
GHG:	greenhouse gas
GIS:	Geographic Information System
GNS:	Institute of Geological and Nuclear Sciences
GRUAN:	GCOS Reference Upper Air Network
GSN:	Global Surface Network
GUAN:	Global Upper Air Network
HFC:	hydrofluorocarbon

HPMV:	high productivity motor vehicle
IMOS:	Integrated Marine Observing System
IPCC:	Intergovernmental Panel on Climate Change
ITL:	International Transaction Log
LCDB:	Land Cover Database
LEARN:	Livestock Emissions and Abatement Research Network
LINZ:	Land Information New Zealand
LUCAS:	Land Use and Carbon Analysis System
LULUCF:	land use, land-use change and forestry
MBIE:	Ministry of Business, Innovation and Employment
MfE:	Ministry for the Environment
MPI:	Ministry for Primary Industries
N_2O:	nitrous oxide
NABERS:	National Australian Built Environment Rating System
NASA:	National Aeronautics and Space Administration
NCSN:	National Climate Station Network
NGMP:	National Groundwater Monitoring Programme
NIR:	National Greenhouse Gas Inventory or National Inventory Report
NIWA:	National Institute of Water and Atmospheric Research
NMVOC:	non-methane volatile organic compound
NOAA:	National Oceanic and Atmospheric Administration
NO_x:	oxides of nitrogen
NRCSN:	National Reference Climate Station Network
NZ ETS:	New Zealand Emissions Trading Scheme
NZAGRC:	New Zealand Agricultural Greenhouse Gas Research Centre
NZCCC:	New Zealand Climate Change Centre
NZD:	New Zealand dollar
NZEUR:	New Zealand Emission Unit Register
NZU:	New Zealand Unit
OECD:	Organization for Economic Co-operation and Development
pCO_2:	partial pressure of CO_2
PFC:	perfluorocarbon
PI-GCOS:	Pacific Islands Global Climate Observing System
PV:	photovoltaic

QA: quality assurance

QC: quality control

RANET: RadioInternet

RMU: removal unit

SF_6: sulphur hexafluoride

SMC: Science Media Centre

SO_2: sulphur dioxide

SREX: Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation

SWFDDP: Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project

TREP: Tokelau Renewable Energy Project

UN: United Nations

UNFCCC: United Nations Framework Convention on Climate Change

USD: United States dollar

VOS: Voluntary Observing Ships

VOSClim: VOS Climate Project

WMO: World Meteorological Organization

XBT: expandable bathythermography

1 Executive summary

Climate change is a global issue and New Zealand is committed to playing its part in a global response. New Zealand is actively working to contribute to the development of a new and comprehensive global agreement and is prepared to consider increasing the ambition of its targets in line with this. New Zealand has a broad range of measures to address climate change, on both a domestic and an international level, and focuses actions where it can make the greatest contribution.

New Zealand's national circumstances and unusual emissions profile mean that it is likely to have fewer low-cost abatement options than most other developed countries. This has shaped New Zealand's approach to action on climate change and emissions reduction.

New Zealand's small population is widely distributed across a long, narrow and mountainous country. It is located in the South Pacific and is distant from the majority of its trading partners. It has an export-dependent economy, with a significant reliance on the agricultural sector. Some 85 per cent of New Zealand's total food production goes to the international market. New Zealand's geography and population distribution has contributed to a dependence on fossil fuel-powered transport.

High levels of agricultural activity mean almost half of New Zealand's emissions come from agriculture. This compares with an average of 12 per cent in other developed countries.[1] There are few economically viable technologies for reducing greenhouse gas emissions from agriculture, but New Zealand continues to make improvements in efficiency across the agricultural sector. This has led to significant decreases in emissions per unit of product for sheep, beef and dairy. Improvements, however, have occurred alongside increases in production. As a consequence, New Zealand's agricultural emissions have continued to grow, though at a slower rate than would otherwise be the case.

New Zealand already has high levels of renewable energy utilisation and a long history of renewable energy development. Around three quarters of New Zealand's electricity generation uses renewable resources – primarily hydro generation. Continued development of geothermal and wind generation has seen the amount of electricity generated from these sources more than triple over the last two decades. New Zealand is looking to make further gains in this area and the recently renewed *New Zealand Energy Strategy 2011 – 2021* and companion *New Zealand Energy Efficiency and Conservation Strategy 2011 – 2016* reaffirm New Zealand's commitment to a goal of 90 per cent of electricity generation from renewable resources by 2025.[2]

1 Ministry for the Environment, *New Zealand's Greenhouse Gas Inventory 1990–2011*. Submitted to the United Nations Framework Convention on Climate Change 12 April 2013.

2 Providing this does not affect security of supply.

New Zealand's emissions targets

New Zealand has set a number of targets for reducing emissions:

1. A target under the First Commitment Period of the Kyoto Protocol (2008–2012) to reduce greenhouse gas emissions to 1990 levels on average over the five year commitment period, or take responsibility for any emissions over these levels.

2. An unconditional responsibility target of a five per cent reduction in emissions below New Zealand's 1990 greenhouse gas emission levels by 2020, managed using the Kyoto Protocol's second commitment period framework of rules.

3. A conditional medium-term responsibility target of a 10 to 20 per cent reduction in emissions below 1990 levels by 2020, made in the context of a comprehensive global agreement and with five specific requirements:

   a. the global agreement sets the world on a pathway to limit temperature rise to not more than 2°C

   b. developed countries make comparable efforts to those of New Zealand

   c. advanced and major emitting developing countries take action fully commensurate with their respective capabilities

   d. there is an effective set of rules for Land Use, Land-Use Change and Forestry (LULUCF)

   e. there is full recourse to a broad and efficient international carbon market.

4. A long-term emission reduction target of a 50 per cent reduction in net greenhouse gas emissions from 1990 levels by 2050; in short 50 by 50.

New Zealand is on track to meet its Kyoto Protocol target. The latest *Net Position* report produced in April 2013, projected that New Zealand will have a surplus of 29.6 million units over the First Commitment Period of the Kyoto Protocol. The actual surplus or deficit of units will be confirmed once the true-up process has been completed, likely to be 2015/16.[3]

New Zealand will take responsibility for meeting its 2020 commitment of a five per cent reduction in emissions from 1990 levels through a combination of:

- domestic emissions reductions
- removal of carbon from forests
- participation in international carbon markets
- recognising surplus achieved during the first commitment period of the Kyoto Protocol.

These contributions to international mitigation action continue to be reviewed in light of the latest science, development of new technologies and progress by other countries. The new climate change agreement is expected to be concluded by December 2015, and will enter into

[3] A period of 100 days following the completion of the Kyoto Protocol reviews of greenhouse gas emissions information relating to the First Commitment Period (2008–2012). Transfers of units may still take place until the end of this period, allowing Annex 1 parties to trade and retire units to comply with their emissions obligations.

force by 2020. It is expected to introduce a more comprehensive and effective global mitigation agreement, and New Zealand's actions will reflect the progress that is made.

Action on climate change

The New Zealand Emissions Trading Scheme (NZ ETS) is the principal policy tool underpinning New Zealand's domestic emissions reduction action. It requires emitters that are participants in the scheme to report on their emissions and surrender emissions units that correspond to their obligations. NZ ETS participants are able to meet their NZ ETS obligations by surrendering New Zealand Units, the primary unit of trade in the scheme, and also eligible international units.

The NZ ETS is a broad based trading scheme that enables New Zealand to meet its international targets using international carbon markets. Entry to the scheme was phased by sector, with forestry the first sector to have reporting and surrender obligations. Since then, the transport, stationary energy[4], industrial processes, synthetic gases and waste sectors have joined the NZ ETS. The agriculture sector faces reporting obligations and currently there is no legislated date for when biological agricultural emissions will assume surrender obligations under the NZ ETS.

Introduced in 2008, the NZ ETS was reviewed in 2011 with consequential amendments made in 2012. The resulting changes were designed to ensure the NZ ETS remains flexible and able to respond to a range of international agreement outcomes in the 2013 to 2020 period, while more effectively supporting Government's economic growth priorities. The NZ ETS is a long-term tool and the Government is committed to regularly reviewing the NZ ETS and making any modifications as needed to ensure New Zealand meets its international climate change obligations and reduces emissions.

Agricultural research: New Zealand has a strong focus on researching ways to reduce emissions from agriculture production and it is an area where New Zealand can provide expertise. This has seen an enduring commitment to providing leadership in research, innovation and technical solutions to reduce greenhouse gas emissions from agriculture, and sharing this knowledge internationally. Notable achievements in the reporting period include:

- leading the establishment of the Global Research Alliance on Agricultural Greenhouse Gases with the aim of increasing international cooperation, collaboration and investment in agricultural research
- establishing the New Zealand Agricultural Greenhouse Gas Research Centre focusing on practical ways to reduce methane and nitrous oxide emissions while improving productivity.

Financial support: New Zealand remains committed to assisting developing countries to address climate change. New Zealand delivered on its fast-start finance commitment, providing NZ$30 million per annum over the three-year period 2010 – 2012. New Zealand has given and delivered on undertakings to continue to provide climate change related financial support to developing countries, with a focus on renewable energy in the Pacific.

Public awareness campaigns: The Government actively supports initiatives that encourage public awareness of climate change. Over the past four years, the Government has run a

4 The stationary energy sector includes all fossil fuels (gas and coal) used in electricity generation and in the direct production of industrial heat, as well as geothermal energy.

number of public awareness campaigns, including household and vehicle energy efficiency campaigns, greenhouse gas reduction certification schemes, tools for measuring emissions, and environmental awards.

Research on impacts, adaptation and vulnerability: During the reporting period the Government has funded research relating to the impacts of climate change in a range of subject areas. In particular, research has focused on the land-based sectors and the built environment. The Government has undertaken work to identify vulnerabilities in the tourism and transport sectors. New Zealand has committed investment towards a four year research project investigating community vulnerability to climate change.

International engagement: New Zealand engages widely at the international level to address climate change. In addition to participating actively in IPCC working groups and UNFCCC negotiations, New Zealand contributes to a number of scientific organisations and plurilateral initiatives. For example, New Zealand is active in international efforts to eliminate fossil fuel subsidies and is a member of the Friends for Fossil Fuel Subsidy Reform group.

Carbon dioxide removal from forests: New Zealand's net emissions are significantly affected by carbon dioxide removals from the planted forest estate. Planted forest in New Zealand covers 2.1 million hectares of land and makes up 21% of the total forest cover. Extensive forest planting on pastoral land in the early 1990s has partially offset New Zealand's greenhouse gas emissions.

New Zealand's greenhouse gas emissions

New Zealand remains committed to transparent, accurate and regular national greenhouse gas inventory reporting as a critical activity to support effective mitigation. New Zealand actively seeks to improve available data to support meeting reporting obligations. In 2011, (the most recent year of available data) New Zealand's gross emissions[5] were 72,834.9 Gg CO_2-e, an increase of 22 percent since 1990. New Zealand's net emissions[6] were 59,294.7 Gg CO_2-e, an increase of 88 per cent since 1990.

Greenhouse gas emissions projections

New Zealand uses projections to anticipate future emissions.[7] Projections of emissions and removals are useful but inherently uncertain. Economic variables such as commodity and oil prices, the assumed carbon price, the assumed rate of afforestation and deforestation, and the harvest age of forests have significant effects on projected emissions and removals. Seasonal changes, especially variation in rainfall can affect agriculture emissions. There is also

5 Gross emissions reported under the UNFCCC and under the Kyoto Protocol are emissions from five sectors: energy, industrial processes, solvents, agriculture and waste.

6 Net emissions under the UNFCCC are gross emissions plus emissions and removals from the land-use, land-use change and forestry sector (LULUCF)

7 Emissions projections in National Communication reports are calculated using reporting rules under the UNFCCC, as required by reporting guidelines. In contrast, New Zealand's Kyoto Protocol projections, and emission reduction targets, are based on emissions calculated under the Kyoto Protocol framework of rules. As a result, the projections here are not strictly relevant to New Zealand's emissions reductions targets.

uncertainty in the methodology to estimate emissions from biological sources such as agriculture and forestry.

Based on current data, projections show that New Zealand's gross emissions are projected to gradually increase. New Zealand's net emissions are also projected to increase. Given the influence of forests on New Zealand's emissions, net emissions at any given point in time will be strongly influenced by the planting and harvesting cycles of New Zealand's planted forest in the LULUCF sector (Figure 1.1).

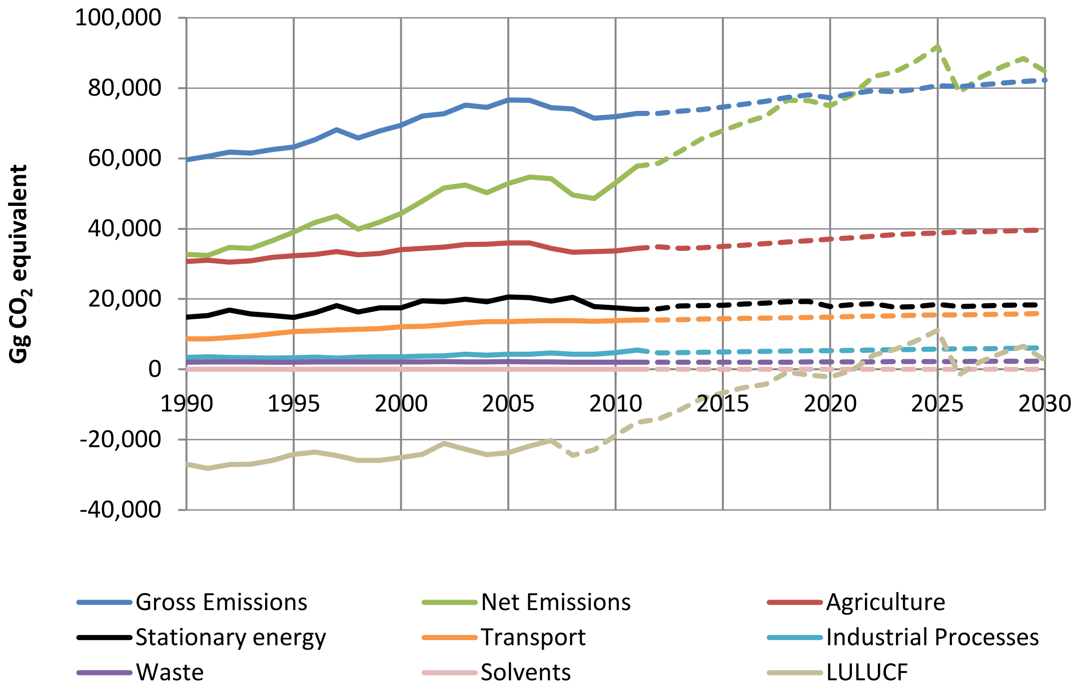


Figure 1.1: New Zealand's actual and projected emissions 1990 – 2030 under the UNFCCC

Note: Gross emissions exclude the LULUCF (forestry) sector. LULUCF projections are based on a mid-point emissions scenario.

Plantation forestry is expected to temporarily transition from a net sink to a net source of emissions sometime around 2020. This is because forests planted in the late 1980s and early 1990s will be harvested for timber production around this time, as part of the managed forestry cycle. The forestry sector is expected to revert to a net carbon dioxide sink in the late 2030s, once the forests are replanted and the trees have matured enough to absorb enough carbon dioxide to act as a net sink.

These projections assume that New Zealand's natural forests are in a steady state with respect to carbon dioxide emissions, that is, neither a sink nor a source. This assumption is currently being reassessed. Projections of net emissions will be subject to change depending on the final outcome of this analysis.

Comparisons of New Zealand's projected net emissions 'with measures' and 'without measures' can be used to show some, but not all, of New Zealand's policies and measures. [8] As a result, the difference between the 'with measures' scenario and the 'without measures' scenario does not demonstrate the full impact of the Government's policies and measures. For example, New Zealand's investment in agricultural research will reduce domestic and global agriculture emissions, but the benefits cannot be predicted and are not included in emission estimates until proven. Projections show that New Zealand's policies and measures are estimated to avoid 9,810.0 Gg CO_2-e emissions in 2020, and 3,624.3 Gg CO_2-e emissions in 2030 (figure 1.2).

Figure 1.2 shows that the gap between projected emissions 'with measures' and 'without measures' varies over time. This effect arises because the NZ ETS is expected to change the timing of forestry harvesting cycle decisions versus the 'without measures' projection. Emissions reductions achieved also depend in part on the price of carbon faced by NZ ETS participants, which is related to the international price. New Zealand anticipates that the carbon price will rise as progress is made in international negotiations on a new post-2020 global agreement and countries set more ambitious emission reduction targets.

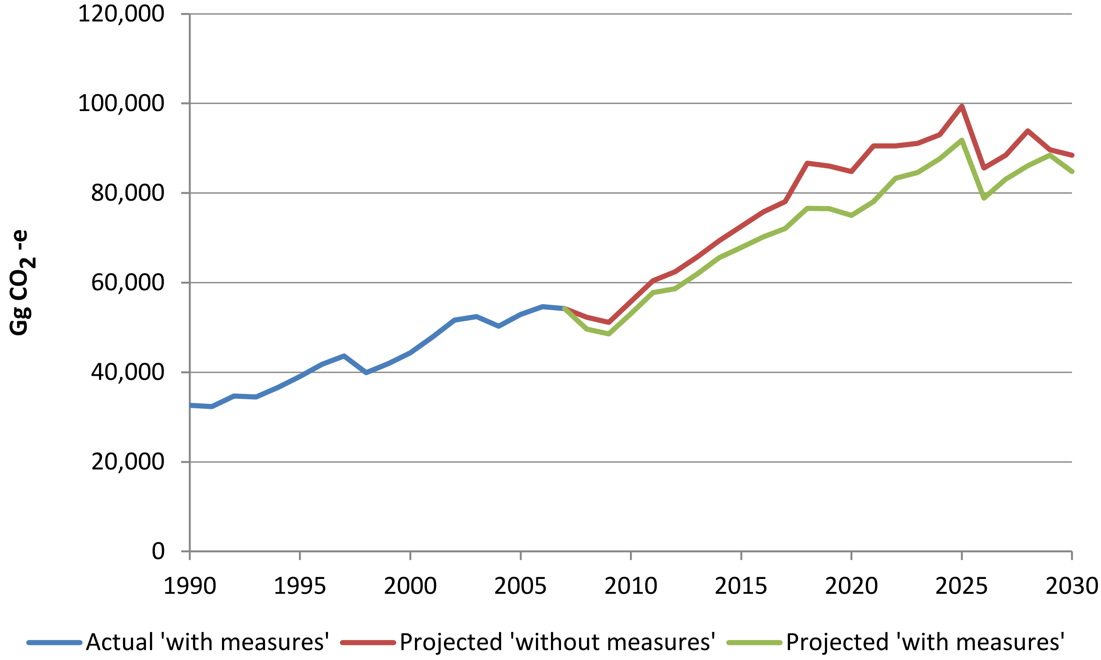


Figure 1.2: Actual and projected net emissions, with measures versus without measures, 1990 – 2030

Note: Projections start at 2008 because forestry data from 2008–2012 will not be confirmed until 2014.

[8] It is not possible to quantify the effect of all types of measures in the projections. Consequently, the 'with measures' scenario includes only the modelled impacts of the NZ ETS, Government afforestation grant schemes and the National Environmental Standard to control methane emissions from landfills. The 'with measures' scenario does not include the impact of policy measures such as investment in research. It is also not possible to isolate the impact of Government policies and measures on energy efficiency, so both the 'with measures' and 'without measures' scenarios assume the same energy efficiency trends.

Report structure

This *Sixth National Communication* provides a snapshot of New Zealand's progress in implementing its commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. It covers the period from the submission of the *Fifth National Communication* in 2009 through to the end of December 2013. This *Sixth National Communication* document also contains New Zealand's *Report on the Global Climate Observing System*.

New Zealand's *Sixth National Communication* provides information on:

- national circumstances to provide context for New Zealand's emissions (Chapter 2)
- New Zealand's latest greenhouse gas emissions and trends (Chapter 3)
- policies and measures in place to address climate change (Chapter 4)
- projections of New Zealand's greenhouse gas emissions (Chapter 5)
- climate change impacts on New Zealand and vulnerability and adaptation work (Chapter 6)
- the financial assistance and technology transfer New Zealand gives to other countries (Chapter 7)
- research and systematic observation (Chapter 8)
- education, training and public awareness campaigns (Chapter 9)
- New Zealand's *Report on the Global Climate Observing System*.

2

National circumstances

2 National circumstances

Key points

- New Zealand is a long, mountainous country in the Pacific Ocean with a temperate but variable climate.
- Due to the small but widely distributed estimated population of 4.4 million people, roads are the main form of transport.
- New Zealand has an export-dependent economy based on the services, manufacturing and primary sectors.
- New Zealand's highly efficient agricultural system is fundamental to the economy, and products are exported to countries all over the world.
- The majority of electricity generation comes from renewable sources – primarily hydro, geothermal and wind.
- Total emission numbers and trends are susceptible to year-to-year variation due to localised events.
- Historical forest planting and the resulting planting and harvesting cycles will affect New Zealand's plantation forestry emissions profile well into the future.

2.1 Geographic profile

New Zealand is a long, narrow, mountainous country. It consists of two large islands, the North Island and the South Island, and a number of smaller islands. It is located in the southwest Pacific Ocean between 33° and 55° south latitude. The nearest large land mass (Australia) is more than 2,000 kilometres away.

New Zealand has a combined land area of around 27 million hectares and is similar in size to Japan or the United Kingdom. Its coastline is one of the longest in the world (at 15,000 kilometres) and, in some places, is the most deeply indented. New Zealand's Exclusive Economic Zone is also one of the largest in the world. Combined, the Exclusive Economic Zone and New Zealand's territorial sea cover 4.4 million square kilometres.

New Zealand straddles the boundary of the Pacific and Indo-Australian tectonic plates. The resulting earth movements have produced hilly and mountainous terrain over two-thirds of the land. There are frequent earthquakes in most parts of the country (see 'The Canterbury earthquakes', below). There is also a zone of volcanic and geothermal activity in the central North Island.

The Canterbury earthquakes

The Canterbury earthquakes are an example of how local events can affect New Zealand's emissions. Two major earthquakes occurred in the Canterbury region in the South Island on 4 September 2010 and on 22 February 2011, followed by a series of aftershocks. The magnitude 7.1 September earthquake occurred at night, and caused some damage but no loss of life. The magnitude 6.3 February earthquake caused widespread damage in the Canterbury region, particularly in the central and eastern parts of Christchurch City. One hundred and eighty five lives were lost.

The earthquakes had further consequences for New Zealand and its emissions, including:

- cancellation of the 2011 census
- impacts on the economy
- reduced electricity use.

These are explained further in the relevant sections below.

After New Zealand's land mass broke away from the continents, plants and animals evolved in isolation for millions of years, almost entirely without the presence of mammals. As a result, New Zealand's biodiversity is unique, with a huge diversity of birdlife and a high number of species found nowhere else in the world.

Today, grassland for agriculture, natural forest and plantation forestry are New Zealand's main land uses (figure 2.1). Around one-third of New Zealand's land is protected for conservation purposes.

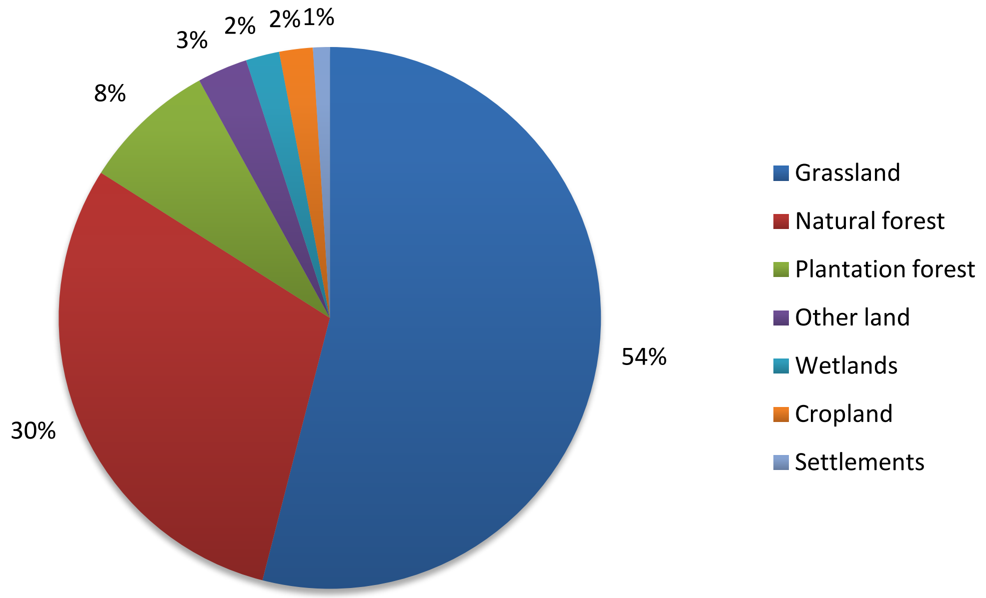


Figure 2.1: Land cover in New Zealand, 2011

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Wellington: Ministry for the Environment.

2.2 Population profile

According to the 2006 census, the New Zealand population was 4.1 million[9] and by September 2012 this was estimated to have grown to 4.4 million people.[10] The majority of the population is highly urbanised and 77 per cent live in the North Island. The largest city is Auckland, and 34 per cent of New Zealand's total population live within the Auckland region alone.[11] New Zealand's population density is relatively low, with 16 people per square kilometre.

Between 1951 and 2012 the population of New Zealand grew at an average rate of 1.3 per cent per year. Due to falling fertility rates and an ageing population the population growth rate has been slowing. In the decade ending in 2012 population growth averaged 1.2 per cent per year. By the 2030s it is projected to slow to 0.6 per cent per year. The New Zealand population is projected to reach 5.4 million in 2036 and 6 million in 2061.[12]

Net migration (the number of permanent and long-term migrants entering New Zealand, minus those leaving) has varied greatly over the years as a result of legislative and economic factors, both in New Zealand and overseas. In the 5 years to June 2013 the net number of migrants was 37,602.[13]

Census data

Following the census in 2006 the next census was scheduled for March 2011. However, much of the census operation was run out of Christchurch city, which was severely damaged in the Canterbury earthquake of February 2011. As a result, the 2011 census was cancelled. It was instead carried out in March 2013 with the results becoming available from October 2013 onwards.

9 Statistics New Zealand. 2007. QuickStats about New Zealand's Population and Dwellings. Retrieved from http://www.stats.govt.nz/Census/2006CensusHomePage/QuickStats/quickstats-about-a-subject/nzs-population-and-dwellings.aspx

10 Statistics New Zealand. 2012. National Population Estimates: September 2012 Quarter. Retrieved from http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalPopulationEstimates_HOTPSep12qtr.aspx

11 Statistics New Zealand. 2012. Subnational Population Estimates: At 30 June 2012. Retrieved from http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/SubnationalPopulationEstimates_HOTPYe30Jun12.aspx

12 Statistics New Zealand. 2012. National Population Projections: 2011(base)–2061. Retrieved from http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalPopulationProjections_HOTP2011.aspx

13 Statistics New Zealand. 2013. International Travel and Migration: June 2013 – Tables. Retrieved from http://www.stats.govt.nz/browse_for_stats/population/Migration/IntTravelAndMigration_HOTPJun13.aspx

2.3 Climate

2.3.1 Current climate

New Zealand has climate zones ranging from subtropical to subantarctic. The climate is heavily influenced by New Zealand's location in a latitudinal zone with prevailing westerly winds and by the surrounding ocean. It is also influenced by mountain chains that modify the weather systems as they sweep eastward. This leads to more rainfall in the west and drier conditions in the east.

The average rainfall in most urban areas is between 600 and 1600 millimetres a year.[14] In the mountain ranges annual rainfall often exceeds 5 metres, and in the Southern Alps annual rainfall can be more than 10 metres a year. However, areas to the east of the main ranges have an average rainfall of less than 600 millimetres a year.[15]

Average annual temperatures range from 10°C in the southern part of New Zealand to 16°C in the north. For the most part, variations between summer and winter temperatures are relatively small. Greater temperature variations (up to 14°C) do occur inland and to the east of the ranges.[14] New Zealand's average annual temperature has increased by about 1°C over the past century.

2.3.2 Projected changes in climate

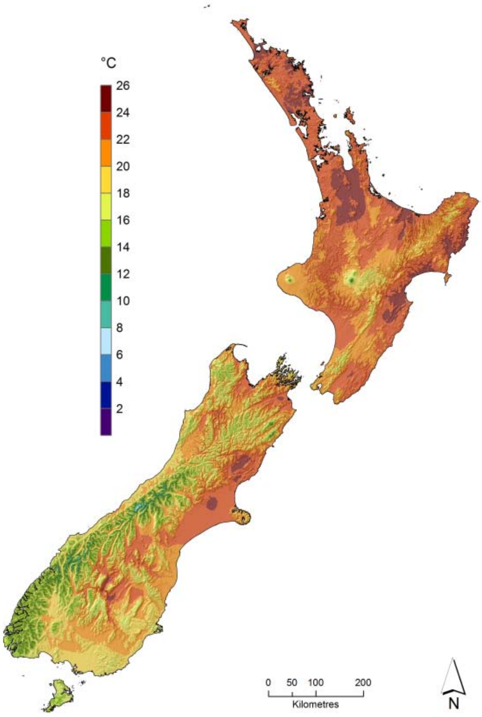
Climate change scenarios suggest that New Zealand's average annual temperature could rise by about 1°C by 2040 and 2°C by 2090, relative to 1990.[16] According to a mid-range scenario, average annual rainfall is expected to increase in the west by up to 5 per cent by 2040 and 10 per cent by 2090. It is expected to decrease in the east and north, up to 5 per cent less in places, by 2090.

---

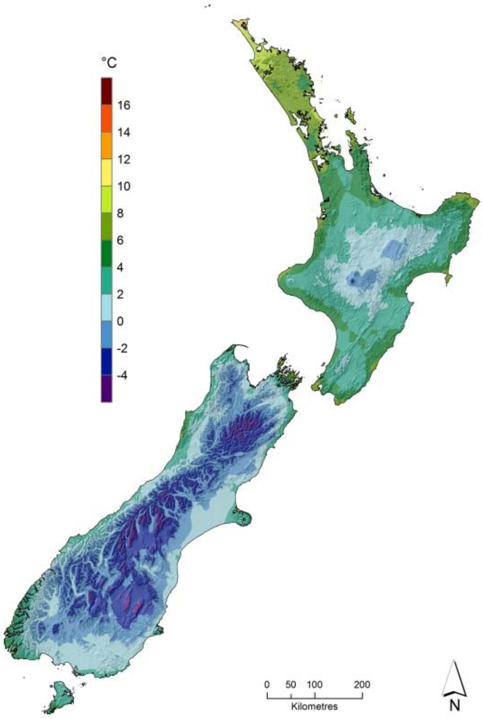
14 National Institute of Water and Atmospheric Research (NIWA). *Overview of New Zealand Climate*. Retrieved from http://www.niwa.co.nz/education-and-training/schools/resources/climate/overview

15 Ministry for the Environment. 2007. *Environment New Zealand 2007*. Wellington: Ministry for the Environment.

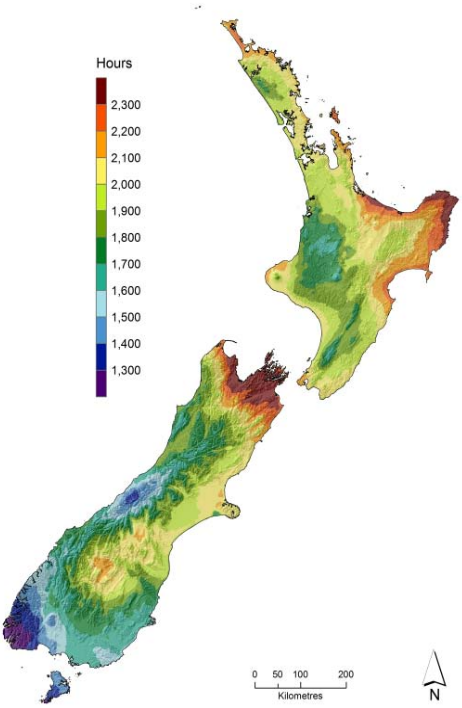
16 Ministry for the Environment. 2008. *Climate Change Effects and Impacts Assessment*. Wellington: Ministry for the Environment.



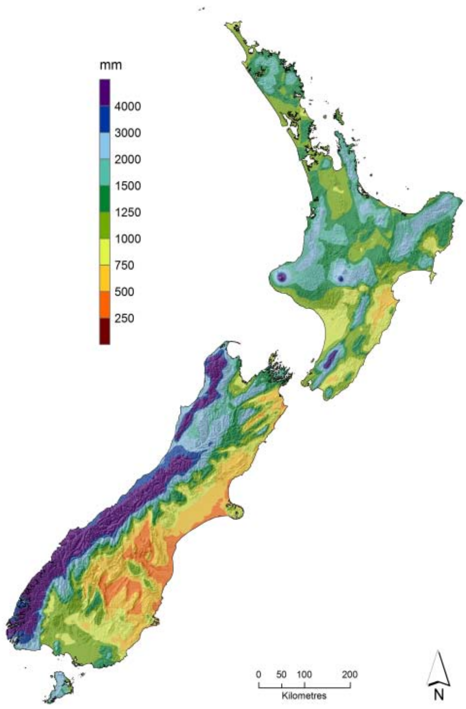
Maximum daily temperature (mid-summer median)



Minimum daily temperature (mid-winter median)



Sunshine hours (annual median)



Rainfall (annual median)

Figure 2.2: Median values for New Zealand’s climate, 1981 – 2010

Source: NIWA

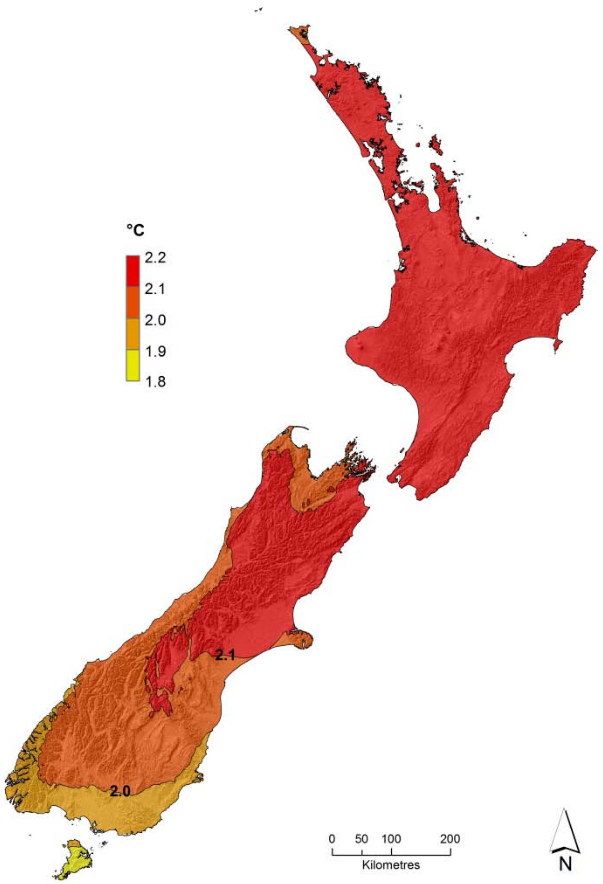


Figure 2.3: Projected annual mean temperature change between 1980 – 1999 and 2080 – 2099

Source: NIWA

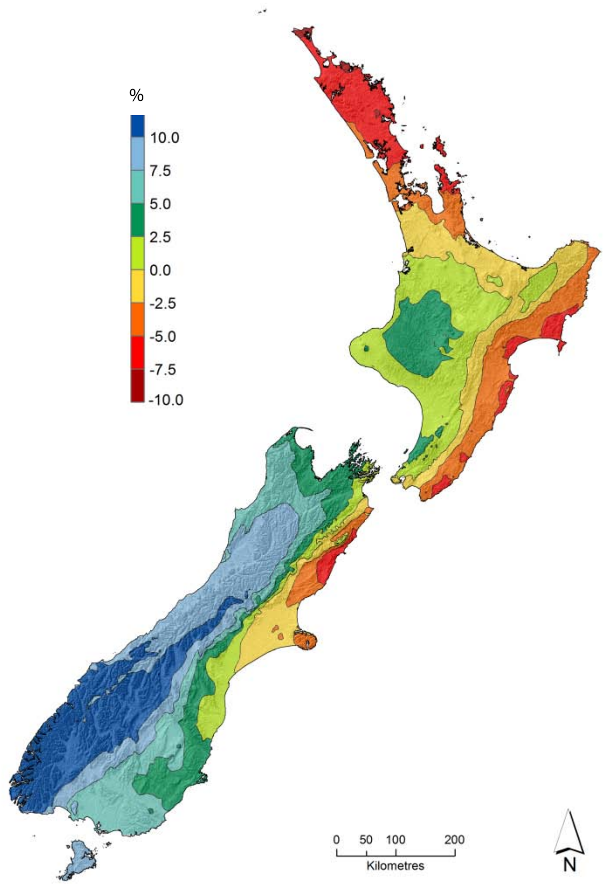


Figure 2.4: Projected annual mean precipitation change between 1980 – 1999 and 2080 – 2099

2.4 Government structure

2.4.1 Central government

New Zealand's central government is formed from a democratically elected House of Representatives. The Government advises New Zealand's head of state, Queen Elizabeth II (the Sovereign). The Queen is the source of all executive legal authority in New Zealand but acts on the advice of the Government in all but the most exceptional circumstances. This system is known as a constitutional monarchy. The Queen is represented in New Zealand by a Governor-General, currently Lt Gen Rt Hon Sir Jerry Mateparae.[17]

Parliament consists of the House of Representatives and the Sovereign. The principal functions of Parliament are to enact laws and to hold the Government to account over its policies, actions and spending. Since 1996 members of Parliament have been elected using the Mixed Member Proportional representation system. There are currently eight political parties with parliamentary representation.

2.4.2 Local government

New Zealand has a system of local government comprising 78 local authorities. Due to devolved decision-making, local authorities are largely independent of the central executive government. Local authorities fall into two main tiers: regional councils and territorial authorities (city and district councils). They have their own sources of income independent of central government, derived from taxes on land and property and council-owned enterprises.

The purpose of the Local Government Act 2002 is for local government to promote the social, economic, environmental and cultural well-being of communities and to enable democratic decision-making. A sustainable development approach and community planning are cornerstones of the Local Government Act. This Act requires local authorities to consult communities on their desired outcomes and prepare long-term Council Community Plans. The activities of local government include the provision of utility services, recreational assets, transportation services, and land and resource management. [18]

Local authorities have the primary responsibility for regulating resource use in New Zealand. The mandate for this derives from a range of legislation, but in particular the Resource Management Act 1991. This Act integrated the provisions of more than 75 earlier laws and is founded on the principle of sustainable management of natural and physical resources. The Resource Management Act has undergone several reviews and amendments to keep up with changing needs and circumstances.

2.5 Building stock and urban structure

There were 1.5 million occupied dwellings (7000 of which were public dwellings and the rest private) and 173,000 unoccupied dwellings recorded in the 2006 census. That year there was

[17] See http://www.gg.govt.nz

[18] More information on the role of local government bodies can be found at http://www.localcouncils.govt.nz/

an average of 2.7 people per dwelling. Seventy-seven per cent of occupied dwellings were separate houses, 17 per cent were two or more flats or apartments joined together, and the remaining 6 per cent were a mixture of other types of dwellings including holiday homes, mobile homes and improvised dwellings.[19]

In March 2013 the number of private and unoccupied dwellings was estimated to be 1.8 million. This estimate does not take into account the impacts of the Canterbury earthquakes, as the net impact of the earthquakes on total dwelling numbers has not been assessed.[20]

2.6 Economy

New Zealand has an export-dependent economy operating on free market principles. For the year ended March 2013 New Zealand's nominal gross domestic product (GDP) was NZ$211.5 billion (US$145.9 billion) and the nominal GDP per capita was NZ$47,600.[21,22] The economy has grown at an average annual rate of 2.6 per cent since 1990.

The economy is largely based on the provision of services (roughly two-thirds of the total GDP) and the manufacturing and primary sectors. The primary sector (agricultural, horticultural, forestry, mining and fishing industries) plays a fundamental role, particularly in the export sector and in employment. This sector contributed 8 per cent to New Zealand's GDP in the year ending March 2013.[21] It contributes around three quarters of New Zealand's total export earnings.[23] In 2012 the primary sector employed 114,610 people.[24,25]

---

19 Statistics New Zealand. 2007. QuickStats about Housing. Retrieved from http://www.stats.govt.nz/Census/2006CensusHomePage/QuickStats/quickstats-about-a-subject/housing.aspx

20 Statistics New Zealand. 2013. Dwelling and Household Estimates. Retrieved from http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/dwelling-and-household-estimates.aspx#dwellings. Estimate does not include public dwellings.

21 Statistics New Zealand. 2013 Gross Domestic Product: March 2013 Quarter. Retrieved from http://www.stats.govt.nz/browse_for_stats/economic_indicators/GDP/GrossDomesticProduct_HOTPMar13qtr.aspx

22 OECD. 2013. Economics: Key Tables from the OECD 11: Purchasing Power Parities for GDP. August 2013. Retrieved from http://www.oecd-ilibrary.org/economics/purchasing-power-parities-for-gdp-2013-8_ppp-gdp-table-2013-8-en

23 Statistics New Zealand. Global New Zealand – International Trade, Investment and Travel Profile. Year ended December 2012. Retrieved from http://www.stats.govt.nz/browse_for_stats/industry_sectors/imports_and_exports/global-nz-dec-12.aspx

24 Approximately 5 per cent of the 2.22 million people in employment in 2012. See http://www.stats.govt.nz/browse_for_stats/snapshots-of-nz/nz-in-profile-2013/labour-force.aspx

25 Statistics New Zealand. New Zealand Business Demography Statistics: At February 2012. Retrieved from http://www.stats.govt.nz/browse_for_stats/businesses/business_characteristics/BusinessDemographyStatistics_HOTPFeb12.aspx

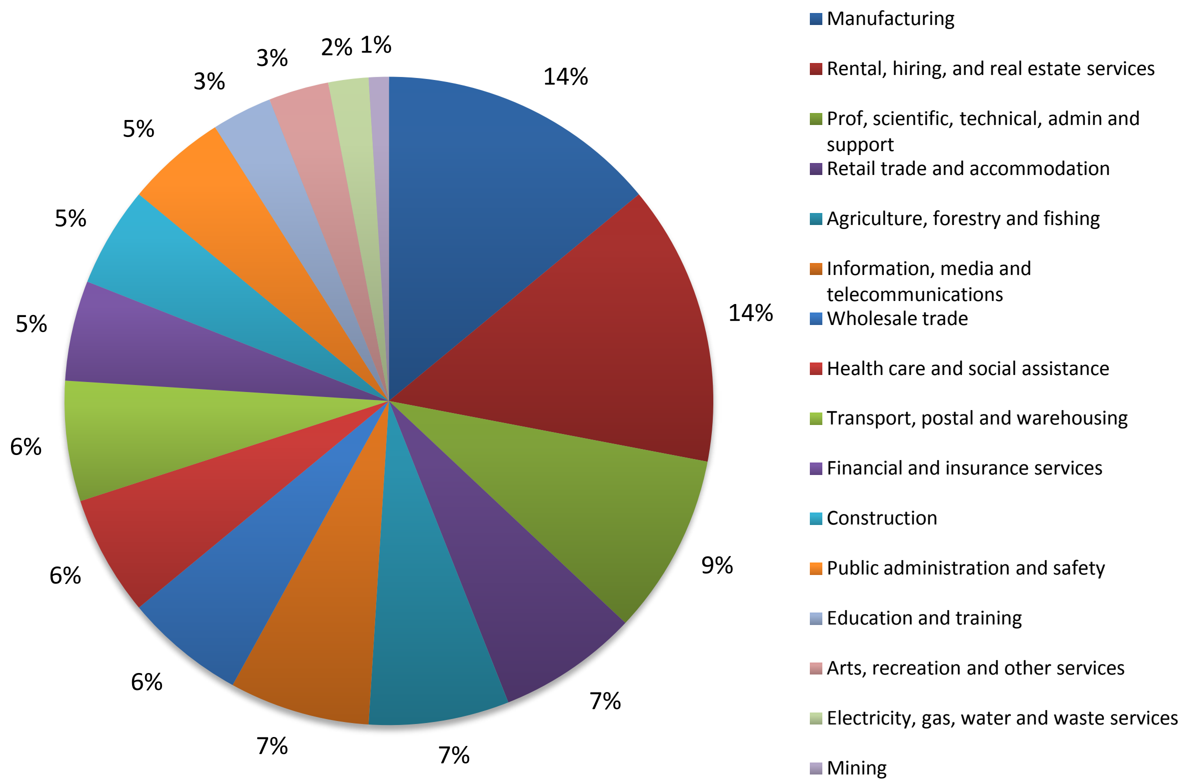


Figure 2.5: Contribution of different sectors to New Zealand's GDP

Source: Statistics New Zealand, GDP data from financial year ended March 2013.

The economic importance of the primary sector means that climatic conditions can have a significant effect on New Zealand's economy. Droughts led to a reduction in agricultural productivity over the summer and autumn of 2007/08 and the summer of 2013. The 2007/08 drought cost the economy NZ$2.8 billion dollars and the 2013 drought NZ$1.5 billion dollars.[26, 27] Droughts do, however, result in reduced greenhouse gas emissions.

Tourism is also an important source of income for New Zealand, directly contributing NZ$6.2 billion (3.3 per cent) to New Zealand's GDP.[28] There were 2.58 million overseas visitor arrivals in the year ended February 2013. The most important sources of visitors to New Zealand over this period were Australia, China, the United Kingdom, the United States and Japan.[29]

---

26 Ministry for Primary Industries. 2009. *Regional and National Impacts of the 2007–2009 Drought.* Retrieved from http://www.mpi.govt.nz/news-resources/publications.aspx?title=Regional%20and%20national%20impacts%20of%20the%202007-2009%20drought

27 The Treasury. *Budget Economic and Fiscal Update 2013.* Retrieved from http://www.treasury.govt.nz/budget/forecasts/befu2013

28 Ministry of Business, Innovation and Employment (MBIE). 2013. *Key Tourism Statistics*. Retrieved from http://www.med.govt.nz/about-us/publications/publications-by-topic/tourism-publications/key-tourism-statistics

29 Statistics New Zealand. *International Travel and Migration: February 2013*. Retrieved from http://www.stats.govt.nz/browse_for_stats/population/Migration/IntTravelAndMigration_HOTPFeb13.aspx

Like other countries, New Zealand was affected by the global financial crisis. In early 2008 the New Zealand economy entered a recession and New Zealand experienced negative economic growth until mid-2009. As a result of the economic downturn, emissions from transport and energy fell in 2009. Emissions from manufacturing, and particularly from freight, were lower because fewer goods needed to be transported. During 2010 growth was led by strong demand for exports. Growth in the year ending March 2011 rose 1.6 per cent despite the occurrence of the Canterbury earthquakes in September 2010 and February 2011. Growth continued at 1.9 per cent in the year ending March 2012.

The Canterbury economy has shown resilience to the impacts of the earthquakes. The total cost of the rebuild from the Canterbury earthquakes is estimated to be around NZ$40 billion.[30] Much of this cost is covered by private insurance, reinsured by overseas insurance providers, and public insurance in the form of the Government-owned Earthquake Commission. The rebuild is expected to help drive economic growth over the next 5 to 10 years.[27,31]

2.6.1 Exports

New Zealand’s goods exports were valued at NZ$46.1 billion for the year ended December 2012. Australia continued to be New Zealand’s primary export market, worth NZ$9.9 billion, followed by China (NZ$6.9 billion) and the United States (NZ$4.2 billion).[32]

New Zealand is the world’s largest single-country exporter of dairy products and sheep meat. It is also a significant player in the kiwifruit, pip fruit and wool industries. Some 85 per cent of New Zealand’s total food production goes to the international market. Dairy products were New Zealand’s largest export earner in the year ending December 2012, accounting for 25 per cent of exports at NZ$11.6 billion. In the same year meat products and wood products were New Zealand’s next two largest exports, accounting for 11 per cent and 7 per cent of total exports, respectively. This was followed by mineral fuels and oils (5 per cent) and machinery (4 per cent).

2.6.2 Imports

New Zealand’s goods imports were valued at NZ$47.2 billion in the year ending December 2012. China is now New Zealand’s largest source of imports, accounting for 16 per cent of the total, followed by Australia (15 per cent) and the United States (9 per cent).[32] Mineral fuels and oils were New Zealand’s most valuable imported products in the year to December 2012, accounting for 18 per cent of total imports. Other significant imports were machinery and vehicles, with 13 per cent and 10 per cent, respectively.[32]

---

30 This definition of cost is based on the value of investment required to repair and replace damaged capital assets. It includes the value of improvements to replaced assets. It does not include non-capital expenses and estimates of foregone business.

31 M Parker, D Steenkamp. 2012. The economic impact of the Canterbury earthquakes*. Reserve Bank of New Zealand: Bulletin* 75(3). Retrieved from http://www.rbnz.govt.nz/research/bulletin/ 2012_2016/sep2012.html

32 Statistics New Zealand. *Global New Zealand – International Trade, Investment and Travel Profile*. Year ended December 2012. Retrieved from http://www.stats.govt.nz/browse_for_stats/ industry_sectors/imports_and_exports/global-nz-dec-12.aspx

2.7 Energy

New Zealand's total primary energy supply was 845 petajoules in 2012.[33] Of this, renewable energy contributed 37 per cent, compared with around 30 per cent for most of the last 20 years. The remainder of the primary energy supply was dominated by oil (33 per cent) and gas (21 per cent).[34]

Since 1990 New Zealand's GDP has grown at a far greater rate than the amount of energy used by consumers. The overall energy intensity of the economy improved, in real terms, at an average of 1.4 per cent per year between 1990 and 2012. In 2011 New Zealand's energy sector (including transport) contributed 43 per cent of New Zealand's total domestic greenhouse gas emissions.

2.7.1 Electricity

New Zealand has abundant renewable energy resources and a long history of renewable energy development. As a result, the majority of New Zealand's electricity generation comes from renewable sources (73 per cent in 2012). In 2012 hydro generation provided 53 per cent of New Zealand's total electricity, followed by geothermal (14 per cent), wind (5 per cent) and bioenergy (1 per cent). The remaining 27 per cent was provided by fossil fuel thermal generation plants using gas, coal and oil (figure 2.6).

Due to the abundance of renewable energy, New Zealand's electricity generation emissions per capita are low compared with many other countries. In 2011 electricity generation contributed 8 per cent of New Zealand's total greenhouse gas emissions, an increase of 40 per cent since 1990.[35]

---

33 The most recent data available has been referenced. For energy statistics, the most recent data is from 2012. For emissions this is the 2011 inventory.

34 MBIE. 2013. *Energy in New Zealand 2013.* Wellington: MBIE.

35 MBIE. *Energy Greenhouse Gas Emissions: 2011 Calendar Year Edition*. Retrieved from http://www.med.govt.nz/sectors-industries/energy/energy-modelling/publications/energy-greenhouse-gas-emissions

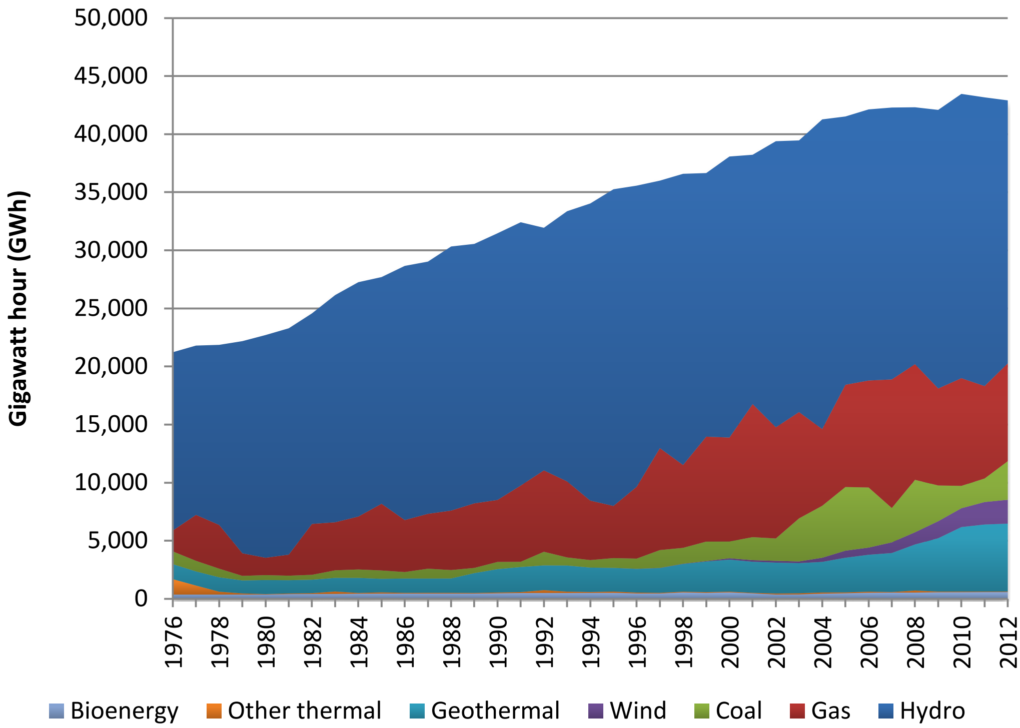


Figure 2.6: Electricity generation, by fuel type, 1976 – 2012

Source: Ministry of Business, Innovation and Employment. 2013. *Energy in New Zealand 2013.* Wellington: Ministry of Business, Innovation and Employment.

The proportion of electricity that is generated by hydro power each year changes depending on the rainfall. In a dry year, low rainfall affects the majority of New Zealand's hydro lake levels. During these years the shortfall is made up by non-renewable electricity generation. Figure 2.7 shows the close inverse relationship between non-renewable and hydro generation. This relationship has historically influenced the yearly fluctuations seen in New Zealand's total energy and total greenhouse gas emissions. Figure 2.7 also shows that the amount of electricity generated by renewable sources other than hydro power has more than tripled since 1990.

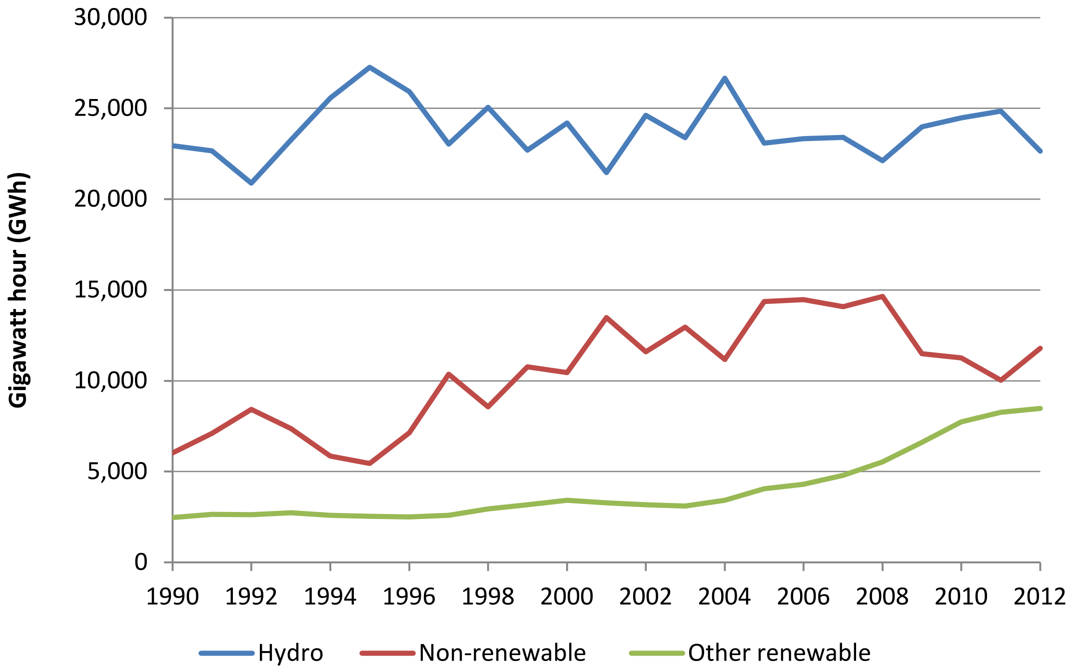


Figure 2.7: New Zealand's hydro-electric, other renewable and non-renewable electricity generation, 1990–2012

Source: Ministry of Business, Innovation and Employment. 2013. *Energy in New Zealand 2013.* Wellington: Ministry of Business, Innovation and Employment.

Because of the relatively small size of New Zealand's population and electricity use, local events can cause variation in electricity emissions from year to year. The Canterbury earthquakes are an example of this as they contributed to reduced emissions from electricity generation between 2010 and 2011. Demand for electricity in Canterbury was reduced because of people leaving the region. It was also due to earthquake damage to infrastructure, resulting in the closure or demolition of much of the Christchurch central business district.

The electricity industry has gone through a long process of reform. Competition in the generation sector was first introduced in 1996 with the establishment of a wholesale electricity market. Wholesale electricity is sold by generators and bought by retailers and large industrial users under rules that are now administered by the Electricity Authority, an independent regulator.

The national transmission grid is operated by Transpower, a state-owned enterprise, and there are currently 29 distribution network businesses with a variety of ownership structures. Economic regulation of Transpower and 17 distribution businesses that are not consumer-owned is administered by the Commerce Commission. Electricity consumers can choose between competing suppliers of electricity. There are currently five main generation companies providing around 92 per cent of New Zealand's total electricity generation in 2012. One of these is a state-owned enterprise, two are private companies and two are under mixed state and private ownership.

2.7.2 Gas

Natural gas is produced in the Taranaki region and transmitted by pipelines across the North Island to various distribution networks. In 2012 New Zealand produced 192 petajoules of gas from 17 gas fields. Of New Zealand's total consumption in 2012 (179 petajoules), the largest proportion (44 per cent) was used for electricity generation, followed by industrial use (27 per cent) and as a feedstock for petrochemicals (19 per cent). The remainder was used by the commercial and residential sectors, and the agriculture, forestry and fishing industries.[36]

In 2011 gas contributed 9 per cent of New Zealand's total greenhouse gas emissions. Between 1990 and 2011 emissions from gas consumption decreased by 3 per cent.[35]

2.7.3 Oil

New Zealand is a net importer of oil. In 2012 it had a 'self-sufficiency' indicator for oil of 31 per cent, down from 36 per cent in 2011.[37] Due to its high quality, and consequent high value, almost all of New Zealand's crude oil (98 per cent in 2012) is exported. Most of the refined oil consumed in New Zealand (about 70 per cent in 2012) has been imported and refined domestically.

In 2012 New Zealand produced 87 petajoules (or 40,300 barrels per day) of oil from 19 fields in the Taranaki region. In recent times oil production has generally consisted of 52 per cent crude, 46 per cent condensate and 2 per cent naphtha. The domestic oil sector consists of a number of oil-producing companies, one refinery, five wholesalers, a range of independent distributors and five main oil retailers.

In 2011 oil contributed 25 per cent of New Zealand's total greenhouse gas emissions. Between 1990 and 2011 emissions from oil increased by 50 per cent.[35]

2.7.4 Coal

Currently a net exporter of coal, New Zealand produced 4.9 million tonnes of coal in 2012. Of this, 46 per cent was bituminous (premium coal), 47 per cent was sub-bituminous and the remainder was lignite (low grade). Around half of local production was exported, and most of this was bituminous coal. New Zealand has an estimated 15 billion tonnes of coal deposits, with lignite making up 80 per cent of this.

In 2012 New Zealand consumed 3.2 million tonnes of coal. The coal was mainly used for electricity generation and industrial purposes. Coal consumption contributed 5 per cent of New Zealand's total greenhouse gas emissions in 2011. Between 1990 and 2011 emissions from coal increased by 16 per cent.[35]

Because of the small size of New Zealand's coal-mining industry, local changes in mining operations can lead to a variation in emissions from year to year.[38] The closing of two coal

---

36 MBIE. 2013. *Energy in New Zealand 2013*. Wellington: MBIE.

37 The 'self sufficiency indicator' is domestic production divided by observed consumption.

38 Emissions from coal mining are 'fugitive emissions' – those emissions that arise from the production, processing, transmission and storage of fuels, and from non-productive combustion.

mines resulted in a 30 per cent decrease in emissions from coal mining between 2010 and 2011.[39]

2.8 Transport

Road transport is the central element of New Zealand's transport system, reflecting New Zealand's small but widely distributed population and long, narrow geography. As a result, transport in New Zealand is energy intensive and relies on fossil fuels. In 2011 transport contributed 19 per cent of New Zealand's total domestic greenhouse gas emissions, an increase of 63 per cent from 1990.[40] The majority of these emissions are from road transport (figure 2.8). International aviation and shipping are critical due to New Zealand's isolated position in the Pacific Ocean and the importance of primary industry exports and tourism to the economy.

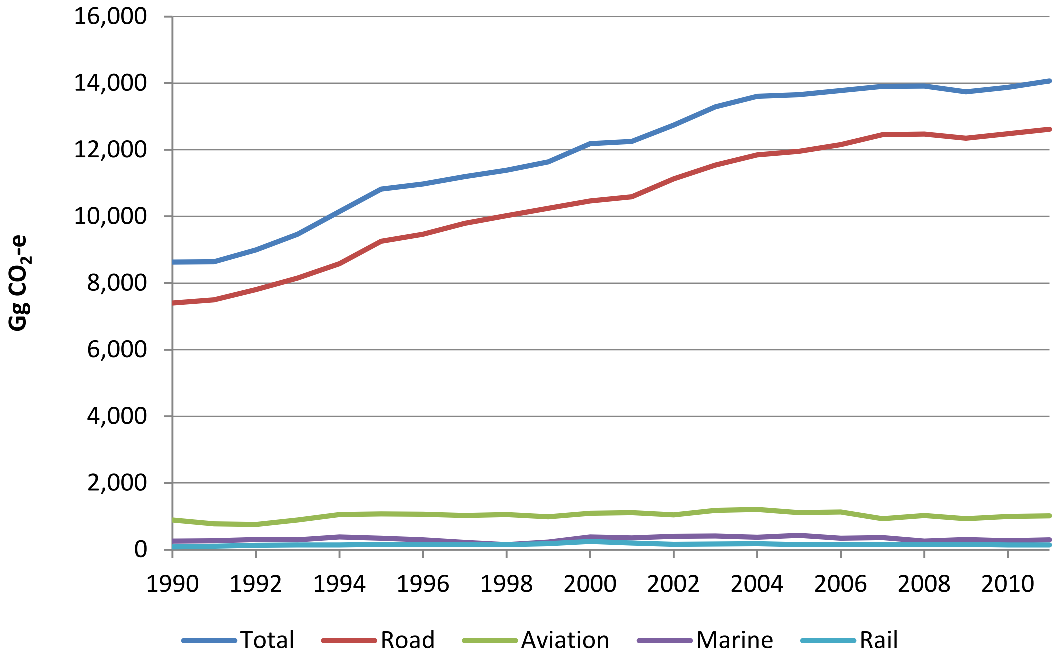


Figure 2.8: Transport emissions, by mode, 1990 – 2011

Source: Ministry of Business, Innovation and Employment. *Energy Greenhouse Gas Emissions: 2011 Calendar Year Edition.* Retrieved from http://www.med.govt.nz/sectors-industries/energy/energy-modelling/publications/energy-greenhouse-gas-emissions.

[39] Pike River Mine was sealed in January 2011 due to explosions in November 2010. Spring Creek Mine suspended its coal production from November 2010 to May 2011 to accelerate work on a safety improvement programme.

[40] Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Retrieved from http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2013/index.html

2.8.1 Road transport

Most New Zealanders (86 per cent) use private road transport to get to work.[41] Road transport also carries most of the domestic freight (70 per cent).[42] The majority of vehicles in New Zealand (over 90 per cent) are light vehicles (those that have a gross vehicle mass less than 3.5 tonnes). In 2012, 84 per cent of the light fleet was powered by petrol and 16 per cent by diesel.

In 2012 there were 3 million light vehicles in New Zealand – the equivalent of 682 light vehicles for every 1000 people. Between 2000 and 2007 the number of light vehicles increased significantly, but since 2007 it has changed little. This initial increase was due to the entry of a large number of used vehicles from Japan. Economic and import conditions have now changed, so this kind of increase is unlikely to be replicated.

The total annual distance travelled by all vehicles on roads increased from 2000 to 2007, when it peaked at 40.5 billion kilometres.

2.8.2 Aviation

Domestic aviation has increased, in part due to a reduction in the real cost of airfares and increased cost of road transport fuel. At the same time the fuel efficiency of air travel has increased due to higher load factors, advances in aircraft design and improvements in air traffic management for aircraft approaches to airports.

Almost all passenger travel to and from New Zealand is by air. There were 4,783,744 passenger arrivals into New Zealand in the year ended December 2012, an increase of 7 per cent since the year ended December 2007. Of the total arrivals, 53 per cent were overseas visitors, 45 per cent were returning New Zealanders, and the remainder were permanent and long-term migrants.[43]

Aviation is also essential for the export of time-sensitive goods, such as horticultural and seafood products. Freight movements by air make up 15 per cent of exports by value.

2.8.3 Maritime

Domestic shipping is relied on to transport some freight within New Zealand, including across Cook Strait. Some domestic shipping cargo is carried across Cook Strait, between the North and South Islands. Daily ferry services are operated by two competing companies using a total of five vessels (rail and road ferries). These ferries transport passengers and freight across Cook Strait, with a journey time of around three hours. There are a small number of passenger ferries operating in the coastal cities (predominantly Auckland), which provide commuter and recreational services.

---

41 Ministry of Transport. 2013. *Travel Patterns: Household Travel: Data from 2008–2012*. Retrieved from http://www.transport.govt.nz/ourwork/TMIF/Pages/TP006.aspx

42 Ministry of Transport. *Freight and the Transport Industry: Freight Volume: Data from 2006/07*. Retrieved from http://www.transport.govt.nz/ourwork/TMIF/Pages/FT008.aspx

43 Statistics NZ. 2013. *International Travel and Migration – information releases.* Retrieved from http://www.stats.govt.nz/browse_for_stats/population/migration/international-travel-and-migration-info-releases.aspx

International shipping is crucial to New Zealand's trading, carrying more than 99 per cent of imports and exports by weight.

2.8.4 Rail

The national rail network totals approximately 4,000 kilometres. The Government owns and controls the rail infrastructure and the majority of the locomotives and carriages. There are urban rail networks in both Wellington and Auckland, which provide approximately 22.1 million passenger trips annually: 11.3 million in Wellington and 9.9 million in Auckland.[44] Fifteen percent of freight moved within New Zealand is carried by rail. [45]

2.9 Agriculture

Agriculture in New Zealand is based on the pastoral farming of dairy cattle, beef cattle, sheep and deer. As at June 2012 there were 6.4 million dairy cattle,[46] 3.7 million beef cattle, 31.3 million sheep and 1.1 million deer.[47] New Zealand also produces a number of different horticultural products, including kiwifruit, pip fruit, wine, and fresh and processed vegetables.

New Zealand's temperate climate means that animals are fed on grass outside all year round and are rarely housed inside. There is limited but increasing use of supplementary feeds. In New Zealand the primary source of nitrogen is nitrogen fixation by legumes. Fertiliser also supplies a small amount of nitrogen. Between 1990 and 2011 there was a six-fold increase in the use of nitrogen-based fertiliser.

The climate is generally favourable for agriculture, but droughts can occur. Droughts reduced pasture production in 2007/08, and more recently in early 2013. This resulted in lower livestock performance and livestock numbers, and consequently lower greenhouse gas emissions. The effects of the 2013 drought on New Zealand's greenhouse gas emissions will be evident in the 2015 annual inventory submission for 1990 to 2013.

2.9.1 Agricultural exports

Agricultural exports accounted for over half of New Zealand's total goods export value in the year to December 2012. The highest-earning exports were dairy products, worth NZ$12.6 billion, and meat and meat products worth NZ$5.6 billion. Fruit and vegetables were worth NZ$2.3 billion, and wine was worth NZ$1.2 billion.[48]

---

44 Ministry of Transport. *Transport Volumes: Public Transport Volume: Data from 2011/12*. Retrieved from http://www.transport.govt.nz/ourwork/TMIF/Pages/TV020.aspx

45 Measured as net tonne kilometres, which means that it is the distance the freight travels as well as its weight that accounts for the 15 per cent.

46 Includes 5.0 million cows in calf or in milk.

47 Statistics New Zealand. *Agricultural Production Statistics – June 2012.* Retrieved from http://www.stats.govt.nz/browse_for_stats/industry_sectors/agriculture-horticulture-forestry/info-releases.aspx

48 Statistics New Zealand. *Global New Zealand – International Trade, Investment and Travel Profile*. Year ended December 2012. Retrieved from http://www.stats.govt.nz/browse_for_stats/industry_sectors/imports_and_exports/global-nz-dec-12.aspx

The top five export destinations for 2013 by value for dairy products, in order, were China, the United States, Japan, Australia and Saudi Arabia. Over the past decade there has been a shift in the composition of New Zealand's dairy export market due to greater demand for dairy products from countries in Asia, the Middle East and Africa.[49]

The top five export destinations by value for meat and meat products in 2013 were, in order, the United States, China, the United Kingdom, Germany and Japan.

2.9.2 Changes in the agricultural industry

Agriculture in New Zealand has undergone a transformation to become the highly competitive and efficient sector it is today. This transformation was triggered by the removal of agricultural subsidies in 1984. New Zealand's agricultural sector is now the least subsidised in the OECD.

Agricultural productivity improved substantially (by 34 per cent[50]) between 1990 and 2011 due to improvements in technology and animal breeding, the expansion of the average size of farms and improved animal and plant nutrition. There have also been changes in the proportions of the main livestock species farmed in New Zealand. From the early 1990s to the present dairy cow numbers grew while sheep numbers declined (figures 2.9 and 2.10). This was due to the relatively higher profitability of dairy products compared to sheep and beef products.

2.9.3 Emissions

High levels of agricultural activity mean almost half of New Zealand's emissions come from agriculture. This compares with an average of 12 per cent in other developed countries. Agricultural emissions increased by 12 per cent between 1990 and 2011. However, the share of agricultural emissions in total emissions and the emissions intensity of New Zealand's agricultural production have both declined. The share has decreased from 51 per cent in 1990 to 47 per cent in 2011. This decrease is due to decreases in livestock other than dairy cattle, such as the number of beef cattle and sheep in New Zealand and the increasing efficiency of producing dairy and meat products.

Between 1990 and 2011 these improvements in efficiency led to an 18 per cent decrease in emissions from dairy cattle per kilogram of milk solid. There was also a 23 per cent reduction in sheep emissions per kilogram of lamb and mutton, and a 27 per cent reduction in non-dairy (beef) emissions per kilogram of beef.[51]

---

49 Ministry for Primary Industries. 2013 *Situation and Outlook for Primary Industries 2013.* http://www.mpi.govt.nz/news-resources/news/situation-amp-outlook-for-primary-industries

50 Statistics New Zealand. 2013. *Industry Productivity Statistics: 1978–2011*. http://www.stats.govt.nz/browse_for_stats/economic_indicators/productivity/IndustryProductivityStatistics_HOTP78-11.aspx

51 Calculated as emissions per animal species divided by main product produced. This excludes the dairy cull for beef, and emissions per wool are not included. The emissions data comes from New Zealand's National Greenhouse Gas Inventory for 1990 to 2011.

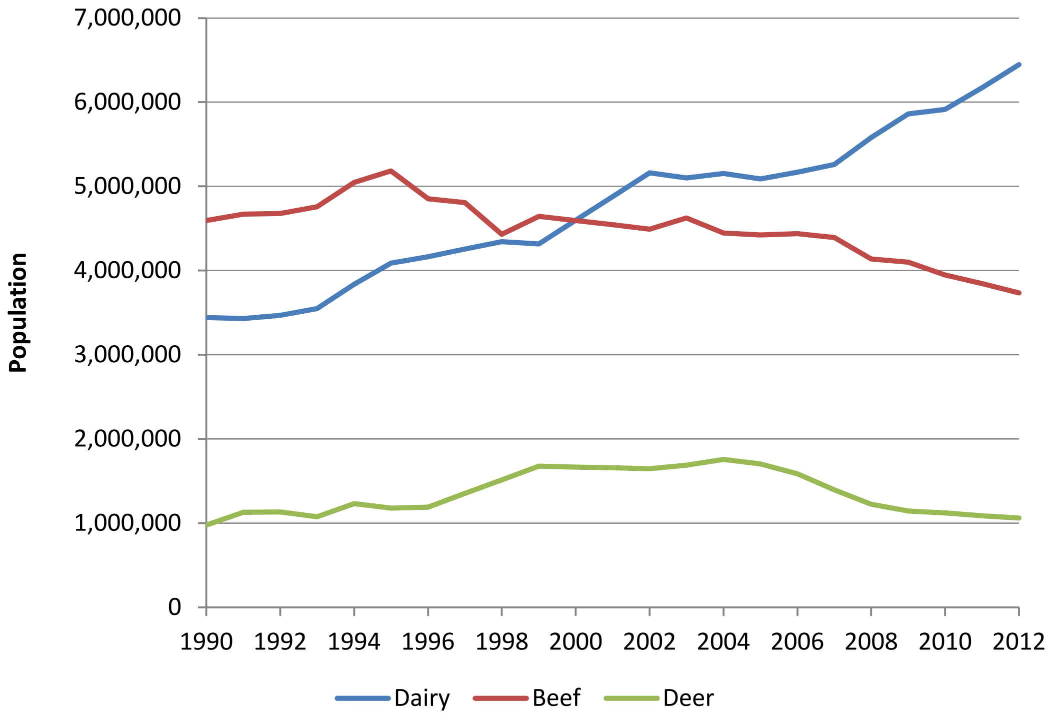


Figure 2.9: Changes in New Zealand's dairy, beef and deer populations, 1990 – 2012

Source: Ministry for Primary Industries. 2013. *Detailed Methodologies for Agricultural Greenhouse Gas Emission Calculation.* Statistics New Zealand. 2013. *Agricultural Production Statistics: June 2012 (final).*

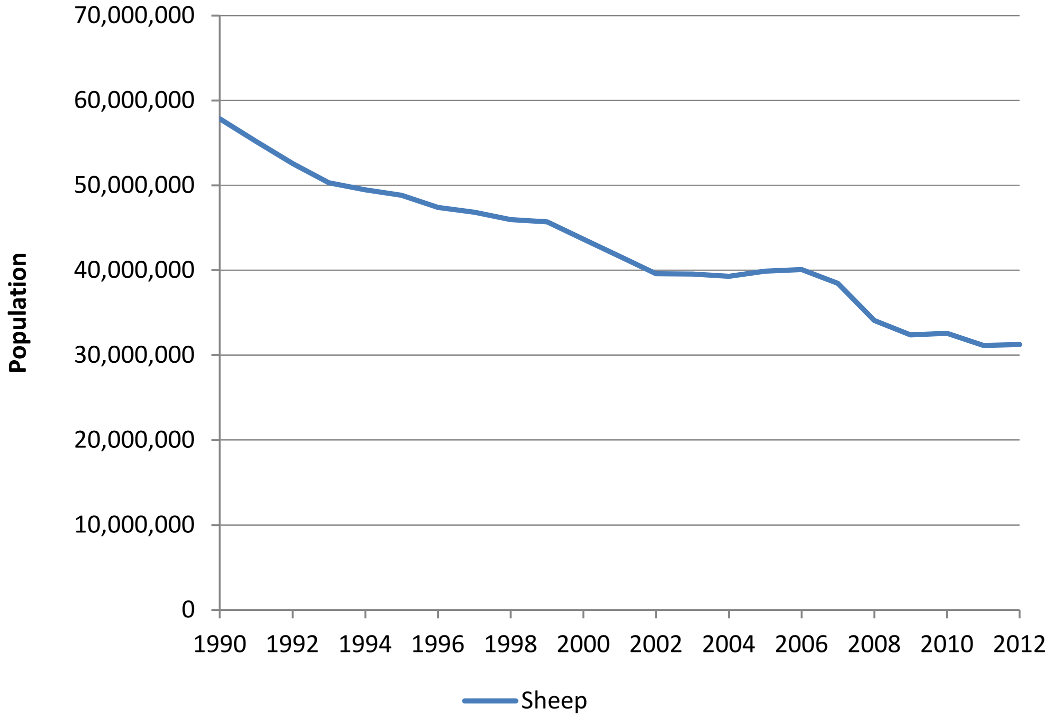


Figure 2.10: Changes in New Zealand's sheep population, 1990 – 2012.

Source: Ministry for Primary Industries. 2013. *Detailed Methodologies for Agricultural Greenhouse Gas Emission Calculation.* Statistics New Zealand. 2013. *Agricultural Production Statistics: June 2012 (final).*

2.10 Forestry

In 2011 the total area of forest land in New Zealand was estimated at 10.2 million hectares (38 per cent of New Zealand's land area). Natural, largely indigenous forest made up an estimated 79 per cent (8.1 million hectares) of the total forest area, and forest planted specifically for timber purposes or erosion control made up the remaining 21 per cent (2.1 million hectares). There are two main types of indigenous forest in New Zealand: beech (mainly *Nothofagus*) and podocarp/broadleaf. In addition, shrublands (mainly mānuka and kānuka) and retired grasslands are classified as forests when they meet New Zealand's forest definition.[52]

Less than 0.1 per cent of New Zealand's total forest production is harvested from natural indigenous forests, and the timber industry is now based almost entirely on planted forests. In the year to December 2012 forestry contributed 9 per cent of export income from goods. *Pinus radiata* makes up 90 per cent of the planted forests, which are usually composed of stands of trees of a single age class, and most production forests are managed under relatively standard silvicultural regimes.

Historical forest planting and the resulting planting and harvesting cycles will affect New Zealand's plantation forestry emissions profile well into the future. Plantation forest in New Zealand is usually harvested after 25 to 30 years.

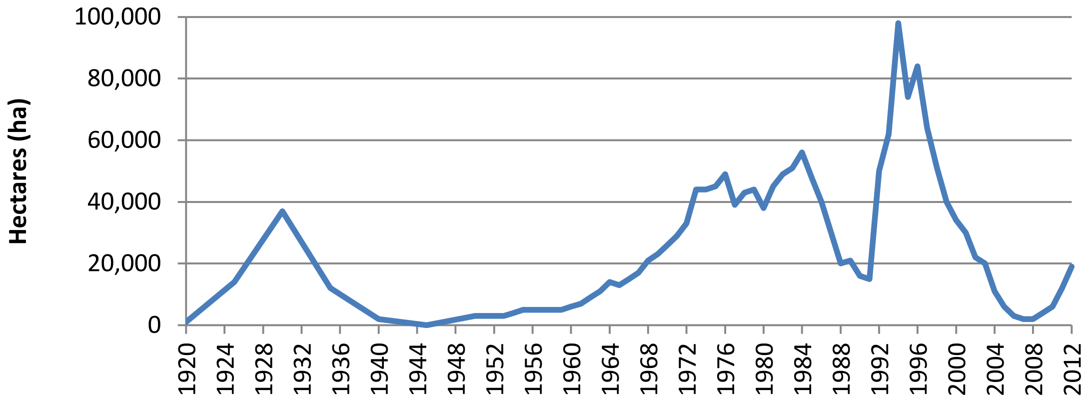


Figure 2.11: New Zealand's historical production forest planting, 1920 – 2012

Source: Ministry for Primary Industries. *National Exotic Forest Description, as at 1 April 2012*. Retrieved from http://www.mpi.govt.nz/news-resources/statistics-forecasting/statistical-publications/national-exotic-forest-description, page 5, figure 2.4.

Forest planting rates were particularly high in the mid-1990s (figure 2.11). This followed a change in the taxation regime, an unprecedented price spike for forest products (with subsequent favourable publicity), a Government focus on forestry as an instrument for regional development, and the conclusion of the state forest assets sale. The removal of agricultural subsidies and generally poor performance of the New Zealand and international share markets also encouraged investors to seek alternatives.[53]

---

52 Under the UNFCCC, the figures collected for exotic and natural forest area equate to the area of 'forest land'. 'Forest land' is defined as: an area of at least 1 hectare and 30 metres in width, that is expected to have at least 30 per cent canopy cover and the potential to exceed 5 metres in height.

53 D Rhodes, J Novis. 2002. *The Impact of Incentives on the Development of Plantation Forest Resources in New Zealand*. MAF Information Paper No: 45. Wellington: MAF Policy Division.

After the late 1990s the rate of planting declined. The subsequent increase in planting between 2008 and 2012 is largely attributable to the NZ ETS, and to the Afforestation Grant Schemes and Permanent Forest Sink Initiative, which have been introduced by the New Zealand Government to encourage new planting and the regeneration of natural species (see chapter 4 for more details).

Rates of deforestation are influenced by the comparative economics between land uses, Government policy and the carbon emission unit price. Planted forest deforestation peaked in 2007 but then declined. Since the introduction of the NZ ETS, carbon prices globally have been in steady decline. It is expected that low carbon prices will have an impact on deforestation levels by reducing the liability on forest owners. [54]

As is the case with agriculture, forestry producers do not receive price or production subsidies from the Government. As a result, their incomes are directly influenced by changes in international prices, exchange rates, market conditions and other external and domestic factors. However, the Government has devolved international carbon units (removal units, or RMUs) to foresters if they qualify under the NZ ETS. The foresters that participate are also liable for any debits, and must surrender units equal to the emissions they incur when they harvest the forest.

2.11 Waste

Solid waste in New Zealand is disposed of at landfills or recycled. In 2011 around 2.5 million tonnes of waste was sent to municipal landfills in New Zealand.[55,56] Twenty-two of these landfills (which collectively received almost two-thirds of the waste sent to landfill) had methane recovery systems in 2011. There is no incineration of municipal waste in New Zealand. The only incineration is for small specific waste streams, including medical, quarantine and hazardous wastes. Figure 2.12 shows estimates of waste composition for 2008.[54]

The Waste Minimisation Act 2008 introduced a levy on all waste disposed of in municipal landfills. The funding from this levy helps local government, communities and businesses to reduce waste. The Act also provides for requirements for reporting, clarification of the roles and responsibilities of territorial authorities, and accreditation for product stewardship schemes.

Wastewater from almost every town in New Zealand with a population over 1000 is collected and treated in community wastewater treatment plants. There are approximately 300 municipal wastewater treatment plants in New Zealand. In addition, there are approximately

---

[54] Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Retrieved from http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2013/index.html

[55] Municipal landfills are landfills where waste disposed of includes some household waste and that operate, at least in part, as a business to dispose of waste.

[56] This figure uses information collected under the Waste Minimisation Act and is more accurate than the inventory figure of 3.3 million tonnes. Work is being undertaken to determine if this information can be incorporated into future inventory submissions.

50 Government or privately owned treatment plants serving populations of between 100 and 1,000 people.[57]

In 2011 the waste sector contributed 3 per cent of New Zealand's total greenhouse gas emissions. Emissions in the waste sector were from solid waste disposal to land (67 per cent), wastewater (33 per cent) and incineration (0.1 per cent). Waste emissions have decreased by 4 per cent since 1990, largely due to improvements made to solid waste management practices.

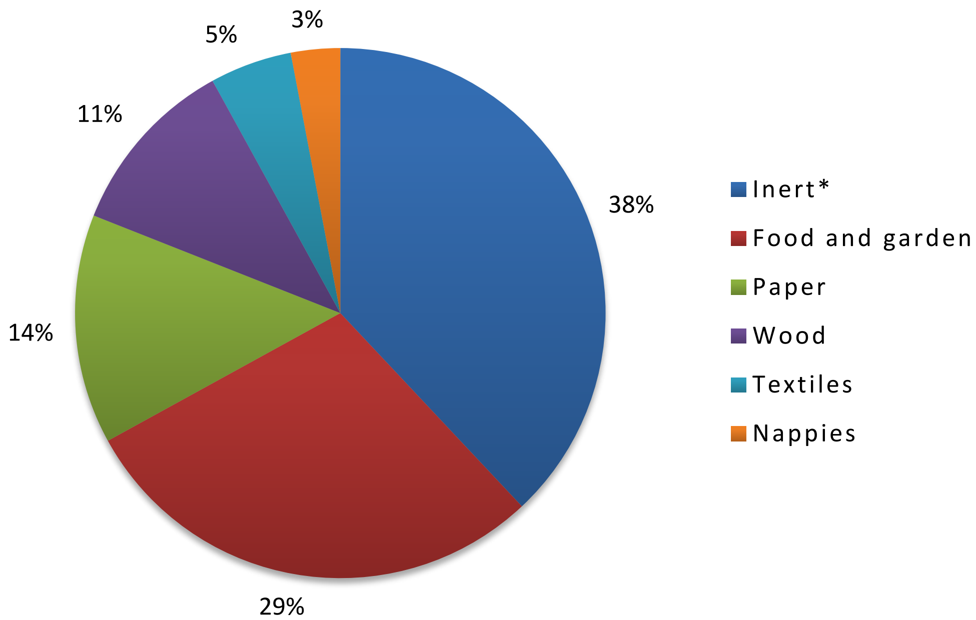


Figure 2.12: Composition of New Zealand's waste in 2008

Note: *Non-greenhouse gas-producing waste

Source: Ministry for the Environment. Data based on survey and solid waste composition studies.

57 SCS Wetherill Environmental. 2002. *National Greenhouse Gas Inventory from the Waste Sector 1990-2020.* A report prepared for the Ministry for the Environment.

3

Greenhouse gas inventory

3 Greenhouse gas inventory

3.1 Introduction

New Zealand believes that transparent, accurate and regular national greenhouse gas inventories are the building block of effective mitigation. As a Party to the UNFCCC and the Kyoto Protocol, New Zealand has an obligation to prepare, publish and update greenhouse gas inventories on an annual basis. New Zealand is also required to construct and maintain a national inventory system for estimating greenhouse gas emissions and removals.

This chapter provides summary information on the latest trends in human-induced emissions of greenhouse gases in New Zealand. Annex A to this report includes numerical data on inventory trends. A full description of New Zealand's inventory system and New Zealand's emission units database (the registry) is contained in Annex B. Further information on New Zealand's emissions and national inventory system can be found in *New Zealand's Greenhouse Gas Inventory Report* (NIR).

New Zealand's most recent inventory report (NIR-2013) was submitted to the UNFCCC on 12 April 2013.[58] NIR-2013 includes information on emissions and removals of greenhouse gases for a complete time series from 1990 to 2011[59]. Inventory reporting under the UNFCCC covers six sectors:

- energy (eg, transport, electricity generation and fuel used by industries such as agriculture or metal production)
- agriculture (eg, agricultural soils, manure management)
- industrial processes – emissions from the chemical transformation of materials from one substance to another (eg, glass production)
- solvents and other product use
- waste (eg, municipal landfills and wastewater management)
- land use, land-use change and forestry (LULUCF).

The greenhouse gas emissions and removals reported in this chapter were prepared in accordance with the UNFCCC accounting rules. Under these rules, the inventory reports emissions and removals from the entire LULUCF sector. For accounting purposes under the Kyoto Protocol, only the activities of afforestation, reforestation and deforestation are included (commonly referred to as Article 3.3 activities). There are some differences between the UNFCCC rules and the rules used for reporting under Article 3.3 of the Kyoto Protocol. This means the emissions totals and trends for the purposes of the UNFCCC and the Kyoto Protocol are different.

An amount of greenhouse gas emissions is usually expressed as a carbon dioxide equivalent or CO_2-e to account for the different global warming potency of the different gases, and allow them to be reported and traded consistently. Gases are converted to CO_2-e using the amount

---

58 Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011*. Retrieved from http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2013

59 The inventory submission is always delayed by 15 months due to the time constraints for data collection and processing

of warming they would cause in the 100 years following emission, compared to the effect of CO_2 itself.

3.2 National trends in New Zealand's greenhouse gas emissions and removals

3.2.1 New Zealand's emissions in 2011

In 2011 New Zealand's total greenhouse gas emissions (excluding the LULUCF sector) were 72,834.9 Gg CO_2-e. The two largest contributors to New Zealand's emissions profile were the agriculture and energy sectors (with approximately 90 per cent of gross emissions). The emissions associated with industrial processes, waste, and solvents and other product use sector were relatively minor (figure 3.1).

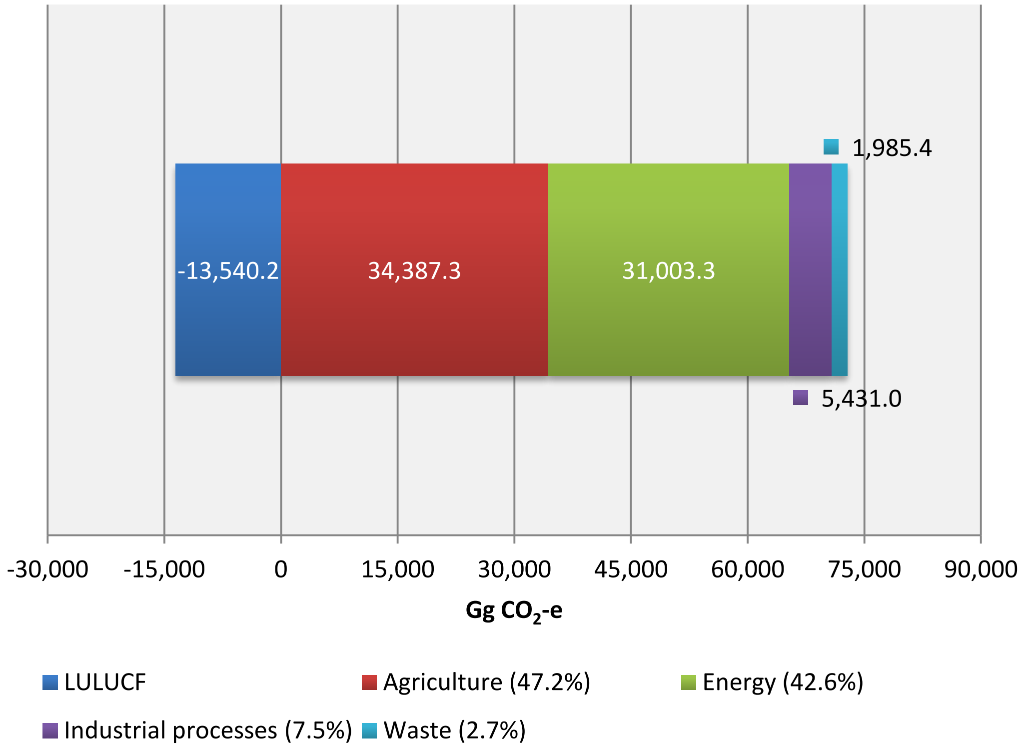


Figure 3.1: New Zealand's total greenhouse gas emissions, by sector, 2011

Notes: Gg CO_2-e = gigagrams of carbon dioxide equivalent

The industrial processes emissions shown here include emissions from the solvent and other product use sector.

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Wellington: Ministry for the Environment.

3.3.2 Changes in New Zealand's emissions between 1990 and 2011

Between 1990 and 2011 New Zealand's total emissions increased by 22.1 per cent (table 3.1). The average annual growth of emissions was approximately 1.0 per cent per year. The four emission sources that contributed most to this increase were methane emissions from dairy cattle,[60] carbon dioxide from road transport, nitrous oxide from agricultural soils, and the use of hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.[61] Figure 3.2 shows the yearly emission changes by sector across the entire time series from 1990 to 2011, using 1990 emissions as a base level.

Table 3.1: New Zealand's emissions of greenhouse gases, by sector, 1990 and 2011

Sector	Gg CO_2-e		Change from 1990, Gg CO_2-e	Change from 1990 (per cent)
	1990	2011		
Energy	23,487.7	31,003.3	+7,515.6	**+32.0**
Industrial processes	3,392.8	5,431.0	+2,038.1	**+60.1**
Solvent and other product use	41.5	27.9	–13.6	**–32.8**
Agriculture	30,661.9	34,387.3	+3,725.4	**+12.1**
Waste	2,059.1	1,985.4	–73.7	**–3.6**
Total gross (excluding LULUCF)	**59,643.1**	**72,834.9**	**+13,191.9**	**+22.1**
LULUCF	-28,112.7	–13,540.2	+14,572.5	**+51.8**
Total net (including LULUCF)	**31,530.4**	**59,294.7**	**+27,764.4**	**+88.1**

Note: Net removals from the LULUCF sector are as reported under the UNFCCC (chapter 7 of the Inventory). Columns may not sum to the total due to rounding.

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Wellington: Ministry for the Environment.

60 Methane emissions produced from ruminant livestock.

61 Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are referred to as 'halocarbons' in annex A and the common reporting format (CRF) tables.

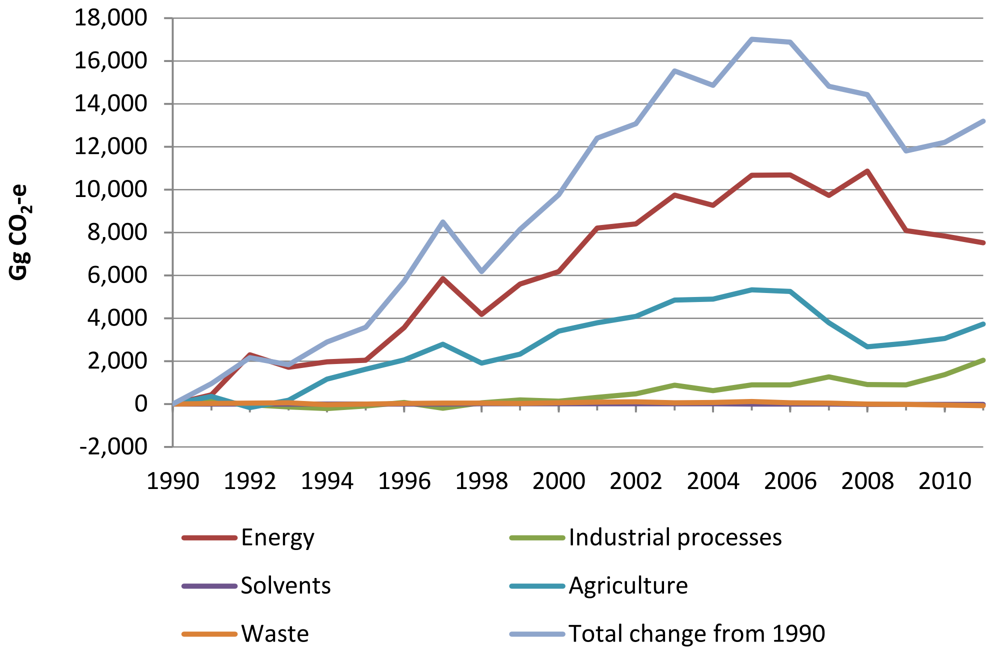


Figure 3.2: Trends in New Zealand's greenhouse gas emissions, by sector, 1990 – 2011

Note: Total emissions exclude net removals from the LULUCF sector.

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Wellington: Ministry for the Environment.

3.3.3 New Zealand's net emissions

With the inclusion of the LULUCF sector under UNFCCC accounting rules, New Zealand's net emissions in 2011 were significantly lower than gross emissions, amounting to 59,294.7 Gg CO_2-e (table 3.1). This is because in New Zealand a significant area of the land is covered by forests. Growing plants reduce the amount of carbon dioxide in the atmosphere, and these results in the LULUCF sector being a sink rather than a source of carbon dioxide. As a result, New Zealand's net emissions are generally much lower than gross emissions estimates.

New Zealand's net emissions are sensitive to yearly changes in the LULUCF sector. Removals from the sector are strongly influenced by cycles of harvesting plantation forests and changes in land use.

Despite showing some fluctuations from year to year, New Zealand's net greenhouse gas emissions under the UNFCCC increased by 88.1 per cent between 1990 and 2011 (figure 3.3).

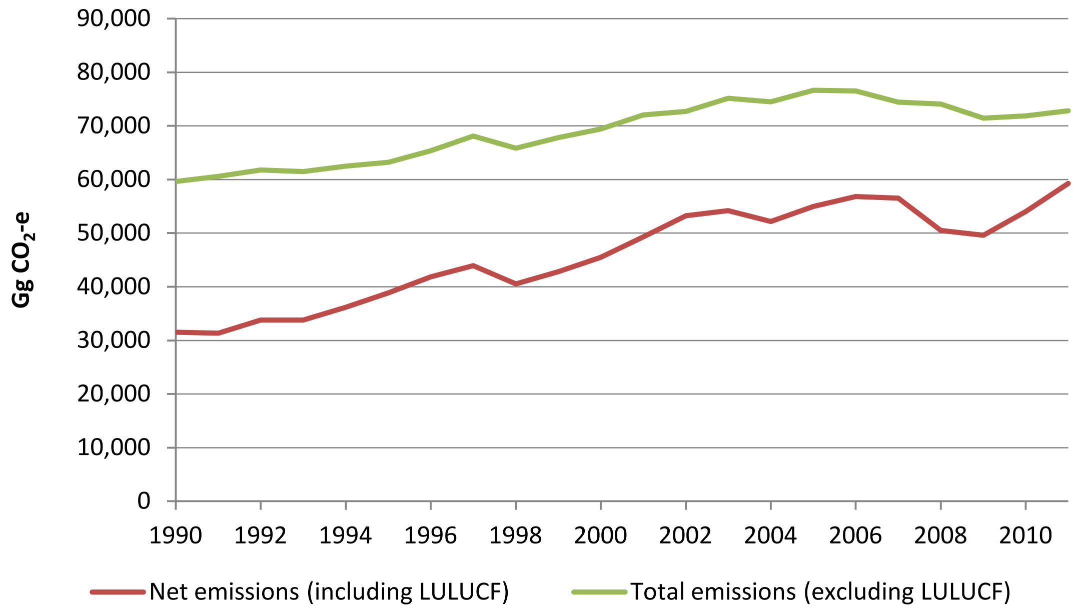


Figure 3.3: New Zealand's total and net greenhouse gas emissions and removals, 1990 – 2011

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Wellington: Ministry for the Environment.

Energy sector

This sector produces two types of emissions: combustion emissions and fugitive emissions. Combustion emissions result from fuel being burnt to produce useful energy. Examples of combustion emissions are:

- emissions from transport
- provision of heat to industry
- emissions from thermal electricity generation.

Fugitive emissions result from the production, transmission and storage of fuels, and from non-productive combustion. Examples of fugitive emissions are:

- the venting of carbon dioxide at gas treatment plants
- gas flaring at oil production facilities
- emissions from geothermal fields released as a result of geothermal electricity production.

Combustion emissions from road transport, and public electricity and heat production, constitute the largest share of domestic emissions from the energy sector in New Zealand. Electricity generation from the combustion of coal, oil and gas plays a crucial role in New Zealand's electricity system: in 2011 fossil fuel thermal plants provided 23 per cent of New Zealand's total electricity supply. However, the emission intensity of New Zealand's electricity generation is low by international standards due to the high proportion of demand met by hydro generation, as well as other renewable sources such as wind. While this provides a strong base in good hydro years, electricity emissions remain sensitive to rainfall.

Between 1990 and 2011 emissions from the energy sector increased by 32.0 per cent above 1990 levels, reaching 31,003.3 Gg CO_2-e. This growth in emissions is primarily from road transportation, and public electricity and heat production (figure 3.4). Emissions from the energy sector showed a notable decline after 2008. This was mainly driven by the effects of the global recession, as well as lower demand for residential energy in Canterbury after the earthquake in February 2011. There was also an increase in wind-generated energy into the national grid in 2011 with the addition of two new wind farms.

In addition, there was a decrease in fugitive emissions from coal mining and handling as a result of closing two large coal mines: one due to explosions in November 2010, and one due to accelerated work on mine safety improvement.

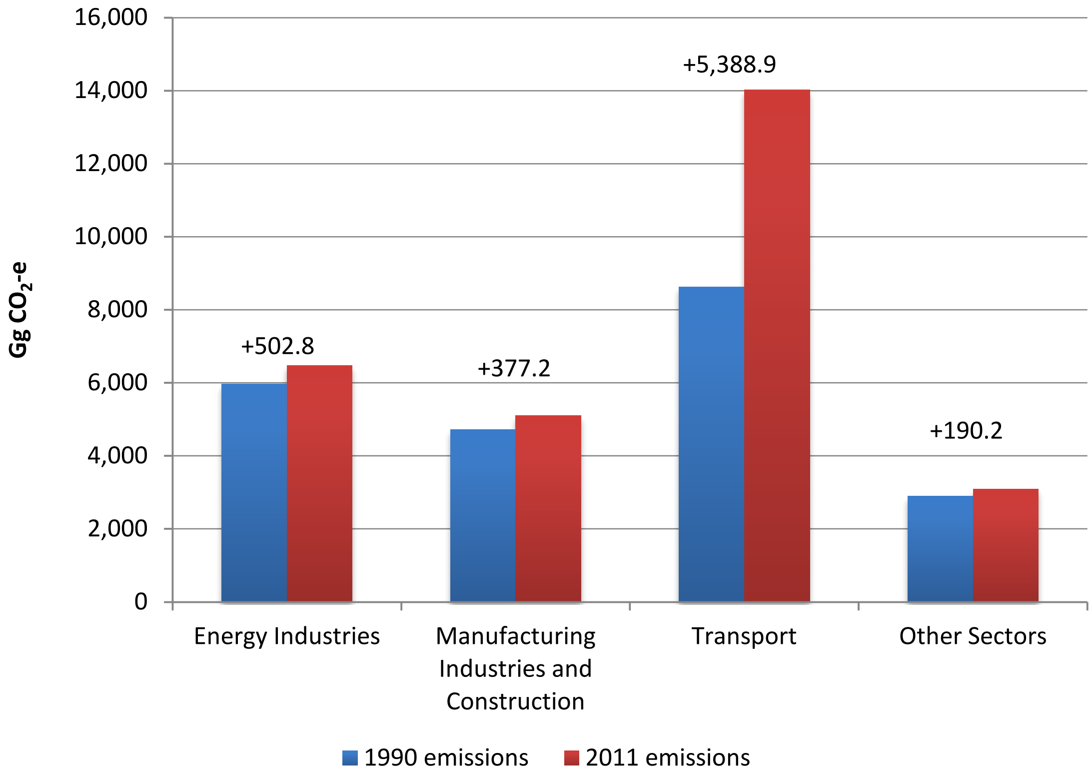


Figure 3.4: Change in New Zealand's emissions from fuel combustion, by category, 1990 – 2011

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Wellington: Ministry for the Environment.

Agriculture sector

The agriculture sector contributed 47.2 per cent of total emissions in 2011 (34,387.3 Gg CO_2-e). It accounted for 89.4 per cent of New Zealand's methane emissions and 95.4 per cent of the country's nitrous oxide emissions. In most other developed countries agricultural emissions are typically around 12 per cent of national emissions, which means New Zealand has an unusual emissions profile in this regard. Dairy cattle, beef cattle, sheep and deer are grazed outside all year round. This means that New Zealand, like Australia, has a much lower proportion of agricultural emissions from manure management compared with other Annex 1 Parties, because intensive housing of major livestock is not practised in New Zealand.

Between 1990 and 2011, the emissions from the agriculture sector increased by 12.1 per cent. This was primarily due to an increase in methane emissions from the enteric fermentation[62] category and an increase in nitrous oxide emissions from the agricultural soils category (figure 3.5).

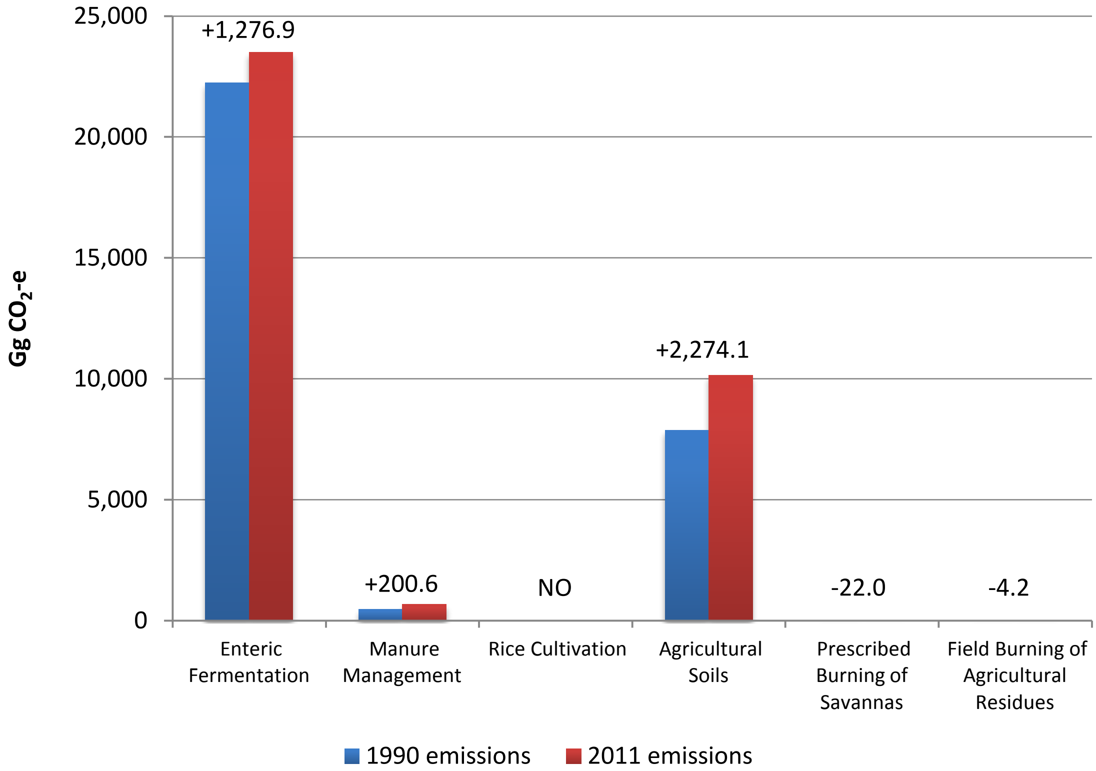


Figure 3.5: Change in New Zealand's emissions from the agriculture sector, 1990 – 2011

Note: Rice cultivation does not occur (NO) in New Zealand.

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Wellington: Ministry for the Environment.

Since 1990 there have been changes in the proportions of the main livestock species farmed in New Zealand because the profitability of dairy products has become higher compared to sheep and beef products. Pastoral land used for dairy has increased and pastoral land used for sheep and to a lesser extent beef has decreased. Within the same time period the land area used for horticulture has increased and the types of produce grown have changed. There is now less cultivated land area for barley, wheat and fruit, but more for grapes (for wine production) and vegetable production.

Between 2010 and 2011 emissions from the agriculture sector increased by 2.0 per cent due to an increase in demand for New Zealand dairy products and favourable milk prices. This led to an increase in the dairy cattle population and in the use of nitrogen-containing fertiliser in 2011, as the dairy industry is a major user of nitrogen fertiliser in New Zealand. The increase in

62 Enteric fermentation is the process in which animals produce methane via digestion of consumed plant material. The amount of methane emitted by an animal as a result of enteric fermentation is driven primarily by the type of digestive system, and the type and amount of feed consumed.

dairy cattle and fertiliser emissions outweighed emission reductions from decreases in the population of sheep, non-dairy cattle and deer.

Industrial processes sector

This sector covers greenhouse gas emissions from industrial processes (excluding direct combustion emissions). Industrial process emissions occur when materials are transformed from one substance to another in an industrial setting. Emissions result from the chemical reactions involved in these processes.

In New Zealand, activities or emissions covered by the sector include:

- iron or steel production
- aluminium production
- gold production
- cement clinker or burnt lime production
- glass production using soda ash
- emissions associated with hydroflurocarbons and perfluorocarbons, used mostly for refrigeration and air conditioning
- sulphur hexafluoride associated with aluminium production and electric switchgear equipment.

Greenhouse gas emissions from New Zealand's industrial processes sector contributed 7.5 per cent to the country's total greenhouse gas emissions (5,431.0 Gg CO_2-e). The largest source of industrial process emissions is the metal production category, contributing nearly half (42.2 per cent) of the total industrial process emissions.

Between 1990 and 2011, emissions from industrial processes increased by 60.1 per cent. This was largely driven by emissions from the consumption of halocarbons and sulphur hexafluoride. Emissions of hydrofluorocarbons (HFCs) have increased because of their use as substitutes for chlorofluorocarbons (CFCs), phased out under the Montreal Protocol.

There was also a notable increase (of 14.0 per cent) in emissions from the industrial processes sector between 2010 and 2011. The main emission source that drove this increase was the consumption of HFCs. This large increase in HFC emissions was mainly due to one supplier changing its buying behaviour and importing a very high amount of HFC-134a in 2011 compared to previous years.

Solvents and other product use sector

The solvents and other product use sector comprises emissions from the use of chemical products. It includes information on solvent emissions from applications in industry, trade and commerce, and households, as well as evaporative emissions of greenhouse gases arising from other types of product use (eg, nitrous oxide emissions from medical use).

In 2011 the sector was a minor contributor to New Zealand's total greenhouse gas emissions, being responsible for 0.04 per cent of total emissions (27.9 Gg CO_2-e). This was from nitrous oxide emissions from anaesthesia and other uses.

Waste sector

Greenhouse gas emissions from the waste sector result from the processing and disposal of solid waste and from wastewater treatment. In New Zealand, emissions from the waste sector are predominantly methane (90.8 per cent), followed by nitrous oxide (9.2 per cent) and then carbon dioxide (0.05 per cent).

In 2011 the waste sector accounted for 2.7 per cent of New Zealand's total emissions. The largest source was solid waste disposal on land, followed by wastewater handling (67.0 and 32.8 per cent of total waste sector emissions, respectively). Waste incineration is only a minor contributor to the sector's emissions (0.1 per cent).

Between 1990 and 2011, the total emissions from the waste sector decreased by 3.6 per cent. This reduction occurred in the solid waste disposal on land category as a result of initiatives to improve solid waste management practices and the recovery of landfill gas.

LULUCF sector

New Zealand's net emissions reflect the contribution of emissions and removals from the LULUCF sector. Together with agriculture, plantation forestry forms a core part of the New Zealand economy and has a significant influence on the LULUCF emissions profile. Intensive forest management combined with a temperate climate, fertile soils and high rainfall mean New Zealand has amongst the highest rates of exotic forest growth among Annex 1 countries.

To improve the transparency and accuracy of reporting in the LULUCF sector, and to meet the supplementary reporting requirements for Article 3.3 of the Kyoto Protocol, New Zealand has developed the Land Use and Carbon Analysis System (LUCAS).[63] The land categories mapped and monitored through LUCAS are designed specifically for reporting under the UNFCCC and the Kyoto Protocol.

In New Zealand, the LULUCF sector was a net carbon sink: in 2011 net removals of greenhouse gases from this sector (as reported under the UNFCCC) were 13,540.2 Gg CO_2-e. This was mainly carbon dioxide (13,606.0 Gg), with a very small amount of methane and nitrous oxide (0.38 and 0.1 per cent of the net LULUCF emissions estimates). The greatest contribution to removals was from the 'land converted to forest land' category. The largest source of emissions was the 'forest land remaining forest land' category.

Between 1990 and 2011 net removals of greenhouse gases from the LULUCF sector decreased by 51.8 per cent, largely as a result of increased harvesting of plantation forests as a larger proportion of the estate reaches harvest age. The decrease in removals in the grassland land-use category is primarily due to the shift in land-use changes occurring among the grassland subcategories since 1990 and the conversion of plantation forests to grassland that has occurred since 2003. The biomass emissions from land-use change are reported in the 'land converted to...' categories (eg, 'land converted to grassland') in the year of the event.

Between 2010 and 2011, net removals of greenhouse gases from the LULUCF sector decreased by 24.0 per cent. The main contributor to the change occurred within the forest land category, as a greater proportion of forest land was harvested in 2011 compared with 2010 due to its age class profile. Emissions have also increased in the grassland category due to larger areas of forest land being converted to grassland in 2011 than in 2010.

63 Ministry for the Environment. 2009. *Looking at LUCAS*. Retrieved from http://www.mfe.govt.nz/publications/climate/ looking-at-LUCAS/index.html (16 September 2009).

Article 3.3 activities under the Kyoto Protocol

Carbon dioxide removals resulting from afforestation and reforestation activities (as accounted for under Article 3.3 of the Kyoto Protocol) in 2011 were 18,445.8 Gg. The difference between the estimates reported under the UNFCCC and accounted for under the Kyoto Protocol is largely due to the pre-1990 forest portion within the LULUCF sector. While reporting under UNFCCC includes pre-1990 forests, they are excluded from all but deforestation reporting under the Kyoto Protocol. In 2011 carbon dioxide emissions from deforestation of all forests (3,700 hectares) contributed 1,674.6 Gg to net emissions. The deforestation was mainly for conversion into grassland, largely due to the relative profitability of pastoral farming (particularly dairy farming) compared with forestry.

3.3 Emissions and removals, by gas

3.3.1 Overview

Inventory reporting under the UNFCCC covers six direct[64] greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs). Figure 3.6 shows New Zealand's emissions profile by gas in 2011. Table 3.2 shows the change in each direct greenhouse gas between 1990 and 2011. Trends in carbon dioxide, methane and nitrous oxide emissions over the period 1990–2011 are shown in figure 3.7, using 1990 emissions as a base level.

In accordance with UNFCCC reporting guidelines, indirect greenhouse gases are included in inventory reporting but not in the national emissions total. These indirect gases include carbon monoxide (CO), sulphur dioxide (SO_2), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs). Removals of carbon dioxide from the atmosphere are reported in the LULUCF sector.

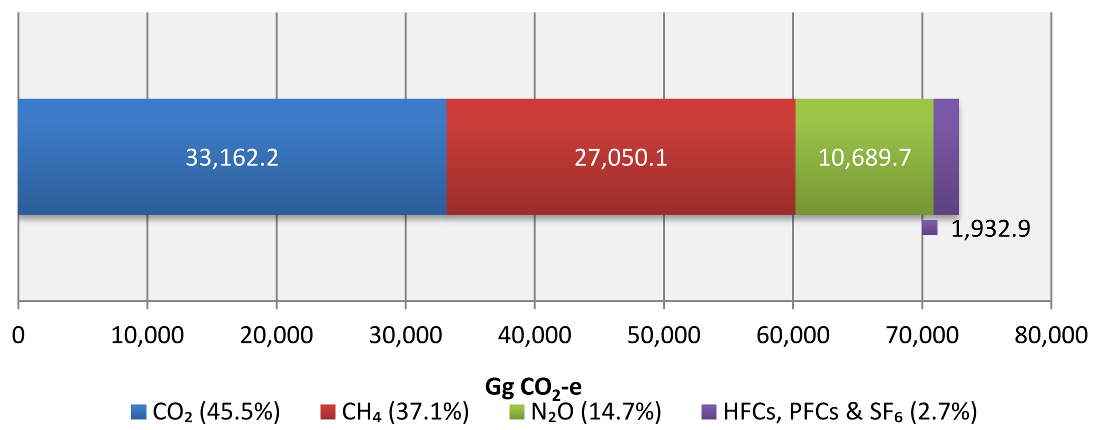


Figure 3.6: New Zealand's total greenhouse gas emissions, by gas, 2011

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990 – 2011.* Wellington: Ministry for the Environment.

[64] Direct greenhouse gases are the atmospheric gases that absorb and emit heat radiation. The indirect greenhouse gases influence the abundance of the direct greenhouse gases in the atmosphere through chemical processes.

Table 3.2: New Zealand's emissions of greenhouse gases, by gas, 1990 and 2011

Direct greenhouse gas emissions	Gg CO_2-e		Change from 1990 (Gg CO_2-e)	Change from 1990 (per cent)
	1990	2011		
CO_2	25,047.1	33,162.2	+8,115.2	**+32.4**
CH_4	25,650.3	27,050.1	+1,399.8	**+5.5**
N_2O	8,300.6	10,689.7	+2,389.1	**+28.8**
HFCs	NO	1,885.1	+1,885.1	**NA**
PFCs	629.9	30.2	–599.7	**–95.2**
SF_6	15.2	17.6	+2.4	**+15.9**
Total	**59,643.1**	**72,834.9**	**+13,191.9**	**+22.1**

Note: The percentage change for HFCs is not applicable (NA) because consumption of HFCs in New Zealand in 1990 was not occurring (NO).

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Wellington: Ministry for the Environment.

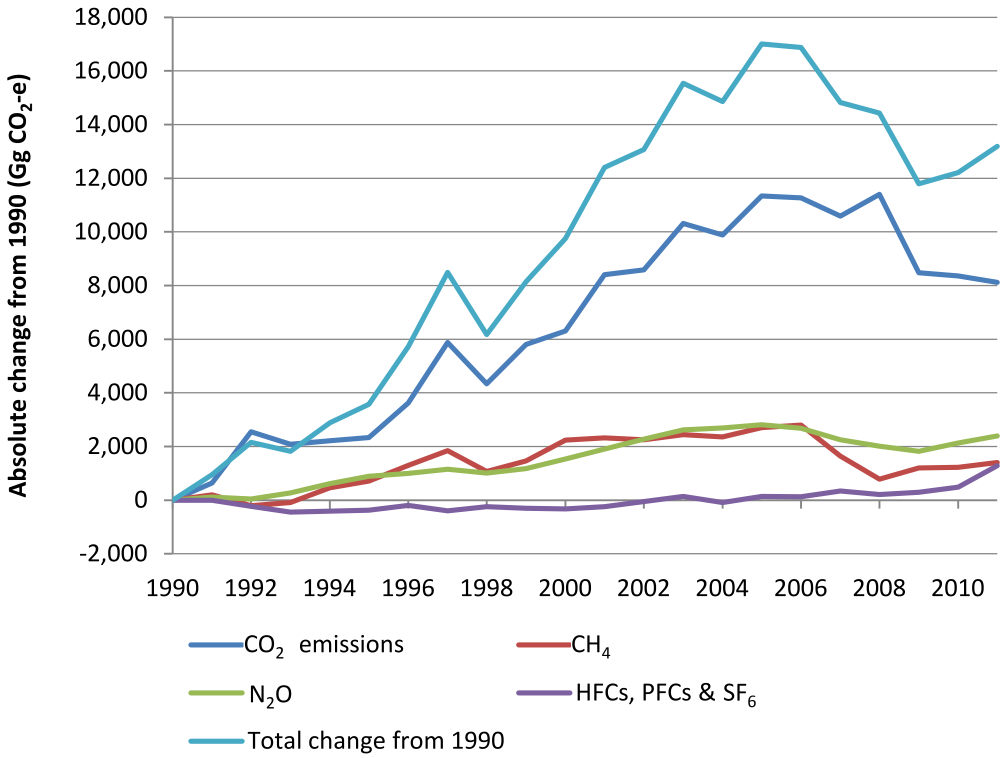


Figure 3.7: Change from 1990 in New Zealand's total emissions, by gas, 1990 – 2011

Source: Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011.* Wellington: Ministry for the Environment.

3.3.2 Carbon dioxide

Carbon dioxide is the primary greenhouse gas emitted by human activities. Human activities are altering the carbon cycle, both by adding more carbon dioxide to the atmosphere and by influencing the ability of natural sinks, like forests, to remove carbon dioxide from the atmosphere. The main human activity that emits carbon dioxide is the combustion of fossil fuels (coal, natural gas and oil) for energy and transportation. Some industrial processes, waste processing and land-use changes also emit carbon dioxide.

Carbon dioxide emissions contributed the largest proportion of New Zealand's total emissions in 2011 (45.5 per cent). The main contributors to total carbon dioxide emissions were road transport (37.4 per cent), and public electricity and heat production (15.4 per cent).

From 1990 to 2011 total carbon dioxide emissions increased by 32.4 per cent due to increased emissions from road transport, and public electricity and heat production (Table 3.3).

Table 3.3: New Zealand's emissions of carbon dioxide, 1990 and 2011

Carbon dioxide source	1990	2011	Change 1990 – 2011 (Gg CO_2-e)	Change 1990 – 2011 (per cent)
Energy	22,286.4	29,663.2	7,376.8	33.1
Stationary energy	13,388.3	14,419.3	1031	7.7
Transport	8,439.2	13,835.3	5,396.1	63.9
Fugitive emissions	458.9	1,408.6	949.6	206.9
Industrial processes	2,747.8	3,498.1	750.3	27.3
Waste	12.9	0.9	-12	–92.8
Total emissions (excluding LULUCF)	25,047.1	33,162.2	8,115.2	32.4
LULUCF	–28,195.3	–13,606.0	14,589.3	–51.7
Total emissions (including LULUCF)	–3,148.2	19,556.2	22,704.4	721.2

3.3.3 Methane

Methane is the second most prevalent greenhouse gas emitted by human activities. It is emitted from agricultural systems (eg, the raising of livestock) as well as from human activities related to coal mining, natural oil and gas systems, and waste processing. Natural processes in soil and chemical reactions in the atmosphere help remove methane from the atmosphere. Methane's lifetime in the atmosphere is much shorter than that of carbon dioxide, but methane is more efficient at trapping radiation.

Methane (excluding LULUCF) contributed 37.1 per cent of total emissions in 2011, with 86.9 per cent coming from enteric fermentation in ruminant livestock (mainly dairy cattle) in the agriculture sector. Between 1990 and 2011 methane emissions grew by 5.5 per cent from 1990 levels. This is largely attributed to the increase in the national dairy cattle herd over the same period.

Table 3.4: New Zealand’s emissions of methane, 1990 and 2011

Methane source	1990	2011	Change 1990–2011, Gg CO_2-e	Change 1990 – 2011, (per cent)
Energy	1,012.1	1,060.5	48.4	4.8
Agriculture	22,738.7	24,186.9	1,448.2	6.4
Waste	1,899.5	1,802.8	–96.8	–5.1
Total emissions (excluding LULUCF)	25,650.3	27,050.1	1,399.8	5.5

3.3.4 Nitrous oxide

Nitrous oxide is naturally present in the atmosphere as part of the Earth’s nitrogen cycle and has a variety of natural sources. However, human activities such as agriculture, fossil fuel combustion, wastewater management and industrial processes are increasing the amount of nitrous oxide. Nitrous oxide molecules stay in the atmosphere longer than methane, but shorter than carbon dioxide molecules, before being removed by a sink or destroyed through chemical reactions. A significant portion of total nitrous oxide emissions come from human activities. In New Zealand the biggest sources of nitrous oxide emissions are agriculture and transportation.

Nitrous oxide contributed 14.7 per cent to New Zealand’s total emissions in 2011, with 95 per cent of these emissions coming from agricultural soils. The growth in nitrous oxide resulted from an almost six-fold increase in elemental nitrogen applied through nitrogen-based fertiliser over the 1990–2011 time series. This affected emissions from the use of nitrogen-containing fertilisers in the agricultural sector. Another cause of increasing nitrous oxide emissions is an increase in emissions from animal excreta, mostly due to growing numbers of cattle. Total nitrous oxide emissions in 2011 exceeded the 1990 level by 28.8 per cent (table 3.5).

Table 3.5: New Zealand’s emissions of nitrous oxide, 1990 and 2011

Nitrous oxide source	1990	2011	Change 1990–2011, Gg CO_2-e	Change 1990–2011, (per cent)
Energy	189.2	279.6	90.4	47.8
Agriculture	7,923.2	10,200.4	2,277.2	28.7
Waste	146.6	181.7	35.1	23.9
Total emissions (excluding LULUCF)	8,300.6	10,689.7	2,389.1	28.8

3.3.5 Hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are sometimes referred to together as the fluorinated gases, or F-gases. They are man-made chemicals, mostly used in refrigeration and air conditioning, but also in foams, aerosols, fire protection and solvents. F-gases can escape to the atmosphere during maintenance or through leaks from faulty or outdated equipment. These gases have long atmospheric lifetimes (decades for HFCs, millennia for PFCs and sulphur hexafluoride), and they are potent greenhouse gases, hundreds or thousands of times more powerful than carbon dioxide over a 100-year timeframe.

In total, F-gases contributed 2.7 per cent of the total emissions in the inventory in 2011. The largest contributor of these emissions was the consumption of HFCs and PFCs (98.6 per cent of all PFC, HFC and sulphur hexafluoride emissions).

These gases have also undergone large relative changes between 1990 and 2011. Emissions of PFCs have decreased by 95.2 per cent from 1990 levels. This decrease is the result of improvements in the aluminium smelting process at New Zealand's only aluminium smelter. HFC emissions have increased because of their use as a substitute for chlorofluorocarbons, which were phased out under the Montreal Protocol. No emissions of HFCs occurred in 1990. Meanwhile, emissions of sulphur hexafluoride have increased by 15.9 per cent; the majority of these emissions are from its use in electrical equipment.

Table 3.6: New Zealand's emissions of HFCs, PFCs and SF_6, 1990 and 2011

Fluorinated gases, from the industrial process sector	1990	2011	Change 1990–2011 (Gg CO_2-e)	Change 1990 – 2011 (per cent)
HFCs	0	1,885.1	1,885.1	100
PFCs	629.9	30.2	–599.7	–95.2
SF_6	15.2	17.6	2.4	15.9
Total emissions	645.1	1,932.9	1287.8	199.6

4

Policies and measures

4 Policies and measures

Key developments since the *Fifth National Communication*

- New Zealand has created a comprehensive emissions trading scheme – the New Zealand Emissions Trading Scheme (NZ ETS). Forestry, stationary energy, industrial processes, liquid fossil fuels and waste sectors are full participants in the NZ ETS, along with bulk importers and users of synthetic greenhouse gases (SGGs). The agricultural sector is required to report on its major emissions - methane and nitrous oxide from biological processes.
- The NZ ETS has undergone its first substantive review in 2011. Consequential amendments made in 2012 ensure it more effectively supports the Government's economic growth objectives and is flexible enough to cater for a range of future international outcomes in the period 2013 to 2020.
- Aspects of greening growth have been integrated into the Government's wider Business Growth Agenda, including a commitment to transition to a low-emissions economy.
- The New Zealand Energy Strategy 2011-2021 and the companion New Zealand Energy Efficiency and Conservation Strategy 2011-2016 have been released. These identify environmental responsibility and efficient use of energy as priorities for the New Zealand Government, as well as reconfirming the 90 percent target for renewable electricity generation by 2025.
- New Zealand led the establishment of the Global Research Alliance on Agricultural Greenhouse Gases with the aim of increasing international cooperation, collaboration and investment in agricultural research.
- The New Zealand Agricultural Greenhouse Gas Research Centre was established in 2010, whose current focus is on practical ways to reduce methane and nitrous oxide emissions while improving productivity.

4.1 Introduction

Recognising that climate change is a global issue requiring a global response, the New Zealand Government continues to express its support for the development of a comprehensive international agreement on climate change and is actively involved in negotiations to reach such an agreement. Internationally, New Zealand has sought to take leadership in areas where it considers it can most effectively make a contribution, most notably in agricultural productivity and emissions research, particularly in the Pacific region.

Domestically, New Zealand's policies reflect a commitment to doing its fair share to achieve emissions reductions and the transition to a low carbon economy, while continuing to grow the domestic economy. As other nations have found, this has been made more challenging in the context of the global financial crisis and the need to remain competitive with major trading partners.

The primary tool underpinning New Zealand's domestic action is the New Zealand Emissions Trading Scheme (NZ ETS). Over the reporting period, amendments have been made to the NZ ETS to ensure it is flexible enough to respond to a range of international agreement outcomes in the 2013 to 2020 period and to more effectively support the Government's economic growth priorities. The amendments have also extended the transitional phase for some sectors and delayed the entry of agriculture in order to reduce the effect of the NZ ETS on the New Zealand economy, particularly during the recovery from the global financial crisis. The Government is committed to reviewing these settings in 2015.

The NZ ETS is complemented by a range of other domestic measures designed to support a reduction in domestic emissions while supporting economic growth. For example, the Government has integrated aspects of 'greening growth'[65] into its wider Business Growth Agenda[66], and continues to explore measures to improve productivity while reducing greenhouse gas emissions.

4.1.1 Key targets

The Government has set a number of national targets for reducing New Zealand's greenhouse gas emissions.

Kyoto Protocol Commitment Period One target: a target under the Kyoto Protocol for Commitment Period One (2008-2012) to reduce greenhouse gas emissions to 1990 levels on average over the five year commitment period, or take responsibility for any emissions over these levels**.** The first commitment period[67] of the Kyoto Protocol ended in 2012. New Zealand's latest *Net Position Report*[68] shows that the county is on track to meet its first commitment period target.

Unconditional target: a 5 per cent reduction in emissions below New Zealand's 1990 greenhouse gas emissions levels by 2020. This unconditional target is equivalent to a 2013 – 2020 QELRO[69] of 96.8 on 1990 emissions. It has been tabled under the UNFCCC (outside the Kyoto Protocol) but will be managed using the framework of rules applicable to the Kyoto Protocol's second commitment period.

Conditional target range: between 10 and 20 per cent reduction below 1990 greenhouse gas emissions levels by 2020, made in the context of a comprehensive global agreement and with five specific requirements:

1 the global agreement sets the world on a pathway to limit temperature rise to not more than 2°C

2 developed countries make comparable efforts to those of New Zealand

---

65 Green growth is a concept that reflects the importance of economic growth while also caring for, and enhancing, the environment. Early in 2011, the Government established an independent advisory group to look at green growth topics of particular importance to New Zealand. More detail on this can be found in section 4.2.2.

66 More detail on this can be found on p. 91

67 The first commitment period of the Kyoto Protocol spanned 2008 to 2012.

68 http://www.mfe.govt.nz/issues/climate/greenhouse-gas-emissions/net-position/index.html

69 A QELRO (Quantified Emission Limitation and Responsibility Objective) specifies the *average* emissions permitted by a target over time, in line with a multi-year carbon budget approach.

3 advanced and major emitting developing countries take action fully commensurate with their respective capabilities

4 there is an effective set of rules for LULUCF

5 there is full recourse to a broad and efficient international carbon market.

Long-term target: a 50 per cent reduction in emissions below 1990 levels by 2050. This is in line with IPCC conclusions and the UNFCCC global goal of limiting warming to a maximum of 2°C above pre-industrial levels. It provides long-term direction for New Zealand's domestic policies as well as influencing New Zealand's approach to the comprehensive new international climate change agreement under negotiation.

Because New Zealand's emissions profile is very different from that of most developed countries, the cost of further mitigation by New Zealand is likely to be higher than for most other developed countries.[70] New Zealand's targets will therefore present a challenge and will be met through a mixture of domestic emission reductions, removal of carbon by forests and participation in international carbon markets. For the unconditional 2020 target it will also involve recognising the surplus achieved during the first commitment period of the Kyoto Protocol.

New Zealand has pledged to take action in line with the undertakings of other countries and is prepared to consider increasing its ambition in future as part of a comprehensive global agreement. New Zealand will continue to regularly review its contributions to international mitigation action, taking into account the latest science, development of new technologies and progress by other countries. The new climate change agreement likely concluded by December 2015, and entered into force by 2020, is expected to introduce a more comprehensive and effective global mitigation agreement, and New Zealand's actions will reflect the progress that is made.

Summary of key targets and target setting

New Zealand has:

1. a target under the Kyoto Protocol for Commitment Period One (2008-2012) to reduce greenhouse gas emissions to 1990 levels on average over the five year commitment period, or take responsibility for any emissions over these levels
2. an unconditional responsibility target of a 5 per cent reduction in emissions below New Zealand's 1990 greenhouse gas emissions levels by 2020, managed using the Kyoto Protocol's second commitment period framework of rules.
3. a conditional medium-term responsibility target of a 10 to 20 per cent reduction in emissions below 1990 levels by 2020
4. a long-term emission reduction target of a 50 per cent reduction in net greenhouse gas emissions from 1990 levels by 2050 ('50 by 50').

[70] http://www.pbl.nl/en/publications/2009/Exploring-comparable-post-2012-reduction-efforts-for-Annex-I-countries

4.2 Policy context for climate change actions

4.2.1 Roles and responsibilities

The Ministry for the Environment (MfE) is established under statute and is the New Zealand Government's primary advisor on the environment, international matters affecting the environment and climate change. Key climate change-related activities undertaken by MfE include international negotiations and reporting under the UNFCCC and the Kyoto Protocol, and advising the Government on the NZ ETS legislation and the development of allocation plans and regulations under the scheme.

MfE also advises the Government on other mitigation measures and the impacts of climate change on New Zealand, and New Zealand's response to these. MfE is also responsible for coordinating climate change policy across Government.

The implementation of specific climate change policies, once agreed to by Government, is frequently led by other relevant departments. The following agencies execute functions relevant to climate change policy:

The Ministry of Business, Innovation and Employment (MBIE)[71] was formed on 1 July 2012. Its overarching purpose is to "grow New Zealand for all", and it therefore has a strong focus on sustainable economic growth "that doesn't compromise our environment". MBIE's responsibilities include energy policy, science and innovation policy, research funding and economic development. Current activities of interest in relation to climate change include providing the appropriate regulatory and policy framework for the exploration and use of oil, natural gas, renewable energy resources and alternative fuels; energy efficiency and conservation-related policy; carbon capture and storage policy; and energy information and modelling.

MBIE also provides advice to the Government on research, innovation and scientific policy. This includes advice on the national science priorities, administering Government investment in science, oversight of the Crown's research agencies, and investing in research in science and innovation that relates directly to understanding the climate system, its observation, mitigation of emissions (eg, carbon capture and storage, and renewable energy), climate change impacts, and adaptation.

The Energy Efficiency and Conservation Authority (EECA) is the primary Government agency responsible for encouraging the more efficient use of energy. EECA runs programmes in various sectors to improve energy efficiency, as well as promoting the use and development of renewable sources of energy.

The Environmental Protection Authority (EPA) is a relatively new Crown entity established by the New Zealand Government in July 2011 with the aim of providing "stronger central government leadership on environmental issues" and giving "greater clarity to national environmental functions". It brings together environmental regulatory functions previously administered by the Ministry for the Environment, the Ministry of Economic Development and the Environmental Risk Management Authority.

---

[71] MBIE brought together four previously separate government agencies: the Ministry of Economic Development, the Ministry of Science and Innovation, the Department of Building and Housing, and the Department of Labour.

The Authority is responsible for the operation of the New Zealand Emission Unit Register (NZEUR) and the administration of all the non-forestry sectors[72] and applications for eligible industrial allocation under the NZ ETS.

The Ministry of Foreign Affairs and Trade (MFAT) is responsible for leading New Zealand's international climate change negotiations, and it coordinates inputs from experts from MfE, the Ministry for Primary Industries, the Treasury and other Government agencies for this purpose.

The Ministry for Primary Industries (MPI) contributes to Government policy development for forestry and agriculture. It has particular responsibility for the implementation of the NZ ETS in relation to forestry, and it administers a number of key forestry-related initiatives, details of which can be found in section 4.3.6. MPI collects data on national annual greenhouse gas emissions for the agricultural and forestry sectors to support reporting under the UNFCCC and annual accounting under the Kyoto Protocol. It also provides direct funding for some elements of climate change research (including agriculture for the national inventory) and sustainable farming, and is responsible for maximising the sustainable utilisation of fish stocks within environmental limits, including research on climate change and its effects on the ocean environment, aquaculture and wild fish stocks.

New Zealand Trade and Enterprise (NZTE) is New Zealand's international business development agency. One of its goals is to introduce offshore investors and strategic partners to New Zealand companies that are developing clean technologies or projects.

The Ministry of Transport (MoT) is the Government's principal advisor on transport policy in New Zealand. It advises Government on enhancing domestic transport efficiency. It also represents the New Zealand Government at international forums.

The New Zealand Transport Agency (NZTA) is the operational agency for delivering land transport objectives, as directed by the Minister of Transport and the Ministry of Transport. The Agency's main functions are to plan land transport networks, invest in land transport infrastructure and public transport services (in conjunction with local government), plan and deliver the national state highway network, and manage access to the land transport system through setting standards and licensing drivers and vehicles. The Agency also has a major role in education, compliance and enforcement of road safety.

The Department of Conservation (DOC) manages large tracts of native forest and provides policy advice on climate change issues, including planning for adaptation measures where they relate to and intersect with conservation issues. The Department supports the Minister of Conservation's role in sustainable coastal management under the Resource Management Act 1991, which includes the preparation of a New Zealand Coastal Policy Statement to set national priorities for the coastal environment.

The Ministry of Health (MoH) is New Zealand's principal advisor on health and disability: improving, promoting and protecting the health of all New Zealanders including the human impacts of climate change.

The Treasury provides fiscal, regulatory, and economic perspectives on climate change policy.

Local government has a range of functions and responsibilities relating to managing climate change effects under the Local Government Act 2002, the Resource Management Act 1991 (and its subsequent amendment) and other legislation. This includes a requirement to plan for

[72] The Ministry for Primary Industries has responsibility for the forestry sector.

the future in terms of managing the effects of land use, avoiding and mitigating natural hazards, and having specific regard to the effects of climate change. In particular, regional councils have responsibility for managing water, air and land resources where there are regionally significant management issues; biosecurity; natural hazards; emergencies; and regional land transport. For city and district councils, responsibilities include land-use planning and decision-making, building control, emergency management, and the provision of infrastructure and community services.

The Natural Resources Sector (NRS) is a network of Government agencies whose core membership consists of the Department of Conservation, Land Information New Zealand, the Ministry for Primary Industries, Ministry of Business Innovation and Employment, Ministry for the Environment, Te Puni Kōkiri. The main purpose of the NRS is to enhance collaboration between Government agencies and ensure a strategic, integrated and aligned approach is taken to natural resources development and management across Government agencies. The network is chaired by the Chief Executive of the Ministry for the Environment.

4.2.2 Key strategies

The impacts of the global financial crisis, the Government's goal to grow the New Zealand economy and a commitment to do New Zealand's fair share to reduce global emissions have informed the Government's approach to climate change. As a result, New Zealand's strategic approach reflects a programme that seeks to maintain a balance between emissions reductions and economic growth. The key developments in New Zealand's policy context since the finalisation of the *Fifth National Communication* in 2009 are outlined below.

Energy strategy

The *New Zealand Energy Strategy 2011 – 2021*, the Government's high-level energy policy statement, was released in August 2011. This sets the strategic direction for the energy sector and the role energy will play in the New Zealand economy in the context of two key challenges: energy security and responding to climate change. The Government's overarching goal is for "New Zealand to make the most of its abundant energy potential – through environmentally-responsible development and efficient use of the country's diverse energy resources."[73]

The strategy identifies four priority areas:

- diverse resource development, including investment in, and use of, both renewable energy resources and non-renewable energy resources (this includes a goal that 90 per cent of electricity generated will come from renewable resources by 2025)
- environmental responsibility – reducing energy-related greenhouse gas emissions and best practice in environmental management for energy projects
- efficient use of energy
- secure and affordable energy.

[73] Ministry of Economic Development (now the Ministry for Business, Innovation and Employment). *The New Zealand Energy Efficiency and Conservation Strategy 2011 – 2016.* Wellington: Ministry of Economic Development. The document is available online at www.med.govt.nz/energy-strategy

New Zealand Energy Efficiency and Conservation Strategy 2011 – 2016

The *New Zealand Energy Efficiency and Conservation Strategy 2011 – 2016*, a companion to the Energy Strategy, was released simultaneously. It focuses on promoting energy efficiency, energy conservation and renewable energy. The Conservation Strategy is prepared in accordance with the Energy Efficiency and Conservation Act 2000 and will be in force for a period of 5 years.

In addition to an economy-wide target for energy intensity improvement,[74] the Conservation Strategy sets out objectives for six sectors:

- transport: a more energy-efficient transport system, with a greater diversity of fuels and alternative energy technologies
- business: enhanced business growth and competitiveness resulting from energy intensity improvements
- housing: warm, dry and energy-efficient homes with improved air quality to avoid ill-health and lost productivity
- products: greater business and consumer uptake of energy-efficient products
- electricity system: an efficient, renewable electricity system supporting New Zealand's global competitiveness
- public sector: greater value for money from the public sector through increased energy efficiency.

Transport strategy

August 2011 saw the Government release a summary of New Zealand's policy direction for transport, *Connecting New Zealand.* The document draws together the policy direction set out in a number of policy decisions and guidance documents over the preceding two and half years.[75] It includes a continued reduction in carbon dioxide emissions from land transport as one of the Government actions for road transport over the next decade[76]. Further detail on this can be found in section 4.3.3 of this chapter.

Green Growth Advisory Group

In January 2011 the Government established a Green Growth Advisory Group. The Group was tasked with exploring how New Zealand can build a more productive and competitive economy while achieving high-quality environmental outcomes.

The Group reported to the Government in December 2011.[77] Its central conclusion was that rather than focusing on a select group of 'green' industries, New Zealand needs a broad growth strategy whereby all sectors take into account their environmental performance. In making this recommendation, the Group noted that "New Zealand faces two major challenges

---

74 The target is to continue to achieve a rate of energy intensity improvement of 1.3 per cent per annum to 2016.

75 These include the National Infrastructure Plan, the Government Policy Statement on Land Transport Funding 2012/13–2021/22, the New Zealand Energy Efficiency and Conservation Strategy, the KiwiRail Turnaround Plan, and Safer Journeys: New Zealand's Road Safety Strategy 2010–2020.

76 Ministry of Transport. 2011. *Connecting New Zealand: A Summary of the Government's Policy Direction for Transport*. Wellington: Ministry of Transport, p. 4.

77 Green Growth Advisory Group. 2011. *Greening New Zealand's Growth: Report of the Green Growth Advisory Group*. Wellington: Ministry of Economic Development.

in de-coupling economic growth from GHG emissions growth. Many of the industries of particular importance to the economy have high emissions intensity."[78] New Zealand therefore needs to:

- focus on innovation and productivity gain to reduce emissions intensity in growth industries that currently have high intensity
- accelerate growth in industries of already lower emissions intensity.

The Group favours a combination of both scenarios, consistent with New Zealand's long-term targets for emissions reduction.[79]

Business Growth Agenda

Approved by Cabinet in late 2012, the Government's Business Growth Agenda is a programme of work that is intended to support New Zealand businesses to grow in order to create jobs and improve New Zealanders' standard of living. It focuses on six key ingredients businesses need in order to grow: export markets, innovation, infrastructure, skilled and safe workplaces, natural resources[80] and capital. Each of these has its own programme of work.

More recently, the Business Growth Agenda has been informed by the Government's response to a report by the Green Growth Advisory Group (see above).[81] The Government agreed with the central conclusion of the report, and in response recommendations contained in the report have been integrated into this wider Business Growth Agenda, including transitioning to a low-emissions economy.

4.3 Policies and measures, and their effects

In preparing this chapter, New Zealand has been mindful of the *Reporting Guidelines on National Communications*[82] and the *Report of the In-depth Review of the Fifth National Communication of New Zealand*. As a result, priority has been given to policies and measures – or combinations of policies and measures – that have the most significant impact on greenhouse gas emissions and removals, or that are innovative or easily replicated by other parties. Website links are provided to allow the interested reader to access more detail on specific initiatives. A summary of the policies and measures reported in this chapter is presented in table C.1, in Annex C.

4.3.1 Cross-cutting measures

The New Zealand Emissions Trading Scheme (NZ ETS)

The NZ ETS creates an obligation on emitters who are participants in the scheme to report on their emissions and surrender emission units that correspond to their obligations. NZ ETS

---

78 Ibid.

79 Ibid.

80 The natural resources area includes primary industries, energy and resources, land use, water, environment (including climate change), local government, and conservation.

81 *Greening Growth in Business Growth Agenda*, New Zealand Government press release, 11 December 2011.

82 See http://unfccc.int/resource/docs/cop5/07.pdf

participants are allowed to surrender both New Zealand Units (NZU), the primary unit of trade in the scheme, and eligible international units to meet their NZ ETS obligations.

NZ ETS reporting and surrender obligations

The following sectors of the economy have obligations under the NZ ETS: forestry, transport fuels, stationary energy, industrial processes, synthetic gases, agriculture and waste. Entry to the NZ ETS was phased by sector. Forestry was the first sector to have reporting and surrender obligations, entering the scheme retrospectively on 1 January 2008. Specific obligations, however, differ based on whether a forest was established before 1 January 1990 (pre-1990 or non-Kyoto forests) or after 31 December 1989 (post-1989 or Kyoto forests).

The stationary energy, industrial processes and liquid fossil fuels sectors entered the scheme, and assumed reporting and surrender obligations, in 2010. The waste sector followed in 2012, with reporting obligations commencing from 2012 and surrender obligations coming into effect from 2013.[83] Bulk importers and users[84] of synthetic greenhouse gases joined the NZ ETS from 2013 and assumed reporting and surrender obligations at this time. The agriculture sector has been required to report on its major emissions (methane and nitrous oxide from biological processes) since 1 January 2012, but currently there is no legislated date for when biological agricultural emissions will assume surrender obligations under the NZ ETS.

Legislated amendments to the NZ ETS

The policy settings for the NZ ETS are contained in the Climate Change Response Act 2002. There have been further amendments to the Act since those reported in New Zealand's *Fifth National Communication*. In 2012 amendments were made to the NZ ETS to:

- support New Zealand contributing its fair share to international action to reduce emissions, including meeting international obligations
- deliver emission reductions in the most cost-effective manner
- support efforts to maximise the long-term economic resilience of the New Zealand economy for the least cost.[85]

The changes maintain transition phase settings and aim to ensure the NZ ETS is flexible enough to cater for future international scenarios by giving the Government the power to auction NZ Units and introducing a number of technical amendments to improve the operation and administration of the NZ ETS. In particular, the changes:

- extend transitional measures to reduce the cost impacts of the scheme beyond 2012 – this has seen the introduction of two-for-one surrender obligations and the choice for participants to meet their obligations by paying the Government NZ$25 per tonne of emission (the fixed price option)
- remove the start date for surrender obligations for biological emissions from agriculture – the Government has indicated that the agriculture sector will only face surrender obligations if there are economically viable and practical technologies available to

---

83 This refers to methane emissions from waste disposal sites.

84 The 2012 NZ ETS amendments also introduced a levy system for small importers and users of synthetic greenhouse gases.

85 *Cabinet Paper: Emissions Trading Scheme Review 2012 – Final Decisions on Amendments to the Climate Change Response Act 2002*, para 16.

reduce emissions and when New Zealand's trading partners make more progress on tackling their emissions in general

- introduce 'offsetting' as an option for pre-1990 forests – this provides forest land owners with the flexibility to convert their land to a better use, while avoiding deforestation costs by planting a carbon-equivalent area of forest elsewhere
- remove forest land with naturally regenerated tree weeds (ie, pest species) from post-1989 registration eligibility, unless the Environmental Protection Authority is satisfied that the risk of spread is low.

The Government has indicated that it will next review the NZ ETS settings in 2015.

NZ ETS implementation costs

The budgeted NZ ETS combined implementation and administration costs borne by Government for the year ending March 2013 come to approximately NZ$18.8 million. There is incomplete data regarding the administration costs borne by participants. Implementation and administration costs since the inception, disaggregated by agency, are shown in the table below.

Table 4.1: Government implementation and administration costs associated with the NZ ETS

Agency	Activity	2007/08 budgeted ($m)	2008/09 budgeted ($m)	2009/10 budgeted ($m)	2010/11 budgeted ($m)	2011/12 budgeted ($m)	2012/13 budgeted ($m)
Ministry for the Environment / Environmental Protection Authority (EPA)	Administration of the NZ ETS.	0	0	0	0	0.236	0.177
	NZ ETS (EPA): this appropriation is for the implementation and operation of the NZ ETS and maintenance of a register to enable the holding and transfer of climate change units.	0	0	0	0	4.992	7.937
Ministry for Business, Innovation and Employment	Emissions trading implementation: this appropriation is limited to the implementation and administration of the NZ ETS.	3.312	6.384	3.063	4.839	1.634	0
	Provision of Climate Change Unit Register and information: this appropriation is limited to services relating to the operation of a register to enable	1.456	1.461	1.454	1.559	0.524	0

	the allocation and trading of climate change units under the Climate Change Response Act 2002.						
Ministry for Primary Industries	Implementation of the NZ ETS and indigenous forestry: this appropriation is limited to the implementation of the agriculture and forestry provisions of the Climate Change Response Act 2002 and the indigenous forestry provisions of the Forests Act 1949.	0*	0*	0*	11.629	14.915	10.877
Total		**4.768**	**7.845**	**4.517**	**18.027**	**22.301**	**18.991**

Source: Ministry for the Environment Finance Team, taken from supplementary estimates budgets. Figures include direct costs plus corporate overheads and exclude climate change policy advice.

***Note** that these figures have been listed in the table as 0 because the costs for implementation were unable to be separated from the costs for policy advice.

Other information

Greenhouse gases affected: all greenhouse gases covered by the Kyoto Protocol: carbon dioxide, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons and sulphur hexafluoride. New Zealand has no emissions of nitrogen trifluoride.

Quantitative effect of the policy/measure: Chapter 5 shows that an estimated 9,810.0 Gg CO_2-e emissions will be avoided by key quantifiable policies and measures by 2020. The NZ ETS is assumed to be responsible for the majority of this total, but its exact effect has not been quantified. This is because the impacts of the NZ ETS are difficult to entirely distinguish from impacts of other policies. Also, the NZ ETS is a long-term intervention, and its impacts need to be evaluated on that basis. The Ministry for the Environment is establishing a work programme to ensure that the NZ ETS and its impacts are monitored and evaluated over time.

Type of policy or measure: economic, regulatory.

Implementing entity: the Environmental Protection Authority administers the register and enforces the scheme. The Ministry for the Environment develops regulations for the NZ ETS. The Ministry for Primary Industries administers the forestry allocation plan and compliance with forestry regulations.

Status of implementation: implemented

More information: details of the NZ ETS can be found at http://www.climatechange.govt.nz/emissions-trading-scheme/index.html, and the register can be viewed at http://www.eur.govt.nz

4.3.2 Energy

Renewable energy

The Government's approach to developing New Zealand's renewable energy resources is to ensure market incentives and the regulatory framework support further investment in appropriate renewable energy projects by removing any unnecessary regulatory barriers. There is no Government subsidy for new electricity generation in New Zealand because renewable energy is already cost-competitive, however, the NZ ETS is intended to send a clear price signal and create a competitive advantage for renewable generation.

As of November 2012, the Ministry of Business, Innovation and Employment had invested around NZ$15.36 million[86] per annum in science programmes supporting renewable energy research. This figure includes Crown Research Institutes such as GNS Science (geothermal) and SCION (biofuels). These organisations include renewable energy in their Statements of Core Purpose[87] and invest core funding to support capability in this area (refer section 8.2.2).

86 This figure includes contestable and core funding, including geothermal energy, bioenergy, solar energy, marine energy, and a Heavy Engineering Research Association contract of NZ$0.919 million per year, but it excludes Callaghan Innovation (business-related) funding.

87 Agency Statements of Core Purpose can be found on the respective agency websites.

Energy efficiency programmes

Efficient products programmes

As noted in the *Fifth National Communication*, New Zealand and Australia have a joint Equipment Energy Efficiency (E3) programme.[88] This is part of the Trans-Tasman Mutual Recognition Arrangement between the countries and means that any product produced in, or imported into, one country may be legally sold in the other. Since 2006 there has been on-going development of energy efficiency labels and mandatory performance standards for a range of commonly used electrical residential, commercial and industrial products, allowing both countries to set consistent standards and measures for energy efficiency.

As described below, the programme aims to reduce emissions from electricity generation by enabling consumers to assess and compare the energy efficiency of products when purchasing appliances. Complementing this, New Zealand also operates a voluntary product endorsement scheme (ENERGY STAR) to encourage consumers to purchase more efficient products.

Minimum energy performance standards

Under the minimum energy performance standards, products must be tested and shown to meet a minimum standard for energy efficiency before they can be sold. The standards are currently in place for 15 product classes in New Zealand.[89]

Compulsory product labelling

Product labelling regulations require retailers of all whiteware appliances, heat pumps, air conditioners, monitors and televisions to provide energy efficiency information to consumers at the point of sale. The labels assess how much electricity the appliance is likely to use in a year (on average) and provide a star rating that compares the appliance's efficiency to other appliances of its type. As with the minimum energy performance standards, mandatory labels in New Zealand align with those set by the Australian Government.

Voluntary product labelling – ENERGY STAR®

ENERGY STAR® is an independent international programme that awards labels to only the most energy-efficient products on the market.[90] ENERGY STAR® was launched in New Zealand in 2005, and by March 2013 coverage had been extended to 20 product classes.[91]

---

88 See http://www.energyrating.gov.au/programs/e3-program/

89 Product classes are: televisions; external power supplies; set top boxes; domestic fridges and freezers; gas water heaters; computer room air conditioners; air conditioners / heat pumps; commercial chillers; distribution transformers; electric hot-water cylinders; compact fluorescent lamps; ballasts for fluorescent lamps; linear fluorescent lamps; three-phase electric motors; and computers and monitors (from 1 October 2013).

90 ENERGY STAR® is typically available to only the top 25 per cent of products in a class, based on energy efficiency.

91 The products currently included in the programme in New Zealand are: dishwashers; fridge/freezers; washing machines; home theatres; televisions; DVD players/recorders; heat pumps / air conditioners; gas space heaters; solar water heaters; compact fluorescent lights; LEDs; luminaires; computer monitors and displays; computers; lap tops; printers; copiers; scanners; faxes; and multi-purpose devices (offices).

Other information

Greenhouse gases affected: carbon dioxide.

Quantitative effect of the policy/measure: in 2020 the measures implemented in the efficient products programme are projected to save 10 petajoules of energy and avoid 1400 Gg of carbon dioxide emissions.[92]

Type of policy or measure*:* regulatory, voluntary information.

Implementing entity: Energy Efficiency and Conservation Authority.

Status of implementation*:* implemented.

More information is available on:

- minimum performance energy standards and labelling at: http://www.eeca.govt.nz/standards-and-ratings/minimum-energy-performance-standards-and-labelling
- product models registered under minimum energy performance standards in New Zealand and Australia at: http://www.energyrating.gov.au/regulations/overview/
- the ENERGY STAR® programme at: http://www.eeca.govt.nz/standards-and-ratings/energy-star

ENERGYWISE Homes

ENERGYWISE™ is the EECA's consumer programme that provides information and funding for householders so that they can make the most of energy efficiency, energy conservation and renewable energy.

Warm Up New Zealand: Heat Smart

This programme ended in September 2013. Until then, *Warm Up New Zealand: Heat Smart* had been the Government's principal energy efficiency programme in the residential sector for the last four years. The programme provided consumers with information on home insulation, grants for the installation of energy efficiency measures (through subsidies for ceiling and underfloor insulation installed through approved service providers) and clean heating devices[93] in homes built prior to 2000.[94]

The scheme paid – without income restriction – one-third of the cost of installing ceiling and under-floor insulation up to a maximum of NZ$1,300. People on lower incomes were eligible for up to 60 per cent of the total cost of insulation and NZ$1,200 towards a clean heating appliance, provided the home was first insulated. Landlords whose tenants were low-income earners could also receive the 60 per cent subsidy.

---

[92] This is a maximum potential savings projection and includes projected savings from autonomous energy efficiency intensity improvements.

[93] Clean heating devices approved by the EECA include specified wood burners, pellet burners, heat pumps and flued gas heaters. The clean heating component of the programme stopped in October 2012, when the Government decided to re-focus the remaining funding on insulation retrofits.

[94] After January 2000 insulating ceiling and underfloors became a requirement when building a new home.

The programme operated on a co-funding basis with four sets of partners: local government, iwi,[95] existing and new service providers, and energy retailers. Generally this third-party funding was applied to low-income households to cover the remaining 40 per cent of the costs of insulation not provided by the programme.

In Budget 2009 the Government allocated the programme NZ$323 million over 4 years. The initial aim was to retrofit over 180,000 homes. In November 2009 the Government announced that the programme would be enhanced by an additional NZ$24 million of funding targeted at low-income families, allowing an additional 8000 households to benefit.

In Budget 2012, the programme was extended further, to deliver a total of at least 230,000 insulation retrofits. To the end of September 2013, the programme has delivered 235,000 insulation retrofits. The programme is expected to have insulated a total of 238,000 houses before funding runs out in later in the 2013/14 financial year. This is well above the original target.

Evaluation reports confirm and quantify the success of the programme.[96] To date, net benefits to New Zealand are calculated to be worth NZ$1.3 billion over the expected lifetime of measures delivered under the programme, with a benefit:cost ratio of more than 4:1. The majority (99 per cent) of the measured net benefit is from improved health resulting from warmer, drier conditions after insulation is installed.

Warm Up New Zealand: Healthy Homes

In May 2013 the Government announced that it will invest in a new 3-year insulation programme delivering warmer, drier and healthier homes to communities in most need. It allocated NZ$100 million of operating funding to the new programme, *Warm Up New Zealand: Healthy Homes* to insulate 46,000 houses. The programme targets low-income households, particularly those with high health needs, which include children, the elderly, and people at risk of cold-related illness. Unlike its predecessor (*Warm Up New Zealand: Heat Smart*), the new programme only provides targeted funding and does not provide funding for clean-heating devices.

As with the previous programme, the Government's investment of up to 60 per cent of the cost of a home's insulation will be augmented by significant levels of funding from trusts and other third parties. This will make insulation available to those households in most need, at low or no cost. Like *Heat Smart*, *Healthy Homes* will be delivered through the EECA. The EECA expects projects to roll out progressively from the end of August 2013 following a request for proposals, evaluation of projects and contract negotiations in May to July.

---

95 An iwi is one of the larger collective Māori groupings and is sometimes described as a tribe.

96 Evaluation reports can be found at http://www.healthyhousing.org.nz/research/current-research/evaluation-of-warm-up-new-zealand-heat-smart

Other information

***Greenhouse gases affected*:** carbon dioxide

***Quantitative effect of the policy/measur**e*: 20 Gg CO_2-e annually by 2020.

***Type of policy or measure*:** fiscal, information.

Implementing entity: Energy Efficiency and Conservation Authority.

***Status of implementation*:** implemented

More information is available on:

- the ENERGYWISE homes programme at: http://www.energywise.govt.nz/your-home and http://www.eeca.govt.nz/eeca-programmes-and-funding/programmes/homes
- the Warm Up New Zealand: Heat Smart programme at: http://www.eeca.govt.nz/node/3107

Business programmes

Businesses currently consume about 70 per cent of New Zealand's total energy. It is estimated that businesses could reduce their current energy use by about 20 per cent. To support improvements in energy consumption by businesses, the EECA works directly with energy-intensive businesses[97] on their energy management, and with industry associations in energy-intensive industries to promote best practice in energy management.

The EECA has identified four priority areas for energy savings for businesses:

- commercial buildings – targeting lighting, heating, ventilation and air conditioning (HVAC) technology and refrigeration
- industrial heat – targeting motorised systems and process heat
- lighting – targeting more efficient lighting technology in businesses and on New Zealand's roads
- business transport – targeting more efficient fuel use (more detail on this can be found in section 4.3.3).

The programmes are designed to overcome market barriers, and they include capability tools (such as energy use audits and savings plans, or training programmes for energy advisors and facilities managers), information tools (such as lighting guides), regulations (such as minimum energy performance standards for commercial refrigerators, motors or building chillers) and, to a reducing extent, grants (eg, to help fund the costs of large capital items or detailed audits).

The EECA provides part-funding of up to NZ$100,000 per project via loans to public sector organisations (such as schools, hospitals, central and local government buildings and facilities, such as swimming pools) to fund energy improvements.

---

97 Energy-intensive businesses are those that spend more than NZ$500,000 per year on energy.

Commercial buildings

In May 2013 the EECA, in collaboration with the New Zealand Green Building Council, launched a new scheme to measure and rate the energy performance of commercial buildings in New Zealand. The scheme, NABERSNZ™, is based on the successful National Australian Built Environment Rating System (NABERS) and has been adapted for New Zealand conditions.

NABERSNZ™ is a voluntary scheme that aims to help owners and tenants to reduce energy use and costs, and also reduce greenhouse gas emissions. Under NABERSNZ™ qualified assessors measure and score the energy performance of office buildings, giving tenants and owners a star rating out of 6.

Industrial heat

Process heat is New Zealand's second-largest area of national energy use, with only one-third of fuels in this area coming from renewable sources (such as wood and geothermal). As such, it is also a significant contributor to greenhouse gas emissions. The EECA works with industry associations to promote the use of renewable fuels, particularly for process heat (e.g., switching from coal to wood boilers). The EECA provides advice, and funds feasibility studies, boiler tuning grants, energy management plan contracts to heavy and light industry, and provides education for energy consultants and business managers.

Efficient lighting

The KEMA[98] Potentials Study[99] estimated lighting was the single biggest area of potential energy efficiency savings. Lighting constitutes 8 per cent of electricity consumed in New Zealand homes and 14 per cent of electricity used in commercial and public buildings. It is estimated that 0.65 million tonnes of greenhouse gas emissions are generated annually to meet New Zealand's lighting needs.

The New Zealand Government launched its Efficient Lighting Strategy in mid-2008, aiming to reduce lighting energy consumption by 20 per cent by 2015 through the uptake of efficient, affordable lighting technologies. Although the Strategy initially featured a mandatory phase-out of incandescent lamps, the Government has since decided against this measure in favour of alternatives that promote efficient lighting without limiting consumer choice.

The EECA supports in-store labelling promoting energy-efficient lighting and provides grants and education designed to promote the uptake of new, efficient lighting technology. The EECA also runs RightLight, a web-based programme for information on energy-efficient lighting and design (http://www.rightlight.govt.nz).

98 KEMA is a global energy consultancy company.

99 The 2007 KEMA Potentials Study examined electric energy efficiency potential in New Zealand's residential, commercial and industrial sectors. The resulting report can be seen at http://www.eeca.govt.nz/node/11002

Other information

Greenhouse gases affected: carbon dioxide

Quantitative effect of the policy/measure: the Efficient Lighting Programme is estimated to reduce emissions by 81 Gg CO_2-e per year. The industrial and commercial programmes reduce CO_2-e emissions by a further 8 Gg annually.

Type of policy or measure: information, fiscal

Implementing entity: Energy Efficiency and Conservation Authority

Status of implementation*:* implemented

More information is available on:

- the Efficient Lighting Programme at: http://www.rightlight.govt.nz
- the commercial sector programmes at: http://www.eecabusiness.govt.nz/services-and-funding/commercial-buildings
- the industrial sector programmes at: http://www.eecabusiness.govt.nz/services-and-funding/industrial

Energy efficiency in Government: sustainable government procurement

In 2009 the New Zealand Government established a programme to reform Government procurement. This builds on the foundations established by the Australia and New Zealand Government Framework for Sustainable Procurement and supporting guides[100] on sustainability. The reforms are based on three core elements: policy transformation, capability building, and greater use of collaborative contracts for common areas of spending. The reform programme aims to make sustainable procurement an integral part of everyday procurement practice.

To support implementation of the reform programme, the Government has designated Ministry of Business, Innovation and Employment as the procurement functional leader, with responsibility for leading initiatives to strengthen agencies' procurement capability and practices.

Policy transformation

The policy transformation work introduced new principles of Government procurement[101] in 2012. The principles require Government agencies to make procurement decisions based on best value for money, take account of costs and benefits over the life of the goods or services being procured, and have regard to environmental, economic and social impacts. To implement the principles and embed them in agencies' practice, the Government has introduced new rules for sourcing and has issued guidance on the practical application of total cost of ownership and sustainable procurement.

---

100 See http://www.business.govt.nz/procurement/for-agencies/guides-and-tools/A-to-Z-guides-tools-templates

101 See http://www.business.govt.nz/procurement/for-agencies/key-guidance-for-agencies/principles-rules-and-the-law

Entity capability reviews

Changes to Government policy have been complemented by independent procurement capability reviews of high-spending Government agencies. Sustainable procurement is one of the eight areas assessed for these reviews, and agencies' practices are benchmarked against internationally recognised criteria. On completing a review, agencies are given a capability development roadmap to implement changes, and are then reviewed again after 2 years to measure their progress.

Collaborative contracts

New Zealand has negotiated a series of contracts under which all Government agencies can source commonly used goods and services.[102] Where relevant, these contracts have tough sustainability criteria built into them. The high number of agencies purchasing under the contracts has effectively lifted the level of sustainable procurement across Government and has encouraged suppliers to improve their sustainability performance.

Other information

Greenhouse gases affected: carbon dioxide

Quantitative effect of the policy/measure: the emissions reductions directly associated with this programme have not been quantified.

Type of policy or measure: fiscal, information.

Implementing entity: Energy Efficiency and Conservation Authority.

Status of implementation: implemented.

More information is available at: http://www.eecabusiness.govt.nz/services-and-funding/crown-loans

4.3.3 Transport

The transport sector is responsible for 44 per cent of New Zealand's energy sector greenhouse gas emissions, with road vehicles responsible for the majority of carbon dioxide emissions. Technological advances, improvements in infrastructure and the potential for emissions reductions through behavioural changes mean this is an area that offers potentially significant energy savings for New Zealand.

The Government's primary mechanism to mitigate greenhouse gas emissions from the transport sector is to include transport fuels in the NZ ETS. Other transitional incentives and research are underway to complement the scheme in the areas of new fuels and technology, improved efficiency of commercial fleets, and encouraging forms of transport that are less carbon intensive. These policies and measures are discussed below.

[102] Contracts have been negotiated for office consumables, vehicles, desktop and laptop computers, print devices, air travel, legal services, mobile voice and data, travel management, recruitment and electricity.

Strategic context

The Government's overarching goal for the New Zealand transport system is "an effective, efficient, safe, secure, accessible and resilient transport system that supports the growth of our country's economy, in order to deliver greater prosperity, security and opportunities for all New Zealanders."[103]

The New Zealand Energy Strategy 2011 –2 021 and the New Zealand Energy Efficiency and Conservation Strategy 2011 – 2016 add a focus on energy efficiency to the strategic direction and infrastructure planning for the transport sector. They highlight the potential to reduce energy use in urban areas through walking, cycling and greater use of public transport, and place an expectation on local authorities to ensure integrated travel options through their transport and planning roles. Local authorities are also expected to improve the efficiency of local transport networks and layouts so that people and freight can move about with greater ease and energy efficiency.

Reflecting this context, the Government Policy Statement includes the following short to medium term impacts:

- investment in the state highway network to increase the efficient movement of people and freight
- making quality investments in public transport that can help manage road congestion and give people alternatives to private car use
- investing in walking and cycling.

Vehicle efficiency

Vehicle fuel economy labelling

The Vehicle Fuel Economy Labelling scheme came into effect in April 2008 and makes it compulsory for vehicle traders and online vendors to display information about the fuel economy of their vehicles. The aim of the programme is to allow consumers to make a more informed choice when purchasing a vehicle and place an appropriate value on fuel economy.

---

103 Ministry of Transport. 2011. *Connecting New Zealand: A Summary of the Government's Policy Direction for Transport*. Wellington. Ministry of Transport. p.3.

Other information

Greenhouse gases affected: carbon dioxide.

Quantitative effect of the policy/measure: the Energy Efficiency and Conservation Authority estimates that the Vehicle Fuel Economy Labelling scheme will encourage carbon dioxide savings of 43.0 Gg CO_2-e per year by 2020.

Type of policy or measure: regulation.

Implementing entity: New Zealand Transport Agency and the Energy Efficiency and Conservation Authority.

Status of implementation: implemented.

More information is available at**:** http://www.eeca.govt.nz/content/vehicle-fuel-economy-labels

Fleet Best Practice Programme

Commercial vehicle fleet fuel efficiency was a significant area of New Zealand-based research during 2008. As a result, the New Zealand Fleet Best Practice Programme was developed, including the recent addition of the Heavy Vehicle Fuel Efficiency programme (described below). The programme added fleet management and monitoring to the driver training components of the Fleet Best Practice Programme. This programme has now been replaced with the Heavy Vehicle Fuel Efficiency programme, described below.

Heavy Vehicle Fuel Efficiency programme

The EECA launched this programme in September 2012. It aims to improve the fuel efficiency of heavy vehicle fleets through expert advice and funding assistance. Under the programme the EECA trains independent and in-company fuel advisors and trainers, and provides grants for fleet audits, information about how to save fuel, and training for fuel-efficient and safe driving. More detail on the training programme can be found in Chapter 9, section 9.3.4. The EECA is considering extending the programme to smaller fleets of heavy vehicles and to promote fuel efficiency in light commercial fleets in 2013/14.

High productivity motor vehicles

The Land Transport Rule: Vehicle Dimension and Mass Rule Amendment 2010 allows for high productivity motor vehicles (HPMVs). These are a special category of permitted freight trucks that are allowed to exceed standard lengths and/or weight. Work so far has highlighted economic, environmental and safety benefits from using HPMVs because they improve productivity and reduce the number of truck movements needed to cope with current and increasing freight volumes. Lowering the number of truck movements reduces fuel consumption and emissions while retaining the freight transport capacity.

Technology

Biofuels

Over the period 2008–2014 the Government has committed NZ$42 million for research and innovation into biofuels. Initially the focus was on first-generation biofuels produced from sugars, starches, vegetable oils or animal fats. The potential of conventional biofuels in New Zealand is, however, limited by the availability of feed stocks. As a result, the Biodiesel Grant Scheme to encourage the production of first-generation biodiesel was discontinued in 2012 (see section 4.6).

More recently the Government's focus has shifted to advanced (second-generation) biofuels. Advanced biofuels generally refer to new methods of producing biofuels. They are not yet ready for commercial development but are the subject of extensive research and development internationally.

Advanced biofuels made from forestry waste may have particular potential for New Zealand, given its well-established forestry industry. The Government considers that advanced biofuels are likely to provide New Zealand with much greater volume and offer a more valuable source of low-emission transport fuels compared to first-generation biofuels. Reflecting this, in July 2013 the Government approved co-funding with business to undertake a feasibility study to determine the commercial viability of establishing a modular test plant to process New Zealand forest waste into sustainable transport fuel. The Government and its business partners[104] have each committed NZ$6.75 million to the project.

Other information

Greenhouse gases affected: carbon dioxide.

Quantitative effect of the policy/measure: the emissions reductions directly associated with this programme have not been quantified.

Type of policy or measure*:* fiscal.

Implementing entity*:* Energy Efficiency and Energy Conservation Authority.

Status of implementation: implemented.

More information is available at**:** http://www.eeca.govt.nz/eeca-programmes-and-funding/programmes/renewable-transport-energy/biofuels

Electric vehicles

In June 2009 the Government passed legislation to provide an exemption from road-user charges for electric vehicles from October 2009 until July 2013. In 2012 the exemption was extended to 2020. The exemption recognises the role electric vehicles will play in assisting with the reduction of greenhouse gas emissions from the transport sector. Combining highly efficient electric motors with New Zealand's competitive advantage in renewable electricity generation will reduce the greenhouse gases produced by the transport sector as well as harmful emissions that affect air quality.

[104] 'Stump to Pump' business partners are Norske Skog and Z Energy.

Other information

Greenhouse gases affected: carbon dioxide.

Quantitative effect of the policy/measure*:* the emissions reductions directly associated with this programme have not been quantified.

Type of policy or measure: fiscal.

Implementing entity: Ministry of Transport.

Status of implementation: implemented – legislation to implement the exemption was passed by Parliament in August 2009 and extended in 2012 to 2020.

More information is available at*:* http://www.transport.govt.nz/ourwork/Land/RUC-exemption-for-light-electric-vehicles-2009/

Intelligent transport systems

Intelligent transport systems apply information and communication technologies to vehicles (including trains, aircraft and ships), transport users and transport infrastructure to improve traffic management and efficiency. New Zealand already has some examples of intelligent transport systems in place, helping aircraft find the most efficient routes into airports and telling public transport users when their bus or train can be expected to arrive.

In addition to this existing capability, the Ministry of Transport:

- has completed a conversation paper to canvas stakeholders' views on the opportunities intelligent transport system technologies provide and any barriers to their implementation
- has trialled cooperative intelligent transport systems between Auckland and Tauranga
- is currently undertaking public consultation on the Government Intelligent Transport System Action Plan.

The Model Communities Programme

The New Zealand Transport Agency has recently provided funding to New Zealand's first walking and cycling 'model communities' in Hastings and New Plymouth. The Model Communities programme aims to encourage a planning and investment approach that fully integrates walking and cycling into urban transport networks.

Infrastructure

Public transport

The Government is committed to on-going investment in public transport. As part of the 2012–2015 National Land Transport Programme, it has committed NZ$945 million from the National Land Transport Fund for public transport. This is divided into NZ$830 million for public transport services and NZ$115 million for public transport infrastructure – the highest-ever investment in any 3-year period. Through the National Land Transport Fund, the Government is also providing Auckland (New Zealand's largest urban area) and Wellington with NZ$1.6 billion and NZ$485 million, respectively, for the upgrade of the rail network and the purchase of new electric multiple units.

New Zealand is implementing a new policy framework for planning and contracting public transport, known as the Public Transport Operating Model. The model provides the framework for delivering the Government's goal of growing patronage and increasing the value for money of investment in public transport. Central to the model is an on-going partnership between regional councils and public transport operators, which recognises that both parties have a stake in, and rely on each other for, delivering high-quality, efficient and affordable urban bus, ferry and rail services that people want to use.

Roads of national significance

Current work on the Government's seven roads of national significance includes redesigning the roading network to move high-volume freight routes away from residential areas, schools and vulnerable road users. Where these roads move through urban areas, the New Zealand Transport Agency is investing in ways to reduce the impact of this traffic on neighbouring communities. This provides benefits to communities, saves time and money in moving freight, and reduces congestion and heavy vehicle emissions.

State highway design, construction and operation

The New Zealand Transport Agency aims to reduce greenhouse gas emissions via the design, construction and operation of state highways. To support this commitment, the Agency, along with Australian state road authorities, formed the Transport Authorities Greenhouse Group to share information on estimating, reporting and minimising greenhouse gas emissions. The Group developed the *Greenhouse Gas Assessment Workbook* and accompanying 'Carbon Gauge' tool to provide road designers, builders, managers and operators with a way to consistently estimate greenhouse gas emissions during construction, operation and maintenance.

The New Zealand Transport Agency has completed carbon footprints for a number of its large capital projects and has established targets and programmes to reduce and monitor emissions during construction. When evaluating the costs and benefits of a new capital project, the Agency estimated the carbon dioxide emissions resulting from users of the network, in accordance with the economic evaluation manual.

Other information

***Greenhouse gases affected*:** carbon dioxide.

Quantitative effect of the policy/measure: the emissions reductions directly associated with this programme cannot be quantified.

***Type of policy or measure*:** educational and fiscal.

Implementing entity: Ministry of Transport.

***Status of implementation*:** The legislative components of the Public Transport Operating Model were established under the Land Transport Management Amendment Act 2013 and came into force on 13 June 2013.

More information is available at: http://www.transport.govt.nz/ourwork/Land/PTOM/

4.3.4 Industry

Emissions produced as a result of industrial processes are captured by the NZ ETS. Bulk importers of hydrofluorocarbons (HFCs) and perflurocarbons (PFCs) and users of sulphur hexafluoride have obligations to surrender NZUs equivalent to the amount of HFCs and PFCs they import or the sulphur hexafluoride emitted through use. Manufacturers of HFCs and PFCs also have these obligations for the synthetic greenhouse gases they manufacture.[105]

In addition, since 1 July 2013 a levy has been imposed on imported goods and motor vehicles containing synthetic greenhouse gas (HFCs and PFCs). The levy applies to goods such as fridges, freezers, heat pumps, air-conditioners, refrigerated trailers and air conditioning units contained in motor vehicles. The levy is linked to the price of carbon and will vary between items to reflect the amount of gas, the specified gas and its global warming potential.

Carbon capture and storage (CCS)

The Government supports the global uptake of carbon capture and storage (CCS) internationally, especially by large carbon dioxide emitters, because it is considered to be a significant climate change mitigation technology.

The opportunities for adopting CCS in New Zealand are more limited than in some other countries because New Zealand has relatively few large point sources of carbon dioxide emissions, particularly given the high renewable contribution to electricity generation. This means that CCS has limited potential to help New Zealand mitigate current carbon emissions. However, the possibility of using CCS may help maintain flexibility in the future use of New Zealand's energy resources for economic development.

The Government's focus is on removing any barriers to implementation, ensuring appropriate policy is in place and facilitating related research. The Ministry of Business, Innovation and Employment is the lead agency for CCS policy. Its work programme focuses on ensuring an appropriate legislative and regulatory framework is in place to regulate CCS, should it be used here, and to allow for proactive investment decisions. More information about this work programme is available on the following websites:

- http://www.med.govt.nz/sectors-industries/energy/energy-environment/ccs/ccs-in-new-zealand.
- http://www.msi.govt.nz/get-funded/research-organisations/types-of-funding/carbon-capture-and-storage-investment-round/.

4.3.5 Agriculture

Reflecting the significance of agricultural emissions in New Zealand's overall emissions profile, New Zealand remains committed to exploring innovative technological solutions to reduce greenhouse gas emissions from agriculture. The New Zealand Government has invested heavily in climate change research in agriculture through various mechanisms and provides leadership internationally on research to reduce ruminant greenhouse gas emissions. The Ministry for Primary Industries is responsible for setting agricultural policy in New Zealand.

---

[105] Exporters of HFCs and PFCs are eligible to receive NZUs from 1 January 2013, as long as they meet prescribed eligibility criteria.

Since 1990 improvements in efficiency and productivity have been made across the New Zealand agricultural sector. This has led to significant decreases in emissions per unit of product for sheep, beef and dairy.

Currently there are few economically viable technologies for reducing greenhouse gas emissions from agriculture. New Zealand's main policy approach therefore focuses on investment in research, and the Government and private sector continue to invest over NZ$20 million per year into research to reduce agricultural emissions. Research is carried out under the:

- Global Research Alliance on Agricultural Greenhouse Gases
- Primary Growth Partnership
- New Zealand Agricultural Greenhouse Gas Research Centre
- Pastoral Greenhouse Gas Research Consortium
- Sustainable Land Management and Climate Change Plan of Action.

These initiatives are outlined in more detail below. The research has also benefited the National Greenhouse Gas Inventory (also see section 8.4 for further details).

Global Research Alliance on Agricultural Greenhouse Gases

In 2009 and 2010 New Zealand led the establishment of the Global Research Alliance on Agricultural Greenhouse Gases. The aim of the Alliance is to increase international cooperation, collaboration and investment in research into ways to grow more food without increasing greenhouse gas emissions. To date 40 countries have joined the Alliance, including most of the world's major agricultural producers.

The Alliance focuses on connecting research across three main areas: croplands, livestock and paddy rice. It also seeks to bring together related research on soil carbon and nitrogen cycling, and emissions inventories and measurement. Work plans have been developed for each of these areas and are designed to build capacity and capability worldwide by fostering collaboration, and the sharing of knowledge and best practice.

New Zealand provides a range of support to the Alliance (including secretariat support) and currently holds the co-chair for the Livestock Research Group. From June 2011 to June 2012 New Zealand was chair of the Alliance Council. The New Zealand Government also contributes funding support and has committed NZ$45 million to June 2016 to support the work of the Alliance. This investment is split into two categories: research and development, and capability building.

In addition, New Zealand has established a contestable fund for Global Partnerships in Livestock Emissions, alongside an initiative to support greater collaboration between New Zealand and Australia. The Government also funds a competitive fellowship programme through the Livestock Emissions and Abatement Research Network. These fellowships provide capability-building opportunities for technicians, doctoral students, postdoctoral fellows and scientists in the area of livestock emissions reduction research. Government funding is also used to provide support for the development of virtual networks, collaborative projects, technical manuals and international workshops. (More information on the workshops supported by the New Zealand Government can be found in section 9.5.)

Other information

Greenhouse gases affected: methane, nitrous oxide, carbon dioxide.

Quantitative effect of the policy/measure: the emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: research, information sharing, training, education.

Status of implementation: implemented.

More information is available at:

http://www.globalresearchalliance.org/

http://www.mpi.govt.nz/environment-natural-resources/climate-change/international-response-to-climate-change/global-research-alliance.aspx

Primary Growth Partnership

In 2009 the Government established the Primary Growth Partnership. The scheme focuses on boosting productivity through on-going investment in innovation and delivering long-term economic growth and sustainability across the following primary industry sectors:

- pastoral (including wool) and arable production
- horticulture
- seafood (including aquaculture)
- forestry and wood products
- food processing (including nutraceuticals and bioactives).

Investments cover the whole of the value chain (from producer to consumer) and include education and skills development, research and development, product development, commercialisation, commercial development and technology transfer.

Programmes undertaken under the Primary Growth Partnership require joint investment between the Government and industry. Contributions by the co-investors must be equal to or greater than Government funding. In 2009 the Government increased its funding contribution from NZ$30 million for 2009/10 to NZ$50 million for 2011/12, and NZ$70 million per annum from 2012/13. The Primary Growth Partnership aims to provide funding of no less than NZ$500,000 over the lifetime of the programme. So far eight funding rounds have been held and 13 programmes have been funded. Many programmes also provide climate change co-benefits in terms of either reducing absolute emissions from the primary sector or reducing emissions per unit of product.

The Primary Growth Partnership also provides core funding for the New Zealand Agricultural Greenhouse Gas Research Centre (described in more detail in the following section).

Other information

Greenhouse gases affected: methane, nitrous oxide, carbon dioxide.

Quantitative effect of the policy/measure: the emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: research, information, training.

Implementing entity: Ministry for Primary Industries.

Status of implementation: implemented.

More information is available at: http://www.mpi.govt.nz/agriculture/funding-programmes/primary-growth-partnership

New Zealand Agricultural Greenhouse Gas Research Centre

In 2010 the New Zealand Government established the New Zealand Agricultural Greenhouse Gas Research Centre. The Centre brings together nine research organisations that conduct research to reduce agricultural greenhouse gas emissions: seven Crown Research Institutes and universities,[106] DairyNZ, and the Pastoral Greenhouse Gas Research Consortium.

Research at the Centre is focused on finding practical ways of reducing methane and nitrous oxide emissions on-farm while improving productivity. The research builds on the existing efforts of the Pastoral Greenhouse Gas Research Consortium (established in 2002) and the Sustainable Land Management and Climate Change Plan of Action (published in 2007). The Centre also funded two major measurement facilities that opened in 2011: the Ruminant Methane Measurement Facility and the National Centre for Nitrous Oxide Measurement.

Progress so far includes:

- the identification and selection of high- and low-methane-producing sheep for breeding
- partial sequencing of several methanogen genomes (genomes of the microbes responsible for methane formation in the rumen) to aid the development of a vaccine to reduce methane emissions from enteric fermentation
- the identification and testing of possible methanogen inhibitors.

106 Member Crown research institutes and universities are: AgResearch, Landcare Research, Lincoln University, Massey University, NIWA, Plant and Food Research, and SCION.

Other information

Greenhouse gases affected: methane, nitrous oxide, carbon dioxide.

Quantitative effect of the policy/measure: the emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: research, information, capability building, education.

Implementing entity: Ministry for Primary Industries.

Status of implementation*:* implemented.

More information is available at: http://www.nzagrc.org.nz/

Pastoral Greenhouse Gas Research Consortium

The Pastoral Greenhouse Gas Research Consortium is a 50:50 Government/industry-funded partnership that aims to provide livestock farmers with the information and means to mitigate their greenhouse gas emissions. It is strongly linked to the New Zealand Agricultural Greenhouse Gas Research Centre and currently funds research within the Centre to reduce methane emissions in ruminant animals.

The Consortium has been in operation since 2002 and includes eight partners from the dairy, sheep, beef, deer, agricultural research and fertiliser industries. It includes DairyNZ, Beef+Lamb and Fertiliser Research, all of which conduct research for the benefit of the industry as a whole. Key outcomes achieved by the Consortium include the identification of heritable markers for high- and low-methane-emitting sheep and the sequencing of the first methanogen genome. In February 2013 the Government and industry partners committed a further NZ$5.4 million per annum to the Consortium over the next 7 years.

Other information

Greenhouse gases affected**:** methane, nitrous oxide.

Quantitative effect of the policy/measure**:** the emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure**:** research, information, education.

Implementing entities**:** Ministry for Primary Industries and Ministry of Business, Innovation and Employment.

Status of implementation**:** implemented.

More information is available at: http://www.pggrc.co.nz

Sustainable Land Management and Climate Change Plan of Action

In September 2007 the Government outlined an integrated package for the land-based sectors called the Sustainable Land Management and Climate Change Plan of Action. The Plan of Action is still in operation and covers all aspects of climate change in the land-based sectors, including reducing greenhouse gas emissions and increasing carbon sinks. It has also helped to deliver resources and demonstration programmes encouraging climate change mitigation to rural professionals.

Reducing emissions is a key area of focus under the Plan of Action. Work undertaken in this area includes:

- the development of greenhouse gas footprinting methodologies and generic carbon footprints for each of the land-based sectors in New Zealand – carbon footprints have now been developed for forestry, dairy, lamb, strong wool, beef, and fertiliser
- an ongoing research programme, initiated in 2007, to derive New Zealand-specific emissions factors for New Zealand's greenhouse gas inventory – this research has led to a 4 per cent reduction in the emissions reported for agriculture (see section 8.4.5 for further details)
- research on how to reduce methane emissions from agriculture – key outcomes from this work include the identification of feeds that can decrease methane emissions in sheep, and the development of bio-filters to capture methane emissions from housed animals, effluent ponds and landfills
- a 5-year grant to support the establishment of a Life Cycle Analysis Centre at Massey University and funding for two biochar professorships to study the production and use of biochar as an approach to carbon sequestration in New Zealand
- the use of the nitrification inhibitor dicyandiamide (DCD), which reduces nitrous oxide emissions from livestock-grazed pasture by approximately 30 per cent and is currently the only commercially available technology for this purpose – further work in this area is on hold pending the development of an international food safety standard for DCD.

Recognising the link between improved land management to reduce climate change and climate change impacts on waterways, the Plan of Action has funded the development of Overseer®, an on-farm nutrient budgeting tool. This tool can provide farmers with information about nitrogen-use efficiency and nitrate leaching and includes a module for estimating greenhouse gas emissions on-farm.

It is currently being rolled out to over 10,500 dairy farmers in New Zealand as a tool to more effectively manage nitrogen and reduce nitrate leaching on-farm. This roll-out has been implemented by Fonterra, the largest dairy-processing company in New Zealand, as part of its environmental management programme. Regional councils are also starting to use the tool to set limits on the amount of nitrogen that can flow into waterways from farms in certain catchments.

Since 1990 significant improvements in efficiency and productivity have been made across the agriculture sector (attributed in part to technology transfer). Between 1990 and 2011 these improvements have led to an 18 per cent decrease in emissions from dairy cattle per kilogram of milk solid; a 23 per cent reduction in sheep emissions per kilogram of lamb and mutton; and a 27 per cent reduction in non-dairy (beef) emissions per kilogram of beef (figure 4.1). More information about the Plan of Action (impacts and adaptation) can be found in section 6.4.2.

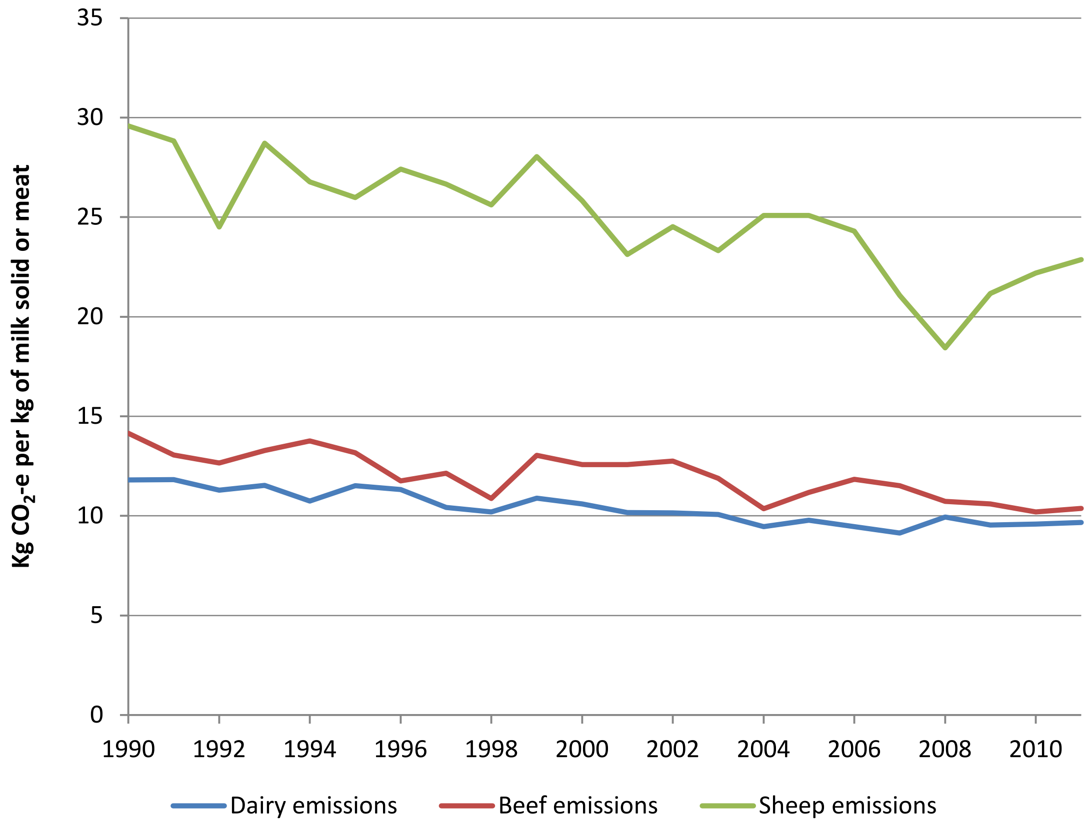


Figure 4.1: Agricultural emissions from dairy, beef and sheep, 1990 – 2011

Note: Excludes dairy cull for beef, and emissions for wool are not included.

Other information

Greenhouse gases affected: methane, nitrous oxide, soil carbon and forest carbon.

Quantitative effect of the policy/measure: the emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: research, information, education, capability.

Implementing entity: Ministry for Primary Industries.

Status of implementation: implemented.

More information is available on:

- climate change measures at: http://www.mpi.govt.nz/environment-natural-resources/climate-change
- the agricultural section of the National Inventory at: http://www.mpi.govt.nz/news-resources/statistics-forecasting/greenhouse-gas/agricultural-greenhouse-gas-inventory
- Overseer at: http://www.overseer.org.nz

4.3.6 Forestry

In 2011 the Land Use and Carbon Analysis System (LUCAS) measured 2.1 million hectares of plantation forest and 8.1 million hectares of natural forest. Less than 0.1 per cent of New Zealand's annual forest production is harvested from natural forests. Commercial timber harvested from privately owned natural forest is restricted to that sourced under sustainable forest management plans and permits, and no harvesting is permitted in natural forest on public land. These changes have been in place since 1993 and 2002, respectively, following amendments to the Forests Act 1949.

Extensive forest planting on pastoral land in the early 1990s has partially offset New Zealand's greenhouse gas emissions. Most of this new planting occurred on a commercial basis, between 1992 and 2003, due to a relatively high expected rate of return for forests (due to high export log prices). These forests will continue to contribute to offsetting New Zealand's projected emissions growth until 2020. This planting has occurred almost exclusively on pastoral land.

New Zealand has four principal measures that promote afforestation and provide incentives to maintain forests:

- NZ ETS
- Permanent Forest Sink Initiative
- East Coast Forestry Project
- Afforestation Grant Scheme.[107]

Since 2008 the impact of these measures has been to slightly increase afforestation and to reduce deforestation. Fifty-five per cent of new planting since 2008 has received grants through either the East Coast Forestry Project or the Afforestation Grants Scheme. Further details of these measures are provided below.

New Zealand Emissions Trading Scheme

The NZ ETS is the main policy instrument to encourage afforestation and reduce deforestation. The forestry sector entered the NZ ETS in 2008, and around 61 per cent of forests planted after 1989 have been voluntarily registered. The majority of land owners with forests planted before 1990 face deforestation liabilities under the NZ ETS if they deforest.

Permanent Forest Sinks Initiative

The Permanent Forest Sinks Initiative promotes the establishment of permanent forests on land that was unforested before 1 January 1990. It offers land owners with land enrolled with the Initiative the opportunity to earn emission units for the carbon sequestered by their forests since 1 January 2008.

Participants enter a covenant with the Government, which is registered against their land title(s). The covenant is in perpetuity, even if the land is sold, although there is an ability to terminate at certain times. Land owners are responsible for establishing and maintaining the forest. Limited harvesting is allowed on a continuous forestry cover basis. More than 18,000 hectares of land have been entered into the Permanent Forest Sinks Initiative, with over 75 per cent of this being regenerating indigenous forest.

---

[107] The Afforestation Grant Scheme is still active, but no new applications rounds are planned at present.

East Coast Forestry Project

The East Coast Forestry Project was implemented in 1992 to address soil erosion in the Gisborne District of New Zealand. The project aims to encourage tree planting on 60,000 hectares of severely eroding or erodible land. Land owners in specific areas are eligible for Government grants, which help to fund the cost of establishing and managing forest on this land. The project allows a range of treatments, including exotic afforestation, reversion to indigenous forest, and wide-spaced poplar and willow planting.

Although the main purpose of this project is to reduce erosion, the project also contributes to the sequestration of carbon in forest sinks. Around 40,000 hectares of forest have been planted as a result of this project.

Afforestation Grants Scheme

The Afforestation Grants Scheme is a contestable fund to encourage the establishment of new forests. It offers an alternative to the NZ ETS as a way to encourage greater levels of greenhouse gas absorption by increasing the area of new forests. Under the Scheme, land owners can receive a Government grant for establishing new forests on Kyoto-compliant land (land that was not forested as at 31 December 1989). Recipients of the grant own the new forests and earn income from the timber, while the Government retains the Kyoto Protocol removal units (and liabilities) generated during the 10-year period of the grant agreement.

So far 12,500 hectares of land have been established under this Scheme. Approximately half of the funding has been managed by regional councils to help them meet their sustainable land management objectives. The other half of the funding was available to the public on a contestable basis. No new application rounds are planned at present, and no new funding was allocated to the Afforestation Grants Scheme in 2013. Land owners who have received a grant from the scheme, however, have on-going obligations to maintain their grant forests.

Other information

Greenhouse gases affected: carbon dioxide.

Quantitative effect of the measures: total net removals between 2008 and 2020 are estimated to be 136 million tonnes of carbon dioxide, compared to 72 million tonnes without these measures. ('Without these measures' assumes no NZ ETS, low rates of new planting, higher rates of deforestation, no change to post-1989 harvest rotation ages and no afforestation schemes.)

Type of policy or measure: voluntary agreements, fiscal.

Implementing entity: Ministry for the Environment (NZ ETS), Ministry for Primary Industries (forestry and agricultural funding and programmes).

Status of implementation: implemented

More information is available at:

http://www.mpi.govt.nz/forestry/forestry-in-the-ets

http://www.mpi.govt.nz/forestry/funding-programmes

4.3.7 Waste

The major legislation governing waste management in New Zealand is the Waste Minimisation Act 2008. The Act sets out the Government's long-term priorities and:

- places a levy on all waste going to disposal facilities (those landfills that receive household waste and operate at least in part as a business) to fund waste minimisation initiatives
- creates a process for accrediting voluntary product stewardship schemes and for making the development of product stewardship schemes mandatory (for 'priority' products)
- clarifies the roles and responsibilities of territorial authorities with respect to waste minimisation
- established the Waste Advisory Board to provide advice to the Minister for the Environment.

The legislation is supported by the New Zealand Waste Strategy. This strategy was revised in 2010 (replacing the 2002 strategy) and replaces the previous targets with two high-level goals:

- reduce the harmful effects of waste
- improve the efficiency of resource use.

In addition, the waste management sector is required to report on their emissions and has obligations to surrender emission units under the NZ ETS.

National Environmental Standard for Landfill Methane

In 2004 the Government introduced specific standards for landfills in the Resource Management (National Environmental Standards for Air Quality) Regulations. The standards are designed to ensure effective management of discharges of greenhouse gases generated from large landfills. Since the implementation of the Regulation, to the end of 2012 it is estimated that 1640 Gg CO_2-e have been recovered from landfills that would have otherwise contributed to greenhouse gas emissions.

Waste Minimisation Fund

Fifty per cent of the levy on waste disposed of to landfills (minus administration) is allocated to waste minimisation projects through the Waste Minimisation Fund. The purpose of the Fund is to support projects that increase resource efficiency, reuse, recovery and recycling, and decrease waste to landfill. Several projects targeting organic waste have been awarded funding through the Waste Minimisation Fund. Examples of projects awarded funding can be found in section 9.4.1.

Other information

***Greenhouse gases affected*:** methane.

***Quantitative effect of the policy/measure*:** the emissions reductions directly associated with this programme cannot be quantified.

***Type of policy or measure*:** regulatory.

***Implementing entity*:** Ministry for the Environment.

***Status of implementation*:** implemented.

***More information is available on*:**

- the Waste Minimisation Act at: http://www.mfe.govt.nz/laws/waste-minimisation.html
- waste policies at: http://www.mfe.govt.nz/issues/waste

4.4 Monitoring, evaluation and review

The New Zealand Emissions Trading Scheme

As previously mentioned, the NZ ETS is New Zealand's principal policy response to climate change. The policy settings for the NZ ETS are contained in the Climate Change Response Act 2002. The Act was amended in 2009 and reviewed again in 2011, with consequential amendments made in 2012. The objectives and results of the amendments are outlined in section 4.3.1.

Following is a summary of the review process to date:

- The Climate Change Response Act 2002 put in place a statutory requirement for 5-yearly NZ ETS reviews, with the first scheduled for 2011. The 2011 review was undertaken by an independent panel appointed by the Minister for Climate Change Issues. The 2012 amendment package was the Government's response to this review.
- The 2012 amendments removed the statutory requirement for review. This was replaced with a clause enabling the Minister for Climate Change Issues to initiate a review at any time.
- The Government indicated in 2012 that it would review the NZ ETS again in 2015.

Forestry Schemes Review

Afforestation schemes were reviewed in 2010. The review covered two schemes developed under the Government's climate change policies: the Permanent Forest Sink Initiative and the Afforestation Grant Scheme; and two schemes developed under the Government's sustainable land-use policies: the East Coast Forestry Project and the Sustainable Land Management (Hill Country Erosion) Programme.

A review panel was established with terms of reference focused on establishing the levels of effectiveness and cost-efficiency in the delivery of each scheme, necessary improvements, and the future role of schemes (with the exception of the East Coast Forestry Project) in contributing to the Government's climate change and sustainable land management objectives.

The panel concluded that the schemes should have clear objectives and that there should be separate payments for separate environmental services. It supported the continuation of all four afforestation schemes, albeit with modification to the overall structure and with amendments to each component. While these schemes continue, as noted in section 4.3.6, no new application rounds are currently planned for the Afforestation Grant Scheme, and no new funding was allocated in 2013.

Waste Minimisation Act 2008

The Minister for the Environment must undertake a statutory review of the effectiveness of the waste disposal levy to monitor progress and to ensure the policy tool remains appropriate. The review must be undertaken at intervals not more than 3 years after the last review with the next review due by 1 July 2014. When reviewing the levy, the Minister:

- must consider whether the amount of waste disposed of in New Zealand has decreased
- must consider whether the amount of waste reused, recycled or recovered in New Zealand has increased
- must consider the advice of the Waste Advisory Board
- may consider any other matters that he or she thinks relevant.

4.5 Policies and measures no longer in place

The following policies and measures that were reported on in the *Fifth National Communication* are no longer in place.

New Zealand Waste Strategy 2002

The New Zealand Waste Strategy 2002 was reviewed and replaced by the New Zealand Waste Strategy 2010. The 'zero waste' vision of the 2002 Strategy was considered too ambitious and many of its targets were unable to be measured or achieved. The revised Strategy enables a more flexible approach to waste management and minimisation through two high-level goals: reducing harm and improving resource efficiency.

Biodiesel Grant Scheme

From July 2009 to June 2012 the Government ran the 3-year Biodiesel Grant Scheme, administered by the EECA to encourage the production of biodiesel in New Zealand. Under the NZ$36 million scheme, grants of up to 42.5 cents per litre were available to biodiesel producers who sold 10,000 or more litres of eligible biodiesel each month.

Although the scheme had some success in boosting the profile and use of sustainable first-generation biodiesel, overall the uptake was much lower than anticipated, with only six producers signing up to the scheme and less than NZ$2 million of grants allocated. The Government's current focus is to bring forward advanced biofuels rather than first-generation biodiesel, with NZ$42 million being spent on nine research projects from 2008 to 2014.

Distributed Generation Fund

The Distributed Generation Fund was established in 2008/09 to kick-start activity and development of small-scale renewable electricity projects in New Zealand. Distributed generation refers to small-scale power generation technologies, typically in the range of 3 kilowatts to 10,000 kilowatts. The technologies used for small-scale power generation include wind turbines, photovoltaics (solar electricity), hydro turbines, geothermal heat, bio-energy, co-generation and diesel or gas turbines.

The Fund provided grants to support feasibility studies as a means of facilitating distributed generation projects that were proposed and implemented by non-traditional generators and close to being commercially viable. Under the fund, the EECA provided part-funding (up to 75 per cent or NZ$20,000) for eligible feasibility studies. Feasibility studies funded under the Distributed Generation Fund have included small wind farms and wind turbines, micro hydro-electricity schemes, and the use of biogas derived from industrial waste products. Although further grants are no longer being provided by the EECA, the feasibility studies that were funded are available at: http://www.eeca.govt.nz/distributed-generation-fund.

Marine Energy Deployment Fund

In October 2007 the Government established a 4-year, NZ$4 million Marine Energy Deployment Fund as part of the New Zealand Energy Strategy 2007. The fund was designed to accelerate innovation and help with the costs associated with concept testing and deployment of marine-based energy-generating devices. While unfortunately none of the projected supported through the Fund were successful, it gave the opportunity to gain some important experience in this emerging renewable energy area.

5

Projections and the total effect of policies and measures

5 Projections and the total effect of policies and measures

Key developments since the Fifth National Communication

- The latest projections show that New Zealand will have a surplus of 29.6 million units over the first commitment period of the Kyoto Protocol.
- Gross emissions in 2020 are projected to be 0.4 per cent higher than they were projected to be in the *Fifth National Communication* in 2009.
- Net emissions in 2020 are projected to be 4.8 per cent lower than they were projected to be in the *Fifth National Communication* in 2009.
- ‘With’ and ‘without’ measures greenhouse gas emissions have been modelled to project the effect of New Zealand’s key quantifiable policies and measures out to 2030.
- Three different forestry scenarios address uncertainties relating to future rates of afforestation, deforestation, harvesting rates, rotation ages and carbon prices.

5.1 Introduction

This chapter reports on projections of New Zealand’s greenhouse gas emissions and removals to 2030. The projections presented in this chapter update those provided in *New Zealand’s Fifth National Communication*. The projections of greenhouse gas emissions cover the energy, transport, industrial processes, agriculture, waste and forestry sectors. All of the projections are ‘with measures’ unless stated otherwise, which means they include the effect of New Zealand’s key quantifiable climate change policies.

The chapter also provides ‘without measures’ projections, which estimate what New Zealand’s emissions could be in the absence of climate change policies. All projections are measured in gigagrams of gas (Gg) unless specifically noted otherwise. Projected removals are net removals resulting from forestry, as defined under the UNFCCC.

New Zealand produces an annual projection of progress towards meeting its commitment under Article 3.1 of the Kyoto Protocol.[108] The latest report produced in April 2013 projected that New Zealand will have a surplus of 29.6 million units over the first commitment period of the Kyoto Protocol.

New Zealand’s projections of emissions are produced by a cross-Government technical group led by the Ministry for the Environment. Agricultural emissions and net removals by forests are projected by the Ministry for Primary Industries. Emissions from stationary energy and transport, and carbon dioxide emissions from industrial processes are projected by the

[108] This projection report is available at http://www.mfe.govt.nz/issues/climate/greenhouse-gas-emissions/net-position/index.html

Ministry of Business, Innovation and Employment. Projections of emissions from the waste sector and emissions of fluorinated gases are completed by the Ministry for the Environment.

The projections methodology for New Zealand is closely linked to the methodology used to estimate emissions and removals in New Zealand's annual National Greenhouse Gas Inventory (NIR).

5.2 Projected greenhouse gas emissions and removals, 'with measures'

5.2.1 Overview

Tables 5.1 and 5.2 summarise actual and projected New Zealand greenhouse gas emissions and removals, by sector and gas respectively, under a 'with measures' scenario. Emissions and removals from 1990 to 2011 for all but the forestry sector are based on actual data, while values for 2012 and later are based on projections. For forestry, three scenarios are provided, which are backdated to 2008. This is due to final levels of deforestation, harvesting and afforestation from 2008 to 2012 only being confirmed once New Zealand's mapping is completed in 2013, at which point they will be included in New Zealand's 2014 inventory submission. In line with emissions reporting up to 2012, CO_2-e calculations in these projections are calculated using 100-year global warming potential values from the IPCC's *Second Assessment Report*.[109]

It is not possible to quantify the effect of all types of measures in the projections. Consequently, emissions projections under a 'with measures' scenario includes:

- the modelled impacts of the NZ ETS for the energy, industrial processes, waste, and forestry sectors, including the changes to the scheme passed into law in November 2012
- Government afforestation grant schemes
- the National Environmental Standard to control methane emissions from landfills.

The 'with measures' scenario does not include the impact of other policy measures. For example, New Zealand's investment in agricultural research will reduce domestic and global agriculture emissions, however the benefits cannot be predicted and are not included in emission estimates until proven. It is also not possible to isolate the impact of Government policies and measures on energy efficiency, so both the 'with measures' and 'without measures' scenarios assume the same energy efficiency trends.

Under a 'with measures' scenario, New Zealand's gross emissions (excluding net emissions and removals from the forestry sector) are projected to rise to 77,218.3 Gg CO_2-e by 2020 (29 per cent above 1990 levels, or 6 per cent above 2011 levels), and 82,244.2 Gg CO_2-e by 2030 (38 per cent above 1990 levels, or 13 per cent above 2011 levels).

New Zealand's net emissions (including removals from the forestry sector) are projected to rise to 75,017.7 Gg CO_2-e by 2020 (130 per cent above net emissions in 1990, or 30 per cent above net emissions in 2011), and to 84,832.0 Gg CO_2-e by 2030 (160 per cent above net emissions in

---

[109] IPCC. 1996. Climate Change 1995: The science of climate change, contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. JT Houghton et al. (eds.). Cambridge University Press.

1990, or 47 per cent above net emissions in 2011). In 2012 net removals from forestry are projected to be approximately 14,151.8 Gg CO_2-e.

In 2011 New Zealand's forestry sector comprised around 8.06 million hectares of natural forest and 2.09 million hectares of planted forest. For reporting under the UNFCCC, and based on current information, natural forests are considered steady state until final plot measurement and analysis are completed. As a result, projected forestry emissions and removals are significantly influenced by New Zealand's exotic forestry age-class profile. New Zealand has undergone three periods of significant afforestation (figure 5.8), which have created a large age-class legacy that will continue to affect New Zealand's emissions and removals well into the future.

Depending on future harvest, deforestation and afforestation rates, New Zealand's forestry sector is expected to temporarily transition from a net sink to a net source of carbon dioxide around 2017 – 2023 as forests planted in the late 1980s and early 1990s are harvested for timber. However, the forestry sector is expected to revert to a net carbon dioxide sink in the late 2030s once the forests harvested in the 2020s are replanted. Net removals from forestry in 2020 are projected to be 2,200.6 Gg CO_2-e and net emissions from forestry are projected to be 2,587.8 Gg CO_2-e by 2030, assuming a midpoint emissions scenario for that sector (see section 5.2.6 for further information).

Table 5.1: Actual and projected emissions and removals, by sector, 'with measures', 1990 – 2030

Sector	Gg CO_2- e									
	1990	1995	2000	2005	2010	2011	2015	2020	2025	2030
Energy	14,861.9	14,735.8	17,512.2	20,535.5	17,487.6	16,988.7	18,247.8	17,854.3	18,524.8	18,310.9
Transport	8,625.7	10,791.5	12,145.6	13,617.6	13,829.9	14,014.6	14,398.7	14,872.5	15,468.4	15,899.5
Industrial processes	3,434.4	3,350.2	3,570.9	4,335.5	4,795.2	5,458.9	4,964.0	5,346.2	5,732.3	6,120.9
Agriculture	30,661.9	32,279.3	34,058.4	35,986.3	33,722.3	34,387.3	34,976.0	37,045.5	38,799.4	39,598.5
Forestry	–26,995.0	–24,149.6	-25,075.5	-23,738.3	-20,370.4	-15,042.1	-6,736.3	–2,200.6	11,087.8	2,587.8
Waste	2,059.1	2,058.2	2,113.7	2,169.5	2,012.8	1,985.4	2,020.6	2,099.8	2,220.6	2,314.5
Total gross emissions (excluding net emissions from forestry)	59,643.1	63,214.9	69,400.7	76,644.4	71,847.8	72,834.9	74,607.1	77,218.3	80,745.4	82,244.2
Total net emissions (including net emissions/ removals from forestry)	32,648.1	39,065.3	44,325.2	52,906.1	51,477.4	57,792.8	67,870.8	75,017.7	91,833.2	84,832.0

Table 5.2: Actual and projected emissions (excluding LULUCF), by gas, 'with measures', 1990 – 2030

Gas (Gg gas except as noted)	1990	1995	2000	2005	2010	2011	2015	2020	2025	2030
CO_2	25,047.1	27,384.6	31,350.3	36,386.4	33,403.2	33,162.2	34,694.5	34,733.0	35,975.5	36,145.6
CH_4	1,221.4	1,255.5	1,327.9	1,350.4	1,279.8	1,288.1	1,310.6	1,371.8	1,425.9	1,452.1
N_2O	26.8	29.7	31.7	35.8	33.6	34.5	35.1	38.0	40.4	41.7
HFC (CO_2-e)	NA, NO	122.8	253.0	712.2	1,077.7	1,885.1	1,472.6	1,867.3	2,261.9	2,656.6
PFC (CO_2-e)	629.9	131.2	58.1	59.6	40.8	30.2	27.7	20.2	15.4	12.2
SF_6 (CO_2-e)	15.2	17.9	10.6	19.0	20.5	17.6	17.9	18.3	18.8	19.2
Gg CO_2-e										
CO_2	25,047.1	27,384.6	31,350.3	36,386.4	33,403.2	33,162.2	34,694.5	34,733.0	35,975.5	36,145.6
CH_4	25,650.3	26,366.3	27,886.7	28,357.9	26,875.7	27,050.1	27,523.3	28,807.1	29,944.5	30,495.0
N_2O	8,300.6	9,192.2	9,842.1	11,109.4	10,429.9	10,683.0	10,871.0	11,772.4	12,529.3	12,915.8
HFC	NA, NO	122.8	253.0	712.2	1,077.7	1,885.1	1,472.6	1,867.3	2,261.9	2,656.6
PFC	629.9	131.2	58.1	59.6	40.8	30.2	27.7	20.2	15.4	12.2
SF_6	15.2	17.9	10.6	19.0	20.5	17.6	17.9	18.3	18.8	19.2
Total Gg CO_2-e	59,643.1	63,214.9	69,400.7	76,644.4	71,847.8	72,834.9	74,607.1	77,218.3	80,745.4	82,244.2

Notes:

NA = not applicable (ie, when the activity occurs in New Zealand but the nature of the process does not result in emissions or removals).

NO = not occurring (ie, when the activity or process does not occur in New Zealand).

Figures 5.1 to 5.3 present actual[110] and projected emissions of carbon dioxide, methane and nitrous oxide in New Zealand from 1990 to 2030.

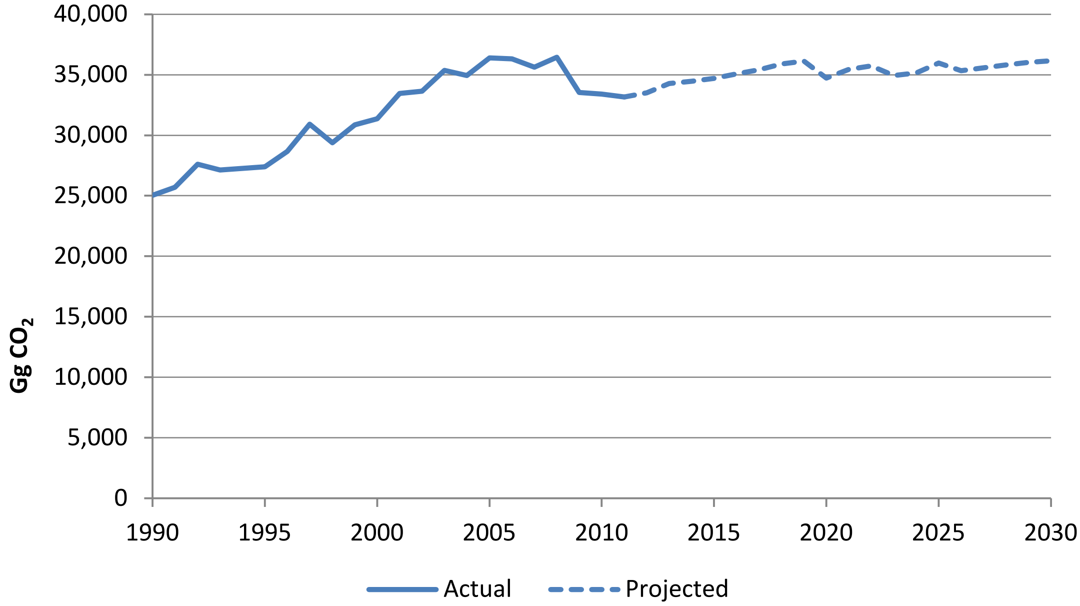


Figure 5.1: Actual and projected carbon dioxide emissions (excluding LULUCF), 1990 – 2030

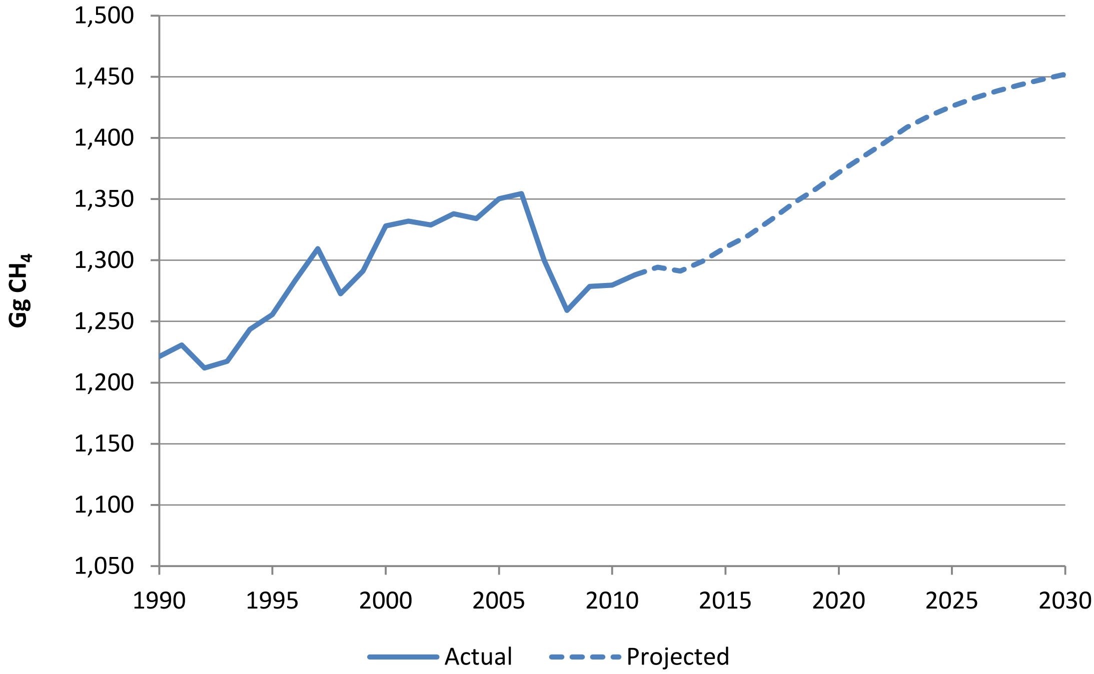


Figure 5.2: Actual and projected methane emissions (excluding LULUCF), 1990 – 2030

110 As estimated in New Zealand's NIR, submitted to the UNFCCC in April 2013.

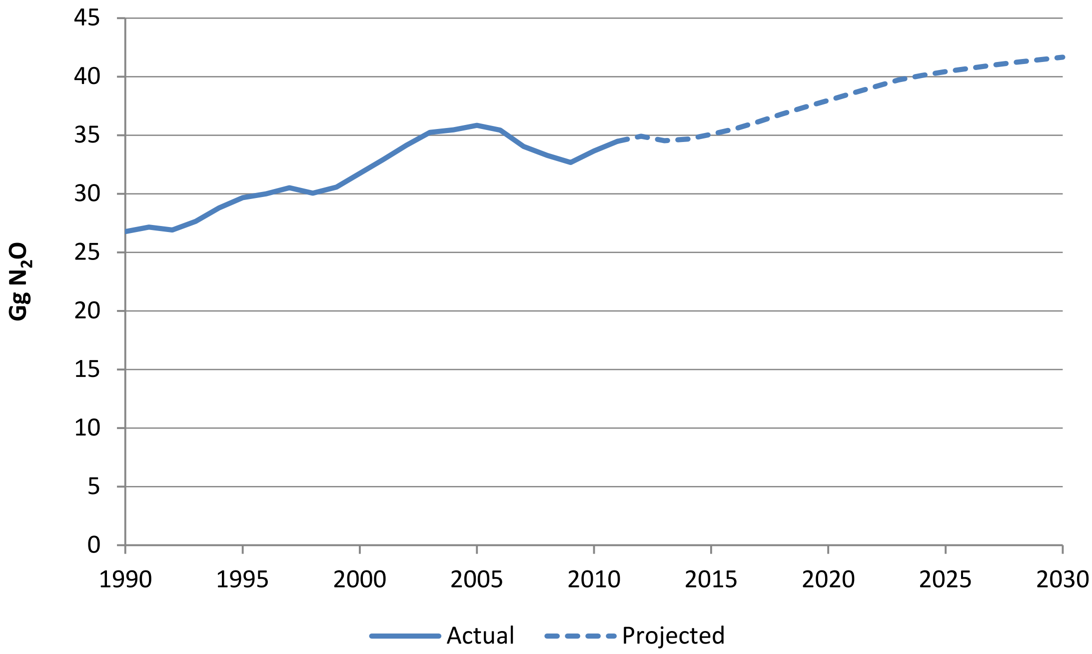


Figure 5.3: Actual and projected nitrous oxide emissions, 1990 – 2030

Figure 5.4 presents actual and projected total gross emissions under a 'with measures' scenario from 1990 to 2030. Total gross emissions do not include emissions and removals from the land use, land-use change and forestry (LULUCF) sector.

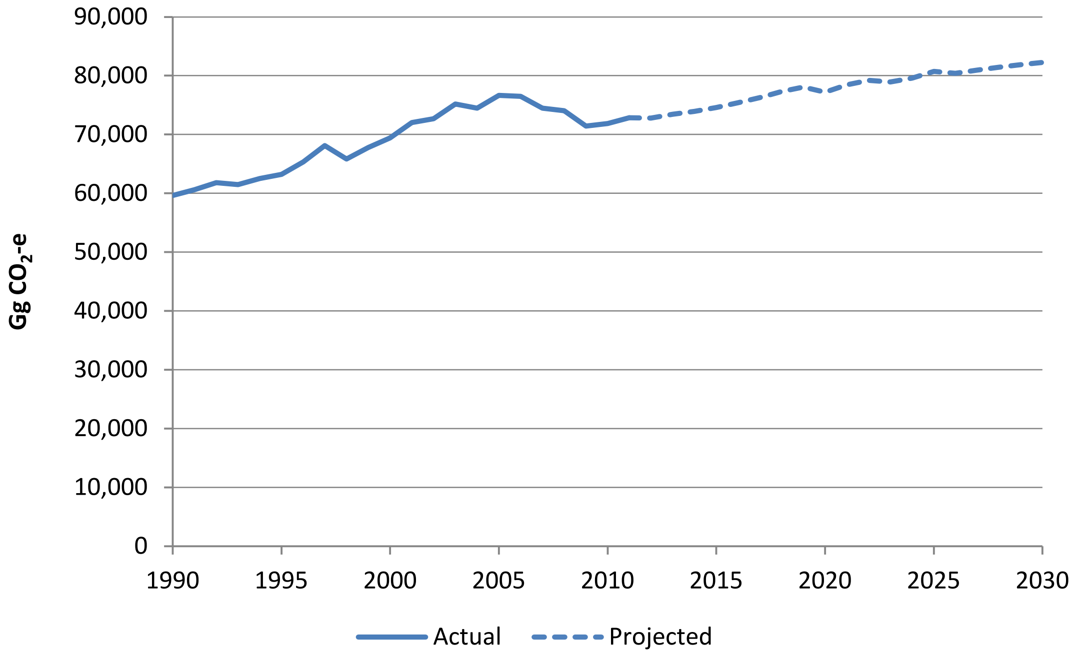


Figure 5.4: Actual and projected total gross emissions, 1990 – 2030

Figure 5.5 presents actual and projected total gross emissions and actual and projected total net emissions under a 'with measures' scenario. Total net emissions include emissions and removals from the LULUCF sector. The emissions trend presented in Figure 5.5 is based on the mid-emissions LULUCF scenario. Please refer to section 5.2.6 for more information on this scenario.

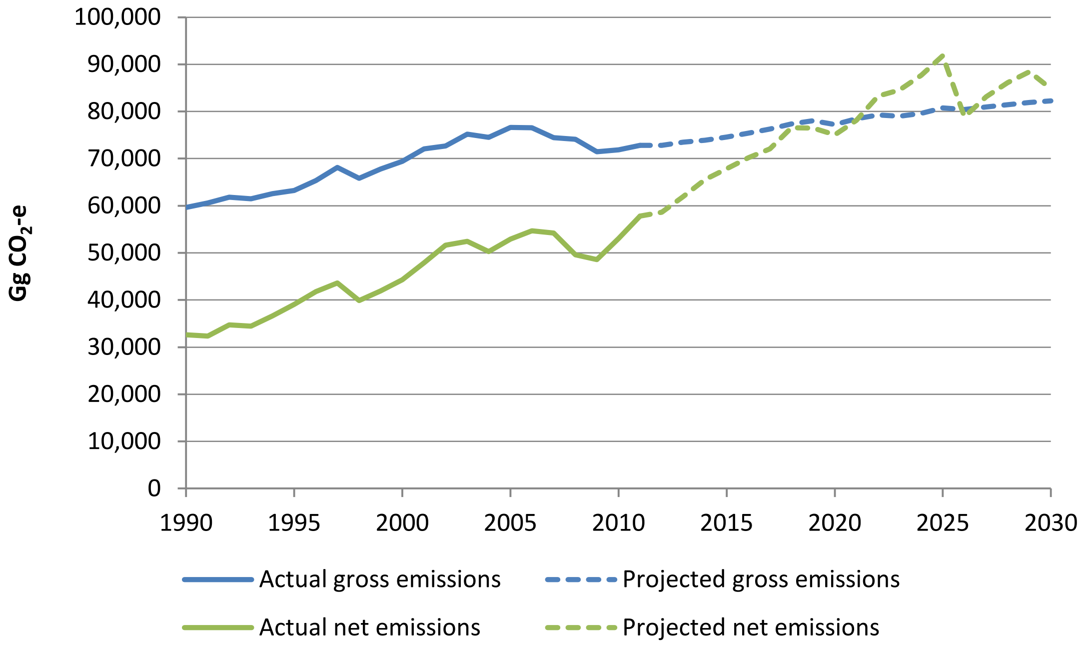


Figure 5.5: Actual and projected total gross (excluding LULUCF) and net (including LULUCF) emissions, 1990 – 2030

The significant differences in trends between the net and gross emissions projections in figure 5.5 are due to the age-class profile of New Zealand's forests. New Zealand's forestry sector will temporarily transition from a net sink to a net source of carbon around 2017–2023 as forests planted in the late 1980s and early 1990s are harvested for timber. More information on these trends is included in the forestry section of this chapter (5.2.6).

5.2.2 Energy sector

For the purposes of projections, the energy sector includes electricity generation, other stationary energy, industrial and commercial use of fossil fuels and/or production of energy, and fugitive emissions. Projections for emissions from transport are presented separately (section 5.2.3). The projections for these sectors were produced by the Ministry of Business, Innovation and Employment.

Projections

Emissions from the energy sector are expected to increase to 17,854.3 Gg CO_2-e in 2020 (20 per cent above 1990 levels, or 5 per cent above 2011 levels), and to 18,310.9 Gg CO_2-e by 2030 (23 per cent above 1990 levels, or 8 per cent above 2011 levels). Total energy demand is expected to continue to grow throughout the modelled period. The emissions intensity of energy supply (emissions per unit of energy delivered) is expected to decline over the modelled period. Table 5.3 presents actual and projected emissions from the energy sector to 2030.

Table 5.3: Actual and projected energy sector emissions, by gas, 1990 – 2030

Gas	Gg gas for energy sector (excluding transport)									
	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2015**	**2020**	**2025**	**2030**
CO_2	13,847.2	13,747.4	16,199.3	19,489.8	16,135.1	15,827.9	17,069.6	16,642.6	17,299.8	17,046.8
CH_4	44.2	42.4	57.0	42.4	58.5	49.3	50.6	52.2	52.5	54.1
N_2O	0.3	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4
CO_2-e	14,861.9	14,735.8	17,512.2	20,535.5	17,487.6	16,988.7	18,247.8	17,854.3	18,524.8	18,310.9

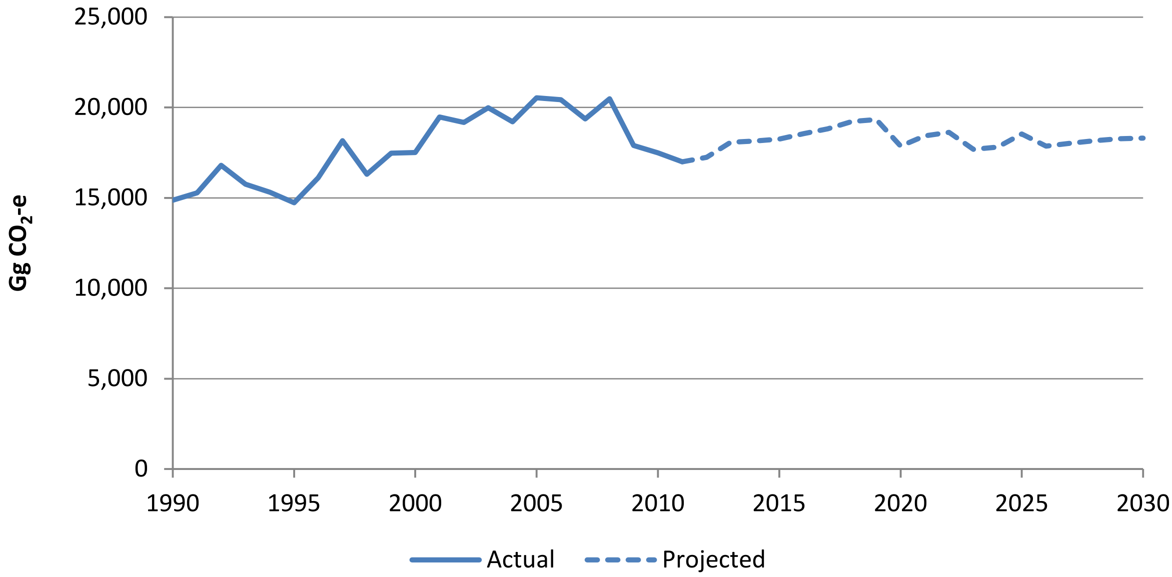


Figure 5.6: Actual and projected emissions from energy, ‘with measures’, 1990 – 2030

Analysis

Between 2013 and 2019 emissions from the energy sector are projected to increase. Scenario modelling indicates that between 2015 and 2019 the utilisation of fossil fuel power plants will increase as electricity demand increases. This will contribute to an overall increase in emissions, and an increase in emissions intensity per unit of energy supplied, during the period 2015 to 2019.

In 2020 modelled annual emissions are projected to decline by approximately 1,500 gigagrams from 2019 levels. By 2020 the remaining coal-fired power plant in New Zealand is expected to be decommissioned, which would remove emissions from coal. This generation is replaced by renewables and gas-fired base-load capacity in the modelled scenario. The switch from coal to gas and renewables results in a reduction in CO_2-e emissions in 2020. Post-2023 emissions are expected to increase as demand increases, but emissions intensity per unit of energy supplied is expected to decline over this period as an increasing proportion of electricity demand is met by renewable forms of generation.

The industrial and commercial sectors include emissions from fossil fuel combustion in heavy industries (defined as metals – primarily iron and steel), oil refining, petrochemicals (primarily methanol and urea), forestry processing (primarily pulp and paper and milling), as well as 'other industrial and commercial'. Large-scale manufacturing in New Zealand is dominated by a small number of firms. As a result, projections from these sources are subject to an unusually high degree of variability because small changes in one firm (or a closure) will significantly affect the total projection.

Fugitive emissions are those that arise from the production, processing, transmission, storage and use of fuels, and from non-productive combustion (eg, the flaring of natural gas at oil and gas production facilities). Fugitive emissions in New Zealand also include methane emissions from geothermal electricity generation. Fugitive emissions are included with energy emissions and make up approximately 10 per cent of projected energy emissions each year between 2013 and 2030.

New Zealand's energy emissions are low by international standards, because a high proportion of New Zealand's electricity is generated from renewable sources: in 2012, 72 per cent of New Zealand's electricity was generated from renewable sources.[111] A large share of this generation is hydroelectricity. This means that in years with below-average rainfall less electricity is available from hydroelectricity, and this must be made up for by fossil fuel-fired generation.

Methodology

The scenarios in this document are mainly based on assumptions in the 'Mixed renewables' scenario published in *New Zealand's Energy Outlook: Electricity Insight* (2013), published by the Ministry of Business, Innovation and Employment.[112] However, the scenarios presented here differ from the 'Mixed renewables' scenario in that they reflect different carbon price trajectories and New Zealand GDP growth. The crude oil price, coal price, exchange rates, gas discoveries and population growth assumptions are, however, the same at those in the 'Mixed renewables' scenario.

Table 5.4: Key assumptions for energy projections

Assumption	2015	2020	2025	2030
GDP (real 1995/96, NZ$ billion)	158	178	201	222
Effective* carbon price (NZ$/tonne CO_2-e)	5	5	5	5
Oil price (2011 US$/barrel)	106	118	127	135
Coal price (2011 NZ$/GJ)	5.30	6.24	6.24	6.24
Exchange rate (NZ$/US$)	0.71	0.60	0.60	0.60
Gas supply from new discoveries (PJ/year)	0	59	133	181
Population (thousand)	4,540	4,760	4,960	5,160

Sources: New Zealand Treasury, Ministry of Business, Innovation and Employment, Statistics New Zealand.

111 http://www.med.govt.nz/sectors-industries/energy/energy-modelling/data/electricity

112 Full details of the New Zealand energy outlook and the models used for these projections can be found at http://www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling/new-zealands-energy-outlook-electricity-insight

*Stationary energy participants under the NZ ETS are only required to surrender one NZU for every 2 tonnes of emissions. This policy has been accounted for in the energy emissions modelling. This means an effective price of NZ$5 per tonne of CO_2-e equates to an NZU price of NZ$10 per tonne of CO_2-e.

Oil prices are based on the International Energy Agency's *World Energy Outlook 2011* 'current policies' scenario projections.[113] Coal prices are the mid-case assumptions from the Covec 2011 coal price update.[114] Population projections are based on the stochastically generated P50 population series from Statistics New Zealand.[115]

GDP and carbon prices differ from the assumptions in the 'Mixed renewables' scenario. GDP growth is taken from the Treasury's latest budget update and the Long Term Fiscal Model. Carbon price assumptions are consistent with recent historical averages in the NZ ETS and reflect current policies.

Historical rates of energy efficiency improvements are assumed to continue in each of the emissions projections, because the effects of policy-induced energy efficiency improvements cannot be robustly separated from the effects of autonomous energy efficiency improvements.

5.2.3 Transport sector

The projections for the transport sector were produced by the Ministry of Business, Innovation and Employment, using the Ministry of Transport's demand and fleet models.

Projections

Emissions from the transport sector are projected to rise to 14,872.5 Gg CO_2-e by 2020 (72 per cent above 1990 levels, or 6 per cent above 2011 levels) and to 15,899.5 Gg CO_2-e (84 per cent above 1990 levels, or 13 per cent above 2011) by 2030 (table 5.5).

Table 5.5: Actual and projected transport emissions, 'with measures', 1990 – 2030

	Gg gas for transport emissions									
Gas	**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2015**	**2020**	**2025**	**2030**
CO_2	8,439.2	10,591.2	11,943.0	13,392.6	13,641.9	13,835.3	14,193.6	14,659.0	15,244.4	15,667.4
CH_4	4.0	3.2	2.1	1.7	1.3	1.2	2.4	2.4	2.4	2.4
N_2O	0.3	0.4	0.5	0.6	0.5	0.5	0.5	0.5	0.6	0.6
CO_2-e	8,625.7	10,791.5	12,145.6	13,617.6	13,829.9	14,014.6	14,398.7	14,872.5	15,468.4	15,899.5

113 The International Energy Agency's World Energy Outlook 2011 is available for purchase at http://www.worldenergyoutlook.org/publication/weo-2011

114 http://www.med.govt.nz/sectors-industries/energy/energy-modelling/technical-papers/coal-prices-in-new-zealand-markets

115 Population projections from Statistics New Zealand are available at http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalPopulationProjections_HOTP2011.aspx

Analysis

Figure 5.7 shows actual and projected CO_2-e emissions for the transport sector. These emissions grew rapidly until 2005, but have slowed since 2006 due to higher crude oil prices and the worldwide economic recession. Over the next few years emissions from transport are projected to continue to resume growing. This increase is expected to be due to growth in the heavy vehicle transport of freight, reflecting an expected recovery in the New Zealand economy.

Emissions from light vehicles are expected to remain fairly constant, with increases in vehicle kilometres due to population growth being offset by improvements in vehicle efficiency. The rate of growth in transport emissions is expected to be at lower levels than seen from 1990 to 2005. During that period the New Zealand vehicle fleet grew rapidly to a per capita level that is now one of the highest in the world and near saturation level.

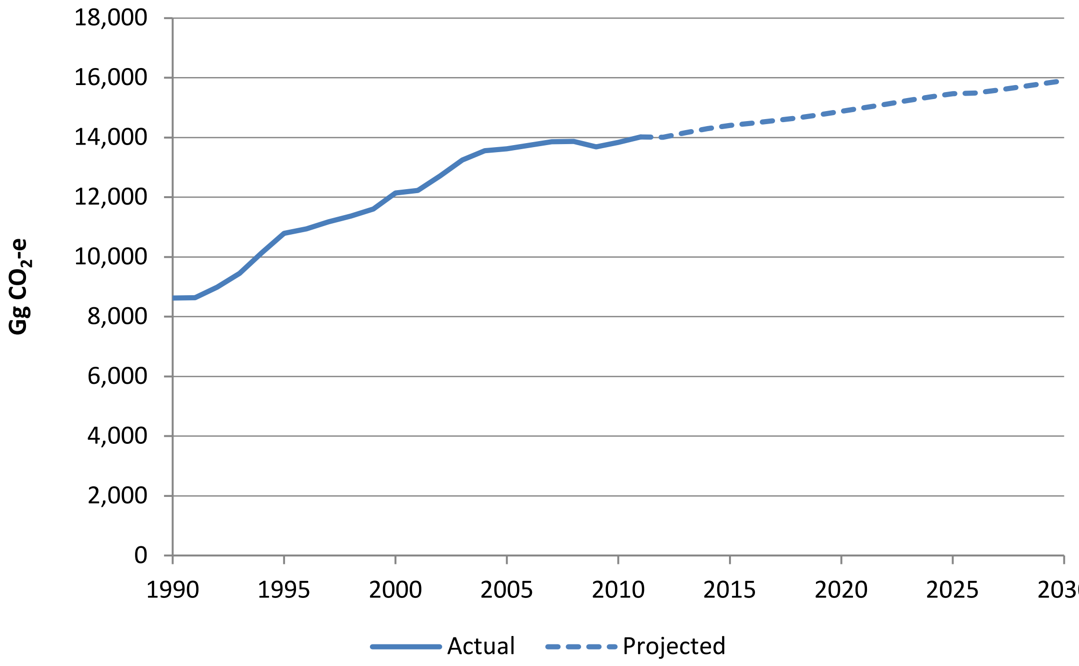


Figure 5.7: Actual and projected emissions from transport, 'with measures', 1990 – 2030

Emissions from international air and sea transport

Emissions from fuel used in international air and sea transport are reported separately and are not included in the historical or projected national totals of transport emissions. Tables 5.6 and 5.7 show the imputed emissions from fuel sold in New Zealand for use in international air and sea transport, respectively. The sea transport numbers tend to be highly variable and difficult to project because international sea carriers have flexibility to choose the country where they buy their fuel.

Emissions from international air transport showed continued growth between 1990 and 2005. Between 2005 and 2009 emissions flattened in the face of higher fuel prices and an ongoing focus from carriers on fuel efficiency and optimal loading of aircraft. Growth in international travel demand occurred in 2010 and 2012 and is expected to continue as the global economy recovers from recession.

Due to New Zealand's geographic situation, all passenger travel to and from New Zealand (with the exception of a growing cruise ship industry) is by air. A large proportion of air freight by value is used for transporting high-value machinery and equipment.

More than 99 per cent by weight of imports and exports to and from New Zealand are carried by international shipping.

Table 5.6: Actual and projected New Zealand emissions from international air transport, 1990 – 2030

Gas	Gg gas for international air transport									
	1990	1995	2000	2005	2010	2011	2015	2020	2025	2030
CO_2	1,405.9	1,699.6	1,901.3	2,342.0	2,443.0	2,463.1	2,783.2	3,089.4	3,419.0	3,753.1
CH_4	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CO_2-e	1,419.0	1,715.3	1,919.0	2,363.7	2,465.7	2,486.0	2,809.1	3,118.1	3,450.7	3,787.9

Table 5.7: Actual and projected New Zealand emissions from international sea transport, 1990 – 2030

Gas	Gg gas for international sea transport									
	1990	1995	2000	2005	2010	2011	2015	2020	2025	2030
CO_2	1,092.9	1,197.5	787.9	1,033.4	1,101.6	978.2	973.8	1,026.1	1,078.3	1,130.6
CH_4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO_2-e	1,107.3	1,212.9	797.1	1,044.8	1,113.5	989.1	984.2	1,037.0	1,089.8	1,142.6

5.2.4 Industrial processes

Industrial process carbon dioxide emissions in New Zealand are derived from the production of iron and steel, aluminium, urea, cement, lime and hydrogen. Industrial process emissions also include emissions from hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur heaxafluoride. For confidentiality reasons, emissions from methanol manufacture are included under the chemicals combustion category within the energy sector in New Zealand's NIR.

Projections

Emissions from the industrial processes and solvents sectors are projected to rise to 5,346.2 Gg CO_2-e by 2020 (56 per cent above 1990 levels, 2 per cent below 2011 levels) and to 6,120.9 Gg CO_2-e by 2030 (78 per cent above 1990 levels, or 12 per cent above 2011) (table 5.8). Industrial process carbon dioxide emissions in New Zealand are derived from the manufacture of iron and steel, aluminium, urea, cement, lime and hydrogen. The level of output from these industries is assumed to remain steady between 2012 and 2030 in these projections.

Table 5.8: Actual and projected emissions from industrial processes, 1990 – 2030

Gas	Gg gas for industry									
Industrial processes	**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2015**	**2020**	**2025**	**2030**
CO_2	2,747.8	3,033.4	3,202.1	3,500.4	3,625.3	3,498.1	3,430.5	3,430.5	3,430.5	3,430.5
CH_4	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
N_2O	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
HFC (CO_2-e)	NA, NO	122.8	253.0	712.2	1,077.7	1,885.1	1,472.6	1,867.3	2,261.9	2,656.6
PFC (CO_2-e)	629.9	131.2	58.1	59.6	40.8	30.2	27.7	20.2	15.4	12.2
SF_6 (CO_2-e)	15.2	17.9	10.6	19.0	20.5	17.6	17.9	18.3	18.8	19.2
CO_2-e	3,392.8	3,305.2	3,523.8	4,291.1	4,764.2	5,431.0	4,948.7	5,336.3	5,726.5	6,118.4
Solvent and other product use										
CO_2	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
CH_4	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
N_2O	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0
CO_2-e	41.5	45.0	47.1	44.3	31.0	27.9	15.3	9.9	5.8	2.4
Total industrial processes and solvents (CO_2-e)	3,434.4	3,350.2	3,570.9	4,335.5	4,795.2	5458.9	4,964.0	5346.2	5,732.3	6,120.9

Analysis

Emissions of PFCs, HFCs and sulphur hexafluoride are included in the projections of emissions from the industrial processes sector. Projected emissions of these fluorinated gases were not directly modelled, but were assumed to follow historical trends. The use of HFCs has grown rapidly since the early 1990s when they replaced chlorofluorocarbons, which are being phased out under the Montreal Protocol. Emissions of HFCs are expected to continue to be the main source of industrial process emissions up to 2030.

Emissions from solvents and other product use make up a very small proportion of industrial emissions. These emissions have been extrapolated from historical trends.

Methodology

Projected energy and transport emissions and carbon dioxide emissions from industrial processes are calculated by the Ministry of Business, Innovation and Employment using a range of models from across Government agencies. Detailed information can be found in the technical guide *Energy Outlook Modelling*.[116] Emissions of fluorinated gases are projected by the Ministry for the Environment, based on historical trends.

[116] A technical guide which describes the modelling techniques in detail can be found at http://www.med.govt.nz/sectors-industries/energy/energy-modelling/technical-papers/energy-modelling-methodology

5.2.5 Agriculture

Projections

Greenhouse gas emissions from agriculture are projected to rise to 37,045.5 Gg CO_2-e by 2020 (21 per cent above 1990 levels, or 8 per cent above 2011 levels), and to 39,598.5 Gg CO_2-e by 2030 (29 per cent above 1990 levels, or 15 per cent above 2011 levels). Table 5.9 and Figure 5.8 present actual and projected emissions for the agriculture sector

Table 5.9: Actual and projected emissions from agriculture, 1990–2030

	Gg gas for agriculture									
Gas	**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2015**	**2020**	**2025**	**2030**
CH_4	1,082.79	1,120.27	1,176.35	1,211.73	1,132.87	1,151.76	1,170.65	1,226.85	1,275.34	1,295.79
N_2O	25.56	28.24	30.18	34.00	32.04	32.90	33.52	36.39	38.76	39.96
CO_2-e	30,661.93	32,279.28	34,058.41	35,986.34	33,722.30	34,387.32	34,976.00	37,045.54	38,799.37	39,598.47

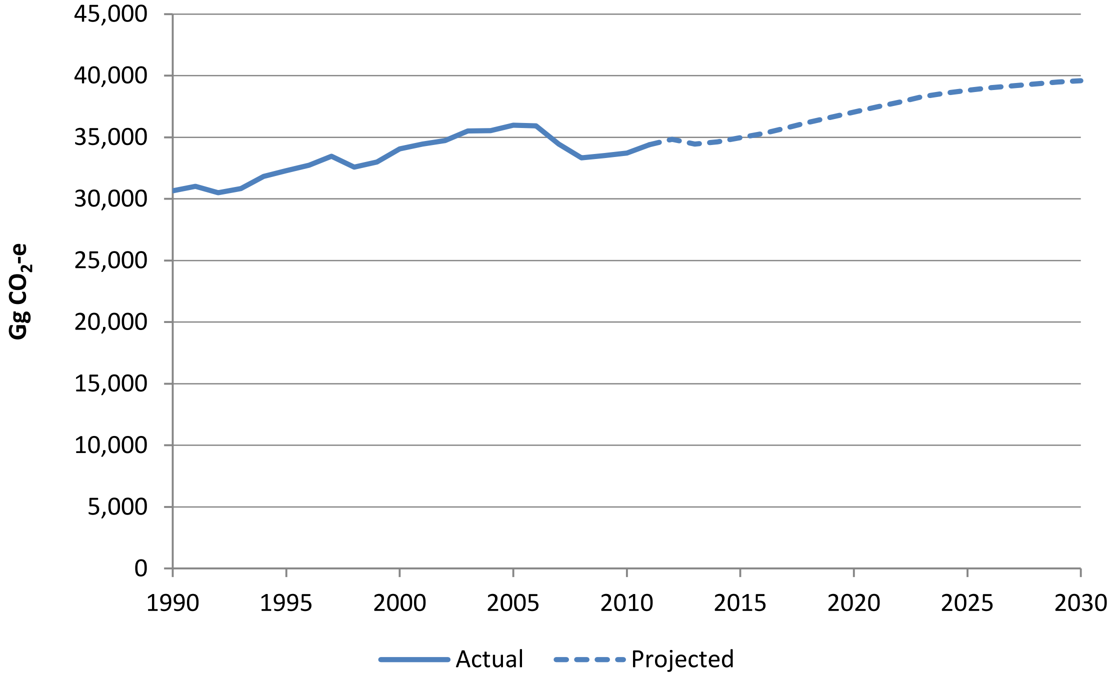


Figure 5.8: Actual and projected emissions from agriculture, 1990 – 2030

Analysis

Agricultural emissions in New Zealand are projected to rise as animal productivity and nitrogen fertiliser use continue to increase. Animal performance in New Zealand is below biological limits, and it is assumed that the rate of increase in productivity per animal to 2030 will be similar to the rate of increase since 1990.

The relative proportions of the main livestock species farmed in New Zealand have changed over time. From the early 1990s to the present, dairy cow numbers have grown while sheep numbers have declined (refer to figure 2.9 in the 'National Circumstances' chapter). These changes have been due to the relatively higher profitability of dairy products compared to sheep and beef products. This has led to a trend over the past 10–15 years of pastoral land being converted from meat and wool production to dairy production. This trend is expected to continue, with further (albeit smaller) reductions in sheep and beef grazing.

Droughts over 2007/08, 2010 and 2013 reduced pasture production, resulting in lower livestock performance and livestock numbers, and consequently reduced greenhouse gas emissions. The effects of the 2013 drought on New Zealand's greenhouse gas emissions will be seen in the 2015 annual inventory submission for 1990 to 2013. The decrease evident in figure 5.8 for 2013 is an early forecast of the effects of the 2013 drought on agricultural emissions.

The projections need to be assessed in light of the uncertainties of the economic circumstances of the agricultural industry, which are largely driven by overseas markets, and the biological processes and climatic conditions involved.

Methodology

Forecasts of greenhouse gas emissions are derived by applying the agricultural greenhouse gas emissions methodology to economic forecasts of agricultural activity. The forecast activity data, such as animal production and animal population numbers, is estimated from the Ministry for Primary Industries' Pastoral Supply Response Model (PSRM). [117] This data is then fed into the agricultural greenhouse gas inventory model to estimate future emissions. Emissions from 1990 to 2011 are those reported in New Zealand's NIR (submitted to the UNFCCC on 12 April 2013). The projections use the same methodology as that used for the 2013 inventory submission.

Projected agricultural activity

The Ministry for Primary Industries projects New Zealand's agricultural activity, such as animal numbers and nitrogen fertiliser use, by using economic analysis and bottom-up modelling. Projections for animal numbers and performance data are obtained from the PSRM, and projections of nitrogen fertiliser use are obtained from the Ministry for Primary Industries' Nitrogen Demand Model.[118] Animal performance is modelled as a function of a linear trend of past performance, days of soil moisture deficit and, where statistically significant, farm-gate price.

Animal number projections are driven in the PSRM by prices and farm income levels for different sectors. Therefore, an increase in income in one sector, relative to another, will result in an increase in animal numbers in that sector versus decreasing numbers in sectors of other land use. The Ministry for Primary Industries estimates key farm-gate prices based on international price movements and the New Zealand Treasury's assumptions on the future exchange rate and inflation. These assumptions are reported in the 2013 *Situation Outlook for Primary Industries.*[119]

---

117 The full report is available at http://www.mpi.govt.nz/news-resources/publications

118 See http://ageconsearch.umn.edu/handle/31970

119 See http://www.mpi.govt.nz/news-resources/news/situation-amp-outlook-for-primary-industries

The PSRM was originally developed to provide short-term (up to 5 year) projections to inform policy advice on the primary industry sector, and input to economic and fiscal projections for the New Zealand Treasury. It was not intended to be used for the production of longer-term forecasts, and there are currently limitations not included in the PSRM that may constrain agricultural production in the long term. These limitations include possible limits on nitrogen loading on pasture, new water storage capacity, and the availability of suitable pastoral land for dairying. New Zealand's agricultural greenhouse gas research programmes are expected to deliver emissions reductions in the future, however, these are not included in the agriculture projections. Agriculture emission reductions due to current research are not included in New Zealand's agriculture greenhouse gas inventory until the research is proven, quantified and can be implemented in the agriculture inventory methodology. The projections may therefore be considered conservative.

Estimating greenhouse gases

Estimates of emissions from New Zealand's four largest sources of livestock emissions (dairy, beef cattle, sheep and deer) are determined using a tier 2 inventory model. Greenhouse gas emissions are proportional to the dry matter intake of an animal. Dry matter intake in turn is determined by the energy requirements of that animal to meet the needs of maintenance, and the extra energy required to meet the demands for growth, conception/gestation, milk production and wool growth. Therefore, if dry matter intake is estimated, this can be multiplied by a species-specific factor to estimate methane emissions.

The amount of nitrogen in the feed consumed by an animal can be estimated using dry matter intake if the nitrogen content of the feed is known. Determining the difference between nitrogen intake and the estimate of how much nitrogen is retained in the animal and animal products results in an estimate of nitrogen excreted by an animal. From this excreted nitrogen, nitrous oxide emissions can be determined by using emission factors.

For other animal species and emissions from crop-related activities, emissions are estimated using a combination of New Zealand-specific emissions factors and default emissions factors applied to livestock population estimates and crop production.

New Zealand's greenhouse gas methodology is based on the revised 1996 IPCC guidelines[120] and the 2000 IPCC good practice guidance.[121] A further summary of the methodology can be found in New Zealand's NIR submitted to the UNFCCC in April 2013, and full details are given in *Detailed Methodologies for Agricultural Greenhouse Gas Emission Calculation*[122] on the Ministry for Primary Industries' website.

---

120 IPCC. 1996. Houghton JT, Meira Filho LG, Lim B, Treanton K, Mamaty I, Bonduki Y, Griggs DJ, Callender BA (eds). IPCC/OECD/IEA. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.* Bracknell: United Kingdom Meteorological Office.

121 IPCC. 2000. Penman J, Kruger D, Galbally I, Hiraishi T, Nyenzi B, Emmanul S, Buendia L, Hoppaus R, Martinsen T, Meijer J, Miwa K, Tanabe K (eds). *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. IPCC National Greenhouse Gas Inventories Programme. Published for the IPCC by the Institute for Global Environmental Strategies: Japan.

122 The full report is available at http://www.mpi.govt.nz/news-resources/publications

5.2.6 Forestry

Background

Figure 5.9 shows New Zealand's annual planting of production forests from the 1920s to 2012. Historical periods of increased planting, particularly in the 1990s, have created a large forest age-class legacy that will affect New Zealand's forestry emissions profile well into the future.

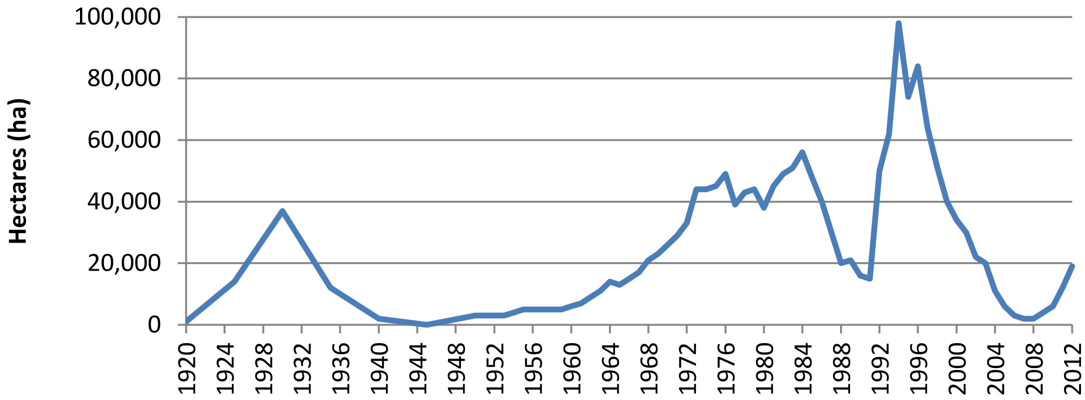


Figure 5.9: New Zealand's historical production forest annual planting, 1920 – 2012

Methodology

Emissions and removals from the forestry sector are calculated using methodologies consistent with those used for the 2013 NIR.[123] As with projections of emissions for any sector, the forestry sector is sensitive to the underlying assumptions used. Uncertainty has been included in the projections through the use of scenarios that represent low, midpoint and high emissions. The three forestry scenarios incorporate assumptions to address uncertainties relating to future rates of afforestation, deforestation, harvesting rates, rotation ages and carbon prices.

The three projection scenarios model variations in deforestation, harvesting and afforestation from 2008 to 2030. Alternative scenarios are provided for 2008 to 2011 as projections are backdated to 2008. This is due to final levels of deforestation, harvesting and afforestation from 2008 to 2012 only being confirmed once New Zealand's mapping is completed in 2013, and then included in New Zealand's 2014 NIR.

New Zealand is producing a 2012 land-use map derived from high-resolution satellite data. This mapping will be used to make comparisons with the 2007 land-use map to identify land-use changes between 1 January 2008 and 31 December 2012. As part of the land-use mapping process, areas of forest harvesting and deforestation will be identified. These areas will be assessed for land-use change (deforestation) using site-specific oblique aerial photography. The results of the new land-use map will be included in New Zealand's 2014 NIR.

[123] Projections of carbon stock changes have been developed for forest land and grassland categories only. In New Zealand's 2011 NIR, the forestland and grassland categories accounted for the majority of net emissions in the sector (figure 7.1.1 and 7.1.2, 2013 NIR). Soil carbon stock changes have also not been included in the projections.

Projections

Three different forestry scenarios have been modelled to address uncertainties relating to future rates of afforestation, deforestation and harvesting, rotation ages, and carbon prices (see box).

Low, midpoint and high emissions scenario assumptions for the forestry sector

Low emissions projections assume carbon prices of around NZ$25 per tonne of CO_2-e, and average annual rates of deforestation and afforestation of around 3400 and 14,300 hectares, respectively, from 2008 to 2030. This scenario assumes post-1989 forest rotation ages of around 32 years.

Midpoint emissions projections assume carbon prices of around NZ$12 per tonne of CO_2-e, and average annual rates of deforestation and afforestation of around 5400 and 9600 hectares, respectively, from 2008 to 2030. This scenario assumes post-1989 forest rotation ages of around 30 years.

High emissions projections assume very low carbon prices, and average annual rates of deforestation and afforestation of around 7800 and 5000 hectares, respectively, from 2008 to 2030. This scenario assumes post-1989 forest rotation ages of around 28 years.

Harvesting

The projections of planted production forestry removals are particularly sensitive to harvest levels. The average rotation length in New Zealand is currently 28.6 years, and during the 1990s rates of afforestation in New Zealand were high (figure 5.9). This means harvesting of production forests planted in the 1990s is expected to increase leading into 2020.

The main driver of forest emissions is the level and timing of harvest. This is why rotation ages of 28, 30 and 32 years are factored into the three projection scenarios to highlight the sensitivity of projections to harvest levels. Average rotation length can change due to log market conditions, forest owner objectives and (potentially) in response to the NZ ETS. Thus, land owners with forests planted after 1990 that are registered under the NZ ETS will not only consider log prices and harvesting costs, but also the carbon balance in the forest (eg, whether it is better to continue to accrue units, or harvest and meet liabilities), and also the price of carbon, which could be a significant new factor that comes into harvesting decisions.

Deforestation

Scenarios of future planted forest deforestation used in these projections are based on annual surveys of planted forest owners' intentions.[124] However, planted forest owners' and investors' intentions to deforest can be influenced by a range of factors, such as:

- perceptions of land-use economics
- Government policy
- the carbon emission unit price
- the lease of land expiring.

[124] Ministry for Primary Industries. 2013. *Deforestation Survey 2012*. The full report is available at http://www.mpi.govt.nz/news-resources/publications

Natural forest deforestation estimates are mainly based on the assumption that clearing of self-sown exotic tree weeds continues (exempt under the NZ ETS) and there continues to be small amounts of shrubland clearance.

Afforestation

Afforestation scenarios used in the projections are dependent on variables that can only be forecast with considerable uncertainty. These variables include:

- log prices
- carbon prices
- forest/land owners' future intentions
- future international LULUCF accounting rules
- current private sector interest in participating in forestry schemes administered by the Government.

Regardless, the effect of various rates of new planting on increased sequestration is not a key factor in determining removals in the short-term, as significant carbon sequestration is only noticeable 5 to 6 years after planting.

New Zealand's carbon stock

These projections assume that New Zealand's pre-1990 natural forests are in a steady state with respect to carbon dioxide emissions, that is, neither a sink nor a source. This assumption is currently being reassessed. Once the plot network has been measured twice, estimates for carbon change in New Zealand's natural forests will be included in New Zealand's NIR.[125] Projections of net emissions will be subject to change depending on the final outcome of this analysis.

New Zealand's forestry sector is currently a net sink of carbon dioxide. In 2011 forest land contributed around 16 million tonnes of net carbon dioxide removals. This value includes removals from the growth of planted forests, emissions from the conversion of land to planted forest, and emissions from harvesting and deforestation.

Analysis

Assuming the midpoint emission projection scenario, New Zealand's forestry sector is likely to temporarily transition from a net sink to a net source of carbon between 2017 and 2023 as forests planted in the late 1980s and early 1990s are harvested for timber production. However, given the cyclical nature of plantation forests (absorbing carbon dioxide during growth and releasing it after harvest), the forestry sector is expected to revert to a net carbon sink in the late 2030s once the forests harvested in the 2020s are replanted and sequester carbon dioxide.

Emissions for forestry are very sensitive to future forest owner harvest behaviour. The three projection scenarios of low, midpoint and high emissions use rotation ages of 32, 30 and 28 years, respectively, to reflect this uncertainty. The effect of forest owners delaying harvest and moving to a longer rotation length would be increased removals in the short-term as the trees grow and sequester more carbon, but then increased emissions as eventually these trees are harvested for timber in later years.

---

[125] Further detail of the plot network in natural forests can be found in New Zealand's 2013 NIR.

For example, the low emission scenario assumes a delayed harvest rotation of around 32 years on average. This has the effect of lowering emissions in the years leading up to 2020 when compared with the high scenario. However, emissions later increase by a corresponding amount in the late 2020s as these forests are eventually harvested. Similarly, the high emissions scenario assumes forests are harvested at the earlier age of 28 years, which causes an initial increase in emissions before and into the 2020s, but a reduction in emissions in the late 2020s (table 5.10).

Table 5.10 shows net emissions from 1990 to 2011 from the 2013 NIR. Table 5.10 and figure 5.10 show projected low, midpoint and high emission scenarios from 2008 to 2030.[126]

Table 5.10: Net emissions from LULUCF as presented in the 2013 Greenhouse Gas Inventory (1990 – 2011), and projected (2010 – 2030) low, midpoint and high scenarios of net emissions, UNFCCC basis

	Net emissions (Gg CO_2-e)									
	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2015**	**2020**	**2025**	**2030**
2013 NIR	-26,995.0	-24,149.6	-25,075.5	-23,738.3	-20,370.4	-16,101.2				
High emissions projection					-17,202.5	-13,771.1	-4,406.2	4,837.6	15,475.5	2,708.6
Midpoint emissions projection					-18,779.3	-15,042.1	-6,736.3	-2,200.6	11,087.8	2,587.8
Low emissions projection					-20,280.4	-16,218.4	-8,971.7	-9,144.0	6,795.0	2,561.7

Notes:

Negative values denote net removals of carbon dioxide. Positive values denote net emissions of carbon dioxide. 'Net emissions' means gross removals by planted forests, less emissions from deforestation and harvesting. Numbers are rounded to 1 decimal place.

Alternative scenarios are provided for 2010 and 2011 as projections are backdated to 2008. This is due to final levels of deforestation, harvesting and afforestation from 2008 to 2012 only being confirmed once New Zealand's mapping is completed in 2013, and then included in New Zealand's 2014 inventory submission.

126 These values include removals from the growth of planted forests, emissions from the conversion of land to planted forest, and emissions from harvesting and deforestation.

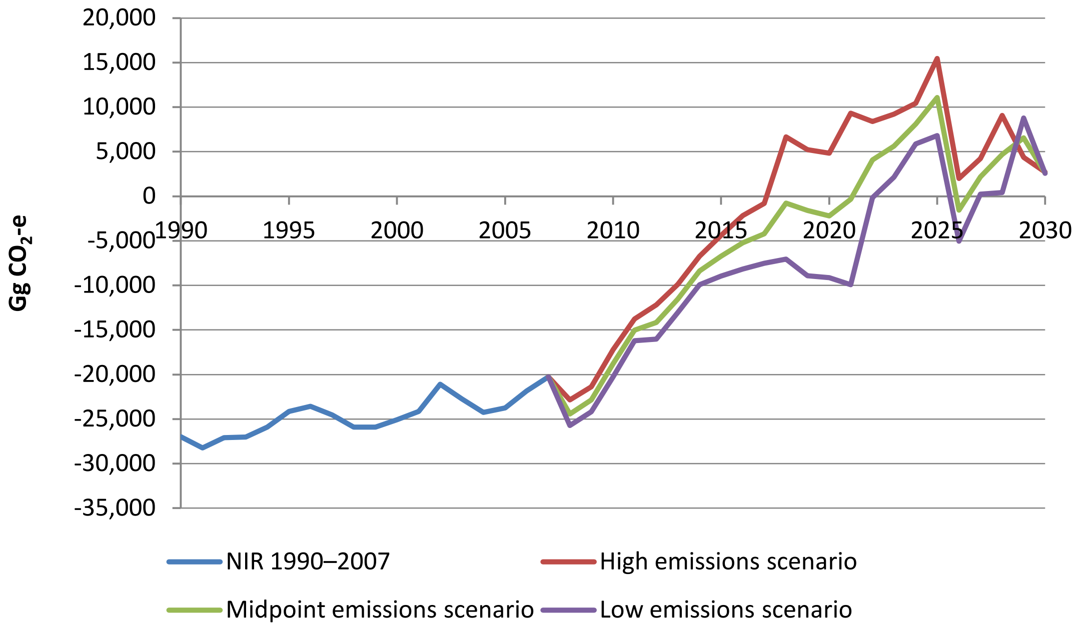


Figure 5.10: Net emissions as presented in the 2013 Greenhouse Gas Inventory (1990 – 2007), and projected (2088 – 2030) low, midpoint and high scenarios of net emissions, UNFCCC basis

Biomass burning emissions

Non-carbon dioxide emissions from biomass burning from 1990 to 2011 (based on the 2013 NIR) and projections from 2015 are provided in table 5.11. Biomass burning projections are based on historical trends in wildfire and controlled burning, and include non-carbon dioxide emissions from both forest and grassland. Biomass burning is not a significant source of emissions for New Zealand, because the practice of controlled burning is limited, and wildfires are not common due to New Zealand's temperate climate and vegetation.

Table 5.11: 2013 Greenhouse Gas Inventory (1990 – 2011) and projected (2015 – 2030) non-carbon dioxide LULUCF emissions from biomass burning activities

Gas (Gg)	1990	1995	2000	2005	2010	2011	2015	2020	2025	2030
CH_4	2.74	3.5	2.64	2.64	2.59	2.45	2.58	2.58	2.58	2.58
N_2O	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

5.2.7 Waste sector

Projections

Emissions from the waste sector are projected to increase to 2,099.8 Gg CO_2-e (2 per cent above 1990 levels, or 6 per cent above 2011 levels) by 2020, and to 2,314.5 Gg CO_2-e (12 per cent above 1990 levels, or 17 per cent above 2011 levels) by 2030 (table 5.12). Waste sector emissions are mainly driven by the increase in population.

Table 5.12: Actual and projected emissions from the waste sector, 1990 – 2030

Gas	Gg gas for the waste sector									
	1990	1995	2000	2005	2010	2011	2015	2020	2025	2030
CO_2	12.91	12.62	5.89	3.63	0.92	0.92	0.91	0.91	0.91	0.91
CH_4	90.45	89.70	92.46	94.47	87.14	85.85	86.99	90.37	95.72	99.81
N_2O	0.47	0.52	0.54	0.59	0.59	0.59	0.62	0.65	0.68	0.70
CO_2-e	2,059.06	2,058.15	2,113.65	2,169.55	2,012.80	1,985.40	2,020.61	2,099.76	2,220.55	2,314.51

Methane emissions from landfills are expected to be below 1990 levels in the first commitment period of the Kyoto Protocol, but are projected to increase shortly afterwards. Emissions have decreased because a greater proportion of landfill gas (methane) is being captured and destroyed, but this is being offset by an increase in gross landfill gas emissions due to population growth. Figure 5.11 shows projections of methane emitted and recovered from landfills.

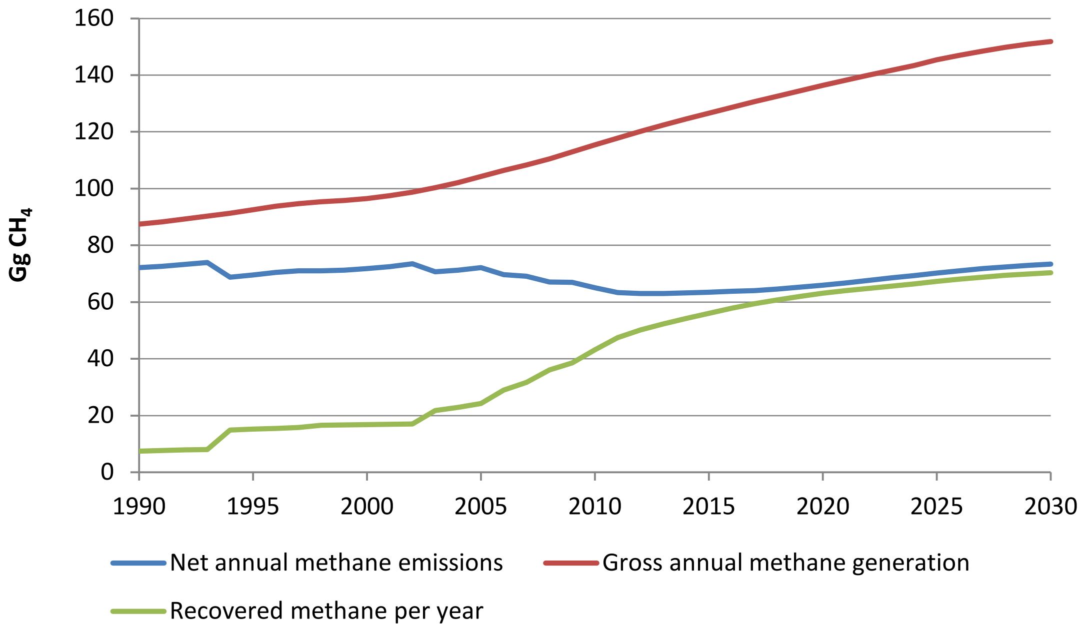


Figure 5.11: Gross methane generated from landfills, methane recovery and net methane emissions, 1990 – 2030

Analysis

The amount of waste disposed of is generally expected to increase as population increases. As New Zealand's population is predicted to continue to increase, this results in an estimated increase in the amount of emissions from solid waste disposal to land. For the projections it has been assumed that waste per capita remains constant, based on the most recent national survey, at 750 kilograms per person per annum.

Methodology

Emissions from solid waste disposal are projected by calculating solid waste disposal per capita from the NIR and applying this to national population projections produced by Statistics New Zealand. The estimate from the most recent national survey of 750 kilograms per person per annum is used.

The proportions of methane recovered by landfills that operate methane recovery systems have been determined up to 2012. The expected impacts of Government policies are assumed to reduce the future levels of solid waste disposal per capita and increase the amounts of methane recovered from landfills. The effects of the NZ ETS on methane recovery are included in this modelling. The effects of the waste levy have not been included because there is not yet any empirical data to quantify them.

National population projections have been used to estimate total domestic and commercial wastewater treated and the resulting emissions from wastewater treatment. Past trends in industrial activity have been used to estimate future industrial activity and resulting wastewater emissions from this sector.

The projections in this section also account for greater population growth out to 2030.

5.3 Differences since the *Fifth National Communication*

The differences between the projections of emissions set out in this chapter and those set out in the *Fifth National Communication* are shown in table 5.13.

Table 5.13: Differences in projections for 2020 since the Fifth National Communication, by sector

Sector	Emissions (Mt CO_2-e)			
	Sixth National Communication	Fifth National Communication	Difference (absolute)	Difference (percentage)
Energy	17,854.28	15,946.20	1,908.08	12.0
Transport	14,872.47	15,583.60	–711.13	–4.6
Industrial processes	5,346.23	4,572.20	774.03	16.9
Agriculture	37,045.54	39,072.40	–2,026.86	–5.2
Forestry	–2,200.62	1,926.90	–4,127.52	–214.2
Waste	2,099.76	1,721.30	378.46	22.0
Total gross emissions (excluding LULUCF)	77,218.28	76,895.70	322.58	0.4
Total net emissions (including LULUCF)	75,017.66	78,822.60	–3,804.94	–4.8

The differences between the projected removals in the *Sixth* and *Fifth National Communications* result from a combination of factors, described below by sector.

Energy

Overall, total projected emissions for stationary energy have increased. This increase is due to a number of confounding factors.

- New Zealand's only methanol production company has made recent investments in 2013 to increase production capacity. Gas combusted to produce methanol by the company is included in the 2020 energy demand projection in the Sixth National Communication. Combustion of this gas accounts for approximately 70 per cent of the increase in CO_2-e emissions in the Sixth National Communication. The company was assumed not to be operational from 2014 in the Fifth National Communication.
- The effective carbon price assumption in the Sixth National Communication is NZ$5/tonne CO_2-e. This assumption is much lower than the assumed medium-term carbon price used in the Fifth National Communication (ranging from NZ$25 to NZ$50 per tonne of CO_2-e). The lower carbon price has an impact on the economics of fossil fuel use in the modelled scenario.
- Changes in the methodology for the allocation of liquid fuels have recently been made, which resulted in a reallocation of liquid fuels from the transport category into the energy category. More details of this methodological change can found on page 51 of the 2013 NIR.[127]

Transport

Demand growth for liquid transport fuels is lower in the *Sixth National Communication* than in the *Fifth National Communication*. This change is due to different assumed trajectories for the drivers of transport demand, including the following.

- Population growth is assumed to be lower in the *Sixth National Communication* than in the *Fifth National Communication*. The lower population used in the modelling of transport results in a lower demand for light passenger vehicle kilometres travelled.
- International crude oil prices are used as the basis to calculate the New Zealand domestic diesel and petrol prices. The assumed crude oil price trajectory, and hence the petrol and diesel prices, is higher in the *Sixth National Communication* than in the *Fifth National Communication.* Higher transport fuel costs have a downward effect on transport demand.

Industrial processes

The 2020 total greenhouse gas emissions projections from industrial processes are higher in the *Sixth National Communication* than they were in the *Fifth National Communication*. The carbon dioxide emissions from industrial processes are projected to be at very similar levels to those projected in the *Fifth National Communication*, but emissions of fluorinated gases are projected to be higher due to the observed increased use of fluorinated gases since 2009.

Agriculture

The differences between the projected emissions and removals in the *Sixth* and *Fifth National Communications* for the agriculture sector are influenced by droughts over 2007-2008, 2010,

---

[127] http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2013/greenhouse-gas-inventory-2013.pdf

and by improvements in New Zealand's annual greenhouse gas inventories submitted between 2009 and 2013.

- There have been improvements to the country-specific tier 2 livestock model used to estimate emissions from enteric fermentation, manure management and agricultural soils.
- Recalculations have been made to the dairy, beef, and sheep population models for the tier 2 model. The population model that is used to calculate emissions from cattle, sheep and deer uses assumptions about livestock birthdates, slaughter and culling to determine a monthly population profile. The model breaks the calculation of emissions down into monthly time steps to capture the seasonal variation in emissions throughout each year.
- Changes have been made to the population model assumptions, productivity and energy equations for deer.
- There are new emissions factors for direct nitrous oxide emissions from the 'pasture range and paddock' category, differentiating emissions by urine and dung.
- Country-specific nitrogen excretion rates for goats, swine and poultry have replaced default emissions factors.
- Revised models have been used to estimate live weights of cattle and sheep.
- Updated data has been used for the proportions of excreta treated by different animal waste management systems for poultry and swine.
- Country-specific methodologies have been adopted, and new crops have been included, to estimate emissions from nitrogen-fixing crops and crop residue.
- Minor livestock species have been included: alpaca and llamas, mules and asses, and emus and ostriches.
- The area of cultivated organic soil in agriculture has been re-estimated and harmonised with the definitions used in the LULUCF sector.
- The emission factors and methodologies used to estimate emissions from prescribed burning of savannas and field burning of agricultural residues have been developed to provide a more country-specific methodology.

Forestry

The differences between the projected emissions and removals in the *Sixth* and *Fifth National Communication*s are influenced by general improvements to national greenhouse gas inventories since the *Fifth National Communication*, and by changes to future assumptions on forest emissions and removals.

The differences between the *Fifth National Communication* forestry projections and the midpoint projections in the *Sixth National Communication* from 1990 to 2007 are a combination of continued improvements in the estimates of forest area, emission factors and methodology detailed in each of the 2008 to 2011 NIRs.

The net result of all the improvements to activity data, emissions factors and methodology is that projected forestry emissions are lower for 2020 compared to those published in the *Fifth National Communication*. However, point-in-time comparisons are misleading because variations in harvesting, deforestation and afforestation rates can lead to large yearly variation. Overall, there is only a marginal difference in cumulative forestry emissions and removals from 2008 to 2020 when comparing the projections for the *Fifth* and *Sixth National Communication*s.

The differences between the *Fifth National Communication* forestry projections and the midpoint projections in the *Sixth National Communication* are a combination of continued improvements in forest area, emission factors and methodology and are summarized as follows:

- Revised afforestation, deforestation and harvesting area data from 1990–2007 and improved forest carbon stock yield tables as detailed in New Zealand's 2011 greenhouse gas inventory
- Revised assumptions on projected planted forest harvest rotations
- Updated projections on deforestation, afforestation and harvest rates from 2008–2020.

Waste

A number of improvements have been made to the methodologies for calculating emissions from the waste sector. The most substantial of these changes are the estimates of methane produced and recovered by landfills that have methane recovery systems. The method for projecting emissions from the treatment of industrial waste water has been amended and also contributes to the difference.

5.4 Total effect of policies and measures

5.4.1 'Without measures' scenario

New Zealand has estimated the effect of key quantifiable Government policies and measures by producing 'without measures' projections which can be compared to the 'with measures' projections. Table 5.14 shows the projections 'without measures' by sector. Total 'with' and 'without measures' projections are compared in tables 5.15 and 5.16, and in figure 5.12. As the 'with measures' scenario includes only key quantifiable policies, the difference between the 'with measures' scenario and the 'without measures' scenario does not demonstrate the full impact of the Government's policies and measures.

The 'without measures' projection excludes the modelled effect of the NZ ETS from the energy, transport, waste and forestry sectors. This projection also excludes new planting resulting from Government afforestation schemes, as well as the effect of the landfill gas standard on waste emissions.

Total gross emissions (excluding forestry) 'with measures' are projected to be 77,218.3 Gg CO_2-e in 2020, 1 per cent lower (437.1 Gg CO_2-e) than projected emissions 'without measures'. Total net emissions, including forestry 'with measures' are projected to be 75,017.7 Gg CO_2-e in 2020, 12 per cent lower (9,810.0 Gg CO_2-e) than projected emissions 'without measures'.

As was noted above, because New Zealand's industrial processes sector is dominated by a few large operators, a change in behaviour by one company can have a large effect on industrial process emissions. For this reason, the effect of the NZ ETS on industrial process emissions could not be modelled and has not been separated out in the 'without measures' projection.

Overall, New Zealand's policies and measures are estimated to avoid 9,810.0 Gg CO_2-e emissions in 2020 and 3,624.3 Gg CO_2-e emissions in 2030 (tables 5.15 and 5.16).

Implemented policies and measures are projected to have the most impact on New Zealand's forestry and waste.

Table 5.14: Projected emissions, 'without measures', 2015 – 2030

Sector	Emissions (Gg CO_2-e) 2015	2020	2025	2030
Energy	18,287.8	17,905.2	18,581.4	18,359.8
Transport	14,406.0	14,878.6	15,473.7	15,904.1
Industrial processes	4,964.0	5,346.2	5,732.3	6,120.9
Agriculture	34,976.0	37,045.5	38,799.4	39,598.5
Forestry	–2,476.2	7,172.3	18,217.4	5,908.0
Waste	2,408.8	2,479.8	2,548.3	2,565.1
Total gross emissions (excluding net emissions from forestry)	75,042.6	77,655.4	81,135.1	82,548.3
Total net emissions (including net emissions from forestry)	72,566.4	84,827.7	99,352.5	88,456.3

Table 5.15: Comparison of projected emissions, 'with measures' and 'without measures' in 2020[127]

	Without measures (Gg CO_2-e)	With measures (Gg CO_2-e)	Absolute difference (Gg CO_2–e)	Percentage difference
Sector				
Energy	17,905.2	17,854.3	–50.9	-0.3%
Transport	14,878.6	14,872.5	–6.2	0.0%
Industrial processes	5,346.2	5,346.2	0.0	0.0%
Agriculture	37,045.5	37,045.5	0.0	0.0%
Forestry	7,172.3	–2,200.6	–9,372.9	-130.7%
Waste	2,479.8	2,099.8	–380.0	-15.3%
Total gross emissions (excluding LULUCF)	77,655.4	77,218.3	–437.1	-0.6%
Total net emissions (including LULUCF)	84,827.7	75,017.7	–9,810.0	-11.6%

Table 5.16: Comparison of projected emissions, 'with measures' and 'without measures' in 2030[128]

	Without measures (Gg CO_2-e)	With measures (Gg CO_2-e)	Absolute difference (Gg CO_2-e)	Percentage difference
Sector				
Energy	18,359.8	18,310.9	–48.9	-0.3%
Transport	15,904.1	15,899.5	–4.6	0.0%
Industrial processes	6,120.9	6,120.9	0.0	0.0%
Agriculture	39,598.5	39,598.5	0.0	0.0%
Forestry	5,908.0	2,587.8	–3,320.2	-56.2%
Waste	2,565.1	2,314.5	–250.6	-9.8%
Total gross emissions (excluding LULUCF)	82,548.3	82,244.2	–304.1	-0.4%
Total net emissions (including LULUCF)	88,456.3	84,832.0	–3,624.3	-4.1%

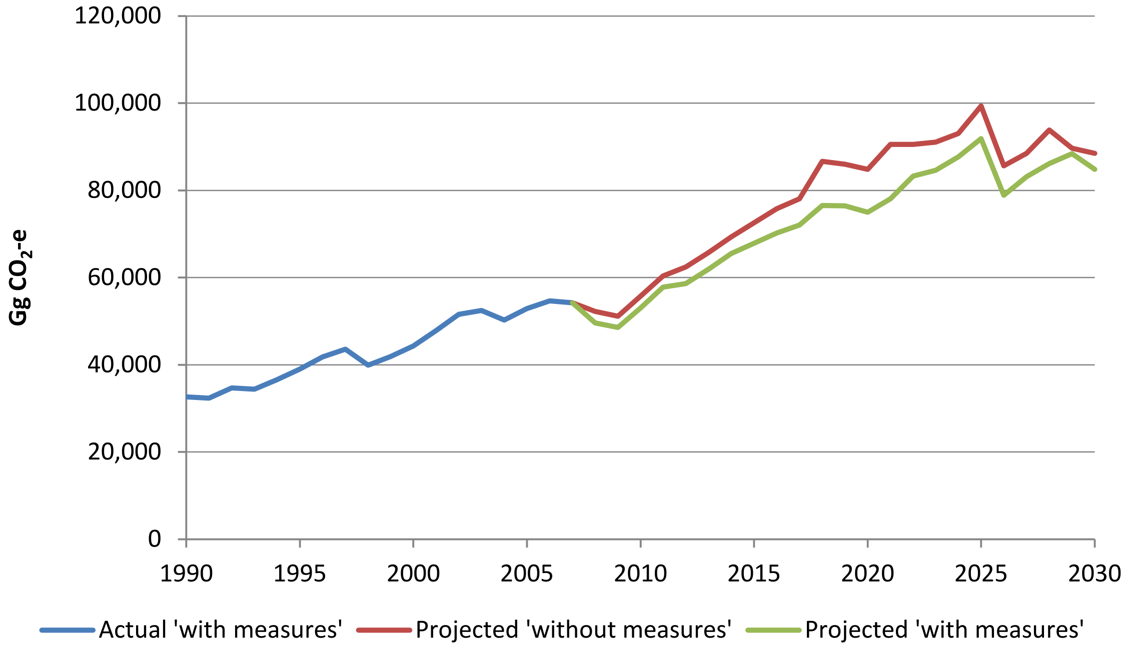


Figure 5.12: Actual and projected net emissions, 'with measures' versus 'without measures', 1990 – 2030

128 Assuming the midpoint emissions scenario for LULUCF.

Note: Projections start at 2008 due to forestry data from 2008 to 2012 only being confirmed once New Zealand's mapping is completed in 2013, and then included in New Zealand's 2014 NIR. This means that net emissions for 2008–2011 in the graph above differ to net emissions presented in New Zealand's 2013 NIR.

The effect of policies and measures on the forestry sector

Point-in-time comparisons between 'with' and 'without measures' emissions for forestry are misleading, because variations in harvesting, deforestation and afforestation rates can lead to large yearly variations. A more representative measure for comparing emissions between scenarios is cumulative emissions/removals over a period of time. Estimates of cumulative emissions for the four forestry scenarios modelled are presented below.

The 'with measures' projections in figure 5.11 include the modelled effects of the NZ ETS under the previously described emission scenarios. The 'without measures' projection excludes the modelled effects of the NZ ETS from the forestry sector, and also excludes new planting resulting from Government afforestation schemes. The 'without measures' scenario assumes:

- higher rates of deforestation, because there is no NZ ETS deforestation liability
- lower rates of afforestation
- the exclusion of Government afforestation schemes
- a normal harvest rotation of 28 years.

Assuming the midpoint scenario, the inclusion of New Zealand Government initiatives is projected to increase removals in the forestry sector. The introduction of the NZ ETS in 2008 and other Government forestry initiatives result in projected total net removals between 2008 and 2020 of 136 million tonnes of carbon dioxide, assuming the midpoint emission scenario 'with measures', compared to removals of 72 million tonnes 'without measures' (table 5.17).

Table 5.17: Comparison of projected net emissions, 'with measures' scenarios and 'without measures', cumulative total 2008 to 2030

Comparison of scenarios with measures and without	Cumulative emissions 2008 – 2020 ($Mt\ CO_2$)	Cumulative emissions 2021 – 2030 ($Mt\ CO_2$)
Without measures	–72	103
With measures:		
• low emission projection	–175	12
• midpoint emission projection	–136	43
• high emission projection	–95	75

Note: Negative values denote net removals of carbon dioxide. Positive values denote net emissions of carbon dioxide. 'Net emissions' means gross removals by planted forests, less emissions from deforestation and harvesting. Numbers are rounded to 1 decimal place.

The effect of policies and measures on the waste sector

The Waste Minimisation Act 2008 encourages a reduction in the amount of waste generated and disposed of in New Zealand and aims to lessen the environmental harm of waste. The Act provides ongoing benefits and currently does not lend itself well to quantifying its impacts on emissions.

In 2004 the Government introduced specific standards for landfills in the Resource Management (National Environmental Standards for Air Quality, NESAQ) Regulations. The policy intent of the standards is to ensure emissions of greenhouse gases generated from large landfills are effectively managed.

A brief analysis has been carried out and it was found that the regulations applied to landfills have decreased the emissions from solid waste disposal on land (table 5.18).

Table 5.18: Decrease in emissions from regulations applicable to landfills, 2005 – 2012

	2005	2006	2007	2008	2009	2010	2011	2012	Total
Emissions recovered because of the NESAQ (Gg CO_2-e)	18	109	135	191	216	277	331	364	**1,641**
Cumulative emissions recovered because of the NESAQ (Gg CO_2-e)	18	128	263	453	669	946	1,277	1,641	**1,641**

In the later years the NZ ETS may have had an influence on the amount of methane recovered from landfills. However, the proportion of the NZ ETS's influence has not been quantified.

Cumulative emissions 2008 – 2030

Figure 5.13 presents projected cumulative emissions between 2008 and 2030 under 'with measures' and 'without measures' scenarios. The graph shows that over this period it is projected that the effect of implemented measures will avoid 131,508.8 Gg CO_2-e being emitted.

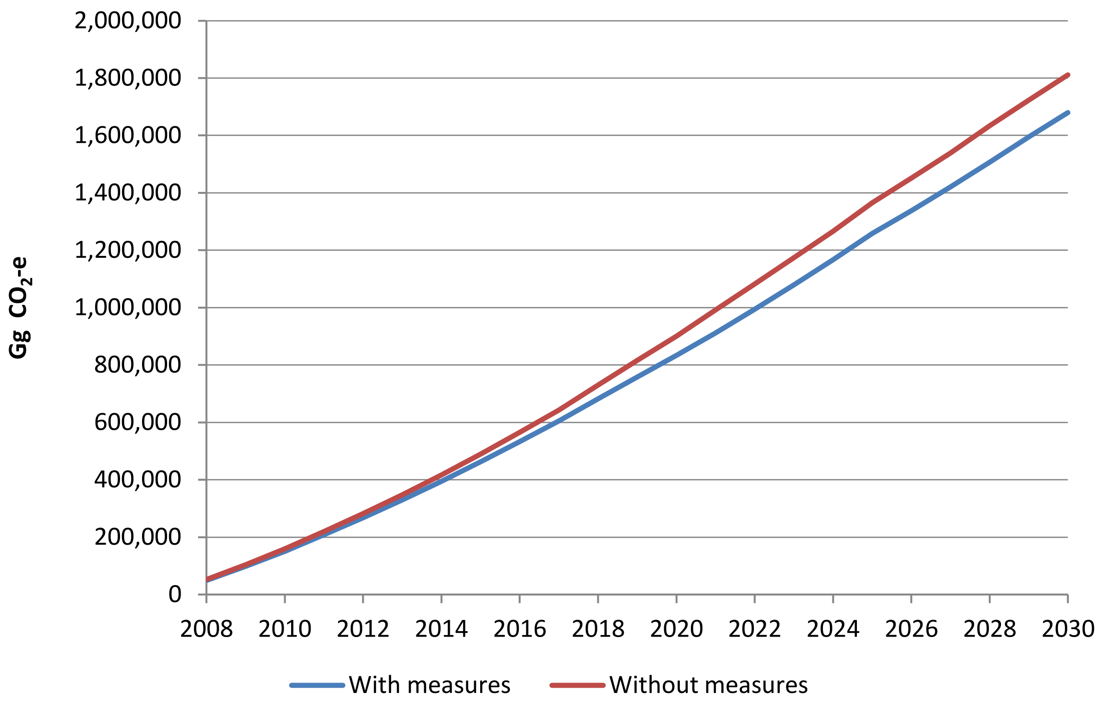


Figure 5.13: Cumulative emissions under a 'with measures' and 'without measures' scenario, 2008 – 2030

5.4.2 Sensitivity analysis for energy emissions

A sensitivity analysis was done for the projections in the energy sector (figure 5.14). Projections using a carbon price of NZ$0 (no emissions trading obligations) and an effective[129] carbon price of NZ$12.50/tonne of CO_2-e (the current maximum price) were modelled, with other assumptions remaining constant. The results showed that New Zealand's energy emissions are more sensitive to growth in GDP and climatic effects on hydroelectric generation than changes in carbon prices.

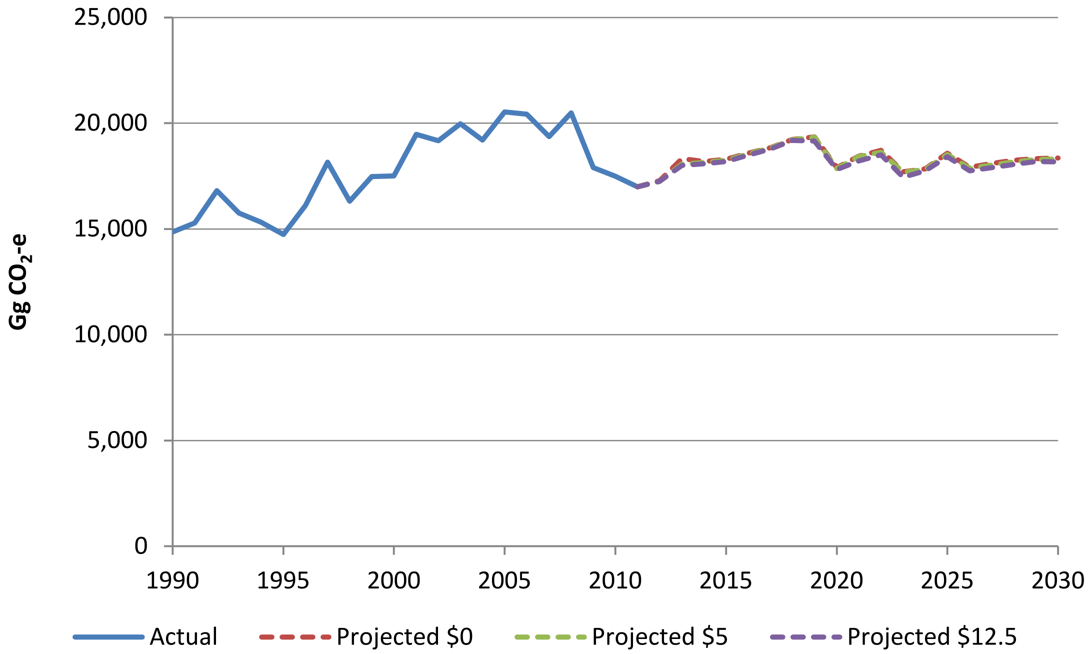


Figure 5.14: Sensitivity analysis for the energy sector

Further scenarios of emissions, focusing on the electricity sector, are available in the *New Zealand Energy Outlook: Electricity Insight*.[130]

129 Stationary energy participants under the NZ ETS are only required to surrender one NZU for every 2 tonnes of emissions. This policy has been accounted for in the energy emissions modelling. This means an effective price of NZ$12.50 per tonne of CO_2-e equates to an NZU price of NZ$25 per tonne of CO_2-e.

130 http://www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling/new-zealands-energy-outlook-electricity-insight

6

Vulnerability assessment, climate change impacts and adaptation measures

6 Vulnerability assessment, climate change impacts and adaptation measures

Key developments since the *Fifth National Communication*

- A major report was published in 2012 outlining the impacts of climate change on the land-based sectors in New Zealand.
- Guidance for local government on the effects of climate change on flooding was developed in 2010.
- The New Zealand Coastal Policy Statement (2010) has provided national policy direction on coastal activities, including managing coastal hazards and the effects of climate change.
- A five year technology transfer programme to promote more resilient farming practices in New Zealand was launched in 2010.
- The National Policy Statement for Freshwater Management (2011) now requires regional councils to have regard to climate change impacts.
- The Impacts of Climate Change on Urban Infrastructure and the Built Environment Toolbox was launched in 2012.

6.1 Introduction

A low population density (and related long-distance infrastructure), a long coastline, varied landscape and an economy reliant on the primary production sector make New Zealand vulnerable to risks associated with extreme weather, sea-level rise and shifts in climatic conditions. Climate change is expected to exacerbate these risks.

Information on future climate change scenarios for New Zealand is contained in the Ministry for the Environment's technical manual *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand* (2nd edition, May 2008).[131] More information about projected changes in climate can also be found in section 2.3.2. Key points are as follows:

- The best estimates of New Zealand temperatures are for an expected increase of about 1°C by 2040 and 2°C by 2090. However, owing to the different emission scenarios and climate model sensitivities, the projections of future warming cover a wide range: 0.2–2.0°C by 2040 and 0.7–5.1°C by 2090.

[131] See http://www.mfe.govt.nz/publications/climate/climate-change-effect-impacts-assessments-may08

- Projected rainfall and wind patterns show a marked seasonality. Westerlies are projected to increase in winter and spring, along with more rainfall in the west of both the North and South Islands and drier conditions in the east and north.
- Conversely, the models suggest a decreased frequency of westerly conditions in summer and autumn, with drier conditions in the west of the North Island and possible rainfall increases in Gisborne and Hawke's Bay.
- Other changes expected are: decreased frost risk, increased frequency of high temperatures, increased frequency of extreme daily rainfalls, decreased seasonal snow cover, and a possible increase in strong winds.
- The rate of temperature increase is expected to be higher than a linear extrapolation of the historical New Zealand temperature record for the 20th century.

As detailed in section 8.4.3, significant investment has been made over the reporting period into research programmes studying the impacts of climate change on New Zealand. Part 6.2 of this chapter summarises the key findings in specific areas of climate change impacts research in New Zealand.

Research during the reporting period has also looked at vulnerabilities in coping with the adverse impacts of climate change and means of adapting to climate change. Part 6.3 reviews specific work to identify community vulnerabilities to climate change, and vulnerabilities in the tourism and transport sectors. Part 6.4 discusses the steps taken to adapt to the risks, challenges and opportunities of climate change.

6.2 Climate change impacts research

This section summarises the findings of key climate change impacts research undertaken by the New Zealand Government during the reporting period in the following areas:

- agriculture and forestry
- biodiversity and natural ecosystems
- coastal zones
- fresh water and glaciers
- human health
- infrastructure and economy
- the marine environment and fisheries.

6.2.1 Agriculture and forestry

Over the past five years research has been undertaken to study the impacts of climate change on the land-based sectors. During the reporting period, over 40 reports focused on impacts and adaptation have been commissioned by the Ministry for Primary Industries. The majority of these studies explore the impacts on the major agricultural sectors of mid-range future climate scenarios.

The effects of climate change on crop/pasture productivity and persistence, pollinators, water resources, forest productivity, soil ecosystem services, erosion, pest and disease incidence, biocontrol systems and subtropical grass boundaries have been investigated. Research also covers the likely impacts from droughts, fire incidence, extreme winds, floods and frosts. Some work has been undertaken on wider social and economic implications, including rural water infrastructure, global trade and farm finance systems, and farmer resilience.

In 2012 the New Zealand Government issued a review report entitled *Impacts of Climate Change on Land-based Sectors and Adaptation Options*[132] outlining the impacts of climate change on the land-based sectors in New Zealand and various adaptation options.[133] The report made use of previous findings and modelled sector-specific responses to projected regional climate change to assess impacts on land-based industries. The report predicts that climate change under a low and higher temperature change scenarios (IPCC B1 and A2) is expected to have mild to moderate effects (some positive, some negative) on New Zealand's primary sectors to 2050. This assumes adequate water and soil nutrient supply. However, the report also indicates it is likely that some parts of the country will spend significantly longer periods in drought by mid-century.

The key findings are summarised below.

- Direct production impacts will present the primary sectors with both opportunities and challenges. There will be a general shift towards more production variability and changes in the timing of seasons. In some seasons and years, rising temperatures, carbon dioxide fertilisation and rainfall changes will increase yields.
- At other times, changes in rainfall will cause production downturns more pronounced than those currently experienced. Variability will be greater in the dry-land pastoral and arable sectors, which will experience more fluctuations in pasture and crop yields. Water availability will oscillate between larger surpluses and deficits. All sectors are exposed to temperature-driven changes in the seasonality of plant and crop responses. The severity of impacts will vary by sector and region. Some impacts will be indirect. Risks and costs from extreme weather will increase across all sector groups, ranging from short-term inconveniences to longer-term operational restrictions. Such impacts will affect not just the production landscape, but also the water, processing and transport infrastructure that supports it.
- Some secondary effects are difficult to quantify. Pests and diseases (including zoonotic diseases[134]), as well as environmental responses such as increasing erosion and nutrient run-off, are all possibilities. Similarly, there may be socio-economic implications beyond the land-based sectors, such as supply shocks.
- The cumulative impacts of back-to-back climatic events are important for all sectors, but they are difficult to identify and anticipate. This is the least-understood, but potentially the largest, challenge. Some sectors have already experienced such a phenomenon in the sequence of droughts and extreme weather in the period 2007 to 2010.
- Drought affects all primary production, but the arable and pastoral sectors (dairy, sheep and beef) are especially vulnerable to the relatively short, seasonal droughts typical of New Zealand. Future drought projections signal changes for some leading agricultural regions. These range from a doubling, to well over a doubling, of major droughts in drought-prone regions by mid-century. Change is centred on the east coast, particularly Canterbury, but much of the North Island may also be affected.

---

[132] The full technical report is available at http://www.mpi.govt.nz/news-resources/publications

[133] A summary report, *Impacts of Climate Change on Land-based Sectors and Adaptation Options: Stakeholder Report*, produced by the Ministry for Primary Industries in November 2012, is available at http://www.mpi.govt.nz/Default.aspx?TabId=126&id=1581

[134] Zoonotic diseases or infections are naturally transmissible from vertebrate animals to humans and vice-versa: see the World Health Organisation's *Zoonoses and the Human-Animal-Ecosystems Interface* at http://www.who.int/zoonoses/en

Dairy

New Zealand's climate is ideal for pasture-based dairy systems. Potential changes in pasture growth rates are already well understood in New Zealand. The combined effects of rainfall changes, temperature shifts and increasing carbon dioxide fertilisation were assessed through literature review and whole-farm models and are likely to be manifested as:

- changes in the seasonal timing of production (eg, changes in calving dates)
- increased seasonal pasture growth rates during late autumn, winter and early spring due to warmer temperatures
- shorter spring seasons, but with higher potential pasture growth
- earlier summer onset, with more water deficiencies and more variable autumns
- an increase in pasture growth rate variability, bringing additional deficits and higher surpluses of feed.

Sheep and beef

To identify potential climate change impacts on the sheep and beef sector, a farm modelling approach was used to project future pasture growth rates, availability and variability under a range of future climate scenarios. To provide a sample of the production diversity in the sector, three farm types were carefully selected: an extensive finishing-breeding operation in Southland, a hill country farm in the Hawke's Bay and an unimproved hill country farm in the Waikato. These three farm types account for nearly 70 per cent of New Zealand farm types but do focus on higher performing units.

The analysis revealed the following:

- In Southland, total annual dry matter production increased with climate change, allowing more stock to be carried. There was a marked shift in the seasonality of the pasture growth curves, with the spring peak occurring earlier, as well as a drop in dry matter production in late summer/autumn.
- In the Hawke's Bay farm production in the late summer/autumn increased only slightly with climate change. As in Southland, there was a marked shift in the seasonality of pasture growth curves: the most obvious being a decrease in summer dry matter production.
- In the Waikato, annual dry matter production increased by just over 10 per cent. As with the other two sites, there was a change in seasonality, with more growth in spring, and lower growth rates in the autumn.

Broad acre cropping

Simulation modelling indicates that climate change is likely to affect both the yield and quality of broad acre crops in New Zealand, including wheat, barley and forage crops. Assuming adequate water and soil nutrient supply, potential yields of temperate cereal and forage crops could increase by as much as 20 per cent under future temperature and carbon dioxide concentrations. However, in some cases, yields of other crops such as maize, peas and potatoes could slightly decrease, because high temperatures shorten the crop cycle and reduce the time available for sunlight interception and photosynthesis. Realising these potential increases or minimising the negative impacts will mean adapting crop management, including rotation, nutrients and water.

Horticulture

The expected impacts of climate change on horticultural species (such as apple, kiwifruit and grapes) were modelled. Variables included temperature rises, carbon dioxide increases and rainfall changes. Climate change is likely to affect plant development, flowering and bud break, as well as increase vegetative biomass and increase pest and disease risk. For vegetable production, under IPCC modelling scenarios to 2040 and 2090, climate change is likely to extend the potential growing season, increase yields for some crops, and increase pest and disease risk.

Forestry

Managed plantation forestry in New Zealand has a different impact profile and planning horizon to the other land-based sectors of around 30 years, due to its relatively slow biological response rate and long harvest cycle. The most certain direct impact of climate change under scenarios modelled to 2040 and 2090 is increased yield of radiata pine in many plantations where there are no moisture or nutrient limitations. Under these scenarios, forestry also faces less predictable, but expected, increases in risks of secondary impacts from pests and diseases, fire and extreme storms, which may reduce productivity and compromise wood quality.

6.2.2 Biodiversity and native ecosystems

New Zealand has been geographically separated from other land masses for over 80 million years so its biodiversity is unique. It has a high percentage of endemic species (found nowhere else in the world) in the terrestrial, freshwater and marine environments. The Department of Conservation commissioned a review of climate change impacts on New Zealand's biodiversity, which was published in 2011 as *Potential Effects of Climate Change on New Zealand's Terrestrial Biodiversity and Policy Recommendations for Mitigation, Adaptation and Research*.[135]

This report emphasises that freshwater, coastal and alpine ecosystem types may be particularly vulnerable to climate change, and that further work is needed to understand the expected impacts of climate change on these ecosystems and the species they contain. The report also highlights the significance of indirect impacts of climate change on biodiversity, in particular increased pressure from invasive pests, as well as pressure from land-use and management changes by other sectors adapting to climate change.

For the marine environment, another report commissioned by the Department of Conservation[136] made general predictions for climate change impacts on marine ecosystems, including the following:

- There will be increased smothering of coastal and estuarine habitats from terrestrial sedimentation as a result of more intense rainfall events, and increased inland and coastal erosion.

---

135 See http://www.doc.govt.nz/documents/science-and-technical/sfc312entire.pdf

136 TJ Willis, SJ Handley, FH Chang, CS Law, DJ Morrisey, AB Mullan, *et al*. 2007. *Climate Change and the New Zealand Marine Environment.* Prepared for the Department of Conservation by the National Institute of Water and Atmospheric Research. Retrieved from http://www.niwa.co.nz/our-science/climate/information-and-resources/clivar/climate_change

- Increasing temperatures are likely to result in cooler water-adapted species with a lower temperature tolerance either moving southward or suffering increased rates of mortality during extreme heat events. It is also likely that invasion of tropical and sub-tropical species will increase.
- Ocean acidification will cause declines in calcifying organisms, with cold-water species (including deep sea corals) likely to decline first.
- Sea-level rise will reduce coastal habitats (especially coastal wetland habitats such as salt marsh), changing inundation patterns and increasing vulnerability to storm surges and tides.

Research is currently underway to identify indicators to monitor marine biodiversity and the marine environment.[137] More information about research in the marine environment is discussed in the 'Marine environment and fisheries' section below.

Predation and competition for food sources by invasive (non-native) species are key causes of native animal extinction in New Zealand and also have an impact on native plant life. Climate change may have two kinds of impact on invasive species. Firstly, a number of invasive species (including ship rats, hedgehogs, rabbits and wasps) are limited in their range and/or abundance by temperature and may be able to respond quickly to changes in climate. For example, collaborative research is underway to investigate the relationship between invasive ship rats, temperature, beech seed fall (a source of food for ship rats) and altitude.[138] In response to warming temperatures, ship rats are expected to increase their distribution into higher-altitude forests and alpine zones. Controlling ship rats is a large cost to the Department of Conservation.

The second potential impact is indirect, through seed-masting events in beech forests and grasslands. Seed-masting is the production of unusually high quantities of seed that occurs in some plants in some years. It is quite common in New Zealand plants, including beech trees. The occasional large flower and seed crops usually lead to large increases in populations of introduced animals that feed on the seed (including mice and rats) and consequently predator populations (including stoats and feral cats). When the introduced rodents and other mammal predators in New Zealand ecosystems increase, they generally consume more native birds and insects.[139]

Seed-masting events occur in response to temperatures the previous summer. If temperature extremes become the norm, seed-masting events may become more common,[140] with the additional loss of associated functions such as pollination and seed dispersal, implying

---

137 More information on this research can be found in: Fisheries Management Science Team, Ministry for Primary Industries. 2012. *Aquatic Environment and Biodiversity Annual Review 2012: A Summary of Environmental Interactions between Fisheries and the Aquatic Environment*. Wellington: Ministry for Primary Industries, Chapter 8, pp 89–284. Retrieved from http://fs.fish.govt.nz/Page.aspx?pk=113&dk=23115

138 This research is being conducted by the Department of Conservation and Landcare Research, with some funding from the Ministry of Business, Innovation and Employment.

139 See http://www.landcareresearch.co.nz/about/news/media-releases/new-research-assists-predictions-for-mast-seeding-and-predator-explosions.

140 D Kelly, A Geldenhuis, A James, EP Holland, MJ Plank, RE Brockie, *et al*. 2013. Of mast and mean: differential-temperature cue makes mast seeding insensitive to climate change. *Ecology Letters* 16: 90–98.

potentially serious adverse impacts of climate change for biodiversity and ecosystem function.[141]

6.2.3 Coastal zones

Global sea-level rise resulting from climate change is expected to affect New Zealand. Long-term continuous tide gauge records from four New Zealand ports, and fragmented observations from six others, indicate an average rise in relative mean sea level (with respect to the land surface) of 1.7 ± 0.1 millimetres per year (or 0.17 metres per century) over the 20th century.[142] This result is consistent with the world-wide average for the 20th century, and climate models project that sea-level rise in the New Zealand region over the 21st century will be within 10 per cent of the global mean.[143]

New Zealand is a tectonically active country. A study of vertical land movement by GNS Science found that although some sites are experiencing uplift or subsidence of several millimetres per year when measured over a few years, on long time scales in most places it is less than 1 mm/year.[144] This means that in most places the effect of sea-level rise will be greater than the movement of the land.

In summary, climate change is expected to affect New Zealand's coastal margins through:

- increased coastal erosion
- more frequent and extensive coastal inundation
- higher storm surge flooding
- increased drainage problems in adjacent low-lying areas
- seawater reaching further inland in estuaries and coastal aquifers
- changes in surface water quality, groundwater characteristics and sedimentation
- increases in seawater temperatures
- changes in seawater towards a lower pH (acidification).

Several local councils in New Zealand have commissioned studies to investigate the impacts of sea-level rise and coastal hazards in their areas. Depending on the land forms, infrastructure and assets present in each region, these studies have examined changing sea level, wave height, storm surge and coastal erosion.

141 DM Tompkins, AE Byrom, RP Pech. 2013. Predicted responses of invasive mammal communities to climate-related changes in mast frequency in forest ecosystems. *Ecological Applications* 23(5). Retrieved from http://www.esajournals.org/doi/abs/10.1890/12-0915.1

142 J Hannah, RG Bell. 2012. Regional sea level trends in New Zealand. *Journal of Geophysical Research* 117, C01004. doi:10.1029/2011JC007591.

143 See GA Milne, WR Gehrels, CW Hughes, ME Tamisiea. 2009. Identifying the causes of sea-level change. *Nature Geoscience* 2: 471–478.

144 RJ Beavan, NJ Litchfield. 2012. *Vertical Land Movement Around the New Zealand Coastline: Implications for Sea-level Rise*. Wellington: Institute of Geological and Nuclear Sciences Limited Science Report 2012/29. Retrieved from http://www.gns.cri.nz.

6.2.4 Fresh water and glaciers

Climate change is set to modify the average – and most importantly the variability of – water availability in catchments by mid-century. River flows across the country are likely to decrease, or remain unchanged, with the exception of those sourced from the Southern Alps, which may show increases, particularly in winter and spring. More extreme floods are expected, particularly in the north, along with more drought, particularly in the east.[145]

As noted in the 'Agriculture and forestry' section above, droughts and floods cause significant damage to the land-based sector and create risks for water resource infrastructure.[146] Average temperatures will be higher, as will evaporation rates. It is less clear how climate change will affect lakes, aquifiers and water quality.[147]

New Zealand catchments show variation in water volumes, so these general impacts need to be considered alongside local hydrological properties. Water demand is expected to increase, for both production and in-stream uses (such as hydropower, as well as recreational uses including fishing and boating).[148]

Increased erosion and sedimentation rates, along with more frequent and extreme flooding, will have significant effects on infrastructure such as bridges and flood protection works. This will result in additional maintenance and operation costs.

NIWA has conducted annual monitoring of 50 South Island glaciers in New Zealand since 1977. The results indicate a loss of 15 per cent of glacier ice since monitoring began. In New Zealand an estimated 90 per cent of ice loss from glaciers since 1977 is due to thinning and ice breaking into lakes. NIWA's snowline surveys show an overall decrease in the glacier mass balance (and thereby volume) over the past 33 years, but this is punctuated by periods where the prevailing weather conditions have caused the glacier mass balance to increase for a few years.[149]

6.2.5 Human health

A collaborative research programme led by the Institute of Environmental Science and Research Limited (a Crown Research Institute)[150] has produced a modelling and map portal that projects the impacts of greenhouse gas emissions scenarios on infectious diseases. The scenarios used in the modelling are low (B1), medium (A1B) and high (A2).[151] Six infectious diseases (campylobacteriosis, cryptosporidiosis, meningococcal disease, influenza, and Ross River and dengue fevers) are used in the modelling. The Geographic Information System (GIS)

---

145 Ministry for Primary Industries. 2012. *Impacts of Climate Change on Land-based Sectors and Adaptation Options: Stakeholder Report*. Wellington: Ministry for Primary Industries, p 53.

146 Ibid.

147 Ibid.

148 Ibid.

149 T Chinn, BB Fitzharris, A Willsman, MJ Salinger. 2012. Annual ice volume changes 1976–2008 for the New Zealand Southern Alps. *Global and Planetary Change* 92–93: 105–118.

150 More information can be found at http://www.esr.cri.nz.

151 MBIE Contract C03X0801 ran from October 2008 to September 2012. Collaborators included NIWA, Landcare Research, Massey and Waikato Universities, the World Health Organisation, and the Universities of Queensland and Adelaide in Australia.

web-based interface displays the projections at a 5 x 5 kilometre scale across New Zealand, for three time periods (2015, 2040 and 2090).

As an example, the mathematical disease modelling shows that for campylobacteriosis the projected impact of a high emissions climate change scenario (A2) for 2090 presents a maximum annual average percentage change in reported illness rates (compared to 2002 reported rates) across parts of New Zealand of 26 per cent increase. For seasonal influenza (with vaccination), statistical modelling for the same scenario shows a projected decrease of 5 per cent of cases. The modelling has also shown that impacts will not be equal across New Zealand: communities are likely to be differentially affected due to variations across geographic regions and demographic factors (eg, sex and age).

6.2.6 Infrastructure and economy

Climate change is expected to have an adverse effect on the resilience of New Zealand's infrastructure.[152] In preparing New Zealand's first National Infrastructure Plan (published in 2010), the 2009 discussion document identified climate change as a cross-sectoral issue and noted that it is a significant environmental and economic issue. A number of potential impacts of climate change, including rising sea-levels and changes to rainfall patterns, could have implications for the resilience of New Zealand's infrastructure. Economic impacts of climate change include the cost of measures to adapt to climate change, such as protecting or relocating existing assets.[153]

The Ministry for Primary Industries has also commissioned a number of targeted reports to assess the likely impacts of climate change on critical infrastructure for the rural economy and to assess likely trade impacts. These include:

- impacts on rural water infrastructure
- physical impacts of climate change on primary sector infrastructure beyond the farm gate
- climate change and trade
- trends in land-use with climate change.

6.2.7 Marine environment and fisheries

The New Zealand Government has funded a number of research projects to progress the development of a national Marine Environmental Monitoring Programme and to examine the impacts of climate change on New Zealand's marine resources. This includes impacts on commercial fish stocks and shellfish populations. The research commissioned by the Ministry for Primary Industries falls under three broad categories:

- repeated physical measurements and biological observations in the marine environment
- fish stock abundance and fish recruitment correlation with environmental change

---

152 National Infrastructure Unit. 2009. *Infrastructure: Facts and Issues: Towards the First National Infrastructure Plan.* Retrieved from http://www.infrastructure.govt.nz/plan/2010development/ifi/

153 National Infrastructure Unit. 2010. *National Infrastructure Plan.* Retrieved from http://www.infrastructure.govt.nz/plan/mar2010

- the direct effects of changing marine environmental variables on marine species in the wild and in captivity.

Mean sea surface temperature has increased in New Zealand since the early 1900s, but the trend has not been uniform.[154] The clearest example of a link between coastal sea surface temperature and fish recruitment and growth is for northern stocks of snapper (*Pagras auratus*), where relatively high recruitment and faster growth rates have been correlated with warmer conditions.[155] Other species where fisheries indices appear to be linked to sea surface temperature include elephantfish, southern gemfish, hoki, red cod, red gurnard, school shark, snapper, stargazer and tarakihi.[156] The causal mechanisms are not well understood.

There is also some evidence that New Zealand waters are becoming more acidic (see figure 6.1). In New Zealand the change in surface water pH between the 1990s and 2070 is predicted to decrease by 0.15–0.18 pH units.[157]

---

154 AB Mullan, SJ Stuart, MG Hadfield, MJ Smith. 2010. *Report on the Review of NIWA's 'Seven-Station' Temperature Series*. NIWA Information Series No. 78, p 175.

155 From the Leigh Sea Surface Temperature series. See: MP Francis. 1993. Does water temperature determine year class strength in New Zealand snapper (*Pagrus auratus*, Sparidae)? *Fisheries Oceanography* 2(2): 65–72; MP Francis. 1994. Growth of juvenile snapper, *Pagrus auratus* (Sparidae). *New Zealand Journal of Marine and Freshwater Research* 28: 201–218.

156 RJ Hurst, JA Renwick, PJH Sutton, MJ Uddstrom, SC Kennan, CS Law, *et al*. 2012. Climate and oceanographic trends of potential relevance to fisheries in New Zealand region. *New Zealand Aquatic Environment and Biodiversity Report* No. 90. Wellington: Ministry for Primary Industries.

157 AJ Hobday, TA Okey, ES Poloczanska, TJ Kunz, AJ Richardson. 2006. *Impacts of Climate Change on Australian Marine Life.* CSIRO Marine and Atmospheric Research report to the Department of the Environment and Heritage.

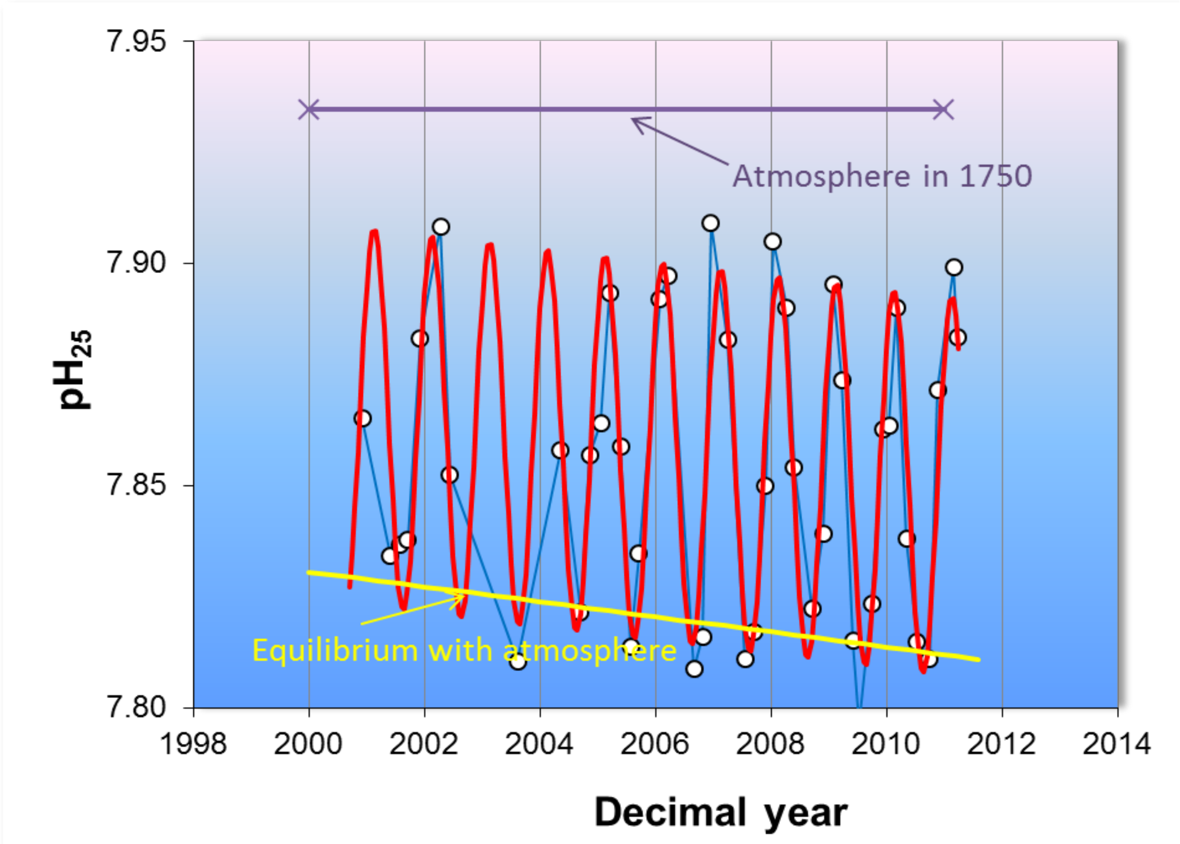


Figure 6.1: Ocean pH at 25°C in subantarctic surface seawater from the R.V. *Munida* transect, 2001 – 2011

Notes

The white circles and joining lines are the actual measurements and the red line is a best fit to the points using a sine wave function to represent seasonal change and a constant slope to represent decreasing pH. The purple line represents what the pH would have been in 1750 assuming equilibrium with the atmosphere at that time. The yellow line is what the pH would be assuming equilibrium with actual carbon dioxide concentrations as measured at Baring Head. pH_{25} is the pH measured at 25°C.

Source: KC Hunter, MR Currie, H Reid, A Doyle. 2011. A Southern Hemisphere Time Series for CO_2 Chemistry and pH. A presentation made at the International Union of Geodesy and Geophysics (IUGG) General Assembly Meeting, Melbourne, June 2011.

Increasing acidification in New Zealand waters is expected to have an impact on organisms that produce shells or skeletal structures of calcium carbonate. Organisms most likely to be affected are those at the base of the food chain (bacteria, protozoa, plankton), coralline algae, rhodoliths (maerl), shallow and deep-water corals, echinoderms, molluscs, and possibly cephalopods (such as squids) and high-activity pelagic fish (such as tuna).[158]

---

[158] See RA Feely, CL Sabine, K Lee, W Berelson, J Kleypas, VJ Fabry, *et al*. 2004. Impact of anthropogenic CO_2 on the CaCO3 System in the oceans. *Science* 305(5682): 362–266, and references therein; JC Orr, VJ Fabry, O Aumont, L Bopp, SC Doney, RA Feely, *et al*. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature* 437: 681–686; J Barcelos e Ramos, H Biswas, KG Schulz, J LaRoche, and U Riebesell. 2007. Effect of rising atmospheric carbon dioxide on the marine nitrogen fixer Trichodesmium, *Global Biogeochem Cycles* 21, GB2028, doi: 10.1029/2006GB002898; G Langer, M Geisen, KH Baumann, J Klas, U Riebesell, S Thoms, *et al*. 2006. Species-specific responses of calcifying algae to changing seawater carbonate chemistry. *Geochemistry, Geophysics, Geosystems* 7, Q09006. doi: 10.1029/2005GC001227.

In deep-sea habitats, increasing acidification may lead to biogenic structures (features that are caused by living organisms or biological processes), such as cold-water corals moving to the tops of seamounts, or widespread die-back.[159] Changes to biogenic structures may have an impact on the organisms that live on or near the seabed, and perhaps also on deep-sea ecosystems in New Zealand waters, and this could potentially affect New Zealand's deep-water fisheries. For example, these biogenic structures are deep sea habitats for commercial fish species, including orange roughy.[160] Conversely, some species, including phytoplankton (microscopic plants drifting or floating in the sea) and sea-grass, may benefit from the increase in dissolved carbon dioxide due to increased photosynthesis.

The Ministry for Primary Industries has commissioned research ranging from exploring the vulnerability of shellfish and echinoderms, to ocean acidification in Antarctica, integrated studies of rocky reef systems in New Zealand, and offshore fishery-scale trophic studies. The effects of ocean climate change and ocean acidification on shellfish, rhodolith communities, plankton productivity and the microbial productivity engines of polar waters are being explored. A major project to investigate shelf communities in relation to climate over the past 1000 years has resulted in the development of new methods, and insights into past changes and human impacts on New Zealand's marine environment.

6.3 Vulnerability assessments

In addition to the research described in the previous section, the New Zealand Government has undertaken work to identify vulnerabilities in the tourism and transport sectors, as well as supporting a community vulnerability research project. These studies are discussed below.

6.3.1 Tourism

The *Preparing the Tourism Sector for Climate Change* project[161] ran over 2009–2012 and developed a computer simulation for modelling impacts on the New Zealand tourism sector. The programme modelled the long-term effects of changes in prices for a variety of inputs, such as the oil price and exchange rate.

A key part of the research programme was a national-level screening exercise to assess vulnerability to climate change in the tourism sector. A background paper was produced which identified several vulnerabilities, the most significant of which were the ski fields around the country, which could be severely affected by climate change. The value of Queenstown as a tourist destination is dominated by the presence of ski fields and, because of this vulnerability, it was used as a case study in the report.

---

159 RE Thresher, JM Guinotte, R Matear, S Fallon. 2012. *Adapting to the Effects of Climate Change on Australia's Deep Marine Reserves*. Fisheries Research and Development Corporation / National Climate Change Adaptation Research Fund Report 2010/510.

160 DM Tracey, AA Rowden, KA Mackay, T Compton. 2011. Habitat-forming cold-water corals show affinity for seamounts in the New Zealand region. *Marine Ecology Progress Series* 430: 1–22.

161 This project was funded by the Foundation of Science, Research and Technology and conducted by Lincoln University. See http://www.lincoln.ac.nz/Research-Centres/LEaP/Tourism-Business--Communities/Projects/Adaptation-to-Climate-Change-in-New-Zealand/

6.3.2 Transport

In 2009 the New Zealand Transport Agency published a report on a two-stage project to identify and assess the impacts climate change may have on New Zealand's land transport networks (road, rail, ports and coastal shipping). The project examined the regional effects of climate extremes on transport networks, how these vary by region, when and where these risks emerge, and which parts of the land transport networks are most vulnerable. The study describes three national climate change profiles, covering rail heat buckle from extreme temperature, flood risk from extreme rainfall, and coastal inundation risk from low-lying sections of the networks.

Data from transport agencies and port authorities was used to assess the current vulnerability of networks to extreme weather. Extrapolation was used to predict future effects based on modelling of climate extremes for 10, 50 and 100-year projections using a mid-range (A1B) scenario. Regional impacts were determined on maps by overlaying climate change projections with transport infrastructure. Priority adaptation responses were discussed for each national profile in the context of design, operation, research and policy issues, and related emerging climate change research.[162]

6.3.3 Community vulnerability, resilience and adaptation to climate change

The New Zealand Government supported a four year research programme on community vulnerability, resilience and adaptation to climate change over the reporting period.[163] The programme focused on the effects of climate change in three different contexts – local government management of climate risks, a range of climate effects on human health, and Māori[164] community responses – and made a start towards identifying issues, options and priorities for adaptation.

Following are some of the key findings:

- Vulnerability to climate change will be affected by warmer temperatures, more intense flooding and a significant rise in sea level, but their magnitudes and rates of change cannot be defined precisely. Planning for the future will therefore be carried out in the knowledge of likely impacts but with uncertainty about their onset and magnitude.
- Vulnerability will be exacerbated by extreme events, which are likely to become more frequent and may start creating conditions that have not been experienced previously. The role that flexible and anticipatory land-use planning can play to address a range of climate conditions was highlighted, consistent with the findings in the IPCC's *Special*

162 See http://www.nzta.govt.nz/resources/research/reports/378/

163 MSI Programme VICX0805-CR-1 ran from October 2008 to September 2012. The project was collaborative and involved the following researchers: Victoria University of Wellington (M Manning, R Chapman, A Reisinger, J Lawrence, G Hart, N Taplikis), NIWA, Otago University (P Howden-Chapman, S Hales), Auckland University (A Woodward, G Lindsay), Health and Environment International Trust (T Kjellström), and PS Consulting Ltd. More information can be found at http://www.victoria.ac.nz/sgees/research-centres/ccri/research/community-vulnerability,-resilience-and-adaptation-to-climate-change,-2008-2013.

164 Māori are the indigenous people of New Zealand.

Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX).[165]

- Communication of risk and the way it is presented can underplay potential damages, which has implications for vulnerability.
- Changes in sea level and flooding highlight the value to local government of new assessment and planning methods that address changing risk over long timeframes for assets and settlements that have long lifetimes.
- Water security at the local level was identified as an issue. Greater efficiency of use through a wider range of measures to support water conservation, metering and distributed water provision is needed.
- Changes in public health risks were explored, and the programme has started specific monitoring of heat exposure in outdoor workers, developed empirical models for relating communicable disease to social and climatic factors, and assessed the effect of rainfall variability on households and others relying on rainwater tanks.
- The Māori community research led to the identification of four principal determinants of community sensitivity and adaptive capacity, in line with previous studies: social networks, conventions and transformation; knowledge, skills and expertise; resourcing and finance; and institutions, governance and policy.
- The adaptive capacity of New Zealand communities is deeply connected to existing socio-economic-political and environmental conditions. This requires further analysis to integrate information from scientists, policy analysts and decision-makers to develop strategies and policies that can tackle vulnerability and enhance the ability to adapt.

6.4 Adaptation measures

6.4.1 Overview

The role of the New Zealand Government in adapting to climate change is focused on:

- setting the legislative and policy framework
- providing information and guidance to support local government and private parties to make effective adaptive decisions
- funding research to understand and support climate change adaptation.

Framework

New Zealand has a devolved system of resource management. The key piece of legislation is the Resource Management Act 1991, which sets out how New Zealand manages its environment. The Act requires all persons exercising duties and functions under the Act to have particular regard to the effects of climate change. Managing the effects of climate change in New Zealand is undertaken as part of wider natural hazards management. Natural hazards management in New Zealand is a function of local authorities under the Act.[166]

---

165 http://ipcc-wg2.gov/SREX/

166 A natural hazard is defined in section 2 of the Resource Management Act as any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire, or flooding) the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment.

The Government also provides national policy direction to local government under the Resource Management Act. The New Zealand Coastal Policy Statement (2010) and the National Policy Statement for Freshwater Management (2011) have been produced during the reporting period and are discussed below.

Information and guidance

The New Zealand Government provides information and guidance on climate change effects considered most likely to have a significant impact at a regional, national or sectoral level, and the expected timing of these effects. This information and guidance are provided so that local government, engineers, businesses and individuals have access to the information they need in order to adapt.

The Ministry for the Environment has produced technical manuals that provide detailed information on climate change impacts and help local government and other decision-makers plan for the effects of climate change. The technical manuals contain a large amount of detailed information, and so summary reports have also been developed that present the key information in an easy-to-understand format.

The technical manual, *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand* (2nd edition, May 2008),[167] was produced for New Zealand's local government and updates the 2004 edition to include the findings of the IPCC's *Fourth Assessment Report*. This manual contains information on trends in New Zealand's historical climate and scenarios of future climate change. *Preparing for Climate Change*[168] (July 2008) is the accompanying summary publication.

Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand [169] (July 2008) is a technical guidance manual that provides information on planning for climate change in the coastal margins. This report also includes information from the IPCC's *Fourth Assessment Report*. *Preparing for Coastal Change*[170] (March 2009) is the accompanying summary publication.

A key development during the reporting period was the development of guidance for local governments on the effects of climate change on flooding. The Ministry for the Environment published the technical manual *Tools for Estimating the Effects of Climate Change on Flood Flow: A Guidance Manual for Local Government in New Zealand* in May 2010. The guidance includes techniques for including climate change in flood planning, and tools for estimating the effect of climate change on flood flow. The accompanying summary publication is *Preparing for Future Flooding: A Guide for Local Government in New Zealand*, which was also released in May 2010.

The New Zealand Government will consider updating the information contained in the above publications once the updated assessment of the science of climate change in the Working Group I contribution to the *Fifth Assessment Report of the Intergovernmental Panel on Climate Change* is finalised.

---

167 http://www.mfe.govt.nz/publications/climate/climate-change-effect-impacts-assessments-may08

168 http://www.mfe.govt.nz/publications/climate/preparing-for-climate-change-guide-for-local-govt

169 http://www.mfe.govt.nz/publications/climate/coastal-hazards-climate-change-guidance-manual

170 http://www.mfe.govt.nz/publications/climate/preparing-for-coastal-change-guide-for-local-govt

Another information resource provided by the Ministry for the Environment is a climate change guidance note, published on the Quality Planning website in 2012.[171] This website is designed for council practitioners and others involved in resource management practice under the Resource Management Act. The guidance note provides best practice information on how to assess the significance of, and respond to, the effects of climate change. In particular, it focuses on how this can be done within local authorities' existing risk assessment, policy-making and decision-making processes.

Research

The New Zealand Government invests in research to better understand the impacts, vulnerabilities and adaptation options for climate changes specific to New Zealand (see also section 8.4.6). Changes in research funding (discussed in section 8.2.2) have made research on the impact and adaptation to climate change part of the expected work programmes of a number of Crown Research Institutes and universities. There is an expectation that this research will be conducted together with the end-users of the research who make decisions about how to respond to climate change.

The Government has committed funding for a targeted research project to update and improve projections of climate trends, variability and extremes across New Zealand out to 2100 in a form that is decision-relevant. The Climate Change Impacts and Implications project is scheduled to run for four years from October 2012 to September 2016 and will generate new knowledge about the potential impacts of climate change on New Zealand's environment, including natural ecosystems and native species, and productive activities. The research will be undertaken by Crown Research Institutes, universities and private research agencies.[172]

The Climate Change Impacts and Implications project covers five inter-related research areas:

- improved climate projections
- case studies of key pressures, critical time steps, and potential responses for five important environments: alpine and high-elevation native forest ecosystems, high- and hill-country environments, lowland environments, coastal and estuarine systems, and marine food webs.
- identifying feedbacks, understanding cumulative impacts and recognising limits
- increasing the relevance of climate change science and decision-making capacity to consider climate change risks through collaborative learning processes
- synthesising the research to support coordinated, evidence-based decision-making and policy development by New Zealand organisations.[173]

The Government established the Natural Hazards Research Platform in 2009 to provide secure long-term funding for natural hazards research. The initiative also helps research providers and end users to work more closely together. Research undertaken as part of the Platform includes research into hazards that are expected to be exacerbated or made more frequent by climate change. This includes developing quantitative estimates of flood, snow, wind, rainstorm and landslide activity in New Zealand. The research also evaluates how well New Zealand society is prepared for these hazards. Risk models include data on different vulnerabilities in different

171 http://www.qualityplanning.org.nz

172 http://ccii.org.nz/our-partners-2/research-partners

173 http://ccii.org.nz/about-ccii

parts of New Zealand, and the age and quality of buildings and infrastructure. Social science and land-use planning applied to natural hazards are a distinctive and important part of the research.

The Government has also provided support and funding for *Envirolink*, a regional council-driven investment scheme which supports the uptake of research on environmental issues that are relevant to regional council management. *Envirolink* grants over the review period have supported work on climate issues, including in the area of adaptive risk management as it relates to council decision making on changing climate risks.[174]

6.4.2 Specific adaptation responses

Agriculture and forestry

Sustainable Land Management and Climate Change Plan of Action

In September 2007 the Government outlined an integrated package for the land-based sectors called the Sustainable Land Management and Climate Change Plan of Action. The Plan of Action has been in operation during the reporting period and covers all aspects of climate change in the land-based sectors, including impacts and adaptation. More information on the Plan of Action can be found in section 4.3.5.

It is run in partnership with primary industry representatives, local government and Māori, and is overseen by a group known as the Peak Group. This group provides leadership and strategic direction on the development and implementation of the Plan of Action. Three working groups, made up of technical experts and specialists, have also been established to provide peer-review and practical advice on managing and coordinating work within the programme, and report to the Peak Group.

The Plan of Action has helped to deliver climate change resources and demonstration programmes to rural professionals and land managers through the Climate Change Technology Transfer Fund. In 2010 the Government funded a five year technology transfer programme to promote more resilient farming practices in New Zealand. The programme:

- develops and provides climate change information to land managers and their advisors
- runs demonstration programmes
- provides programmes on climate change to support and train rural professionals.

As part of the programme a number of reports, fact sheets and case studies have been placed on the Ministry for Primary Industries website, along with a toolbox to help land managers respond to climate change.

The Climate Change Technology Transfer Fund is part of the technology transfer programme under the Plan of Action. Projects under the programme started in October 2011. The purpose of the Fund is to promote more resilient land-based businesses by co-ordinating sector and government initiatives and providing relevant information through external parties to land managers/owners and their advisors.

There have been eight projects (totalling NZ$3.5 million) contracted since the Fund's inception in 2011. These projects have focused on developing climate change resources, holding sector-specific technology transfer events, and the development of a digital library of New Zealand

[174] The results are available on the *Envirolink* website: http://www.envirolink.govt.nz

climate change-related information for land managers. More information about the ‘Climate Cloud’ digital library can be found in section 9.2.4. In addition, one project focuses on upskilling rural professionals throughout New Zealand.

The technology transfer programme complements work already being carried out in a range of primary sector organisations. These organisations fund industry-good research, extension and technology transfer, and provide training for members. Research and technology transfer has also been ongoing under the Ministry for Primary Industries administered Sustainable Farming Fund, including work to improve water management and irrigation efficiency.

Rural Support Trusts

A nationwide network of Rural Support Trusts has been established to help rural people and their families during and after extreme weather or environmental events that affect their livelihoods. This includes pastoral farming, forestry, horticulture and other land-based activities. The Trusts work with a range of organisations including local civil defence organisations[175] and can provide information and assistance during and following an adverse event. Assistance may include coordinating the rescue and movement of stock, financial support, labour, technical information, or other needs depending on the events scale and severity.

Many of the trusts also provide their services in times of general hardship, such as personal and/or financial difficulties. The trusts can help rural people by either providing or facilitating referral to professional counselling, financial advice and farm management expertise. Help may also include providing mentors or colleagues from rural backgrounds to talk to, facilitation of financial assistance, Work and Income support,[176] and labour assistance.

Irrigation

Irrigation development, particularly water harvesting and storage, also has a climate change adaptation function. Drought risk management and mitigation (future proofing) provides resilience both for farm-level businesses and for regional economies. The Ministry for Primary Industries administers the Irrigation Acceleration Fund, which is intended to help realise the potential for irrigated agriculture to contribute to sustainable economic growth throughout New Zealand. It will be a key tool in climate change adaptation.

In 2011 the Government allocated funding of NZ$35 million over five years to support the development of irrigation infrastructure proposals to reach the investment-ready stage. Irrigation infrastructure investment-ready proposals must be technically and commercially robust and demonstrate a high level of community support. The proposals will inform the analyses and decision-making of potential investors in both scheme construction and commissioning.

The Irrigation Acceleration Fund’s primary purpose is to support regional-scale rural water infrastructure proposals. The Fund will continue to provide support for strategic water management studies and strategies and community irrigation schemes previously available through other initiatives, including the Sustainable Farming Fund and the Community Irrigation Fund.

---

175 Local government in New Zealand is responsible for civil defence in local areas. More information can be found at http://www.civildefence.govt.nz/

176 Work and Income is a service of the Ministry of Social Development. Work and Income provides government support by way of financial assistance and employment services throughout New Zealand.

In January 2013 the Government established a new company, Crown Irrigation Investments Ltd, to manage funding for equity investment in the construction of regional-scale schemes. The company will act as a bridging investor for regional water infrastructure development and as a minority partner investing in individual irrigation schemes on commercial terms. The Government has initially earmarked NZ$80 million for irrigation investment.

Biodiversity and native ecosystems

The Department of Conservation is currently preparing a report, *Adapting to Climate Change: A Proposed Framework for Conservation of Terrestrial Native Biodiversity in New Zealand*, which will be published and available online. This report outlines how management of climate change impacts should be integrated into the Department's existing natural heritage management framework. This framework seeks to manage the full range of New Zealand's ecosystems and species to encourage resilience against threats such as climate change. The work represented by this report will further the Department's intention to integrate adaptation to climate change into monitoring, review and planning systems currently under development for biodiversity management.

Coastal zones

A major development during the reporting period is the publication of the New Zealand Coastal Policy Statement (2010). This is a national policy statement under the Resource Management Act and provides national policy direction to local government on the management of activities in the coastal environment, including the management of coastal hazards and the effects of climate change.

The Coastal Policy Statement includes general principles for the sustainable management of New Zealand's coastal environment and contains national priorities for the preservation of its natural character. It also contains specific policies regarding the management of coastal hazards and requires consideration of the effects of climate change. Directions include the following.

- The assessment of coastal hazard risks must take account of climate change.[177]
- A precautionary approach is to be applied in the use and management of coastal resources that are potentially vulnerable to the effects of climate change.[178]
- Integrated management of the coastal environment must include considering physical changes to the coast resulting from climate change.[179]
- Assessments of areas potentially affected by coastal hazards should use a 100-year risk assessment timeframe and include an assessment of sea-level rise and other climate change effects.[180]

The Department of Conservation has made information on the background and intent behind the above policy directions available on its website.[181] It is also preparing guidance to support implementation by local authorities, for release in 2013.

---

177 Objective 5.

178 Policy 3.

179 Policy 4.

180 Policy 24.

181 Available at http://www.doc.govt.nz/conservation/marine-and-coastal/coastal-management/nz-coastal-policy-statement/.

As noted above, the Ministry for the Environment provides information and guidance to local authorities planning for climate change in the coastal zone.[182] The guidance for coastal hazards and sea-level rise uses a risk-based assessment and recommends planning for

> a base value sea-level rise of 0.5 metres by the 2090s (2090–2099) relative to the 1980–1999 average, along with an assessment of the potential consequences from a range of possible higher sea-level rises. At the very least, all assessments should consider the consequences of a mean sea-level rise of at least 0.8 metres relative to the 1980–1999 average.

For planning for the period beyond 2100, an allowance for sea-level rise of 10 millimetres per year beyond 2100 is recommended.[183]

The Government supports a number of nationwide research projects that aim to enable the management of coastal hazards by planners, engineers and coastal scientists. These include the development of:

- a consistent national overview of coastal vulnerability to climate change, from which local scenarios of future impacts can be derived
- readily available, consistent information on the trends and extremes for wave, swell and storm surge at a regional scale, both now and incorporating future climate change effects.

In particular, the four year programme Coastal Adaptation to Climate Change project was led by NIWA.[184] It was set up to create information and tools to promote adaptation to the impacts of climate-induced change on the coastal environment. The project provided a national perspective on how adaptation to coastal changes can be facilitated at the regional and local levels to address specific local issues.

Key outcomes of the project were to enable more informed proactive communities and to help local authorities to develop local adaptation plans that encompass community values. The adaptation guidance *Pathways to Change* was published in November 2011 and is a synthesis of findings from the overall programme.[185]

The Coastal Adaptation to Climate Change project included the development of the Coastal Vulnerability Index and the Coastal Sensitivity Index. These indices were developed as a way of characterising the relative vulnerability of coasts to hazards. The Coastal Sensitivity Index provides a snapshot of the potential sensitivity of New Zealand's non-rocky coastline to coastal inundation (flooding) and coastal erosion as a result of climate change in the future. The index can be viewed online as maps of coastal inundation and coastal erosion. Mapping the Coastal Sensitivity Index for New Zealand is a first step in understanding where the impacts of climate change on the coast may be most significant, and where adaptation activities would be most

---

182 *Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand* (July 2008). Retrieved from http://www.mfe.govt.nz/publications/climate/coastal-hazards-climate-change-guidance-manual/

183 Ibid.

184 This project ran from July 2008 to September 2012 and was funded by the Ministry of Business, Innovation and Employment (MBIE contract C0X0802). More information is available at http://www.niwa.co.nz/our-science/coasts/research-projects/coastal-adaption-to-climate-change

185 NIWA. 2011. *Coastal Adaptation to Climate Change: Pathways to Change.* Retrieved from http://www.niwa.co.nz/

usefully targeted. It will also raise community awareness about coastal hazards and how they are likely to be affected by climate change.[186]

Local government in New Zealand is making efforts to tackle sea-level rise and the increased risk of coastal hazards expected as a result of climate change. Wellington City Council has developed five scenario-based models of the consequences of a range of sea levels, from 0.6 metres to 3 metres, plus storm effects. Kāpiti Coast District Council and Central Hawke's Bay Regional Council have both undertaken an assessment of coastal erosion hazard, including the impact of sea-level rise. In doing so these councils have identified multiple risk zones for coastal erosion and inundation. These risk zones are reflected in regulations that are stronger where the risk is higher; for example, by establishing 'no build' zones seaward of 50-year lines, with existing buildings restricted to the current footprint and floor area, and 'relocatable' buildings between 50- and 100-year lines.

Emergency management

The Civil Defence and Emergency Management Act 2002 provides for the comprehensive management of hazards and risks, and emergency response and recovery, through coordinated and integrated policy, planning and decision-making processes at the national and local level. It sets out the duties, functions and powers of central government, local government, emergency services, lifeline utilities and the general public.

The Ministry of Civil Defence and Emergency Management has integrated preparing for climate change into aspects of its work programmes, including the following:

- Climate change and climate variability are included as modifying factors for coastal, weather and climate-related hazards in the National Hazardscape Report.[187]
- The National Civil Defence Emergency Management Strategy[188] recognises considering the implications of climate change for civil defence emergency management when undertaking hazard risk reduction, and emergency readiness, response and recovery planning.

In addition, the Ministry of Civil Defence and Emergency Management encourages including messages about climate change adaptation in communications with stakeholders.

Fresh water

Freshwater management in New Zealand is largely devolved to regional councils under the Resource Management Act 1991. Regional councils are responsible for managing water bodies in their region, including the flows and levels in any water body; control of the taking, use or damming, and diversion of water; the allocation of water; and the control of discharges.

In 2009 the Government embarked on a programme of freshwater reforms with the goal of providing stronger central government direction and leadership. Advice was sought through a collaborative group, the Land and Water Forum, which included representatives from a range of primary industries, electricity generators, recreational groups, environmental organisations

---

186 More information on the Coastal Sensitivity Index and the geomorphic and oceanographic variables used in the index can be found at https://www.niwa.co.nz/coasts-and-oceans/nz-coast/coastal-explorer/sensitivity-index

187 http://www.civildefence.govt.nz/memwebsite.NSF/wpg_URL/For-the-CDEM-Sector-Publications-National-Hazardscape-Report?OpenDocument

188 http://www.civildefence.govt.nz/memwebsite.nsf/wpg_url/for-the-cdem-sector-national-cdem-strategy-index?opendocument

and iwi,[189] along with active observers from regional councils and central government. With its first report released in 2010 and two subsequent reports in 2012, the Forum succeeded in building a wide consensus on a way forward for reform, based on more active and effective management of fresh water and stronger national direction.

In 2011 the National Policy Statement for Freshwater Management (2011) came into effect. This provides national policy direction to regional councils on freshwater management and requires that regional councils:

- state management objectives for water bodies that reflect national and local needs
- ensure objectives are achieved by setting flow, allocation and water quality limits
- efficiently allocate fresh water to users within those limits
- avoid over-allocation and address existing over-allocation
- manage land use and fresh water in an integrated way
- involve iwi and hapū in freshwater decision-making and planning.[190]

Under the National Policy Statement for Freshwater Management, regional councils must have regard to the reasonably foreseeable impacts of climate change. As such, the National Policy Statement encourages national consistency in regional councils taking climate change impacts into account in freshwater planning. Communities and businesses require long-term stability in allocations and rules. Therefore, when rules are set, future changes in catchments and climate need to be considered.

The National Policy Statement's *Implementation Guide* states that, in setting limits, it is important to consider matters such as:

- changes in the frequency and severity of droughts.
- rainfall, snow and evaporation rates, which are likely to change water flows and aquifer levels, or worsen or otherwise change existing problems with availability
- changes in temperatures, which may influence algal blooms or changes to water quality
- changes in sea level, which are likely to affect salination and groundwater quality
- deterioration of water quality in some areas as a result of lower flows in freshwater bodies.

Human health

The Health Analysis and Information for Action resource system referred to in section 6.2.5 is the first of its kind internationally. It aims to provide central, regional and local authorities with information to help them formulate and plan the implementation of responses and adaptive strategies for increasing human health resilience to the infectious disease consequences of climate variation and change. It consists of:

- the modelling and map portal referred to in section 6.2.5 above
- reviews and stakeholder interviews – literature reviews on web system development, information for action, technology transfer and stakeholder interviews
- water supply vulnerability assessment – a tool to guide small communities in assessing the vulnerability of their water supply to climate change impacts

[189] An iwi is one of the larger collective Māori groupings and is sometimes described as a tribe.

[190] A hapū generally refers to a grouping of related families.

- environmental health indicators – a tool to assess and monitor the impacts of climate change on food and waterborne diseases
- a disease-attributable intelligence system – a dynamic risk assessment tool for monitoring emerging disease risk.

Infrastructure and economy

The National Infrastructure Plan 2011 was published in July 2011. The Plan is designed to reduce uncertainty for businesses by outlining the Government's intentions for infrastructure development over a 20 year timeframe. It seeks to provide a common direction for how infrastructure in New Zealand is planned, funded and built.

The Plan is overseen by the National Infrastructure Unit. The Unit is located within the New Zealand Treasury and works with the various agencies responsible for the different infrastructure sectors to ensure a coordinated work programme is in place to deliver the Plan's vision. The Plan recognises the critical role local government and businesses play in delivering the Plan, and the National Infrastructure Unit has extensive networks throughout the infrastructure community.

The Plan sets out a vision that by 2030 New Zealand's infrastructure is resilient, coordinated and contributes to economic growth and enhanced quality of life. It outlines infrastructure issues in five key sectors: transport, telecommunications, energy, water and social infrastructure. A key challenge it identifies is that New Zealand's infrastructure is vulnerable to outages, including through natural hazards, and that New Zealand has insufficient knowledge of network resilience at a national level.

In the Plan, climate change is reflected in one of the key principles for infrastructure: Resilience. Resilience is defined as "National infrastructure networks are able to deal with significant disruption and changing circumstances", which includes disruption caused by extreme weather events as well as the gradual impacts of climate change.[191]

The scope of resilience in the Plan is wider than natural disasters and covers the capacity of public, private and civic sectors to withstand disruption, absorb disturbance, act effectively in a crisis, adapt to changing conditions (including climate change) and grow over time.

The Plan includes a programme of action to drive change before an updated version is published in 2015. One of these actions is a focus on the development of design and construction standards (where cost-effective) that ensure infrastructure is able to withstand natural hazards and long-term changes, such as those resulting from climate change.

Specifically, within the transport sector, and considering the movement of freight, a need is identified for a more strategic approach to land-use, aligned with the need to examine the resilience of New Zealand's supply chains across the country. More information on transport initiatives can be found in the 'Transport' section below.

Within the energy sector, a key issue identified in the Plan is that New Zealand's energy mix will need to change over the next 20 to 40 years, in part because of resilience issues. The Plan notes that New Zealand's electricity market is currently highly reliant on rainfall, and that, increasingly, wind and other less weather dependent renewable sources (eg, tidal and

[191] National Infrastructure Unit. 2011. *National Infrastructure Plan.* Retrieved from http://www.infrastructure.govt.nz/plan/2011

geothermal) are being developed. Reliance on thermal energy during periods of unfavourable weather brings its own climate change challenges.[192]

Work has also been done to develop a toolbox to support planners, engineers, asset managers and hazard analysts in New Zealand to understand and evaluate the potential impacts of climate change on cities.[193] The *Impacts of Climate Change on Urban Infrastructure and the Built Environment Toolbox* was launched in 2012. The toolbox is designed with an overall five-step evaluation framework, represented by the 'trays' in the toolbox. Within each tray are downloadable reports (or 'tools'), each with a specific purpose.

Each tool has been written so that it can be read and understood on its own, with references to other tools included within it. The tools demonstrate, using worked examples, methods and approaches that can be used to perform an assessment of climate change impacts. Readers are encouraged to contact the authors of the tools to discuss using specific software or other proprietorial material.

The information in the toolbox is consistent with the Australian and New Zealand Standard for Risk Management, AS/NZS ISO31000:2009, which is widely used in the public and private sectors to guide strategic, operational and other forms of risk management.

Marine environment and fisheries

A number of policies and measures are in place to ensure the sustainable management of fisheries resources in New Zealand. The Government operates a Quota Management System, which controls the total commercial catch for virtually all the main fish stocks found within New Zealand's exclusive economic zone. The Harvest Strategy Standard provides for targets and limits to be set for fisheries and fish stocks in New Zealand waters and to take into account changes in environmental conditions.[194]

In 2008 the *Marine Protected Areas: Classification, Protection Standard and Implementation Guidelines* were released. New Zealand has established a network of 34 marine reserves, which collectively protect 7 per cent of New Zealand's territorial sea.

Tourism

A Tourism Climate Change Plan was developed in 2008 and has been available for use by the tourism industry during the reporting period.[195] Many of the initiatives launched as part of the Plan have continued over the past four years, including monitoring overseas policies on climate change and visitors' satisfaction of environmental practices in New Zealand. Part of New Zealand's overseas tourism brand involves the image of New Zealand as 'clean and green', and as such it is important for the tourism industry to monitor New Zealand's environmental image, both in terms of climate change and ongoing tourism operations.

---

192 Ibid.

193 Funding for the Toolbox was provided by MBIE. The Toolbox was produced by researchers at NIWA, MWH New Zealand Ltd, GNS Science and BRANZ. More information can be found at http://www.niwa.co.nz/climate/urban-impacts-toolbox

194 http://fs.fish.govt.nz/Doc/16543/harveststrategyfinal.pdf.ashx

195 http://www.med.govt.nz/sectors-industries/tourism/tourism-research-data/other-research-and-reports/research-supported-by-science-innovation-funding

Transport

The New Zealand Transport Agency is responsible for keeping the state highway network safe, reliable and resilient. The agency works closely with project managers to collect best practices in environmentally responsible practice, identify relevant international trends, develop New Zealand-specific standards and guidelines, disseminate information and continuously improve service delivery. The *Highway and Network Operations Environmental and Social Responsibility Manual*[196] is a collection of standards, guidelines, tools and references applicable to all capital works and maintenance operations.

The State Highway Environmental Plan (June 2008) [197] includes the following climate change objectives:

- manage increased hazards from climate change impacts on state highway infrastructure
- collect and analyse information on greenhouse gas emissions and the impact of climate change on the functioning of the state highways to support decision-making.

The 2009 research report *Climate Change Effects on the Land Transport Network* (discussed in section 6.3.2) made recommendations on policy options and adaptation measures in response to the climate change impacts and risks identified. The research findings are intended to supply land transport infrastructure providers and policy makers with the information they need to adapt the design, operation and maintenance of critical assets to the impacts of climate change.[198] Several policy initiatives resulted from this initial research. Most recently the Coastal Asset Report Card project was developed following increased recognition that multiple transport assets are within the highly dynamic coastal zone, and that risks associated with this are not part of existing risk management and planning processes.

The first task of the Coastal Asset Report Card project is to set questions for further research into transport assets located on the coast (including bridges, causeways, culverts, retaining walls, embankments and vegetation controls) and the threats posed to them by the dynamic character of the coastal environment. Climate change impacts, including sea-level rise, will be assessed as part of the project, and the anticipated outcome is a process that will be added to asset management systems to assist long-term planning.

Finally, KiwiRail[199] is responsible for 4000 kilometres of rail network in New Zealand. Preventive measures are key to KiwiRail’s strategy for ensuring the rail network is able to withstand the impact of severe weather events. Measures include:

- strengthening and monitoring programmes that work to prevent rail buckling in high temperatures
- work programmes to maintain and strengthen the rail network, to reduce vulnerability to floods or tidal surges
- programmes to measure track stability on the rail network, using an automated data collection car.

---

196 http://www.nzta.govt.nz/resources/environmental-and-social-responsibility-manual/index.html

197 http://www.nzta.govt.nz/resources/environmental-plan

198 http://www.landtransport.govt.nz/research/reports/index.html

199 KiwiRail is a statutory corporation established under the New Zealand Railways Corporation Act 1981. As a state-owned enterprise it is subject to the State-Owned Enterprises Act 1986.

7

Financial resources and technology transfer

7 Financial resources and technology transfer

7.1 Introduction

New Zealand remains committed to addressing climate change in developing countries to ensure good outcomes and to manage risks. During the reporting period, New Zealand has given and delivered on undertakings to continue to provide climate change-related financial support, with a focus on renewable energy in the Pacific region. New Zealand is addressing the challenges posed by climate change by delivering considerable financial resources through a range of channels, primarily to its partner countries in the Pacific, but also to countries in Asia, Africa and Latin America.

This chapter reports on the financial and technological support New Zealand has provided to developing countries for climate change actions from 2009 to 2012 (inclusive) since the *Fifth National Communication* (2005 to 2008 inclusive). It covers the support provided through multilateral, bilateral and regional channels, as well as specific resources provided for mitigation, adaptation and technology transfer.

During the reporting period New Zealand's financial assistance for climate change outcomes had five main components:

- New Zealand's total annual contribution to the Global Environment Facility (GEF), including the proportion that is likely to be spent on climate change projects – total funding of NZ$10.68 million (see table 7.1)
- contributions to a range of multilateral organisations and programmes, including special funds under the UNFCCC, and scientific, technological and training institutions in the Pacific region – total funding of approximately NZ$228 million (see table 7.2)
- funding for specific projects administered through the Ministry for the Environment (see examples in table 7.2)
- support for bilateral climate change-related assistance managed by the Ministry of Foreign Affairs and Trade through the New Zealand Aid Programme and elsewhere – total funding of approximately NZ$70 million (see tables 7.3–7.6).

Across these components New Zealand delivered on its commitment to provide up to NZ$90 million in grant funding over the 2010 to 2012 'fast-start' period (through to the end of the 2012/13 financial year).

During this *Sixth National Communication* reporting period the New Zealand Aid Programme was reintegrated into the Ministry of Foreign Affairs and Trade (MFAT). The New Zealand Aid Programme has a core focus on sustainable economic development, with a particular emphasis on the Pacific region where the need for climate change assistance is great and where New Zealand has most experience.

The New Zealand Aid Programme's approach to climate change is to support developing country partners to become more resilient to the adverse impacts of climate change, climate variability and natural disasters. This includes building stronger public infrastructure and housing, strengthening disaster preparedness, and supporting low-carbon economic growth, in particular through renewable energy and energy efficiency initiatives. Integrating environment and climate change objectives as cross-cutting issues is in keeping with international best practice. New Zealand considers this to be the most effective way to manage climate change risks and therefore designs development assistance with environment and climate change co-benefits in mind.

The New Zealand Aid Programme has systems in place to track, measure and record climate change-related assistance provided to developing countries. For example, the Programme's Climate Change Operational Policy, implemented from mid-2012, provides detail on how support for climate change is to be delivered, recorded and quantified. In addition, the Environmental and Social Impacts Operational Policy (Programme's environmental 'safeguards' policy) seeks to identify and manage risks posed by climate change while taking advantage of opportunities to strengthen the resilience of communities and infrastructure.

During this reporting period, as part of the global effort to implement the Copenhagen Accord New Zealand delivered on its commitment to assist developing countries to adapt to and mitigate the effects of climate change by providing its fair share of fast-start financing. New Zealand provided NZ$90.34 million in grant funding through a range of bilateral, regional and multilateral contributions over the 2010 to 2012 fast-start period (through to the end of the 2012/13 financial year). New Zealand has confirmed that a post fast-start finance contribution will continue at a similar level, with the focus remaining on renewable energy and climate resilience in the Pacific.

New Zealand, alongside other bilateral and multilateral donors, is a member of the International Aid Transparency Initiative, which was launched in 2008 at the High Level Forum on Aid Effectiveness in Accra, Ghana. As a first step towards meeting the International Aid Transparency Initiative standard, in April 2012 New Zealand published information about projects funded through the New Zealand Aid Programme. Efforts to provide greater transparency for New Zealand's development assistance were recognised in the 2012 Publish What You Fund Aid Transparency Index. The Programme was placed 16th out of 72 organisations for levels of aid transparency. The index ranks development organisations across the world and includes country donors, multilateral agencies and private foundations. (For further information, see http://www.aid.govt.nz.)

The remainder of this chapter outlines New Zealand's contribution through multilateral, bilateral and regional funding channels, including support for the transfer of technology.

7.2 Multilateral support

7.2.1 Global Environment Facility

The Global Environment Facility (GEF) is the international entity entrusted with the operation of the financial mechanism of the UNFCCC. The GEF distributes financial assistance associated with the major multilateral environmental agreements on climate change, biodiversity, persistent organic pollutants, ozone-depleting substances and desertification, and also supports activities relating to land degradation and international waters. New Zealand is fulfilling its Article 4.3 commitments through its contribution to the GEF.

For the fifth replenishment of the GEF Trust Fund in 2010 New Zealand committed a total of NZ$10.68 million. Table 7.1 provides details of New Zealand's total annual contributions to the GEF Trust Fund for 2009 to 2012 (the reporting period for this national communication). At the time of writing, negotiations were underway for the sixth replenishment of the GEF Trust Fund

(GEF-6), covering the period 2014 to 2018. These negotiations are expected to be completed in early 2014.

Table 7.1: New Zealand's financial contributions to the Global Environment Facility, 2009–2012

Contributions[1] (NZ$ million[2]) to the GEF Trust Fund				
2009	**2010**	**2011**	**2012**	**Total**
2.81	2.19	3.54	2.14	10.68

1 Annual contributions represent the combined total of New Zealand's payments to the GEF Trust Fund in the financial year (July to June). GEF projects address six global environmental issues, or 'focal areas', of which climate change is one. Expenditure under the climate change focal area is estimated to be approximately one-third of total expenditure.

2 Over 2009 to 2012 the value of 1 NZ dollar has fluctuated between 0.49 and 0.88 USD.

7.2.2 Other multilateral support

New Zealand continues to support a number of UN development agencies and other international financial institutions and programmes, including those with specific programmes related to the implementation of the UNFCCC (see table 7.2). This includes, for instance, the World Bank and the United Nations Development Programme. Some of the New Zealand contributions to humanitarian agencies (non-core funding) also had a climate change component (eg, NZ$2 million funding for the Sahel crisis, Horn of Africa, in the 2010/11 financial year). However, these amounts are not included in the table.

New Zealand contributed NZ$0.5 million to the UNFCCC Trust Fund for Participation to assist developing countries' participation in UNFCCC meetings, and contributed NZ$1.4 million to the Least Developed Countries Fund.

Table 7.2: Financial contributions to multilateral institutions and programmes, 2009–2012 (full amounts)

Institution or programme	Contributions[1] (NZ$ million[2])				
	2009	**2010**	**2011**	**2012**	**Total**
Multilateral institutions					
1. World Bank	14.22	18.17	19.71	12.51	64.61
2. Asian Development Bank	8.18	11.69	11.51	6.53	37.91
3. United Nations Development Programme	8.00	8.00	8.00	8.00	32.00
4. United Nations Environment Programme	0.27	0.30	0.28	0.32	1.17
5. UNFCCC Trust Fund for Participation*	0.50	0	0	0	0.50
6. UNFCCC Least Developed Countries Fund*	1.40	0	0	0	1.40
7. UNFCCC Trust Fund for Supplementary Activities*	0.05	0.12	0.01	0.23	0.41
8. UNFCCC / Kyoto Protocol	0.13	0.12	0.11	0.12	0.48
9. Nairobi Work Programme	–	0.08	0.06	–	0.14
10. UNFCCC Fellowship Programme	–	–	0.02	0.01	0.03

Institution or programme	Contributions[1] (NZ$ million[2])				
11. Montreal Protocol	0.55	0.55	0.55	0.60	2.25
12. World Food Programme	13.00[200]	6.00	6.00	6.00	31.00
13. Consultative Group on International Agricultural Research (CGIAR)	1.90	1.50	2.50	2.50	8.4
Total					**180.30**
Regional organisations – scientific, technological and training					
1. Secretariat of the Pacific Regional Environment Programme (SPREP)	1.24	1.92	1.43	2.05	6.64
2. Secretariat of the Pacific Community (SPC)	4.60	7.86	5.07	5.84	23.37
3. Secretariat of the Pacific Islands Applied Geoscience Commission (SOPAC)	1.48	1.18	Merged into SPC	Merged into SPC	2.66
4. University of the South Pacific (USP)	2.60	3.20	4.42	5.00	15.22
Total					**47.89**

1 Sum of contributions provided by the New Zealand Ministry of Foreign Affairs and Trade and the New Zealand Ministry for the Environment. Annual contributions cover calendar years, except for those institutions or programmes marked with an asterisk (*), which cover financial years (July–June). Contributions represent the full amounts provided to the organisation for the full range of activities covered by their programmes, which include climate change mitigation and adaptation.

2 Over 2009 to 2012 the value of 1 NZ dollar has fluctuated between 0.49 and 0.88 USD.

7.3 Regional support

New Zealand, through the New Zealand Aid Programme, is a major funder of the Pacific regional organisations that are mandated to provide Pacific Island countries with technical and policy assistance in a number of sectors, including those affected by climate change. These organisations include:

- the Secretariat of the Pacific Regional Environment Programme (http://www.sprep.org), which currently has the lead responsibility for coordinating the region’s response to climate change and provides policy and technical support to its Pacific Island country members to meet their commitments under the UNFCCC, and to support climate adaptation actions
- the Secretariat of the Pacific Community (http://www.spc.int), which provides assistance to its members in a number of climate-affected sectors such as health, geoscience, agriculture, forestry, water resources, disaster management and energy
- the Applied Geoscience and Technology Division of the Secretariat of the Pacific Community (http://www.sopac.org), which provides policy and technical assistance to members in the key climate sectors of ocean and islands, water and sanitation, and disaster risk reduction

[200] Core contribution to WFP including one-off NZ$7 million towards the global food crisis

- the University of the South Pacific (http://www.usp.org.fj), which is a centre of excellence for tertiary education and research in the Pacific region, providing instruction and research programmes in areas related to, and affected by, climate change.

The New Zealand Aid Programme funds provided to Pacific regional organisations are directed to programmes and projects identified in their strategic plans. This donor funding to regional organisations (as for multilateral core contributions) is not monitored at a level that tracks specific climate change activities. This is also the case for multilateral allocations. The figures provided in table 7.2 are therefore total allocations to multilateral and regional agencies rather than estimates of expenditure on specific climate change actions.

New Zealand supports the development and implementation of regional frameworks, policies and action plans designed to address climate change and disaster risk management. It does this through its membership of the Pacific Islands Forum, which is the Pacific region's intergovernmental political and economic policy organisation. In the Forum Communique agreed at the 43rd Forum in 2012, leaders tasked the Forum Secretariat, in collaboration with other regional agencies and development partners, to continue to assist Forum Island countries in effectively responding to climate change, including through adaptation measures, mitigation efforts, climate change financing, capacity building and international negotiations.

At the 43rd Forum leaders also discussed progress made in implementing the Pacific Islands Framework for Action on Climate Change, including efforts to integrate regional disaster risk management and climate change frameworks and improve access to and management of climate change finance.[201] The New Zealand Aid Programme is working towards integrating its climate change and disaster risk management frameworks.

New Zealand also supports the Pacific Climate Change Roundtable,[202] a regional climate change forum that brings together Pacific Island countries, regional and international agencies, partners and donors, as well as a wide range of stakeholders, to coordinate their climate change actions in support of the regional frameworks. The Roundtable, which meets bi-annually, is the main forum in the Pacific region for sharing ideas on climate change and ensuring coordination in support of Pacific Island countries' and territories' efforts on climate change.

During the final year of this reporting period New Zealand, in partnership with the European Union, announced and planned for the Pacific Energy Summit, which took place in Auckland during 24–26 March 2013. The Summit was designed to enable Pacific Island countries and territories to work with development partners to progress the implementation of energy efficiency and renewable energy initiatives, with a particular focus on the generation and distribution of electricity.

The Summit secured donor commitments of NZ$635 million to advance renewable energy projects across the Pacific. This was made up of NZ$255 million in grant funding and NZ$380 million in concessional loans. New Zealand committed grant funding of NZ$65 million towards the overall Summit target. Following the progress made at the Summit, New Zealand will work

201 http://www.forumsec.org/pages.cfm/newsroom/press-statements/2012/43rd-pacific-islands-forum-communique.html

202 http://www.sprep.org/climate_change/pccr.htm

with the private sector over the next 3 years to implement many of these renewable energy initiatives across the Pacific.[203]

7.4 Bilateral support

During the reporting period, New Zealand's climate change priority has been to focus on providing climate-related support and finance to small island states in the Pacific. New Zealand takes seriously its commitment to take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of or access to environmentally sound technologies and 'know-how' to other parties, particularly developing country parties, to enable them to implement the provisions of the UNFCCC.

Small island developing states, such as those in the Pacific, are especially vulnerable to the effects of climate change and extreme weather events. New Zealand is focused on supporting these countries to adapt to the impacts and mitigate the effects of climate change through the delivery of bilateral assistance to partner countries, with the overall aim of increasing their resilience to climate- and weather-related impacts. In 2012 the New Zealand Aid Programme's Climate Change Operational Policy was approved and implemented. New Zealand, through the Aid Programme, contributed approximately NZ$70 million in climate-related bilateral assistance during the 2009 to 2012 period.

Support for clean, efficient and affordable energy sources through direct investment and technology transfer is also assisting New Zealand's partner countries to reduce their carbon emissions and improve energy efficiency. A priority for New Zealand has been supporting renewable energy initiatives, such as the planning and facilitation of the Pacific Energy Summit and the delivery of renewable energy projects as a direct outcome of the Summit.

During the reporting period New Zealand contributed to technology and knowledge distribution through various initiatives in the Pacific region. New Zealand has, for example, supported the production of the *Island Climate Update*, a monthly Pacific regional climate bulletin designed to build capacity among Pacific island national meteorological services to generate their own national climate summaries and seasonal forecasts. The bulletin has covered topics such as the El Niño / Southern Oscillation, and modelling for sea-surface temperature, tropical rainfall and drought events. New Zealand also provides support for the recovery and safe storage of historical climate data and helps with a number of capacity-building activities for Pacific Island hydrological and meteorological services.

Further details of support for country-level mitigation, adaptation and technology transfer actions are provided in the relevant sections below, while tables 7.3 to 7.6 contain details of annual financial contributions made from 2009 to 2012 in support of these areas.

---

[203] Note that New Zealand's collaboration with the private sector in renewable energy projects following the Summit will be initiated outside of the reporting period.

Table 7.3: Bilateral and regional financial contributions[1] related to the implementation of the UNFCCC, 2009 (NZ$ million[2])

	Mitigation						Adaptation				Total
Recipient country/region	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Capacity building	Coastal zone management	Water resources	Other vulnerability assessment	
Solomon Islands										1.39	1.39
Vanuatu			0.06							1.00	1.06
Tokelau										0.86	0.86
Pacific regional							0.45	0.01		0.07	0.53
Tonga	0.01									0.50	0.51
Cook Islands									0.01	0.38	0.39
Global/ international				0.09						0.15	0.24
Ecuador										0.23	0.23
Indonesia	0.12										0.12
Fiji										0.08	0.08
Samoa										0.04	0.04
2009 total	0.13		0.06	0.09			0.45	0.01	0.01	4.70	**5.45**

1 Sum of contributions provided by the New Zealand Ministry of Foreign Affairs and Trade and the New Zealand Ministry for Environment.

2 Over 2009 to 2012 the value of 1 NZ dollar has fluctuated between 0.49 and 0.88 USD.

Table 7.4: Bilateral and regional financial contributions[1] related to the implementation of the UNFCCC, 2010 (NZ$ million[2])

	Mitigation						Adaptation				Total
Recipient country/region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity building**	**Coastal zone management**	**Water resources**	**Other vulnerability assessment**	
Solomon Islands							0.09			1.43	1.52
Cook Islands									0.14	1.30	1.44
Indonesia	0.16									1.00	1.16
Tokelau										1.13	1.13
Global/ international				0.46						0.30	0.76
Philippines							0.69				0.69
Vanuatu			0.11							0.55	0.66
Fiji										0.46	0.46
Tonga	0.12									0.19	0.31
Pacific regional	0.06						0.10			0.05	0.21
Ecuador										0.15	0.15
Samoa	0.02						0.03			0.09	0.14
Kiribati							0.02		0.05	0.05	0.12
Tuvalu	0.07										0.07
Nepal					0.06						0.06

	Mitigation						Adaptation				Total
Recipient country/region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity building**	**Coastal zone management**	**Water resources**	**Other vulnerability assessment**	
Vietnam							0.04				0.04
Afghanistan	0.03										0.03
2010 total	0.46		0.11	0.46	0.06		0.97		0.19	6.70	**8.95**

[1] Sum of contributions provided by the New Zealand Ministry of Foreign Affairs and Trade and the New Zealand Ministry for Environment.

[2] Over 2009 to 2012 the value of 1 NZ dollar has fluctuated between 0.49 and 0.88 USD.

Table 7.5: Bilateral and regional financial contributions[1] related to the implementation of the UNFCCC, 2011 (NZ$ million[2])

	Mitigation						Adaptation				Total
Recipient country/region	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Capacity building	Coastal zone management	Water resources	Other vulnerability assessment	
Indonesia	3.13									1.75	4.88
Tokelau	3.40									1.25	4.65
Tonga	4.18									0.30	4.48
Cook Islands	0.20								0.26	1.47	1.93
Philippines							0.69			0.78	1.47
Solomon Islands							0.09	0.49		0.58	1.16
Global/ international				0.53						0.35	0.88
Pacific regional	0.26						0.11			0.21	0.58
Fiji										0.53	0.53
Samoa	0.02						0.12			0.29	0.43
Afghanistan	0.33										0.33
Kiribati					0.10		0.05		0.07	0.09	0.31
Vietnam							0.30				0.30
Vanuatu			0.08							0.21	0.29
Tuvalu	0.21										0.21

Recipient country/region	Mitigation						Adaptation				Total
	Energy	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity building**	**Coastal zone management**	**Water resources**	**Other vulnerability assessment**	
Ecuador										0.17	0.17
Bangladesh	0.09										0.09
Nepal					0.06						0.06
2011 TOTAL	11.81		0.08	0.53	0.16		1.36	0.49	0.33	7.98	**22.74**

1 Sum of contributions provided by the New Zealand Ministry of Foreign Affairs and Trade and the New Zealand Ministry for Environment.

2 Over 2009 to 2012 the value of 1 NZ dollar has fluctuated between 0.49 and 0.88 USD.

Table 7.6: Bilateral and regional financial contributions[1] related to the implementation of the UNFCCC, 2012 (NZ$ million[2])

	Mitigation						Adaptation				Total
Recipient country/ region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity building**	**Coastal zone management**	**Water resources**	**Other vulnerability assessment**	
Afghanistan	10.87										10.87
Tonga	4.69									0.55	5.24
Tokelau	3.40									0.71	4.11
Indonesia	2.97									0.76	3.73
Solomon Islands	0.75						0.17	0.49		1.42	2.83
Papua New Guinea	1.23										1.23
Cook Islands	0.52								0.12	0.52	1.16
Global/ international				0.70						0.20	0.90
Philippines										0.78	0.78
Pacific regional	0.28						0.05			0.18	0.51
Samoa							0.09			0.25	0.34
Fiji										0.29	0.29
Vietnam							0.27				0.27

	Mitigation						Adaptation				Total
Recipient country/ region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity building**	**Coastal zone management**	**Water resources**	**Other vulnerability assessment**	
Kiribati					0.09		0.04		0.02	0.07	0.22
Vanuatu			0.05							0.14	0.19
Ecuador										0.11	0.11
Tuvalu	0.11										0.11
Bangladesh	0.09										0.09
2012 TOTAL	24.91		0.05	0.70	0.09		0.62	0.49	0.14	5.99	**32.98**

1 Sum of contributions provided by the New Zealand Ministry of Foreign Affairs and Trade and the New Zealand Ministry for Environment.

2 Over 2009 to 2012 the value of 1 NZ dollar has fluctuated between 0.49 and 0.88 USD.

7.5 Mitigation

New Zealand's main areas of engagement in terms of mitigation have been in the energy and agriculture sectors. The New Zealand Aid Programme's support for climate change mitigation is primarily designed to increase access to clean, efficient and affordable energy through measures such as switching from oil-fired generators to solar panels. These measures also have co-benefits, such as increasing energy security, reducing reliance on costly diesel imports, encouraging growth in emerging green industries, and reducing greenhouse gas concentrations in the atmosphere.

Pacific Island countries currently depend on imported fossil fuels as their main energy source, and they have prioritised increases in renewable energy in order to reduce energy imports. New Zealand has responded to this request with a renewed focus on supporting clean, efficient and affordable energy in the Pacific. Safer, cleaner and more reliable sources of energy are critical to tackling climate change, but also for creating the conditions for economic opportunities and growth to build more resilient and greener societies.

The small nation of Tokelau, for example, has installed renewable energy systems that will dramatically reduce reliance on expensive and difficult to import diesel. Over the life of this activity (2010 to 2013) New Zealand will provide funding of NZ$8.45 million to the Government of Tokelau to install photovoltaic solar systems that will help Tokelau achieve its long-term goals of energy independence. Renewable energy now accounts for more than 90 per cent of the atoll's electricity needs, from a zero base (table 7.7).

New Zealand's unusual agricultural emissions profile has motivated New Zealand to use its expertise to help address the 14 per cent of global emissions that come from the agriculture sector worldwide. New Zealand initiated the Global Research Alliance on Agricultural Greenhouse Gases in late 2009. This is a major initiative involving the collaboration of 40 developed and developing member countries in identifying ways to reduce agricultural greenhouse gas emissions without compromising food security. The Alliance is focused on agricultural greenhouse gas mitigation research, knowledge sharing, collaborative projects and the extension of technologies and practices. (See section 4.3.5 for more detail on the Alliance.)

New Zealand has committed NZ$45 million to activities that support the Alliance until June 2019. The majority of this funding is allocated to international collaborative research funds, targeted research projects, capability-building workshops and fellowships, and the establishment of global science networks. New Zealand is the current co-chair of the Livestock Research Group (along with The Netherlands) and supports many of the priority activities identified in this Group's work plan. New Zealand also participates in and supports the Croplands Research Group and the two cross-cutting groups on Soil Carbon and Nitrogen Cycling, and Inventories and Measurement. New Zealand was chair of the Alliance Council until June 2012, when Canada took on this role. New Zealand continues to support the Alliance Secretariat.

Table 7.7: Description of a project that promises practical steps to facilitate and/or finance the transfer of, or access to, environmentally sound technologies

Project/programme title			
Tokelau Renewable Energy Project			
Purpose			
The creation of new solar power systems across Tokelau to assist the transition from diesel-generated electricity to 90 per cent solar power-generated electricity.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Tokelau	Energy	NZ$8.45 million	2010–2013
Description			
The Tokelau Renewable Energy Project (**TREP**) was a joint undertaking between the Government of Tokelau and the New Zealand Ministry of Foreign Affairs and Trade. Started in 2010, this initiative culminated in the construction of three solar photovoltaic (PV) power systems, one for each atoll of the small island nation. Prior to the TREP systems being installed, all three atolls had their power provided by diesel generator sets. The new solar power systems were designed to provide at least 90 per cent of the islands' electricity needs from solar power and they are expected to save approximately NZ$900,000 per year in diesel costs (for a capital cost of NZ$8.45 million). Construction of the last TREP system was completed in late October 2012 after a 5-month construction phase for all three atolls: Fakaofo, Nukunonu and Atafu. Each TREP system is composed of an array of PV panels, power conditioning equipment, batteries for night-time energy delivery, and a diesel generator as backup for several days during periods of cloud cover.			
Indicate factors that led to the project's success			
Increase in solar energy: TREP is successfully contributing to the production of renewable solar energy across Tokelau. After the first 4 months of production TREP has produced (on average) 89 per cent of the atoll's solar power needs (just below the expected figure of 90 per cent). The solar fraction is expected to increase once weather conditions improve and once operators become more familiar with operating systems.[204] *Low electricity costs:* TREP has also produced lower electricity costs, meaning this is a much more economically viable power option for Tokelau. Prior to the installation of the PV systems, fuel costs for the atolls were close to NZ$1million per year, but with the new TREP system in place the cost savings are expected to be approximately NZ$900,000 per year on fuel alone, and savings will grow with increasing diesel fuel prices. Furthermore, the annual running costs of the TREP systems will be low as maintenance will require little to no spare parts or equipment beyond what has already been provided as part of the TREP project. *Training:* Training/capacity-building for TREP implementation was extremely effective. In order to facilitate retention of knowledge, technicians were supported with training being delivered gradually over several weeks.			
Technology transferred			
TREP will reduce Tokelau's reliance on diesel generation through a significantly greater use of solar power electricity.			
Impact on greenhouse gas emissions/sinks			
A greater use of renewable energy will reduce Tokelau's use of diesel for electricity generation and therefore reduce greenhouse gas emissions. Over 900 tonnes CO_2-e emissions reduction will be achieved each year as a result of TREP.			

204 The solar fraction in the first 4 months has not been at 90 per cent on average as these were some of the cloudiest months of the year. January was particularly cloudy, and all three atolls suffered from poor solar radiation that month.

7.6 Adaptation

New Zealand's support for climate change adaptation is primarily designed to reduce the vulnerability of human or natural systems to the impacts of climate change and climate variability by increasing community resilience and adaptive capacity in key climate-sensitive sectors. National and community-level actions are implemented within the context of national and regional plans, strategies and frameworks, which New Zealand helps to shape and deliver in cooperation with its development partners, including regional agencies.

Small Island Developing States in the Pacific are especially vulnerable to the physical effects of climate change and extreme weather events. Climate change threatens to reduce resilience and exacerbate existing development and environmental challenges. New Zealand has therefore invested in climate change adaptation particularly in the small island states of the Pacific through the activities of the New Zealand Aid Programme.

Adaptation and disaster risk reduction are closely related processes, which both aim to reduce risk to short-term acute hazards and longer-term chronic hazards. New Zealand therefore also supports greater integration of disaster risk reduction and climate change adaptation. New Zealand participates in the annual United Nations Office for Disaster Risk Reduction *Global Platform on Disaster Risk Reduction*, and in 2011 New Zealand hosted the Pacific Platform on Disaster Risk Reduction.

Climate change impacts in critical areas such as health and food supply are likely to exacerbate existing development challenges in small island developing states. In the Cook Islands, New Zealand has funded the upgrade of cyclone shelters in Tukao and Tauhunu, on Manihiki Island, which sit only a few metres above sea level and are therefore especially vulnerable to the effects of climate change. The cyclone shelters on Manihiki will provide a safe haven and over 80,000 litres of safe drinking water for the local community in the event of a cyclone.

Climate change is also likely to compound already over-stretched water and sanitation systems in Pacific Island countries, particularly in atoll nations such as Kiribati, Tuvalu and Tokelau. In Kiribati, for example, New Zealand is supporting water supply and sanitation initiatives, thus strengthening community resilience to extreme weather events. New Zealand also responded during the reporting period by supporting communities to cope with prolonged droughts.

Support has been provided for increased potable water storage and management in drought-vulnerable atolls. For example, the Koevavaku community in Solomon Islands has benefited from a water system that uses a solar-powered pump and rainfall collection. A major rainwater harvesting initiative was supported in South Tarawa, Kiribati (where 50 per cent of the population of 110,000 live), which is helping to reduce the risk of water shortage due to periodic drought.

During the reporting period New Zealand also provided funding for the Kiribati Adaption Programme, which supports measures to reduce Kiribati's vulnerability to the effects of climate change and sea-level rise by raising awareness of climate change, assessing and protecting available water resources, and managing inundation.

7.7 Technology transfer

7.7.1 Overview

Good development outcomes, increasingly delivered through partnerships, are a core pillar of New Zealand's wider foreign policy relationships. Partnerships are important for encouraging research and generally speeding up the development and deployment of new technologies, including soft technology such as information and knowledge sharing.

The creation of 'enabling environments' is viewed as important for research and development activities and for the commercial deployment of current, new and innovative technologies. The investment community, for example, needs clear incentives when it comes to research, development and the deployment of climate change mitigation technologies. A carbon price signal and the removal of environmentally harmful subsidies are critical for establishing environments that enable effective technology development and transfer.

In 2010, following the G-20 and APEC[205] members' commitments to phase out inefficient fossil-fuel subsidies that encourage wasteful consumption, New Zealand established an informal 'Friends Group' of non-G-20 countries to encourage APEC and G-20 leaders to implement their commitments with maximum ambition and transparency. The Friends Group currently comprises eight developed and developing countries (Costa Rica, Denmark, Ethiopia, Finland, Norway, Sweden, Switzerland and New Zealand). The Group also proactively champions fossil-fuel subsidy reform through memberships of international organisations and forums. It aims to build political consensus on the need for reform to promote the benefits and to provide information and tools to facilitate reform. Fossil-fuel subsidy reform offers significant environmental, economic, energy, trade and social benefits. At the same time, the Friends Group recognise the political, social and economic challenges related to such reform, and the need for energy access for vulnerable populations that may require targeted assistance.

As founder and coordinator of the Friends Group, New Zealand plays a leading role in promoting the fossil-fuel reform agenda internationally to help address the US$600 billion that is spent globally on fossil fuel subsidies each year. Phasing out fossil fuel subsidies would deliver benefits for the climate, reduce local pollution and cut global greenhouse gas emissions by 10 per cent in 2050 compared with business as usual. [206] The Friends Group has raised fossil-fuel subsidy reform in a number of submissions to the UNFCCC and the UN Conference on Sustainable Development (Rio+20), as well as holding a series of side-events with ministerial-level engagement.

In 2012 New Zealand announced it would join the Climate and Clean Air Coalition, a partnership of governments, intergovernmental organisations and representatives of the private sector, which works to mitigate the impacts of short-lived climate pollutants. These pollutants include black carbon, methane and hydrofluorocarbons, which are responsible for a substantial proportion of current global warming. Combined, their contribution to climate forcing is projected to climb to as much as 19 per cent of global carbon dioxide emissions by 2050. The Climate and Clean Air Coalition is the first multilateral group focusing on short-lived climate pollutants, and, in its own words, "aims to bolster rapid, scaled-up efforts to reduce

---

205 Asia–Pacific Economic Cooperation.

206 "Analysis of the Scope of Energy Subsidies and Suggestions for the G-20 Initiative" IEA, OPEC, OECD, World Bank Joint Report 16 June 2010, p5.

methane, black carbon, and hydrofluorocarbons (HFCs).” Since the Coalition was launched in February 2012 it has commenced efforts to reduce methane from landfills and oil/gas production, black carbon from diesel engines, and hydrofluorocarbons through the use of new technologies.

The practical aims of the Coalition include:

- a holistic focus on all short-lived climate pollutants, and coordination at a high level between governments, as well as the private sector and financial institutions, to voluntarily undertake actions
- mobilising high-level political will and action, leveraging existing funding streams, and deploying technical expertise – Coalition funding aims to facilitate and catalyse commitments and actions, not dispense project-level grants
- build on and scale up existing international efforts complementing the formal negotiations.

New Zealand is also involved in other initiatives that support technology transfer, including the Livestock Emissions Abatement Research Network and capacity building in relation to geothermal energy.

7.7.2 Livestock Emissions Abatement Research Network

Recognising the lack of understanding about agricultural emissions and the importance of this sector to New Zealand and other countries, New Zealand established the Livestock Emissions Abatement Research Network (LEARN) in 2007. New Zealand now funds this capacity-building activity through its Global Research Alliance on Agricultural Greenhouse Gases budget (see section 7.5).

LEARN is an international research network focused on improving the understanding of greenhouse gas emissions from livestock (see http://www.livestockemissions.net). To support the Alliance, New Zealand, through LEARN, runs a fellowship and awards programme allowing researchers from developing countries to travel to New Zealand for short-term training, or students to complete PhDs and post-doctoral research in agricultural greenhouse gases while based at a New Zealand research institute or university. Recent participants in this programme have come from China, Indonesia, Mexico, Vietnam, Cuba, Ghana and Brazil. Since the launch of the Alliance, New Zealand has also awarded short-term exchanges to senior scientists from Alliance member countries through its Global Research Alliance Senior Scientists (GRASS) award programme.

LEARN activities also include technical training workshops; for example, a 3-week training course on methane measurement was held in New Zealand during January 2013, with nine participants from South East Asia and Latin America.

7.7.3 Provision of geothermal energy training

In 2012 the New Zealand Aid Programme, together with GNS Science, delivered the 2012 Joint University of Gadjah Mada – GNS: Basic Geothermal Geoscience Course. The course provided Indonesian geothermal industry and University of Gadjah Mada staff and students with a practical understanding of geological, chemical and physical processes that occur in geothermal systems (using New Zealand and Indonesian case studies) and introduced techniques and tools to delineate, explore, and develop geothermal systems in a sustainable manner.

By jointly delivering the training course, New Zealand sought to build skills and knowledge in human resources that are critical for the growth of the Indonesian geothermal industry. It also aimed to update and improve the understanding of University of Gadjah Mada academic staff and students in the application of geoscience for exploring, developing and understanding physical and chemical processes in geothermal systems with the objective of increasing their in-house research and teaching capability.

8

Research and systematic observations

8 Research and systematic observations

Key developments since the *Fifth National Communication*

- The New Zealand Government's investment in climate change research in the 2011/12 financial year was approximately NZ$55.7 million.
- Systematic weather and climate observations and information exchange were supported by a further NZ$20 million.
- The Government departments supporting research have been reorganised, as has the system for allocating research funds to Crown Research Institutes, to promote research that contributes to the wellbeing and prosperity of New Zealand.
- A set of 10 National Science Challenges have been adopted, several of which include a significant component of climate change research.
- Research on projected regional climate changes and impacts follows the most recent global climate model results.
- Greenhouse gas emissions mitigation research continues to focus on the agriculture sector.

8.1 Introduction

New Zealand has continued to support and promote collaboration in research and systematic observations on climate change, as required by Articles 4 and 5 of the UNFCCC. Central government investment in climate change-related research for the 2011/12 financial year is estimated at NZ$55.7 million. This was complemented by substantial expenditure from the private sector, which matches Government funding in some research consortia, and also from regional governments.

NIWA receives funding for climate observations and for maintaining the National Climate Database as part of its core work. Meteorological Service of New Zealand Limited (MetService) undertakes systematic weather observations to support its weather forecasting programme. Where appropriate, these observations are incorporated into the climate record either through the GCOS programme or NIWA's National Climate Database. MetService's observing network is supported in part through a NZ$20 million contract with the Ministry of Transport for provision of New Zealand's National Meteorological Service.

Through the Government's investment in research and observations, climate observations have been maintained and new knowledge has been generated about climate change and its impacts in New Zealand and the southwest Pacific. Using this knowledge, adaptation and mitigation options are being identified and developed.

New Zealand continues to contribute personnel and funding to support the work of the IPCC and participates in the production of its reports. New Zealand researchers participate in international research and observation programmes of the World Meteorological Organization; the World Climate Research Programme; the Global Climate Observing System (GCOS), and its Pacific component (PI-GCOS); the International Geosphere-Biosphere Programme; and the Asia–Pacific Network for Global Change Research.

New Zealand led the establishment of the Global Research Alliance on Agricultural Greenhouse Gases in December 2009 and established the New Zealand Agricultural Greenhouse Gas Research Centre in March 2010. New Zealand and international scientists are active participants in the Livestock Emissions Abatement Research Network (LEARN).

Under a New Zealand Government contract, MetService provides some assistance to a number of Pacific Island nations (the Cook Islands, Kiribati, Niue, Tonga, Tuvalu, Samoa and Tokelau) with their weather and climate observing systems. With other New Zealand and international funding, NIWA has participated in a Pacific Islands data rescue programme. Past New Zealand overseas development aid programmes have covered training in technical maintenance and observing practices in several of these countries.

NIWA continues to coordinate the production and publication of the *Island Climate Update*, in collaboration with various scientific organisations in the Pacific Islands, Australia, the United States, the United Kingdom and France. The *Island Climate Update* provides updates of current climate conditions and outlooks for the coming season to help Pacific Island countries plan and adapt to climate variability and change. NIWA also works with Pacific Island and Australian partners on climate adaptation work in several Pacific Island countries, supported from a range of funding sources and bilateral arrangements.

8.2 Research and systematic observations: policy and funding

8.2.1 Strategy for research and systematic observations

The New Zealand Government supports a range of climate research and observations to ensure core national needs are addressed. It also aims to maintain and develop international collaboration, especially in areas of national research excellence.

Funding agencies

Since the *Fifth National Communication on Climate Change* in 2009, the ministries responsible for funding and coordinating climate change research in New Zealand have been reorganised. Much of the Government research investment is now made through the Science and Innovation group within the newly established Ministry of Business, Innovation and Employment (MBIE). The former Ministry of Agriculture and Forestry has been integrated into the new Ministry for Primary Industries, which is also a major provider of funding for research relevant to the land-based primary sector. The Ministry for the Environment, which has overall responsibility for climate change issues in New Zealand, liaises closely with other Government departments, scientists and science organisations to monitor and review the adequacy of the climate change research portfolio to meet national needs.

Funding is allocated through core funding to Crown Research Institutes (see section 8.2.2), together with competitive bidding, which is open to all research providers including universities and other institutes as well as the Crown Research Institutes. Collaborative research projects involving subcontracting to a mix of different organisations are common. To be allocated funding, the areas of research must align with the strategic directions and goals set by the Government.

Central government programmes provide most of the funding for climate change research, with additional contributions from the private sector and local government. Government-funded research ranges from fundamental and underpinning research, to applied and operational research, including the development of specific tools and technologies for both mitigation of and adaptation to climate change. The range of different funding mechanisms is explained in more detail below.

The New Zealand Climate Change Centre is a joint initiative between New Zealand's seven Crown Research Institutes, Callaghan Innovation, and three New Zealand universities. It provides support for collaboration between research providers, links with research stakeholders and users, and submissions on research gaps and strategies.

The Royal Society of New Zealand operates a Climate Expert Panel, which facilitates interactions between scientists and stakeholders in New Zealand and maintains New Zealand's international links with the World Climate Research Programme. The Royal Society also supports the National Committee for the International Geosphere-Biosphere Programme (IGBP), which links New Zealand research with international IGBP projects.

Research needs

New Zealand's climate change research needs are dictated by its geographical situation, population distribution and economy. The country spans a wide range of latitudes, with climatic zones ranging from subtropical to subantarctic and significant differences between the east and west coasts. Research therefore has to address a wide set of climate phenomena, ranging from tropical cyclones to the behaviour of Antarctic sea ice, as well as producing regional climate change projections and determining the likely effects of climate change on a diverse range of ecosystems.

Mitigation and adaptation research has to cover equally diverse issues, including transport in a country with a low population base but large travel distances; substantial agricultural and forestry activities; energy demand and supply; and the sustainable development of growing urban settlements, often at or near coastal areas. The dependence of New Zealand's economy on export and international trade also means that mitigation options need to be compatible with the commercial requirements and technology standards of the international market.

New Zealand's unique emissions profile among developed countries and the significant contribution agriculture makes to the New Zealand economy mean that New Zealand faces a particular need to undertake research to understand the climate change impacts and adaptation options for agriculture. In addition to carbon pricing, research is a key Government measure to reduce greenhouse gas emissions from this sector. Domestically, this need for research is addressed by the Government-funded New Zealand Agricultural Greenhouse Gas Research Centre and the Pastoral Greenhouse Gas Research Consortium. Internationally, it is addressed by leadership and financial support for the Global Research Alliance on Agricultural Greenhouse Gases (see below).

Agricultural greenhouse gases

Direct mitigation research in the land-based sectors commenced in earnest in 2002 through the establishment of the Pastoral Greenhouse Gas Research Consortium, a consortium between the Government and the agriculture sector in which Government support is matched by industry funds. The Consortium's programmes have been supported through strong collaboration with other Government programmes.

The New Zealand Agricultural Greenhouse Gas Research Centre was opened in March 2010 to build scientific capability and infrastructure to address the challenges faced in greenhouse gases mitigation in agriculture. The Centre is a consortium of nine public and private research organisations led by AgResearch (one of the Crown Research Institutes) and based in Palmerston North. Its programmes address ruminant methane, soil nitrous oxide emissions, soil carbon and integrated farm systems. It is supported by an annual NZ$5 million grant through the Primary Growth Partnership[207] and is contracted for a 10-year period, with reviews every 2.5 years. The Centre has an important role in supporting the Global Research Alliance.

New Zealand led the establishment of the Global Research Alliance on Agricultural Greenhouse Gases in December 2009 (see section 4.3.5). The Alliance supports mitigation research efforts in the three areas of paddy rice, cropping and livestock, and the cross-cutting themes of soil carbon, nitrogen cycling, and inventory and measurement issues. Work plans have been developed for each of these areas and are designed to build capacity and capability worldwide by fostering collaboration and the sharing of knowledge and best practice.

Under the Alliance, New Zealand has also established a New Zealand Fund for Global Partnerships in Livestock Emissions Research, which has held three funding rounds and has had funding extended to 2019.

The Alliance has so far also formed partnerships with the following organisations in order to help advance its work:

- Consultative Group on International Agricultural Research
- Inter-American Development Bank
- Inter-American Institute for Cooperation in Agriculture
- World Bank
- Africa Development Bank
- Tropical Agricultural Research and Higher Education Centre
- UN Food and Agriculture Organization.

8.2.2 Funding policies

A significant amount of climate research and systematic observation in New Zealand is conducted by the Crown Research Institutes (CRIs). In the past this work was supported by contestable funding from programmes that were also available to universities and other institutions. In 2010 the Government committed to reviewing how the CRIs are managed and

207 The Primary Growth Partnership aims to improve the future market success of New Zealand primary industries through long-term innovation programmes that are jointly funded by government and industry. A key goal is to encourage more private investment in research and development in New Zealand.

funded. An independent taskforce identified that the ownership and funding model that applied to the CRIs at the time was leading to undue emphasis on research and development that individual CRIs could capture in their balance sheets, rather than on research that contributes to the wellbeing and prosperity of New Zealand. The CRIs also lacked clear mandates on their areas of responsibility and were heavily dependent on competitive contracts for funding, which were often short-term relative to the timeframe in which science produces results.

In response to the taskforce's report, the Government has taken the following actions:

- The roles of the CRIs have been clarified via a Statement of Core Purpose, outlining high-level expected outcomes of the activities and the scope of operations of each CRI, and the key operating principles. Of the seven CRIs, six have climate change in their scope of operation.
- How the CRIs are funded has been changed. Approximately 60 per cent of the contestable funding CRIs receive from central government was transferred to CRI core funding. Core funding provides the CRIs with a stable level of funding to invest in capability and science research programmes and to deliver on their Statement of Core Purpose. Contestable funding is converted to core funding when the CRI has consistently won a contestable contract for a number of periods, indicating that they are the major provider of the research in New Zealand. This is particularly relevant for a number of long-term observational programmes.
- It has been made clear that the CRIs are expected to work to develop long-term strategic partnerships with Government, their sectors and potential research collaborators. This will help to set the priorities for the CRIs, maximising private involvement in the research process (eg, by leveraging private investment in collaboration) and facilitating in technology transfer and knowledge exchange. The aim is to promote wide engagement in research relating to describing, mitigating and adapting to climate change, and to help ensure the results are taken up as rapidly as possible.

The CRIs with the most climate-related research portfolios are:

- NIWA – atmospheric physics and chemistry, greenhouse gas measurements, climate observations and analysis, climate processes and causes of change, national and regional predictions and projections, impacts and adaptation options
- AgResearch – agricultural greenhouse gas mitigation and climate change impacts and adaptation in agriculture
- Landcare Research – indigenous forest measurement and management, agricultural greenhouse gas mitigation, soil carbon, impacts of climate change on natural, productive and built environments, and assessing life-cycle greenhouse emissions profiles for various sectors
- GNS Science – palaeoclimate, geo-sequestration of carbon dioxide
- Scion – Planted forests, indigenous forests, soil carbon and biofuels.

In mid-2013 the Ministry of Business, Innovation and Employment announced significant new research funding aligned to 10 new National Science Challenges,[208] to be supported for 10

[208] http://www.msi.govt.nz/update-me/major-projects/national-science-challenges

years. Climate change issues are expected to form a significant part of several Challenges, including:

- understanding the role of the Antarctic and the Southern Ocean in determining our climate and our future environment (see section 8.4.1 below)
- resilience to natural hazards
- enhancing primary sector production and productivity while maintaining and improving our land and water quality for future generations.

The Ministry for Primary Industries is also a significant funder of climate change research. To ensure New Zealand's primary sectors are resilient and can respond to the opportunities and challenges of climate change, the Ministry provides policy advice to Government, provides information to industry, farmers, growers and foresters, and contributes internationally on climate change issues. It funds research to support these goals through a number of programmes, but particularly through the Sustainable Land Management and Climate Change Plan of Action, the New Zealand Agricultural Greenhouse Gas Research Centre and the Global Research Alliance.

Some additional Government support for research comes through:

- the Marsden Fund, which is administered by the Royal Society of New Zealand and is not subject to Government research priorities
- funding for university research within Vote Education
- the Health Research Council through Vote Health
- the Pastoral Greenhouse Gas Research Consortium through Vote Research, Science and Technology.

There is also direct funding of research in some climate change areas by core Government departments to meet operational and policy development needs; for example, the Ministry for the Environment's guidance to local government on flooding, and planning for coastal hazards. The Ministry for Primary Industries also invests NZ$1.6m in the agricultural greenhouse gas inventory research programme, specifically for research to improve the accuracy of the inventory and implement methodology improvements.

Systematic observations are part-funded through the Crown contract for public weather forecasts and warnings administered by the Ministry of Transport and awarded to MetService, which cover routine upper air and surface weather observations that are also used for climate research. Further observations for climate research are supported by CRI core funding to NIWA, and both weather and climate observations are incorporated in the National Climate Database managed by NIWA. Some support for observations in the Pacific is provided through the Ministry of Transport's contract with MetService.

8.2.3 Funding levels

Table 8.1 summarises the estimated Government-funded annual investment in climate change-related research. A further NZ$20 million is spent on systematic weather and climate observations.

Table 8.1: Estimated annual investment in climate change research by central government for the 2011/12 year

Area	Investment (NZ$ million)						
	MBIE	MPI (incl. GRA)	Core CRI		Government other	Marsden	Total
			NIWA	Other			
Underpinning science	4.4	–	8.0	3.5	–	3.0	**18.9**
Emissions reduction	1.3	14.8	–	2.1	10.3	0.9	**29.3**
Adaptation	3.3	–	0.4	1.4	–	0.7	**5.8**
Technology transfer	–	1.2	–	–	0.5	–	**1.7**
Total	**9.0**	**16.0**	**8.4**	**7.0**	**10.8**	**4.6**	**55.7**

Notes

MBIE = Ministry of Business, Innovation and Employment; MPI = Ministry for Primary Industries; GRA = Global Research Alliance; CRI = Crown Research Institute; NIWA = National Institute of Water and Atmospheric Research

8.3 Information exchange and dissemination of knowledge

The Ministry for the Environment and the Ministry for Primary Industries work in conjunction with science providers to disseminate research findings on climate change, mitigation options, and adaptation processes to the appropriate audiences. The Ministry for Primary Industries provides publications and online information for farmers and businesses in the primary sector, while the Ministry for the Environment publishes online information on climate projections and impacts for all New Zealanders, and guidelines for planning for climate change, both in a popular format for local governments and residents and as larger technical documents for engineers and planners.

Outside of central government, NIWA provides public access to the national climate database via the internet, and also produces monthly updates of recent climate and the seasonal outlook. The New Zealand Climate Change Centre facilitates knowledge dissemination through conferences, workshops, round tables and climate briefs.

8.3.1 International exchange of data and information

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

New Zealand has identified particular opportunities for the dissemination of real-time climate data throughout the Pacific to provide up-to-date information on current climate conditions and seasonal outlooks to Pacific Island nations, and to help them deal with climate variability. This has led to the establishment of the *Island Climate Update* (discussed above in section 8.1), and NIWA also produces a similar monthly publication for New Zealand, the *New Zealand Climate Update*. Additional exchanges of information occur under the auspices of the Pacific Islands Global Climate Observing System (PI-GCOS) and the Asia–Pacific Network for Global Change Research.

8.3.2 Partnerships

Multilateral partnerships

In 2007 New Zealand initiated the establishment of a multilateral partnership, the Livestock Emissions and Abatement Research Network (LEARN[209]), which brings together scientists to share information and expertise on greenhouse gas emissions from livestock. It also supports graduate student scholarships and postdoctoral fellowships, training opportunities in New Zealand for emerging scientists from developing countries, and visiting awards for senior scientists and technicians. The Global Research Alliance on Agricultural Greenhouse Gases supports LEARN trainee and post-doctoral fellowships.

In addition, New Zealand is a member of the International Energy Agency and the International Partnership for the Hydrogen Economy, and is a member of the Carbon Sequestration Leadership Forum.

Bilateral partnerships

As part of its Carbon Farming Futures programme, Australia has established a new research investment scheme called Filling the Research Gap, aimed at reducing agricultural greenhouse gas emissions. The second round of this scheme now includes a priority on international collaboration with member countries of the Global Research Alliance. New Zealand has allocated funding to support researchers involved in successful bids to this programme that also meet New Zealand's priority areas for research. Similar research links have been established with the European Union and South America.

International organisations

New Zealand is an active member of the WMO and exchanges information and data through both the WMO and its subsidiary and associated bodies. Through membership of GCOS and its Pacific arm, PI-GCOS, and through the Asia–Pacific Network for Global Change Research, New Zealand works to lower barriers to, and further facilitate, such data exchanges. New Zealand has provided input to development and implementation of the Global Framework for Climate Services and is represented on the Intergovernmental Board for Climate Services.

New Zealand continues to contribute actively to the work of the IPCC. New Zealand provides support for one elected member of the IPCC Bureau and one member of the Bureau of the Task Force on National Greenhouse Gas Inventories, as well as participating in plenary meetings, task groups, workshops, and expert meetings, and contributing to the IPCC's *Fifth Assessment Report*. The Government also provides some financial support for New Zealand lead authors of the *Fifth Assessment Report*'s chapters, and has ensured that drafts of the report volumes received wide Government review.

---

209 http://www.livestockemissions.net

8.4 Research

This section presents some of the highlights, innovations and significant projects in climate change research in New Zealand since the *Fifth National Communication on Climate Change*. More details about the research projects funded by the Ministry of Business, Innovation and Employment can be obtained from its searchable database of abstracts and project reports, using the search term "climate change".[210]

Climate change research in New Zealand seeks to develop information and knowledge on a wide variety of issues. Particular information needs and areas of national research excellence include:

- past climate trends and variability
- climate processes and phenomena, and the causes of variability and change
- regional climate modelling, predictions and projections
- the impacts of these projected changes on the environment of New Zealand, the southwest Pacific, Southern Ocean and Antarctica, and on society and the economy
- adaptation options
- reducing the emissions of greenhouse gases, particularly those resulting from pastoral production
- enhancing sinks, particularly forest sinks and soil carbon
- community resilience and human health
- oceanic and atmospheric chemistry
- greenhouse gas measurement and national greenhouse gas inventory development and support.

8.4.1 Climate processes and climate system studies

Climate variability and trends

Work to identify regional climate trends and variability has continued, largely through core-funded research at NIWA. It includes observations, analysis and documentation of atmospheric, oceanic, coastal, river and stream, lake, snow, glacier, sea-ice and sea-level conditions in New Zealand, the southwest Pacific, the Southern Ocean and Antarctica. There is substantial international collaboration, including analysing data from Argo floats to provide improved knowledge of physical ocean conditions in the region, and contributions to the Atmospheric Circulation Reanalysis over the Earth project.

The research leads to journal papers, regular monthly, seasonal and annual climate updates, briefings to stakeholders (eg, on drought conditions), and annual reports on the state of the climate. A set of regional climatology publications providing information of interest to councils, farmers and other regional stakeholders is currently being updated.

Climate processes, phenomena and causes of variability and change

The goal of this research, also carried out mainly through core funding at NIWA, is to understand how the dynamics of the climate system influence atmosphere, ocean, ice and

[210] http://www.msi.govt.nz/update-me/who-got-funded/

hydrospheric conditions in the New Zealand region, and to identify the causes of changes. This includes research on particular climate phenomena of regional relevance, including the El Niño/Southern Oscillation, the Interdecadal Pacific Oscillation, the Southern Annular Mode, and tropical cyclones. It also includes studies of tropical-extra-tropical links, and detection and attribution research to identify the causes of climate change and climate extremes in the region. Further work streams address interactions between sea ice and atmospheric circulation at both the large and small scales, and the impact these have on the ocean, along with work on how ocean variability affects the regional climate. The knowledge gained in this research contributes to, and underpins, New Zealand research on seasonal climate predictions and climate change modelling.

Palaeoclimate

The past climates of the New Zealand region are investigated using proxy records to study temperatures, vegetation, glaciers and ocean circulation, among other climate parameters, on a variety of time scales. It is of particular interest to relate the changes seen in New Zealand to global changes in atmospheric and oceanic circulation. Research is being conducted to synthesise results from disparate sources of palaeoclimate information and quantify climate changes that have occurred in the past. This includes information on the regional and temporal patterns of climate change. In addition, such research provides information on natural periodicities, such as the frequency and intensity of El Niño–La Niña events, as well as the frequency of more extreme events.

Palaeoclimate research in Antarctica is an area of national excellence. With substantial leadership and participation from New Zealand scientists, the ANDRILL (ANtarctic geological DRILLing) project successfully recovered two long rock cores from beneath the seafloor. These cores reveal substantial glacial and interglacial fluctuations of the West Antarctic Ice Sheet over the past 14 million years, and other changes in ice, vegetation and sea level during climates warmer than the present. This project is a multinational collaboration comprising more than 200 scientists, students and educators from eight nations (Brazil, Germany, Japan, Italy, New Zealand, Republic of Korea, the United Kingdom and the United States). More recently, New Zealand has developed the capability for drilling long ice cores, and recovered a 750-metre deep ice core from Roosevelt Island in Antarctica to investigate the past 20,000 years, and the stability of the Ross Ice Shelf and the West Antarctic Ice Sheet in a warming world.

A research project recently concluded is *Antarctic New Zealand Interglacial Climatic Extremes – a window into a warmer world*. This work reports new observations and develops new models to improve projections of future change in the region between New Zealand and Antarctica, part of a vast southern region that is a major influence on the world's climate and ocean. The response of the ice, ocean and atmosphere to these previous warm phases will provide insights into how the planet is likely to behave in the future. The importance of understanding how the Antarctic and the Southern Ocean drives New Zealand's future environment is reflected by the creation in 2013 of a National Science Challenge on Understanding the Deep South.[211]

211 http://www.msi.govt.nz/update-me/major-projects/national-science-challenges

Atmospheric chemistry

NIWA is continuing measurements and computer modelling to improve knowledge about the sources, sinks and transport of greenhouse gases in the atmosphere. This work includes participation in the international Total Carbon Column Observing Network, the World Meteorological Organization's Global Atmospheric Watch, and the Network for the Detection of Atmospheric Composition Change. Research is also being undertaken on the implications of climate change for the recovery of stratospheric ozone concentrations.

Ocean–atmosphere gas exchange

This programme at NIWA provides information on the transfer of carbon dioxide, key trace gas species and aerosols between the ocean and atmosphere, with the aim of quantifying their variation in time and space. It considers biogeochemical and physical processes that drive exchange and their response to climate forcing through feedback mechanisms. Long-term regional monitoring and modelling provide critical inputs into national policy and strategy – and international commitments – on climate change, ocean acidification and geo-engineering.

In particular, knowledge of carbon sinks in the New Zealand region is a key requirement of regional budgets and models that inform national policy. The Southern Ocean is the largest regional sink for anthropogenic carbon dioxide, and so understanding the controls and rate of marine carbon dioxide uptake is critical for global carbon budgets. Knowledge from these studies could also inform assessment of possible future oceanic geo-engineering techniques to combat climate change.

8.4.2 Modelling and prediction, including general circulation models

Regional climate scenarios for New Zealand through the 21st century, based on statistical downscaling from global climate models, have been extended to correspond to the full range of global temperature projections available from models used in the IPCC's *Fourth Assessment Report*. Work is underway to complete updated projections using the Coupled Model Intercomparison Project Phase 5 (CMIP5) global climate models, produced in association with the IPCC's *Fifth Assessment Report*. This downscaled data has been mapped onto a 5-kilometre grid to produce estimates of temperature and rainfall for any location across the country.

Work is underway on updated projections based on CMIP5 global climate model runs, assessed in the *Fifth Assessment Report*. This will involve both statistical downscaling and dynamical downscaling utilising a climate model installed in NIWA's supercomputer, and should also assist in assessing likely changes in climatic extremes. Outputs from the dynamical modelling are also being linked to hydrological models to provide river flow projections. More fundamental research on uncertainties in climate models and their implications for regional predictability is also underway. NIWA has strong links to the UK MetOffice, the Commonwealth Scientific and Industrial Research Organisation (Australia's national science agency), the Australian Bureau of Meteorology and Melbourne University, and this international collaboration on climate modelling helps underpin the research and development within the programme.

The projections based on both the downscaling and the regional climate modelling provide data that is used extensively in other research, such as that for engineering design, health and other biological impacts, and socio-economic modelling. This programme also produces regular seasonal climate outlooks, expressed in probabilistic terms, which when interpreted and used properly can improve the management of agriculture, energy, water and production in other climate-sensitive industries.

8.4.3 Research on the impacts of climate change

Research studies on the projected impacts of climate change have been commissioned for all regions of New Zealand, as well as for several specific economic sectors. It should be noted that most of the impact studies conducted in recent years are based on the global climate projections produced by the Coupled Model Intercomparison Project Phase 3 (CMIP3) results, which were assessed in the IPCC's *Fourth Assessment Repo*rt in 2007. It is likely that in coming years impact studies will be updated using statistical downscaling or regional climate models applied to the CMIP5 global projections, as presented and assessed in the IPCC's *Fifth Assessment Report*.

A major research study involving multiple providers and funded by the Ministry for Primary Industries covered primary sector impacts and adaptation options. Separate reports were produced for the dairy, sheep and beef, broad acre cropping, horticulture and forestry sectors, along with a stakeholder report[212] summarising key material for each sector and with material on drought and water resources. The main focus was on the period up to the middle of the 21st century.

Another impact study carried out with funding from the Ministry for Primary Industries addressed the question of what New Zealand might look like in 2100 – and the possible consequences for the country's primary producers – should New Zealand experience global warming of around 4°C compared to pre-industrial times. This report did not expressly predict four degrees of warming by the end of the 21st century: the aim was to explore the possible impacts for New Zealand if temperatures were to rise by this much, to complement previous New Zealand studies that focused on low-to-medium temperature change scenarios.

An important, recently completed research study on climate change impacts and urban infrastructure led to the development of an Urban Impacts Toolbox, which can also be utilised to develop adaptation options.

One of the first projects to use the new climate projections is a wide-ranging, multi-year research project, Climate Change Impacts and Implications. Led by NIWA and Landcare Research and involving researchers from a number of CRIs, universities and other institutions, the programme will undertake targeted research on climatic conditions, impacts and implications for New Zealand up to 2100, through five inter-related research aims:

- improving climate projections
- identifying pressure points, critical steps and potential responses
- identifying feedbacks, understanding cumulative impacts and recognising limits
- enhancing capacity and increasing coordination to support decision-making
- exploring options for New Zealand under different global climates.

[212] http://www.mpi.govt.nz/Default.aspx?TabId=126&id=1581

Wind

Information on the patterns and extremes of New Zealand's future wind environment is important for understanding New Zealand's wind energy resources, infrastructure design constraints, and the wind-throw and fire risk impacts on New Zealand's planted forests. A research project has been completed to provide estimates of the future wind environment, including changes to extremes, based on both the downscaled data and the regional climate modelling projections. Included in this research are efforts to understand how changes to the atmosphere will affect the strength, frequency and location of convective storms.

Hydrology

Agriculture is a significant part of New Zealand's economy and society, and projected scenarios of rainfall and soil moisture are an important part of planning for climate change. Research drawing on a range of IPCC scenarios and climate models has suggested that soils in the east and far north of New Zealand will experience more long, dry periods (droughts) over the coming century. Results are now also available on the implications of these same scenarios for future river flows, and further analysis and research on this topic is underway looking at issues such as flooding and the availability of water for irrigation.

Research and modelling have also been undertaken on possible increases in the frequency of heavy rainfall events and the potential implications for flooding in some locations. Initial results suggest that some areas could see increases in extreme events, even beyond that expected from the higher moisture-holding capacity of warmer air.

Coastal impacts

Research is underway to build the capacity of New Zealand coastal communities to effectively adapt to climate change. It extends research reported in the *Fifth National Communication* to include the interaction of tides, storms and local wave climate with the projected rise in sea level. This will be achieved by providing resources, decision-support tools and future policy and implementation options that can be used as the basis for adaptation to coastal hazards and climate-change impacts. This research is developing a consistent national overview of coastal vulnerability to climate change,[213] from which local scenarios of future impacts can be derived. The development of a suite of resources and decision-support tools will help both communities and decision-makers to work towards sustainable and appropriate adaptation measures.

An additional project is investigating wave and storm surge projections due to climate change, to ensure that the management of weather-related coastal hazard impacts on New Zealand communities can be based on readily available, consistent information on the trends and extremes for wave, swell and storm surge at a regional scale, both now and incorporating future climate change effects.

Agriculture

Initial studies using the CMIP3 global climate projections addressed the primary impacts of climate change on agriculture, such as the effects of rainfall, drought, frost frequency and carbon dioxide fertilisation. More recent work has investigated some second-order impacts, such as the effects of changing climate on rural infrastructure and finance, and on some of the

[213] http://wrenz.niwa.co.nz/webmodel/coastal

biocontrol systems used to combat noxious plants. With the release of the newer CMIP5 climate projections, this cycle is likely to repeat as the important questions are addressed using updated information. Limited research has been carried out on many second- and third-order impacts and the interactions between impact drivers.

Substantial progress has been made in modifying the ecosystem model Apsim to simulate climate change by validating the model output against AgResearch's long-term Free Air CO_2 Enrichment (FACE) data set. FACE has provided critical data on grazed pastoral systems exposed to 10 years of enhanced carbon dioxide. It has explored nutrient, microbiology, plant species and soil relationships, and the interaction with grazing sheep. FACE will be revamped to give an experimental platform to address remaining critical questions on climate change impacts, particularly the impact of changed frequency and intensity of rainfall. The facility allows the control of carbon dioxide concentration, soil temperature, and rainfall frequency and intensity.

Plantation forestry

Initial research into plantation forestry addressed carbon sequestration rates in New Zealand's most common plantation forest species, *Pinus radiata*, to inform the inclusion of carbon forestry in New Zealand's Emissions Trading Scheme. More recent projects have investigated additional planted and indigenous species and forestry systems for different regions and terrains. Research has also investigated the likely changes in forest fire risk over New Zealand in coming decades as a consequence of climate change, and the vulnerability of forests to some of the potential major pests under a changing climate.

Health

A recently completed project addressed the relationship between climate change and public health risk in New Zealand due to communicable diseases, heat stress and a wide range of issues affecting social infrastructure, such as housing, income and livelihoods. Work carried out in this programme has started specific monitoring of heat exposure in outdoor workers, developed empirical models for relating communicable disease to social and climatic factors, assessed the effect of rainfall variability on households and others relying on rainwater tanks, and assessed vulnerability for those who use prepayment electricity meters.

8.4.4 Research and development on adaptation to climate change

In addition to the research on climate change impacts described in section 8.4.3, research and the development and dissemination of methods for implementing adaptation measures have also been a major focus. More information on climate change adaptation measures can be found in chapter 6.

The Ministry for the Environment has supported research to produce guidance manuals for local government on the expected impacts of climate change, which describe a risk management framework for assessing the consequences and determining the appropriate responses. These guidance manuals are described in chapter 6.

Research is also being conducted into the social aspects of successful adaptation. One example is a recent project studying Coastal Adaptation to Climate Change. The goal of this research was to build the capacity of New Zealand coastal communities to effectively adapt to climate change by providing resources, decision support tools and future policy and implementation options that can be used as the basis for adaptation to coastal hazards and climate change impacts. This has three main strands: building a national coastal vulnerability profile, engaging and informing communities, and encouraging best practice planning. More information on this project can be found online at NIWA's National Centre for Coasts.[214]

Guidance documents produced by the Ministry for the Environment on the projected flooding and coastal hazard impacts of climate change are being used by local authorities to inform the development of new infrastructure. Further research has led to the development of an Urban Impacts Toolbox,[215] which is a resource to help planners, engineers, asset managers and hazard analysts in New Zealand urban councils understand and evaluate the potential impacts of climate change in their city. The tools demonstrate methods and approaches that can be used to perform an assessment of climate change impacts, and provide information consistent with the Australian and New Zealand Standard for Risk Management, which is widely used in the public and private sectors.

Adaptation research specific to the land-based sectors has also been carried out. This has included:

- the impacts from, and adaptation of pasture plants to, future climate scenarios
- assessing the impacts and movement of C4 plants, which photosynthesise more efficiently in high temperature and drought conditions
- selecting drought-tolerant varieties of *Pinus radiata* and conservation trees (such as poplar and willow)
- assessing the growth of maize and other crops under future climate scenarios.

The New Zealand Climate Change Centre has continued to organise events for New Zealanders working on climate change, particularly in the area of adaptation. Since the *Fifth National Communication* the Centre has organised workshops and two further relevant conferences: Degrees of Possibility: Igniting Social Knowledge around Climate Change (2010), and Sea-level Rise: Meeting the Challenge (2012). The Centre also organised the New Zealand Climate Change Conference 2013, which included invited keynote papers as well as submitted papers organised under the following four headings: The Physical Science Basis; Impacts, Vulnerability & Adaptation; Mitigation; and Integration & Cross-cutting Issues.

8.4.5 Socio-economic analysis, including impacts and response options

Economic modelling work has identified impacts from climate variations on New Zealand's gross domestic product (GDP) through changes in pastoral production. This work uses the projected impacts – particularly the impacts on the occurrence of droughts – to estimate the changes in production, both in average years and in drought years.

Integrated socio-economic/natural-science models have been developed for use in policy design and analysis for land-use and climate change issues. These models can investigate the likely influence of various possible policies on changes in land use for forestry, including the effects of different levels of carbon pricing. A further research project has examined

[214] http://www.niwa.co.nz/our-science/coasts/research-projects/all/coastal-adaption-to-climate-change

[215] http://www.niwa.co.nz/climate/urban-impacts-toolbox

greenhouse gas emission paths in connection with different New Zealand economic development scenarios. A global trade model has been developed to support policy and address how global climate change impacts may affect the New Zealand economy.

A recently completed 4-year project addressed diverse aspects of community vulnerability, resilience and adaptation to climate change[216]. It aimed to develop integrative and consistent frameworks for assessing multiple socio-economic and physical hazard effects on community vulnerability to climate change, which could be used by local and central government agencies as well as Māori authorities. The impact of climate change on Māori land has been assessed at the national level and at an individual farm-scale level.

8.4.6 Research and development on mitigation

Due to the fact that an unusually high proportion of New Zealand's greenhouse gas emissions are from the agriculture sector, research into the reduction of greenhouse gas emissions is focused on reducing emissions from agriculture. Significant research efforts are also being made on the role of forestry in sequestering carbon.

A number of research programmes address the mitigation of agricultural greenhouse gas emissions. Much of the industry funding is channelled through the Pastoral Greenhouse Gas Research Consortium,[217] in which the Government matches the investment of the pastoral industry into research on the reduction of greenhouse gases from pastoral production. The Consortium's research programme, which commenced in 2002, aims to provide New Zealand livestock farmers with the knowledge and tools to mitigate greenhouse gas emissions from the agricultural sector. The Consortium is a commitment by the pastoral sector to address pastoral emissions while ensuring that New Zealand's economic wealth is enhanced.

The New Zealand Agricultural Greenhouse Gas Research Centre is a Government-funded consortium of Crown Research Institutes, universities and industry, whose role is to find ways for New Zealand to meet its international greenhouse gas emission obligations without reducing agricultural output.

Internationally, New Zealand's leadership in establishing and hosting the Global Research Alliance on Agricultural Greenhouse Gases (see section 8.3.2, and chapters 4 and 9) aims to foster collaborative international research projects, global data sets, and standard measurement and mitigation techniques and protocols between countries. It also works to set up global networks of scientists creating capability development and training opportunities, particularly for scientists from developing countries, and to identify good practice mitigation options for different production systems and climates.

Mitigation of agricultural greenhouse gas emissions

A significant amount of agricultural mitigation research is undertaken through the Pastoral Greenhouse Gas Research Consortium. The Ministry for Primary Industries also funds research through the Sustainable Land Management and Climate Change Plan of Action, the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) and the Global Research

[216] http://www.victoria.ac.nz/sgees/research-centres/ccri/research/community-vulnerability,-resilience-and-adaptation-to-climate-change,-2008-2013

[217] http://www.pggrc.co.nz

Alliance on Agricultural Greenhouse Gases. A particular focus is the investigation of rumen microbial strategies to lower methane emissions.

There are six key strands of ruminant methane research:

- understanding the rumen ecology of ruminants
- understanding the genomes of methanogens
- finding chemical inhibitors that affect methanogens
- developing a vaccine to reduce methanogens
- selecting and breeding animals for low methane emissions per unit of intake
- identifying the impact of various forages and feeds on methane emissions.

The genomes of nine ruminant methanogens have been sequenced. New information has been obtained on rumen factors that affect methanogen survival and that have the potential to be used in methane-abatement strategies.

A project between the dairy industry and Government, called Pastoral 21, has carried out research on management practices to reduce nitrate leaching and nitrous oxide emissions. This includes the evaluation of intensive dairy farm systems, which involves treatments with nitrogen fertiliser, maize silage and winter management strategies. The inclusion of low protein forage (eg, maize) to reduce dietary nitrogen concentration, and winter management practices to reduce excreta to soil, can potentially reduce nitrous oxide emissions and increase efficiency. A national trial overseen by the Pastoral Greenhouse Gas Research Consortium was conducted to assess the impact of the nitrification inhibitor dicyandiamide (DCD) on nitrous oxide emissions, nitrate leaching and pasture growth. DCD has, however, been voluntarily withdrawn from the market due to customer concern at a low residue level in milk products. There is no risk to humans from these levels of inhibitor in milk products.

The NZAGRC operates four research work streams:

- research on the mitigation of enteric methane, which supports the work of the Pastoral Greenhouse Gas Research Consortium and the Global Research Alliance
- research on the mitigation of nitrous oxide, which looks at reducing nitrogen inputs, modifying the nitrogen process and limiting nitrous oxide outputs
- research on soil carbon storage, which seeks to understand the potential and drivers for increasing soil carbon and improve the means of measuring carbon and reducing uncertainty
- research on integrated systems, which seeks to improve the components in models that address methane and nitrous oxide emissions.

The NZAGRC also serves as a centre for collaboration, delivery and technical advocacy.

The research on integrated systems includes provisions to: contribute to the development of a national strategy, ensure NZAGRC is involved in national and international approaches to deliver mitigation options and technical advocacy, support processes related to the Global Research Alliance, and build capability and capacity through scholarships and fellowships. Under the Alliance, the NZAGRC has identified priority projects that would best assist the international research effort into livestock greenhouse gas mitigation. These have included research networks, best practice and technical manuals and guidelines, a global database of rumen samples, and testing of an in-field methane measurement system.

The New Zealand Fund for Global Partnerships in Livestock Emissions Research is a contestable international research fund set up by New Zealand in 2011, in support of the Alliance. The

Fund is aimed at accelerating global research into mitigating greenhouse gas emissions from pastoral livestock farming. It draws on the NZ$45 million the New Zealand Government committed to the Alliance in 2009, and is allocated over seven years ending on 30 June 2019. The Fund is open to international scientists, and multi-stakeholder/country consortium bids are encouraged. The final portfolio of projects seeks to balance innovative science with the achievement of cost-effective and sustainable solutions for livestock farmers in New Zealand and around the world.

Two funding rounds have been held, with projects to be completed by 30 June 2016. Round one approved the following projects, with a value of NZ$6.62 million:

- 'Deep sequencing the rumen microbiome', which involves partners from New Zealand, the US, Australia, France and Ireland
- 'Accelerated discovery of methanogen-specific inhibitors', which involves partners from New Zealand, the US, Australia and Japan
- 'Vaccine to reduce methane emissions in ruminants', which involves partners from New Zealand and Australia
- 'Animal delivery of DCD in urine by provision in feeds', which involves partners from New Zealand, Australia and Ireland.

Round two approved the following projects, with a value of NZ$2.4 million:

- 'Fast-tracking development of methanogen-specific inhibitors', which involves partners from New Zealand and the US
- 'Reducing ruminant methane emissions by disrupting microbial interspecies hydrogen transfer', which involves partners from New Zealand and Germany
- 'Reducing N2O emissions from urine patches through accelerating N_2O reduction', which involves partners from New Zealand, Ireland and Norway.

The third round of the Fund opened in August 2013, with total funding of NZ$10 million, supporting projects of up to 4 years (ending 30 June 2019). Like the previous two rounds, the third round seeks proposals in response to a set of high-level research challenges that were identified by an international strategic science panel. These challenges are in the areas of:

- manipulating rumen function
- reducing nitrous oxide emissions from soils in predominantly grazing livestock systems
- manipulating the rates of soil carbon change in predominantly grazing livestock systems.

Land use, land-use change and forestry (LULUCF): inventories and sequestration research

The New Zealand Land Use and Carbon Analysis System (LUCAS) has completed a long-term research programme designed to meet New Zealand's international reporting requirements for land use, land-use change and forestry (LULUCF) for the first commitment period under the Kyoto Protocol. The aim of the programme was to improve New Zealand's ability to assess forest and forest soil carbon stock and change in a transparent, robust and defensible manner.

The research built on earlier work to design unbiased, representative forest plot networks for ground-based continuous forest inventories, in both natural and planted forests. The methodologies for data collection were refined allometries in the case of natural forests and models in the case of planted forests. These models were improved and uncertainties were reduced by the use of lidar (light interception detection and ranging) in planted forests. Detailed studies were carried out to improve wood density estimates and decay rates.

Research also focused on the effects of forest management activities and harvest residues on carbon stocks of biomass and soils to improve the estimates. New Zealand-specific emission factors have been developed in the woody subcategories of the grassland and cropland land-use classes.

The research has resulted in improved carbon stock and change estimates in land-use categories with woody biomass present, including post-1989 forests, pre-1990 planted and natural forests, grassland with woody biomass, and perennial cropland. Improvements to the soil carbon-monitoring system model were also a focus of the research programme.

There has also been research into harvested wood products and the impacts of natural disturbance on forest carbon. Research has been conducted on improving models of non-traditional species such as Douglas fir, as well as the natural establishment and growth of indigenous species under various environmental conditions and cover species. The strategies for establishment, growth, management and harvesting on difficult slopes are also being researched, because much of New Zealand's forests are planted on steep landscape.

Research is continuing into the role of forests in the mitigation of climate change. This programme focuses on the effects of climate change on forests and using this knowledge to support the development of climate mitigation and adaptation responses, both by Government and by the forestry sector. Objectives include the development of spatial and temporal models that will allow better prediction of how forests may respond to climate change, which will enable the development of adaptation and mitigation approaches. Research into improving estimates for the current tree carbon look-up tables and the field measurement approach for forestry in the NZ ETS is also being conducted.

Energy efficiency, renewables and mitigation of industrial emissions

Massey University hosts the New Zealand Biochar Research Centre, which aims to advance the understanding of biochar (a stable form of carbon) for mitigating global climate change and to enable its use in New Zealand, particularly by the agriculture and forestry sectors. This technology could provide an opportunity to permanently remove carbon dioxide from the atmosphere and store it as inert carbon in soils. Biochar can also be used to make a bioenergy product that can be used to produce heat and generate electricity, and for other applications. The Centre supports two professorships: one in biochar use and the other in biochar production.

New Zealand's commercial buildings have direct and indirect responsibility for 8 per cent of national greenhouse gas emissions, directly using 11 per cent of national energy and 23 per cent of New Zealand's electricity (2008). As a sector it is extremely vulnerable to supply and transmission problems, as well as future carbon costs. Research is underway to identify how energy and water are used, and cost-effective mitigation options and the barriers to their uptake by building owners and users. This work involves a number of different work streams, tailored to different building sizes and uses.

Another project focuses on processing plants that produce milk powder, which is a major component of New Zealand's dairy exports. It aims to develop new methods and practices to achieve a 3–5 per cent improvement in energy efficiency, which will contribute to mitigation in New Zealand through deferred installation of electricity generation capacity, and reduced fuel use.

The Ministry of Business, Innovation and Employment is also funding research to develop technology that will remove carbon dioxide from the output of industrial processes at minimal cost and with the lowest consumption of power. Scientists at GNS Science are investigating the potential of sites for the geo-sequestration of carbon dioxide. New Zealand also collaborates in an Australian cooperative research centre programme on carbon dioxide geo-sequestration.

Transport

Public and private research into biofuels is facilitated by the Advanced Biofuels Research Network, which aims to accelerate the development of biofuel technology for the benefit of New Zealand by encouraging a coordinated approach to biofuels research. The purpose of this Network is to improve communication across the New Zealand biofuels research community, establish collaborations within the New Zealand biofuels research community, and build interactions between New Zealand biofuels researchers and industry, Government, and international research organisations.

8.5 Systematic observations

New Zealand maintains observation programmes for atmospheric, terrestrial and oceanic measurements for a suite of essential climate variables. These measurements are complemented by archives of historical observations of climate-related parameters. Details on the measurement programmes are described in New Zealand's *Report on the Global Climate Observing System*, (included after the Annexes in this report), and are presented in accordance with the revised UNFCCC reporting guidelines on global climate change observing systems (Decision 11/CP.13).

9

Education, training and public awareness

9 Education, training and public awareness

Key developments since the *Fifth National Communication*

- Energy Spot™ advertisements promoting household energy efficiency have screened during prime-time television.
- The public have been consulted about whether the 2050 emissions reduction target should be notified in the New Zealand Gazette.
- Institutes and research organisations, including the New Zealand Climate Change Centre and the New Zealand Climate Change Research Institute, have organised events and published information on climate change.
- The Heavy Vehicle Fuel Efficiency Training Programme has been launched.
- The New Zealand Government has engaged internationally on climate change issues in the Pacific Islands Forum, the Asia–Pacific Carbon Markets Roundtable and the Global Research Alliance on Agricultural Greenhouse Gases.

9.1 Introduction

The New Zealand Government actively supports initiatives that encourage public awareness of climate change. Climate change information is actively provided to the public, local government and particular sectors. Resources and support are also provided for education and training on climate change-related issues. In addition, engagement on climate change issues with the public, businesses, Māori[218] and young people has taken place over the past four years. The New Zealand Government also actively engages with other countries on climate change issues.

This chapter provides information about initiatives in these areas that have been run or supported by the New Zealand Government over the reporting period. The initiatives are divided into five sections: public awareness campaigns and behavioural change, public access to information, education and training, public engagement, and international engagement.

9.2 Public awareness campaigns and behavioural change

This section outlines campaigns the New Zealand Government has run during the past four years to provide the public with information to help them to make informed consumer decisions to reduce greenhouse gas emissions and encourage long-term behavioural change.

[218] Māori are the indigenous people of New Zealand.

Public awareness campaigns have focused on household and vehicle energy efficiency, certification schemes, tools for measuring emissions, and environmental awards.

9.2.1 Energy efficiency campaigns

ENERGYWISE™

The ENERGYWISE™ campaign is a major New Zealand Government public awareness initiative to promote energy efficiency, energy conservation and the uptake of renewable energy in New Zealand households. The campaign is run by the Energy Efficiency and Conservation Authority (EECA) and:

- explains the benefits of energy efficiency, energy conservation and renewable energy
- motivates people to take action
- shows householders and consumers how to take action.

The information provided to the public includes:

- general home energy efficiency information
- information on Government funding available for home insulation retrofits and other energy efficiency solutions
- information to help consumers improve their energy choices (eg, by purchasing and running energy-efficient home appliances)
- information on energy labelling schemes, including ENERGY STAR®.

More information on the ENERGY STAR® programme can be found in Chapter 4.

The ENERGYWISE™ public awareness campaign is also promoted on national television through Energy Spot™ television advertisements. These advertisements are a high-profile way of raising public awareness and consumer interest in energy efficiency. The Energy Spot™ advertisements screen as 1-minute 'programmes' during prime-time television – usually at the end of the evening news bulletins on a number of television channels – and offer tips and advice on energy savings to households and businesses. Topics covered include hot-water wastage, energy efficient renovation, holiday driving tips and choosing efficient lighting.

There are currently 30 Energy Spot™ television advertisements available to be viewed at: http://www.energywise.govt.nz/resource-centre/videos/. These advertisements have been well received in New Zealand, and a number of countries have asked for information about the campaign.

A further opportunity for high-profile promotion of the ENERGYWISE™ public campaign is through the popular New Zealand reality television series *Mitre 10 Dream Home*, which screened in New Zealand from 1999 to 2009, and again in 2013. It is one of the most widely watched reality television shows in New Zealand: viewer surveys show that 400,000 viewers watch *Mitre 10 Dream Home* every week (around 10 per cent of the New Zealand population). The show features two families renovating (in the 2013 series, building) their 'dream home'. EECA is a key sponsor of the 2013 series (as it was in 2009) and key messages on energy efficiency are included in the series. On-screen graphics show energy efficiency information, and the weekly judging of each team includes a score for energy efficiency.

More information on the ENERGYWISE™ campaign can be found at http://www.energywise.govt.nz. EECA is also starting to use social media as a cost-effective and appealing way of engaging with New Zealand consumers. The ENERGYWISE™ online social media accounts are gaining in popularity.

Transport

Public awareness of vehicle efficiency has been promoted through compulsory fuel economy labelling during the reporting period.[219] Labels are displayed on all new and used cars available for sale through registered motor vehicle traders and on internet listings (provided the information is available). The labels help consumers make informed decisions about environmental impacts when purchasing a car. The scheme is unique in that it also applies to private sales on the internet. It covers both new and used vehicles manufactured after 2000.

EECA has negotiated a deal with New Zealand's leading vehicle sales website to have vehicle fuel economy information appear next to each qualifying vehicle listing. This makes it easier for consumers to factor fuel efficiency into their decision. EECA also runs the FuelSaver website (http://www.rightcar.govt.nz/ and http://www.fuelsaver.govt.nz), which enables consumers to compare the fuel efficiency of vehicles.

9.2.2 Carbon reduction and neutrality certification

Landcare Research (a Crown Research Institute) runs a programme to provide tools for individuals and organisations to measure and reduce greenhouse gas emissions. As part of this programme, Landcare Research offers two greenhouse gas certification programmes:

- **CEMARS** (Certified Emissions Management And Reduction Scheme) certification - for carbon measurement and reduction claims
- **carboNZero** certification - for carbon neutrality claims.

Members that are ready to meet the programme's requirements are verified by a programme-approved auditor. Once approved, members are issued with a certificate and can display the CEMARS or carboNZero certification mark or logo. Case studies featuring the emissions reduction achievements of member companies are available on the carboNZero website. Energy efficiency is recognised as an important part of the actions that companies need to take to reduce their greenhouse gas emissions.

9.2.3 Other environmental certification schemes

In addition to the CEMARS and CarboNZero certification schemes, the New Zealand Government also supports two other environmental certification schemes: the Enviro-Mark programme and the Environmental Choice New Zealand ecolabel.

The Enviro-Mark programme is an environmental certification programme established in 2001 by Landcare Research. Energy efficiency is an important part of the actions that companies need to take to improve their environmental performance under the Enviro-Mark programme. It operates as a five-step environmental management system, with a focus on continuous improvement, as companies work from 'Bronze' upwards to a 'Diamond' level of certification. Enviro-Mark Diamond (the final step) is equivalent to ISO International Standard 14001. Participating companies are supported through checklists and training, including seminars and

---

219 See also section 4.3.3.

workshops. Online resources are also provided to participating companies, including case studies featuring the environmental performance improvements achieved by member companies.[220]

The Environmental Choice New Zealand[221] ecolabel is a life-cycle impact ecolabel. It is managed for the New Zealand Government by the independent New Zealand Ecolabelling Trust. Companies must meet published specifications before they can use the ecolabel. These specifications can include (among other life-cycle impact areas) requirements such as energy management plans and the use of recycled content to reduce energy embodied in products and services. In 2011/12 there were 67 companies and 2335 products eligible to carry the Environmental Choice New Zealand ecolabel. These numbers are expected to grow by 23 per cent over 2012/13.[222]

Users of the Environmental Choice New Zealand ecolabel include purchasers from:

- corporate and small businesses (business-to-business procurement)
- government (central and local government, schools, Crown entities)
- the building industry
- household consumers.

Through the Global Ecolabelling Network,[223] New Zealand has mutual recognition agreements with Japan, Taiwan, Thailand, South Korea, China, the Czech Republic, the US, Canada, Hong Kong, Ukraine, and Scandinavian countries.

9.2.4 Green Ribbon Awards

The Green Ribbon Awards[224] started in 1990 and have become the Ministry for the Environment's annual flagship event to recognise outstanding contributions of individuals, organisations, businesses and communities to protecting and enhancing New Zealand's environment. Since 2010 the Green Ribbon Awards have included an award category for reducing greenhouse gas emissions. The Awards are presented by the Minister for the Environment and provide an opportunity to raise public awareness of people making a difference for the environment.

9.3 Public access to information

A key part of the New Zealand Government's response to climate change is providing climate change information to the public, businesses, local government and the land-based sector.

---

[220] Online resources are provided by Enviro-Mark Solutions Limited (a wholly owned subsidiary of Landcare Research).

[221] Type I (ISO International Standard 14024).

[222] http://www.environmentalchoice.org.nz

[223] The Global Ecolabelling Network is a non-profit association of third-party environmental performance recognition, certification and labelling organisations founded in 1994 to improve, promote and develop the 'ecolabelling' of products and services. See http://www.globalecolabelling.net

[224] http://www.mfe.govt.nz/withyou/awards/green-ribbon.html

9.3.1 Information for the public

The New Zealand Government's Climate Change website was established in 2003. It is the key source of climate change information provided by the Government, and it supplies information about the causes of, the evidence for and the effects of climate change. It describes the key Government policies to reduce emissions, and the work being done to help people prepare for, and adapt to, climate change. It also acts as a portal to a number of other Government and non-government organisations involved in climate change work. The Climate Change website can be found at http://www.climatechange.govt.nz.

Information can also be obtained from the following websites:

- http://www.mfe.govt.nz/issues/climate – a wide range of climate change issues, from mitigation to impacts and assessment, are described
- http://www.climatechange.govt.nz/carbon-reports/reports.html#greenhousegas – shows New Zealand's actual and projected greenhouse gas emissions, by sources, and removals, by sinks.

Links to other Government ministries and departments with important climate change programmes are available at http://www.climatechange.govt.nz/reducing-our-emissions/who-does-what.html.

New Zealand Emissions Trading Scheme

The New Zealand Government provides general information about the NZ ETS specifically aimed at the public. This includes a set of basic information booklets, which outline how the scheme affects households, Māori, and small and medium businesses. These information sheets are available online at: http://www.climatechange.govt.nz/emissions-trading-scheme/about/ what-it-means-for-me/.

Additional information about the NZ ETS is available online in other parts of the main NZ ETS website at: http://www.climatechange.govt.nz/emissions-trading-scheme/. The information provided covers a section on frequently asked questions as well as a basic, high-level description of how emissions trading works, the links with international climate change commitments, and the policy thinking underlying the scheme.

New Zealand's Greenhouse Gas Inventory Snapshot

Each year over the reporting period the New Zealand Government has published an *Inventory Snapshot* summarising *New Zealand's Greenhouse Gas Inventory*. The *Snapsho*t is released at the same time as the *Inventory*. The *Inventor*y is a large, technical document, and producing a summary means that the information is accessible to a wider audience.

Using a simple question-and-answer format, the *Snapshot* informs the public about New Zealand's emissions in a straightforward manner. It covers sources of emissions, trends and changes, comparisons with other countries, and New Zealand's net position under the Kyoto Protocol. The most recent release is *New Zealand's Greenhouse Gas Inventory 1990–2011 and Net Position: Snapshot April 2013*.[225]

[225] http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2013-snapshot/

9.3.2 Information for businesses

As explained in section 4.3.1, the NZ ETS has been amended twice since it was first implemented in 2008, and various sectors have been brought into the scheme at different times. Ongoing communication about participants' obligations and the development of the NZ ETS has been important for participants and other affected businesses. Most of the information on the NZ ETS website is aimed at participants in the scheme.

As the NZ ETS has developed, the Government has carried out consultation with the public and affected businesses on a multitude of issues and proposals. (Consultation with the public is discussed further in section 9.5.1 below.) When changes are made, information bulletins or fact sheets are produced to inform affected businesses. Similarly, as regulations for emissions reporting in sectors such as forestry, industry and liquid fuels have been introduced and amended over time, bulletins and other information and materials have been provided to affected groups. Much of this material is available online at http://www.climatechange.govt.nz/emissions-trading-scheme/building/policy-and-legislation/regulations.html.

Material that is needed for the ongoing participation of businesses in various sectors is available through the nine sector-specific links on the main NZ ETS website. Participants also receive updates and notifications from the New Zealand Emission Unit Register: http://www.eur.govt.nz.

NZ ETS obligations for the forestry and agriculture sectors are administered by the Ministry for Primary Industries. Information about NZ ETS obligations for these sectors is available on the Ministry for Primary Industries' website. In particular, detailed information bulletins and updates are important for forestry participants and are made available at: http://mpi.govt.nz/forestry/forestry-in-the-ets.

9.3.3 Information for local government

The Ministry for the Environment has published technical manuals to provide local government with information about the predicted impacts of climate change.[226] These are:

- *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand* (2nd edition, May 2008)[227]
- *Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand* (July 2008)[228]
- *Tools for Estimating the Effects of Climate Change on Flood Flow: A Guidance Manual for Local Government in New Zealand* (May 2010).[229]

226 These technical manuals were produced by science provider teams (led by NIWA), under contract to the Ministry for the Environment.

227 http://www.mfe.govt.nz/publications/climate/climate-change-effect-impacts-assessments-may08/

228 http://www.mfe.govt.nz/publications/climate/coastal-hazards-climate-change-guidance-manual/

229 http://www.mfe.govt.nz/publications/climate/climate-change-effects-on-flood-flow/index.html

The technical manuals contain a large amount of detailed information, so summary reports[230] have also been developed that present the key information in an easy-to-understand format:

- *Preparing for Future Flooding: A Guide for Local Government in New Zealand* (May 2010)[231]
- *Preparing for Coastal Change: A Guide for Local Government in New Zealand* (March 2009)[232]
- *Preparing for Climate Change: A Guide for Local Government in New Zealand* (July 2008).[233]

More information about the technical manuals and the summary publications can be found in section 6.4.1.

Quality Planning

The Quality Planning website is the primary tool for delivering robust information on processes and environmental policy to resource management practitioners in New Zealand. The website promotes good practice by providing guidance on aspects of the planning process and draws on practitioner experience and knowledge.

The Quality Planning website includes a guidance note on climate change, which is available at http://qualityplanning.org.nz/index.php/planning-tools/climate-change.

The guidance promotes a better understanding of the effects of climate change and provides best practice information on how to assess the significance of, and respond where necessary to the effects of, climate change. The guidance includes information and advice on methods for considering and addressing climate change impacts.

9.3.4 Information for the land-based sector

The Ministry for Primary Industries website explains what climate change means for the rural sector, and has links to forestry and agriculture in the NZ ETS, sustainable forestry and sustainable land management, international climate change, and legislation and regulation.[234]

Climate Cloud

The Ministry for Primary Industries is currently working on building a digital library of New Zealand climate change-related resources for land managers. The digital library is designed to help land managers obtain information about the effects of climate change in order to make successful adaptation and mitigation decisions. It will provide information on:

- climate change causes, risks and impacts
- sector-specific areas of risk and vulnerability

[230] Summary reports were produced by the Ministry for the Environment, with assistance from science provider teams at NIWA.

[231] http://www.mfe.govt.nz/publications/climate/preparing-for-future-flooding-guide-for-local-govt/index.html

[232] http://www.mfe.govt.nz/publications/climate/preparing-for-coastal-change-guide-for-local-govt/index.html

[233] http://www.mfe.govt.nz/publications/climate/preparing-for-climate-change-guide-for-local-govt/

[234] http://www.mpi.govt.nz/environment-natural-resources/climate-change

- adaptive strategies to aid the development of resilience within primary production sector institutions and businesses.

The library will be called Climate Cloud and will be available online at http://www.climatecloud.co.nz. The resource is currently under development and is expected to be live towards the end of 2013.

9.4 Education and training

The New Zealand Government provides resources and funding for climate change-related education and training in schools, institutes and research centres, and industry training. Details of Government-supported initiatives are set out below.

9.4.1 Education in schools

The Government provides resources and funds programmes to facilitate and encourage environmental education in schools.

The New Zealand Curriculum and *Te Marautanga o Aotearoa*

The New Zealand Curriculum (2007) and *Te Marautanga o Aotearoa* (2008) set the direction for teaching and learning programmes in New Zealand schools. There are opportunities to learn about climate change and sustainability issues across many areas and year levels of the curriculum. Te Kete Ipurangi (http://www.tki.org.nz) is the Ministry of Education's bilingual (te reo Māori/English) education portal. It provides schools and students with information, resources and curriculum materials (including about climate change and sustainability) to enhance teaching and learning for the education sector.

The Education for Sustainability website[235] is designed to help teachers engage students in relevant learning about sustainability, and encourage them to act sustainably and contribute to the well-being of New Zealand. It does this by making connections between the learning areas, vision, principles, values and key competencies of the national curricula: *The New Zealand Curriculum*[236] and *Te Marautanga o Aotearoa*.[237]

Enviroschools and Te Aho Tū Roa

The Enviroschools Foundation is a non-governmental organisation which runs programmes that take a holistic approach to creating more sustainable communities. The programmes involve working with children and young people through both the formal education system and communities. The Foundation receives part-funding from the Ministry for the Environment.

The two programmes run by the Foundation are Enviroschools and Te Aho Tū Roa. The Enviroschools programme operates in English-language schools and early childhood education

---

235 http://efs.tki.org.nz/

236 http://nzcurriculum.tki.org.nz/

237 http://tmoa.tki.org.nz/

centres, and Te Aho Tū Roa operates in te reo Māori immersion settings. Both programmes are designed to work in conjunction with the national curricula (outlined above) and produce a range of environmental, educational, social and cultural outcomes. The resources provided as part of the programmes include information on climate change.

Students are involved in the planning, design and implementation of action projects based on local priorities identified by the students in conjunction with their community. A range of projects across the 900 schools, kura[238] and centres involved in the Enviroschools and Te Aho Tū Roa programmes have relevance to climate change, including projects on waste minimisation, ecological restoration, school landscape projects, local food production, active transport to schools, and energy efficiency.

Other learning materials

Teachers are encouraged to provide opportunities for students to access information that will enable them to debate issues and make informed decisions, and to take responsibility through personal and/or group actions for addressing environmental issues.[239] For assistance with lesson structure, teachers can also refer to the Action Oriented Approach[240] in the *Environmental Education Guidelines* (1999).[241]

- The New Zealand Government's Climate Change website provides learning materials for school teachers, including cross-curricular activities designed for junior students.[242] The website provides general educational resources and activities for children, including:
- 'Play it Cool', an interactive web-based activity aimed at helping children find out about reducing greenhouse gas emissions and the effects of climate change
- 'Greenhouse Effect in a Jar', instructions aimed at children for making a miniature version of the greenhouse effect in a jar
- a picture gallery providing photos for use in projects on climate change or the environment.

9.4.2 Institutes and research centres

The New Zealand Government provides support for the Royal Society of New Zealand and other institutions and research centres that educate professionals and the public more generally on climate change issues.

The New Zealand Climate Change Centre

New Zealand has strong research and academic communities with particular expertise in climate change. The New Zealand Climate Change Centre is a joint initiative by New Zealand's Crown Research Institutes and three universities (Massey University, the University of

---

238 Kura is a term that refers to schools operating under Māori custom and using Māori as the medium of instruction.

239 http://efs.tki.org.nz/Curriculum-resources-and-tools/Environmental-Education-Guidelines

240 http://efs.tki.org.nz/Curriculum-resources-and-tools/Environmental-Education-Guidelines/An-Action-oriented-Approach

241 http://efs.tki.org.nz/Curriculum-resources-and-tools/Environmental-Education-Guidelines

242 http://www.climatechange.govt.nz/reducing-our-emissions/schoolstuff

Canterbury and Victoria University of Wellington). The Centre has held annual conferences and workshops on climate change-related topics since 2009. These provide opportunities for researchers to describe recent research findings on climate change and to interact with end-users. Conferences and workshops so far include:

- Climate Change Adaptation: Managing the Unavoidable (conference, May 2009)
- Degrees of Possibility: Igniting Social Knowledge around Climate Change (workshop, December 2010)
- Sea-level Rise: Meeting the Challenge (conference, May 2012)
- The New Zealand Climate Change Conference 2013 (conference, June 2013).

In 2010 the New Zealand Climate Change Centre published *Climate Change Adaptation in New Zealand: Future Scenarios and Some Sectoral Perspectives*. The publication contains nine individual papers providing both a broad overview and individual sector perspectives on climate change adaptation in New Zealand.[243]

In June 2011 the Centre published *Degrees of Possibility: Igniting Social Knowledge around Climate Change – Workshop Report*. This report summarised presentations and group discussions from workshops held by the Centre in December 2010. Based on this, the report draws conclusions and makes recommendations to advance research in the social sciences and climate change field.[244]

NIWA National Climate Centre

The NIWA National Climate Centre produces climate summaries, models, forecasts and general information about the New Zealand climate. More information about the services and information that NIWA provides through the National Climate Database can be found in Chapter 8.

Information publically available on the NIWA National Climate Centre website[245] includes detailed information about greenhouse gas measurements, global climate models, climate change scenarios for New Zealand, information on climate change and the marine environment in New Zealand, and regional climate change impacts.

New Zealand Agricultural Greenhouse Gas Research Centre

The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) (see section 4.3.5 for details) produces regular publications, newsletters and reports, which are publicly available on its website at http://www.nzagrc.org.nz/publications.html. Fact sheets recently produced by the NZAGRC (in November 2012) include:

- *The Impact of Livestock Agriculture on Climate Change*
- *Impacts of Global Climate Change on New Zealand Agriculture*
- *Economic and Policy Implications of Alternative GHG Metrics*.

Apart from investing in a portfolio of research, the NZAGRC attracts and supports a significant number of master's, doctoral and post-doctoral students each year, expanding the pool of

243 NZCCC 09/10 Year-End Review (26 July 2010), retrieved from http://www.nzclimatechangecentre.org

244 NZCCC 10/11 Year-End Review (29 July 2011), retrieved from http://www.nzclimatechangecentre.org

245 http://www.niwa.co.nz/our-science/climate

researchers with skills in the agricultural greenhouse gas mitigation area and ensuring succession in science leadership.

The NZAGRC has held three annual workshops since it was established in 2010. These are attended by NZAGRC members, Government agencies, research organisations and industry stakeholders. The workshops ensure NZAGRC researchers are connected with each other, with relevant international researchers, and with the agricultural industry and extension services.[246] The NZAGRC acts as focal point for information on agricultural greenhouse gases for the media, and routinely hosts visiting scientific and policy delegations from other countries.

The NZAGRC also acts as agent for the New Zealand Government in supporting the goals and objectives of the Global Research Alliance on Agricultural Greenhouse Gases. This includes a comprehensive awards programme to build the capacity of technicians, doctoral and post-doctoral students from developing countries, and to facilitate exchanges of senior scientists between New Zealand and other Alliance member countries. The Government also has, through the NZAGRC, supported agricultural greenhouse gas capacity-building projects in Latin America and southeast Asia, and has contributed to capacity-building workshops in east and west Africa.

The Royal Society

The Royal Society of New Zealand is New Zealand's independent national academy of science, technology and the humanities. It provides expert advice to the Government and the wider community on a range of issues, including climate change. Over the reporting period, the Royal Society has published an advice paper on sea-level rise[247] and has held an interactive workshop exploring how geo-engineering proposals could be assessed.[248] In 2012 the Royal Society hosted a meeting for Members of the New Zealand Parliament with Prof Dr Ottmar Edenhofer, Co-Chair of Working Group III of the IPCC, on the mitigation of climate change.

The New Zealand Climate Change Research Institute

The New Zealand Climate Change Research Institute was established in 2008 by Victoria University of Wellington to develop interdisciplinary decision-relevant climate change information. The team of researchers and policy thinkers work at the interface between climate change science and the decisions people have to make about climate change. There is a particular emphasis on work that spans the natural and social sciences.[249]

The Institute collaborates internationally and within New Zealand with other researchers at New Zealand's Crown Research Institutes and universities, and with private institutes and researchers. It contributes to public debates about climate change and delivers courses to students and practitioners.

---

246 http://www.nzagrc.org.nz/nzagrc-2012-conference.html

247 Royal Society of New Zealand. 2010. *Sea Level Rise: Emerging Issues*. Retrieved from http://www.royalsociety.org.nz/2010/09/21/new-paper-on-sea-level-rise

248 http://www.royalsociety.org.nz/expert-advice/information-papers/yr2011/geo-engineering-an-interactive-workshop

249 Source: http://www.victoria.ac.nz/sgees/research-centres/ccri/ccri-about

Institute for Governance and Policy Studies

The Institute for Governance and Policy Studies is part of the School of Government at Victoria University of Wellington. The aim of the Institute is to deliver independent, high-quality and high-impact research that informs the policy-making process and influences policy development and implementation in important areas of public policy. Climate change is a major part of the work.

The Institute for Governance and Policy Studies runs 'roundtable' discussions on particular climate change policy topics that bring together experts and stakeholders from Government, business and non-governmental organisations in a Chatham House Rule[250] setting. Central government agencies, including the Ministry for the Environment, contribute to the cost of the roundtable discussions and are represented on the steering committee. The Institute also runs public events on climate change, including frequent lectures and seminars. Recent topics have included adaptation, agriculture, greenhouse gas metrics, and assessment of the outcomes of UNFCCC meetings, including the implications of the Durban Platform. These activities provide a useful contribution to public policy as well as an opportunity for informal engagement among and with stakeholders.

Motu Economic and Public Policy Research

Motu Economic and Public Policy Research is a non-profit economic and public policy research institute. It is independent but partly funded (through research grants and sponsorship for its Public Policy Seminar Series) by the New Zealand Government.[251] It is currently involved in several projects exploring policies to mitigate and adapt to climate change.[252] Recent Motu public policy seminars covering climate change issues include:[253]

- Creating a Seller: How New Zealand can Effectively Help Reduce Greenhouse Gas Emissions in Developing Countries (Auckland, November 2012)
- The Allocation of Water by the New Zealand Electricity Market: Effects of Particular Climatic Changes (Wellington, November 2012)
- Global and Local Fairness in Climate Policy (Wellington, March 2012)
- The Economics of Climate Change: Why Is It So difficult and Controversial? (Wellington and Auckland seminar, co-hosted with the New Zealand Institute of Economic Research and The Treasury, December 2011).

Antarctic Research Centre

The Antarctic Research Centre is a centre of research excellence within the Faculty of Science of Victoria University of Wellington. It seeks to improve understanding of Antarctic climate history and processes, and assess their impacts within the southwest Pacific region, and

---

250 Participants attending a meeting held under Chatham House Rule are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed. See http://www.chathamhouse.org

251 http://www.motu.org.nz/about. The Motu Public Policy Seminar Series is part sponsored by The Treasury, Statistics New Zealand and the Auckland Policy Office.

252 http://www.motu.org.nz/research/group/climate_change

253 http://www.motu.org.nz/building-capacity/past_public_policy_seminars#2013

specifically on the New Zealand region that includes the Ross Dependency.[254] A key element in the scientific success of the Centre has been the development of expertise in Antarctic geological drilling and ice coring, integrated with numerical modelling of ice sheets and glaciers,[255] to study past climates that are relevant to future projections.[256] More information about this can be found in section 8.4.1.

In terms of public engagement, the Antarctic Research Centre has held several events and seminars over the reporting period on topics relevant to climate change. The Centre also hosts the annual S.T. Lee Lecture in Antarctic Studies. The series has hosted several climate experts, including the following recent lectures:

- 'Linking cryospheric science in China and Antarctica', a lecture by Qin Dahe of the China Meteorology Administration and the State Key Laboratory of Cryospheric Sciences, Chinese Academy of Sciences, China (September 2012)
- 'Waking giants: Ice sheets in a warming world', a lecture by Robert Bindschadler, Emeritus Scientist, Hydrospheric and Biospheric Sciences Laboratory, National Aeronautics and Space Administration, United States of America (May 2010).

Other recent events held or contributed to by the Antarctic Research Centre include:[257]

- the global launch of *Thin Ice: The Inside Story of Climate Science*, a film screening (April 2013)
- 'MBIE big issues: Climate change – What it means for New Zealand' and 'UC Science Cafe: climate change – up close and uncomfortable', presentations at New Zealand Icefest (September 2012)
- 'Our far south', expedition and lunchtime seminars and public talks covering major issues faced in the far south, including 'Is climate change real and have we caused it?' and 'Climate change in our far south' (February–July 2012)
- Climate Futures: Pathways for Society Forum (March–April 2011).

9.4.3 Science Media Centre

The Science Media Centre (SMC)[258] facilitates links between the media and science so that the media have easy access to relevant scientific information. By providing access to evidence-based information and supporting the professional development of journalists and scientists, the SMC improves media coverage of climate change, with the ultimate aim of a better-informed public. The SMC has established one of the most comprehensive databases of experts in New Zealand, featuring over 3000 scientists and researchers, including dozens of climate scientists.

Key activities of the SMC during the reporting period included:

- issuing **rapid round-ups**, quoting climate scientists on new research papers as well as breaking climate-related news, including severe weather events, new research on ozone

---

254 http://www.victoria.ac.nz/antarctic/about

255 http://www.victoria.ac.nz/antarctic/research/glacial-modelling

256 http://www.victoria.ac.nz/antarctic/about/science-drilling-office

257 http://www.victoria.ac.nz/antarctic/about/events/past-events

258 http://www.sciencemediacentre.co.nz

levels, ocean acidification, glaciers, ocean and surface temperature trends, sea-level rise, adaptation to climate change and impacts on biodiversity

- holding **virtual briefings** allowing journalists to dial in to web conferences from their desks to listen to a panel of scientists make presentations on climate science, ask questions, and find leads for science stories – issues covered include the Antarctic ANDRILL ice core drilling project, the potential impact of sea-level rise in New Zealand, and the 2013 New Zealand drought.[259]

In 2011 the SMC partnered with visiting climate change expert Dr Kevin Trenberth to run a briefing for journalists on climate change and extreme weather. The SMC also ran workshops for journalists in Auckland and Wellington featuring *New Scientist* climate change writer Fred Pearce and science writer and historian Erik Conway.

9.4.4 Industry training

Heavy Vehicle Fuel Efficiency training

The Energy Efficiency and Conservation Authority (EECA) launched the Heavy Vehicle Fuel Efficiency programme in September 2012. The programme improves the fuel efficiency of heavy vehicle fleets through expert advice and funding assistance. It builds on the existing SAFED (Safe and Fuel Efficient Driving) campaign[260] and provides comprehensive advice for the freight industry on implementing a range of strategies for improving fuel efficiency.

EECA trains independent and in-company fuel advisors and trainers, and provides grants for fleet audits, information about how to save fuel, and training for fuel-efficient and safe driving.[261] EECA is currently looking at extending the programme into smaller fleets of heavy vehicles and promoting fuel efficiency in light commercial fleets.

9.5 Public engagement

The preparation of the *Sixth National Communication* is a cross-Government effort, with contributions from a wide range of Government agencies and organisations that receive funding or other support from the New Zealand Government. Although the public and non-governmental organisations are not consulted on the content of the *Sixth National Communication*, the Government actively engages with the public on climate change issues and has continued to do so since the last reporting period.

The section below contains information about the Government's engagement with the public during the reporting period. This includes consultation on gazetting the 2050 emissions reduction target, ongoing consultation with Māori, engagement with youth and support for community groups.

---

259 These are available online at http://www.sciencemediacentre.co.nz/category/briefings/

260 http://safednz.govt.nz/

261 http://www.eecabusiness.govt.nz/content/transport-heavy-vehicles

9.5.1 Engaging with the public

Proposals to amend the NZ ETS

As reported in section 4.3.1, since 2009 the Government has consulted with interested parties on a large number of proposals to make technical and detailed amendments to the NZ ETS. These include a consultation on a field measurement approach for post-1989 forests, applying restrictions on the use of certain international units in the NZ ETS, making amendments to the NZ ETS agricultural regulations, and the introduction of pre-1990 forest land offsetting. In addition, in 2011 and 2012 there were substantial public consultations in relation to a statutory review of the NZ ETS, and more substantial changes that required amendments to legislation.

2050 emissions reduction target

As reported in New Zealand's *Fifth National Communication*,[262] the Government consulted with the New Zealand public on a mid-term emissions reduction target in 2009. The public was consulted in early 2011[263] about whether the 2050 emissions reduction target should be notified in the *New Zealand Gazette*. During the consultation period the Ministry for the Environment received 1737 written submissions. A summary of submissions was provided to the Minister and is available on the Ministry for the Environment website.[264]

In March 2011 the Government published notice in the *New Zealand Gazette*[265] of the target of a 50 per cent reduction in New Zealand greenhouse gas emissions from 1990 levels by 2050. More information on the 2050 target can be found in chapter 4.

Climate Change Iwi Leaders Group

The Treaty of Waitangi (Te Tiriti o Waitangi) is at the foundation of the relationship between the New Zealand Government and Māori. There is a shared desire for tenable and long-term solutions for environmental issues, including climate change.

The Ministry for the Environment has a Strategic Relationship Agreement with the Climate Change Iwi Leaders Group (CCILG). The agreement facilitates an open dialogue between Ministers and the CCILG in relation to climate change policies and issues. Meetings between members of the CCILG and the Minister for Climate Change Issues are held at least three times a year to allow frank, informed and open dialogue to improve mutual understanding of interests and issues.

The CCILG is a subset of the wider Iwi Chairs Forum, which meets four times a year, with each hui[266] hosted at different marae[267] throughout the country. Collectively the forum represents more than 400,000 Māori, over two-thirds of the Māori population.

---

262 See section 9.2.1 of New Zealand's Fifth National Communication on Climate Change.

263 The consultation period ran from 31 January to 28 February 2011.

264 http://www.mfe.govt.nz/issues/climate/emissions-target-2050/index.html

265 The official New Zealand Government newspaper.

266 A hui refers to a gathering or meeting. It can involve individuals, a hapū (a grouping of related families) or several hapū, an entire iwi (a larger Māori grouping, sometimes called a tribe), or several iwi.

Sir Peter Blake Youth Enviroleaders Forum

The annual Youth Enviroleaders Forum was established in 2004. It provides an opportunity for 50 young people aged between 15 and 18 to take part in practical environmental projects, voice their opinion on environmental issues and learn firsthand about environmental management. The forum is hosted by the Ministry for the Environment in partnership with the Sir Peter Blake Trust.[268]

Previous forum themes have covered environmentally responsible business, urban water management, sustainable tourism, marine conservation, freshwater management, and resource management practice. In 2010 one of the three topics the Forum focused on was 'reducing our emissions'. The delegates are encouraged to take what they learn at the Forum back to their schools and communities.

Environment centres

Environment centres have received funding from the Ministry for the Environment for the past 12 years. They provide an important community service by educating the public on key environmental issues, including climate change. An environment centre provides projects, activities and services that encourage, inspire and foster communities to take action to improve the environment for the benefit of present and future generations.

Waste Minimisation Fund

Various education and awareness campaigns that reduce landfill waste (with the aim of reducing methane emissions from organic waste) have received public funding through the Waste Minimisation Fund. Examples include the 42 Collective and the Pare Kore projects. The 42 Collective project was awarded funding to incentivise and promote awareness of the benefits associated with sustainable business practice (including waste minimisation) in New Zealand's hospitality sector. The Para Kore (Zero Waste) project has been awarded funding to implement a waste minimisation programme on marae in Waikato, Taranaki and the northern South Island.

9.5.2 Engaging with the land-based sector

The Ministry for Primary Industries is working closely with land-based sectors, local government and Māori under the Sustainable Land Management and Climate Change Plan of Action to ensure effective change can occur on the ground. The Plan of Action has helped to deliver climate change resources and demonstration programmes to rural professionals.

In 2010 the Government funded a 5-year technology transfer programme to promote more resilient farming practices in New Zealand. The programme provides climate change information to land managers and their advisors, runs demonstration programmes and trains

---

[267] Marae are Māori community facilities that usually consist of a carved meeting house, a dining hall and cooking area and the marae ātea (sacred space in front of the meeting house). See http://www.korero.maori.nz/forlearners/protocols/marae.html

[268] The Sir Peter Blake Trust is a private charitable trust established with the support of the Blake family in December 2003 "to help New Zealanders make a positive difference for the planet through activities that encourage environmental awareness and action, and leadership development." See http://www.sirpeterblaketrust.org/get-involved/youth-enviroleaders-forum

rural professionals. A number of reports, fact sheets and case studies have been placed on the Ministry for Primary Industries website, along with a toolbox to help land managers respond to climate change.

This technology transfer programme complements work already being carried out in a range of primary sector organisations. These organisations fund research for industry and technology transfer, and provide training for members.

Coordination and Cooperation for Effective Climate Policy Design and Implementation

The Coordination and Cooperation for Effective Climate Policy Design and Implementation project was funded by the Ministry for Primary Industries and led by Motu Economic and Public Policy Research (Motu). It aimed to provide empirical evidence and a clear conceptual framework to encourage cooperation to enable the NZ ETS to be implemented effectively for agriculture. The research also looked into how to facilitate the coordination required for the rapid uptake of new adaptation and mitigation technology. The project ran from July 2009 to June 2012.

As part of this project, Motu (in collaboration with EcoClimate[269]) ran a professionally facilitated dialogue group (the AgDialogue Group) on how to efficiently control agricultural emissions in the medium term. It was designed to help:

- technical people understand the real-world constraints that must be addressed, making their technical knowledge more applicable
- stakeholders more easily understand the science and economics relevant to addressing allocation and institutional issues.

The dialogue process drew on, and provided feedback to, Motu's research and looked to ensure that agricultural emissions are addressed in a way that is robust, effective, efficient and fair. The group was made up of farmers, Māori, representatives from farm industry groups and non-governmental organisations, and representatives of the New Zealand Government. It was informed by a wide range of climate change experts from many different institutions.

Motu has also produced an environmental trading game, which is freely available for downloading. Participants act as farmers in a nutrient (or emissions) trading system, although the game can be adapted for any other environmental problem. It is suitable for use with any group interested in better understanding these issues, either in an educational or a professional setting, and comes with non-technical instructions.[270]

At the end of the AgDialogue process Motu released a film on New Zealand's greenhouse gas emissions, *The New Zealand Farming Story: Tackling Agricultural Emissions*.[271] This short film covers a wide range of topics, many of which spring directly from the AgDialogue Group's work. In particular, the film addresses ways in which New Zealand could achieve real reductions in agricultural greenhouse gas emissions. The film comes with a range of teaching

---

269 Members of EcoClimate included people from NIWA, Landcare Research / New Zealand Centre for Ecological Economics, Infometrics, AgResearch and GNS Science. See http://www.motu.org.nz/research/group/integrated_economics_of_climate_change

270 More information and the downloadable game can be found at http://www.motu.org.nz/building-capacity/environmental_trading_game

271 http://agriculturalemissions.blogspot.co.nz/2012/10/the-new-zealand-farming-story-tackling.html

materials,[272] including an editable presentation and speaking notes, designed to make it a good resource to use with secondary and tertiary students, farmers, or people working with farmers.

9.6 International engagement

The New Zealand Government has been active in engaging with a broader regional audience on climate change. The section below outlines work undertaken to engage internationally on climate change matters over the last four years.

The New Zealand Government hosted the 42nd Pacific Islands Forum in 2011. In its role as chair of the Forum, the Government focused discussions on the impacts of climate change faced by the Pacific region. In 2013 the Government co-hosted the Pacific Energy Summit with the European Union. The Summit was attended by heads of government and high-level officials from 23 Pacific Island countries, as well as by international and regional representatives and private sector stakeholders.[273] Its aim was to encourage moves towards clean energy in the Pacific and a reduction in the region's fossil fuel dependence.

The Government has also promoted the sharing of technical-level expertise. The Asia–Pacific Carbon Markets Roundtable was initiated by New Zealand in 2011 to promote regional cooperation and information exchange on carbon markets. The initiative brings together senior officials from countries and jurisdictions around the region to discuss and progress the potential development of a regional carbon market.

The Government provides funding to support the technical contribution of New Zealand-based scientists at international scientific unions, such as the International Council for Science and a number of its global research programmes actively involved in coordinating research into climate change, including the International Geosphere-Biosphere Programme and the Scientific Committee on Antarctic Research. This funding ensures the Government is well supported technically and that the scientific and policy advice provided by New Zealand is valued for its excellence, relevance and strategic awareness.

Contribution to the IPCC

The New Zealand Government provides a financial contribution to support New Zealand scientists selected to be part of the writing team for the IPCC's *Fifth Assessment Report*. The authors also receive funding from the Ministry of Business, Innovation and Employment to travel to attend to IPCC meetings.

---

272 http://agriculturalemissions.blogspot.co.nz/2012/10/the-new-zealand-farming-story-tackling.html

273 Heads of government attended from the Cook Islands, the Federated States of Micronesia, French Polynesia, the Republic of Kiribati, New Caledonia, Niue, Samoa, Tokelau and Tonga, along with representatives from American Samoa, the Republic of Nauru, Fiji, Guam, Papua New Guinea, the Republic of the Marshall Islands, the Republic of Palau, Northern Marianas, Pitcairn, the Solomon Islands, Tuvalu, Vanuatu, and Wallis and Futuna. Other international and regional representatives attending included the Association of Small Island States, the Caribbean Community, the European Investment Bank, the International Energy Agency, the International Renewable Energy Agency, Japan, the Pacific Islands Forum Secretariat, the Secretariat of the Pacific Community, the Secretariat of the Pacific Regional Environment Programme, the United Arab Emirates and the United Nations.

The Government hosted the second lead author meeting for the IPCC Working Group III (Mitigation) in March 2012 in Wellington. The meeting was attended by over 230 authors contributing to the IPCC Working Group III's work on the *Fifth Assessment Report*.

Global Research Alliance on Agricultural Greenhouse Gases

The Global Research Alliance on Agricultural Greenhouse Gases was launched in December 2009 and now involves 40 member countries and several international organisations as Alliance partners. (More information about the Alliance is included in chapter 4.) The New Zealand Government's engagement with the Alliance during the reporting period has included sponsoring a series of regional technical workshops. These workshops have helped to build the participants' ability to measure and mitigate greenhouse gas emissions from livestock systems.

A workshop was held in Bangkok, Thailand, in March 2012, on the measurement and mitigation of greenhouse gases in South-East Asian livestock systems. The workshop was jointly hosted by the New Zealand and Thai Governments and four countries from the region participated: Thailand, Indonesia, Malaysia and Vietnam. A regional technical training workshop was held in Nairobi, Kenya, in September 2012. The workshop was hosted by the International Livestock Research Institute (ILRI), and sponsored by the New Zealand Government, the ILRI and its Climate Change Agriculture and Food Security programme.

A third workshop was held in Accra, Ghana, in November 2012, to improve understanding of African farming systems and to document gaps that need to be addressed to enhance the ability to measure, monitor and quantify greenhouse gas emissions. This workshop was jointly hosted by the Governments of Ghana, Canada, France, the Netherlands and New Zealand, and was attended by participants from Benin, Gabon, Ghana, Kenya, Malawi, Mali, Niger, South Africa, Togo, Zambia and Zimbabwe.

The New Zealand Government has also funded a training course to increase the global research capacity in methane measurement. Eight technicians from Indonesia, Malaysia, Thailand, Vietnam, Argentina, Chile, Colombia and Uruguay came to New Zealand for a 3-week intensive training course in January 2013 on 'Methods for the measurement of methane emissions from forage-fed ruminants'.

Asia and Pacific activities

The New Zealand Government (through the Ministry for the Environment) has supported outreach activities in the Pacific on the Pacific-relevant findings of the IPCC Special Report *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, as well as the Pacific Climate Change Science Programme's report *Climate Change in the Pacific: Scientific Assessment and New Research.*

The outreach activities were undertaken in conjunction with the Secretariat of the Pacific Regional Environment Programme 23rd annual meeting in 2013, and the 2012 meeting of the Pacific Platform for Disaster Risk Management. The purpose of the outreach activities was to share and discuss with Ministers and officials the key Pacific-relevant findings from these two reports in order to help them to take climate extremes into account when planning for adaptation, risk management and future development.

New Zealand holds one of the World Meteorological Organization (WMO) Region V (southwest Pacific) seats on the IPCC Bureau, representing not just New Zealand but the other countries in WMO Region V. Prior to the start of the process for the IPCC *Fifth Assessment Report*, the New Zealand Government funded its Bureau member to engage with IPCC focal points, senior officials and scientists in capitals of some of the major countries he represents on the IPCC Bureau. Singapore, Malaysia, and Indonesia were included, and he was joined in this activity by the IPCC Bureau member from Malaysia. The goal was to improve the relevance, coverage and inclusion of material for this region in the *Fifth Assessment Report* and to involve regional stakeholders in the review process and uptake of the findings.

Over the reporting period the 9th and 10th International Conferences on Southern Hemisphere Meteorology and Oceanography were held (in Australia in 2009 and New Caledonia in 2012). Funding was provided by the New Zealand Government to support the participation of young scientists in both meetings.

In 2011 the New Zealand Government provided funding to New Zealand's MetService to deliver in-country training for the Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project for 10 Pacific Island countries and territories. This is a WMO initiative that provides a web-based tool which uses a cascading forecast guidance process. The process is designed to improve the information flow from global centres, to regional meteorological specialised centres, to national meteorological centres. The aim of the training was to increase the ability of national meteorological services in the participating countries to forecast severe weather events. The Cook Islands, Kiribati, Fiji, Niue, Samoa, Solomon Islands, Tuvalu, Tonga, Tokelau and Vanuatu participated.

Other activities

Over the reporting period the New Zealand Government has provided funding to support two UNFCCC workshops under Article 6 of the UNFCCC (education, training and public awareness). In addition, the Government provides funding to support the OECD Global Forum on climate change, which is aimed at promoting dialogue and enhanced understanding between a wide range of countries on technical issues in the international climate change negotiations.

Annex A: Summary of emissions and removals from New Zealand's 2011 national inventory

Common Reporting Format for the provision of inventory information by Annex I Parties to the UNFCCC in April 2013.

Table A.1: Emission trends (CO_2 – Part 1 of 3)

Greenhouse gas source and sink categories	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**22,286.38**	**22,786.24**	**24,632.31**	**24,061.38**	**24,302.75**	**24,338.61**	**25,645.15**	**27,962.68**	**26,325.99**	**27,600.82**
A. Fuel combustion (sectoral approach)	21,827.46	22,232.21	24,092.73	23,543.50	23,762.65	23,838.83	24,979.51	27,234.47	25,619.41	26,985.47
1. Energy industries	5,955.71	6,070.15	7,547.88	6,616.22	5,512.24	4,786.86	5,537.96	7,131.90	5,566.15	6,773.95
2. Manufacturing industries and construction	4,639.31	5,108.70	4,961.34	5,199.27	5,519.51	5,588.69	5,969.64	6,359.03	6,018.43	5,825.60
3. Transport	8,439.17	8,448.12	8,796.62	9,260.52	9,940.00	10,591.24	10,745.02	10,972.32	11,165.21	11,402.64
4. Other sectors	2,793.27	2,605.24	2,786.88	2,467.49	2,790.90	2,872.03	2,726.90	2,771.21	2,869.62	2,983.29
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive emissions from fuels	458.92	554.03	539.58	517.88	540.10	499.78	665.64	728.21	706.58	615.35
1. Solid fuels	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2. Oil and natural gas	458.92	554.03	539.58	517.88	540.10	499.78	665.64	728.21	706.58	615.35
2. Industrial processes	**2,747.77**	**2,890.49**	**2,948.34**	**3,062.56**	**2,943.87**	**3,033.38**	**3,013.10**	**2,950.13**	**3,042.91**	**3,240.23**
A. Mineral products	561.85	572.40	648.53	646.69	625.38	674.58	646.18	695.07	650.95	728.34
B. Chemical industry	430.20	447.73	400.44	423.50	445.41	423.77	410.86	442.09	480.50	527.79

C. Metal production	1,755.71	1,870.36	1,899.37	1,992.36	1,873.08	1,935.03	1,956.06	1,812.97	1,911.47	1,984.09
D. Other production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Production of halocarbons and SF_6										
F. Consumption of halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and other product use	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE
4. Agriculture										
A. Enteric fermentation										
B. Manure management										
C. Rice cultivation										
D. Agricultural soils										
E. Prescribed burning of savannas										
F. Field burning of agricultural residues										
G. Other										
5. Land use, land-use change and forestry(2)	**-28,195.28**	**-29,309.43**	**-28,051.93**	**-27,775.77**	**-26,453.64**	**-24,444.90**	**-23,629.02**	**-24,302.50**	**-25,387.72**	**-25,075.76**
A. Forest land	-27,738.48	-29,024.50	-27,941.93	-27,921.19	-26,871.86	-25,109.93	-24,543.51	-25,513.24	-26,893.04	-26,880.63
B. Cropland	549.43	541.76	534.27	527.27	520.58	510.79	501.15	494.76	488.36	481.96
C. Grassland	-1,275.64	-1,084.31	-891.16	-617.75	-326.40	-57.41	213.06	527.23	839.50	1,155.75
D. Wetlands	167.30	159.59	151.89	144.18	136.47	128.76	121.06	113.35	105.64	97.93
E. Settlements	97.57	93.44	90.38	87.03	82.85	78.10	74.39	70.52	66.89	64.25
F. Other land	4.54	4.58	4.63	4.68	4.73	4.78	4.83	4.88	4.93	4.98

G. Other	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA
6. Waste	**12.91**	**12.91**	**12.90**	**12.78**	**12.78**	**12.62**	**12.25**	**12.16**	**12.05**	**11.41**
A. Solid waste disposal on land	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
B. Wastewater handling										
C. Waste incineration	12.91	12.91	12.90	12.78	12.78	12.62	12.25	12.16	12.05	11.41
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 emissions including net CO_2 from LULUCF	**-3,148.22**	**-3,619.79**	**-458.38**	**-639.05**	**805.76**	**2,939.71**	**5,041.48**	**6,622.47**	**3,993.23**	**5,776.70**
Total CO_2 emissions excluding net CO_2 from LULUCF	**25,047.06**	**25,689.64**	**27,593.54**	**27,136.72**	**27,259.40**	**27,384.61**	**28,670.50**	**30,924.97**	**29,380.96**	**30,852.46**
Memo items:										
International bunkers	**2,340.47**	**2,184.46**	**2,112.96**	**2,188.96**	**2,621.37**	**2,720.77**	**2,690.42**	**2,716.80**	**2,828.65**	**2,735.05**
Aviation	1,308.44	1,269.34	1,245.76	1,271.37	1,268.59	1,585.87	1,611.10	1,597.67	1,752.51	1,818.18
Marine	1,032.03	915.12	867.20	917.59	1,352.77	1,134.89	1,079.32	1,119.13	1,076.14	916.87
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	4,170.91	4,272.00	4,274.71	4,499.04	4,722.08	4,862.89	4,662.02	4,872.75	5,150.82	5,684.30

Table A.1: Emission trends (CO2 – Part 2 of 3)

Greenhouse gas source and sink categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**28,142.26**	**30,145.92**	**30,352.16**	**31,872.96**	**31,477.55**	**32,882.41**	**32,801.85**	**31,957.09**	**33,017.60**	**30,168.01**
A. Fuel combustion (sectoral approach)	27,549.69	29,525.34	29,758.68	31,262.20	30,614.67	31,967.57	31,841.89	30,936.93	31,777.32	28,801.60
1. Energy Industries	6,447.45	7,930.01	7,313.48	8,626.64	8,247.61	10,288.47	10,178.85	8,804.57	9,722.99	7,526.38
2. Manufacturing Industries and Construction	6,091.03	6,441.28	6,713.78	6,109.35	5,592.68	4,794.34	4,746.69	5,194.40	5,236.24	4,907.94
3. Transport	11,942.98	12,022.43	12,494.28	13,029.34	13,330.39	13,392.64	13,523.00	13,649.38	13,667.98	13,492.96
4. Other Sectors	3,068.24	3,131.61	3,237.15	3,496.88	3,443.99	3,492.12	3,393.35	3,288.58	3,150.11	2,874.32
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	592.57	620.58	593.48	610.76	862.88	914.84	959.96	1,020.17	1,240.28	1,366.42
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	592.57	620.58	593.48	610.76	862.88	914.84	959.96	1,020.17	1,240.28	1,366.42
2. Industrial Processes	**3,202.14**	**3,300.36**	**3,273.06**	**3,486.48**	**3,452.86**	**3,500.37**	**3,507.45**	**3,672.02**	**3,432.80**	**3,352.24**
A. Mineral Products	718.53	716.88	706.95	697.25	666.67	756.17	719.13	861.49	807.02	752.15
B. Chemical Industry	514.46	556.59	539.35	574.35	555.90	561.33	617.01	586.28	580.91	629.85
C. Metal Production	1,969.15	2,026.89	2,026.75	2,214.87	2,230.29	2,182.86	2,171.31	2,224.25	2,044.87	1,970.24
D. Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										

G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry[(2)]	**-23,970.47**	**-22,783.72**	**-19,506.73**	**-21,035.45**	**-22,358.74**	**-21,721.15**	**-19,742.48**	**-18,013.17**	**-23,622.69**	**-21,890.86**
A. Forest Land	-27,172.73	-26,211.30	-23,009.22	-25,970.69	-29,476.62	-32,868.71	-32,771.58	-35,057.55	-27,597.24	-25,777.06
B. Cropland	482.10	475.41	462.59	454.80	458.98	470.38	469.62	477.92	396.57	387.41
C. Grassland	2,548.51	2,790.99	2,893.24	4,332.90	6,494.78	10,472.86	12,339.98	16,314.89	3,473.55	3,424.98
D. Wetlands	90.23	82.52	74.81	67.10	59.39	51.69	43.98	36.27	28.56	20.86
E. Settlements	70.43	67.87	62.85	66.77	79.89	107.13	119.58	142.78	45.43	34.76
F. Other Land	10.99	10.80	8.99	13.68	24.83	45.49	55.94	72.54	30.45	18.19
G. Other	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
6. Waste	**5.89**	**5.89**	**5.31**	**4.73**	**4.48**	**3.63**	**2.42**	**0.93**	**0.92**	**0.92**
A. Solid Waste Disposal on Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
B. Waste-water Handling										

C. Waste Incineration	5.89	5.89	5.31	4.73	4.48	3.63	2.42	0.93	0.92	0.92
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 emissions including net CO_2 from LULUCF	**7,379.83**	**10,668.45**	**14,123.80**	**14,328.73**	**12,576.14**	**14,665.26**	**16,569.24**	**17,616.88**	**12,828.63**	**11,630.33**
Total CO_2 emissions excluding net CO_2 from LULUCF	**31,350.29**	**33,452.17**	**33,630.53**	**35,364.17**	**34,934.88**	**36,386.41**	**36,311.72**	**35,630.04**	**36,451.32**	**33,521.18**
Memo Items:										
International Bunkers	**2,529.93**	**2,735.17**	**2,804.24**	**2,837.22**	**2,935.47**	**3,168.80**	**3,115.40**	**3,243.59**	**3,387.16**	**3,253.63**
Aviation	1,782.08	1,923.79	1,914.64	1,982.35	2,205.81	2,188.78	2,158.28	2,264.65	2,281.08	2,171.68
Marine	747.86	811.38	889.60	854.88	729.66	980.02	957.11	978.95	1,106.08	1,081.94
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass	6,179.65	6,101.35	6,555.89	6,628.28	7,124.39	7,091.42	7,059.56	6,762.74	6,300.15	5,844.31

Table A.1: Emission trends (CO_2 – Part 3 of 3)

Greenhouse gas source and sink categories	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
1. Energy	**29,776.98**	**29,663.18**	**33.10**
A. Fuel combustion (sectoral approach)	28,340.30	28,254.63	29.45
1. Energy Industries	6,758.18	6,452.31	8.34
2. Manufacturing Industries and Construction	5,094.34	4,966.76	7.06
3. Transport	13,641.85	13,835.30	63.94
4. Other Sectors	2,845.93	3,000.25	7.41
5. Other	NA	NA	0.00
B. Fugitive Emissions from Fuels	1,436.67	1,408.55	206.93
1. Solid Fuels	NA,NO	NA,NO	0.00
2. Oil and Natural Gas	1,436.67	1,408.55	206.93
2. Industrial Processes	**3,625.25**	**3,498.11**	**27.31**
A. Mineral Products	719.96	699.68	24.53
B. Chemical Industry	630.02	536.43	24.69
C. Metal Production	2,275.27	2,262.01	28.84
D. Other Production	NA	NA	0.00

E. Production of Halocarbons and SF_6			
F. Consumption of Halocarbons and SF_6			
G. Other	NA	NA	0.00
3. Solvent and Other Product Use	NA,NE	NA,NE	0.00
4. Agriculture			
A. Enteric Fermentation			
B. Manure Management			
C. Rice Cultivation			
D. Agricultural Soils			
E. Prescribed Burning of Savannas			
F. Field Burning of Agricultural Residues			
G. Other			
5. Land use, land-use change and forestry[(2)]	**-17,883.35**	**-13,606.02**	**-51.74**
A. Forest Land	-21,383.09	-17,758.32	-35.98
B. Cropland	382.90	381.89	-30.49
C. Grassland	3,051.01	3,713.53	-391.11
D. Wetlands	20.86	20.86	-87.53
E. Settlements	34.73	34.70	-64.44
F. Other Land	10.24	1.32	-70.87
G. Other	IE,NA	IE,NA	0.00
6. Waste	**0.92**	**0.92**	**-92.84**

A. Solid waste disposal on land	NE,NO	NE,NO	0.00
B. Waste-water Handling			
C. Waste Incineration	0.92	0.92	-92.84
D. Other	NO	NO	0.00
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**0.00**
Total CO_2 emissions including net CO_2 from LULUCF	**15,519.81**	**19,556.20**	**-721.18**
Total CO_2 emissions excluding net CO_2 from LULUCF	**33,403.15**	**33,162.22**	**32.40**
Memo Items:			
International Bunkers	**3,345.03**	**3,248.79**	**38.81**
Aviation	2,294.73	2,314.89	76.92
Marine	1,050.31	933.90	-9.51
Multilateral Operations	NO	NO	0.00
CO_2 Emissions from Biomass	6,543.13	6,612.89	58.55

Table A.2: Emissions trends (CH_4 – Part 1 of 3)

Greenhouse gas source and sink categories	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	48.20	44.85	45.52	44.35	44.34	45.57	56.07	53.63	52.18	58.05
A. Fuel combustion (sectoral approach)	9.26	9.55	8.90	8.82	9.02	9.56	10.23	10.25	9.81	10.18
1. Energy Industries	0.22	0.24	0.27	0.25	0.21	0.18	0.22	0.29	0.23	0.28
2. Manufacturing Industries and Construction	1.47	2.16	1.93	2.11	2.54	3.35	4.27	4.42	4.23	4.84
3. Transport	4.01	3.94	3.79	3.64	3.40	3.17	2.89	2.69	2.49	2.26
4. Other Sectors	3.56	3.21	2.91	2.81	2.88	2.86	2.85	2.85	2.86	2.80
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	38.94	35.30	36.62	35.53	35.31	36.00	45.84	43.38	42.37	47.87
1. Solid Fuels	13.07	8.73	8.91	8.63	10.19	12.88	19.07	13.44	15.50	17.07
2. Oil and Natural Gas	25.87	26.57	27.72	26.90	25.13	23.13	26.76	29.94	26.87	30.80
2. Industrial Processes	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
C. Metal Production	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO
D. Other Production										

E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use										
4. Agriculture	**1,082.79**	**1,094.21**	**1,074.04**	**1,080.06**	**1,110.67**	**1,120.27**	**1,136.27**	**1,164.31**	**1,129.01**	**1,141.98**
A. Enteric Fermentation	1,059.09	1,069.92	1,050.17	1,055.72	1,085.63	1,094.89	1,109.99	1,137.28	1,102.86	1,115.79
B. Manure Management	21.74	22.24	22.18	22.55	23.47	24.17	24.82	25.48	24.94	25.03
C. Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Prescribed Burning of Savannas	1.06	1.25	0.93	0.92	0.65	0.41	0.54	0.50	0.26	0.22
F. Field burning of agricultural residues	0.90	0.80	0.76	0.87	0.92	0.80	0.92	1.05	0.94	0.94
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land use, land-use change and forestry	**2.74**	**1.82**	**2.46**	**3.26**	**3.86**	**3.50**	**4.08**	**3.93**	**5.16**	**3.32**
A. Forest Land	0.92	0.76	1.11	1.28	1.80	1.60	1.86	2.05	1.50	1.07
B. Cropland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Grassland	1.82	1.05	1.35	1.97	2.05	1.90	2.22	1.88	3.66	2.26
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
F. Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE
6. Waste	**90.45**	**91.79**	**92.29**	**92.89**	**88.47**	**89.70**	**90.89**	**91.61**	**91.44**	**91.21**

A. Solid waste disposal on land	72.11	72.56	73.25	74.00	68.79	69.57	70.46	71.06	70.99	71.24
B. Waste-water Handling	18.34	19.23	19.03	18.90	19.67	20.14	20.42	20.55	20.45	19.98
C. Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CH_4 emissions including CH_4 from LULUCF	**1,224.18**	**1,232.67**	**1,214.31**	**1,220.56**	**1,247.33**	**1,259.03**	**1,287.32**	**1,313.49**	**1,277.79**	**1,294.57**
Total CH_4 emissions excluding CH_4 from LULUCF	**1,221.44**	**1,230.85**	**1,211.85**	**1,217.30**	**1,243.47**	**1,255.54**	**1,283.23**	**1,309.55**	**1,272.63**	**1,291.24**
Memo Items:										
International Bunkers	0.09	0.08	0.08	0.08	0.12	0.10	0.10	0.10	0.10	0.09
Aviation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Marine	0.08	0.07	0.07	0.07	0.11	0.09	0.09	0.09	0.09	0.08
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

Table A.2: Emissions trends (CH_4 – Part 2 of 3)

Greenhouse gas source and sink categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	59.13	60.59	58.67	49.08	44.96	44.17	48.78	44.97	48.52	53.37
A. Fuel combustion (sectoral approach)	10.73	10.08	10.31	7.69	7.86	6.31	6.24	6.17	6.15	6.57
a. 1. Energy Industries	0.27	0.33	0.28	0.28	0.22	0.28	0.28	0.31	0.28	0.24
b. 2. Manufacturing Industries and Construction	5.61	5.05	5.41	2.79	3.10	1.60	1.71	1.73	1.94	2.38
c. 3. Transport	2.09	2.05	2.00	1.94	1.86	1.75	1.62	1.55	1.44	1.38
d. 4. Other Sectors	2.76	2.65	2.62	2.68	2.68	2.68	2.62	2.56	2.48	2.57
e. 5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	48.41	50.51	48.35	41.39	37.10	37.86	42.54	38.81	42.37	46.80
f. 1. Solid Fuels	16.77	16.98	16.86	15.83	14.85	15.72	20.04	12.79	16.15	21.06
g. 2. Oil and Natural Gas	31.64	33.54	31.49	25.56	22.25	22.14	22.51	26.01	26.22	25.73
2. Industrial Processes	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
C. Metal Production	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO

D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use										
4. Agriculture	**1,176.35**	**1,177.85**	**1,175.51**	**1,196.71**	**1,196.32**	**1,211.73**	**1,213.75**	**1,163.66**	**1,121.19**	**1,136.71**
A. Enteric Fermentation	1,148.75	1,149.54	1,146.78	1,167.04	1,166.69	1,181.78	1,183.44	1,133.40	1,091.43	1,106.42
B. Manure Management	26.25	26.96	27.35	28.36	28.60	28.69	29.03	28.54	28.32	29.16
C. Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
h. E. Prescribed Burning of Savannas	i.	j.	k.	l.	m	n.	o.	p.	q.	r.
F. Field Burning of Agricultural Residues	0.94	1.04	1.03	0.98	0.73	0.88	0.82	1.02	0.90	0.92
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land use, land-use change and forestry	**2.64**	**2.74**	**2.73**	**2.71**	**2.03**	**2.64**	**2.26**	**2.87**	**2.12**	**2.85**
A. Forest Land	1.10	1.01	0.98	0.89	0.80	0.72	0.70	1.09	0.76	1.04
B. Cropland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Grassland	1.54	1.73	1.76	1.81	1.23	1.93	1.55	1.78	1.36	1.81
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
F. Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

G. Other	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE
6. Waste	**92.46**	**93.63**	**94.53**	**92.20**	**92.74**	**94.47**	**92.04**	**91.05**	**89.26**	**88.66**
A. Solid waste disposal on land	71.76	72.52	73.52	70.69	71.26	72.08	69.67	69.04	67.01	66.94
B. Waste-water Handling	20.70	21.12	21.01	21.50	21.48	22.39	22.37	22.00	22.25	21.72
C. Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CH_4 emissions including CH_4 from LULUCF	**1,330.58**	**1,334.81**	**1,331.44**	**1,340.69**	**1,336.05**	**1,353.02**	**1,356.83**	**1,302.55**	**1,261.09**	**1,281.60**
Total CH_4 emissions excluding CH_4 from LULUCF	**1,327.94**	**1,332.07**	**1,328.70**	**1,337.99**	**1,334.02**	**1,350.37**	**1,354.57**	**1,299.68**	**1,258.98**	**1,278.74**
Memo Items:										
International Bunkers	0.08	0.08	0.09	0.09	0.08	0.10	0.10	0.10	0.11	0.11
Aviation	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Marine	0.06	0.07	0.08	0.07	0.06	0.09	0.08	0.09	0.10	0.10
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

Table A.2: Emissions trends (CH_4 – Part 3 of 3)

Greenhouse gas source and sink categories	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
1. Energy	59.78	50.50	4.78
A. Fuel combustion (sectoral approach)	6.51	6.47	-30.08
1. Energy Industries	0.26	0.23	7.33
2. Manufacturing industries and construction	2.49	2.51	70.34
3. Transport	1.32	1.25	-68.82
4. Other Sectors	2.44	2.48	-30.31
5. Other	NA	NA	0.00
B. Fugitive Emissions from Fuels	53.27	44.03	13.07
1. Solid Fuels	26.30	18.60	42.34
2. Oil and Natural Gas	26.97	25.42	-1.72
2. Industrial Processes	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**0.00**
A. Mineral Products	NA	NA	0.00
B. Chemical Industry	IE,NA,NO	IE,NA,NO	0.00
C. Metal Production	IE,NA,NE,NO	IE,NA,NE,NO	0.00
D. Other Production			
E. Production of Halocarbons and SF_6			

F. Consumption of Halocarbons and SF_6			
G. Other	NA	NA	0.00
3. Solvent and Other Product Use			
4. Agriculture	**1,132.87**	**1,151.76**	**6.37**
A. Enteric Fermentation	1,101.73	1,119.89	5.74
B. Manure Management	29.83	30.82	41.75
C. Rice Cultivation	NO	NO	0.00
D. Agricultural Soils	NE,NO	NE,NO	0.00
E. Prescribed Burning of Savannas	0.31	0.29	-72.54
F. Field Burning of Agricultural Residues	1.01	0.75	-16.85
G. Other	NO	NO	0.00
5. Land use, land-use change and forestry	**2.59**	**2.45**	**-10.54**
A. Forest Land	0.86	0.74	-19.23
B. Cropland	NE	NE	0.00
C. Grassland	1.73	1.71	-6.18
D. Wetlands	NE	NE	0.00
E. Settlements	NE	NE	0.00
F. Other Land	NE	NE	0.00
G. Other	IE,NA,NE	IE,NA,NE	0.00
6. Waste	**87.14**	**85.85**	**-5.09**
A. Solid waste disposal on land	65.05	63.38	-12.10

B. Waste-water Handling	22.09	22.46	22.47
C. Waste Incineration	0.00	0.00	-44.40
D. Other	NO	NO	0.00
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**0.00**
Total CH_4 emissions including CH_4 from LULUCF	**1,282.39**	**1,290.55**	**5.42**
Total CH_4 emissions excluding CH_4 from LULUCF	**1,279.80**	**1,288.10**	**5.46**
Memo Items:			
International Bunkers	0.11	0.10	8.60
Aviation	0.02	0.02	75.40
Marine	0.09	0.08	0.88
Multilateral Operations	NO	NO	0.00
CO_2 emissions from biomass			

Table A.3: Emissions trends (N_2O – Part 1 of 3)

Greenhouse gas source and sink categories	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**0.61**	**0.61**	**0.65**	**0.68**	**0.72**	**0.75**	**0.75**	**0.79**	**0.80**	**0.85**
A. Fuel combustion (sectoral approach)	0.61	0.61	0.65	0.68	0.72	0.75	0.75	0.79	0.80	0.85
1. Energy Industries	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.03
2. Manufacturing Industries and Construction	0.17	0.18	0.18	0.19	0.20	0.20	0.19	0.20	0.21	0.22
3. Transport	0.33	0.34	0.36	0.38	0.41	0.43	0.44	0.46	0.47	0.49
4. Other Sectors	0.09	0.08	0.09	0.09	0.09	0.10	0.09	0.10	0.10	0.10
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
2. Industrial Processes	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF_6										

F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	0.13	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15
4. Agriculture	**25.56**	**25.92**	**25.64**	**26.33**	**27.42**	**28.24**	**28.57**	**29.04**	**28.56**	**29.05**
A. Enteric Fermentation										
B. Manure Management	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10
C. Rice Cultivation										
D. Agricultural Soils	25.43	25.79	25.51	26.21	27.29	28.11	28.44	28.91	28.44	28.93
E. Prescribed Burning of Savannas	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
F. Field burning of agricultural residues	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land use, land-use change and forestry	**0.08**	**0.07**	**0.07**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.09**	**0.07**
A. Forest Land	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
B. Cropland	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05
C. Grassland	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.03	0.02
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
F. Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE
6. Waste	**0.47**	**0.48**	**0.49**	**0.50**	**0.50**	**0.52**	**0.53**	**0.53**	**0.53**	**0.53**
A. Solid waste disposal on land										

B. Waste-water Handling	0.47	0.48	0.48	0.49	0.50	0.52	0.52	0.53	0.53	0.52
C. Waste Incineration	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total N_2O emissions including N_2O from LULUCF	**26.86**	**27.23**	**26.99**	**27.73**	**28.86**	**29.73**	**30.08**	**30.59**	**30.13**	**30.64**
Total N_2O emissions excluding N_2O from LULUCF	**26.78**	**27.16**	**26.91**	**27.65**	**28.78**	**29.65**	**30.00**	**30.51**	**30.05**	**30.57**
Memo Items:										
International Bunkers	**0.08**	**0.07**	**0.07**	**0.07**	**0.08**	**0.09**	**0.08**	**0.08**	**0.08**	**0.08**
Aviation	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Marine	0.04	0.04	0.03	0.03	0.05	0.04	0.04	0.04	0.04	0.03
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

Table A.3: Emissions trends (N_2O – Part 2 of 3)

Greenhouse gas source and sink categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**0.88**	**0.91**	**0.96**	**1.04**	**1.09**	**1.11**	**1.09**	**1.03**	**1.01**	**0.94**
A. Fuel combustion (sectoral approach)	0.88	0.91	0.96	1.04	1.09	1.11	1.09	1.03	1.01	0.94
1. Energy Industries	0.03	0.04	0.03	0.06	0.08	0.09	0.09	0.05	0.08	0.05
2. Manufacturing Industries and Construction	0.24	0.25	0.27	0.28	0.29	0.29	0.28	0.28	0.26	0.24
3. Transport	0.51	0.52	0.55	0.58	0.61	0.61	0.59	0.58	0.55	0.53
4. Other Sectors	0.10	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.11	0.11
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
2. Industrial Processes	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

3. Solvent and Other Product Use	0.15	0.15	0.18	0.17	0.16	0.14	0.13	0.14	0.10	0.09
4. Agriculture	**30.18**	**31.33**	**32.44**	**33.46**	**33.63**	**34.00**	**33.64**	**32.29**	**31.57**	**31.06**
A. Enteric Fermentation										
B. Manure Management	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11
C. Rice Cultivation										
D. Agricultural Soils	30.05	31.20	32.31	33.33	33.49	33.87	33.50	32.14	31.44	30.93
E. Prescribed Burning of Savannas	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
F. Field Burning of Agricultural Residues	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.02
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land use, land-use change and forestry	**0.06**	**0.06**	**0.06**	**0.06**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
A. Forest Land	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01
B. Cropland	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03
C. Grassland	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
F. Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE	IE,NA,NE
6. Waste	**0.54**	**0.54**	**0.55**	**0.57**	**0.58**	**0.59**	**0.59**	**0.59**	**0.60**	**0.58**
A. Solid waste disposal on land										
B. Waste-water Handling	0.53	0.54	0.55	0.57	0.58	0.58	0.58	0.58	0.59	0.58
C. Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total N_2O emissions including N_2O from LULUCF	**31.81**	**32.99**	**34.19**	**35.30**	**35.50**	**35.89**	**35.49**	**34.10**	**33.32**	**32.72**
Total N_2O emissions excluding N_2O from LULUCF	**31.75**	**32.93**	**34.13**	**35.24**	**35.45**	**35.84**	**35.44**	**34.05**	**33.27**	**32.67**
Memo Items:										
International Bunkers	**0.07**	**0.08**	**0.08**	**0.08**	**0.08**	**0.09**	**0.09**	**0.09**	**0.10**	**0.09**
Aviation	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Marine	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

Table A.3: Emissions trends (N_2O – Part 3 of 3)

Greenhouse gas source and sink categories	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
1. Energy	**0.92**	**0.90**	**47.79**
A. Fuel combustion (sectoral approach)	0.92	0.90	47.79
1. Energy Industries	0.03	0.04	105.39
2. Manufacturing Industries and Construction	0.26	0.26	51.79
3. Transport	0.52	0.49	49.46
4. Other Sectors	0.10	0.11	21.71
5. Other	NA	NA	0.00
B. Fugitive Emissions from Fuels	IE,NA,NO	IE,NA,NO	0.00
1. Solid Fuels	NA,NO	NA,NO	0.00
2. Oil and Natural Gas	IE,NA,NO	IE,NA,NO	0.00
2. Industrial Processes	**NA,NO**	**NA,NO**	**0.00**
A. Mineral Products	NA	NA	0.00
B. Chemical Industry	NA,NO	NA,NO	0.00
C. Metal Production	NA	NA	0.00
D. Other Production			
E. Production of Halocarbons and SF_6			

F. Consumption of Halocarbons and SF_6			
G. Other	NA	NA	0.00
3. Solvent and Other Product Use	0.10	0.09	-32.84
4. Agriculture	**32.04**	**32.90**	**28.74**
A. Enteric Fermentation			
B. Manure Management	0.11	0.12	38.71
C. Rice Cultivation			
D. Agricultural Soils	31.90	32.77	28.84
E. Prescribed burning of savannas	0.01	0.01	-72.54
F. Field burning of agricultural residues	0.02	0.01	-19.51
G. Other	NO	NO	0.00
5. Land use, land-use change and forestry	**0.05**	**0.05**	**-42.71**
A. Forest Land	0.01	0.01	-19.23
B. Cropland	0.03	0.03	-52.91
C. Grassland	0.01	0.01	-7.75
D. Wetlands	NE	NE	0.00
E. Settlements	NE	NE	0.00
F. Other Land	NE	NE	0.00
G. Other	IE,NA,NE	IE,NA,NE	0.00
6. Waste	**0.59**	**0.59**	**23.94**
A. Solid waste disposal on land			

B. Waste-water Handling	0.58	0.58	24.45
C. Waste Incineration	0.00	0.00	-21.77
D. Other	NO	NO	0.00
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**0.00**
Total N_2O emissions including N_2O from LULUCF	**33.69**	**34.53**	**28.57**
Total N_2O emissions excluding N_2O from LULUCF	**33.64**	**34.48**	**28.78**
Memo Items:			
International Bunkers	**0.09**	**0.09**	**22.67**
Aviation	0.06	0.06	75.40
Marine	0.03	0.03	-28.09
Multilateral Operations	NO	NO	0.00
CO_2 Emissions from Biomass			

Table A.4: Emission trends (HFCs, PFCs and SF_6 – Part 1 of 3)

Greenhouse gas source and sink categories	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of HFCs[3] - (Gg CO_2 equivalent)	**NA,NO**	**NA,NO**	**1.30**	**2.60**	**57.57**	**122.81**	**198.01**	**61.96**	**257.52**	**264.46**
HFC-23	NA,NO	NA,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-32	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.00	0.01
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-125	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.01	0.00	0.01	0.01
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-134a	NA,NO	NA,NO	0.00	0.00	0.04	0.08	0.12	0.04	0.16	0.14
HFC-152a	NA,NO	NA,NO	NA,NE,NO	NA,NE,NO	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-143a	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.01	0.00	0.01	0.01
HFC-227ea	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed HFCs[4] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of PFCs[3] - (Gg CO_2 equivalent)	**629.87**	**625.05**	**396.61**	**180.45**	**159.87**	**131.16**	**236.77**	**172.52**	**125.34**	**58.96**

CF_4	0.08	0.08	0.05	0.02	0.02	0.02	0.03	0.02	0.01	0.01
C_2F_6	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_3F_8	NA,NO	NA,NO	NA,NO	NA,NO	NA,NE,NO	0.00	0.00	0.00	0.01	NA,NE,NO
C_4F_{10}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
c-C_4F_8	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_5F_{12}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_6F_{14}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed PFCs[(4)] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of SF6[(3)] - (Gg CO_2 equivalent)	**15.20**	**15.77**	**16.49**	**16.93**	**17.29**	**17.88**	**17.65**	**18.17**	**16.90**	**16.06**
SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A.4: Emission trends (HFCs, PFCs and SF_6 – Part 2 of 3)

Greenhouse gas source and sink categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of HFCs[3] - (Gg CO_2 equivalent)	**252.99**	**336.04**	**504.64**	**664.65**	**452.07**	**712.16**	**666.41**	**927.66**	**807.26**	**872.41**
HFC-23	NA,NE,NO	NA,NE,NO	0.00	0.00	NA,NE,NO	NA,NE,NO	0.00	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-32	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.02
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-125	0.01	0.02	0.04	0.05	0.04	0.07	0.06	0.09	0.09	0.09
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-134a	0.15	0.15	0.20	0.22	0.15	0.21	0.22	0.25	0.20	0.23
HFC-152a	NA,NE,NO	0.00	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-143a	0.01	0.02	0.04	0.06	0.04	0.07	0.05	0.09	0.07	0.08
HFC-227ea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed HFCs[4] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of PFCs[3] - (Gg CO_2 equivalent)	**58.06**	**60.64**	**71.91**	**107.83**	**84.53**	**59.57**	**90.99**	**41.47**	**38.84**	**46.14**
CF_4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01

C_2F_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_3F_8	NA,NE,NO	NA,NE,NO	0.00	0.00	0.00	NA,NE,NO	0.00	0.00	0.00	0.00
C_4F_{10}	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
c-C_4F_8	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_5F_{12}	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_6F_{14}	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed PFCs[4] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of SF6[3] - (Gg CO_2 equivalent)	**10.57**	**10.91**	**14.92**	**17.60**	**22.31**	**19.03**	**15.47**	**14.70**	**15.13**	**19.79**
SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A.4: Emission trends (HFCs, PFCs and SF_6 – Part 3 of 3)

Greenhouse gas source and sink categories	2010	2011	Change from base to latest reported year
	(Gg)	(Gg)	%
Emissions of HFCs[3] - (Gg CO_2 equivalent)	**1,077.69**	**1,885.07**	**100.00**
HFC-23	0.00	NA,NE,NO	0.00
HFC-32	0.03	0.04	100.00
HFC-41	NA,NO	NA,NO	0.00
HFC-43-10mee	NA,NO	NA,NO	0.00
HFC-125	0.12	0.15	100.00
HFC-134	NA,NO	NA,NO	0.00
HFC-134a	0.30	0.77	100.00
HFC-152a	NA,NE,NO	NA,NE,NO	0.00
HFC-143	NA,NO	NA,NO	0.00
HFC-143a	0.09	0.11	100.00
HFC-227ea	0.00	0.00	100.00
HFC-236fa	NA,NO	NA,NO	0.00
HFC-245ca	NA,NO	NA,NO	0.00
Unspecified mix of listed HFCs[4] - (Gg CO_2 equivalent)	NA,NO	NA,NO	0.00

Emissions of PFCs[3] - (Gg CO_2 equivalent)	**40.81**	**30.18**	**-95.21**
CF_4	0.01	0.00	-95.16
C_2F_6	0.00	0.00	-95.48
C_3F_8	NA,NE,NO	NA,NE,NO	0.00
C_4F_{10}	NA,NO	NA,NO	0.00
$c\text{-}C_4F_8$	NA,NO	NA,NO	0.00
C_5F_{12}	NA,NO	NA,NO	0.00
C_6F_{14}	NA,NO	NA,NO	0.00
Unspecified mix of listed PFCs[4] - (Gg CO_2 equivalent)	NA,NO	NA,NO	0.00
Emissions of SF6[3] - (Gg CO_2 equivalent)	**20.46**	**17.62**	**15.89**
SF_6	0.00	0.00	15.89

Table A.5: Emissions trends summary (Part 1 of 3)

Greenhouse gas emissions	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)
CO_2 emissions including net CO_2 from LULUCF	-3,148.22	-3,619.79	-458.38	-639.05	805.76	2,939.71	5,041.48	6,622.47	3,993.23	5,776.70
CO_2 emissions excluding net CO_2 from LULUCF	25,047.06	25,689.64	27,593.54	27,136.72	27,259.40	27,384.61	28,670.50	30,924.97	29,380.96	30,852.46
CH_4 emissions including CH_4 from LULUCF	25,707.88	25,886.01	25,500.47	25,631.67	26,193.92	26,439.71	27,033.69	27,583.20	26,833.59	27,185.90
CH_4 emissions excluding CH_4 from LULUCF	25,650.33	25,847.83	25,448.78	25,563.31	26,112.93	26,366.26	26,947.92	27,500.65	26,725.21	27,116.12
N_2O emissions including N_2O from LULUCF	8,325.64	8,440.87	8,365.85	8,595.67	8,947.52	9,216.11	9,324.16	9,483.51	9,340.62	9,499.53
N_2O emissions excluding N_2O from LULUCF	8,300.60	8,418.47	8,342.68	8,571.07	8,922.25	9,192.22	9,299.44	9,459.60	9,314.00	9,477.83
HFCs	NA,NO	NA,NO	1.30	2.60	57.57	122.81	198.01	61.96	257.52	264.46
PFCs	629.87	625.05	396.61	180.45	159.87	131.16	236.77	172.52	125.34	58.96
SF_6	15.20	15.77	16.49	16.93	17.29	17.88	17.65	18.17	16.90	16.06
Total (including LULUCF)	**31,530.38**	**31,347.91**	**33,822.33**	**33,788.27**	**36,181.93**	**38,867.38**	**41,851.76**	**43,941.84**	**40,567.18**	**42,801.61**
Total (excluding LULUCF)	**59,643.06**	**60,596.77**	**61,799.40**	**61,471.09**	**62,529.32**	**63,214.93**	**65,370.28**	**68,137.87**	**65,819.91**	**67,785.89**

Greenhouse gas source and sink categories	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)
1. Energy	23,487.69	23,918.61	25,789.93	25,202.21	25,455.66	25,527.32	27,055.39	29,333.60	27,670.39	29,082.25
2. Industrial Processes	3,392.84	3,531.31	3,362.73	3,262.54	3,178.60	3,305.23	3,465.54	3,202.79	3,442.66	3,579.70
3. Solvent and Other Product Use	41.54	42.78	43.09	43.71	44.33	44.95	45.88	46.19	46.50	46.81
4. Agriculture	30,661.93	31,013.22	30,501.98	30,844.27	31,823.91	32,279.28	32,719.57	33,453.46	32,563.45	32,986.85
5. Land use, land-use change and forestry(5)	-28,112.69	-29,248.85	-27,977.07	-27,682.82	-26,347.39	-24,347.55	-23,518.52	-24,196.04	-25,252.72	-24,984.28
6. Waste	2,059.06	2,090.84	2,101.66	2,118.36	2,026.81	2,058.15	2,083.91	2,101.84	2,096.90	2,090.28
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)(5)	**31,530.38**	**31,347.91**	**33,822.33**	**33,788.27**	**36,181.93**	**38,867.38**	**41,851.76**	**43,941.84**	**40,567.18**	**42,801.61**

Table A.5: Emissions trends summary (Part 2 of 3)

Greenhouse gas emissions	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)
CO_2 emissions including net CO_2 from LULUCF	7,379.83	10,668.45	14,123.80	14,328.73	12,576.14	14,665.26	16,569.24	17,616.88	12,828.63	11,630.33
CO_2 emissions excluding net CO_2 from LULUCF	31,350.29	33,452.17	33,630.53	35,364.17	34,934.88	36,386.41	36,311.72	35,630.04	36,451.32	33,521.18
CH_4 emissions including CH_4 from LULUCF	27,942.10	28,031.05	27,960.19	28,154.52	28,056.95	28,413.38	28,493.43	27,353.51	26,482.97	26,913.52
CH_4 emissions excluding CH_4 from LULUCF	27,886.67	27,973.50	27,902.79	28,097.71	28,014.41	28,357.86	28,446.06	27,293.19	26,438.52	26,853.62

N_2O emissions including N_2O from LULUCF	9,861.97	10,226.83	10,600.01	10,942.98	11,006.07	11,126.12	11,001.90	10,570.57	10,329.31	10,142.88
N_2O emissions excluding N_2O from LULUCF	9,842.14	10,207.49	10,581.35	10,924.69	10,989.90	11,109.37	10,986.44	10,554.05	10,315.14	10,127.80
HFCs	252.99	336.04	504.64	664.65	452.07	712.16	666.41	927.66	807.26	872.41
PFCs	58.06	60.64	71.91	107.83	84.53	59.57	90.99	41.47	38.84	46.14
SF_6	10.57	10.91	14.92	17.60	22.31	19.03	15.47	14.70	15.13	19.79
Total (including LULUCF)	**45,505.52**	**49,333.91**	**53,275.47**	**54,216.32**	**52,198.07**	**54,995.52**	**56,837.43**	**56,524.78**	**50,502.14**	**49,625.06**
Total (excluding LULUCF)	**69,400.72**	**72,040.75**	**72,706.13**	**75,176.66**	**74,498.10**	**76,644.41**	**76,517.08**	**74,461.10**	**74,066.21**	**71,440.94**

Greenhouse gas source and sink categories	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO_2 equivalent (Gg)	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**	**CO_2 equivalent (Gg)**
1. Energy	29,657.78	31,699.45	31,882.25	33,225.21	32,758.21	34,153.07	34,163.05	33,219.96	34,348.54	31,579.38
2. Industrial Processes	3,523.76	3,707.94	3,864.52	4,276.57	4,011.77	4,291.13	4,280.32	4,655.84	4,294.03	4,290.58
3. Solvent and other product use	47.12	47.43	56.11	52.39	48.36	44.33	40.30	43.40	31.00	27.90
4. Agriculture	34,058.41	34,445.63	34,742.02	35,503.54	35,547.00	35,986.34	35,916.19	34,446.62	33,332.24	33,500.42
5. Land use, land-use change and forestry(5)	-23,895.20	-22,706.84	-19,430.67	-20,960.35	-22,300.03	-21,648.89	-19,679.65	-17,936.32	-23,564.07	-21,815.88
6. Waste	2,113.65	2,140.30	2,161.23	2,118.96	2,132.77	2,169.55	2,117.21	2,095.28	2,060.40	2,042.67
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)(5)	**45,505.52**	**49,333.91**	**53,275.47**	**54,216.32**	**52,198.07**	**54,995.52**	**56,837.43**	**56,524.78**	**50,502.14**	**49,625.06**

Table A.5: Emissions trends summary (Part 3 of 3)

Greenhouse gas emissions	2010	2011	Change from base to latest reported year
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	(%)
CO_2 emissions including net CO_2 from LULUCF	15,519.81	19,556.20	-721.18
CO_2 emissions excluding net CO_2 from LULUCF	33,403.15	33,162.22	32.40
CH_4 emissions including CH_4 from LULUCF	26,930.19	27,101.64	5.42
CH_4 emissions excluding CH_4 from LULUCF	26,875.70	27,050.15	5.46
N_2O emissions including N_2O from LULUCF	10,444.45	10,704.03	28.57
N_2O emissions excluding N_2O from LULUCF	10,429.95	10,689.68	28.78
HFCs	1,077.69	1,885.07	100.00
PFCs	40.81	30.18	-95.21
SF_6	20.46	17.62	15.89
Total (including LULUCF)	**54,033.41**	**59,294.74**	**88.06**
Total (excluding LULUCF)	**71,847.77**	**72,834.93**	**22.12**

Greenhouse gas source and sink categories	2010	2011	Change from base to latest reported year
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	(%)
1. Energy	31,317.45	31,003.32	32.00
2. Industrial Processes	4,764.22	5,430.99	60.07
3. Solvent and other product use	31.00	27.90	-32.84
4. Agriculture	33,722.30	34,387.32	12.15
5. Land use, land-use change and forestry[(5)]	-17,814.36	-13,540.19	-51.84
6. Waste	2,012.80	1,985.40	-3.58
7. Other	NA	NA	0.00
Total (including LULUCF)[(5)]	**54,033.41**	**59,294.74**	**88.06**

Notes

[(1)] The signs for removals are always negative (-) and for emissions positive (+).

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

[(4)] Includes net CO_2, CH_4 and N_2O from LULUCF.

[(5)] Includes net CO_2, CH_4 and N_2O from LULUCF.

NA =”Not applicable”, NO = “Not occurring”, NE = “Not estimated”, IE = “Included elsewhere”

Annex B: Supplementary information under Article 7.2 of the Kyoto Protocol

New Zealand's national system

Supplementary information under Article 7.2 of the Kyoto Protocol

Overview

The Climate Change Response Act 2002 (updated 26 September 2012) was enacted to enable New Zealand to meet its international obligations under the UNFCCC and Kyoto Protocol. According to the UNFCCC definition, a national system includes all institutional, legal and procedural arrangements made within a Party included in Annex 1 for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information. Essentially, a Party's national inventory system is the basis upon which a country prepares its greenhouse gas inventory.

A prime ministerial directive for the administration of the Climate Change Response Act names the Ministry for the Environment (MfE) as New Zealand's 'inventory agency'. MfE is responsible for the overall development, compilation and submission of the inventory to the UNFCCC secretariat.

National entity contact

Title	National inventory focal point and national inventory compiler
Name	Olia Glade
Organisation	Ministry for the Environment
Address	Environment House 23 Kate Sheppard Place PO Box 10 362 Wellington New Zealand
Email	olia.glade@mfe.govt.nz
Phone	+64 4 439 7747
Fax	+64 4 439 7700
Website	http://www.mfe.govt.nz

Inventory roles and responsibilities

MfE is New Zealand's single national entity for the greenhouse gas inventory. MfE's primary functions as New Zealand's inventory agency are specified in the Climate Change Response Act 2002. Thus MfE is responsible for the overall development, compilation and submission of the inventory to the UNFCCC Secretariat.

MfE coordinates all the Government agencies and contractors involved in the inventory and the national inventory compiler is based at MfE. Arrangements with other Government agencies have evolved over time as resources and capacity have allowed, and as a greater understanding of the reporting requirements has been attained. MfE calculates estimates of emissions for the waste sectors, and emissions and removals from the land use, land-use change and forestry (LULUCF) sector.

The Ministry of Business, Innovation and Employment (MBIE, incorporating the former Ministry of Economic Development) collects and compiles all emissions from the energy sector and carbon dioxide emissions from the industrial processes sector. Emissions of the non-carbon dioxide gases from the industrial processes sector are obtained through industry surveys undertaken by consultants contracted to MfE.

The Ministry for Primary Industries (MPI, incorporating the former Ministry of Agriculture and Forestry) compiles emissions from the agriculture sector and provides data to MfE to estimate emissions and removals from the LULUCF sector. Estimates provided by MPI are underpinned by the research and modelling of researchers at New Zealand's Crown research institutes and universities.

The Environmental Protection Authority is the agency responsible for the implementation and operation of New Zealand's national registry under the Kyoto Protocol, the New Zealand Emission Unit Register. The registry is electronic and accessible via the internet (www.eur.govt.nz). Information on the annual holdings and transactions of transferred and acquired units under the Kyoto Protocol is provided in the standard electronic format tables that accompany the annual greenhouse gas inventory submission.

New Zealand's national statistical agency, Statistics New Zealand, provides many of the official statistics for the agriculture sector through regular agricultural censuses and surveys. Population (human) census data from Statistics New Zealand is used in the waste and solvent and other product use sectors. Consultants provide essential data for the industrial processes, solvent and other product use, waste, agriculture and LULUCF sectors of the inventory.

Where an expert in a relevant sector is identified outside MfE or any of the other key contributing Government departments, a contract is established to ensure the inventory can be completed in an accurate and timely manner and to a standard that meets the satisfaction of the Minister responsible for Climate Change Issues. The contracts are legally binding and require transparency in their work and processes.

Legislation relating to the public sector accountability framework is extensive and includes the:

- Public Finance Act 1989
- Public Audit Act 2001
- Official Information Act 1982
- Ombudsman Act 1975
- Public Records Act 2005
- Crown Entities Act 2004.

Contractors for the annual greenhouse gas inventory are selected for their expertise in their field. Although it is preferable to use the same contractor each year, contractors are reviewed regularly, depending on the terms of each specific contract. Through this competitive process the best contractor is selected, ensuring inventory data is of the highest quality in accordance with good practice guidance.

The Reporting Governance Group provides effective leadership of the reporting, modelling and projections of greenhouse gas emissions and removals. Membership includes representation from MfE, MPI and MBIE. The key roles and expectations of the Group are to:

- guide, confer on and approve:
  - inventory and projection improvements and assumptions (on the basis of advice from technical experts)
  - planning and priorities
  - key messages
  - management of stakeholders
  - risk management
- focus on the delivery of reporting commitments to meet national and international requirements
- provide reporting leadership and guidance to analysts, modellers and technical specialists
- share information, provide feedback and resolve any differences between departments that have an impact on the delivery of the work programme
- monitor and report to the Climate Change Directors Group (a cross-agency group that oversees New Zealand's international and domestic climate change policy) on the big picture of the reporting work programme, direction, progress in delivery, and capability to deliver.

List of responsibilities of the inventory agency as per the Climate Change Response Act 2002

The Climate Change Response Act 2002 enables New Zealand to meet its international obligations under the UNFCCC and the Kyoto Protocol. A prime ministerial directive for the administration of the Act names MfE as New Zealand's 'inventory agency'. The Act specifies that the primary functions of the inventory agency are to:

- estimate annually New Zealand's human-induced emissions by sources, and removals by sinks, of greenhouse gases
- prepare the following reports for the purpose of discharging New Zealand's obligations:
  - New Zealand's annual inventory report under Article 7.1 of the Protocol, including (but not limited to) the quantities of long-term certified emission reduction units and temporary certified emission reduction units that have expired or have been replaced, retired or cancelled
  - New Zealand's National Communication (or periodic report) under Article 7.2 of the Protocol and Article 12 of the UNFCCC
  - New Zealand's report for the calculation of its initial assigned amount under Article 7.4 of the Protocol, including its method of calculation.

In carrying out its functions, the inventory agency must:

- identify source categories
- collect data by means of:
  - voluntary collection
  - collection from Government agencies and other agencies that hold relevant information
  - collection in accordance with regulations made under the Act (if any)
- estimate the emissions and removals by sinks for each source category
- undertake assessments on uncertainties
- undertake procedures to verify the data
- retain information and documents to show how the estimates were determined.

Section 36 of the Climate Change Response Act 2002 provides for the authorisation of inspectors to collect the information needed to estimate emissions or removals of greenhouse gases.

Inventory preparation process

In accordance with the UNFCCC's reporting guidelines, each inventory report is published 15 months after the calendar year reported, allowing time for data to be collected and analysed. Sector-based data analysis, data entry into the UNFCCC common reporting format database, and quality checking occur over the period October to February. The *National Inventory Report* (NIR) is also updated over this 4-month time period.

Once the sector-based emissions estimates are updated, the national inventory compiler at MfE calculates the inventory uncertainty, undertakes the key category assessment and further quality checking, and finalises the NIR. The inventory is reviewed within MfE, MBIE, MPI and the Environmental Protection Authority before being approved and submitted to the UNFCCC Secretariat.

The inventory and all required data for the submission to the UNFCCC Secretariat are stored on MfE's central computer network in a controlled filing system. The inventory submission is available from the websites of both MfE and the UNFCCC.

Following the annual submission of the NIR, a post-inventory review is undertaken. The review focuses on the lessons learned and how improvements can be incorporated into the inventory for the following year. Questions asked include:

- Was the timing of activities suitable?
- What activities went well?
- What activities could be improved?

The review also encompasses key contributors to the inventory.

Activity data, emission factors, and methods

The guiding documents for inventory preparation are the:

- *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*[274]
- *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*[275] (the Good Practice Guidance)
- *Good Practice Guidance for Land Use, Land-Use Change and Forestry*[276]
- Kyoto Protocol[277]
- UNFCCC guidelines on reporting and review.[278]

The concepts incorporated in the Good Practice Guidance are implemented in stages, according to sector priorities and national circumstances.

The IPCC provides a number of different possible methods for calculating a given emission or removal. In most cases the differences are in the level of detail at which the calculations are carried out. The guidance provides a tiered approach that describes and connects the various levels of detail at which estimates can be made, depending on the importance of the inventory category, the availability of data and other capabilities, as follows.

- Tier 1 methods apply IPCC default emission factors and use IPCC default models for emissions and/or removals calculations.
- Tier 2 methods apply country-specific emission factors and use IPCC default models for emissions and/or removals calculations.
- Tier 3 methods apply country-specific emission factors and use country-specific models for emissions and/or removals calculations.

Energy

Greenhouse gas emissions from the energy sector are calculated using a mix of IPCC Tier 1 and Tier 2 approaches. The data from New Zealand's energy activities are based on:

- surveys conducted by MBIE (such as the Delivery of Petroleum Fuels by Industry Survey and the New Zealand Quarterly Statistical Return of Coal Production and Sales)
- the New Zealand Energy Data File [279]
- information from the NZ ETS via the Environmental Protection Authority.

Data collected by New Zealand's Ministry of Transport was used to estimate emissions from road transportation. New Zealand-specific emission factors are used for carbon dioxide emission calculations. Applicable IPCC default factors are used for non-carbon dioxide emissions where New Zealand emission factors are not available.

---

274 http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

275 http://www.ipcc-nggip.iges.or.jp/public/gp/english

276 http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

277 http://unfccc.int/kyoto_protocol/items/2830.php

278 http://unfccc.int/documentation/documents/advanced_search/items/3594.php?rec=j&priref=600003988#beg

279 Ministry of Economic Development. 2012. *New Zealand Energy Data File*. Wellington: Ministry of Economic Development.

Industrial processes and solvent and other product use

Activity data and carbon dioxide emissions are supplied directly to MBIE by industry sources. The production data and/or emissions data provided by the cement producers, lime producers and glass producers through their NZ ETS returns have been used in the inventory reported in 2013 to calculate emissions from their respective categories for the 2010 and 2011 calendar years. The NZ ETS will remain the main source of emissions data for mineral products categories for future inventory submissions.

The IPCC Tier 2 approach is used and emission factors are New Zealand specific. Activity data for the non-carbon dioxide gases is collected via an industry survey. Emissions of hydrofluorocarbons and perfluorocarbons are estimated using the IPCC Tier 2 approach, and sulphur hexafluoride emissions from large users are assessed via the Tier 3a approach from the IPCC 2006 guidelines.[280]

Agriculture

Livestock population data is obtained from Statistics New Zealand through the agricultural production census and surveys. Productivity data from New Zealand Dairy Statistics, Beef and Lamb New Zealand and slaughter statistics are collected by MPI. A Tier 2 (model) approach is used to estimate methane emissions from dairy cattle, non-dairy cattle, sheep and deer. This method uses New Zealand animal productivity data to estimate dry-matter intake and methane production. The same dry-matter intake data is used to calculate nitrous oxide emissions from animal excreta. A Tier 1 approach is used to calculate methane and nitrous oxide emissions from livestock species present in insignificant numbers.

Land use, land-use change and forestry (LULUCF)

The LULUCF sector is completed using a mix of IPCC Tier 2 and Tier 1 approaches. A Tier 2 approach is used for the planted forest subcategory of forest land. Changes in planted forest stocks are assessed from national forest survey data and computer modelling of the planted forest estate. A Tier 1 approach is used for the cropland, grassland, wetland, settlements and other land categories. Changes in land area for these categories are based on modified national land-cover databases reclassified to the IPCC's LULUCF categories. Results from the Land Use and Carbon Analysis System (LUCAS), as described in New Zealand's National Greenhouse Gas Inventory, have improved the reporting in the LULUCF sector and provide better consistency with reporting under the Kyoto Protocol.

Waste

Emissions from the waste sector are estimated using waste survey data, combined with population data from Statistics New Zealand. Calculation of emissions from solid waste disposal uses the model from the 2006 IPCC guidelines. A mix of New Zealand-specific and IPCC default parameters is used. Methane and nitrous oxide emissions from domestic and industrial wastewater handling are calculated using a refinement of the IPCC's methodology. There is no incineration of municipal waste in New Zealand. Emissions from the incineration of medical, quarantine and hazardous wastes are estimated using the Tier 1 approach, consistent with the 2006 IPCC guidelines.

[280] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Retrieved from http://www.ipcc-nggip.iges.or.jp/public/ 2006gl/index.html

Process and results of key category identification

The IPCC's *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* identifies a key category as "one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both". Key categories identified within the inventory are used to prioritise inventory improvements.

The key categories in the New Zealand inventory have been assessed using the Tier 1 level and trend methods from the IPCC Good Practice Guidance. The methods identify sources of emissions and removals that sum to 95 per cent of the total level of emissions, and 95 per cent of the trend of the inventory in absolute terms.

In accordance with the *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, the key category analysis is performed once for the inventory excluding LULUCF categories, and is then repeated for the inventory including the LULUCF categories. Non-LULUCF categories that are identified as key in the first analysis but not when the LULUCF categories are included are still considered to be key categories. The key categories identified in the 2011 year are summarised in table B.1.

Using the IPCC approach, at a high level the most important categories in New Zealand's inventory are: carbon dioxide removals from land converted to forest, methane from dairy cattle, carbon dioxide from road transportation, carbon dioxide from deforestation, and methane from sheep.

Recalculation of previously submitted inventory data

Activity data, emission factors, methods, and modelling techniques used in the inventory compilation process may be refined as Government agencies and consultants identify areas for improvement. Re-calculations that result from the improvement process are regarded as a standard part of inventory compilation.

Before the annual inventory is compiled, areas for improvement are identified at a planning session. The quality assurance and quality control plan is reviewed annually during the inventory debriefing and planning phase. Cross-Government inventory managers and general managers are consulted when a large improvement is considered for adoption. For the 2010 inventory submission and beyond, all recalculations are required to be approved through a recalculations approval form before changes are made to the inventory data tables.

Quality assurance and quality control plan, quality objectives, internal and external evaluation, and review processes and their results

Quality assurance and quality control plan – Overview

Quality assurance (QA) and quality control (QC) are an integral part of preparing New Zealand's inventory. MfE developed a QA/QC plan in 2004, as required by the UNFCCC reporting guidelines, to formalise, document and archive the QA/QC procedures. The plan is updated annually in conjunction with New Zealand's inventory improvement plan. The details of the plan are presented in *New Zealand's National Inventory System Guidelines* for compiling New Zealand's Greenhouse Gas Inventory, which is available to view on request.

New Zealand's Greenhouse Gas Inventory QA/QC plan has been designed to improve the transparency, consistency, comparability, completeness and accuracy of New Zealand's annual greenhouse gas inventory in order to meet IPCC good practice. The plan closely follows the definitions, guidelines and processes presented in Chapter 8, 'Quality assurance and quality control', of the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. New Zealand's plan is an open document and is subject to modification and improvement when changes in processes are updated, or on advice from independent reviewers.

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

- applying greater quality control efforts for key categories and for those categories where data and methodological changes have recently occurred
- periodically checking the validity of all information as changes in sample size, methods of collection, or frequency of data collection occur
- conducting general quality control procedures (Tier 1) on all parts of the inventory over a period of time
- balancing efforts between development and implementation of QA/QC procedures and continuous improvement of inventory estimates
- customising the quality control procedures to the resources available and the particular characteristics of New Zealand's Greenhouse Gas Inventory
- confirming that the national statistical agency and other agencies supplying data to the inventory have implemented QA/QC procedures.

The QA/QC coordinator is defined as the person who is the national inventory compiler for New Zealand. The responsibilities of the role include:

- keeping the QA/QC plan current by updating it as necessary
- ensuring all planned Tier 1 and Tier 2 quality checks are carried out as planned (these may be undertaken in the agencies where the data is compiled)
- ensuring New Zealand's inventory improvement plan is implemented
- working with sector leads to verify and map quality control processes and procedures, and to identify the QC areas that need further improvement
- initiating and facilitating a shift towards more robust and efficient QA/QC systems and mechanisms to ensure the high quality of the inventory compilation process.

The QA/QC plan, combined with annual inventory experience, indicates areas for future improvements for the inventory, which are then incorporated into the next inventory and each subsequent inventory thereafter.

QA/QC plan: 2012/13 changes and improvements

Quality control

For the 2013 inventory submission MfE used the IPCC Tier 1 check sheets. The Tier 1 checks are based on the procedures suggested in the good practice guidance.[281] All key categories for the 2011 inventory year were checked. All sector-level data was entered into the common reporting format (CRF) database by 6 February 2013. The deadline allowed 2 months for further quality checking at the sector level (between data spreadsheets and the CRF tables) and checking consistency between the CRF tables and the NIR.

In 2012/13 the inventory team designed and implemented several computerised tools to enable better-quality and more efficient key-category and uncertainty analyses. The team performed a combination of manual and computerised checks on the inventory report for the 2013 submission. Checks included ensuring the data from the spreadsheets and models were accurately transferred to the CRF database, and that data from the database were accurately represented in the draft NIR. No significant errors within the source data spreadsheets or between the spreadsheets and the CRF database and the draft NIR were identified.

Data in the CRF database was checked visually for anomalies, errors and omissions. The Ministry for the Environment used the QC checking procedures included in the database to ensure the data submitted to the UNFCCC Secretariat was complete.

Quality assurance

New Zealand's inventory is progressively improving its quality control and assurance (QC/QA) system to ensure quality is built in at all stages of the inventory compilation process. In 2008 KPMG, an audit specialist, developed a risk register for the Ministry to highlight potential risks in the data compilation process. The Ministry for the Environment will continue to use the risk register to help prioritise further improvements to the inventory.

During 2012/13, New Zealand's QA/QC system became more strongly process-based. QC procedures for each sector have been reviewed and relevant process maps have been created in consultation with each sector lead. The maps were used for refining sectoral QC processes and procedures.

The UNFCCC encourages sector leads to schedule QA audits of their systems at least every 5 years. The agriculture sector began a major QA review of their calculation models with an external party in 2012. Regular meetings between the QA/QC coordinator and sector leads to discuss progress with QA/QC processes and relevant issues have been put in place.

The document *New Zealand's National Inventory System Guidelines for Compiling New Zealand's Greenhouse Gas Inventory*, which is used by the inventory agency to guide the inventory compilation process, was updated in July 2013 to include post-submission error processing, alert processing, and updated maps for the sectoral QC processes and procedures.

---

281 http://www.ipcc-nggip.iges.or.jp/public/gp/english/

Other significant changes to the national system that relate to specific sectors include the following.

- Some QC procedures in the waste, agriculture and industrial processes sectors have been computerised. For example, an Excel-based tool has been developed for a complete check of landfill data consistency to replace previously used manual spot-checking. The tool reads and compares data from multiple files and provides user-friendly diagnostics on whether the data compares, as well as the scale and source of inconsistencies if they occur.
- A VBA-based modelling tool is being developed for the agriculture sector (to be completed in 2013).
- A new approach is being applied in the energy sector to compare carbon dioxide implied emission factors to the default IPCC range that shows the position of New Zealand emission factors within the corridor of the international IPCC range with respect to the IPCC median.

QA reviews of individual sectors and categories were included in the national inventory plan and commissioned by MfE. A list of previous QA reviews, their major conclusions and follow-up are included in the MS Excel worksheets available with New Zealand's 2013 NIR submission from MfE's website.[282]

Most of the agricultural activity data (the largest component of New Zealand's inventory) is provided by Statistics New Zealand, which conducts its own rigorous QA/QC procedures on the data.

Internal review

A review of the complete inventory check is performed to ensure all planned checks have been completed before the inventory is submitted. This review includes checking that:

- all the planned Tier 1 and 2 QC checks have been completed
- the QC check results have been included in the appropriate Excel tables
- QA exercises have been completed
- mandatory checks in the CRF software are complete for all sectors.

Before submitting the inventory to the UNFCCC secretariat, an internal review is undertaken by staff within MfE who have not been involved with the NIR compilation process.

The UNFCCC annual inventory review

New Zealand's inventory was reviewed[283] in 2001 and 2002 as part of a pilot study of the technical review process. The inventory was subject to detailed in-country, centralised and desk review procedures. The inventories submitted for the years 2001 and 2003 were reviewed in a centralised review process. The 2006 inventory submission was reviewed as part of the Kyoto Protocol initial review, an in-country review held from 19 to 24 February 2007. The 2007–2009 and 2011/12 inventory submissions were reviewed during centralised reviews.

---

282 http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2013/index.html

283 The review reports for each review event mentioned in this section are published by the UNFCCC and can be retrieved from http://unfccc.int/national_reports/annex_i_ghg_inventories/inventory_review_reports/items/6616.php

The 2010 inventory submission was subject to an in-country review in August/September 2010.

The review report for the 2012 inventory submission was not fully completed at the time of finalising this 2013 submission. All the reviews were coordinated by the Secretariat and conducted by an international team of experts nominated by Parties to the UNFCCC Roster of Experts. Review reports are available from the UNFCCC website (www.unfccc.int).

New Zealand has consistently met the reporting requirements under the UNFCCC and Kyoto Protocol. The submission of the inventory to the UNFCCC Secretariat has consistently met the required deadline under decision 15/CMP.1. The expert review report (UNFCCC, 2012) stated in relation to New Zealand's reporting:

- "The ERT (Expert Review Team) concluded that the national system continued to perform its required functions".
- "The national registry continues to perform the functions set out in the annex to decision 13/CMP.1 and the annex to decision 5/CMP.1, and continues to adhere to the technical standards for data exchange between registry systems in accordance with relevant CMP decisions".

New Zealand's consistency in meeting the reporting requirements allowed it to be one of the first four Parties to be eligible to participate in the Kyoto Protocol mechanisms for the first commitment period. New Zealand's registry, the official transactions and the balance of New Zealand's Kyoto Protocol units were operational on 1 January 2008, the first day of the first commitment period.

Procedures for the official consideration and approval of the inventory

The finalised inventory submission is signed off by the manager responsible for the team compiling the inventory within MfE. The final approval is given by the director who is the designated management sign-off individual for the Chief Executive Officer at MfE.

Further information on New Zealand's national system can be found in the initial report under the Kyoto Protocol: http://unfccc.int/files/national_reports/application/pdf/new_zealands_initial_report_under_the_kyoto_protocol.pdf and in the latest NIR: http://www.mfe.govt.nz/issues/climate/greenhouse-gas-emissions/index.html.

National registry

Overview

New Zealand's Emission Unit Register (NZEUR) was originally developed to meet its commitments and obligations under the Kyoto Protocol. It is New Zealand's only official register of Kyoto units and became operational for this purpose on 6 December 2007 after the initial review in early 2007.

The NZ ETS was established by amendment of the Climate Change Response Act 2002 in December 2009. The NZEUR manages the accounting, reporting and reconciliation of emissions and unit holdings and transactions as part of the NZ ETS.

The NZEUR is currently managed by the Environmental Protection Authority, which is the Government agency responsible for operating the NZ ETS. The NZEUR contains multiple accounts (known as holding accounts, held by both the Crown and private entities) and allows the transfer of units between NZEUR holding accounts and holding accounts in the registry systems of other Parties to the Kyoto Protocol, or between holding accounts within the NZEUR itself. The NZEUR currently supports the:

- opening of holding accounts
- holdings of both Kyoto units and New Zealand's domestic unit of trade, commonly known as New Zealand units (or NZUs)
- transfer of Kyoto units and other information between the NZEUR and other official overseas registries via the International Transaction Log (ITL) under the Kyoto Protocol
- transfer of units between holding accounts within the NZEUR
- registration of participants' activities under the NZ ETS.

The latest reporting period is up to 31 December 2012, and the report was submitted to the UNFCCC as part of the national inventory submission package in 2013.

In January 2008 New Zealand's national registry was issued with New Zealand's assigned amount of 309,564,733 metric tonnes of carbon dioxide equivalents (CO_2-e). At the beginning of the 2012 calendar year New Zealand's national registry held:

- 306,248,485 assigned amount units
- 530,346 emission reduction units
- 2,935,654 certified emission reduction units
- 3,900,000 removal units.

At the end of 2012 there were:

- 306,041,662 assigned amount units
- 16,153,534 emission reduction units
- 8,680,399 certified emission reduction units
- 9,050,000 removal units.

The removal units and the majority of certified emission reduction units (approximately 4,400,000 units) were traded into New Zealand's national registry by private entities. These units will not be part of the Crown account unless surrendered under the NZ ETS.

Registry contact details

The NZEUR can be accessed at: http://www.eur.govt.nz.

Organisation designated as the administrator of New Zealand's national registry	*Environmental Protection Authority* Private Bag 63 002, Wellington 6140, New Zealand Phone: +64 4 462 4289 Fax: +64 4 978 3661 Web: http://www.epa.govt.nz
Main contact	*Guy Windley* Team Leader, Emissions Trading Scheme, Environmental Protection Authority Private Bag 63 002, Wellington 6140, New Zealand Phone: +64 4 474 5514 Fax: +64 4 978 3661

	Email: guy.windley@epa.govt.nz
Alternative contact	*Andrea Gray* General Manager, Emissions Trading Scheme, Environmental Protection Authority Private Bag 63 002, Wellington 6140, New Zealand Phone: +64 4 910 9239 Fax: +64 4 978 3661 Email: andrea.gray@epa.govt.nz
Release manager	*Janine Manhart* Senior Analyst, Emissions Trading Scheme, Environmental Protection Authority Private Bag 63 002, Wellington 6140, New Zealand Phone: +64 4 474 5510 Fax: +64 4 978 3661 Email: janine.manhart@epa.govt.nz

Consolidated registry with other Parties

New Zealand does not maintain a consolidated registry with any other Parties.

Key category analysis: results

Table B.1: Summary of key categories for 2011 (including and excluding LULUCF activities)

Quantitative method used: IPCC Tier 1		
IPCC categories	**Gas**	**Criteria for identification**
Energy		
Transport – road transport – gasoline	CO_2	level, trend
Transport – road transport – diesel oil	CO_2	level, trend
Transport – road transport – gaseous fuels	CO_2	trend
Transport – civil aviation – jet kerosene	CO_2	level
Energy industries – public electricity and heat production – solid fuels	CO_2	level, trend
Energy industries – public electricity and heat production – gaseous fuels	CO_2	level, trend
Energy industries – petroleum refining – liquid fuels	CO_2	level, trend
Energy industries – petroleum refining – gaseous fuels	CO_2	trend
Energy industries – manufacture of solid fuels and other energy industries – gaseous fuels	CO_2	trend
Manufacturing industries and construction – gaseous fuels	CO_2	level
Manufacturing industries and construction – liquid fuels	CO_2	level
Manufacturing industries and construction – solid fuels	CO_2	level, trend
Other sectors – liquid fuels	CO_2	level, trend
Other sectors – solid fuels	CO_2	level, trend
Other sectors – gaseous fuels	CO_2	level
Fugitive emissions – flaring combined	CO_2	level, trend
Fugitive emissions – geothermal	CO_2	level, trend
Fugitive emissions – natural gas	CH_4	trend
Industrial processes		
Mineral products – cement production	CO_2	level
Chemical industry – ammonia production	CO_2	qualitative
Metal production – iron and steel production	CO_2	level
Metal production – aluminium production	CO_2	level
Metal production – aluminium production	PFCs	trend
Consumption of halocarbons and SF_6 – refrigeration and air conditioning	HFCs & PFCs	level, trend
Agriculture		
Enteric fermentation – non-dairy cattle	CH_4	level, trend

Enteric fermentation – dairy cattle	CH_4	level, trend
Enteric fermentation – sheep	CH_4	level, trend
Enteric fermentation – deer	CH_4	level
Enteric fermentation – other	CH_4	trend
Manure management	CH_4	level
Agricultural soils – pasture, range and paddock	N_2O	level, trend
Agricultural soils – indirect emissions	N_2O	level
Agricultural soils – direct emissions	N_2O	level, trend
LULUCF		
Forest land remaining forest land	CO_2	level, trend
Grassland remaining grassland	CO_2	level, trend
Conversion to forest land	CO_2	level, trend
Conversion to grassland	CO_2	level, trend
Conversion to cropland	CO_2	trend
Conversion to wetland	CO_2	trend
Waste		
Solid waste disposal on land	CH_4	level, trend
Wastewater handling	CH_4	level

Table B.2 (a & b): Key category analysis for 2011 – Tier 1 level assessment including LULUCF (a) and excluding LULUCF (b)

(a) IPCC Tier 1 category-level assessment – including LULUCF (net emissions): 2011				
IPCC categories	**Gas**	**2011 estimate (Gg CO_2-e)**	**Level assessment (%)**	**Cumulative total (%)**
Conversion to forest land	CO_2	27,227.0	23.9	23.9
Enteric fermentation – dairy cattle	CH_4	10,381.8	9.1	33.1
Forest land remaining forest land	CO_2	9,468.7	8.3	41.4
Enteric fermentation – sheep	CH_4	7,750.6	6.8	48.2
Transport – road transport – gasoline	CO_2	7,061.4	6.2	54.4
Agricultural soils – pasture, range and paddock	N_2O	5,705.4	5.0	59.4
Transport – road transport – diesel oil	CO_2	5,314.3	4.7	64.1
Enteric fermentation – non-dairy cattle	CH_4	4,860.6	4.3	68.4
Energy industries – public electricity and heat production – gaseous fuels	CO_2	3,622.1	3.2	71.6
Agricultural soils – indirect emissions	N_2O	2,578.4	2.3	73.8
Manufacturing industries and construction – gaseous fuels	CO_2	2,179.9	1.9	75.7
Grassland remaining grassland	CO_2	2,063.5	1.8	77.6
Other sectors – liquid fuels	CO_2	1,880.0	1.7	79.2
Agricultural soils – direct emissions	N_2O	1,874.8	1.6	80.9
Consumption of halocarbons and SF_6 – refrigeration and air conditioning	HFCs & PFCs	1,798.3	1.6	82.4
Manufacturing industries and construction – solid fuels	CO_2	1,752.5	1.5	84.0
Metal production – iron and steel production	CO_2	1,690.8	1.5	85.5
Conversion to grassland	CO_2	1,650.0	1.5	86.9
Energy industries – public electricity and heat production – solid fuels	CO_2	1,489.7	1.3	88.2
Solid waste disposal on land	CH_4	1,331.1	1.2	89.4
Manufacturing industries and construction – liquid fuels	CO_2	1,034.4	0.9	90.3
Transport – civil aviation – jet kerosene	CO_2	971.6	0.9	91.2

(a) IPCC Tier 1 category-level assessment – including LULUCF (net emissions): 2011				
IPCC categories	**Gas**	**2011 estimate (Gg CO_2-e)**	**Level assessment (%)**	**Cumulative total (%)**
Energy industries – petroleum refining – liquid fuels	CO_2	782.9	0.7	91.8
Fugitive emissions – flaring – combined	CO_2	780.6	0.7	92.5
Other sectors – gaseous fuels	CO_2	686.2	0.6	93.1
Manure management	CH_4	647.3	0.6	93.7
Fugitive emissions – geothermal	CO_2	626.8	0.6	94.3
Metal production – aluminium production	CO_2	571.2	0.5	94.8
Mineral products – cement production	CO_2	528.5	0.5	95.2
Enteric fermentation – deer	CH_4	478.2	0.4	95.6
Wastewater handling	CH_4	471.7	0.4	96.1
Other sectors – solid fuels	CO_2	434.0	0.4	96.4
Energy industries – manufacture of solid fuels and other energy industries – gaseous fuels	CO_2	427.4	0.4	96.8
Fugitive emissions – coal mining and handling	CH_4	390.7	0.3	97.2
Fugitive emissions – natural gas	CH_4	359.9	0.3	97.5
Cropland remaining cropland	CO_2	311.4	0.3	97.7
Transport – navigation – residual oil	CO_2	284.3	0.2	98.0
Chemical industry – ammonia production	CO_2	283.2	0.2	98.2
Chemical industry – hydrogen production	CO_2	253.2	0.2	98.5
Wastewater handling	N_2O	180.4	0.2	98.6
Transport – railways – liquid fuels	CO_2	140.8	0.1	98.7
Energy industries – petroleum refining – gaseous fuels	CO_2	127.8	0.1	98.9
Mineral products – lime production	CO_2	119.0	0.1	99.0

(b) IPCC Tier 1 category-level assessment – excluding LULUCF (total emissions): 2011				
IPCC categories	**Gas**	**2011 estimate (Gg CO_2-e)**	**Level assessment (%)**	**Cumulative total (%)**
Enteric fermentation – dairy cattle	CH_4	10,381.8	14.3	14.3
Enteric fermentation – sheep	CH_4	7,750.6	10.6	24.9
Transport – road transport – gasoline	CO_2	7,061.4	9.7	34.6
Agricultural soils – pasture, range and paddock	N_2O	5,705.4	7.8	42.4
Transport – road transport – diesel oil	CO_2	5,314.3	7.3	49.7
Enteric fermentation – non-dairy cattle	CH_4	4,860.6	6.7	56.4
Energy industries – public electricity and heat production – gaseous fuels	CO_2	3,622.1	5.0	61.4
Agricultural soils – indirect emissions	N_2O	2,578.4	3.5	64.9
Manufacturing industries and construction – gaseous fuels	CO_2	2,179.9	3.0	67.9
Other sectors – liquid fuels	CO_2	1,880.0	2.6	70.5
Agricultural soils – direct emissions	N_2O	1,874.8	2.6	73.1
Consumption of halocarbons and SF_6 – refrigeration and air conditioning	HFCs & PFCs	1,798.3	2.5	75.5
Manufacturing industries and construction – solid fuels	CO_2	1,752.5	2.4	77.9
Metal production – iron and steel production	CO_2	1,690.8	2.3	80.3
Energy industries – public electricity and heat production – solid fuels	CO_2	1,489.7	2.0	82.3
Solid waste disposal on land	CH_4	1,331.1	1.8	84.1
Manufacturing industries and construction – liquid fuels	CO_2	1,034.4	1.4	85.5
Transport – civil aviation – jet kerosene	CO_2	971.6	1.3	86.9
Energy industries – petroleum refining – liquid fuels	CO_2	782.9	1.1	88.0
Fugitive emissions – flaring – combined	CO_2	780.6	1.1	89.0

Other sectors – gaseous fuels	CO_2	686.2	0.9	90.0
Manure management	CH_4	647.3	0.9	90.9
Fugitive emissions – geothermal	CO_2	626.8	0.9	91.7
Metal production – aluminium production	CO_2	571.2	0.8	92.5
Mineral products – cement production	CO_2	528.5	0.7	93.2
Enteric fermentation – deer	CH_4	478.2	0.7	93.9
Waste-water handling	CH_4	471.7	0.6	94.5
Other sectors – solid fuels	CO_2	434.0	0.6	95.1
Energy industries – manufacture of solid fuels and other energy industries – gaseous fuels	CO_2	427.4	0.6	95.7
Fugitive emissions – coal mining and handling	CH_4	390.7	0.5	96.2
Fugitive emissions – natural gas	CH_4	359.9	0.5	96.7
Transport – navigation – residual oil	CO_2	284.3	0.4	97.1
Chemical industry – ammonia production	CO_2	283.2	0.4	97.5
Chemical industry – hydrogen production	CO_2	253.2	0.3	97.9
Wastewater handling	N_2O	180.4	0.2	98.1
Transport – railways – liquid fuels	CO_2	140.8	0.2	98.3
Energy industries – Petroleum refining – gaseous fuels	CO_2	127.8	0.2	98.5
Mineral products – lime production	CO_2	119.0	0.2	98.7
Fugitive emissions – geothermal	CH_4	110.1	0.2	98.8
Transport – road transport – gasoline	N_2O	106.1	0.1	98.9
Consumption of halocarbons and SF_6 – foam blowing	HFCs & PFCs	85.0	0.1	99.1

Table B.3: Key category analysis for 2011 – Tier 1 trend assessment including LULUCF (a) and excluding LULUCF (b)

(a) IPCC Tier 1 category trend assessment – including LULUCF (net emissions)						
IPCC categories	**Gas**	**Base year estimate (Gg CO_2-e)**	**2011 estimate (Gg CO_2-e)**	**Trend assessment**	**Contribution to trend**	**Cumulative total**
Enteric fermentation – sheep	CH_4	11,736.1	7,750.6	0.050	18.8	18.8
Enteric fermentation – dairy cattle	CH_4	4,976.5	10,381.8	0.028	10.7	29.5
Forest land remaining forest land	CO_2	4,540.3	9,468.7	0.026	9.7	39.3
Transport – road transport – diesel oil	CO_2	1,409.5	5,314.3	0.024	9.3	48.5
Conversion to forest land	CO_2	23,198.2	27,227.0	0.015	5.9	54.4
Consumption of halocarbons and SF_6 – refrigeration and air conditioning	HFCs & PFCs	0.0	1,798.3	0.012	4.7	59.1
Energy industries – manufacture of solid fuels and other energy industries – gaseous fuels	CO_2	1,717.4	427.4	0.012	4.6	63.8
Enteric fermentation – non-dairy cattle	CH_4	4,983.8	4,860.6	0.010	3.9	67.6
Conversion to grassland	CO_2	201.5	1,650.0	0.010	3.7	71.3
Agricultural soils – direct emissions	N_2O	460.1	1,874.8	0.009	3.4	74.7
Agricultural soils – pasture, range and paddock	N_2O	5,372.5	5,705.4	0.008	2.9	77.6
Manufacturing industries and construction – solid fuels	CO_2	2,172.6	1,752.5	0.007	2.6	80.3
Energy industries – public electricity and heat production – solid fuels	CO_2	469.3	1,489.7	0.006	2.4	82.6
Metal production – aluminium production	PFCs	629.9	30.2	0.005	2.0	84.7
Grassland remaining grassland	CO_2	1,074.1	2,063.5	0.005	1.8	86.5
Solid waste disposal on land	CH_4	1,514.4	1,331.1	0.004	1.6	88.1
Fugitive emissions – flaring – combined	CO_2	228.9	780.6	0.003	1.3	89.3

Other sectors – liquid fuels	CO_2	1,757.9	1,880.0	0.002	0.9	90.3
Fugitive emissions – geothermal	CO_2	228.6	626.8	0.002	0.9	91.2
Enteric fermentation – other	CH_4	209.6	46.6	0.002	0.6	91.7
Other sectors – solid fuels	CO_2	512.1	434.0	0.001	0.6	92.3
Conversion to cropland	CO_2	214.8	70.5	0.001	0.5	92.8
Energy industries – petroleum refining – liquid fuels	CO_2	773.9	782.9	0.001	0.5	93.4
Fugitive emissions – natural gas	CH_4	438.1	359.9	0.001	0.5	93.9
Conversion to wetland	CO_2	167.3	20.9	0.001	0.5	94.4
Transport – road transport – gaseous fuels	CO_2	139.6	2.9	0.001	0.5	94.8
Energy industries – public electricity and heat production – gaseous fuels	CO_2	2,984.6	3,622.1	0.001	0.4	95.3
Energy industries – petroleum refining – gaseous fuels	CO_2	0.0	127.8	0.001	0.3	95.6
Manufacturing industries and construction – gaseous fuels	CO_2	1,619.7	2,179.9	0.001	0.3	95.9
Cropland remaining cropland	CO_2	334.7	311.4	0.001	0.3	96.2
Transport – road transport – liquefied petroleum gases	CO_2	101.0	26.1	0.001	0.3	96.5
Transport – civil aviation – jet kerosene	CO_2	842.5	971.6	0.001	0.3	96.8
Conversion to settlement	CO_2	97.6	34.7	0.001	0.2	97.0
Consumption of halocarbons and SF_6 – foam blowing	HFCs & PFCs	0.0	85.0	0.001	0.2	97.2
Chemical industry – ammonia production	CO_2	277.9	283.2	0.000	0.2	97.4
Manure management	CH_4	456.6	647.3	0.000	0.2	97.6
Chemical industry – hydrogen production	CO_2	152.3	253.2	0.000	0.2	97.7
Enteric fermentation – deer	CH_4	334.7	478.2	0.000	0.1	97.9
Fugitive emissions – geothermal	CH_4	46.0	110.1	0.000	0.1	98.0

Transport – road transport – gasoline	CH_4	50.5	20.3	0.000	0.1	98.1
Transport – railways – liquid fuels	CO_2	77.6	140.8	0.000	0.1	98.2
Fugitive emissions – coal mining and handling	CH_4	274.5	390.7	0.000	0.1	98.4
Manufacturing industries and construction – liquid fuels	CO_2	847.0	1,034.4	0.000	0.1	98.5
Mineral products – cement production	CO_2	448.7	528.5	0.000	0.1	98.6
Transport – road transport – gaseous fuels	CH_4	31.4	0.0	0.000	0.1	98.7
Metal production – iron and steel production	CO_2	1,306.7	1,690.8	0.000	0.1	98.8
Transport – road transport – gasoline	CO_2	5,582.2	7,061.4	0.000	0.1	98.8
Agricultural soils – indirect emissions	N_2O	2,051.8	2,578.4	0.000	0.1	98.9
Emissions from solvents (N_2O use)	N_2O	41.5	27.9	0.000	0.1	99.0

(b) IPCC Tier 1 category trend assessment – excluding LULUCF (total emissions)						
IPCC categories	**Gas**	**Base year estimate (Gg CO_2-e)**	**2011 estimate (Gg CO_2-e)**	**Trend assessment**	**Contribution to trend (%)**	**Cumulative total (%)**
Enteric fermentation – sheep	CH_4	11,736.1	7,750.6	0.074	23.2	23.2
Enteric fermentation – dairy cattle	CH_4	4,976.5	10,381.8	0.048	15.2	38.4
Transport – road transport – diesel oil	CO_2	1,409.5	5,314.3	0.040	12.7	51.0
Consumption of halocarbons and SF_6 – refrigeration and air conditioning	HFCs & PFCs	0.0	1,798.3	0.020	6.3	57.4
Energy industries – manufacture of solid fuels and other energy industries – gaseous fuels	CO_2	1,717.4	427.4	0.019	5.9	63.3
Agricultural soils – direct emissions	N_2O	460.1	1,874.8	0.015	4.6	67.9
Enteric fermentation – non-dairy cattle	CH_4	4,983.8	4,860.6	0.014	4.3	72.2
Energy industries – public electricity and heat production – solid fuels	CO_2	469.3	1,489.7	0.010	3.2	75.4
Manufacturing industries and construction – solid fuels	CO_2	2,172.6	1,752.5	0.010	3.2	78.6
Agricultural soils – pasture, range and paddock	N_2O	5,372.5	5,705.4	0.010	3.0	81.6
Metal production – aluminium production	PFCs	629.9	30.2	0.008	2.6	84.2
Solid waste disposal on land	CH_4	1,514.4	1,331.1	0.006	1.8	86.1
Fugitive emissions – flaring – combined	CO_2	228.9	780.6	0.006	1.8	87.8
Fugitive emissions – geothermal	CO_2	228.6	626.8	0.004	1.2	89.1
Other sectors – liquid fuels	CO_2	1,757.9	1,880.0	0.003	0.9	90.0
Transport – road transport – gasoline	CO_2	5,582.2	7,061.4	0.003	0.9	90.9
Enteric fermentation – other	CH_4	209.6	46.6	0.002	0.7	91.6

Manufacturing industries and construction – gaseous fuels	CO_2	1,619.7	2,179.89	0.002	0.7	92.3
Other sectors – solid fuels	CO_2	512.1	434.0	0.002	0.7	93.0
Fugitive emissions – natural gas	CH_4	438.1	359.9	0.002	0.6	93.6
Transport – road transport – gaseous fuels	CO_2	139.6	2.9	0.002	0.6	94.2
Energy industries – petroleum refining – liquid fuels	CO_2	773.9	782.9	0.002	0.6	94.8
Energy industries – petroleum refining – gaseous fuels	CO_2	0.0	127.84	0.001	0.5	95.2
Transport – road transport – liquefied petroleum gases	CO_2	101.0	26.1	0.001	0.3	95.5
Metal production – iron and steel production	CO_2	1,306.7	1,690.8	0.001	0.3	95.9
Manure management	CH_4	456.6	647.3	0.001	0.3	96.2
Consumption of halocarbons and SF_6 – foam blowing	HFCs & PFCs	0.0	85.0	0.001	0.3	96.5
Agricultural soils – indirect emissions	N_2O	2,051.8	2,578.40	0.001	0.3	96.8
Enteric fermentation – deer	CH_4	334.7	478.2	0.001	0.2	97.0
Chemical industry – hydrogen production	CO_2	152.3	253.2	0.001	0.2	97.2
Transport – civil aviation – jet kerosene	CO_2	842.5	971.6	0.001	0.2	97.4
Chemical industry – ammonia production	CO_2	277.9	283.2	0.001	0.2	97.6
Fugitive emissions – coal mining and handling	CH_4	274.5	390.7	0.001	0.2	97.8
Fugitive emissions – geothermal	CH_4	46.0	110.1	0.001	0.2	98.0
Other sectors – gaseous fuels	CO_2	523.3	686.2	0.001	0.2	98.2
Transport – railways – liquid fuels	CO_2	77.6	140.8	0.001	0.2	98.4
Transport – road transport – gasoline	CH_4	50.5	20.3	0.000	0.1	98.5
Transport – road transport – gaseous fuels	CH_4	31.4	0.0	0.000	0.1	98.6
Other sectors – solid fuels	CH_4	23.4	5.3	0.000	0.1	98.7

Metal production – aluminium production	CO_2	449.0	571.2	0.000	0.1	98.8
Transport – road transport – diesel oil	N_2O	8.7	33.5	0.000	0.1	98.9
Emissions from solvents (N_2O use)	N_2O	41.5	27.9	0.000	0.1	99.0

National registry: a detailed description

Database structure and capacity

The NZEUR is based on the Emissions and Allowance Tracking System (EATS), a comprehensive web-based software application for managing information for emission trading programmes, including data about sources, allowances and emissions. EATS includes reconciliation functions to assess compliance with emissions trading programme rules.

The design and development of EATS was undertaken by the US Environmental Protection Agency to help domestic and foreign environmental agencies implement effective, credible emissions trading programmes. Recognising that all trading programmes are not alike, EATS was designed with flexibility to address these differences and provide a high degree of security and data integrity in a cost-effective and adaptive platform.

The NZEUR comprises three core technical components.

- **A database:** the NZEUR database comprises a single schema, two instances of the database, and a test and a production environment. The test environment enables programme administrators to test software upgrades or transfers, or train new users.
- **An extranet web application:** the NZEUR web application can be used by a single administrator to process data submitted by programme participants on paper forms, or it can run as a secure extranet application supporting multiple users. The web services used to communicate with the UNFCCC ITL are components of the NZEUR.
- **A registry management application:** the NZEUR registry management application enables the system administrator or registry manager to manage all of the administrative processes necessary to maintain the NZEUR. The application is an initialisation tool to define how the NZEUR web operates, and functions as a maintenance tool to update help files, manage batch jobs, review audit and transaction logs, manage security, and perform other daily tasks.

The following diagram (figure B.2.1) shows the current configuration of the NZEUR production environment. The various components are then discussed in the text.

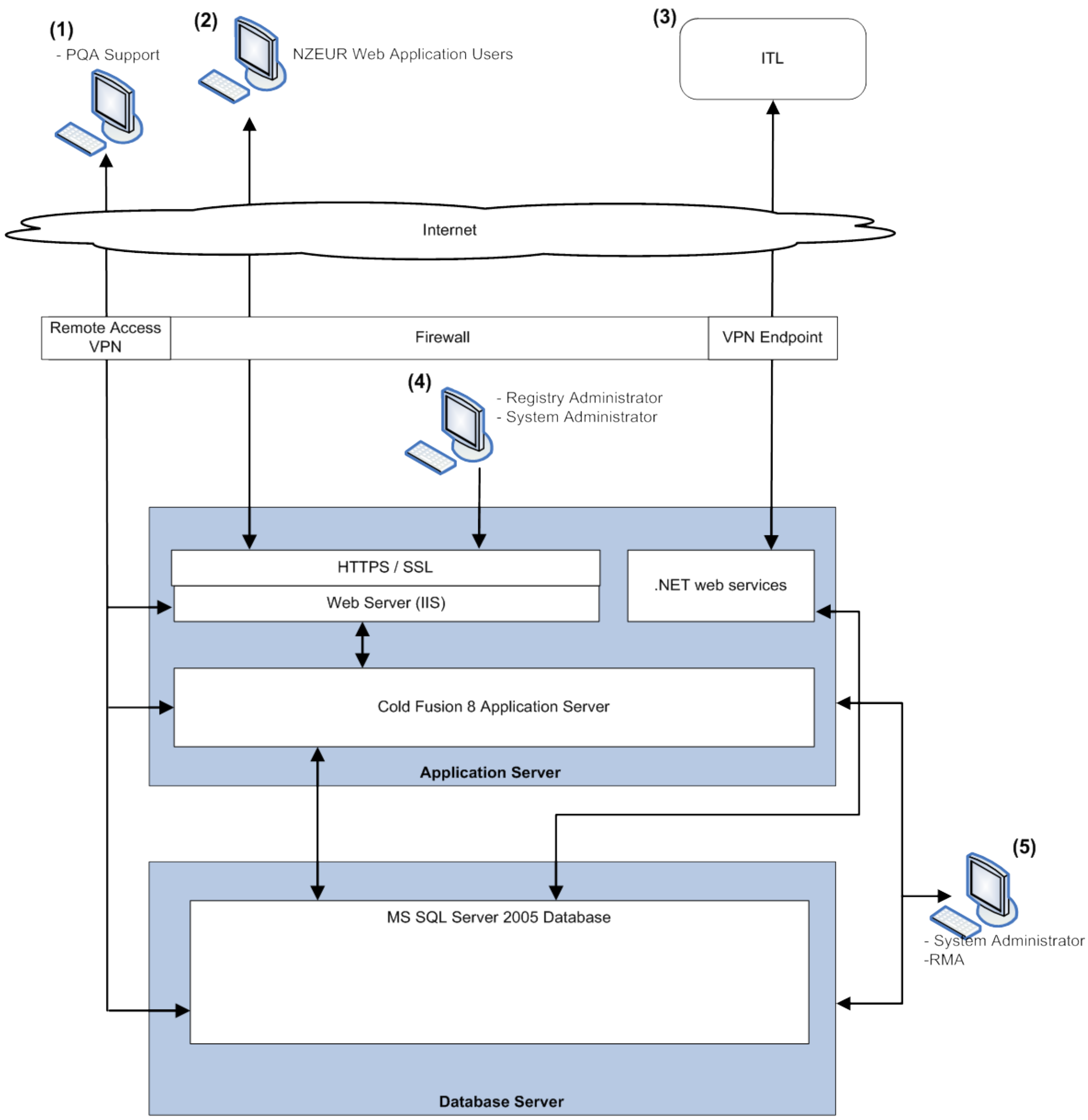


Figure B.2.1: NZEUR logical network topology (production environment)

SQL Server database

The NZEUR database is a Microsoft SQL Server 2005 database. The vast majority of the system's business logic is contained in stored procedures, views and functions contained in the database instance. The NZEUR has a complex system of metadata used to control many aspects of the system's configuration. Much of this metadata can be managed through the registry management application (RMA) tool from a desktop computer with network access to the database hosting environment.

SQL Server 2005 reporting services

SQL Server 2005 reporting services (SSRS) runs on the IIS web server (described below) and is configured with data sources that point to the NZEUR SQL Server 2005 database. SSRS provides reporting functionality to the NZEUR web application. The content for the web application reports is controlled through metadata, which is managed through the registry management application tool from a desktop computer with network access to the database hosting environment.

In addition to the NZEUR web application reports, SSRS hosts two administrative reports that are available through the RMA. These are the Commitment Period Reserve (CPR) Level report and the Kyoto report for submission to the United Nations. The CPR Level report allows the registry administrator to see the status of the registry in relation to the required commitment period reserve. The commitment period reserve is the minimum quantity of Kyoto units the registry must hold at any given time in order to limit the scope of non-compliance. The Kyoto report provides automatic generation of the required annual reports for Kyoto parties (COP 10). The report is generated using the standard electronic format of submission under Article 7.1 of the Kyoto Protocol. SSRS also provides an ad hoc reporting capability, intended for administrators, which is accessible through the RMA.

IIS web server

The NZEUR is primarily accessed through a web application. The web server used is Microsoft IIS, which communicates with the ColdFusion 8 application server.

ColdFusion 8 application server

The NZEUR web application is developed in ColdFusion 8. The files comprising the NZEUR ColdFusion application are distributed as a file tree. The ColdFusion application server runs as a service on the designated machine also hosting the IIS web server.

The NZEUR design has the ability to increase capacity across granular components specifically in relation to:

- internet bandwidth (production and disaster recovery)
- inter-NZEUR platform bandwidth
- server application capacity (including adding new servers to support NZEUR functionality)
- storage capacity.

A capacity management process is put in place as part of the service management framework and documented in the operations documents. To complement this, any required configuration or monitoring is in place to model capacity requirements based on the total number of current and future transactions and to support the capacity management process.

NZEUR production environment

NZEUR components include a production hot-standby/DR and pre-production environment, consisting of two physical locations (primary and hot-standby/DR) with virtual environments for each, namely Wellington and Auckland (figure B.2.2).

The primary databases are set up in a data centre in Auckland, with a synchronous connection to the databases located at the disaster recovery site, linked through a reliable high-speed connection between the sites. Each transaction committed on the principal database is also committed on the mirror server synchronously. Synchronous replication provides the highest level of availability and resilience based on the current design requirements.

The databases are mirrored and monitored by the witness server. The witness server is a server running SQL 2005, set up in database witness mode. This server does not host the databases and its only role is to automate fail over if required. It does this by polling the principal server; if it cannot contact the server, it fails over to the database located in the disaster recovery site. This is done using the ODBC connectors on the application servers located in production. Monitoring of the database, its mirror and the witness server is done using a dedicated monitoring server located on the management network.

In the event of a disaster, the disaster recovery database will be used as the primary database.

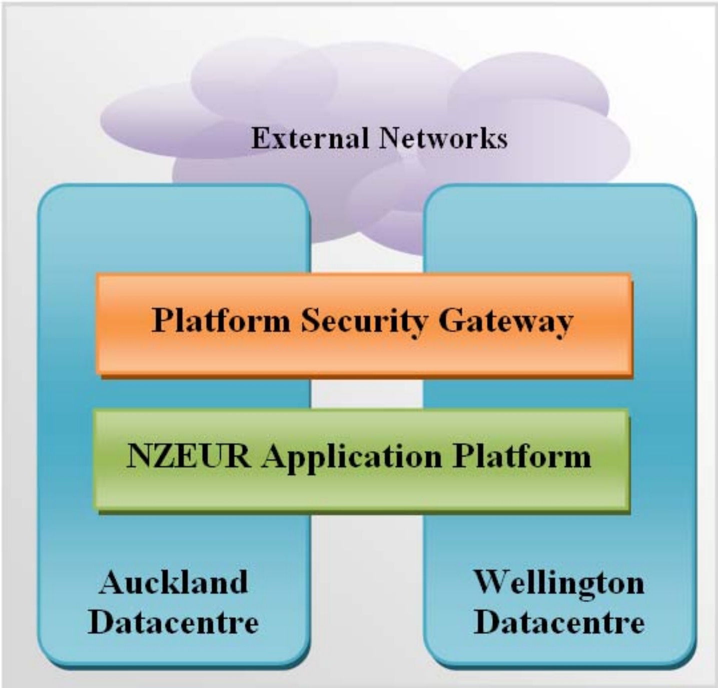


Figure B.2.2: High-level outline of the major components of NZEUR

NZEUR utilises industry-standard components that allow support for the required NZEUR technologies. The registry uses a relational database, which runs on SQL server 2005. The hardware supporting the SQL server in production meets Microsoft's recommended server specifications.

Data exchange

The NZEUR contains multiple holding accounts and allows the transfer of emission units between these holding accounts and holding accounts in the registry systems of other Parties to the Kyoto Protocol. The data exchange standards (DES) define the communication protocol between registry systems and ITL.

The NZEUR has recently updated to the 1.1.9 DES standard. The DES includes:

- security standard guidance
- transaction message flows and content
- reconciliation message flows and content
- administrative processes
- data elements and identifiers
- data element codes
- transaction checks
- registry initialisation requirements

- example transaction messages
- additional specifications.

The NZEUR has been designed to ensure an accurate, transparent, efficient and secure exchange of data with the ITL hosted by the United Nations. It is developed with a strong adherence to the principles of integrity, security and availability. The NZEUR conforms to the technical standards set by the Kyoto Protocol, and therefore complies with the Data Exchange Standard for Registry Systems under the Kyoto Protocol Technical Specifications. The UNFCCC Secretariat manages the ITL and facilitates the international transfer of Kyoto units between entities with holding accounts in national registries.

The United Nations use ITL Virtual Private Network (VPN) to communicate directly with the NZEUR application at an application level. VPN adheres to specific requirements surrounding its configuration as per the UNFCCC. The ITL VPN is used for all communication into and out of the NZEUR for trusted third parties. The UNFCCC has chosen to use VeriSign[284] as the certification authority. VeriSign will be used to issue VPN certificates and SSL client and server certificates.

VeriSign (since 2010 VeriSign owned by Semantec) is used to issue VPN certificates and SSL client and server certificates. The NZEUR has recently been upgraded to a 2048 BIT certificate to bring the system in line with updated ITL requirements.

The VPN tunnel provides a connection between the site containing the registry system and both the primary and secondary data centres in which the ITL is operated. VPNs are established over the internet and utilise the same internet bandwidth configured for the NZEUR application access. Digital certificates are used in the ITL infrastructure by VPN devices as the authentication method during the key exchange phase of establishing the IPSec connection. All certificates are provided by VeriSign.

Figure B.2.3 shows an overview of the VPN connectivity between the ITL primary hub hosted at Logica UK and the registry sites. The VPN connectivity to the secondary site has not been shown in this figure for simplicity. The setup to the secondary site is similar but uses different IP addresses (figure B.2.3).

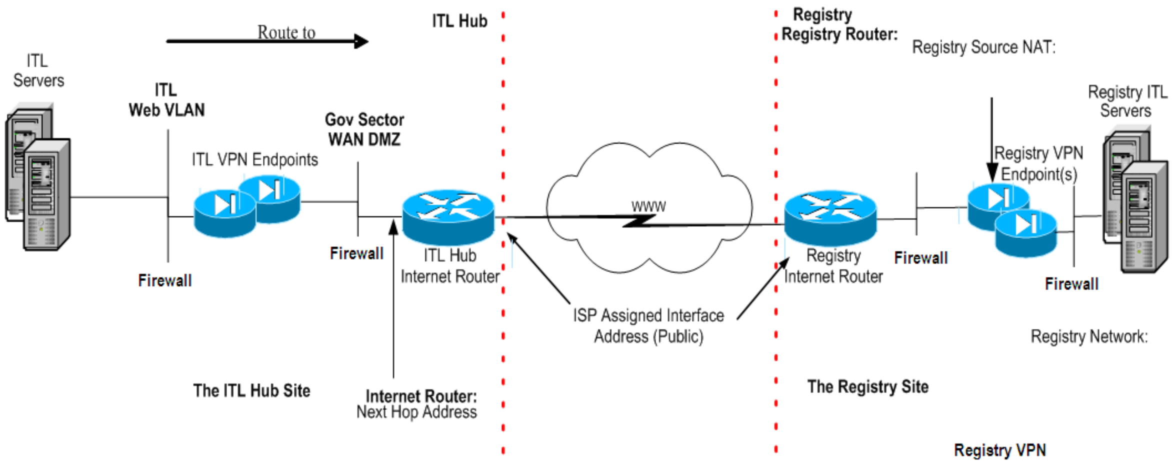


Figure B.2.3: VPN connectivity, which enables exchange of data between the ITL and the NZEUR (overview)

---

284 Since 2010 VeriSign is owned by and operates under Semantec.

The New Zealand Registry was initialised in 2007. During May 2009, and later in 2011, it was successfully re-certified. This has demonstrated that the New Zealand Registry performs as per DES. The New Zealand Registry continues to keep the DES up to date, as requested by the ITL.

Minimising discrepancies

The NZEUR has multiple checks in place to ensure discrepancies in transactions are minimised. For example, the web application interface prevents users from selecting the wrong units to fulfil a notification (where the unit blocks are specified). Checks in the NZEUR generally follow the checks performed by the ITL on a given transaction. The NZEUR also has a robust reconciliation and manual intervention process, which allows ease of correction of reconciliation discrepancies. A more specific set of business rules and the procedures are presented below.

Registry administrators may reverse a transaction made in error or when required to correct discrepancies identified by the ITL. Transactions that have been approved and finalised through the ITL cannot be rolled back without the agreement of the ITL administrator. If the ITL is down, transactions can continue being made in 'interim' mode. When the ITL is back online, the interim transactions will be made in the original order. If a transaction is denied by the ITL, all subsequent interim transactions based on the units involved must be rolled back in the reverse order in which they were performed. Note that whether or not a transaction needs to be verified by the ITL depends on the transaction type (as described above). The same applies to whether or not a transaction needs approval.

In order to minimise discrepancies between the NZEUR and the ITL, the following approach has been adopted.

- Communications between the registry and the ITL are via web services using XML messages, as specified in DES 1.1.9. These web services, the XML message format and the processing sequence are checked by the registry to ensure compliance with DES 1.1.9.
- The registry validates data entries against the formats of information, as specified in Annex F of DES 1.1.9.
- The registry implements internal controls in accordance with the checks performed by the ITL, as documented in Annex E of DES 1.1.9.
- All units that are involved in a transaction are earmarked internally within the registry, thereby preventing the units from being involved in another transaction until a response has been received from the ITL and the current transaction has been completed.
- The web service that sends the message to the ITL for processing will ensure that a message-received acknowledgement is received from the ITL before completing the submission of the message. Where no acknowledgement message has been received after a number of retries, the web service would terminate the submission and roll back any changes made to the unit blocks that were involved.
- Where a 24-hour clean-up message is received from the ITL, the existing web service would roll back any pending transactions and the units that were involved, thereby preventing any discrepancies in the unit blocks between the registry and the ITL.
- Finally, if an unforeseen failure were to occur, the data discrepancies between the registry and the ITL can be corrected via a manual intervention function within the registry. Reconciliation would then be performed to verify that the data is in sync between the registry and the ITL. If a discrepancy recurs in the registry, the following measures will be applied:

- identification, and registration of the discrepancy
- identification of the source of the discrepancy (DES, registry specifications, erroneous programming code)
- elaboration of a resolution plan and testing plan
- correction and testing of the software
- release and deployment of the corrected software.

Security measures

The following security plan for the NZEUR has been established. The plan has three parts:

- server security, which protects the physical servers and access to the underpinning software and databases
- web application security, which prevents unauthorised access to NZEUR information
- session security, which protects NZEUR data as it is transmitted over the internet.

The server security plan restricts physical and remote access to the servers hosting the NZEUR. Only authorised personnel have access to the data centre where the servers are located. The Environmental Protection Authority must authorise any access to the servers, and photo identification is required. Remote access to the servers is controlled by a firewall and a VPN.

User access security is controlled by a combination of access groups and user relationships. For example, a user can have a security group of 'industry user'. Based on him/her being a primary representative for a given holding account, they can access the information about that holding account.

The web application security component ensures that access to the NZEUR has been appropriately authorised. Users must log in to the web application using a unique username and password to gain access. Users are assigned to several different security groups, with different levels of permissions and data access.

Application-level firewalls are used to protect the NZEUR from any application level attacks, as follows.

- All traffic entering the platform is interrogated and checked for application-level attacks, including, where applicable, XML verification. This includes both traffic from the internet and traffic from the UN via the ITL VPN.
- The NZEUR application platform includes firewalls that provide full layer seven mitigation capability across all layers within the platform.

Intrusion detection/prevention (IDS/IDP) technologies are provided within the NZEUR to monitor and log traffic violations at all levels (web, application and database). All traffic within the NZEUR is inspected using both IDS/IDP and application firewalling and analysis techniques for violations to the accepted traffic patterns. This includes the following traffic flows:

- within the perimeter security layer
- across each of the NZEUR application platforms (production, hot-standby and pre-production)
- across each layer within each NZEUR application platform (reverse proxy, application and database)
- within the SQL database, including database-level IDS/IPS.

The NZEUR has a strong anti-virus protection, as follows:

- All hosts are protected with systems in place to automatically update signature files and provide an alert of any potential virus outbreaks.
- All anti-virus engine and core application updates are released into the pre-production environment, tested/verified and then released into production following an agreed change process.

Session security ensures the NZEUR data is not intercepted when it is transmitted over the internet. Data transmitted between the NZEUR and users is encrypted using server-gated cryptography, regardless of the operating system or browser type. An authenticated user session will be automatically terminated (logged out) after 15 minutes of inactivity. To protect the database from malicious activity, an SQL-specific IDS/IDP technology (DBProtect) will be used to log and monitor for any malicious activity from either internal or external access.

Changes have been made to the publically available information reported on the NZEUR: the cell phone, telephone and fax numbers of account holders were removed for security reasons. These changes were introduced on 25 October 2012, as allowed under Section 13 of the Climate Change Response Act 2002, which permits the Registrar to withhold access to email addresses and phone and fax numbers of account holders.

Information availability

New Zealand's national registry list of publicly accessible information is available at http://www.eur.govt.nz, 'Search the Register' tab. The following types of information can be accessed via the publically accessible user interface to the Register:

- a list of emission unit holdings and transactions
- a list of transactions between the Register and overseas registers
- a list of accounts in the Register
- a list of account holders in the Register, and their legal addresses
- a list of New Zealand projects eligible for emission units.

Publicly accessible information from the NZEUR

A detailed list of publicly accessible information is provided in table B4.

Integrity of data storage and disaster recovery plan

To cover NZEUR data security and data recovery in the event of a disaster, the system is backed up daily (figure B.2.4). Key principles of backup of services with the NZEUR hosted solution are as follows.

- Production and disaster recovery databases are backed up daily.
- Database transaction logs are transferred from the production environment to the disaster recovery environment at five minute intervals.
- Server images are taken of each environment before and after any system change.

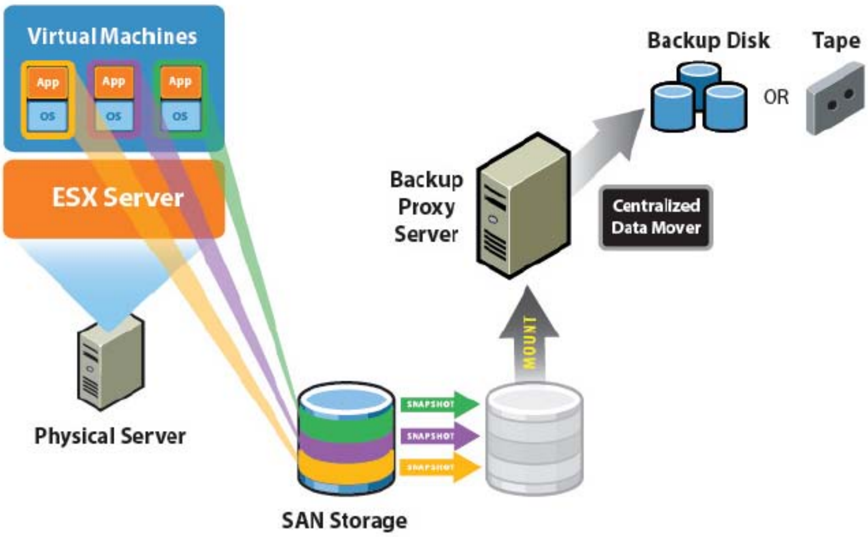


Figure B.2.4: Backup architecture

To backup hardware and software (figure B.2.4), the following measures are put in place.

- Image backups are performed on all the virtual servers across the entire NZEUR environment. As well as image backups, there will be SQL database backups (all databases).
- Backup on client servers is performed using VMware's built-in backup facility (called VCB) and Symantec's backup Exec.
- Full backups are performed whenever there is a system change, and differential backups are done every night.
- A full system image of all of the virtual machines is created daily, and changes to these images are backed up to tape every night.
- The database is backed up to disk as well as tape. Tapes will be rotated through in both Auckland and Wellington and stored offsite in a secure tape storage facility.
- Tape backups are encrypted to ensure security during offsite storage. These keys are stored in backup Exec, and secure backups will be taken of these keys and stored along with other certificates and keys.
- Consolidated backup uses VMTools to make a duplicate of the file system inside the virtual machine, ensuring that when the snapshot is taken, all pending data changes have been written to disk so that the snapshot contains consistent data.
- Once a system snapshot is taken, a separate machine (the backup proxy server) mounts the base disk as if it were a logically attached file system. As a result, a backup agent running on the proxy server can read and backup the files using the same features the agent makes available for backing up physical drives.
- NZEUR specific backup tape retrieval and secure storage is managed by Crown Security.
- Secure backups of encryption keys are taken and stored securely with the third party along with other certificates and keys.
- Offline backups include physical removal of backup media from the site.

In the event of a complete unrecoverable failure of the production NZEUR environment, services will be manually switched to the hot-standby/DR site located in Wellington, in accordance with the DR/BCP Plan. Any roll back from hot-standby/DR will also be in accordance with the DR/BCP Plan (and following data integrity checks).

In the event of total service failure, where both primary and hot-standby/DR environments fail at the same time:

- the NZEUR design includes the requirement to meet a recovery time objective (RTO) of 4 hours; a recovery point objective (RPO) of 1 hour is required for DR
- processes will be created to support the RPO and RTO objectives and to detail how DR will be invoked under what scenarios.

Results of test procedures

During the 2010 in-country review, New Zealand agreed to conduct performance testing on the new hosting environment. The test was completed in July 2011. The test report was published internally[285] and is available on request.

During 2011 New Zealand changed the hosting environment. There were no changes made to the application software.

[285] Telstra Clear Limited. 2011. *New Zealand Emissions Unit Register Project: Performance Test Report*. Wellington: Ministry of Economic Development

Table B.4: List of the publicly accessible information in the NZEUR[286]

Type of information to be made public, pursuant to part E of the annex to 13/CMP.1, paragraphs 44 to 48	Publicly available on NZEUR website (Yes/No/Partial)	Timing of information to be made available under New Zealand's Climate Change Response Act 2002	Relevant reference to New Zealand's Climate Change Response Act 2002 where information is not publicly available in accordance with paragraphs 44 to 48
44. Each national registry shall make non-confidential information publicly available and provide a publicly accessible user interface through the internet that allows interested persons to query and view it.			
45. The information referred to in paragraph 44 above shall include up-to-date information for each account number in that registry on the following:			
(a) account name: the holder of the account	Yes (refer Search the Register: Accounts).	Up to date (real-time).	n/a
(b) account type: the type of account (holding, cancellation or retirement)	Yes (refer Search the Register: Accounts).	Up to date (real-time).	n/a
(c) commitment period: the commitment period with which a cancellation or retirement account is associated	Yes (refer Search the Register: Accounts: Click on Account Number hyperlink to access Account Information Report).	Up to date (real-time).	n/a
(d) representative identifier: the representative of the account holder, using the Party identifier (the 2-letter country code defined by ISO 3166) and a number unique to that representative within the Party's registry	No – the representative identifiers for primary representatives are not publicly available and have been withheld for security reasons.	n/a	Section 27(1)(a) of the Climate Change Response Act 2002 does not require this information to be made publicly available. Only the holding account number for each account in the registry is publicly available under this section.
(e) representative name and contact information: the full name, mailing address, telephone number, facsimile number and email address of the representative of the account holder	Partial – publication of the personal email addresses, telephone and fax numbers of the representatives has been withheld for security reasons (refer Search the	Up to date (real time).	Section 13 of the Climate Change Response Act 2002 permits the Registrar to withhold access to the email address and phone and fax numbers

[286] Ministry for the Environment. 2013. *New Zealand's Greenhouse Gas Inventory 1990–2011*. Retrieved from http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2013

	Register: Accounts: Click on Account Number hyperlink to access Account Information Report: Representative Details).		of account holders' representatives on the grounds of security or integrity of the registry.
46. The information referred to in paragraph 44 shall include the following Article 6 project information, for each project identifier against which the Party has issued ERUs:			
(a) project name: a unique name for the project	Yes (refer Search the Register: Joint Implementation (JI) Projects).	Up to date (real time).	n/a
(b) project location: the Party and town or region in which the project is located	Yes (refer Search the Register: JI Projects).	Up to date (real time).	n/a
(c) years of ERU issuance: the years when ERUs have been issued as a result of the Article 6 project	Yes (this information can be accessed either by clicking on the project ID under the Unit Conversions tab or through the Ministers' Directions menu item. This lists directions relating to the transfer of emission reduction units to individual joint implementation projects. The NZEUR *Unit Holding and Transaction Summary Report* shows in aggregate the total ERUs converted from AAUs by year).	Joint implementation (JI) projects) annually by 31 January for the previous calendar year. Ministers' directions – up to date (real time).	n/a
(d) reports: downloadable electronic versions of all publicly available documentation relating to the project, including proposals, monitoring, verification and issuance of ERUs, where relevant, subject to the confidentiality provisions in decision 9/CMP.1	Partial – this information is published on MfE's website for joint implementation projects at http://www.mfe.govt.nz/issues/climate/policies-initiatives/joint-implementation/notice.html and is not replicated on New Zealand's national registry website (http://www.eur.govt.nz) The following information for each JI project is published on MfE's website: • project description • non-host party project approval • annual reports	This information becomes publicly available once New Zealand gives its approval to the JI project. The information is then updated, when necessary, and annual reports are added annually.	n/a

	• verification reports. Project proposals are not included because they contain financial information which is considered to be commercially sensitive and confidential.		
47. The information referred to in paragraph 44 shall include the following holding and transaction information relevant to the national registry, by serial number, for each calendar year (defined according to Greenwich Mean Time):			
(a) the total quantity of ERUs, CERs, AAUs and RMUs in each account at the beginning of the year	Partial – aggregate unit holdings of ERUs, CERs, AAUs and RMUs for the previous calendar year are disclosed by 31 January of each year (refer Search the Register: NZEUR Holding & Transaction Summary). The total quantity of unit holdings in each account within the most recent calendar year is considered to be confidential information; therefore the total quantity of unit holdings provided for each account is only that completed more than 1 year in the past. (Refer Search the Register: NZEUR Kyoto Unit Holdings by Account: Use Search Criteria to find information pertaining to more than 1 year in the past).	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year. 1 January for the beginning of the previous calendar year.	Section 27(2) of the Climate Change Response Act 2002 only requires total holdings of AAUs, ERUs, CERs, ICERs, tCERs and RMUs to be publicly available by 31 January of each year for the previous calendar year). Section 27(3) of the Climate Change Response Act 2002 only requires holdings of Kyoto units by each holding account for the beginning of the previous calendar year to be made publicly available.
(b) the total quantity of AAUs issued on the basis of the assigned amount pursuant to Article 3, paragraphs 7 and 8	Yes (refer Search the Register: NZEUR Holding & Transaction Summary).	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year.	n/a
(c) the total quantity of ERUs issued on the basis of Article 6 projects	Yes (refer Search the Register: NZEUR Holding	Annually by 31 January for the previous	n/a

	& Transaction Summary – Units Converted to).	calendar year. The Registry makes this information available on 1 January of each year.	
(d) the total quantity of ERUs, CERs, AAUs and RMUs acquired from other registries and the identity of the transferring accounts and registries	Partial – the total quantity of ERUs, CERs, AAUs and RMUs acquired from other registries, and the identity of the registries, is publicly available by 31 January for the previous calendar year (refer Search the Register: NZEUR Incoming Transactions for the Year). The identity of the individual transferring accounts is not available because it is considered to be confidential information.	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year.	Section 27(j) of the Climate Change Response Act 2002 requires that only the following be made publicly available: • total quantity of units transferred • total quantity and type of unit transferred • the identity of the transferring overseas registries, including the total quantity of units transferred from each overseas registry and each type of unit transferred from each overseas registry.
(e) the total quantity of RMUs issued on the basis of each activity under Article 3, paragraphs 3 and 4	Yes (refer Search the Register: NZEUR Holding & Transaction Summary). NOTE: Reported as '0' as this event did not occur in the specified period.	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year, if the event occurred during the reporting period.	n/a
(f) the total quantity of ERUs, CERs, AAUs and RMUs transferred to other registries and the identity of the acquiring accounts and registries	Partial – the total quantity of ERUs, CERs, AAUs and RMUs transferred to other registries, and the identity of the registries is publicly available by 31 January for the previous calendar year. The identity of the individual acquiring accounts is not available because it is considered to be confidential information.	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year.	n/a Section 27(k) of the Climate Change Response Act 2002 requires that only the following be publicly available:

			• total quantity of units transferred • total quantity and type of unit transferred • the identity of the acquiring overseas registries, including the total quantity of units transferred to each overseas registry and each type of unit transferred to each overseas registry.
(g) the total quantity of ERUs, CERs, AAUs and RMUs cancelled on the basis of activities under Article 3, paragraphs 3 and 4	Yes (refer Search the Register: NZEUR Holding & Transaction Summary). NOTE: Reported as '0' as this event did not occur in the specified period.	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year, if the event occurred during the reporting period.	n/a
(h) the total quantity of ERUs, CERs, AAUs and RMUs cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1	Yes (refer Search the Register: NZEUR Holding & Transaction Summary). NOTE: Reported as '0' as this event did not occur in the specified period.	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year, if the event occurred during the reporting period.	n/a
(i) the total quantity of other ERUs, CERs, AAUs and RMUs cancelled	Yes (refer Search the Register: NZEUR Holding & Transaction Summary).	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year, if the event occurred during the reporting period.	n/a
(j) the total quantity of ERUs, CERs, AAUs and RMUs retired	Yes (refer Search the Register: NZEUR Holding & Transaction Summary). NOTE: Reported as '0' as this event did not occur in the specified period.	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year, if the event occurred during the reporting period.	n/a

(k) the total quantity of ERUs, CERs, and AAUs carried over from the previous commitment period	Yes (refer Search the Register: NZEUR Holding & Transaction Summary). NOTE: Reported as '0' as this event did not occur in the specified period.	Annually by 31 January for the previous calendar year	n/a
(l) current holdings of ERUs, CERs, AAUs and RMUs in each account.	Partial – aggregate unit holdings of ERUs, CERs, AAUs and RMUs from the previous calendar year are disclosed by 31 January (refer Search the Register: NZEUR Kyoto Unit Holdings by Account). Total quantity of unit holdings in each account within the most recent calendar year is considered to be confidential information; therefore the total quantity of unit holdings provided for each account is only that completed more than 1 year in the past. (Refer Search the Register: NZEUR Kyoto Unit Holdings by Account: Use Search Criteria to find information pertaining to more than 1 year in the past).	Annually by 31 January for the previous calendar year. The Registry makes this information available on 1 January of each year. 1 January for the beginning of the previous calendar year.	Section 27(2) of the Climate Change Response Act 2002 only requires total holdings of AAUs, ERUs, CERs, ICERs, tCERs and RMUs to be publicly available by 31 January of each year for the previous calendar year. Section 27(3) of the Climate Change Response Act 2002 only requires holdings of Kyoto units by each holding account for the beginning of the previous calendar year to be made publicly available.
48. The information referred to in paragraph 44 shall include a list of legal entities authorised by the Party to hold ERUs, CERs, AAUs and/or RMUs under its responsibility.	Yes (refer Search the Register: Account Holders for list of authorised entities).	Up-to-date (real time).	n/a

Registry processes and business rules

Issue units

The Party's registry administrator creates a block of units of AAUs or RMUs in an origination account by specifying the commitment period, originating party, quantity and unit type. If the unit block contains RMUs, the LULUCF activity must also be specified.

Table B.5: Issuing Kyoto units

General business rules:	• All unit blocks are issued with an original commitment period and applicable commitment period for the current commitment period (as stored as a system parameter in the SYSTEM_PARAMETER table). • LULUCF must be specified for RMUs. • The transaction must be validated by the ITL.
New Zealand business rules:	Issuance transaction requires approval.

Units acquisition (Kyoto transfer to Crown account, internal transaction)

The Party transfers units from its origination account to its Kyoto government holding accounts, which hold Kyoto Units. AAUs and RMUs may be allocated under a project ID in anticipation of conversion to ERUs for JI projects. Allocation transactions (internal transfers) do not need to be validated by the ITL.

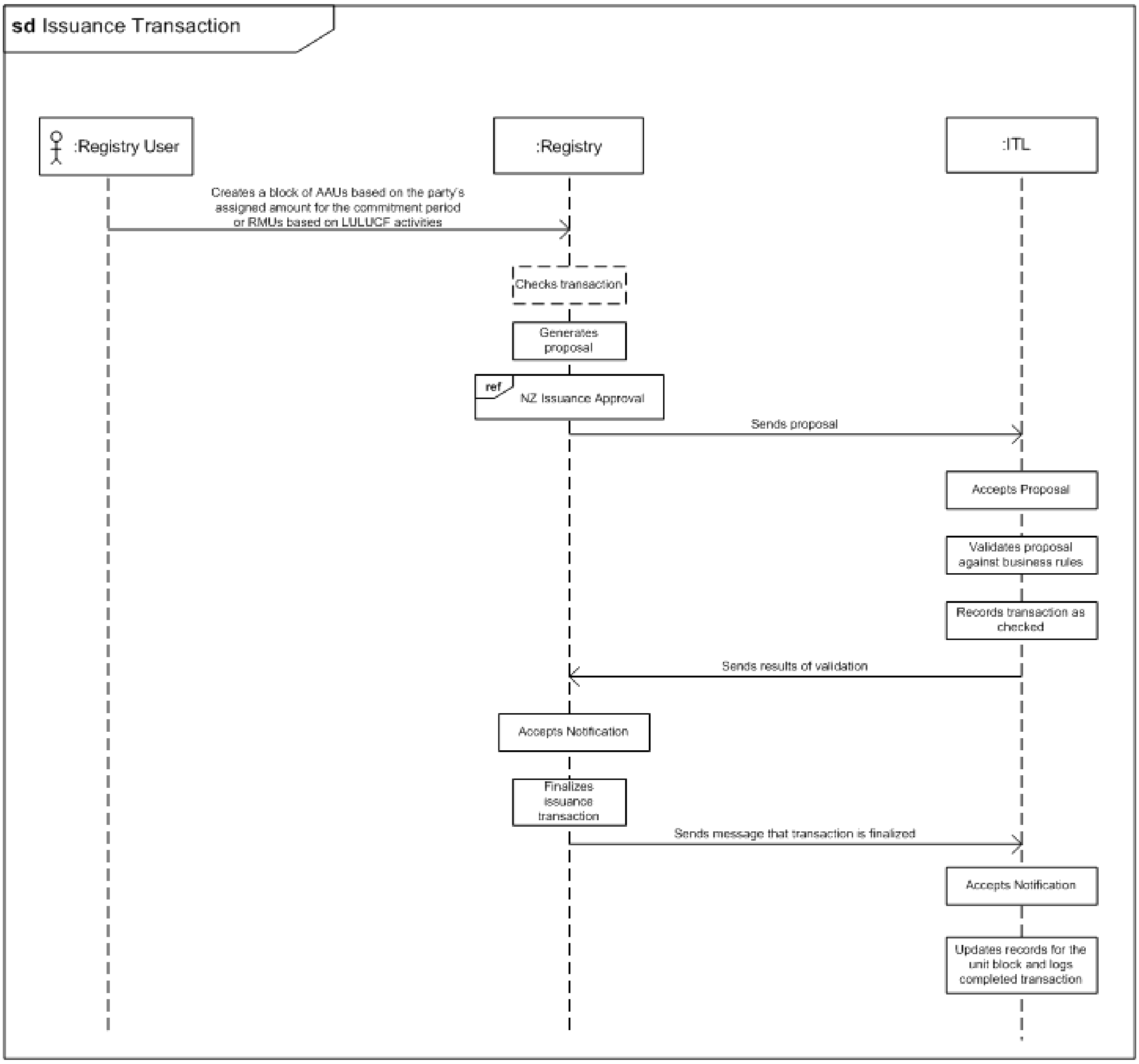


Figure B.2.5: Issuance transaction process flow

Table B.6: Allocating Kyoto units

General business rules:	• Only project IDs associated with projects with a status of 'Open' are available for unit allocation. • If units are allocated to a specific New Zealand project, a check is performed to ensure that the allocation amount does not exceed the maximum units specified for the selected project. If previous allocations have occurred, the check must sum those unit allocations and ensure the new allocation does not exceed the maximum units allowed for said project.
New Zealand business rules:	Transfer to Crown account for Kyoto units from origination account requires approval.

Kyoto transfer units from Crown holding account to holding account

The Party transfers units in its Crown holding account for Kyoto units to holding accounts in the Registry. Internal transfers do not need to be validated by the ITL.

Table B.7: Kyoto transfer units from Crown holding account to holding account

General business rules:	Only Kyoto units may be transferred to a Crown holding account for Kyoto units.
New Zealand business rules:	Transfer to Crown account from origination account requires approval.

Kyoto transfer to (between) internal accounts

The internal transfer of AAUs, RMUs, ERUs, tCERs, lCERs and CERs from a holding account to another holding account within the registry is undertaken by an account representative on the basis of the amount proposed by the transferor. Transactions do not need to be validated by the ITL.

Table B.8: Kyoto transfer to (between) internal accounts

General business rules:	• Industry users may only trade units held in their account. • Only Crown accounts can hold lCERs.
New Zealand business rules:	Only those transactions involving units held in a Crown account are sent to the approvals module.

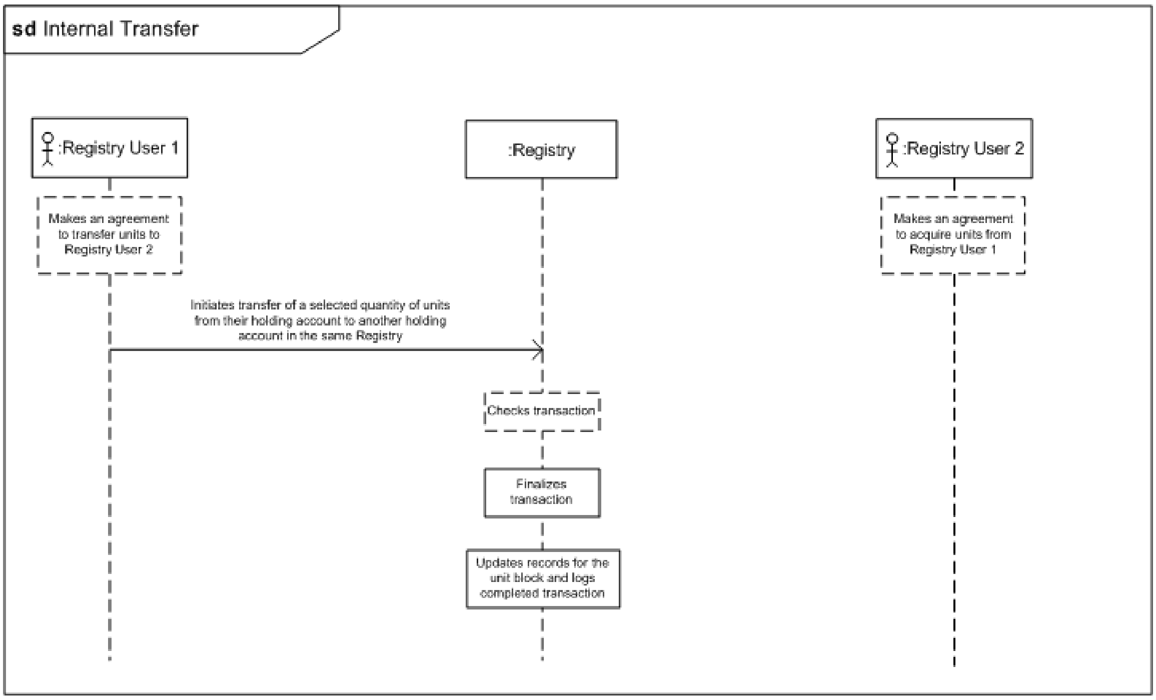


Figure B.2.6: Internal transfer process flow

Kyoto transfer to external account

External transfer refers to the transfer of units between distinct national registries. The external transfer of AAUs, RMUs, ERUs, tCERs, lCERs and CERs to another registry is undertaken by an account holder. Incoming transactions are screened for criteria (eg, units associated with a nuclear project) maintained by the NZEUR administrator.

Table B.9: External transfer transaction

General business rules:	The transaction must be validated by the ITL.
New Zealand business rules:	Outgoing external transactions require approval if a Crown account is involved.

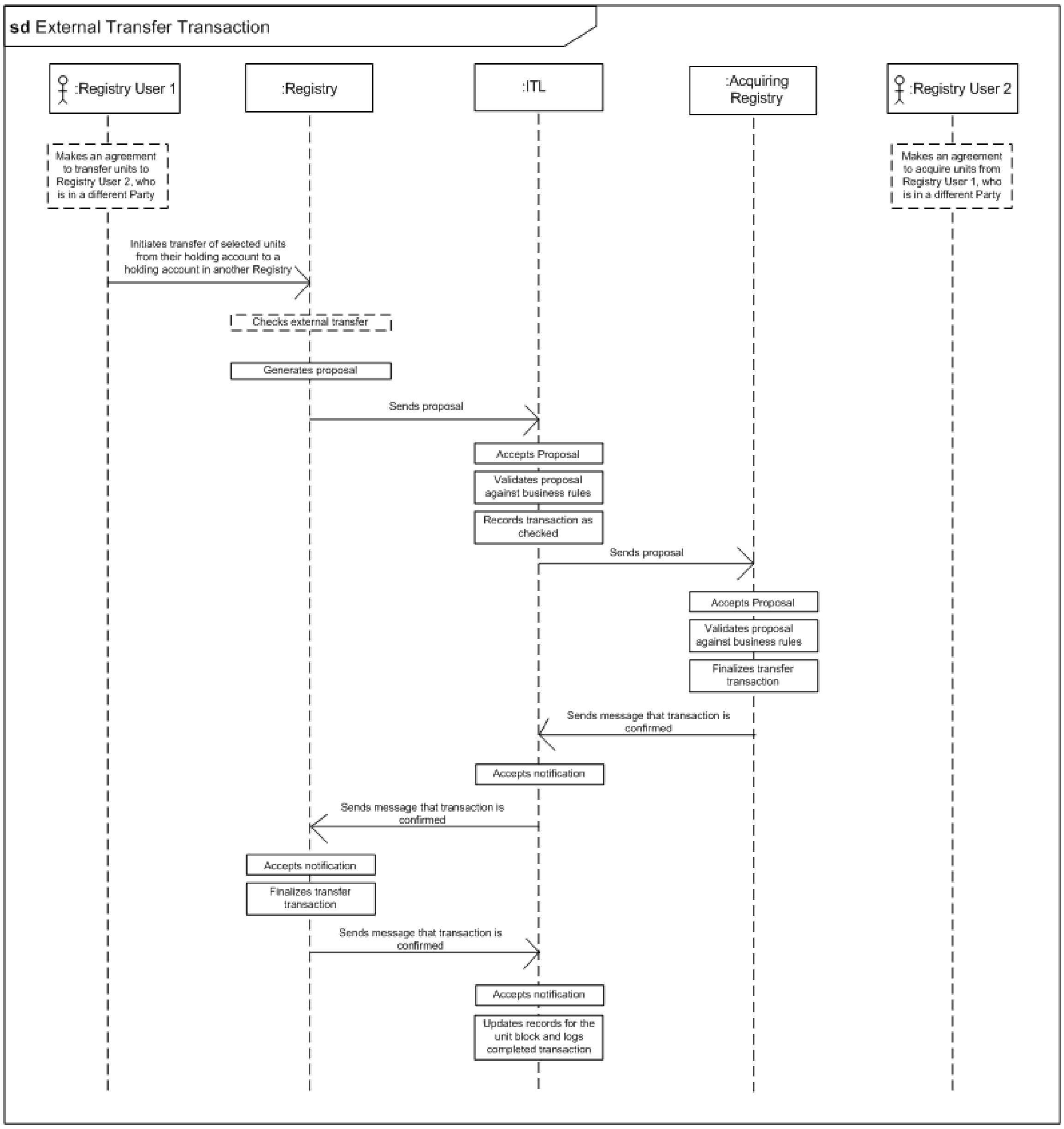


Figure B.2.7: External transfer transaction process flow

Cancel Kyoto units – voluntary

The transfer of AAUs, RMUs, ERUs, CERs, tCERs and lCERs to the general cancellation account is undertaken by an account representative. Voluntary cancellation will likely be conducted to address concerns for the environment. Users can voluntarily cancel units by transferring them to the voluntary cancellation account at any time.

At the end of the Commitment Period, voluntary cancellation of the last Commitment Period's units involves a transfer to the mandatory cancellation account, fulfilling the DES requirement that "Any units for a Commitment Period, which remain in holding accounts after the appropriate carry-over transactions for that Commitment Period have been completed, must be cancelled to the mandatory cancellation account."

Table B.10: External transfer transaction

General business rules:	The transaction must be validated by the ITL.

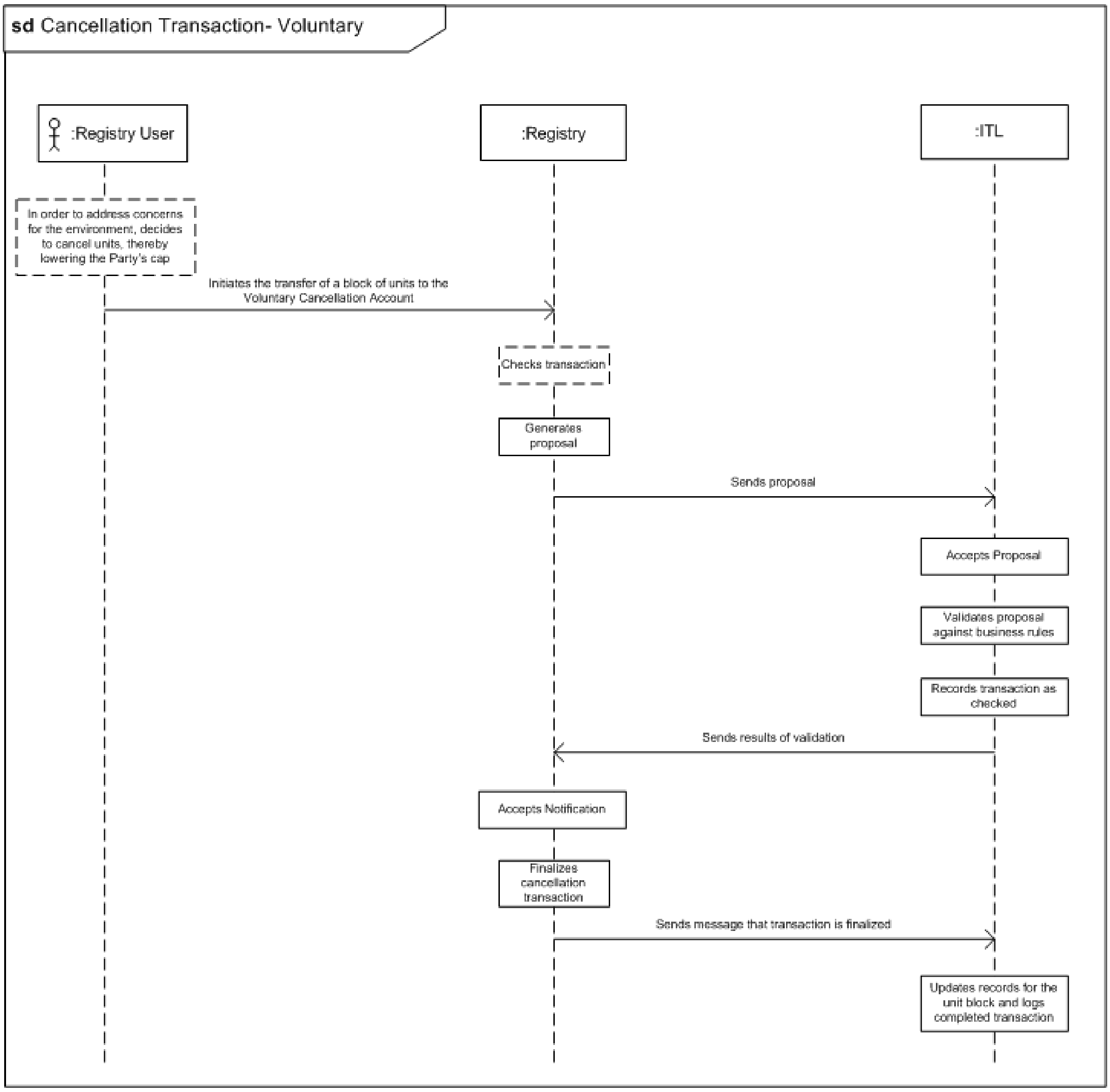


Figure B.2.8: Voluntary cancellation of Kyoto units process flow

Retirement of Kyoto units

The internal transfer of AAUs, RMUs, ERUs, CERs, and lCERs to a retirement account is undertaken by an account representative or the registry administrator. Units that are retired are credited toward meeting New Zealand's commitment as a Party to the Kyoto Protocol.

Table B.11: Retire Kyoto units

General business rules:	• Once retired, units cannot be further transferred or carried over. • The transaction is validated by the ITL.
New Zealand business rules:	• The transaction requires approval • The retirement of tCERs (by anyone) is prohibited in the NZEUR.

Cancel Kyoto units – notification based

The transfer of AAUs, RMUs, ERUs, CERs, tCERs and lCERs to a cancellation account is undertaken by an account representative or the registry administrator, on the basis of the amounts proposed by the transferor and in response to a notification from the ITL. Users must cancel units in accordance with a notification for the following reasons:

- net source cancellation (Type 1)
- non-compliance cancellation (Type 2)
- reversal of storage for Clean Development Mechanism (CDM) project (Type 4)
- non-submission of certification report for CDM project (Type 5)
- excess issuance for CDM project (from the CDM or a national registry) (Type 6)
- cancellation of units for a commitment period, which remain in holding accounts after completion of the true-up period for that commitment period, or cancellation of units for a commitment period which remain in holding accounts after completion of all carry-over transactions for that commitment period.

Table B.12: Cancel Kyoto units – notification based

General business rules:	• Unit blocks available for cancellation include only those units referenced in the notification (if applicable based on notification type). • The transaction must be validated by the ITL.
New Zealand business rules:	• The transaction requires approval. • For a given notification Registry administrators can assign a specific number of units to industry users to respond to.

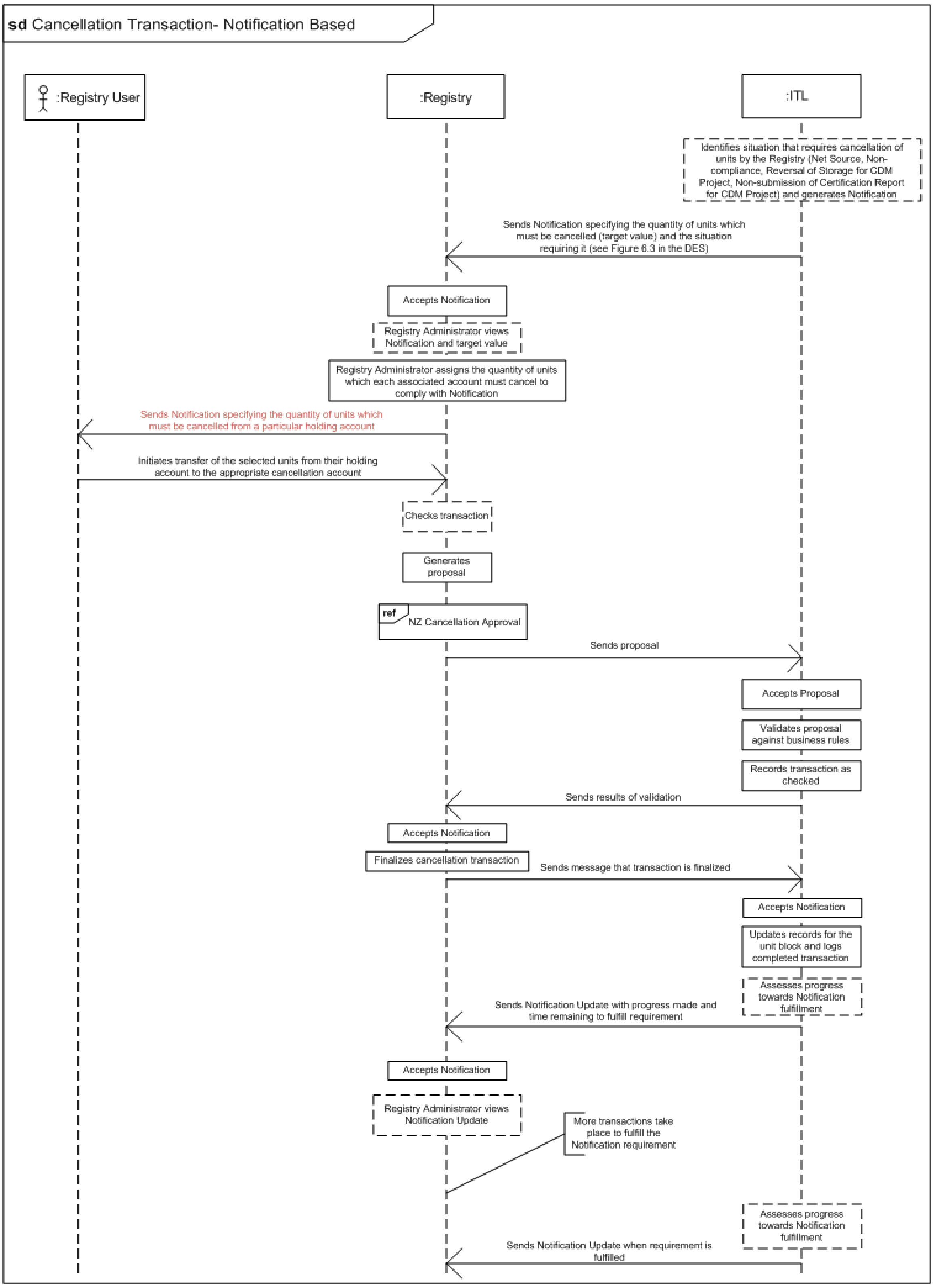


Figure B.2.9: Notification-based cancellation of Kyoto units process flow (general)

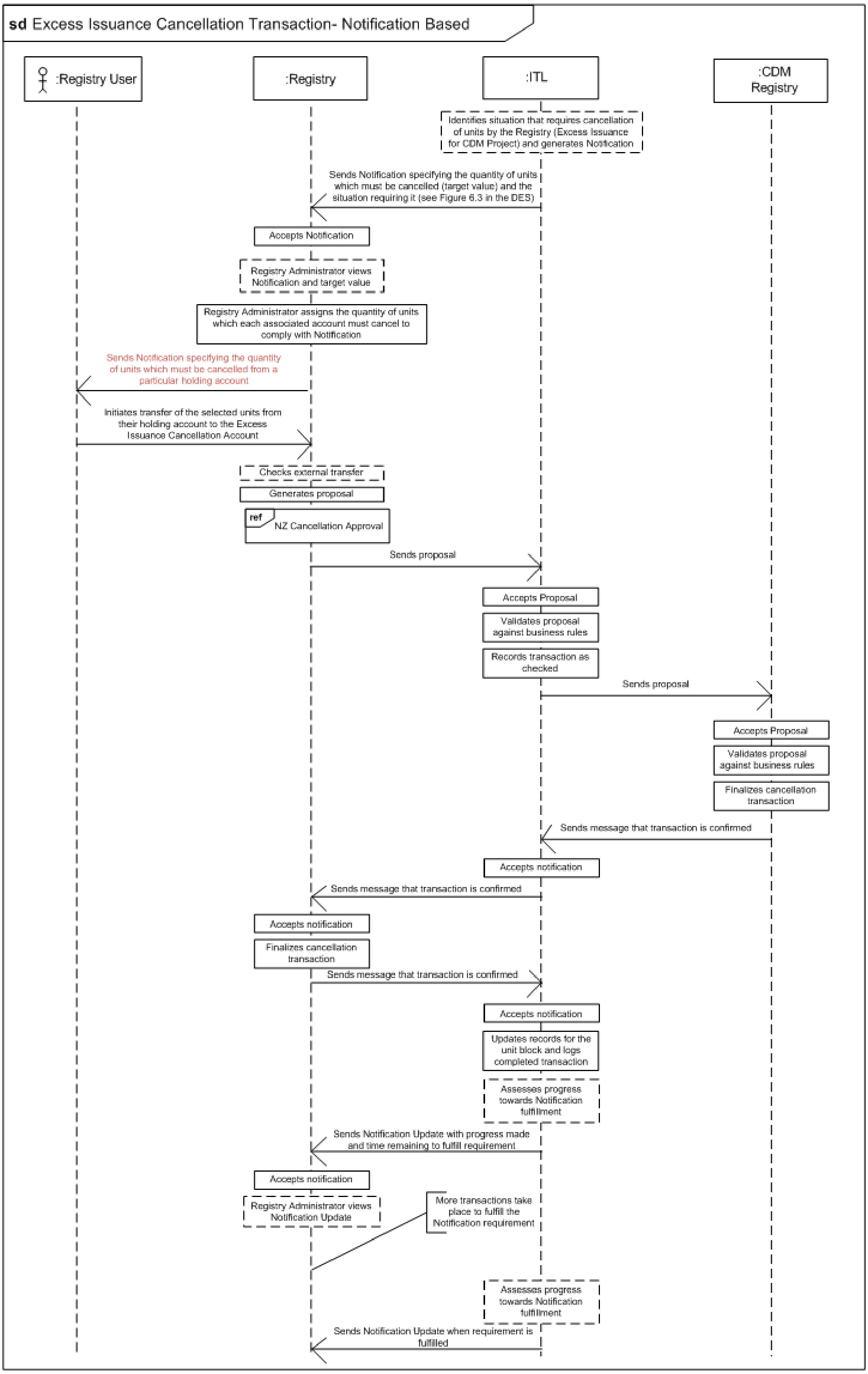


Figure B.2.10: Notification-based cancellation of Kyoto units process flow

NZEUR application and database backup schedule

The daily backup schedule will vary according to operational environments. The latest schedule can be viewed on the NZEUR Service Management Portal. A schedule will be created that specifies the times and days that types of backups can run. The planned backups are as follows:

- A full backup is made of all data that resides within the backup section.
- A backup selection can comprise the entire server or smaller, more manageable portions of the server.
- Full backups affect the Read I/O of the server they are run on and so are scheduled for a non-business section of the week (Saturday and Sunday).
- Incremental backups (for the data that has changed since the last full backup) are run overnight, 7 days a week.
- All scheduled monthly and yearly backups of the system are full backups.
- Full backups are run during a non-business section of the week (between 17:00 Friday and 06:00 Monday).
- A full backup is performed on each backup selection every week.

Supplementary notes related to Articles 6, 12 and 17

In the net position report produced in April 2013, New Zealand's net emissions of greenhouse gases over the first commitment period were projected to be 286.3 million tonnes CO_2-e.[287] A total of 6.8 million Kyoto units have been promised to projects under the Projects to Reduce Emissions programme, so the Government's projected liability is 300 million units, which is 3 per cent under New Zealand's assigned amount (309.6 million units). This includes 85 million tonnes of projected removal units from forests, mostly planted in the mid-to-late 1990s. As a result, New Zealand will not need to use the mechanisms under Articles 6, 12 and 17 of the Kyoto Protocol to meet its emissions reduction target.

Policies and measures in accordance with Article 2

Sustainable development

All of New Zealand's climate change policies promote sustainable development (please refer to chapter 4).

Aviation and marine bunker fuels

New Zealand's geographical remoteness, coupled with international tourism being a significant economic earner, makes addressing international aviation emissions a key concern. Airways New Zealand (New Zealand's air navigation service provider) is working together with other countries' air navigation service providers to improve efficiencies on international or long-haul routes through the Asia–Pacific Initiative to Reduce Emissions (ASPIRE). ASPIRE's work includes demonstrating the capabilities of advanced air navigation services and airline fuel optimisation initiatives in current operations (eg, improved air traffic management, continuous climb

[287] http://www.mfe.govt.nz/issues/climate/greenhouse-gas-emissions/net-position/

departures, user-preferred routes). The New Zealand Government has also facilitated the bio-fuel trials conducted by Air New Zealand. In terms of estimates of emissions from international aviation, New Zealand revised the allocation between domestic and international aviation emissions in 2008.

The Government plays an active role on the International Maritime Organisation's Maritime Environment Protection Committee, where international greenhouse gas emissions are considered. International maritime transport is critical for New Zealand's primary products, which make up two-thirds of exports. A joint inter-departmental project is investigating methods for calculating greenhouse gas emissions from international shipping, and the results of this will contribute to primary sector carbon footprinting analysis.

Minimising adverse effects

New Zealand's Cabinet and legislative processes to establish and implement climate change response measures include consultation with the Ministry of Foreign Affairs and Trade and with members of the public. The Ministry of Foreign Affairs and Trade provides advice to the Government on international aspects of proposed policies. During the public consultation phase, concerns about and issues relating to the proposed measure can be raised by any person or organisation.

Through the New Zealand Government's regular trade, economic and political consultations with other governments, including some non-Annex I Parties, there are opportunities for those who may be concerned about the possible or actual impacts of New Zealand policies to raise concerns and have them resolved within the bilateral relationship. There have been no specific concerns raised about any negative impact of New Zealand's climate change response policies.

The New Zealand Government, through the New Zealand Aid Programme (http://www.aid.govt.nz), has regular Official Development Assistance talks with partner country governments, at which partners have the opportunity to raise concerns about any impacts and to ask for or prioritise assistance to deal with those impacts. Based on these discussions, New Zealand works closely with the partner country to prepare a country strategic framework for development. These engagement frameworks are relatively long term (5 or 10 years) and convey New Zealand's development assistance strategy in each country in which it provides aid. They are aligned to the priorities and needs of the partner country, while also reflecting New Zealand's priorities and policies.

On many of the issues related to the implementation of Article 3.14, New Zealand gives priority to working with countries broadly in the Pacific region. The New Zealand Aid Programme also works with partner developing countries to strengthen governance and improve their ability to respond to changing circumstances.

Climate change, including adaptation and finance, was a key part of discussions by leaders at the 42nd Pacific Island Forum meeting hosted by New Zealand in September 2011. Climate change continues to be a focus for the Forum, and New Zealand continues to work with other Forum members in a wide range of technical, economic and political fields, addressing the climate change concerns raised by leaders.

New Zealand maintains a liberal and open trading environment, consistent with the principles of free trade and investment, ensuring that both developed and developing countries can maximise opportunities in New Zealand's market regardless of the response measures undertaken.

Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures

The Climate Change Response Act 2002 puts in place the legal framework that allowed New Zealand to ratify the Kyoto Protocol and to meet its obligations under the UNFCCC. The Act includes powers for the Minister of Finance to manage New Zealand's holdings of units, which represent New Zealand's target allocation for greenhouse gas emissions under the Kyoto Protocol. It enables the Minister to trade those units on the international market and establishes a register to record holdings and transfers of units. The Act also establishes a national inventory agency to record and report information relating to greenhouse gas emissions in accordance with international requirements.

The Climate Change Response (Emissions Trading) Amendment Act 2008 established the New Zealand Emissions Trading Scheme (NZ ETS). The Act describes the legal details of the scheme. Regulations relating to the NZ ETS have also been made under the Climate Change Response Act. The NZ ETS is described in more detail in chapter 4.

Information under Article 10

Activities undertaken by New Zealand in fulfilment of commitments under Article 10 of the Kyoto Protocol are reported on in chapters 4, 6, 7, 8 and 9. The steps taken by New Zealand to promote, finance and facilitate the transfer of technology to developing countries are reported on in chapter 7.

Financial resources

The steps taken for New Zealand to meet its obligations under Article 11 of the Kyoto Protocol are outlined in chapter 7.

Annex C: Summary of policies and measures

Table C.1: Summary of policies and measures, by sector

Name of policy or measure	Objective and/or activity affected	Year implemented	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimated mitigation in:		
							2009 (Gg CO_2-e per year)	2020 (Gg CO_2-e per year)	2040 (Gg CO_2-e per year)
Cross cutting measures									
New Zealand Emissions Trading Scheme (NZ ETS)	The scheme aims to reduce emissions by making emitters pay for any emissions covered under the Kyoto Protocol. It covers all sectors and all gases, although 2012 amendments removed the date for biological emissions from agriculture to assume surrender obligations.	2008 (entry has been phased by sector)	CO_2, CH_4, N_2O, PFCs, HFCs, SF_6	Economic; regulatory	Implemented	The Environmental Protection Authority administers the register and enforces the scheme. The Ministry for the Environment is responsible for developing NZ ETS regulations. The Ministry for Primary Industries administers the forestry allocation plan and compliance with forestry regulations.		9,810[288]	

[288] Chapter 5 shows that an estimated 9,810.0 Gg CO_2-e emissions will be avoided by key quantifiable policies and measures by 2020. The NZ ETS is assumed to be responsible for the majority of this total, but its exact effect has not been quantified. This is because the impacts of the NZ ETS are difficult to entirely distinguish from impacts of other policies. Also, the NZ ETS is a long-term intervention, and its impacts need to be evaluated on that basis. The Ministry for the Environment is establishing a work programme to ensure that the NZ ETS and its impacts are monitored and evaluated over time.

Name of policy or measure	Objective and/or activity affected	Year implemented	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimated mitigation in:		
							2009 (Gg CO_2-e per year)	2020 (Gg CO_2-e per year)	2040 (Gg CO_2-e per year)
Energy									
Efficient Products Programme	An Equipment Energy Efficiency (E3) Programme jointly developed with Australia. Energy efficiency measures, including energy rating labelling for a range of residential, commercial and industrial products, along with mandatory performance standards, allows both countries to set consistent standards and measures for energy efficiency.	2006	CO_2	Regulatory; voluntary; information	Implemented	Energy Efficiency and Conservation Authority		1,400	
ENERGYWISE homes	Aims to increase energy efficiency in homes by providing information on, and grants for, insulation and clean heat. The programme also provides information on funding available to reduce energy consumption.	The Warm Up New Zealand: Heat Smart programme ran from 2009 to September 2013. This was replaced by the Warm Up New Zealand: Healthy Homes programme, which began rolling out from August 2013.	CO_2	Fiscal; information	Implemented	Energy Efficiency and Conservation Authority		20	

Name of policy or measure	Objective and/or activity affected	Year implemented	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimated mitigation in: 2009 (Gg CO_2-e per year)	2020 (Gg CO_2-e per year)	2040 (Gg CO_2-e per year)
Business programmes	Promotes best practice energy management in energy intensive businesses. The focus is on four priority areas: commercial buildings, industrial heat, business transport, and lighting. The scheme provides information on new technologies and energy management, grants for energy audits, demonstrations of new technology, and one-on-one support.	The current suite of business programmes was implemented in 2012.	CO_2	Fiscal; information	Implemented	Energy Efficiency and Conservation Authority	89		
Energy efficiency in Government – Sustainable Government Procurement	The programme aims to make sustainable procurement an integral part of everyday procurement practice. The reforms are based around three core elements: policy transformation, capability building, and greater use of collaborative contracts.	2009	CO_2	Fiscal; information	Implemented	Ministry of Business, Innovation and Employment		NE	
Transport									

Name of policy or measure	Objective and/or activity affected	Year implemented	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimated mitigation in: 2009 (Gg CO_2-e per year)	2020 (Gg CO_2-e per year)	2040 (Gg CO_2-e per year)
Vehicle fuel economy labelling	A compulsory scheme requiring vehicle traders and online vendors to display information. Allows consumers to make more informed vehicle purchase choices and to place an appropriate value on fuel economy.	2008	CO_2	Regulatory	Implemented	New Zealand Transport Agency and the Energy Efficiency and Conservation Authority		43	
Biofuels	Supports research and innovation in relation to biofuels, with a focus on second-generation biofuels. There is particular interest in fuels made from forestry waste given New Zealand's well-established forestry industry.	2008	CO_2	Fiscal	Implemented	Energy Efficiency and Conservation Authority		NE	
Electric vehicles	Promotes uptake of electric vehicles in New Zealand by exempting them from road-user charges. In 2012 the exemption was extended until 2020.	2009	CO_2	Fiscal	Implemented	Energy Efficiency and Conservation Authority		NE	

Name of policy or measure	Objective and/or activity affected	Year implemented	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimated mitigation in:		
							2009 (Gg CO_2-e per year)	2020 (Gg CO_2-e per year)	2040 (Gg CO_2-e per year)
Other transport measures	These include research and driver training to promote more efficient driving practices in the commercial fleet, research into intelligent transport systems, improvements to roading and rail infrastructure, and promoting the use of public transport in New Zealand.		CO_2	Fiscal, education	Implemented	Ministry of Transport and the New Zealand Transport Agency		NE	
Agriculture									
Global Alliance on agricultural emissions	A network to increase international collaboration and investment in research into increasing agricultural and food production without growing greenhouse gas emissions.	2009	CH_4, N_2O, CO_2	Research; information; training; education	Implemented	Secretariat support and co-chair of the Livestock Research Group are provided by New Zealand		NE	
Primary Growth Partnership (PGP)	Provides funding for programmes of research and innovation to boost the economic growth and sustainability of New Zealand's primary, forestry and food sectors.	2009	CH_4, N_2O, CO_2	Research; information; training	Implemented	Ministry for Primary Industries		NE	

Name of policy or measure	Objective and/or activity affected	Year implemented	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimated mitigation in:		
							2009 (Gg CO_2-e per year)	2020 (Gg CO_2-e per year)	2040 (Gg CO_2-e per year)
New Zealand Agricultural Greenhouse Gas Research Centre	The Centre brings together nine research organisations and focuses on ways to increase productivity and reduce on-farm methane and nitrous oxide emissions.	2010	CH_4, N_2O, CO_2	Research; information; capability building; education	Implemented	Ministry for Primary Industries		NE	
Pastoral Greenhouse Gas Research Consortium (PGGRC)	A partnership between the Government and the dairy and fertiliser industries which provides livestock farmers with the information and means to mitigate their greenhouse gas emissions.	2002	CH_4, N_2O	Research, information, education	Implemented	Ministry for Primary Industries and the Ministry of Business, Innovation and Employment		NE	
Sustainable Land Management and Climate Change Plan of Action	Initiatives and programmes in the agricultural and forestry sectors that focus on adaptation to climate change, reducing emissions and enhancing sinks, and new business opportunities.	2007	CH_4, N_2O, soil carbon, forest carbon	Research; information; education; capability building	Implemented	Ministry for Primary Industries		NE	
Forestry									

Name of policy or measure	Objective and/or activity affected	Year implemented	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimated mitigation in:		
							2009 (Gg CO_2-e per year)	2020 (Gg CO_2-e per year)	2040 (Gg CO_2-e per year)
Permanent Forest Sinks Initiative	Promotes the establishment of permanent forests on previously unforested land. The Initiative offers an assigned number of units for carbon sequestered in permanent forests established after 1 January 1990.	2008	CO_2	Fiscal; voluntary agreement	Implemented	Ministry for Primary Industries			84
East Coast Forestry Project	The main purpose of this project is to reduce erosion by encouraging tree planting on erosion-prone land. The project also enhances the sequestration of carbon in forest sinks.	1992	CO_2	Fiscal; voluntary agreement	Implemented	Ministry for Primary Industries			399
Afforestation Grant Scheme	Offers a contestable fund to encourage the establishment of new forests on Kyoto-compliant land (i.e. land that was not forested as at 31 December 1989) by offering a simpler alternative to the NZ ETS for land owners establishing new forests.	2008	CO_2	Fiscal; voluntary agreement	Implemented	Ministry for Primary Industries			154
Waste									

Name of policy or measure	Objective and/or activity affected	Year implemented	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimated mitigation in:		
							2009 (Gg CO_2-e per year)	2020 (Gg CO_2-e per year)	2040 (Gg CO_2-e per year)
Waste Minimisation Act 2008	Aims to lower the social costs and risks from waste, reduce the damage to the environment from waste generation and disposal, and increase economic benefits by encouraging more efficient use of materials. It will also contribute to reducing greenhouse gas emissions from the waste sector.	2008	CH_4	Regulatory	Implemented	Ministry for the Environment		NE	
National Environmental Standard for Landfill Methane	Requires landfill sites with a lifetime design capacity of greater than 1 million tonnes of refuse to collect and destroy methane emissions.	Standard came into effect in 2004, with full compliance required by 2007	CH_4	Regulatory	Implemented	Ministry for the Environment and regional and local councils	216	502	
Waste Minimisation Fund	Provides funding to support projects that increase resource efficiency, reuse, recovery and recycling, and decrease waste to landfill.		CH_4	Regulatory		Ministry for the Environment		NE	

NE: not estimated

New Zealand's Report on the Global Climate Observing System (GCOS)

Executive summary

New Zealand's major observation programmes for atmospheric, terrestrial and oceanic measurements are detailed in this report, presented in accordance with the revised United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines on global climate change observing systems (Decision 11/CP.13).

Environmental observations related to the Global Climate Observing System (GCOS) essential climate variables (ECVs) are carried out in New Zealand by a variety of providers, including:

- local authorities (regional councils and others)
- Crown Research Institutes (National Institute of Water and Atmospheric Research (NIWA) and others)
- state-owned enterprises (MetService, energy companies)
- public service departments (Land Information New Zealand (LINZ), the Department of Conservation, the New Zealand Transport Authority, the National Rural Fire Authority)
- private corporates (eg, some energy companies).

A range of national initiatives are in place to ensure national consistency and comprehensiveness in environmental monitoring across New Zealand. Various data providers and institutions are working on building up comprehensive catalogues of New Zealand data holdings.

There are four primary observation programmes for New Zealand atmospheric ECV observations:

- weather station observations undertaken by MetService
- upper air weather observations undertaken by MetService
- climate station observations undertaken by NIWA
- atmospheric constituent measurements undertaken by NIWA.

Terrestrial ECV observations are conducted in New Zealand by a range of organisations, with the majority carried out by regional councils. These include freshwater (groundwater, lake and river quality, and river quantity) observations and vegetation surveys.

Surface oceanic ECV observations are carried out by a range of organisations, with five sea-level stations included in the Global Sea Level Observing System (GLOSS) network.

Ocean water column observations are carried out by NIWA. New Zealand also contributes to the Voluntary Observing Ships (VOS) and Argo programmes.

Introduction

New Zealand maintains observation programmes for atmospheric, terrestrial and oceanic measurements for a suite of GCOS ECVs. These measurements are complemented by archives of historical observations of climate-related parameters. The New Zealand GCOS ECV observation programmes are detailed in this report, presented in accordance with the revised UNFCCC reporting guidelines on global climate change observing systems (Decision 11/CP.13).[289] These revised guidelines focus on the contribution of Parties to the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC*.[290]

National observations in New Zealand: situation and general approach

Data collection by multiple providers

In New Zealand, GCOS ECV observations are carried out by a variety of providers, including:

- local authorities (eg, regional councils)
- Crown Research Institutes (eg, NIWA and GNS Science)
- state-owned enterprises (eg, MetService, energy companies)
- public service departments (LINZ, the Department of Conservation, the New Zealand Transport Authority, the National Rural Fire Authority)
- private corporates (eg, some energy companies).

Some of these observations are mandated by legislation or policy, or are covered by agreements between institutions. Some voluntary coordination is also occurring between organisations, to ensure national consistency and comprehensiveness, as outlined below.

High-quality observations versus 'fit-for-purpose'

GCOS ECV observations are used for a variety of practical purposes, including the regional management of environmental resources and the mitigation of hazards. For example:

- all regional authorities operate flood-warning monitoring networks on major rivers
- the National Rural Fire Authority operates a network of weather stations for fire-warning purposes
- energy companies operate river and lake monitoring networks for hydro energy resource and consent management.

Because the data is collected for different purposes, different standards for data collection are used and often the data collection 'regime' for a particular station is optimised for its purpose (eg, stage[291] or low accuracy recording for flood recording sites). As a result, it is often not easy to reuse the data for a different purpose, or to combine data collected from different networks. This problem is being addressed through various national initiatives aimed at facilitating better integration across different providers and working towards best practice in monitoring to fulfil a variety of purposes.

---

[289] UNFCCC. 2008. *Decision 11/CP.13: Reporting on Global Observing Systems for Climate*. FCCC/CP/2007/6/Add.2. Retrieved from http://unfccc.int/resource/docs/2007/cop13/eng/06a02.pdf

[290] GCOS. 2004. *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* (GCOS-92). Retrieved from http://www.wmo.int/pages/prog/gcos/Publications/gcos-92 GIP.pdf; GCOS. 2006. *Systematic Observation Requirements for Satellite-based Products for Climate* ('Satellite Supplement'), GCOS-107. Retrieved from http://www.wmo/int/pages/prog/gcos/Publications/gcos-107.pdf

[291] 'Stage' measurements are observations of river surface level, which is a coarse proxy for more accurate discharge measurements.

Data archives and data centres

A set of nationally significant databases has been set up over the last two decades by individual institutions to support national consistency and data access. These include the Climate Database (NIWA), Water Resources Archive (NIWA), National Groundwater Database (GNS Science), National Freshwater Fish Database (NIWA), and the National Freshwater Bio Information System (NIWA). Contribution to these data sets is voluntary. Also, some climate observation data at Crown Research Institutes is currently funded out of Vote Science and Innovation as part of the core purpose funding by these agencies.

National coordination

National coordination processes and clearly defined institutional arrangements are crucial to ensure national-scale data is collected according to consistent standards and is sufficiently representative to support national-level reporting. National coordination processes and clearly defined institutional arrangements will also ensure data is archived consistently and made available to end-users. To support these national goals, a range of programmes, several projects and various institutions operate across New Zealand.

National Environmental Monitoring Standards is a multi-agency project, led by regional councils, NIWA and the Ministry for the Environment. The purpose of the project is to develop and implement national monitoring standards to support and ensure consistent observation across New Zealand. At this stage the project is focused on developing and implementing a set of national standards for collecting freshwater observations through sensor networks.

National Environmental Monitoring and Reporting is a Ministry for the Environment led project with the goal of developing a standardised national framework to support national freshwater state-of-environment reporting. The project has developed a framework for national freshwater monitoring based on institutionally operated (but nationally optimised) monitoring networks.

Statistics NZ compiles a set of national Tier 1 statistics (Tier 1 are the most important statistics for understanding how New Zealand is performing).[292] These include environmental statistics compiled for Statistics NZ by the Ministry for the Environment. Environmental Tier 1 statistics currently available cover marine protected areas, natural resource/environment accounts, and human-induced greenhouse gas emissions and removals. Environmental Tier 1 statistics under development include air quality, stratospheric ozone, soil health, freshwater quality and use, coastal and recreational water quality, marine biodiversity, terrestrial ecosystem health and atmosphere, and ocean climate change. Tier 1 statistics need to be relevant, authoritative and trustworthy, provide long-term continuity of statistical information, and enable international comparability. The collection and release protocols for Tier 1 statistics are followed to ensure independence, credibility and efficiency. Tier 1 statistics rely on consistent and comprehensive national data sets.

The New Zealand Geospatial Office[293] and the New Zealand Geospatial Strategy[294] provide a framework to support and develop improved availability and sharing of geospatial data sets in New Zealand. As part of the New Zealand Geospatial Strategy, a work stream is in place to identify fundamental data sets and to define their curatorship principles and accessibility rules. These data sets also include climate, freshwater and marine data sets.

292 http://www.statisphere.govt.nz/tier1-statistics.aspx

293 http://www.linz.govt.nz/geospatial-office/about

294 http://www.geospatial.govt.nz/home

Land and Water New Zealand (LAWNZ)[295] is an initiative led by regional councils that aims to provide a national mechanism and presentation layer for combining regional environmental monitoring data sets. This will be further enhanced through a 'federated' approach[296] (see below), supported by national data standards. At this stage the project has successfully demonstrated this collaborative approach by manually collating water quality information and displaying it on its website.

The New Zealand Climate Change Centre[297] was formed by New Zealand's Crown Research Institutes, together with universities, with the goal of improving communication and information flow about climate change and related issues. This initiative also supports the GCOS goal of providing comprehensive information on the total climate system (involving a multidisciplinary range of physical, chemical and biological properties, and atmospheric, oceanic, hydrological, cryospheric and terrestrial processes).

The Declaration on Open and Transparent Government was approved by the New Zealand Government on 8 August 2011 and requires Government agencies to commit to actively releasing high-value public data for reuse. The Open Government Information and Data Work Programme[298] aims to:

- make non-personal, Government-held data and information more widely available and discoverable, easily usable, and compliant with open government data principles within the New Zealand legal context
- facilitate agencies' release of non-personal Government-held data and information that people, communities and businesses want to use and reuse.

A federated information system supported by national standards

Data collection in New Zealand is conducted by multiple data providers and agencies. New Zealand has adopted an approach to integrated data access that involves implementing federated information systems, supported by national standards. The development of these standards is based on existing international standards, such as those developed by or through the International Organisation for Standardisation, the World Meteorological Organisation (WMO), the Open Geospatial Consortium, and the Group on Earth Observations, and will support the WMO Information System through improved availability of consistent environmental data.[299] The national standards include:

- standards for data collection and quality assurance (eg, through the National Environmental Monitoring Standards initiative, see above)
- standards for data management
- standards for data delivery
- standards for metadata (a set of data that describes and gives information about other data) management.

Together these ensure that data is collected consistently and is available through a common interface. This allows users (including portals and models) to access data across a range of agencies.

295 http://www.landandwater.co.nz/

296 A 'federated' (or distributed) approach means empowering individual institutions to manage and publish their data according to well-defined national standards, so that (distributed) data users can access the information using these standards (as opposed to a centralised approach).

297 http://www.nzclimatechangecentre.org

298 http://ict.govt.nz/programme/open-and-transparent-government

299 http://www.wmo.int/pages/prog/www/WIS

Metadata management and federation

It is important that metadata is captured consistently across agencies and made available through common interfaces to enable accessibility of environmental data and information across New Zealand.

A range of data providers are working on building up comprehensive catalogues of New Zealand data holdings; for example, NIWA's data catalogue,[300] the New Zealand geospatial data catalogue,[301] the New Zealand Government data catalogue[302] and the LINZ Data Service.[303]

Through the New Zealand Geospatial Strategy and other initiatives, the Australia New Zealand Land Information Council (ANZLIC) metadata profile[304] is the recommended metadata standard for New Zealand Government agencies[305]. This metadata profile was endorsed by the New Zealand State Services Commission in July 2010 following consultation with the geospatial community. Local government, Crown Research Institutes and the private sector are all encouraged to use the ANZLIC metadata profile. Because the profile is based on ISO19115, it is compatible with the WMO core metadata profile as part of the WMO Information System.

Federation of metadata catalogues should be enabled through adequate exchange standards; for example, the Open Geospatial Consortium catalogue services for the web. A range of New Zealand data providers are working at the moment to ensure:

- metadata from institutional data providers can be easily shared across systems and platforms within New Zealand
- New Zealand metadata catalogues can be harvested into international catalogues, such as those provided by the Group on Earth Observations or WMO.[306]

These metadata management and federation principles are consistent with WMO Information System principles. Several providers in New Zealand are already using WMO Information System-compliant systems (eg, the geonetwork software suite[307]).

Pacific coordination and capacity building

MetService helps to ensure the continuity of GCOS ECV observation programmes in a number of Pacific Island countries and territories (the Cook Islands, Fiji, Kiribati, Niue, Samoa, Tuvalu, Tokelau and Tonga) by providing in-kind advice and technical assistance. This is done in cooperation with the Pacific Islands-Global Climate Observing System (PI-GCOS) programme. As part of a New Zealand–US National Oceanic and Atmospheric Administration (NOAA) PI-GCOS Technical Support Project, which is sustained by the New Zealand – US Climate Change Partnership, MetService provides preventive, routine and emergency site inspections, maintenance and technical support to Global Upper Air

300 http://dc.niwa.co.nz

301 http://geodata.govt.nz

302 https://data.govt.nz

303 http://data.linz.govt.nz

304 http://www.anzlic.org.au

305 http://www.linz.govt.nz/geospatial-office/about/projects-and-news/anzlic-metadata-profile

306 https://www.niwa.co.nz/environmental-information/update/environmental-information-update-4-march-2013/what-are-open-standard-web-services-for

307 http://geonetwork-opensource.org

Network (GUAN) stations in the Cook Islands, Fiji, the Solomon Islands, Papua New Guinea and Vanuatu. These GUAN stations are part of the GCOS GUAN programme.

Under a joint New Zealand–Met Office UK Pacific Trust Fund partnership, MetService also assists in the management and operation of the GUAN stations in Tuvalu and Kiribati. Targeted technical training and observing practices are routinely carried out in the Pacific Islands. At the Wellington Regional Telecommunication Hub of the Global Telecommunication System (GTS), MetService facilitates the transfer of observations from a number of Pacific Island national meteorological centres to the GTS. The Wellington Hub also relays forecasts, analyses and other products from the GTS to these islands. MetService provides the Pacific regional RAdio-InterNET (RANET) hub, which serves as a low-cost back-up telecommunications system for GTS data. The RANET project is a joint collaboration between MetService, the US NOAA National Weather Service, and the Australian Bureau of Meteorology.

In recent years the Pacific Island national meteorological centres have also had access to many GCOS ECV data, information and products via the MetConnect Pacific website, which is hosted by MetService. This website is the hub for the WMO-led Severe Weather Forecasting Disaster Risk Reduction Demonstration Project.

A key part of MetService's work in the Pacific Islands is targeted in-country capacity development. The goal is to ensure Pacific Island national meteorological services are able to manage, operate and sustain their own GCOS ECV observation programmes.

NIWA works with the United Nations Development Programme under the Global Environmental Fund, and with other bilateral arrangements and partner agencies, to support climate adaptation work in a number of Pacific Island countries, including Kiribati, Fiji, Samoa and the Solomon Islands. NIWA has collaborated with the Australian Bureau of Meteorology to develop and install a Pacific Climate Database and associated support for data rescue, quality assurance and climate services. NIWA supports National Meteorological Centres in Fiji and Samoa with support for new climate stations in their national networks, near real-time cellular or satellite-based data telemetry, and in-country data archiving.

Palaeoclimate data

Several Crown Research Institutes and universities are collecting palaeoclimate data with the goals of providing a window into how the Earth's environment was affected by past warm periods, and providing data on natural climate change over time (and the accompanying environmental signals), thus extending the context for historical records.

New Zealand is actively involved in the international ANDRILL (Antarctic DRILLing) programme in Antarctica.[308] Antarctica New Zealand is the project operator, and expertise from Victoria University of Wellington and Webster Drilling and Exploration has been contracted by Antarctica New Zealand to develop, test and operate the drilling system. The goal of ANDRILL is to investigate past Antarctic climate from sediment cores in the McMurdo region. The resulting rock cores provide a unique record of the history of the Ross Ice Shelf and Antarctic ice sheets spanning the last 20 million years, comprising numerous cycles of ice advance and retreat under a range of climatic conditions. Some of this data may represent extended periods when the climate was a few degrees warmer and atmospheric carbon dioxide higher than at present, much like that projected for the future under many current climate change scenarios. ANDRILL palaeoclimate data is being integrated with the latest ice sheet models to better predict the future response of Antarctic ice sheets to global warming.

---

308 http://andrill.org

Although understanding of palaeoclimatology in specific marine regions (eg, the Chatham Rise, Campbell Plateau, eastern North Island) is reasonable, knowledge is sparse in other areas of national and international importance (eg, western New Zealand, south of the Campbell Plateau towards Antarctica, and north of New Zealand to the Tasman Front). Decadal and century-scale records are sparse, with the exception of a few spatially restricted localities along East Cape. For example, core MD97-2121, which shows a rapid sedimentation rate of up to 42 centimetres per thousand years, yields a detailed record of southwest Pacific Ocean conditions over the last glacial cycle.

New Zealand is actively involved in the international Roosevelt Island Climate Evolution (RICE) Project.[309] RICE is a collaboration between New Zealand, the USA, Denmark, the UK, Germany, Australia, Italy, China and Sweden. The aim of the project is to recover a 750-metre-deep ice core from Roosevelt Island in Antarctica to determine the stability of the Ross Ice Shelf and West Antarctica in a warming world. The RICE core will be processed in the New Zealand National Ice Core Research Facility at GNS Science.

Atmospheric essential climate variables

Atmospheric ECVs that can be feasibly measured and are highly relevant to the UNFCCC (according to GCOS[310]) encompass surface measurements, upper air measurements and atmospheric composition, and include the following:

- Surface – air temperature, wind speed and direction, water vapour, air pressure, precipitation, surface radiation budget
- upper air – earth radiation budget (including solar irradiance), upper-air temperature (including MSU radiances measured from satellites), wind speed and direction, water vapour, cloud properties
- composition – carbon dioxide, methane and other long-lived greenhouse gases,[311] ozone and aerosol properties.

General situation: national data collection and support

There are four primary observation programmes for New Zealand GCOS atmospheric ECVs relevant to climate change:

- surface weather observations undertaken by MetService
- upper air weather observations undertaken by MetService
- surface climate observations undertaken by NIWA
- atmospheric constituent measurements undertaken by NIWA.

In addition, New Zealand local authorities operate a large number of meteorological (weather and climate) observations for regional and local purposes, especially rainfall monitoring for flood hazard management. Observations are often carried out for very specific purposes. Instrument and data quality varies, and station locations can change due to local requirements. So although a lot of data is collected, there are some challenges in maintaining long-term time series for these observations.

309 http://www.victoria.ac.nz/antarctic/research/research-prog/rice

310 http://www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables

311 Including nitrous oxide, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, sulphur hexafluoride and perfluorocarbons.

MetService and NIWA both pay particular attention to quality control. NIWA's climate monitoring and archiving programme carries ISO9002 certification, and MetService has ISO9001 certification. NIWA is also assisted by many voluntary observers, especially for rainfall monitoring. NIWA supports its observational programmes, and the related quality assurance and archiving systems, through a Government core funding agreement for Crown Research Institutes as part of the New Zealand Crown Research Institutes Act 1992.[312] MetService supports its observation collection, storage and processing operations through a contract with the Ministry of Transport.

In situ surface observation programme

NIWA reviewed the national operating climate stations in 2011 and has designated 143 stations, operated by NIWA and MetService, as the National Climate Station Network (NCSN), based on various network design criteria. This network aims to cover climate regions, agricultural regions and urban areas, as well as including the National Reference Climate Station Network (NRCSN). NRCSN is a subset of the national climate network and was established in the late 1980s. It currently consists of 49 stations (including 19 back-up stations) located across mainland New Zealand, the outlying islands (Raoul, the Chathams and Campbell) and the Ross Dependency (Scott Base). NRCSN resulted from a recommendation of the 10th session of the WMO Commission for Climatology.

MetService, on behalf of New Zealand, is currently providing data from 10 weather stations to international data centres as part of the Global Surface Network. The Global Surface Network stations at Kaitaia, Paraparaumu Aerodrome and Invercargill Aerodrome are operated manually by observers on contract to MetService. The other seven stations are automatic stations owned and operated by MetService. Detailed metadata for these stations is compiled, and site inspections are regularly carried out by NIWA staff and MetService engineers. Copies of inspection reports are available through NIWA's Instrument Systems Group in Christchurch. At present the Global Surface Network station at Tara Hills does not fully meet GCOS standards because surface pressure is not measured at this site. No progress has been made since the last GCOS report on adding atmospheric pressure to the measurement programme.

Upper air weather observation programme

New Zealand operates four stations providing data to international data centres as part of the GUAN programme. These are Paraparaumu Aerodrome, Invercargill Aerodrome, Raoul Island, and the Royal New Zealand Air Force base Whenuapai (although Whenuapai is not a full GUAN station). All four stations measure air temperature, humidity, wind speed and wind direction. Currently Whenuapai and Raoul Island temperature and humidity are measured by radiosonde, and wind is calculated using GPS modules incorporated into the radiosondes (model Vaisala RS92 SGP). At Paraparaumu and Invercargill, temperature and humidity are measured by radiosonde (model Vaisala RS92K), but wind is calculated using a separate radar tracking system.

Since the last GCOS report the GUAN station at the Chatham Islands has been discontinued. The reasons were financial pressures as well as this site's operations not delivering enough benefit to New Zealand weather forecasting capabilities. Since the last GCOS report a new regular radiosonde measurement programme has been established in Christchurch (but not a full GUAN site).

---

[312] This states: "The CRI [Crown Research Institute] agrees to maintain nationally significant databases and collections to ensure they remain current and fit for the purpose of end-users. The CRI will also pursue best data management practices to ensure appropriate access to and reusability of the data in the databases and collections."

Atmospheric constituents measurement programmes

New Zealand has three stations (Baring Head, Lauder, and Arrival Heights in Antarctica) providing atmospheric constituent data to international data centres (World Data Center for Greenhouse Gases), as part of the Global Atmosphere Watch. *In situ* concentrations of carbon dioxide, methane, carbon monoxide, ozone and nitrous oxide are routinely measured at all three stations, either with discrete flask samples or by continuous measurements. Stable carbon isotope ratios and the radiocarbon content of carbon-bearing gases are measured at Baring Head and Arrival Heights. Near infra-red Fourier transform spectrometer measurements of column amounts of the same gases are also conducted at Lauder as part of the Total Carbon Column Observing Network, and as an integral part of greenhouse gas satellite validation activities.

The continuous *in situ* measurements at Lauder were initiated in August 2007. This measurement programme employs a prototype instrument and is in its commissioning phase. Significant instrument issues have been identified recently, causing unacceptable bias in the retrieved concentrations. An instrument upgrade in April 2013 will help alleviate this issue, and it is planned to submit quality-assured carbon dioxide and methane data to the Global Atmosphere Watch database by July 2014.

Twice-monthly frost point hygrometer flights are made from Lauder under contract from the NOAA GCOS office to measure water vapour profiles into the stratosphere. Complementing the water vapour profile measurements, total column precipitable water vapour measurements using a high-precision GPS system installed at Lauder started in May 2012.

Vertical ozone profile measurements are made at Lauder using ozonesondes, an ozone lidar, a Mid-infrared Fourier transform spectrometer (MIR-FTS) and a microwave radiometer. Total column ozone measurements are made at Lauder and Arrival Heights using Dobson spectrophotometers and MIR-FTSs. Such remotely sensed data is routinely submitted to the Network for the Detection of Atmospheric Composition Change.

Through the NOAA GCOS programme and NIWA support, New Zealand also collects air samples in the data-sparse western Pacific in collaboration with the National Institute of Environmental Studies in Japan. The samples are collected on a vessel travelling between Nelson (New Zealand) and Osaka (Japan), to analyse the principal greenhouse gases and their latitudinal and inter-hemispheric trends. The data is submitted to the World Data Center for Greenhouse Gases. Aerosol measurements made on these transects include high-volume sampling of nutrient species (nitrogen, phosphorus and iron), and continuous condensation nuclei measurements. Microtops sun-photometer readings of aerosol optical depth and ozone are made when sky conditions allow, and this data is available as part of the NASA Aeronet Maritime Aerosol Network.

Satellite-based measurement programmes

New Zealand does not have a dedicated satellite-based measurement programme of atmospheric ECVs, but a number of ground-based measurement programmes contribute data for the validation and interpretation of satellite-based measurements. MetService radiosonde observations are used extensively by global numerical weather prediction centres to remove forward model biases from radiative transfer models. In New Zealand a number of agencies operate satellite receiver stations and data archives, as outlined below.

MetService operates two satellite reception systems from Wellington. The first receiver ingests imagery for all channels provided by the MTSAT-2 satellite, and the second ingests X and L band data (all instruments) from polar orbiter satellites – currently NOAA 16, 18, and 19, metop-B, Terra, Aqua and Suomi NPP. Visible, 7 micron and 11 micron imagery covering the New Zealand area of responsibility for marine forecasts is kept in a long-term archive at MetService.

NIWA holds four satellite data direct broadcast archives:

- NOAA HRPT data (in satellite data stream format), from 1992 to the present, for NOAA 10, 11, 12, 14, 15, 16, 17, 18 and 19
- geostationary meteorological satellite and multifunctional transport satellite data products, from August 1998 to March 2008, including those from the backup of GMS-5 by GEOS-9
- SeaStar SeaWiFS HRPT data, from May 2000 to the present
- Terra and Aqua Direct Broadcast data (all instruments), from August 2007 to the present.

NIWA has developed a number of data products from these data streams, including one kilometre resolution sea-surface temperature analyses, cloud mask, cloud type and estimated rain rate.

These derived data products have been collocated with MetService meteorological radar (three radars), an advanced microwave sounder unit (20 spectral intervals), a high-resolution infrared sounder (20 spectral channels), and an advanced, very-high-resolution radiometer (5/6 channels), for NOAA 14, 15, 16, 17 and 18. This is called the NIWA ATOVS Collocation Archive. It is being used to develop algorithms that could be used to monitor the hydrological cycle over an area within a radius of 2,000 kilometres from Wellington. It is also being used to improve the value of satellite sounder radiances in numerical weather prediction through improved detection of unmodelled radiative transfer processes. NIWA has also developed high-resolution (one kilometre) daily and weekly snow-cover analyses for the New Zealand region using a Bayesian method.

Measurements of atmospheric constituents at the NIWA Lauder research station form part of the total carbon column observing network.[313] Measurements of stratospheric trace gases and aerosols at Lauder and at Arrival Heights support a number of satellite-based measurement programmes in the USA, Europe and Japan. One of these programmes targets the ground-based validation of measurements made from ENVISAT (ENVIronment SATellite). NIWA participates in an international collaboration to provide long-term validation of three of the atmospheric instruments carried on ENVISAT. This includes making correlative measurements of ozone and other atmospheric gases using spectrometers and ozonesondes from several ground-based stations.

Response to the GCOS Implementation Plan

A number of actions have been initiated in response to the recommendations on atmospheric ECVs in the GCOS implementation plan.

- **Applying the global climate monitoring principles to all surface climate networks.** NIWA and MetService have taken the necessary actions to ensure that all their surface climate networks are operating according to GCOS climate monitoring principles.
- **Incorporating atmospheric pressure sensors into drifting buoy programmes.** All of New Zealand's drifting buoy programmes include atmospheric pressure as a measurement.
- **Ensuring availability of 3-hourly, mean sea-level pressure and wind speed and direction data from GSN stations.** NIWA and MetService have worked towards ensuring 3-hourly data is available from GSN stations. There are still some gaps, which these agencies are endeavouring to resolve as resources become available.
- **Implementing a reference network of high-altitude, high-quality radiosondes.** New Zealand has been invited by the WMO to establish a GCOS Reference Upper Air Network (GRUAN) site at Lauder. Representatives from New Zealand have attended various planning and implementation meetings. A submission for GRUAN certification of Lauder has been made and is awaiting comments (and approval) from the GCOS Secretariat.

---

313 http://www.tccon.caltech.edu/

- **Operating the WWW/GOS radiosonde network in full compliance with the global climate monitoring principles and coding conventions.** NIWA and MetService have taken the necessary actions to ensure that all their radiosonde observations are operating according to GCOS monitoring principles.
- **Submitting metadata records and inter-comparisons for radiosonde observations to the specified international data centres.** Although metadata records are collected and forwarded to international data centres, it is not yet practical to conduct inter-comparisons for radiosonde observations on-site in New Zealand. New radiosondes implementations and operations are assessed by international panels before they are set up.
- **Developing a network of ground-based GPS receivers for measuring water vapour**. Initial discussions were held between the GPS industry and the research sector, but so far New Zealand is not in a position to actively pursue the development of a network of ground-based GPS receivers to measure water vapour.
- **Sustained measurements of the atmospheric composition ECVs.** NIWA conducts project-based (ie, not sustained) measurements of other atmospheric variables.
- **Data rescue.** NIWA has been coordinating the collation of a historical severe weather events searchable database for New Zealand going back to the 1840s, including information on impacts, damage, casualties and disruption. This work is now completed and the database is searchable under http://hwe.niwa.co.nz.

NIWA also works on a number of projects focusing on Pacific Island climate data rescue and provides training, in-kind staff and facilities for data rescue. These projects are a joint collaboration between NIWA, the NOAA GCOS programme and the Australian Bureau of Meteorology.

Oceanic essential climate variables

Oceanic ECVs (according to GCOS) relate to ocean surface measurements and ocean water column measurements and include:

- Surface – sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, current, ocean colour (for biological activity), carbon dioxide partial pressure
- sub-surface – temperature, salinity, current, carbon, ocean tracers, ocean acidity, phytoplankton
- water column – temperature, salinity, current, nutrients, carbon dioxide partial pressure, ocean acidity, oxygen, tracers.

Surface ocean measurement programmes

New Zealand does not have a formal, nationally administered network of sea-level gauges. Instead, sea-level gauges are operated independently by various agencies, with some national coordination of daily downloads of data, post-processing and archiving undertaken through voluntary partnerships with either LINZ or NIWA. Since the last GCOS report a new tsunami warning network consisting of 17 sea-level gauges has been built, coordinated by LINZ.[314]

NIWA currently operates four sea-level gauges. Local authorities and port companies operate about another 25 sea-level gauges around New Zealand's coastline. In terms of ocean tides, storm surges and long waves, the open-coast gauges in the NIWA network provide a valuable data set. The earliest site commenced in 1971. NIWA coordinates and archives a loose network of 17 coastal sea-

314 http://www.linz.govt.nz/hydro/projects-programmes/hydro-news/2010/0929-tsunami-monitoring-system

level recorders, including the GLOSS site at Scott Base.[315] In addition, long-term tide gauge records since around 1900 are held by LINZ and the University of Otago (School of Surveying) for the four main ports of Auckland, Wellington, Lyttelton and Dunedin. Shorter records are held from several other ports and open-coast gauges (also held by NIWA in some cases).

Of the five New Zealand GLOSS sea-level sites,[316] those at Wellington, Auckland and Bluff are operated by port companies (or the regional authority on behalf of the port company). The site at Waitangi, in the Chatham Islands, is operated by the Pacific Tsunami Warning Centre. The site at Scott Base, Antarctica, is operated by NIWA and Antarctica New Zealand. LINZ coordinates the submission of data to international data centres from the GLOSS sites located at ports (sites 101, 127 and 129). NIWA coordinates the data from Scott Base (site 134). The Pacific Tsunami Warning Centre coordinates the data from the Chatham Islands gauge (site 128). Sea-level data from GLOSS sites 101 and 129 is regularly submitted by LINZ to the University of Hawaii Sea Level Centre. Data for the Auckland station (site 127) was last submitted in 2000, and discussions are currently underway on providing international access to more recent Auckland data. Quality-assured data from Scott Base is now available in GLOSS databases up to the start of 2007.

Sea-surface temperature is measured in New Zealand at seven of the coastal stations. Ocean waves are routinely monitored around the New Zealand coast at five sites operated by NIWA and/or regional councils, and at a further six sites operated by ports. Remote coastal video cameras have been installed by NIWA for long-term monitoring of beach conditions and erosion at eight sites.[317]

Since the mid-1980s MetService has maintained a network of free-drifting buoys in the Tasman Sea. Until about 2002 the network consisted of First Global Atmospheric Research Programme Global Experiment buoys, which measured air temperature and sea-level pressure, with a few buoys measuring wind speed and direction. Since 2002 a combined meteorological/oceanographic drifting buoy, SVPB (surface velocity programme with barometer) type, has been deployed. SVPB buoys measure sea-surface temperature and sea-level pressure, and ocean current is derived from their drift. All buoys report via satellite using Argos transmitters. In 2007/08 12 buoys were reporting and they have been reduced to the current five reporting buoys as a cost-saving measure. MetService also works collaboratively with the Global Drifter Center in Miami to deploy buoys under the Southern Ocean Buoy Programme in the Pacific Ocean south of 40^{o} S. These buoys are of the SVPB type, and between 20 and 40 buoys are deployed annually during the southern summer months.

Under MetService's Voluntary Observing Ships (VOS) scheme, New Zealand seeks to upgrade or recruit new ships to make climate quality observations under VOSClim (the VOS Climate Project). About 30 ships are operating in the programme per year. Extensive metadata is collected for each VOSClim ship, which details instrument type, location, exposure, etc. The real-time observations are monitored by the UK Real Time Monitoring Centre. The observations, the metadata, the collocated model data and the delayed mode data are all supplied to the US Data Assembly Center for archiving for future research and climate applications.

Water column observations

NIWA has contributed and deployed two profiling floats under the Argo programme annually. Of the 22 Argo floats deployed, 11 are still active.[318] The data from the New Zealand floats is administered

315 http://www.niwa.co.nz/our-science/coasts/tools-and-resources/sea-levels

316 http://www.gloss-sealevel.org

317 https://www.niwa.co.nz/our-services/online-services/cam-era

318 http://www.jamstec.go.jp/ARGORC/status_top.html

by the Scripps Institution of Oceanography and is available from the Argo Global Data Assembly Centers. NIWA intends to continue to purchase and deploy Argo floats at the rate of two per year.

NIWA is also deploying buoys in the Southern Hemisphere from the research vessel (R/V) *Kaharoa* in an ongoing collaboration with the University of Washington and the Scripps Institution of Oceanography. These voyages, dating back to 2004, have deployed over 1140 floats, primarily in the South Pacific, but also in the eastern tropical Pacific and Indian Oceans. In addition, some deployments in the Southern Ocean have been made from R/V *Tangaroa*.

New Zealand has maintained two global reference mooring network sites in deep waters (about 3,000 metres) to the east of the country. These have provided long-term, time-series biophysical data (currents, temperature, salinity, fluorometry and particle flux) in subtropical and subantarctic waters on either side of the Subtropical Front, north and south of the Chatham Rise. Measurements were made between 2002 and 2012 and included a repeated, across-front transect measuring currents, nutrients, fluorometry and, more recently, bio-optics. These moorings have now been removed, and the data has yet to be quality checked and made available. A third site to the northeast of New Zealand, which is not part of the global reference mooring network, supplied current and temperature data in the subtropical inflow region of the East Auckland Current to the northeast of New Zealand and was in place for 6.5 years (1998–2005).

Time-series data of currents, temperature, salinity, light and fluorometry has also been collected at a shallow mooring site (about 40 metres deep) in the Firth of Thames, in the Hauraki Gulf, since 1998. More recently, oxygen and nutrients have also been measured. Meteorological and water column observations (wind speed and direction, barometric pressure, air and sea temperature, salinity, turbidity, waves and currents) have been made since 2007 at a site approximately 30 metres deep, located in the centre of Golden Bay, at the northern tip of the South Island. This is a joint project funded by NIWA and local government.

Although New Zealand does not formally participate in providing carbon inventory survey line data to the International Ocean Colour Coordinating Group, measurements of pCO_2 (partial pressure of CO_2), pH, alkalinity and supporting data are routinely taken on cruises out of Dunedin as part of the *Munida* time-series programme. These surface measurements, undertaken in accordance with the global climate monitoring principles, have been made every two months for the last 12 years. The ocean carbon data will be submitted to the Carbon Dioxide Information Analysis Centre – Ocean CO_2. In 2013 an underway pCO_2 recorder was purchased and installed on NIWA's R/V *Tangaroa*. Data from the instrument will be fed into the Integrated Marine Observing System database.

Satellite-based measurement programmes

New Zealand does not have a dedicated satellite-based measurement programme of oceanic ECVs. However, the NIWA sea-surface temperature archive contains one kilometre resolution sea-surface temperatures retrieved from all NOAA orbits over the southwest Pacific region (1993 to the present).

Response to the GCOS implementation plan

A number of actions have been initiated in response to the recommendations on oceanic ECVs in the GCOS implementation plan, including the following.

- **Improving metadata acquisition and data management for the VOSClim subset of the VOS.** The observations made by VOSClim ships adhere to the GCOS climate monitoring principles. The collection of metadata for VOSClim is well documented under the VOSClim project, and MetService collects the full range of variables for its VOSClim ship. MetService's VOSClim ship is regularly inspected to maintain instrument standards. Monthly monitoring of the real-time reports is carried out by the Regional Specialised Monitoring Centre in the UK, with feedback provided to the ship on any variables that are flagged as suspect.

- **Ensuring high-frequency (hourly or less) sea-level observations are available for all coastal tide gauges (including historical records), corrected for sea-level pressure and submitted to the specified international data centres.** Quality-assured, sea-level data from GLOSS sites 101 and 129 is submitted by LINZ each month to the University of Hawaii Sea Level Centre. Data has not been submitted from GLOSS site 127 (Auckland) for several years. Data from other sea-level gauges is being made available to the Permanent Service for Mean Sea Level by LINZ as time permits.
- **Including sea-level objectives in the capacity-building programmes of GOOS[319], JCOMM[320], WMO, other related bodies and the system-improvement programme of GCOS.** NIWA has been carrying out a number of aid projects in the Pacific (most notably the Cook Island and Kiribati extreme sea-level projects) to help Pacific Islands develop capabilities for assessing the impacts of future sea-level changes and develop mitigation strategies.
- **Developing a robust programme to observe sea-surface salinity that includes VOS ships, research ships, reference moorings and drifting buoys**. NIWA's larger research vessel, R/V *Tangaroa*, is equipped to make underway measurements of sea-surface temperature and salinity. Efforts are being made to maintain and calibrate the sensors so that the salinity data is accurate and stable. Once this is achieved, underway data could be collected from some research voyages. MetService VOS and drifting buoy programmes are robust, operational programmes with proven track records. VOS ships are issued with calibrated instruments (which are referenced to WMO and international standards).There is an ongoing programme of inspection, and data quality is monitored according to VOS quality control guidelines.
- **Delayed mode data is collected and submitted to the global climate centres at 3-monthly intervals under the Marine Climatological Summaries Scheme.** Extensive metadata is collected for each VOS ship and submitted to the WMO quarterly. MetService's drifting buoy programme is a national programme of the Data Buoy Co-operation Panel, and so MetService buoys comply with international specifications for instrument types and standards. Metadata is submitted to the Joint WMO-IOC[321] technical commission for Oceanography and Marine Meteorology for each buoy. Real-time buoy data is monitored using international buoy quality control tools, with bad data removed from the global telecommunication system as required.
- **Implementing a programme for measuring surface pCO_2**: Surface pCO_2 is measured as part of the ongoing *Munida* time-series programme on a 60-kilometre-long transect that includes the Southland Current and subantarctic waters. These measurements have been made every two months since 1998. Surface pCO_2 has also been measured during eight ocean cruises in New Zealand's Exclusive Economic Zone and the southwest Pacific, but this open ocean work has been discontinued due to resource constraints.
- **Implementing a wave measurement component as part of the Surface Reference Mooring Network.** A number of wave buoys are operating in New Zealand for specific projects, but no national effort has been made to include wave measurements in long-term measurement programmes.
- **Improving *in situ* sea-ice observations from buoys, visual surveys (Ship Of Opportunity Programme, or SOOP, and aircraft) and upward-looking sonars, and implementing observations in the Arctic and Antarctic.** Data has been collected on an opportunistic basis,

[319] Global Ocean Observing System

[320] Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology

[321] World Meteorological Organisation – Intergovernmental Oceanographic Commission

with no routine contributions to Antarctic sea-ice observations from buoys, visual surveys or upward-looking sonar. However, in the future the intention is to contribute land-fast sea-ice data from McMurdo Sound to the Antarctic Fast-Ice Network.

- **Conducting the systematic global full-depth water column sampling of 30 sections, repeated every 10 years (including ocean carbon inventory change).** There are currently no systematic long-term full-depth water column observations in New Zealand.
- **Performing the 41 SOOP XBT/XCTD trans-oceanic sections.** NIWA assists Australian (Commonwealth Scientific and Research Organisation) and US (Scripps Institution of Oceanography) research institutions to maintain three high-resolution XBT (expendable bathythermograph) sections in the Tasman–Coral Sea area to monitor ocean temperature changes in the upper 800 metres. The lines are PX34, PX06 and PX31.[322]
- **Developing capability for the systematic measurement of biogeochemical and ecological ECVs.** NIWA is developing a marine biogeochemical database that will house physical and environmental data collected under a time-series project that was initiated in 2000 and curtailed in 2012. This project obtained information about the status of subtropical and subantarctic waters to the east of New Zealand (water depths 0 to 3,000 metres). Data includes CTD[323] temperature, CTD salinity, CTD dissolved oxygen, nutrients, nitrate, nitrogen dioxide, ammonium, dissolved reactive phosphorus, dissolved reactive silica, chlorophyll, particulate organic carbon, particulate organic nitrogen, particulate phosphorus, bacteria biomass and abundance (flow cytometry), picophytoplankton biomass and abundance (flow cytometry) and microzooplankton biomass and abundance. The database will be compatible with conventions established by the Australian IMOS programme to enable regional comparisons to be made.
- **Supporting data rescue projects and implementing regional, specialised and global data and analysis centres.** A project at NIWA is underway to rescue historical oceans data where paper copies are available. This includes seismic and sediment records going back 50 years.

Terrestrial essential climate variables

Terrestrial ECVs[324] (according to GCOS[325]) that can feasibly be measured and are highly relevant to the UNFCCC include:

- snow cover
- glacier and ice caps
- permafrost and seasonally frozen ground
- river discharge
- groundwater
- lake levels
- soil moisture

---

322 http://www-hrx.ucsd.edu

323 CTD refers to Conductivity-Temperature-Depth measurements made by lowering an instrument from a ship. Other variables are commonly measured at the same time.

324 Includes run-off ($m^3\ s^{-1}$), groundwater extraction rates ($m^3\ yr^{-1}$) and location, snow cover extent (km^2) and duration, snow depth (cm), glacier/ice cap inventory and mass balance ($kg\ m^2\ yr^{-1}$), glacier length (m), ice sheet mass balance ($kg\ m^2\ yr^{-1}$) and extent (km^2), permafrost extent (km^2), temperature profiles and active layer thickness, above-ground biomass ($t\ ha^{-1}$), date and location of active fire, and burn efficiency (percentages of vegetation burned per unit area).

325 http://www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables

- water use
- albedo
- land cover (including vegetation type)
- fraction of absorbed photosynthetically active radiation
- leaf area index
- biomass
- fire disturbance
- soil carbon.

General situation: national data collection and support

In New Zealand there are about 1,000 stream-flow gauges, about 1,000 sites where water quality is monitored, and about 1,000 groundwater monitoring wells. There are also hundreds of soil moisture-monitoring sensors and hundreds of lake-level stations in operation. These various stations and networks are operated by NIWA, local authorities, and by energy companies for various purposes. Data is held in institutional data archives.

Currently about 150 river flow and lake-level stations, 77 water quality sampling locations, and about 70 soil moisture monitoring locations, operated by NIWA, are (sometimes partially) funded through NIWA Government funding. The NIWA stream flow monitoring stations and a river water quality network of over 70 river locations and their databases are known as the Water Resources Archive. NIWA plans to consolidate its freshwater monitoring network into a 'benchmark network'[326] and is in the process of reviewing its freshwater monitoring operations.

Operations by local authorities are rate-payer funded and the level of support is dependent on regional budgets and regional needs. Previously there has been little governance structure in place to ensure regional and local operations are supporting national or international needs. However, there is a strong move (championed by the Ministry for the Environment) towards more integrated freshwater monitoring by ensuring regionally operated networks also meet national needs.[327]

National measurement programmes

Ice, snow, and permafrost monitoring

End-of-summer snowline elevations and photographic images of 50 glaciers from special aircraft flights are available annually, dating from 1979, and the terminus positions of key glaciers in the Southern Alps are available from 1800 to the present.[328]

Over the last few years NIWA has established the National Snow and Ice Monitoring Network. It currently comprises 11 high-elevations stations, which have been collecting information mainly since 2008. This network is complemented by two snow-monitoring sites operated for commercial clients at Rose Ridge and Panorama Ridge. Although data from these sites is archived in the National Climate Database (operated by NIWA), the snow-related information is not currently being submitted to international data archives. One additional station has been recently installed for climate and snow at Mount Larkin (1960 metres above sea level). The Mueller Hut site is currently

326 http://www.niwa.co.nz/environmental-information/update/environmental-information-update-3-august-2012/fresh-start-for-niwa%E2%80%99s-freshwater-monitoring-pro

327 See, for example, http://www.mfe.govt.nz/publications/ser/measuring-up-environmental-reporting/index.html

328 http://www.sirg.org.nz/EOSS.html

being fitted with a solid precipitation gauge as part of the WMO Solid Precipitation Inter-Comparison Experiment.[329] Information at this location will be submitted to international archives.

Although there are no permafrost measurement sites in New Zealand, New Zealand is supporting measurements in Antarctica by the US Department of Agriculture and the University of Insubria (Italy). Seven soil climate monitoring stations that monitor temperature to about 1.2 metres depth are operated in the McMurdo Dry Valleys and Ross sea coast by Landcare Research, in collaboration with the US Department of Agriculture.[330] Continuous monitoring data goes back as far as 1999. Two permafrost boreholes, with continuous temperature monitoring to a depth of 29.5 metres, have now provided one full year of data. It is intended that the data from the permafrost boreholes will be made available to the Global Terrestrial Network for Permafrost database.

River flow, lake level, soil moisture, groundwater, water use

In New Zealand there is no nationally coordinated approach to river flow and lake-level monitoring. Regional councils operate about 900 river flow gauging and lake level stations, energy companies about 200, and NIWA about 150. Data collection is of varying length and carried out to varying standards. For example, flood monitoring sites are often monitored to lesser standards. Over the last two years the Ministry for the Environment has commissioned a large project (National Environmental Monitoring and Reporting) to develop a nationally coordinated approach to freshwater monitoring. This project has so far developed a definition for a national standard for river monitoring across New Zealand, reviewed the national network, and made a recommendation for a new national network. It is the intention to use this work to implement a Dependable National Freshwater Monitoring Programme by aligning regional monitoring efforts to those national requirements.

NIWA is collating flow data from across the country on a monthly basis to assess and report on the country's river flows as part of the *New Zealand Climate Update*.[331] NIWA submits river flow data from 40 gauging stations to the Global Runoff Data Centre (GRDC).[332]

Soil moisture is measured across the country by regional authorities and NIWA at several hundred sites, typically in conjunction with climate stations. NIWA compiles a database of about 100 sites across the country and uses the data for regular reporting of the country's soil moisture status as part of the *New Zealand Climate Update*.[333]

At the national scale, groundwater quality is assessed through the New Zealand National Groundwater Monitoring Programme (NGMP). This programme is operated by GNS Science by compiling and archiving data from 110 monitoring sites (operated by regional councils) across the country.[334] At the regional scale, monitoring of groundwater quality in New Zealand is conducted through 15 individual state of the environment programmes operated by 15 different regional authorities, each responsible for environmental management within its own area of jurisdiction. The state of the environment programmes integrate the NGMP monitoring sites with many additional monitoring sites, so that the amalgamation of regional monitoring networks includes a total of over 1000 monitoring sites across New Zealand, of which roughly 10 per cent are included in the NGMP.

329 http://www.wmo.int/pages/prog/www/IMOP/intercomparisons/SPICE/SPICE.html

330 http://www.landcareresearch.co.nz/science/soils-and-landscapes/antarctic-soils/monitoring-soil-climate-in-the-ross-sea-region

331 https://www.niwa.co.nz/climate/nzcu

332 http://www.bafg.de/GRDC/EN/Home/homepage_node.html

333 https://www.niwa.co.nz/climate/nzcu

334 www.mfe.govt.nz/publications/water/national-protocol-groundwater-dec06/index.html

Sampling of the NGMP and most state of the environment sites is undertaken quarterly, although some sites are sampled more, or less, frequently. Sampling is performed according to a nationally standardised protocol, although there is presently no national system for assuring compliance. Depth to groundwater is typically measured prior to sampling. Parameters such as pH, water temperature and electrical conductivity are measured in the field at the time of sampling. NGMP and most state of the environment samples are analysed for major cations and anions, silica, various forms of nitrogen and phosphorus, and selected minor elements such as iron, manganese, bromide and fluoride. National-scale evaluations of groundwater quality are reported by the Ministry for the Environment every five years, with the most recent assessment covering data collected from 1995 to 2008.[335]

Because of recent changes in New Zealand legislation,[336] there are now increasing amounts of water takes (for agriculture and other uses) being monitored (eg, by irrigation companies or individual farmers). Regional councils and the Ministry for the Environment are working to ensure national consistency and the national collection and accessibility of this data. It is expected that over the next few years there will be over 10,000 surface and groundwater takes being monitored and archived by local authorities in New Zealand.

Land use, land-use change and forestry

The Land Cover Database (LCDB) is a national compilation of land cover status conducted in New Zealand using SPOT and Landsat satellite imagery.[337] So far three 'snapshots' have been compiled as part of the LCDB, representing New Zealand land cover layers for 1996/97, 2000/01 and 2007/08. Work on another generation (LCDB-4) is underway and uses images from the 2011/12 time period.

The Land Use and Carbon Analysis System (LUCAS) has been developed to meet New Zealand's international reporting requirements under the Kyoto Protocol and the UNFCCC. LUCAS is comprised of components for measuring and reporting biomass and soil carbon changes from land use, land-use change and forestry activities in New Zealand. This is achieved through a combination of permanent sample plots and remote sensing-based mapping. LUCAS has established national land-use maps at 1990, 2008 and 2012 using SPOT and Landsat satellite imagery. Carbon stock changes are calculated by combining activity data from these land-use maps and national statistics, with emission factors derived from the permanent sample plots. LUCAS provides estimates of biomass and soil carbon stock from land use, land-use change and forestry from 1990 to present as part of New Zealand's National Greenhouse Gas Inventory.

The Ministry for Primary Industries (MPI) also maintains forestry databases for New Zealand through the Climate Change Information System (CCIS) and the National Exotic Forest Description (NEFD). CCIS is designed to monitor carbon changes resulting from afforestation and deforestation through the New Zealand Emissions Trading Scheme. The NEFD monitors forests planted for wood or fibre production in an annual survey of forest owners and managers. All three data sources (LUCAS, CCIS and NEFD) are utilised in the reporting of carbon stock changes under the Kyoto Protocol and the UNFCCC.

LUCAS and CCIS are supported by long running research programmes designed to provide better understanding of the patterns and processes involved in carbon storage and changes resulting from land use, land-use change and forestry.

335 www.mfe.govt.nz/publications/ser/groundwater-quality-trends-2008

336 http://www.mfe.govt.nz/rma/central/measuring-reporting-water-takes.html

337 http://www.lcdb.scinfo.org.nz/

The National Vegetation Survey database maintained by Landcare Research[338] holds records from approximately 45,000 vegetation survey plots around New Zealand, including 12,000 permanent plots. Landcare Research also maintains five New Zealand long-term ecological research and monitoring sites, and monitors the presence or range of self-advective fungal and insect species. Regional authorities are carrying out regular vegetation surveys to varying standards depending on local stressors and needs.

Satellite-based measurement programmes

New Zealand does not have a dedicated satellite-based measurement programme of terrestrial ECVs. However, glaciers in the Southern Alps are monitored as part of the international satellite project GLIMS (Global Land Ice Mapping from Space).

Response to the GCOS Implementation Plan

A number of actions have been initiated in response to the recommendations on terrestrial ECVs within the GCOS Implementation Plan, as follows.

- **Developing a global network of approximately 30 sites based on a progressive evolution of existing reference sites to monitor key biomes and provide the observations required for the calibration and validation of satellite data.** New Zealand maintains a national plot-based monitoring system for the assessment of biodiversity status and change, and assessment of carbon pools. The National Vegetation Survey Databank contains data on 94,000 plots, covering a period of 50 years, including 19,000 re-measured permanent plots. Data from this resource is used to calibrate the interpretation of satellite imagery for the creation of the national Land Cover Database, ecosystem categorisation (EcoSat), environmental domains (LENZ[339]), and national carbon reporting (LUCAS). In addition, the national biodiversity monitoring programme was established in 2011 to support annual reporting of ecological integrity and change. The programme is based on the existing network and protocols, expanded to include additional biotic indicators. It incorporates 2,500 plots distributed on a national 8 kilometre grid, which are re-measured on a five year rotation.
- **Maintaining and expanding programmes for monitoring groundwater and aquifers.** Local authorities maintain extensive groundwater measurement programmes. GNS Science is compiling a national database of about 110 groundwater sites with consistent data.
- **Archiving and disseminating information related to irrigation and water resources.** New Zealand is at the beginning of a phase of introducing consistent observations for monitoring water takes and water use for agriculture. Currently local authorities are overseeing the instrumentation across the country, including adequate data dissemination technologies such as telemetry.
- **Strengthening existing sites for observing snow cover and snowfall, and recovering and submitting historical data to the specified international data centres.** A new focus in recent years has been on infilling remote, data-poor regions and regions sensitive to change. The development of a National Snow and Ice Monitoring Network for New Zealand has led this drive, and has resulted in the upgrading of selected existing stations to measure snow that is very sensitive to change. It has also resulted in the establishment of new snow and climate

338 http://nvs.landcareresearch.co.nz/

339 Land Environments of New Zealand, http://www.landcareresearch.co.nz/resources/maps-satellites/lenz

stations in remote alpine regions not previously captured by New Zealand's network. NIWA now operates 11 high-altitude specialised climate and snow stations.

- **Maintaining sites for observing glaciers and adding additional sites and infrastructure in Africa, the Himalayas, New Zealand and South America.** The end-of-summer snowline elevations and photographic images of 50 glaciers from special aircraft flights will continue for the foreseeable future. Some new index glaciers will be added.
- **Adding the 150 additional permafrost sites identified by GTN-P to cover the high mountains of Asia, Europe and the southern hemisphere, and the North American alpine lands and lowlands, and providing data to the specified international data centres.** Due to the low percentage of permafrost in the country, New Zealand does not maintain or intend to develop a network of permafrost sites.
- **Reanalysing historical data concerning the terrestrial ECVs:** NIWA has worked on a project for compiling a large database of historical weather events for New Zealand, including flooding, land sliding and large snow storms.[340]
- **Building a national, dependable, surface- and groundwater observation programme:** New Zealand is working towards a more nationally comprehensive and consistent freshwater monitoring programme. This will include river flows, river water quality, lake water quality, groundwater quantity and quality, and water use. This will benefit national state of the environment reporting and New Zealand's water resources management in the light of increased water and land-use pressures.

Acknowledgements

The following individuals and organisatios have contributed to this report.

- James Lunny and Wim VanDjick from MetService
- Chris Daughney from GNS Science
- Christian Zammit, MS Srinivasan, Andrew Harper, Mike Harvey, Olaf Morgenstern, Murray Poulter, Barb Hayden, Scott Nodder, Bernard Miville from NIWA
- Graeme Blick from Land Information New Zealand.

340 The data is available at http://hwe.niwa.co.nz/

Appendix 1: Lists of observations

Note: Explanation of terms used

'Number of stations or platforms currently operating' is an estimate of total observational platforms for these essential variables operated in New Zealand.
GCMPs = GCOS climate monitoring principles

Contributing networks specified in the GCOS implementation plan	Essential climate variables	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2015	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with a complete historical record available in international data centres
National contributions to surface-based atmospheric essential climate variables						
GCOS Surface Network (GSN)	Air temperature, precipitation	700 (est)	150 (est)	500 (est)	10	10
Full World Weather Watch / Global Observing System (WWW/GOS) surface network	Air temperature, air pressure, wind speed and direction, water vapour, precipitation	500 (est)	150 (est)	500 (est)	100	100
Baseline Surface Radiation Network (BSRN)	Surface radiation	1	1	1	1	1
Solar radiation and radiation balance data	Surface radiation	100 (est)	4	100 (est)	0	0
Ocean-drifting buoys	Air temperature, air pressure	5	5	5	5	5
Moored buoys	Air temperature, air pressure	0	0	0	0	0

Voluntary Observing Ship Climate Project (VOSClim)	Air temperature, air pressure, wind speed and direction, water vapour	1	1	1	1	1
Ocean Reference Mooring Network and sites on small isolated islands	Air temperature, wind speed and direction, air pressure	8	8	8	8	8
	Precipitation	7	7	7	7	7
National contributions to upper-air atmospheric essential climate variables						
GCOS Upper Air Network (GUAN)	Upper-air temperature, upper-air wind speed and direction, upper-air water vapour	4	4	4	4	4
Full WWW/GOS Upper Air Network		8	8	8	8	12
National contributions to atmospheric composition observations						
World Meteorological Organization / Global Atmosphere Watch (WMO/GAW) Global Atmospheric CO_2 & CH_4 Monitoring Network	Carbon dioxide	1	1	1	1	1
	Methane	3	3	3	2	2
	Other greenhouse gases	4	4	4	3	3
WMO/GAW ozonesonde network	Ozone	1	1	1	1	1
WMO/GAW column ozone network	Ozone	2	2	2	2	2
WMO/GAW aerosol	Aerosol optical	3	3	3	3	3

network	depth					
	Other aerosol properties	4	4	4	4	4
National contributions to the oceanic essential climate variables – surface						
Global surface drifting buoy array on 5 x 5 degree resolution	Sea-surface temperature, sea-level pressure, position-change based current	12	12	12	12	12
GLOSS Core Sea-level Network	Sea level	30 (est)	10 (est)	30 (est)	5	4
Voluntary observing ships (VOS)	All feasible surface essential climate variables	43	31	35	43	32
Ship Of Opportunity Programme (SOOP)	All feasible surface essential climate variables	0	0	0	0	0
National contributions to the oceanic essential climate variables – water column						
Global reference mooring network	All feasible surface and subsurface essential climate variables	0	0	0	0	0
Global tropical moored buoy network	All feasible surface and subsurface essential climate variables	0	0	0	0	0
Argo network	Temperature, salinity, current	11	11	13	11	22
Carbon inventory survey lines (excl. XBTs)	Temperature, salinity, ocean tracers,	2	2	2	2	2

	biogeochemistry variables					
National contributions to the terrestrial domain essential climate variables						
GCOS baseline river discharge network (GTN-R)	River flow	1,000 (est)	400 (est)	1,000 (est)	40	40
GCOS baseline lake level, area and temperature network (GTN-L)	Lake level	50 (est)	10(est)	50 (est)	0	0
WWW/GOS synoptic network	Snow cover	13	13	13	0	0
GCOS glacier monitoring network (GTN-G)	Glaciers' mass balance and length; ice sheet mass balance	50	50	50	50	50
GCOS permafrost monitoring network (GTN-P)	Permafrost borehole temperatures and active-layer thickness	9 (Note: platforms all in Antarctica)	9	9	7	7

Appendix 2: List of permanent stations

Station name	Latitude	Longitude	Agencies	GCOS system	Notes
Kaitaia AWS	-35.1335	173.2629	MetService	GSN	
Gisborne Aero AWS	-38.66	177.984	MetService	GSN	
New Plymouth Aero AWS	-39.008	174.178	MetService	GSN	
Paraparaumu Aero AWS	-40.907	174.984	MetService	GSN	
Hokitika Aero AWS	-42.716	170.983	MetService	GSN	
Tara Hills AWS	-44.528	169.89	MetService	GSN	No surface pressure
Invercargill Aero AWS	-46.413	168.317	MetService	GSN	
Campbell Island AWS	-52.55	169.15	MetService	GSN	
Chatham Island Aero AWS	-43.95	-176.567	MetService	GSN	
Raoul Island AWS	-29.25	-177.917	MetService	GSN	
Paraparaumu Aero	-40.907	174.984	MetService	GUAN	
Invercargill Aero	-46.4174	168.3305	MetService	GUAN	
Raoul Island	-29.25	-177.917	MetService	GUAN	
RNZAF Base Whenuapai	-36.7865	174.6301	MetService	GUAN	Not full GUAN station
Lauder Research Station	-45.05	169.683	NIWA	GRUAN	Proposed
Baring Head	-41.41	174.87	NIWA	GAW	
Lauder Research Station	-45.04	169.68	NIWA	GAW	
Arrival Heights	-77.83	166.66	NIWA	GAW	
Auckland–Waitemata Hbr.	-36.51	174.46	Local authorities	GLOSS	
Chatham Is.	-43.95	-176.55	Pacific Tsunami Warning Center	GLOSS	

Wellington	-41.17	174.47	Local authorities	GLOSS	
Bluff	-46.6	168.35	Local authorities	GLOSS	
Scott Base	-77.51	166.46	NIWA / Antarctica New Zealand	GLOSS	

Note AWS = Automatic Weather Station; GSN = GCOS Surface Network; GUAN = GCOS Upper Air Network; GRUAN = GCOS Reference Upper Air Network; GAW = Global Atmosphere Watch; GLOSS = Global Sea Level Observing System.