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Net Position Report 2008

Projected balance of Kyoto Protocol units during the first commitment period

15 May 2008

New Zealand Government

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Executive Summary

This May 2008 report updates New Zealand's projected balance of Kyoto Protocol units during the first commitment period (2008–2012) of the Kyoto Protocol. A Kyoto Protocol unit is equivalent to one tonne of greenhouse gas emissions or removals converted to carbon dioxide equivalent by the global warming potential. The balance of units is a projection of what actual emissions will be reported in New Zealand national greenhouse inventory submissions over the commitment period and government transfers of Kyoto emissions units. The report is known as New Zealand's net position report and is compiled using the best available information at the time of projection.

As at May 2008, the net position is projected to be a deficit of 21.7 million units during the first commitment period. This comprises 14.7 million tonnes excess emissions over the first commitment period and 7 million tonnes of assigned amount units already promised to successful tenders in the Projects to Reduce Emissions programme. The 2008 update compares with a projected deficit reported in May 2007 of 45.5 million units.

The net position does not evaluate or report the effects of individual policies. All policies are treated together to get the best estimate of New Zealand's emissions and removals over the first commitment period. The net position is calculated consistent with the Public Finance Act 1989 (section 26U) that requires the net position to incorporate to the fullest extent possible, all government decisions and all other circumstances that may have a material effect on the projection and that can be quantified with reasonable certainty.

The 2008 net position report includes all government decisions as at 15 April 2008. The modelled effects of new policies introduced in 2008 are the New Zealand Emissions Trading Scheme, the New Zealand Energy Strategy, and the New Zealand Energy Efficiency and Conservation Strategy. The biofuels sales obligation and solar hot water programme policies were included in the 2007 net position estimate and have been retained in the 2008 projection.

This report has been compiled using sectoral projections reports from across government. Agricultural emissions and net removals by forests eligible under Article 3.3 of the Kyoto Protocol are provided by the Ministry of Agriculture and Forestry. Stationary energy (the energy sector excluding transport), transport and industrial processes emissions projections are provided by the Ministry of Economic Development. Emissions from the waste sector are projected by the Ministry for the Environment. The Ministry for the Environment leads the net position update across government to ensure internal consistency of projections, to project-manage the update, and to compile the Kyoto Protocol compliance equation.

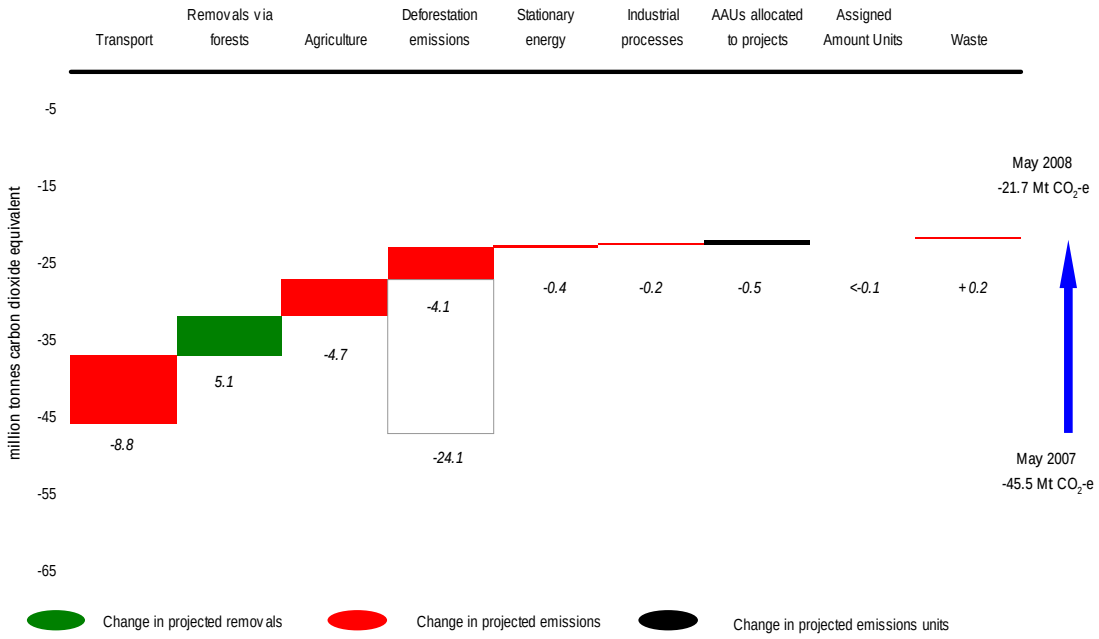
The net position is typically updated on an annual cycle, culminating with the release of the net position report in May. An update may be released when there is a change in policy or economic environment that is judged to have a material effect on the net position. A change of around two million tonnes carbon dioxide equivalent is generally considered a trigger for an update.

The net position will remain uncertain until New Zealand's national greenhouse gas inventory covering the first commitment period has been internationally reviewed, final emissions unit purchases and sales are completed, and the review report is accepted by the Enforcement Branch of the Compliance Committee of the Kyoto Protocol. The internationally agreed timelines for these processes mean that New Zealand will submit its annual inventory for the 2008 calendar year in 2010. As inventory data is submitted for the first commitment period during 2010–2014, uncertainty in the net position will be reduced because actual estimated emissions data will replace projected estimates of emissions. New Zealand's Kyoto Protocol compliance over the first commitment period will not be finalised until 2015.

What has changed since 2007?

Changes in the components of the Kyoto Protocol compliance equation are shown in Figure I.

Figure I: Changes to the estimates since 2007



Note: In 2007, projected deforestation emissions, in the absence of any policy intervention, was 41.0 million tonnes carbon dioxide equivalent. In 2008, emissions from deforestation are projected to be 16.9 million tonnes carbon dioxide equivalent. Projected emissions from deforestation have fallen by 24.1 million tonnes carbon dioxide equivalent compared to the 2007 net position report. The overall effect on the net position as compared with the 2007 report is a reduction in the deficit of 4.1 million tonnes carbon dioxide equivalent.

There are five substantial changes from the net position reported in September 2007; these are summarised below and described in more detail in the appendices to this report.

1) Emissions from the transport sector are now projected to be 8.8 million tonnes carbon dioxide equivalent lower than projected in 2007. Emissions are projected to be lower because actual fuel use data for 2007 is lower than projected last year and higher fuel prices are assumed for the first commitment period (MED 2008, included here as Appendix B).

2) New Zealand's agriculture greenhouse gas emissions are projected to be 4.7 million tonnes lower than projected in 2007 due to the effects of the drought during early 2008 and a continuing decline in sheep numbers. Sheep numbers projected for 2010 are now 1.7 million lower than in the 2007 projection (MAF 2008a, included here as Appendix A).

3) In 2007, projected deforestation emissions, in the absence of any policy intervention was 41.0 million tonnes carbon dioxide equivalent for the first commitment period. The government's stated policy since 2002 has been to cap the liability from deforestation emissions at or below 21.0 million tonnes carbon dioxide equivalent. The 21.0 million tonnes carbon dioxide equivalent figure was used in the 2007 net position projection. In 2008, emissions from deforestation are projected to be 16.9 million tonnes carbon dioxide

equivalent over the first commitment period. Projected emissions from deforestation are lower by 24.1 million tonnes carbon dioxide equivalent. The overall effect on the net position as compared with the 2007 report is a reduction in the deficit of 4.1 million tonnes carbon dioxide equivalent. The Ministry of Agriculture and Forestry (MAF 2008b, included here as Appendix C) explains that the emissions from deforestation may be higher (not quantified) if government decisions at the time of the projection (15 April 2008) are not fully implemented.

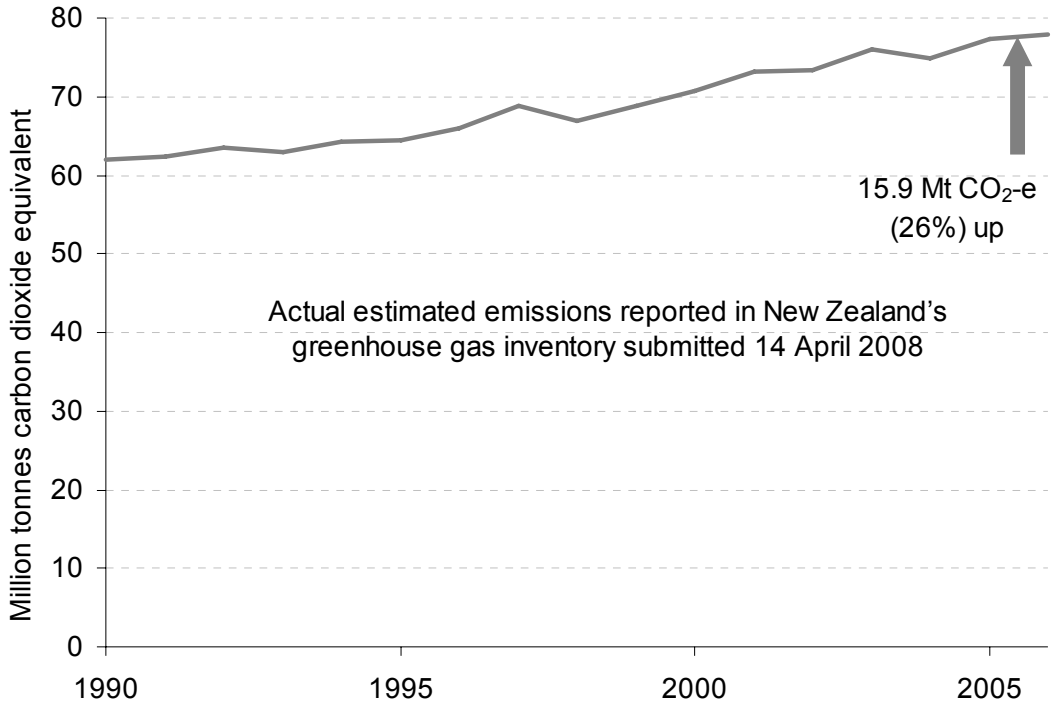
4) An increase of 5.1 million tonnes carbon dioxide equivalent in the estimate of removals due to a change in methodology as recommended by an international review of the 2007 projections by AEA Technology in 2007. The method now combines all factors affecting projected removals in a single model rather than treating each factor separately (MAF 2008b).

5) Projected emissions from stationary energy and industrial processes are 0.7 million tonnes carbon dioxide equivalent lower than projected in 2007 due to higher expected energy prices, and actual emissions data for 2007 being lower than projected previously (MED 2008).

1 New Zealand's emissions profile 1990–2006

In 1990, New Zealand's total greenhouse gas emissions (excluding the land use, land-use change and forestry sector) amounted to 61.9 million tonnes carbon dioxide equivalent. In 2006, total greenhouse gas emissions amounted to 77.9 million tonnes carbon dioxide equivalent. This equates to a 15.9 million tonnes carbon dioxide equivalent (26 per cent) rise in greenhouse gas emissions since 1990 from the five sectors listed in Annex A to the Kyoto Protocol (see Box 1 on page 6). Annex A to the Kyoto Protocol does not include emissions or removals from the land use, land-use change and forestry sector, and internationally accepted practice in reporting under the United Nations Framework Convention on Climate Change is to report total emissions excluding this sector. The annual changes in New Zealand's greenhouse gas emissions are shown in Figure 1.

Figure 1: New Zealand's total emissions 1990–2006



Source: Ministry for the Environment (2008a)

New Zealand is unique among developed nations in that 48 per cent of total emissions are produced by the agriculture sector (Figure 2). New Zealand's agricultural emissions are methane from ruminant farm animals, and nitrous oxide from animal excreta and nitrogenous fertiliser use. Since 1990, emissions from agriculture have increased by 5.2 million tonnes carbon dioxide equivalent (16 per cent). Changes to emissions from the agriculture sector are primarily due to increased emissions from dairying and application nitrogen fertiliser, and reduced emissions from sheep grazing.

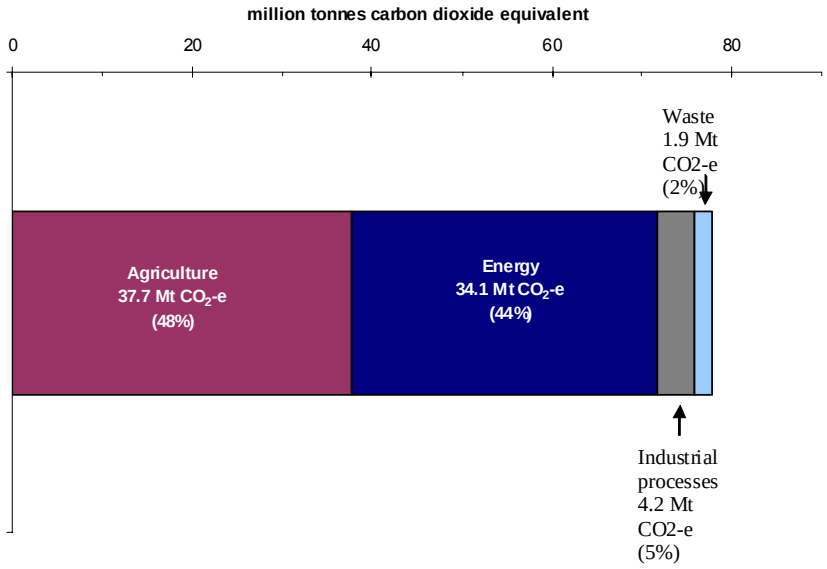
- Emissions from dairy grazing (both methane and nitrous oxide) have increased 5.4 million tonnes carbon dioxide equivalent (71 per cent) between 1990 and 2006 due to increases in the number of dairy cows and improved productivity. Emissions from the application of nitrogenous fertiliser have increased over the same period by 1.5 million tonnes carbon dioxide equivalent (456 per cent).
- Emissions from sheep grazing have declined by 2.8 million tonnes carbon dioxide equivalent between 1990 and 2006 due to a reduction in sheep numbers.

The energy sector (including transport) is the other large component of New Zealand's emissions profile, comprising 44 per cent of total emissions in 2006. Emissions from the energy sector are now 10.6 million tonnes carbon dioxide equivalent (45 per cent) above the 1990 level (Table 1). Changes to emissions from the energy sector are primarily due to increased emissions from road transport and fossil fuel combustion from thermal electricity generation.

- Total emissions from the transport subsector increased by 5.6 million tonnes carbon dioxide (64 per cent) between 1990 and 2006. Emissions from road transport alone have increased by 5.2 million tonnes carbon dioxide equivalent (67 per cent) between 1990 and 2006.
- Emissions from electricity generation have increased by 4.8 million tonnes carbon dioxide equivalent (138 per cent) between 1990 and 2006.

Emissions from the industrial processes and the waste sector are a small component of New Zealand's emissions profile, comprising 5 per cent and 2 per cent, respectively, of all greenhouse gas emissions in 2006. Emissions from industrial processes are now 0.8 million tonnes carbon dioxide equivalent (24 per cent) higher than in 1990. Emissions from the waste sector are now 0.6 million tonnes carbon dioxide equivalent (26 per cent) below the 1990 baseline. The majority of the reduction of emissions in the waste sector has resulted from improvements in management of solid waste disposal.

Figure 2: New Zealand's sectoral emissions in 2006



Source: Ministry for the Environment (2008 a)

Table 1: Annual sectoral emissions of greenhouse gases in 1990 and 2006

Sector	1990 (Mt CO_2-e)	2006 (Mt CO_2-e)	Change from 1990 (%)	Change from 1990 (%)
Energy	**23.5**	**34.1**	**10.6**	**45.0**
Transport	8.8	14.4	5.6	64.1
Road transport	7.7	13.0	5.2	67.2
Domestic air transport	0.8	1.1	0.3	44.2
Domestic sea transport	0.3	0.3	0.1	31.1
Stationary energy	14.7	19.7	4.9	33.6
Electricity	3.5	8.3	4.8	137.6
Residential	0.6	0.6	0.0	6.1
Industrial and commercial	10.6	10.8	0.2	1.5
Industrial Processes	**3.4**	**4.2**	**0.8**	**24.4**
Solvents	**0.0**	**0.0**	**0.0**	**–3.0**
Agriculture	**32.5**	**37.7**	**5.2**	**15.9**
Beef cattle	7.0	7.7	0.7	10.7
Dairy	7.6	13.0	5.4	71.0
Deer	0.6	1.1	0.5	92.3
Sheep	16.3	13.4	–2.8	–17.4
Nitrogen fertiliser	0.3	1.9	1.5	456.3
Other agriculture	0.8	0.6	–0.2	–25.9
Waste	**2.5**	**1.9**	**–0.6**	**–25.9**
Solid waste disposal	2.1	1.4	–0.7	–31.8
Wastewater	0.4	0.3	0.0	–8.6
Incineration	0.0	0.0	0.0	–64.6
TOTAL	**61.9**	**77.9**	**15.9**	**25.7**

Sources: Ministry for the Environment (2008a), Ministry of Economic Development (2008)

Note: One emissions unit is equivalent to one tonne of greenhouse gas emissions converted to carbon dioxide equivalents by their global warming potential (IPCC 1995).

2 Kyoto Protocol compliance equation

The maximum amount of emissions (measured as the equivalent in tonnes of carbon dioxide) that an Annex I Party to the Kyoto Protocol may emit over the commitment period in order to comply with its emissions target, is known as a Party's assigned amount. This is specified in Kyoto Protocol Article 3.1 and Annex B to the Kyoto Protocol (see Box 1 on page 6).

Parties may increase their assigned amount by removing greenhouse gases from the atmosphere by carbon sinks in the land use, land-use change and forestry sector. Mandatory activities in the land use, land-use change and forestry sector are afforestation, reforestation and deforestation since 1990 (Kyoto Protocol Article 3.3). Forest management, cropland management, grazing land management and revegetation are voluntary for the first commitment period (Kyoto Protocol Article 3.4). New Zealand did not elect any Article 3.4 activities. The removal of greenhouse gases from the atmosphere through eligible sink activities minus any harvesting and deforestation emissions generates removal units (RMUs). Removal units are popularly known as carbon credits.

An Annex I Party to the Kyoto Protocol must hold sufficient assigned amount units (AAUs) to cover its total emissions during the first commitment period. If the Party's emissions exceed its assigned amount plus removal units, it must take responsibility for its excess emissions through the Kyoto Protocol's flexibility mechanisms. Flexibility mechanisms include the Clean Development Mechanism, Joint Implementation, and trading of units between Annex 1 Parties. Parties incur a 130 per cent penalty during any future commitment period if during the first commitment period they do not hold enough emissions units to cover their total emissions. The Kyoto compliance equation for the first commitment period may be simplified as shown in Figure 3.

The net position over the commitment period is based on projected emissions, New Zealand's assigned amount, the projected removal units, and emissions units promised to other agents – for example successful tenders in the Projects to Reduce Emissions programme.

Figure 3: Kyoto compliance equation

Note: Emissions include energy, agriculture, waste, industrial processes and solvents and exclude emissions from deforestation between 2008 and 2012.

The New Zealand has promised to provide assigned amount units to projects under its programme Projects to Reduce Emissions. The net position accounts for units promised to these projects by subtracting them from the assigned amount. The projected reduction in emissions from the Projects to Reduce Emissions programme are included in the emissions projections from the energy sector.

2.1 New Zealand's assigned amount

New Zealand's assigned amount is fixed as 309,564,733 metric tonnes carbon dioxide equivalent (this equates to 309.6 million assigned amount units). Each emissions unit is equal to one tonne of greenhouse gas emissions, converted to carbon dioxide equivalents using the global warming potentials as specified by the Second Assessment report of the Intergovernmental Panel on Climate Change (IPCC 1995). These units are lodged in New Zealand's emission unit registry operated by the Ministry of Economic Development. The assigned amount is based on the estimates of emissions for 1990 from the inventory submitted as part of the Initial Report under the Kyoto Protocol (MfE 2006) and reviewed by an international review team in February 2007 (UNFCCC 2007).

The assigned amount is fixed for the first commitment period. In contrast, emissions and removals for all years of the national greenhouse gas inventory will change due to continuous improvement of the inventory. Consequently, the level of emissions in 1990 reported in the 2008 inventory submission is 0.03 million tonnes carbon dioxide equivalent higher (less than 0.1 per cent) than the 1990 level used in the assigned amount calculation.

Box 1: Kyoto Protocol Article 3.1

"The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A [to the Kyoto Protocol, refer below] do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B [to the Kyoto Protocol, refer below] and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012." (Kyoto Protocol 1997)

Annex A to the Kyoto Protocol

Greenhouse gases	Sector	Sub sectors
Carbon dioxide (CO_2) Methane (CH_4) Nitrous oxide (N_2O) Hydrofluorocarbons (HFCs) Perfluorocarbons (PFCs) Sulphur hexafluoride (SF_6)	Energy	*Fuel combustion* Energy industries Manufacturing industries and construction Transport Other sectors Other *Fugitive emissions from fuels* Solid fuels Oil and natural gas Other
	Industrial processes	Mineral products Chemical industry Metal production Other production Production of halocarbons and sulphur hexafluoride Consumption of halocarbons and sulphur hexafluoride Other
	Solvent and other product use	
	Agriculture	Enteric fermentation Manure management Rice cultivation Agricultural soils Prescribed burning of savannas Field burning of agricultural residues Other
	Waste	Solid waste disposal on land Wastewater handling Waste incineration Other

Annex B To the Kyoto Protocol (New Zealand only)

Party	quantified emission limitation or reduction commitment (percentage of base year or period)
New Zealand	100

3 Projections of emissions and removals

The Ministry for the Environment leads the net position update across government to ensure internal consistency of projections, to project-manage the update, and to compile the Kyoto Protocol compliance equation. For the 2008 net position report, each government department has produced a full independent report of projected emissions and removals for their sector. These reports (attached as Appendices A–D) explain the modelling approaches used by the departments, changes in projections since 2007, and how uncertainty was treated in each sector.

3.1 Total emissions

Total emissions (excluding emissions from the land use, land-use change and forestry sector) over the first commitment period are a combination of emissions from the energy (including transport), industrial processes, solvents, agriculture and the waste sectors as specified in Annex A and Article 3.1 of the Kyoto Protocol (refer Box 1).

Total emissions of greenhouse gases are projected to be 391.5 million tonnes carbon dioxide equivalent. Over the first commitment period, this equates to average annual emissions of 78.3 million tonnes carbon dioxide equivalent (Figure 1).

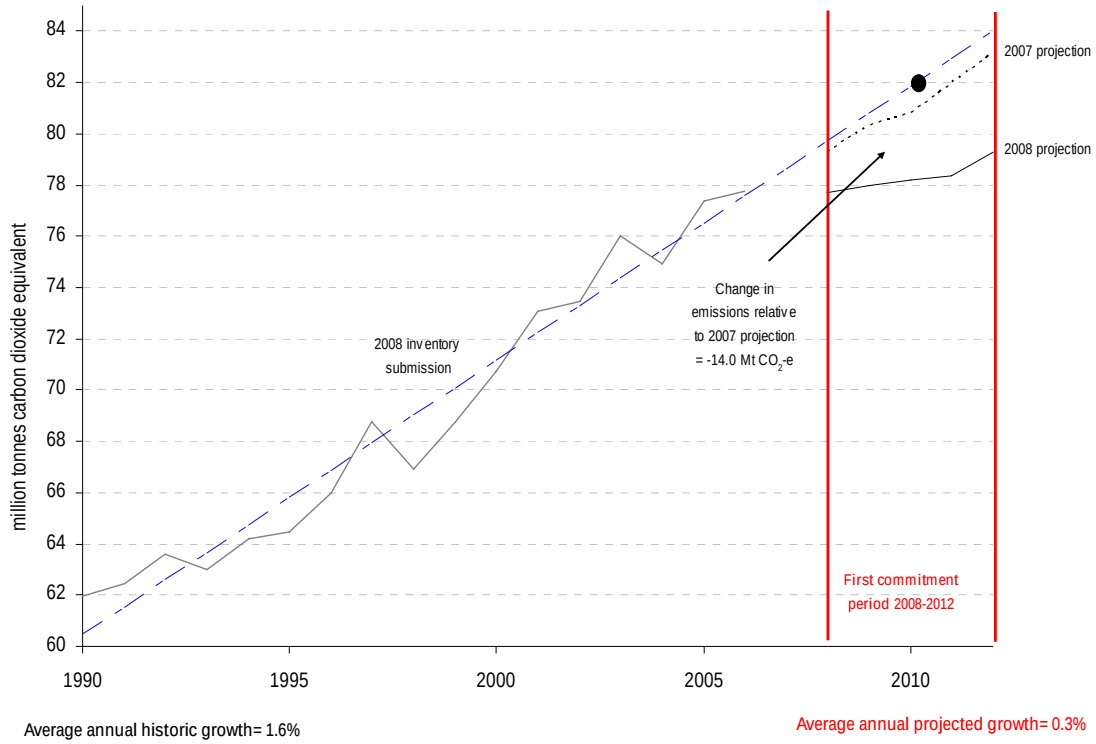
Emissions projections for each sector are based on detailed sectoral modelling. A simple linear extrapolation of total emissions has been included in Figure 4. The simple linear extrapolation projects total annual emissions to be 81.9 million tonnes carbon dioxide equivalent.

3.2 Inclusion of policy

The net position does not evaluate or report the effects of individual policies. All policies are treated together to get the best estimate of New Zealand's emissions and removals over the first commitment period. The net position is calculated consistent with the Public Finance Act 1989 (section 26U) that requires the net position to incorporate to the fullest extent possible, all government decisions and all other circumstances that may have a material effect on the projection and that can be quantified with reasonable certainty.

The 2008 net position report includes all government decisions as at 15 April 2008. The modelled effects of new policies introduced in 2008 are the New Zealand Emissions Trading Scheme, the New Zealand Energy Strategy, and the New Zealand Energy Efficiency and Conservation Strategy. The biofuels sales obligation and solar hot water programme policies were included in the 2007 net position estimate and have been retained in the 2008 projection.

Figure 4: Historical emissions data and projected emissions 1990–2012



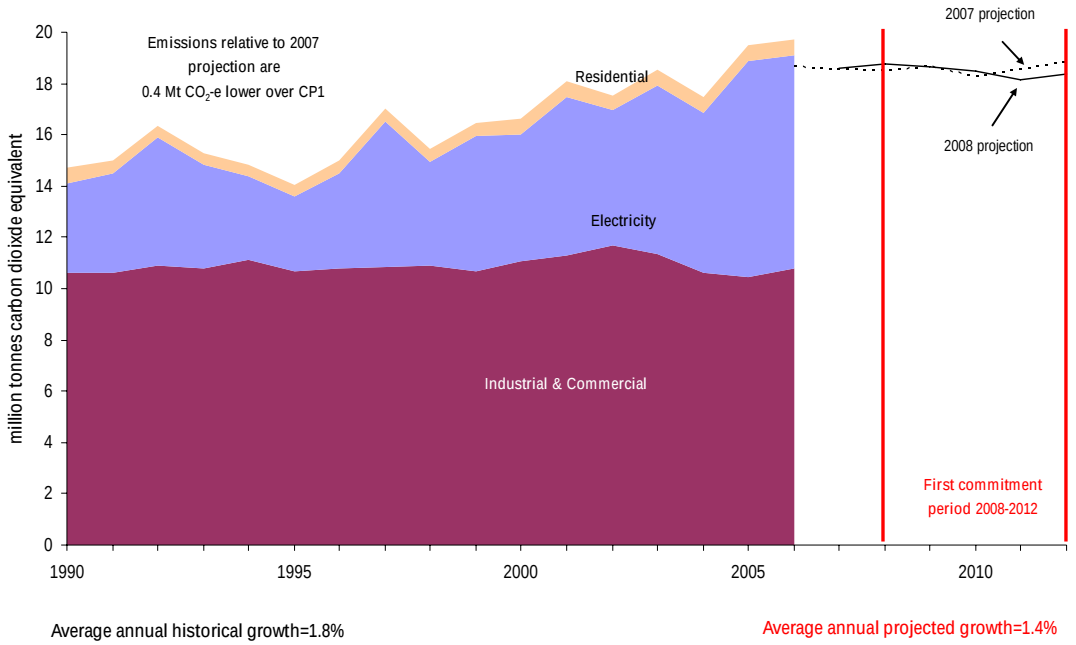
Note: Includes emissions from energy (including transport), agriculture, waste, solvents and industrial processes. Emissions from deforestation are not included.

3.3 Energy and industrial processes emissions

Energy, transport and industrial processes emissions projections are provided by the Ministry of Economic Development (MED 2008, included here as Appendix B). Historical data on emissions for the period 1990–2006 and projected emissions for stationary energy, transport and industrial processes are shown in Figures 5, 6 and 7 below. Stationary energy refers to emissions from energy sources excluding transport.

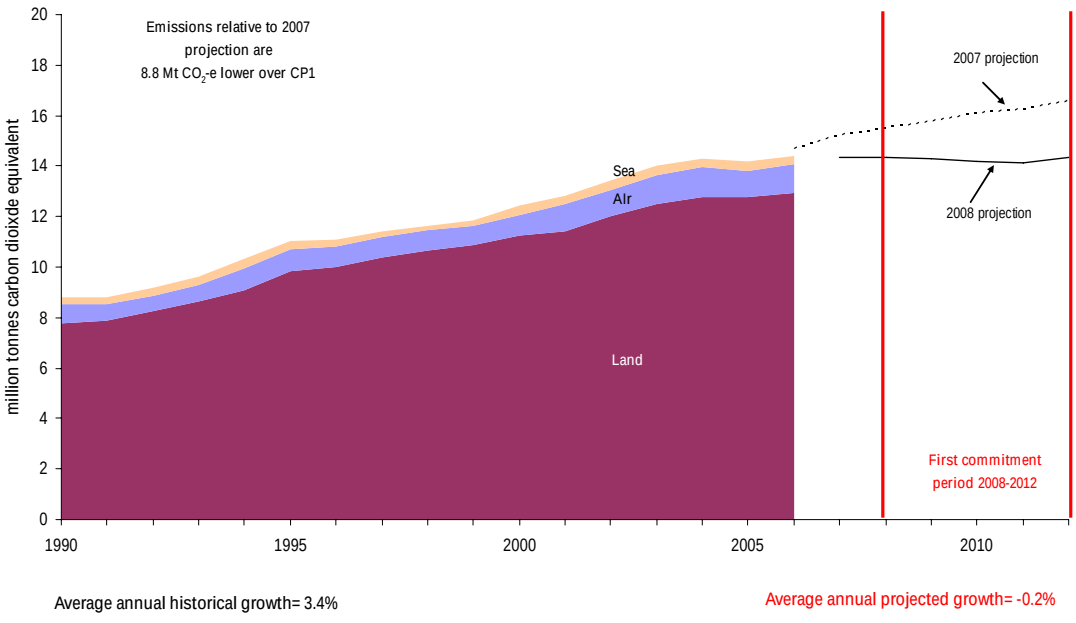
Emissions from stationary energy, transport and industrial processes are projected to be 9.5 million tonnes carbon dioxide equivalent lower than projected in 2007. The most substantive change in projected energy emissions is due to emissions from transport being 8.8 million tonnes carbon dioxide equivalent lower than projected in 2007. The Ministry of Economic Development (MED 2008), in summary, explain the reductions are due to actual fuel use data for 2007 being lower than expected and for higher fuel prices being assumed for the first commitment period.

Figure 5: Historical emissions data and projected stationary energy emissions 1990–2012



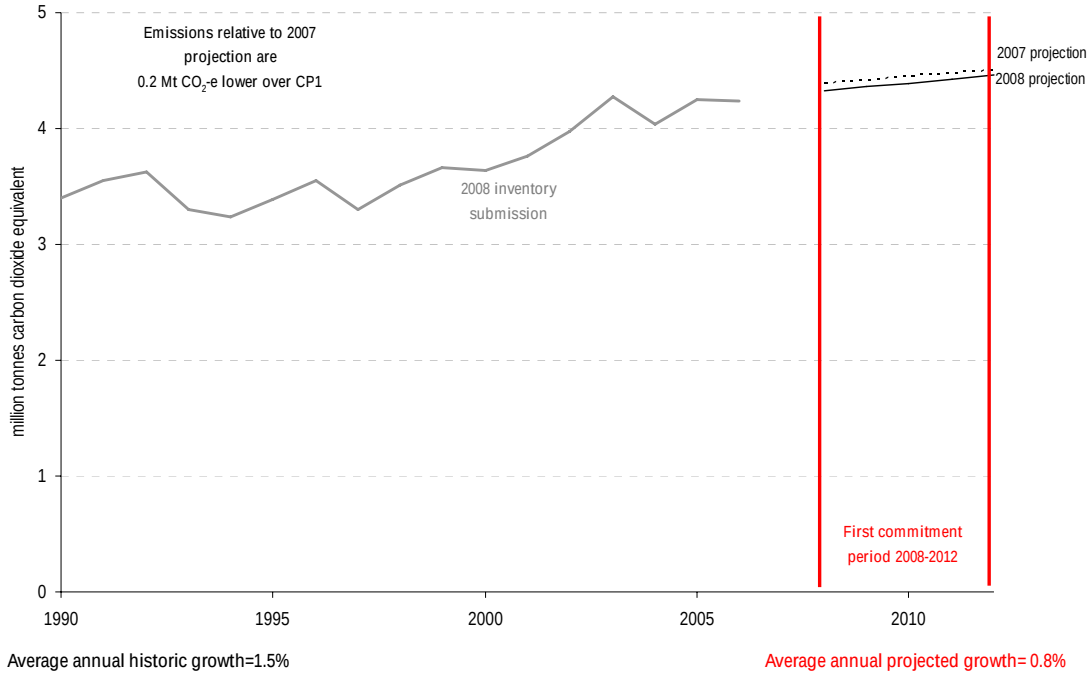
Source: Historical emissions data MfE (2008a), projected emissions MED (2008)

Figure 6: Historical emissions data and projected transport emissions 1990–2012



Source: Historical emissions data MfE (2008a), projected emissions MED (2008)

Figure 7: Historical emissions data and projected industrial processes emissions 1990–2012

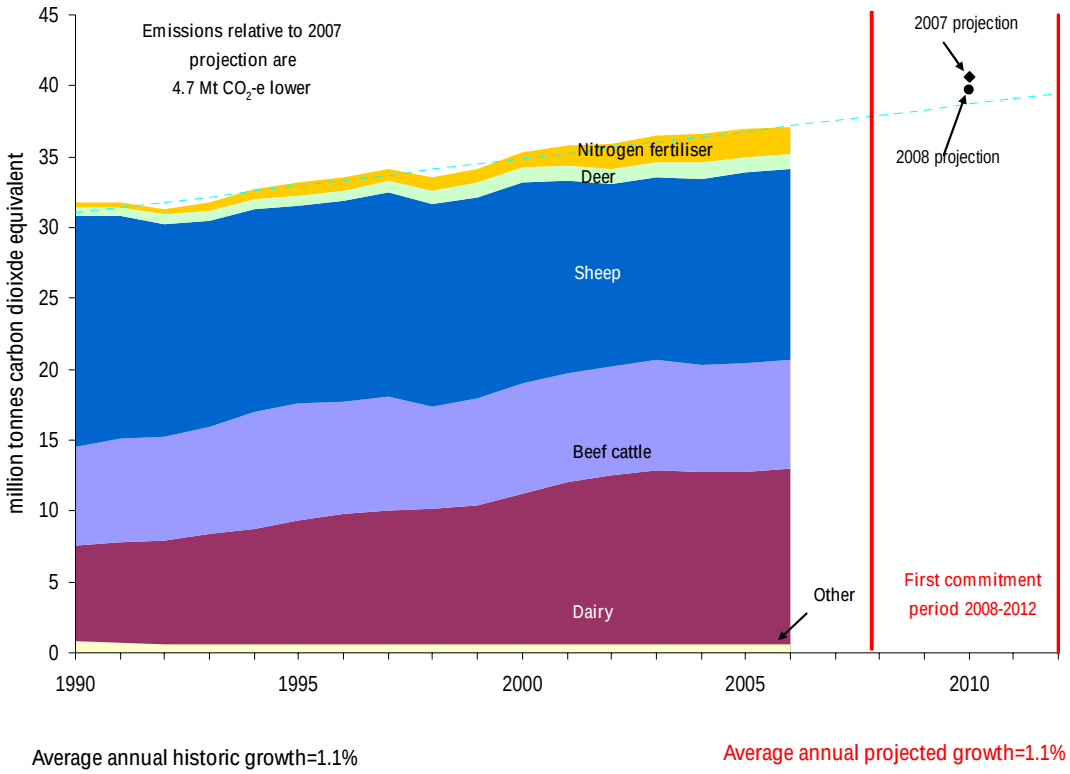


Source: Historical emissions data MfE (2008a), projected emissions MED (2008)

3.4 Agriculture emissions

Figure 8 shows historical data on emissions of greenhouse gases from agriculture reported the 2008 national greenhouse gas inventory (MfE 2008a). The Ministry of Agriculture and Forestry has provided a projection for total agricultural emissions at 2010 (MAF 2008a, included here as Appendix A). New Zealand's agriculture greenhouse gas emissions are projected to be 4.7 million tonnes lower than projected in 2007 due to the effects of the drought during early 2008 and a continuing decline in sheep numbers. Sheep numbers projected for 2010 are now 1.7 million lower than in the 2007 projection (Appendix A: MAF (2008a)).

Figure 8: Historical emissions data and projected agricultural emissions 1990–2012



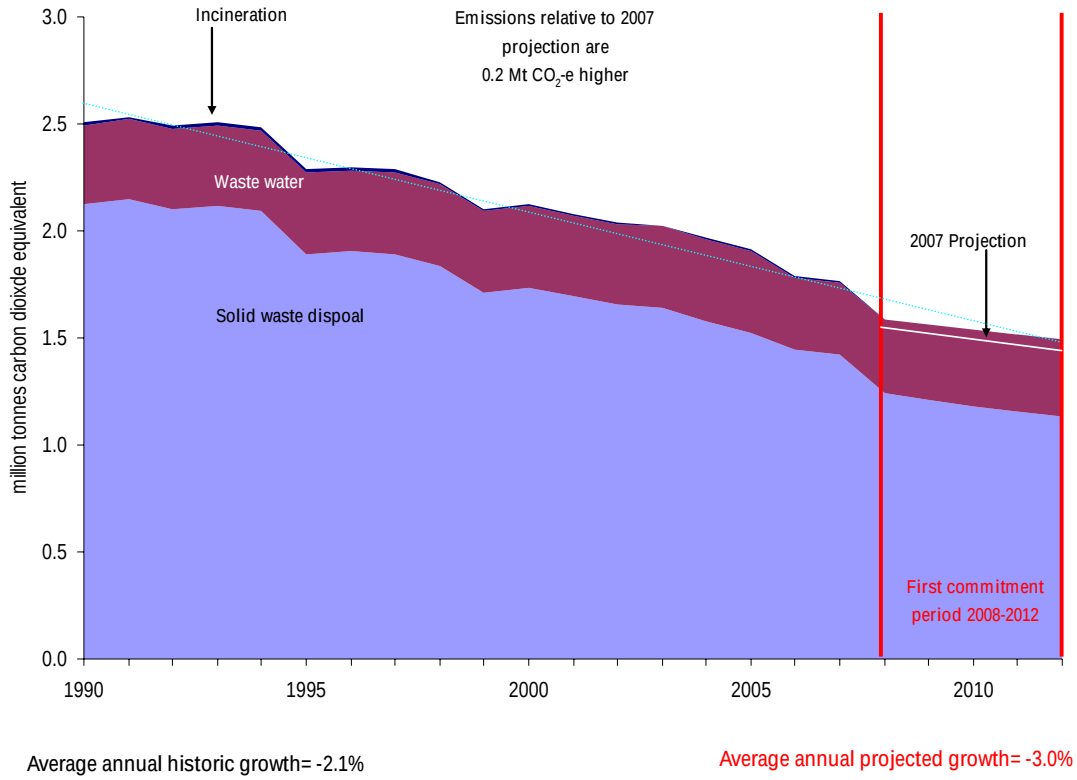
Source: Historical emissions data MfE (2008a), projected emissions MAF (2008a)

Note: Other emissions include savanna burning, crop residue burning, and livestock emissions from poultry, pigs, horses and goats.

3.5 Waste emissions

Waste emissions projections were provided by the Ministry for the Environment (MfE 2008b, included here as Appendix D). Figure 9 shows historical data on emissions of greenhouse gases from the waste sector reported in the 2008 national greenhouse gas inventory submission (MfE 2008a) and projected emissions by the Ministry for the Environment. The inclusion of solid waste incineration for the first time in the 2008 national greenhouse gas inventory submission, and some methodological corrections, has resulted in New Zealand's projected waste emissions increasing by 0.2 million tonnes carbon dioxide equivalent compared to 2007.

Figure 9: Historical emissions data and projected waste emissions 1990–2012



Source: Historical emissions data and projected emissions MfE (2008a,b)

3.6 Emissions and removals from land use, land-use change and forestry

Net removals from land use, land-use change and forestry (total removals less deforestation emissions) were provided by the Ministry of Agriculture and Forestry (MAF 2008b, included here as Appendix C).

Net carbon dioxide removals by forests consistent with afforestation, re-afforestation and deforestation activities under the Kyoto Protocol Article 3.3, minus any deforestation emissions, are projected to be 67.2 million tonnes carbon dioxide. This is an increase of 9.2 million tonnes carbon dioxide equivalent of removals over the first commitment period. The increase is explained as follows:

- In 2007, projected deforestation emissions, in the absence of any policy intervention, was 41.0 million tonnes carbon dioxide equivalent for the first commitment period. The government's stated policy since 2002 has been to cap the liability from deforestation emissions at or below 21.0 million tonnes carbon dioxide equivalent. The 21.0 million tonnes carbon dioxide equivalent figure was used in the 2007 net position projection. In 2008, emissions from deforestation are projected to be 16.9 million tonnes carbon dioxide equivalent over the first commitment period. Projected emissions from deforestation have fallen by 24.1 million tonnes carbon dioxide equivalent. The overall effect on the net position as compared with the 2007 report is a reduction in the deficit of 4.1 million tonnes carbon dioxide equivalent (MAF 2008b).

- An increase of 5.1 million tonnes carbon dioxide in the estimate of emissions removals is due to a change in methodology as recommended by an international review of the 2007 projections (AEA Technology 2007). The method now combines all factors affecting projected removals in a single model rather than treating each factor separately.

3.7 Emissions from solvents and other products

Solvent and other products emissions are less than 0.1 per cent of total emissions; they are projected by a simple linear trend by the Ministry for the Environment and included in the estimate of the net position deficit for completeness.

4 Projections uncertainty

Projections are estimates of future values and are inherently uncertain. To accommodate this uncertainty, upper and lower emissions projections are included for each sector. The uncertainty range for each sector is shown by each sector in Figure 10. The projected net position is expected to continue to change each year when the net position is updated as a result of new policies and new information such as oil prices. The high and low estimates for each sector are reported in Table 2.

The total range of uncertainty summing across all sectors has decreased from 156.7 million tonnes carbon dioxide equivalent reported in the 2007 net position report to 138.7 million tonnes carbon dioxide equivalent.

- **Agriculture**: upper and lower emissions projections for the first commitment period are based on variations in commodity prices used to project future animal numbers combined with high and low changes in productivity, of cattle, sheep and deer. The uncertainty is high for animal numbers because the 95 per cent variance is used for the last 10 years of product prices. There was a substantial jump in prices for milk solids, which increases the 95 per cent confidence interval hence greater uncertainty, compared to the 2007 projection.
- **Stationary energy transport and industrial processes**: upper and lower emissions projections for the first commitment period are based on variations in macroeconomic factors, levels of production and consumption, and policy measures.
- **Net removals from land use, land-use change and forestry**: upper and lower projections for the first commitment period are based on future deforestation and afforestation rates. The largest source of uncertainty is due to information and scientific uncertainty. The uncertainty attributable to the values for forest sinks will continue until the Land Use and Carbon Analysis System (LUCAS) being developed by the Ministry for the Environment becomes operational. LUCAS will use satellite mapping to more accurately locate forests. This is a requirement of reporting Article 3.3 sinks under the Kyoto Protocol. Presently the sink estimates are based on a postal survey of forest owners, known as the National Exotic Forest Description.
  In 2007, projected deforestation emissions, in the absence of any policy intervention, was 41.0 million tonnes carbon dioxide equivalent for the first commitment period. The government's stated policy since 2002 has been to cap the liability from deforestation

emissions at or below 21.0 million tonnes carbon dioxide equivalent. The 21.0 million tonnes carbon dioxide equivalent figure was used in the 2007 net position projection. In 2008, emissions from deforestation are projected to be 16.9 million tonnes carbon dioxide equivalent over the first commitment period. Projected emissions from deforestation have fallen by 24.1 million tonnes carbon dioxide equivalent. The overall effect on the net position as compared with the 2007 report is a reduction in the deficit of 4.1 million tonnes carbon dioxide equivalent. The Ministry of Agriculture and Forestry (MAF 2008b) explains that the emissions from deforestation may be higher (but not quantified) if government decisions at the time of the projection (15 April 2008) are not fully implemented.

- **Waste emissions**: upper and lower emissions projections for the first commitment period are based on variations in the outcome of existing waste minimisation and management practices.

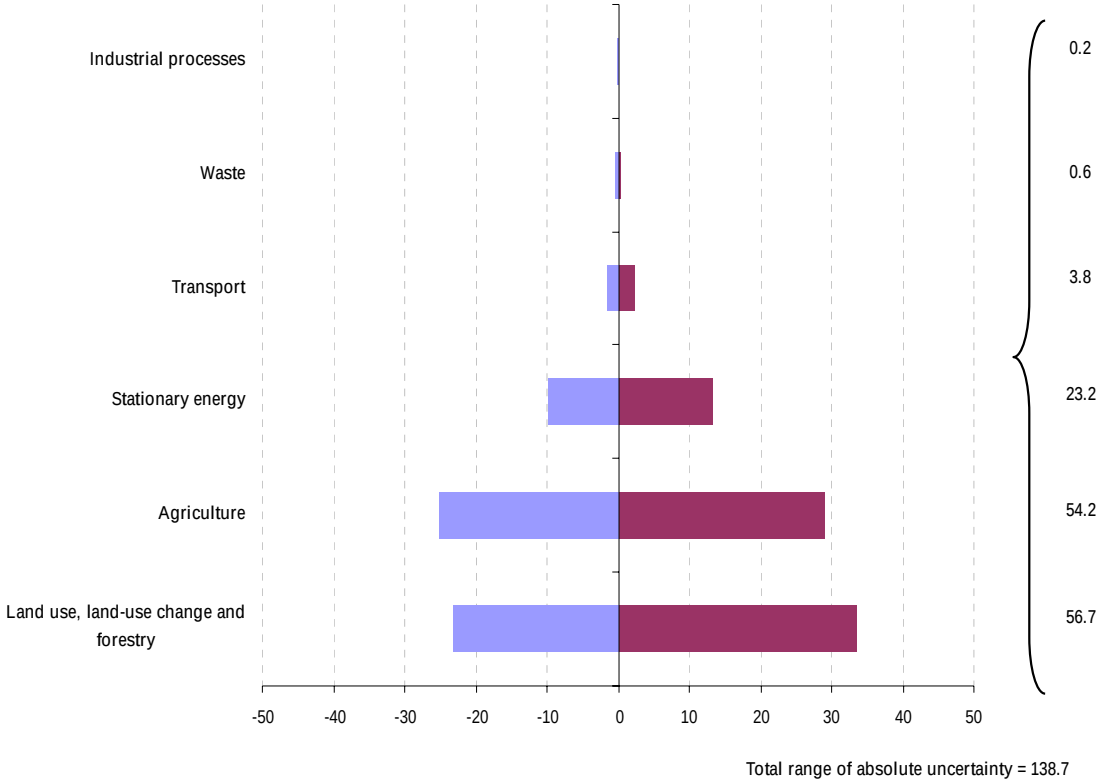
The net position will remain uncertain until New Zealand's national greenhouse gas inventory covering the first commitment period has been internationally reviewed, final emissions unit purchases and sales are completed, and the review report accepted by the Enforcement Branch of the Compliance Committee of the Kyoto Protocol. The internationally agreed timelines for these processes mean that New Zealand will submit its annual inventory for the 2008 calendar year in 2010. As inventory data is submitted for the first commitment period during 2010–2014, uncertainty in the net position will be reduced because actual estimated emissions data will replace projected estimates of emissions. New Zealand's Kyoto Protocol compliance over the first commitment period will not be finalised until 2015.

Table 2: Projected net position over the first commitment period (million emissions units)

	Upper emissions scenarios	Most likely scenarios	Lower emissions scenarios
Projection of Assigned Amount Units			
Stationary energy	105.7	92.4	82.6
Transport	73.5	71.3	69.7
Industrial processes	22.1	22.0	21.9
Total energy and industrial processes	201.3	185.6	174.1
Solvent and other product use		0.2	
Agriculture	227.6	198.5	173.4
Waste	7.5	7.2	6.9
Projected aggregate emissions		**391.5**	
Projection of Removal Units			
Removals via forests	64.2	84.1	107.3
Deforestation emissions	30.5	16.9	16.9
Net removals via forests	**33.7**	**67.2**	**90.4**

Note: One emissions unit is equivalent to one tonne of greenhouse gas emissions converted to carbon dioxide equivalents by their global warming potential (IPCC 1995).

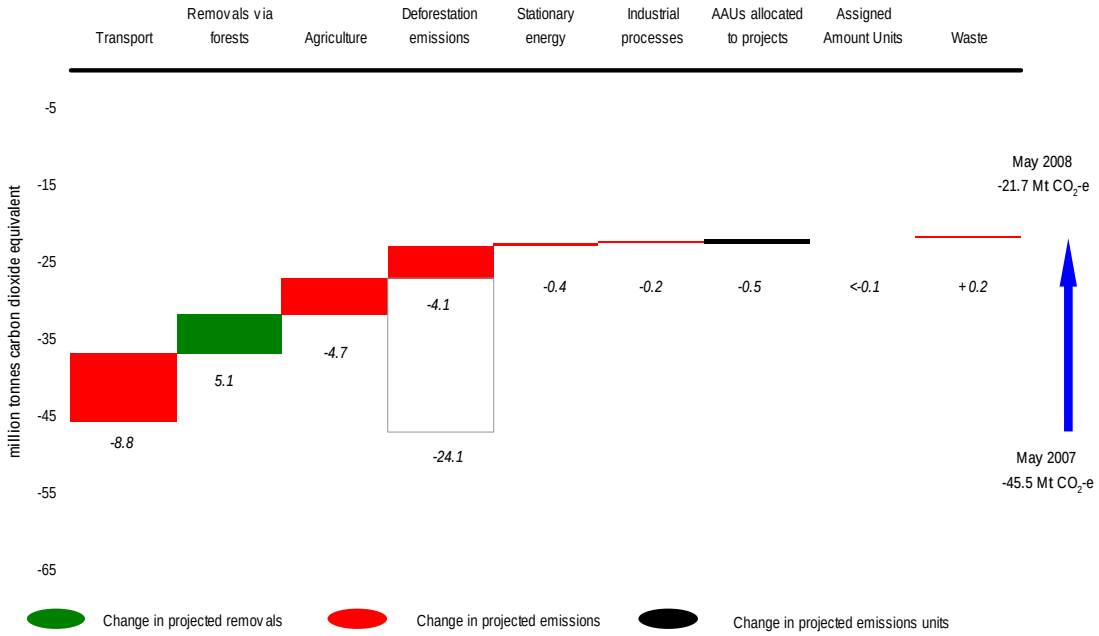
Figure 10: Uncertainty ranges by sector (million tonnes carbon dioxide equivalent)



5 Reconciliation with previous projections

The changes in the components of the Kyoto Protocol compliance equation are shown in Figure 11 and detailed changes in all variables since the 2005 net position report are shown in Table 3. Full explanations of the changes in the methodology, assumptions and results for each sector is found in the sectoral projection appendices (A–D). A summary of the changes since the 2007 net position is shown in the executive summary and chapter 3 of this report.

Figure 11: Changes to the estimates since 2007



Note: In 2007, projected deforestation emissions, in the absence of any policy intervention, was 41.0 million tonnes carbon dioxide equivalent. In 2008, emissions from deforestation are projected to be 16.9 million tonnes carbon dioxide. Projected emissions from deforestation have fallen by 24.1 million tonnes carbon dioxide equivalent compared to the 2007 net position report. The overall effect on the net position as compared with the 2007 report is a reduction in the deficit of 4.1 million tonnes carbon dioxide equivalent.

Table 3: Reconciliation with historic net positions (million tonnes carbon dioxide equivalent)

	May 2008	**Change**	**May 2007**	Change	May 2006	Change	Dec. 2005	Change	May 2005
Projected emissions									
Stationary energy	**92.4**	–0.4	92.8	0.3	91.3				
Transport	**71.3**	–8.8	80.1	1.3	78.8				
Industrial processes	**22.0**	–0.2	22.2	–0.6	22.9				
Total energy and industrial processes	**185.6**	–9.5	195.1	0.9	193.0	–14.5	207.5	13.1	194.4
Solvent and other product use	**0.2**	0.0	0.3	0.0	0.3	0.3	0.0		0.0
Agriculture	**198.5**	–4.7	203.1	4.8	198.8	–3.2	202.0		202.0
Waste	**7.2**	0.2	7.0	0.5	6.5	1.2	5.3		5.3
Projected aggregate emissions	**391.5**	–14.0	405.4	6.3	398.5	–16.3	414.8	13.1	401.7
Assigned Amount Units	**309.6**	0.1	309.5	1.9	307.6	0.0	307.6		307.6
Projected Removals									
Removals via forests (article 3.3)	**84.1**	5.1	79.0	0.8	78.2	1.0	77.2		77.2
Deforestation emissions	**16.9**	–24.1	41.0	0.0	38.5	0.0	21.0	14.7	6.3
Net Removals via forests	**67.2**	29.2	38.0	0.8	39.7	1.0	56.2	–14.7	70.9
NEW ZEALAND'S NET EMISSIONS	**–14.7**	43.3	–58.0	–3.6	–51.2	17.3	–51.0		–23.2
Additional policy and unit transfer adjustments									
AAUs commited to projects	**7.0**	–0.5	7.5	0.0	7.5		7.5		7.5
Effect of deforestation emissions cap	**0.0**	–20.0	20.0	2.5	17.5	17.5	0.0		
Monte Carlo modelling difference						5.5	–5.5		–5.5
NEW ZEALAND'S NET POSITION	**–21.7**	23.8	–45.5	–3.6	–41.2	22.8	–64.0	27.8	–36.2

Notes:

1. One emissions unit is equivalent to one tonne of greenhouse gas emissions converted to carbon dioxide equivalents by their global warming potential (IPCC 1995).
2. Net removals via forests offset emissions and reduce the deficit on the net position.
3. This table shows the impact of the deforestation cap separately under policy and unit transfers, rather than being included with deforestation emissions (as in previous Net Position reports).

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Appendix A: Agriculture Emissions Projections

Report to the Ministry for the Environment

Ministry of Agriculture and Forestry, April 2008

Disclaimer: This report contains forecast projections of greenhouse gas emissions by the agriculture sector. These projections need to be used with an understanding of the significant uncertainties that are due to the complexity of forecasting biological systems: these are inherently variable as they are affected by climate and changing economic conditions. While every effort has been made to provide the best projections as at March 2008, future adjustments will inevitably reflect changes in climatic conditions, economic conditions, international commodity prices and exchange rates.

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Summary

The most likely value of total emissions over the five years of the First Commitment Period (2008–2012) of the Kyoto Protocol for the agriculture sector is projected to be 198.45 million tonnes carbon dioxide equivalents (Mt CO_2-e). The range is projected to lie between 173.35 and 227.55 Mt CO_2-e.

Average annual emissions over that period are projected to range from 34.67 to 45.51 Mt CO_2-e, with a most likely value of 39.69 Mt CO_2-e per annum (Table A1).

Table A1: Summary of annual emission projection scenarios for 2010 in million tonnes carbon dioxide equivalents (Mt CO_2-e), based on the 2006 National Greenhouse Gas Inventory methodology

	1990	2006	2010		
	Baseline	Most recent	Lower	Most likely	Higher
Total projected emissions	32.50	37.67	34.67	39.69	45.51
Projected emissions above 1990		5.17	2.17	7.19	13.01
Percentage change from 1990		15.9%	6.7%	22.1%	40.0%

This recent most likely value for annual emissions at 2010 is 0.93 Mt CO_2-e lower than was projected in 2007 (the total being 4.65 million tonnes lower over the First Commitment Period). Uncertainty has increased: the difference between the lower and higher scenarios is now 10.84 Mt CO_2-e compared to 9.66 Mt CO_2-e in the 2007 forecast estimates.

The reduction in emissions over the First Commitment Period has been largely driven by a significant decrease (4.7%) in sheep numbers since the previous year's projections of sheep numbers for 2010. Drought and poor product prices have played a significant role in the sheep population decline, as discussed in more detail later. The decline in sheep number has not been compensated for by increases in numbers of other animal species. The second feature is the 7.2 per cent decrease in projected nitrogen fertiliser use over the commitment period which will result in decreased nitrous oxide emissions.

Projected forecasts of future agriculture greenhouse gas emissions are influenced by prevailing conditions. All biological systems are greatly affected by climate, and agriculture is subject to changing economic conditions, including changing international commodity prices and the New Zealand dollar exchange rate. Every effort has been made to provide the best projections of future emissions as at March 2008; however, future adjustments are inevitable.

1 Introduction

Our projections are based on:

1) the methodologies used in the National Greenhouse Gas Inventory submitted to the United Nations Framework Convention on Climate Change (UNFCCC) annually, and
2) econometric and physical models developed by the New Zealand Ministry of Agriculture and Forestry (MAF). The inventory methodology conforms to the Good Practice Guidance methodologies developed by the Intergovernmental Panel on Climate Change and adopted by the UNFCCC.

Projections are driven by future estimates of:

- forecasts of animal numbers by species: beef cattle, dairy cattle, deer and sheep in 2010, using MAF's Pastoral Supply Response Model (PSRM)
- forecasts of nitrogen fertiliser use in 2010 using MAF's Nitrogen Demand Model
- ruminant methane emissions per animal in 2010, extrapolated from emissions per animal between 1990 and 2006; and
- nitrogen output per animal in 2010, extrapolated from nitrogen output per animal between 1990 and 2006.

Two further scenarios of projected emissions in 2010 have also been produced that represent the upper and lower bounds of projected emissions. These present emission estimates using the 95 per cent prediction intervals for the upper and lower bounds of methane and nitrous oxide emissions and animal numbers.

Table A2 provides a summary of the forecasts developed in the 2007 Net Position Statement for comparison.

Table A2: Summary of 2007 projection scenario emissions for 2010 in million tonnes carbon dioxide equivalents (Mt CO_2-e)

	1990	2010		
	Baseline	Lower	Most likely	Higher
Total projected emissions	32.50	36.00	40.62	45.66
Projected emissions above 1990		3.50	8.12	13.16
Percentage change from 1990		10.80%	25.00%	40.50%

2 Changes in methodology since last year's assessment

The major change in methodology in this year's projections is that all emissions produced by the National Greenhouse Gas inventory up to 2006 are now reported on a single-year basis rather than the mean of three years' values as previously used. As the inventory is complied for the period two years prior to the present, this allows time for appropriate quality assessment of the data and calculations. Previously, timely provision of animal numbers was hampered by the requirement for the provision of three full year's data. These data are collected through the annual animal production survey carried out for MAF by Statistics New Zealand.

The second major change was the use of a new data set of historical nitrogen fertiliser use for the Nitrogen Fertiliser Demand Model. In deriving the most likely, high and low scenarios for nitrogen fertiliser usage for 2010, the mean usage over the five years of the commitment period was used.

3 Development of the most likely scenario

3.1 Projected animal numbers and nitrogen fertiliser use forecasts

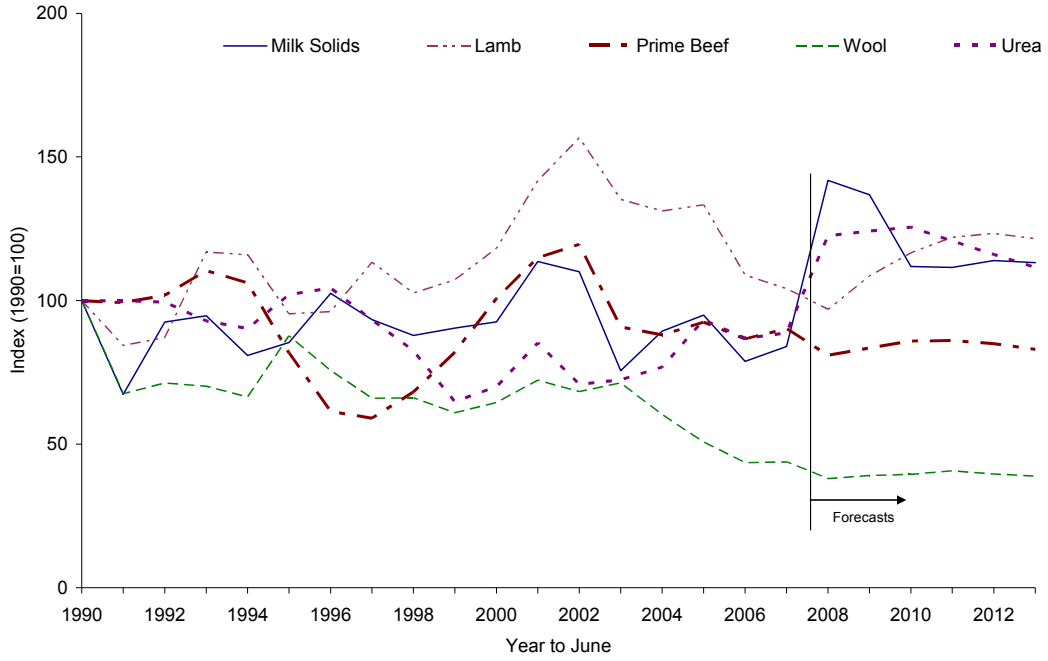
Future numbers of beef cattle, dairy cattle, sheep and deer are modelled using expected changes in farm-gate prices for milk, meat and wool. Urea prices are introduced into the analysis in order to forecast demand for nitrogen fertiliser. Figure A1 illustrates MAF's current expectations for the key farm gate prices to 2010. These were developed based on international price movements and assumptions on exchange rate and inflation published in Treasury's 2007 half yearly fiscal and economic update.

In the first half of 2007, international dairy prices increased rapidly causing the outlook for inflation-adjusted farm-gate milksolid prices to improve dramatically. This was driven by strong global demand for dairy products, and supply interruptions and constraints in key dairy producing countries. Over the first commitment period of the Kyoto Protocol, most, but not all, of these gains in international dairy prices are expected to be eroded by dairy production increases around the globe.

Rising demand around the world and high natural gas prices (natural gas is the main input in nitrogen fertiliser production) have pushed inflation-adjusted urea prices to levels not seen since the 1980s. Urea prices are expected to remain relatively high over the First Commitment Period (2008–2012) of the Kyoto Protocol.

Inflation-adjusted lamb and wool prices have both fallen by 35 per cent since 2002. This has severely affected the relative profitability of farming sheep and, combined with the impact of the 2007 Hawkes Bay drought, has caused national sheep numbers to fall by 4 per cent to the year ended June 2007.

Figure A1: Past and expected changes to key inflation adjusted farm-gate prices



3.1.1 Animal number forecasts

Over the summer of 2007/08, a severe drought developed over many regions of New Zealand. This is having a material impact on the milk and meat production from New Zealand pastoral agriculture and will consequently reduce profitability for pastoral farmers. Sheep and beef farmers were already in a difficult financial position coming into the drought, and are expected to respond to the combination of drought and low lamb prices with deep and permanent reductions to sheep numbers (a decrease of 39% in 2010 compared to the 1990 level: see Table A3). Modest improvements to lamb prices over the first commitment period of the Kyoto Protocol are not expected to be enough to prevent this de-stocking.

Similar to the analysis in the 2007 net position report, record high farm gate dairy milksolids prices result in forecasts of rapid growth in dairy cattle numbers. Expansion of dairy farms is happening through conversions of lamb-finishing properties in the South Island and some areas of plantation forestry in the North Island.

Table A3: Animal numbers and nitrogen fertiliser usage for 1990, and forecast for 2010.

	1990 baseline (000)	2010 most likely (000)	Percentage change
Beef cattle	4,593	4,192	– 9%
Dairy cattle	3,441	6,063	+ 76%
Deer	976	1,508	+ 55%
Sheep	57,852	35,288	– 39%
Tonnes of nitrogen fertiliser applied	59,265	396,967	+ 617%

3.1.2 Nitrogen fertiliser usage forecasts

The application of nitrogen fertiliser rises with improvements in farm gate pastoral agricultural output prices, especially the milksolids price, and falls with increases in the price of the fertiliser itself (see Austin et al, 2006). Empirical evidence suggests that output prices have a stronger effect, however. In the current situation, the strong farm gate milksolids prices are expected to spur increasing nitrogen fertiliser despite the discouragement of high urea prices.

3.2 Development of greenhouse gas emission projections: most likely scenario

3.2.1 Projections of per-animal enteric methane emissions

Projections of methane emissions per animal in 2010 are derived from linear trends of the methane emissions per animal between 1990 and 2006, extrapolated to 2010 (Table A4). The 1990–2006 values are those used in the national greenhouse gas inventory.

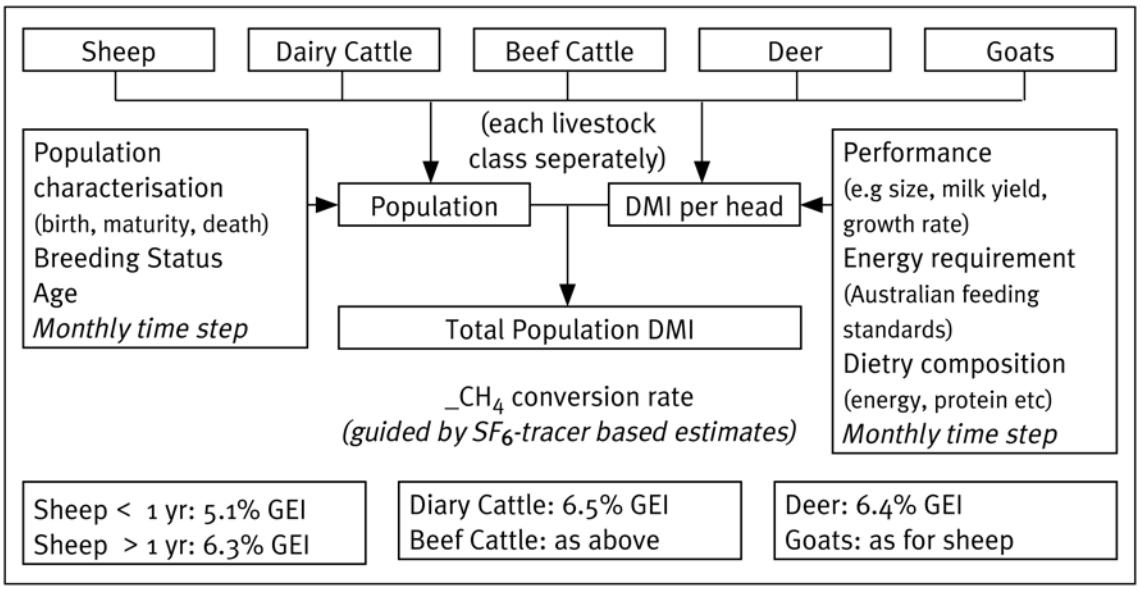
Table A4: Methane emissions per animal, estimated for 1990 and 2006, and projected most likely value for 2010, in kg CH_4/head/annum (increases explained in text)

	1990 estimated	2006 estimated	2010 projected
Beef cattle	50.65	58.02	59.64
Dairy cattle	69.35	79.36	82.30
Deer	18.76	22.17	23.16
Sheep	9.28	11.03	11.70

These animal emissions have been derived from the model developed by Clark et al (2003) that is used to estimate methane emissions in the national inventory (Figure A2).

The model determines animal feed intakes in monthly time steps for different age classes of each animal species based on the mean national animal performance derived from national statistics relevant to each species. For example, dairy cattle inputs include: animal liveweight, total milk production and milk fat and protein percentages. For each animal species, an empirical relationship has been derived for the amount of enteric methane produced per unit of feed intake. These relationships have been developed in New Zealand for beef and dairy cattle, deer and sheep, using the sulphur hexafluoride (SF_6) technique that enables estimation of methane emissions under practical farming situations. The estimated annual methane emissions per animal take into account changes in animal performance over time.

Figure A2: Model for deriving ruminant methane emissions (Clark et al, 2003)



Note: GEI = Gross energy intake

3.2.2 Methane per animal from ruminant animal waste

Methane emissions also arise from faecal material deposited on pasture and, in the case of lactating dairy cows, from animal faecal material in waste management systems. The projected methane emissions factor for each animal species in 2010 is derived by linear extrapolation of emissions data between 1990 and 2006 to 2010 (Table A5).

Table A5: Waste methane emissions per animal, estimated for 1990 and 2006, and projected most likely value for 2010, in kg CH_4/head/annum (increases due to improved animal productivity)

	1990 estimated	2006 estimated	2010 projected
Beef cattle	0.62	0.71	0.73
Dairy cattle	2.92	3.40	3.49
Deer	0.18	0.20	0.21
Sheep	0.09	0.11	0.12

3.2.3 Projections of per-animal nitrous oxide emissions

Nitrous oxide emissions are derived from animal nitrogen output and nitrogen fertiliser use. Animal nitrogen output is a function of animal feed intake and nitrogen content of the pasture eaten, minus any nitrogen stored in animal product (meat, milk, etc). Models developed by Clark et al (2003) for methane emissions also estimate nitrogen output per animal. Projections of nitrogen output per animal in 2010 are derived by linear extrapolation of nitrogen output per animal using data in the national inventory from 1990 to 2006 extrapolated to 2010 (Table A6). Nitrous oxide emissions are then calculated using the methodology used for the national greenhouse gas inventory.

Table A6: Nitrogen output per animal, estimated for 1990 and 2006, and projected most likely value for 2010, in kg N/head/annum (increases due to improved animal productivity)

	1990 estimated	2006 estimated	2010 projected
Beef cattle	65.39	74.98	77.10
Dairy cattle	103.87	116.59	120.23
Deer	24.88	29.48	30.79
Sheep	12.61	15.12	16.08

3.2.4 Other animal species and greenhouse gas sources

No projections were derived for the methane and nitrous oxide emissions of minor animal species present in the national inventory ie, goats, horses, pigs, and poultry. Likewise, there are no projections for nitrous oxide emissions from crop stubble burning, savannah burning and nitrogen-fixing crops. Such emission sources make up less than 1.5 per cent of agricultural sector emissions in 2006, and there was no basis for assuming a significant change from their present levels in 2010. The impact of even large changes in any of these small emission sources on the total national emissions profile would be small, and so 2006 inventory emission values were used for the 2010 projections.

3.3 Development of lower and higher scenarios

Two further scenarios were developed: a lower and higher scenario. The higher scenario combined the upper 95 per cent prediction interval values for animal numbers, methane emissions per head, nitrogen output per head and nitrogen fertiliser use. The lower scenario combined the lower 95 per cent prediction interval values. These two scenarios estimate the values of the upper and lower bounds of future projected emissions at the 95 per cent confidence level.

3.3.1 Animal numbers and nitrogen fertiliser usage

To derive livestock and fertiliser forecasts for different scenarios, price uncertainty is introduced into Pastoral Supply Response Model. Variability of prices (or standard deviations equivalent to a 95 percent confidence interval) during the last 10-year period for each price series was used. This gave estimates for the upper and lower bounds of the stochastic forecasts that could be considered as lower and higher scenarios due to potential in prices (Table A7).

Table A7: Animal number and nitrogen fertiliser usage forecasts for 2010

	Lower (000)	Most likely (000)	Higher (000)
Beef cattle	3,730	4,192	4,669
Dairy cattle	5,796	6,063	6,348
Deer	1,064	1,508	2,202
Sheep	32,198	35,288	38,401
Tonnes or nitrogen fertiliser applied	234,462	396,967	612,250

3.3.2 Methane emissions

Lower and higher estimates of methane emissions per animal were obtained from the 95 per cent prediction interval of the linear regression of emissions from 1990 to 2006. This gives an upper and lower bound for projected methane emissions per head in 2010 at the 95 per cent confidence level (Table A8).

Table A8: Methane emissions per animal, projections for 2010 in kg CH_4/head/annum

	Lower	Most likely	Higher
Beef cattle	57.86	59.64	61.41
Dairy cattle	79.53	82.30	85.06
Deer	22.25	23.16	24.07
Sheep	11.31	11.70	12.08

3.3.3 Nitrogen output

Lower and higher estimates of nitrogen output per animal were obtained from the 95 per cent prediction interval of the linear regression of emissions from 1990 to 2006. This provided an upper and lower bound for projected nitrogen output per head in 2010 (Table A9).

Table A9: Nitrogen output per animal projections for 2010 in kg N/head/annum

	Lower	Most likely	Higher
Beef cattle	74.64	77.10	79.57
Dairy cattle	116.50	120.23	123.96
Deer	29.60	30.79	31.99
Sheep	15.74	16.15	16.56

4 Overall assumptions and limitations of the projections

All the above projections need to be assessed within the inherent uncertainties of biological systems, climate shocks such as droughts, and economic circumstances of the agricultural industry – which is largely driven by overseas markets. An assumption implicit in the projections is that the rate of increase in productivity per animal over the next four years will be similar to the rate of increase in animal performance over the past 16 years, and therefore a linear extrapolation of emissions per animal is appropriate. However, the rate of increase in animal performance may decline over time. Other non-linear relationships that have been tested gave no significant improvement in the relationship. The current per-animal productivity of New Zealand dairy cows is significantly lower than European and American animals and has the potential to rise significantly, thus increasing emission levels per animal.

Mitigation technologies that reduce emissions at an individual animal level may emerge over the next four years. These include products such as the nitrification inhibitor dicyandiamide (DCD), that has been shown to reduce nitrous oxide emissions in grazed pastures and is currently being adopted on a limited scale. No mitigation technologies have been factored into our projections as they may not be widely adopted over the First Commitment Period. For example, a scenario for the potential impact of nitrification inhibitors over the First Commitment Period, at the current rate of adoption, is a reduction of agriculture sector emissions of 0.3 per cent.

The adoption of mitigation technologies may be counter-balanced by greater increases in animal numbers and further improvements in animal productivity growth. Industry strategy plans, particularly the dairy industry, are seeking gains of at least 3 per cent per annum in milk production. The favourable commodity price forecasts suggest that these ambitious growth targets are more likely to be aimed for and possibly met, thus pushing emission levels up.

The recent announcement of the Fast Forward initiative, and the recently announced increased investment into sustainable land management and climate change research under the Plan of Action, may lead to development of other greenhouse gas-reducing technologies and practices in the future.

Current government policy on establishment of an emissions trading system (ETS) has agriculture coming into the ETS in 2013. It is proposed that the sector would initially be liable for 90% of emissions at 2013 based on a reference year for emissions of 2005. This process should result in greater adoption of mitigation technologies on-farm to reduce greenhouse gas emissions from 2013; however, it is uncertain what impact this might have on early adoption of mitigation technologies in the First Commitment Period.

5 References

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Appendix B: Energy (Including Transport) and Industrial Processes Sectors Emissions Projections

Report to the Ministry for the Environment

Ministry of Economic Development, April 2008

New Zealand Government

Contents

Tables

1 Introduction

1.1 Scope coverage of emissions

This report covers emissions from energy and industrial processes. Energy emissions covered are those associated with electricity generation, transport and direct use in the residential, commercial and industrial sectors.

Industrial process emissions are the non-energy emissions ie, those that occur during:

- reduction of ironsand in steel production
- oxidisation of anodes in aluminium production
- hydrogen production
- calcination of limestone of use in cement production
- calcination of limestone for lime.

1.2 Recent trends

The energy sector contributes around 40 per cent of New Zealand's total greenhouse gas emissions.

On average, around two-thirds of New Zealand's annual electricity needs are met by hydro-electric generation. The balance is provided by fossil-fuelled thermal generation using natural gas and coal, and other renewable sources such as geothermal and wind.

Around 40 per cent of energy emissions are from the transport sector. Emissions for this sector have grown significantly since 1990, averaging over three per cent growth per annum. The growth in transport emissions is largely due to the increased use of petrol and diesel as well as increased use of aviation fuels.[1] Recent increases in the price of liquid transport fuels appear to have resulted in a reduction in the growth rate of demand for liquid transport fuels.

Industrial processes contribute around six per cent of New Zealand's total greenhouse gas emissions, with most emissions coming from the metal industry.

1.3 Key drivers of emissions

In general, changes in energy emissions in New Zealand are linked to the overall rate of consumption within the economy. Emissions therefore tend to increase steadily over time, driven by economic growth.

There can be significant year-to-year fluctuation in emissions from electricity generation, with increased thermal generation in a 'dry' hydro year.

Historically, fluctuations in the price of liquid transport fuels have had a limited impact on consumption and emissions. However, the very large recent increases in the price of liquid transport fuels appear to have resulted in a reduction in the growth rate of demand, and therefore emissions from the transport sector.

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[1] *New Zealand's Greenhouse Gas Inventory 1990-2006*, Ministry for the Environment, April 2008, http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-overview-apr08/index.html

2 Modelling

2.1 Description of method

Projections of emissions from energy (including transport) and industrial processes are largely derived from the Ministry of Economic Development's Supply and Demand Equilibrium Model. SADEM is a collection of models, each representing the supply of a form of energy, or the demand from a sector of the economy. The sub-models buy and sell from each other just like in a real market. The Ministry has used SADEM since the early 1990s for internal policy analysis and to make projections of New Zealand's energy supply, demand, prices and emissions.

Modelling CO_2 emissions from combustion is fairly straightforward, since the output of CO_2 depends on the amount of each type of fuel being burned. Emissions of other greenhouse gases and of CO_2 from non-combustion activities, eg, industrial processes, are more complicated to estimate and depend both on the amount of fuel and on the way the fuel is used.

2.2 Improvements to modelling since Net Position 2007

Since the Net Position 2007 report, a number of enhancements have been made:

- Actual data for 2006 and, where possible, 2007 has been incorporated.
- Enhancements have been made to modelling of emissions from the electricity sector, based on the Electricity Commission's Generation Expansion Model (GEM).
- Enhancements have been made to modelling on-road transport, utilising the Ministry of Transport's Vehicle Fleet Emissions Model (VFEM).
- Energy emissions from the dairy sector are now based on projected milk solids production provided by the Ministry of Agriculture and Forestry (MAF).

2.3 Specific assumptions

This section provides an overview of the key assumptions used. An effort has been made to align modelling assumptions across government, and with the assumptions underpinning the New Zealand Energy Strategy. Macroeconomic assumptions are in line with Treasury projections, milk solids projections are supplied by the Ministry of Agriculture and Forestry (MAF) and fuel price assumptions are consistent with those recommended by the Energy Data and Analysis Coordination Group (EDAC).[2]

[2] Recommended Input Assumptions, MED, 7 January 2008,

http://www.med.govt.nz/templates/MultipageDocumentPage____33244.aspx.

(The horizontal rule in each MED web address represent four underscore characters)

2.3.1 Key macro-economic assumptions: most likely scenario

Table B1: Most likely scenario for key macro-economic assumptions for CP1

Year	Economic growth GDP real (per cent per annum)	Exchange rate (NZ$/US$)	Oil prices ($US/bbl)
2007 (actual)	3.00	0.736	100
2008	2.09	0.738	100
2009	2.73	0.697	100
2010	2.67	0.652	100
2011	2.87	0.622	100
2012	2.87	0.607	100

2.3.2 Emissions price

The government has decided in principle that New Zealand will use an emissions trading scheme (ETS) as its core price-based measure for reducing greenhouse gas emissions and enhancing forest carbon sinks. The government has also proposed a staged entry of different sectors into the ETS:

- liquid fossil fuels from 1 January 2009[3]
- stationary energy from 1 January 2010
- industrial process emissions from 1 January 2010
- for the most likely case, an assumption of $NZ25 per tonne of carbon dioxide equivalent has been adopted in the forecast. $NZ50 and $NZ15 per tonne of carbon dioxide equivalent have been adopted for the low and high emission scenarios.

2.3.3 Coal

Coal prices are based on import parity prices around $4.00 per GJ.

2.3.4 Gas

The rate of new gas discoveries is assumed to average 60 PJ/year with production from new discoveries starting in 2012.[4]

2.3.5 Methanex

Methanex is the gas-to-methanol operation in Taranaki. Based on recent announcements by Methanex, it is assumed that it will increase production at Motonui from 2008 and that the smaller Waitara Valley plant will continue operating until mid 2008.

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[3] On 6 May 2008, the Prime Minister announced deferral to 1 January 2011.

[4] http://www.med.govt.nz/templates/MultipageDocumentPage____33244.aspx

2.3.6 Energy efficiency and conservation measures

Energy efficiency measures included in Net Position 2008 are those evaluated as part of the Benefit Cost Analysis of the New Zealand Energy Strategy.[5] These are assumed to be 100 per cent implemented in the most likely case, and 120 and 80 per cent in the low and high emissions scenarios. An "upside" factor has been incorporated to account for increased energy use resulting from the greater uptake of electrical appliances, eg, heat pumps, and take-back effects not included in the models, eg, purchase of larger plasma televisions.

An approximate saving of 2,100 kWh per unit per year from the solar water heating programme is assumed[6]. The programme is funded for three-and-a-half years, therefore we assume no additional solar water heating units installed as a result of the programme beyond 2010.

2.3.7 Projects to reduce emissions

The Projects to Reduce Emissions (PRE) programme allows firms to receive tradable emissions credits for each tonne of carbon emissions saved. Credits have been awarded for a number of projects, with the majority of eligible projects in the electricity generation sector.

2.3.8 Heavy industries

The heavy industries section is under continuing review and sector-specific discussions take place at various times. Key assumptions are:

- Steel – assume constant production over the First Commitment Period (CP1).
- Aluminium – assume constant production over CP1.
- Petrochemical – additional methanol production will continue into CP1.
- Ammonia and urea production forecasts have not changed since Net Position 2006.
- Forestry – the energy demand projections for pulp and paper, sawmill, and panel products are based on estimates from the Heavy Industry report.[7]
- Dairy – the dairy model uses milk solids production projections (provided by the Ministry of Agriculture and Forestry) and calculates the energy required to process these. This is discussed further below.

2.3.9 Other transformation

It is assumed that energy use and emissions from the New Zealand Refinery Company will be steady over time, with a step change occurring following the expected 20 per cent capacity expansion in 2009. This is consistent with Net Position 2007.

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[5] http://www.med.govt.nz/templates/MultipageDocumentTOC____31983.aspx.

[6] This figure is representative of a range of technologies and system types, based on the energy performance modelling to the Standard AS4234, as reported on www.solarsmarter.org.nz.

[7] *Heavy Industry Energy Demand*, Ministry of Economic Development, June 2006

2.3.10 Biofuels sales obligation

In projecting transport emissions it is assumed that the proposed Biofuel Sales Obligation levels are met, which will require biofuels sales of at least 3.4 per cent of total diesel and petrol sales by 2012.[8] It is assumed that this fuel will be used by the transport sector; tail-pipe CO_2 emissions produced from this fuel are not included in the Net Position. CH_4, and N_2O emissions produced from this fuel are included.

Bio-diesel is assumed to supply 30 per cent of the sales obligation and from bio-ethanol 70 per cent.

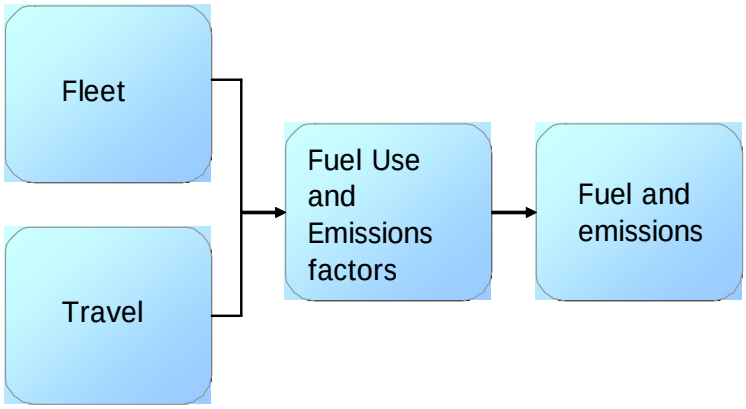
2.3.11 Energy use in dairy

In Net Position 2007, the Ministry of Agriculture and Forestry's dairy herd projections were used to project the dairy sector's energy demand. Enhancements had been made to SADEM for Net Position 2008 whereby MAF's milk solids production projections are used to project energy demand.

MAF's projections take account of the recent drought conditions which have significantly reduced projected milk solids production, resulting in a decrease in the dairy sector's energy demand over CP1.

2.3.12 Transport

The Vehicle Fleet Emissions Model (VFEM) has been used for the transport projections. The VFEM models changes to New Zealand's on-road vehicle fleet, including the number of vehicles, kilometres travelled per vehicle and average fuel economy and adds a level of refinement to estimates of on-road transport energy demand. It also allows an improved estimate to be made of the off-road and non-motor vehicle uses of petrol and diesel. This time series is itself projected forward to give a total projection of future land transport energy demand.



[8] Cabinet Decision, http://www.mot.govt.nz/biofuels-440-index/

2.3.13 Industrial processes

The Ministry of Economic Development models carbon dioxide emissions from industrial processes, which is then adjusted to account for non-carbon dioxide greenhouse gases. A multiplier of 17.6 per cent is used.[9]

2.3.14 Energy demand sectors and modelling techniques

Table B2: Energy demand sectors and modelling techniques used

Major demand sector	Sub-sector	Model
Residential demand	Residential	Multivariate, GDP, price, heating and cooling degree days, lagged demand
Industrial and commercial demand	Forestry	Industry-specific forecasts
	Petrochemicals and refining	Company forecasts
	Metals	Industry-specific forecasts
	Dairy	MAF forecasts (as input)
	Other industrial	Multivariate, GDP, lagged demand
	Commercial	Multivariate, GDP, lagged demand
Transport demand	Land	On road: Vehicle Fleet Emissions Model MoT/MED forecast
		Off road: Multivariate
	Sea	Ordinary least squares
	Aviation	Ordinary least squares

[9] The factor of 17.6% is based on the historical average between 1990-2006 as recommended by the Ministry for the Environment.

3 New policies

The impact of two new policy measures have been incorporated into the modelling for Net Position 2008.

3.1 Emissions trading scheme

In September 2007, the government announced its in-principle decision that New Zealand will use an emissions trading scheme (ETS) as its core price-based measure for reducing greenhouse gas emissions and enhancing forest carbon sinks.

The impact of introducing an emissions price on energy and industrial process activities has been incorporated into the projected emissions over CP1.

3.2 Renewables preference

The government is considering regulatory options to limit investment in baseload fossil-fuelled thermal electricity generation. The projections generated for Net Position 2008 do not include the commissioning of any new baseload thermal electricity generation capacity over CP1.

3.3 New Zealand Energy Efficiency and Conservation Strategy

The New Zealand Energy Efficiency and Conservation Strategy (NZEECS) was released in October 2007. It contains a range of measures to improve energy efficiency throughout the economy, and the impact on emissions of these measures has been incorporated into Net Position 2008.

4 Emissions projection

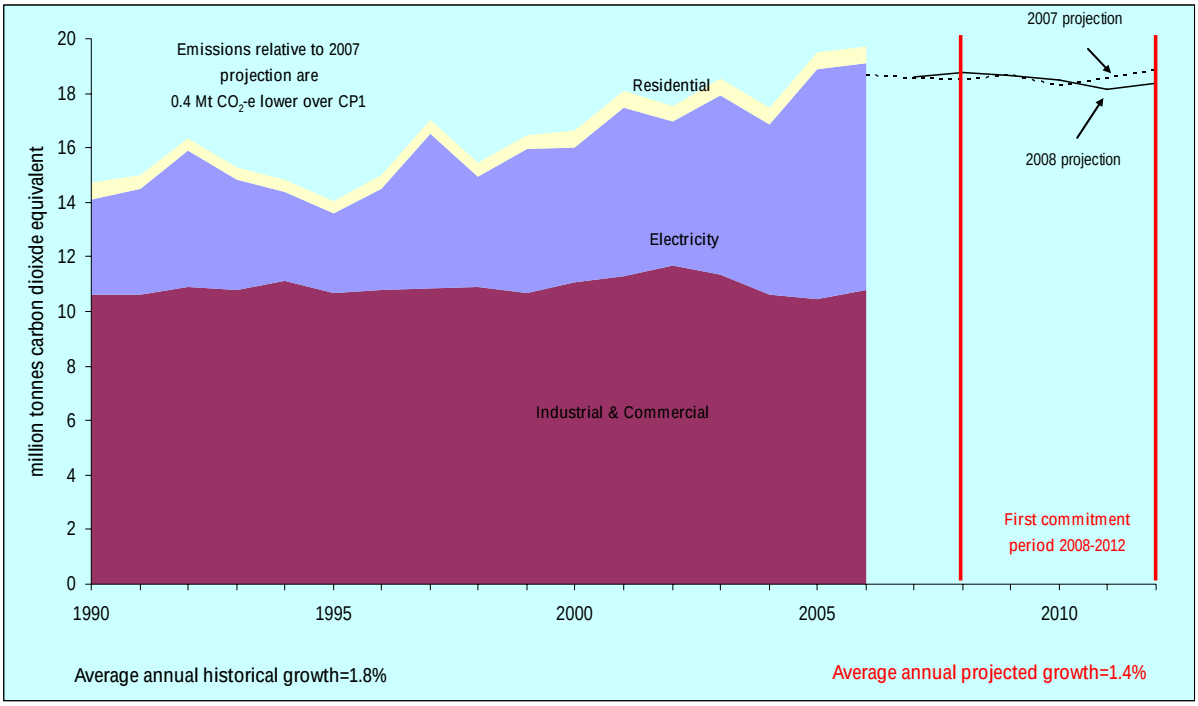
4.1 Total emissions by sector

Total emissions from energy and industrial processes are projected to be 163.7 Mt of carbon dioxide equivalent for the first Kyoto Commitment Period.

Table B3: Emissions by sector during the First Commitment Period (kt CO_2-e)

Year	Energy (excl. transport)	Transport	Industrial Processes	Total
2008	18,759	14,346	4,330	37,434
2009	18,632	14,287	4,361	37,280
2010	18,483	14,170	4,393	37,046
2011	18,128	14,147	4,427	36,702
2012	18,374	14,326	4,461	37,161
Total CP1	**92,377**	**71,274**	**21,972**	**185,623**

4.2 Emissions from energy

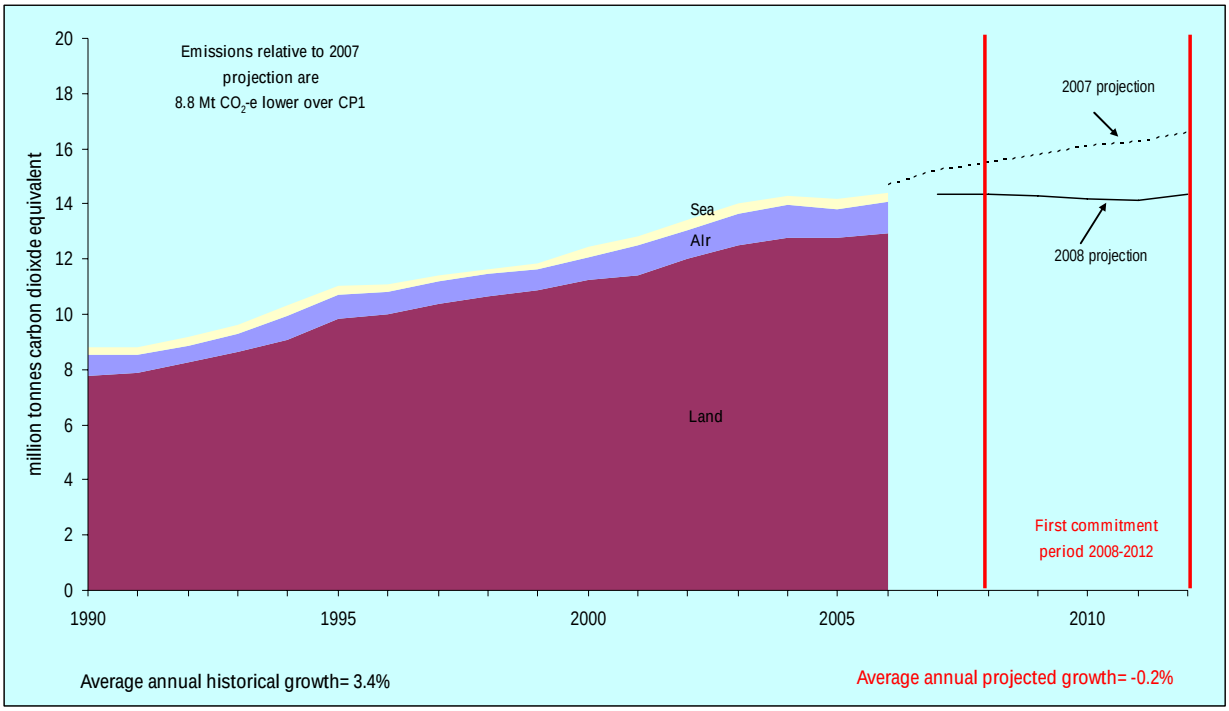


Projected emissions from electricity generation are around 5 per cent lower than for the 2007 Net Position.

This is primarily due to:

- inclusion of an emissions price, which reduces fossil-fuelled electricity generation
- inclusion of a wider range of energy efficiency measures based on modelling completed for the "Benefit Cost Analysis of the New Zealand Energy Strategy", October 2007
- increased emissions from methanol production as a result of Methanex announcing that it will increase production at Motonui from 2008
- increased fugitive emissions from commissioning new geothermal plants and additional flaring from oil and gas fields.

4.3 Emissions from transport

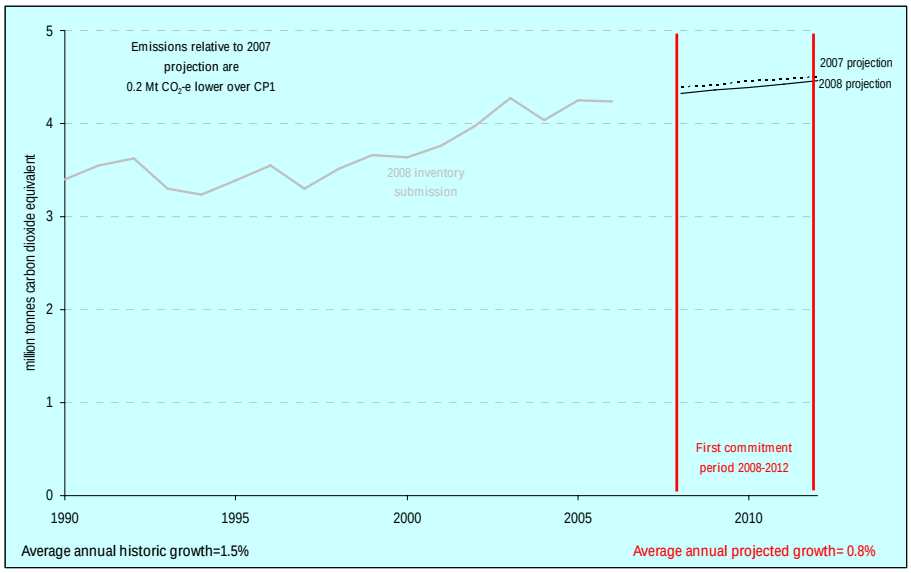


Transport sector emissions are projected to be 8.9 million tonnes CO_2-e lower over CP1 than projected in 2007. The primary reasons for this are:

- Inclusion of actual fuel and emissions data for 2007 and revised data for 2006 account for more than 50 per cent of the difference between the 2007 and 2008 Net Position projections:
  - The latest data on reported fuel sales (2007) shows that emissions from transport have not grown since 2004.
  - The reported 2007 figure of 14.3 million tonnes CO_2-e is well below the 15.1 million tonnes CO_2-e projected in last year's Net Position.
  - Projecting ahead from this lower base leads to a reduction of 4.5 million tonnes CO_2-e over CP1 compared with the 2007 projection.

- Higher fuel prices account for around 25 per cent of the difference:
  - Our modelling now assumes that petrol prices over CP1 will be around 30 per cent higher than those assumed in 2007, resulting in about 4 per cent demand reduction in the short term and out to 8 per cent in the longer term.[10]
  - The assumed future petrol price increases are driven by the increased oil price assumption[11] and the New Zealand exchange rate weakening as per Treasury's assumption.
  - Emissions pricing contributes a relatively small proportion of the price rises expected.[12]
- Another 10 per cent of the difference is accounted for by:
  - biofuels, where we now expect nearly all to be imported, with almost zero emissions for New Zealand – last year's projection assumed local production
  - lower GDP growth assumption.
- The remaining emissions reduction result from the model re-calibrating the long term growth trend. The flat emissions growth observed over the last three years means that the model predicts a lower future growth rate than that projected last year.

4.4 Emissions from the industrial process sector



Projected emissions from industrial processes are effectively unchanged from the 2007 projections.

[10] The petrol price elasticity of travel is assumed at –0.12 in the short term and –0.24 in the longer term. The elasticities are drawn from the latest research in this area commissioned by LTNZ and are the same as those used in last year's modeling. Refer: http://www.landtransport.govt.nz/research/reports/331.pdf .

[11] We now assume oil at $US100 per barrel, compared to $US60 per barrel last year.

[12] An emission price of $NZ25 per tonne of CO_2-e is expected to add 5.5 c/litre (excl. GST).

4.5 Uncertainty reporting and sensitivity analysis

The following is a non-exhaustive list of conditions that could affect actual emissions over the First Commitment Period:

- New Zealand's economic performance
- impact of government policy measures, such as the New Zealand Energy and Energy Efficiency and Conservation Strategies, Emissions Trading Scheme, Biofuels Sales Obligation
- fluctuations in international oil, coal, gas and commodity prices and the exchange rate
- negotiated outcomes between fuel suppliers and electricity generators, who may switch fuels depending upon their price and availability
- hydrological conditions, which can affect emissions from electricity generation
- rate of domestic gas discoveries and production
- degree of fuel switching in the industrial sector
- decisions by industrial consumers to locate operations overseas
- consumer response to changes of oil price (such as buying smaller size cars, diesel cars, or use of public transport)
- pandemic or natural disaster.

The 'high' and 'low' emissions scenarios provide an indication of the range of uncertainty in the projections. The table below presents the results of these two scenarios, compared to the 2008 'most likely' scenario:

Table B4: High and Low emissions scenarios, and assumptions made

Scenario	Assumptions	Total emissions from Energy and Transport during CP1 (CO_2-e)
Low Emissions Scenario	Low GDP growth Low population growth Carbon price $NZ50 per tones of CO_2-e Low milk solids production numbers Methanex not operating after 2010 Biofuels obligation exceeded Energy efficiency gains increased Wet hydrological conditions	152.2 Mt (–11.4 Mt compared to 2008 'most likely' case)
High Emissions Scenario	High GDP growth High population growth Carbon price $NZ15 per tonne of CO_2-e High milk solids production numbers Methanex Motonui plant running during CP1. Waitara Valley plant running between 2013 and 2020 No biofuels No energy efficiency and conservation No solar water heating programme Dry hydrological conditions	179.2 Mt (+15.6 Mt compared to 2007 'most likely' case)

In conclusion, the projected balance of emissions from energy and transport during CP1 lies in the range between 152.2 and 179.2 with the most-likely scenario of 163.7 million tonnes of carbon dioxide equivalent. This compares with a range from 162.8 million tones to 187.7 million tones in 2007 Net Position.

Appendix C: Land Use, Land-use Change and Forestry Sector Emissions Projections

Report to the Ministry for the Environment

Ministry of Agriculture and Forestry, April 2008

Disclaimer: This report contains projected carbon dioxide removals and emissions by the Land Use, Land-use Change and Forestry sector. These projections have significant uncertainties due to information gaps, scientific uncertainty and the complexity of forecasting biological systems which are inherently variable. While every effort has been made to provide the best projections as at March 2008, future changes are inevitable: reflecting likely future changes in economic conditions, improvements in information and new scientific knowledge.

New Zealand Government

Contents

Tables and Figures

Summary

This report provides projections of carbon dioxide (CO_2) removals and emissions from New Zealand's Land Use, Land-use Change and Forestry (LULUCF) sector, limited to post-1989 afforestation, reforestation and deforestation activities accounted for under the Kyoto Protocol.

The projections cover Commitment Period One (CP1: 2008–2012) of the Kyoto Protocol. The LULUCF projections are an input to the "2008 Projected Balance of Emissions Units" report produced by the Ministry for the Environment. This "net position" report brings together the projected quantity of greenhouse gas (GHG) emissions and removals from all sectors of the economy and is an input to estimating both New Zealand's and the Government's forecast liability or credit under the Kyoto Protocol during CP1.

Net removals by the LULUCF sector (that is, removals by post-1989 forests minus deforestation emissions) for the period 2008–2012 are projected to be in the range 33.7 – 90.4 Mt CO_2. The most likely scenario is projected to be 67.2 Mt CO_2. This is higher than the 2007 most likely scenario projection of 58.0 Mt CO_2 – due in part to lower expected future deforestation.

The large uncertainty range is mainly due to gaps in information and scientific knowledge. There is also uncertainty around the level of deforestation that will take place between 2008 and 2012 and the level of emissions from deforestation. Uncertainty has been incorporated into the LULUCF projections through the use of scenarios (described in detail later in this report). Measurement and some scientific uncertainty is expected to be reduced when the Ministry for the Environment's Land Use and Carbon Analysis System (LUCAS) is operational from about 2010. Until then, the LULUCF projections are likely to remain the least certain of all sectors in the net position report.

Table C1: LULUCF projected CO2 removals and emissions (in million tonnes) during CP1 (2008–2012). See Table C3 for further detail.

Contributing factor	Worst-case	Most likely	Best-case
Mean and 95% range of CO_2 removals from 10,000 @Risk simulations	64.2	84.1	107.3
Less deforestation emissions	–30.5	–16.9	–16.9
Net removals (total removals less deforestation emissions)	33.7	67.2	90.4

Forecast removals for the most likely scenario are similar to those made in 2007. The range of uncertainty (between worst case and best case) is lower than in 2007 because a different method has been used to estimate uncertainty. Net removals however, are higher in the most likely scenario because forest owners are expected to deforest less area under the proposed Emissions Trading Scheme (ETS) policy for Forestry, if it is implemented as proposed in September 2007. These levels of deforestation are based on a Deforestation Intentions Survey conducted in the period November 2007 to January 2008.

If policy measures are not implemented to manage deforestation, New Zealand's deforestation liability is likely to increase by a further 14 Mt CO_2 to reach 30.5 Mt CO_2. Furthermore, if the government does not implement policies to reduce deforestation in CP1 but signals that it may do so after CP1, it is likely that forest owners would bring deforestation plans forward into CP1 to avoid future restrictions or costs. Any additional deforestation brought forward into CP1 would further increase deforestation emissions beyond the worst-case deforestation scenario.

With respect to future policy development it is important to note that:

1. New afforestation will have little effect on CO_2 removals in CP1 because newly established forests will remove very little CO_2 from the atmosphere in their early growth years. Afforestation will however remove more substantial levels of CO_2 as the forests mature.
2. Deforestation rates have a substantial effect on New Zealand's net position in CP1 because the CO_2 accumulated over the life of the forest is assumed to be rapidly emitted to the atmosphere.

1 Introduction

Under the terms of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), New Zealand has agreed to take responsibility for its greenhouse gas emissions in Commitment Period One (CP1: 2008–2012).

As forests grow they remove carbon dioxide (CO_2) from the atmosphere through photosynthetic activity. Under the Kyoto Protocol, Parties must account for CO_2 removals by forests established on non-forested land after 31 December 1989 (post-1989 forests). These removal units can be used to offset greenhouse gas emissions from other sectors.

This report provides projections of CO_2 removals and emissions from New Zealand's Land Use, Land-use Change and Forestry (LULUCF) sector, limited to post-1989 afforestation, reforestation and deforestation activities accounted for under the Kyoto Protocol. These LULUCF projections feed into the Ministry for the Environment's "2008 net position" report.

The five key factors used in these projections are:

- future deforestation rates and the speed and level of emissions from deforestation
- post-1989 forest growth rates
- the proportion of afforestation since 1 January 1990 that may be "ineligible Kyoto forests" (over-planted onto land which was already defined as forest as at 1 January 1990)
- the potential loss of soil carbon following afforestation of grassland
- future afforestation rates.

The projections also include error bounds around the existing area of post-1989 afforestation, providing a range of scenarios represented here by "worst-case", "most likely", and "best-case" values.

2 Forestry trends and drivers

Forecasts are greatly influenced by recent historic and prevailing conditions. This section summarises the economic and policy environment of New Zealand's forest industry over the last five to six years.

A high exchange rate, increasing costs (particularly shipping costs), increased competition and changing international markets have adversely affected forest-growing profitability in New Zealand since about 2002.

Recent patterns of forest ownership have changed rapidly, with the largest volume of forest sales since the state forests were privatised in the late 1980s. New Zealand's largest corporate forestry companies (Fletcher Challenge and Carter Holt Harvey) have both been sold to private investors. Superannuation funds and timber investment management organisations (TIMOs) have purchased large areas of plantation forests, now owning more than one-third of the total planted forest area in New Zealand.

There is increasingly greater separation between forest and forest land ownership than has been the case historically. Forest land owners are looking to realise the increase in land value through land sales, often involving conversion to another land-use. For good-quality land near existing farming infrastructure, pastoral farmers are willing to pay significantly higher prices than forest owners and this is resulting in a land use change from forestry to pastoral agriculture.

The net result of these changes and perceptions of forestry future profitability has led to:

- a major decline in the rate of afforestation: from a 30-year annual average (1976 to 2005) of 42,000 ha to less than 2,000 ha in the year to December 2007: this is the lowest level of afforestation reported since 1945
- the relatively new phenomenon of deforestation of plantation forest land. In the year ended December 2007, an estimated 19,000 hectares was deforested, predominantly in the Central North Island and Canterbury regions.

3 Modelling methodology

This report provides scenario-based forecasts (projections) of CO_2 removals and emissions for the LULUCF sector for the period 2008 to 2012. The projections are based on information available as at March 2008.

Removals from the LULUCF sector are derived from data and assumptions provided by the Ministry of Agriculture and Forestry (MAF) and the Ministry for the Environment (MfE). The modelling was undertaken by Scion (formerly the Forest Research Institute). The underpinning science incorporated in the forest carbon models used in these projections, along with scientific assumptions, comes from work carried out by New Zealand's crown research institutes, predominantly Scion and Landcare Research.

Scientific uncertainty, knowledge gaps and the range of possible future outcomes (particularly for afforestation and deforestation) are reflected in a scenario-based analysis. The scenarios are labelled worst-case, most likely and best-case. They cover the likely range of major contributing factors to estimating LULUCF sector removals and emissions based on the current economic environment, policy settings, current land-use statistics, and the state of scientific knowledge.

The projected removals were calculated using a spreadsheet simulation model of the post-1989 planted forest estate. The model is based on a carbon yield table which describes the per-hectare carbon stock at each age during the growth of a typical post-1989 forest stand. To calculate the carbon stock in a given year, values in the yield table are multiplied by the forest area at the corresponding age, and then summed. The forest areas by planting year come from afforestation statistics collected by MAF.

The simulation advances through annual time periods (1990 to 2012). Net CO_2 removals are calculated as the stock change during CP1 (2008–2012), see Table C2; a more detailed model description is also available in Annex 1.

Table C2: Calculating annual carbon stocks from forest areas using a national carbon yield table. Note: cohorts of planted areas "move down one row in the table" each successive year.

Age	Yield	1990		1991		1992	
	(t CO_2)	Area (ha)	Stock (t CO_2)	Area (ha)	Stock (t CO_2)	Area (ha)	Stock (t CO_2)
0	0.0	x 15,400	0	x 15,800	0	x 50,200	0
1	9.2			x 15,400	= 141,680	x 15,800	= 145,360
2	13.9					x 15,400	= 214,060
3	27.9						
4	45.9						
..							
..							
Total area (ha)		15,400		31,200		81,400	
Total stock (t CO_2)			0		141,680		359,420
Stock increase (t CO_2)			0		141,680		217,740

4 Projection results

Table C3 provides a breakdown of the major contributing factors on which the removal and emission projections are based.

Removals from the LULUCF sector for the period 2008 to 2012 are projected to be in the range 33.7–90.4 Mt CO_2. The most likely scenario is projected to be 67.2 Mt CO_2 (compared to 58.0 Mt CO_2 in the previous year's projection).

Table C3: LULUCF projected carbon removals and emissions (Mt CO_2-e) during CP1: comparison of the 2007 "Most likely" projection with the three 2008 scenarios

Contributing factor	2008 projections			2007 projection (Most likely)
	Worst-case	Most likely	Best-case	
Removals based on afforestation only				
Kyoto planted forest CO_2 removals (based on existing 680,000 ha)	95.5	95.5	95.5	96.8
Future afforestation (2007 to 2012): 0, 5,000, 20,000 ha/yr	0.0	0.2	0.3	0.9
Adjustment factors (assumptions see text)				
Area of Kyoto forest planted between 1990 and 2006 ± 5%	–4.8	0.0	4.8	0.0
Kyoto forest growth rates	–9.7	0.0	28.3	0.0
Soil carbon change with afforestation	–11.2	–2.9	0.0	–3.0
Ineligible afforestation	–19.3	–14.6	–7.3	–15.7
Total removals, un-adjusted sum of items above				**79.0**
Mean and 95% range from 10,000 @Risk simulation [1]	**64.2**	**84.1**	**107.3**	Not estimated
Less deforestation emissions [2]	–30.5	–16.9	–16.9	–21.0
Removals less deforestation emissions	**33.7**	**67.2**	**90.4**	**58.0**

Notes:

1. In 2008 the mean and range have been calculated using Monte Carlo simulation (see the Uncertainty Analysis section for further details). In 2007 the mean and range were calculated by adding the adjustment factors to total removals from afforestation. This earlier approach gave a more conservative estimate of the "Most likely" scenario and the uncertainty range (this is represented by the "Worst-case" and "Best-case" scenarios).

2. The "Most likely" and "Best-case" scenario values of 16.9 Mt CO_2 represent 12,000 ha of deforestation based on the ETS Policy scenario from the deforestation intentions survey. A "No Policy Intervention" scenario presented in the deforestation report was 37,000 ha or 30.5 Mt CO_2 and this has been used for the "Worst-case" scenario. For a description of 2007 Deforestation Intentions Survey results refer to Manley, 2008.

5 Model assumptions

5.1 Future afforestation (plantations)

The average new planting rate over the last 30 years has been 40,000 hectares per year. In the period 1992 to 1998 new planting rates were high, averaging 69,000 hectares per year. Since then new planting has declined, to less than 2,000 ha in 2007.

Figure C4: New forest planting, 1920–2007

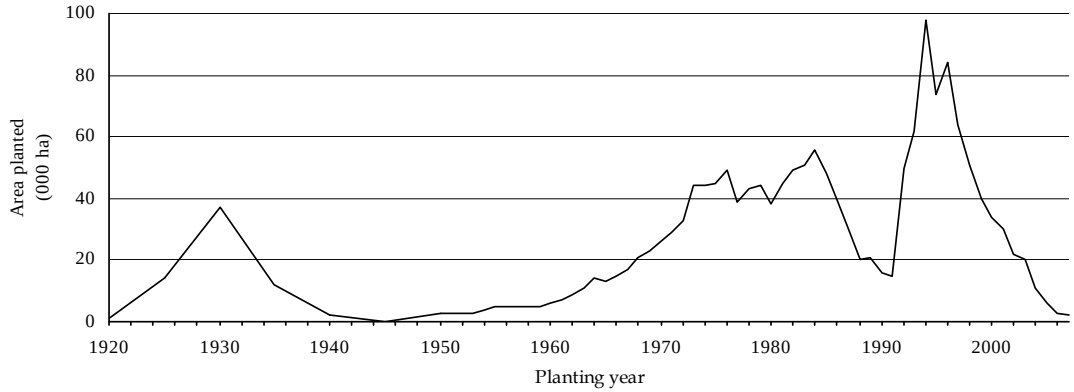


Table C5 shows the afforestation rates used in the 2008 net position projections.

Table C5: Future plantation afforestation (hectares)

Calendar year	Worst-case	Most likely	Best-case
2008	0	5,000	10,000
2009	0	5,000	15,000
2010	0	5,000	20,000
2011	0	5,000	25,000
2012	0	5,000	30,000
Average (2008–2012)	0	5,000	20,000

The **most likely** scenario assumes annual afforestation of 5,000 hectares. The **best-case** scenario assumes average afforestation of 20,000 hectares per year between 2008 and 2012. The **worst-case** scenario assumes no further afforestation occurs after 2007. These assumptions are identical to those in the previous year's projections.

Afforestation rates may increase once the new forestry schemes (Forestry ETS, Permanent Forest Sinks Initiative (PFSI) and an Afforestation Grants Scheme) are fully implemented. Other than PFSI, these schemes have not commenced and there is currently no empirical evidence indicating any significant increase in afforestation. The **best-case** afforestation scenario provides an increased afforestation scenario. As previously noted, because of the very young age any forests established between now and 2012 will only sequester very small amounts of CO_2 in CP1. However, these forests will remove increasing amounts of CO_2 as the forests mature.

5.2 Kyoto forest area

Kyoto forest areas have been estimated from the National Exotic Forest Description (NEFD) database. This combines data from a survey of major forest growers undertaken by the Ministry of Agriculture and Forestry, a Small Forest Growers survey completed by AgriQuality in 2004, and estimates of new planting based on data obtained from nursery surveys (Eyre, 1995). The total area of planted forests in the NEFD database is estimated to be accurate to ±5 per cent.

5.3 Growth rates (plantations)

The **most likely** scenario uses a national carbon yield table developed from the NEFD yield table database. The NEFD yield tables better represent the growth of forests on traditional forestry sites. The generally held view is that post-1989 plantation stands are likely to have higher growth rates than earlier plantings.

Analysis of forest growth data suggests that fully stocked stands planted after 1 January 1990 show a 15–35 per cent improvement in productivity over stands currently being harvested: this is the result of genetic improvement, better site quality and improved forest management. The upper end of this range was used to develop the **best-case** scenario, which is based on a growth model projection for pruned radiata pine growing on an ex-pasture site. Compared with the NEFD-based yield table, the higher yield table has:

- higher volume at maturity
- lower carbon for a given stem volume (trees on fertile ex-pasture sites have lower wood density and therefore lower carbon content per unit of volume)
- a higher rate of growth in the second half of the rotation.

The **worst-case** scenario yield table was set at 10 per cent lower than the NEFD yield table. This assumed:

- no increase in volume productivity over stands currently harvested
- no reduction in wood density (and therefore carbon) due to ex-pasture sites
- the same pattern of growth as assumed by the NEFD-derived yield table.

These assumptions have not changed from those used for the 2007 projections. The growth rate scenarios are indicative only. Accurate estimation of forest CO_2 removals requires representative sampling of Kyoto forests. A statistical representative sample plot network has begun to be established across New Zealand's Kyoto forests as part of the Ministry for the Environment's Land Use and Carbon Analysis System (LUCAS) project.

5.4 Changes in soil carbon

Soil carbon levels vary with climate, land use and soil type. Most pasture to radiata pine afforestation occurs on erosion-prone hill country where soil properties are inherently variable. Work is underway to improve New Zealand's approach to determining changes in soil carbon with afforestation, which at present is done by using:

1. the soil paired plot database; and
2. the New Zealand Soil Carbon Monitoring System (SCMS).

The first method estimates soil carbon change with afforestation from the analysis of the soil paired plot database – a cache of purpose-collected data intended to be used as validation of the SCMS estimates. Data from localities where afforestation has taken place estimate soil carbon loss to be 4.7 ± 2.6 t C/ha, the **most likely** scenario. This dataset contains several outliers, all of which indicate substantial carbon losses. Excluding these outliers from the calculation leads to an estimated loss of –0.2 ± 2.5 t C/ha (ie, a small gain) at the 95 per cent confidence level. Excluding these outlier plots needs more analysis; meanwhile the **best-case** scenario assumes no soil carbon change.

In the second method, the New Zealand Soil Carbon Monitoring System is a model that uses historical soil data from the National Soils Database (NSD). These data are coupled with the key factors that influence soil carbon. The SCMS generates estimates of soil carbon change associated with afforestation as well as for a range of other land-use changes; the system has been described in peer-reviewed, international journals. Model predictions for localities where most of the change from pasture to radiata pine land-use occurs, have recently been scrutinised by the developers and officials: they now suspect that the predicted soil carbon reduction associated with afforestation is overstated, mainly due to the limited number of historic soil data in such localities (erosion-prone hill-country). The estimate produced by the SCMS (a loss of 18 ± 11 t C/ha) is considered to be the **worst-case** estimate of soil carbon change with afforestation.

5.5 Ineligible planting

Initial investigation has suggested that some plantation afforestation since 1 January 1990 may have occurred on land that, from a definitional perspective, already met the adopted New Zealand forest definition. Under carbon accounting rules, such land does not qualify as Kyoto forest as the land was already deemed to be forest as at 1 January 1990.

The estimates of the proportion on "ineligible" exotic forests used in the 2006 and 2007 LULUCF projections were 16 per cent (most likely), 8 per cent (best-case) and 21 per cent (worst-case). These values have continued to be used in the 2008 net position calculations.

The most likely and worst-case figures were based on the use of two national classifications to test the representativeness of a pilot mapping project in Nelson-Marlborough, in terms of post-exotic forest planted into possible forest land. The two sources of data were the 1987 Vegetation Cover Map and the 2001/02 Land Cover Database. Spatial intersection of these indicated the likely area of post-1989 forest planted into possible forest land being: nationally 16 per cent; Marlborough region 21 per cent; and the Gisborne region 15 per cent. Anecdotal information suggested that the levels could be as low as 8–10 per cent, and this was used for the best-case scenario.

Table C6: Percentage of existing forest (shrubland) ineligible under the Kyoto Protocol

	Worst-case	Most likely	Best-case
Percentage of post-1989 afforestation onto shrublands that could already have met New Zealand's Kyoto Forest definition	21%	16%	8%

Forest industry commentators have stated that the value of ineligible Kyoto forests is too high. However, in the absence of further quantitative information the 2008 projections use the 2006

estimates again. Preliminary analysis suggest that the proportion of ineligible forests may be reduced once land-use mapping for the LUCAS project has been further progressed.

A closely related issue is the requirement under the Kyoto Protocol to account for emissions from burning and decay of scrub biomass that is cleared for afforestation. That is, if the previous land use does not meet the definition of forest but still contains significant carbon stocks, then the carbon stock change due to afforestation must be accounted for.

5.6 Future deforestation (plantations)

Since 2004, a trend of not replanting forest after harvesting, and in a number of cases converting immature forest to pasture, has clearly emerged. New Zealand has traditionally had dynamic land-use change patterns so changes in land use are not unusual. The scale of conversion has been high because agriculture returns, particularly for dairy farming are better than for forestry. It is estimated that 19,000 hectares of plantation forests were deforested in the year ended December 2007.

The most likely scenario in these projections assumes that deforestation emissions will be 16.9 million tonnes CO_2 during CP1. This is based on the ETS Policy scenario from the 2007 Deforestation Intentions Survey. This scenario assumes that the proposed ETS policies are implemented as proposed in the Climate Change (Emissions Trading and Renewable Preference) Bill, and results in 12,000 hectares of deforestation between 2008 and 2012.

The "best-case" scenario value is the same as the most likely scenario while the "worst-case" scenario assumes an emission liability of 30.5 Mt CO_2; this is based on the "No Policy" scenario from the 2007 Deforestation Intentions Survey.

All deforestation is assumed to be from mature (28-year-old) radiata pine releasing approximately 800 tonnes of CO_2 per hectare. It is likely that some areas that will be deforested will not be mature radiata pine. However, there is insufficient data to more accurately forecast deforestation emissions at this stage.

If the government does not implement policies to manage deforestation in CP1, some forest owners are likely to bring future deforestation forward into CP1 if they believe policy measures could be introduced post-2012.

No allowance has been made for deforestation of indigenous forest or shrubland that meets New Zealand's adopted Kyoto forest definition. There are currently no national statistics available on the clearance of either indigenous forest or shrubland (that meets the forest definition). A Landcare Research (Stephens et al, 2001) report provided estimates for the area of clearance of indigenous forest and scrub between 1989/90 and 1996/97, using visual interpretation of ground cover from satellite images. Complete coverage for New Zealand was not achieved as there were insufficient cloud-free images for much of Northland, southeast Wairarapa, the northwest and southwest of the South Island. For the areas that could be mapped, 1,809 hectares or 0.03 per cent of the total area of indigenous forest was cleared between 1990 and 1996; 1,409 ha or 0.05 per cent of the total area of scrub was removed between 1990 and 1996.

It is thought that under current legislation (eg, Resource Management Act 1991, Forests Act 1949 amended 1993) and/or codes of practice (eg, The NZ Forest Accord 1991) any significant deforestation of indigenous forest is, in practice, difficult to do. But until improved national mapping of forest area change is available, the actual level of indigenous forest and shrub land clearance remains uncertain until LUCAS is operational (see below).

6 Data limitations

There are acknowledged limitations in some of the data used in the LULUCF sector projections due to information gaps and scientific uncertainty. The Ministry for the Environment commenced implementing the Land Use and Carbon Analysis System (LUCAS) in 2005. LUCAS is being designed to provide more robust inventory data specifically for Kyoto carbon accounting purposes. This is a long-term and large-scale project that will not be fully operational until 2010. Installation of forest carbon inventory plots in plantation forests was delayed until 2007 because of a forest owners' ban in protest over the Government's climate change policies. This ban was lifted in October 2007. A full complement of inventory plots in post-1989 forests are planned to be measured during the 2008 calendar year.

Until LUCAS is generating data, existing forest resource information such as the National Exotic Forest Description database and the Land Cover Database (LCDB) continue to be used for projecting CO_2 removals, even though these data sources were not designed for forest carbon accounting purposes. Hence some information essential for carbon accounting purposes are not currently available. The NEFD describes the pre-1990 forests (with ownership dominated by larger forest growers' forests) well. NEFD information on plantation forests established since 1992 by a large number of smaller-scale forest owners is of poorer quality. Information on carbon stock changes in New Zealand's 6.5 million hectares of indigenous forest and 2.6 million hectares of shrubland remains scant.

7 Uncertainty analysis

A Monte Carlo analysis was carried out using the @Risk software (Palisade Corporation). The ranges for afforestation factors in Table C3 were represented by Triangular probability distributions, with the worst-case values set to the 97.5th percentile of the distribution and the best-case emissions level set to the 2.5th percentile (except for future afforestation where the low value – associated with zero hectares of afforestation – was set as the distribution minimum). The uncertainty analysis used 10,000 iterations to derive the 95th percentile range of predicted values from 64.2 to 107.3 Mt CO_2. Deforestation emissions were then deducted to give an uncertainty range of 33.7 to 90.4 Mt CO_2 (Table C3).

In 2007 the mean and ranges had been calculated by adding all the adjustment factors to total removals from afforestation. This earlier approach to estimating uncertainty gave a lower most likely value and a wider uncertainty range (difference between the best-case and worst-case scenario). AEA Technology conducted a review of the 2007 Net Position Forecasts and recommended that Monte Carlo Simulation be used in future to estimate uncertainty.

8 Forest climate change policy

8.1 Introduction

Climate change policy development has been fluid for most of this decade. Until 2002 no national policy existed and the Kyoto Protocol had not been ratified. The New Zealand Government signed the Kyoto Protocol in 2002 and following the ratification by Russia in 2004, the Kyoto Protocol came into effect in 2005. In October 2002 the Government announced its broad climate change framework with respect to forests. This involved the Government using forest sink credits earned from post-1989 afforestation activities to offset increased greenhouse gas emissions from other sectors, and capping its liabilities for deforestation of pre-1990 forests at 21 million tonnes CO_2.

In late 2006 the Government promulgated its Sustainable Land Management (SLM) proposals and entered into a round of consultation with stakeholders. In the SLM proposals, the Government signalled its continued intention to use post-1989 afforestation credits to offset increasing emissions from other sectors of the economy; and that it would encourage afforestation through:

- an afforestation grant scheme
- giving growers a choice between being part of the afforestation grant scheme or devolution of the sink credits (and their associated liabilities) for all post-2007 afforestation
- that both these proposals would work alongside the Permanent Forest Sink Initiative.

Deforestation of non-Kyoto forests would be discouraged by either:

- a flat charge on land-use change from forestry to another use, for the loss of stored carbon
- a tradeable permit regime where the government allocates tradeable deforestation permits to forest land owners and those who deforest are liable for emissions above the level of permits they hold
- centrally determined deforestation levels where the government passes legislation to prevent deforestation of land unless government approval has been granted (to ensure total deforestation remains within a government-established target)
- Resource Management Act controls on deforestation: a national environmental standard would require local authorities to prescribe limits for greenhouse gas emissions for the explicit purpose of controlling deforestation.

8.2 Development of the Emissions Trading Scheme

After considering feedback from the Sustainable Land Management consultation, the Government announced that it would establish a New Zealand Emissions Trading Scheme (ETS). The Government proposed that the ETS would cover all sectors and all gases but the sectors would commence participation within the scheme in a staged manner. The Government announced that forestry would be the first sector to enter the scheme: owners of post-1989 afforestation would be able to receive New Zealand Units if they chose to opt into the scheme

(noting that owners who received credits would also be liable for CO_2 emissions from harvesting and other events). The Government also proposed, effective from 1 January 2008, that any forest owner deforesting non-exempt pre-1990 forest would need to surrender New Zealand Units to cover the deforestation emissions. As part compensation for this, pre-1990 forest owners would also receive an allocation of free units. A number of deforestation exemptions are also proposed, for example forest owners with less than 50 hectares of pre-1990 forest as at September 2007 can apply to be exempt, as are owners deforesting less than 2 hectares of pre-1990 forest during Commitment Period 1.

The legislation required to enact the Emissions Trading Scheme is contained in the Climate Change (Emissions Trading and Renewable Preference) Bill (2007) that at the time of writing was before Parliament's Finance and Expenditure Select Committee. Until the Bill becomes law and the associated regulations are in place, the treatment of Forestry in the ETS will not be finalised.

These projections assume that the Bill will be passed as proposed. The main outcomes of the proposed policies will be:

- Post-1989 forest owners who opt into the ETS will receive New Zealand Units and therefore the Crown will not be able to use these devolved units to offset increased emissions from other sectors.
- The Crown will also devolve 21 million units (minus an allocation for exemptions) in CP1 to owners of pre-1990 forests. It is proposed that an additional 0.8 million units are allocated for the removal of "weed" trees.
- Non-exempt owners of pre-1990 forest who deforest will be required to surrender New Zealand or Kyoto Units to cover deforestation emissions.

8.3 The Permanent Forest Sinks Initiative

The Permanent Forest Sink Initiative (PFSI) provides an opportunity for landowners to establish permanent forest, and obtain tradable Kyoto-compliant emission units (Assigned Amount Units or AAUs) in proportion to the carbon sequestered by their forests.

8.4 Accounting for Article 3.4 forest management

New Zealand has opted not to account under Article 3.4 of the Kyoto Protocol, which covers additional LULUCF activities in the first commitment period, such as forest management.

Under Article 3.4, New Zealand would have to account for carbon stock changes in its indigenous forests as well as its pre-1990 planted forests. At present, carbon stock changes in New Zealand's indigenous forests are unknown, but available data suggest that the carbon stocks are likely to be in a steady state or possibly in slight decline.

An assessment in 2001 (Baisden et al, 2001) of the significance to New Zealand of Article 3.4 forest management activities, estimated their contribution to be between –92 and +11 Mt CO_2-e over the CP1. If New Zealand accounted for forest management under Article 3.4, it would also have been subject to a cap restricting the maximum amount of carbon dioxide removals it could claim in CP1 to 3.7 Mt CO_2 – but potential emissions and the related liabilities would remain uncapped. The substantial costs of measuring New Zealand's entire forest estate did not warrant securing a maximum of 3.7 Mt CO_2 over the first commitment period.

9 Review of past projections

Since 2005, greenhouse gas projections have been subject to a number of reviews, the most comprehensive being two AEA Technology (United Kingdom) reviews. These reviews identified a number of improvements for producing future projections, most of which have been incorporated; the overall finding of the 2005 projections was that "the methodologies employed to project emissions and sinks across the different sectors [are] generally sound and reasonable in their approach". AEA Technology noted the uncertainties inherent in all countries' approaches to projecting future greenhouse gas emissions, and that it is "not uncommon" for projections to change on re-analysis. The reviewers recognised that many of their recommendations built upon improvements already in train. AEA Technology's key conclusions for the LULUCF sector review were:

- *methodologies and input assumptions are reasonable and the resulting removal and emission projections are of a good standard*
- *a single document should be produced for any future projection estimates that provides a detailed basis and sources for all calculations*
- *four key issues will require further consideration to minimise uncertainty in future projections:*
  1. *reasons and drivers for the downward trend in new forest planting*
  2. *the areas of post-1989 forest planting at a national scale into existing shrublands that meet the Kyoto Protocol definition of forest*
  3. *estimation of areas deforested and drivers for this process*
  4. *time patterns of loss of carbon soil after afforestation*
- *the New Zealand Carbon Accounting System (now called Land Use and Carbon Analysis System) will provide valuable data in assessing removals and emissions for land use land-use change and forestry.*

Issues 1 and 3 above have been addressed. For Issue 1, a report examining the financial returns from forestry and its relationship to forestry planting rates has been published (Horgan, 2007). This report is available on the Ministry of Agriculture and Forestry's website. In respect to Issue 3, deforestation intentions surveys were undertaken in 2005, 2006 and 2007 (Manley, 2006 and Manley, 2008) examining major forest owners' deforestation intentions and examining where deforestation is taking place and why. The survey results have been incorporated in the present projections. The 2006 and 2007 deforestation intention survey reports are also available on the MAF website.

Issues 2 and 4 are expected to be informed by data and analysis undertaken within the Ministry for the Environment's LUCAS project. For further details on LUCAS see http://www.mfe.govt.nz/issues/climate/lucas/.

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Annex 1: Description of the LULUCF net position models

A1 Model for projecting net removals

A1.1 Background

Article 3.3 of the Kyoto Protocol allows the net changes in greenhouse gas emissions by sources and removals by sinks resulting from afforestation, reforestation and deforestation since 1 January 1990 to be used to meet the commitments of Annex B parties. Sources and removals are to be measured as verifiable changes in carbon stocks in each commitment period. The carbon stocks to be accounted for are above-ground biomass, below-ground biomass, dead wood, litter and soil organic carbon.

The Land Use and Carbon Analysis System (LUCAS) is being developed and implemented so that New Zealand can meet its international obligations for reporting under the Kyoto Protocol. The LUCAS project will report emissions and removals of greenhouse gases across the carbon pools for forests planted since 1 January 1990 (= post-1989) and any land deforested over the first commitment period of the Kyoto Protocol (CP1: 2008–2012). The basis for estimating stock changes in the biomass and dead organic matter pools will be a representative sample of the Kyoto Forest estate taken at or near 1 January 2008 and repeated at 31 December 2012.

Because the LUCAS carbon monitoring plots have yet to be established, an alternative approach is used to project CP1 net CO_2 uptake. This is hampered by the absence of a spatial database of post-1989 planted forest areas. This report is based on the methodology used to estimate carbon stocks in planted forests for UNFCCC reporting since the early 1990s.

A1.2 Methodology used in this report

Projected removal units from afforestation and reforestation since 1 January 1990 are calculated as the difference between modelled carbon stocks on 1 January 2008 and 31 December 2012. The base data for calculating carbon stocks are the Ministry of Agriculture and Forestry's estimates of annual afforestation area since 1990, and a national carbon yield table derived from the National Exotic Forest Description regional yield tables.

The national carbon yield table provides carbon stock estimates by age on a per hectare basis for all non-soil forest carbon pools. All forest areas planted in the same year are pooled and modelled as a single forest area for that planting year. The model keeps track of these planted areas as they mature, and generates annual estimates of carbon stock by multiplying planted area by the carbon yields per hectare at the appropriate age (see Table C2). This approach is the same as that employed by routinely-used forest estate planning simulators, such as IFS (Interactive Forest Simulator: García 1981).

Soil organic carbon stocks are estimated in the same way as forests, except that a separate national soil carbon yield table reflects changes in soil organic carbon resulting from afforestation of pasture. These changes are modelled as occurring gradually, rather than instantly at the time of afforestation. Values in the yield table start from a high point

representing steady-state soil organic carbon under pasture, then decline before stabilising at a steady-state planted forest level.

Projected emissions from deforestation are determined by estimating the difference between pre- and post-deforestation carbon stocks on land deforested post-1989. Pre-deforestation stocks are calculated by multiplying the area assumed to be deforested by the per hectare carbon stock value in the national carbon yield table at the nominal deforestation age of 28 years. The Intergovernmental Panel on Climate Change (IPCC) methodology allows for an instantaneous loss of carbon at the time of harvest, or a gradual change over time (eg, through decay of residues). The model allows either option to be applied.

A1.3 The model

Three Microsoft Excel spreadsheets are used to calculate carbon removal and emission units: afforestation, soil carbon, and deforestation.

A1.3.1 Afforestation calculations

This spreadsheet model multiplies the area of forest planted each year post-1989 by the appropriate value in the carbon yield table. This is done for each year in the simulation (1990 to 2012).

The first spreadsheet allows combinations of post-1989 afforestation rate with alternative carbon yield tables. Afforestation rates are varied to allow for different scenarios. These include the modelling of future afforestation rates, and the adjustment of forest areas to deduct ineligible forest areas planted onto existing forest land (ie, shrubland that met New Zealand's forest definition). In the latter case, the over-planted proportion is removed from the calculations. The carbon stock for each planting year cohort is calculated annually from the time of planting to 2012, by multiplying the area by the yield table values at the appropriate age. Each year, carbon stocks are summed across planting cohorts to give the total annual carbon stock. Projected removal units are calculated as the stock change during the commitment period, defined as the stock as at 31 December 2012 minus the stock as at 31 December 2007. Carbon stocks include all living biomass, dead wood and litter, but exclude soil organic carbon.

A1.3.2 Soil carbon calculations

The second spreadsheet models the impact of afforestation on the soil organic carbon pool, including both the magnitude of the change in carbon per hectare and the rate of soil carbon change over time. Projected removal units are calculated as the soil carbon stock change during the commitment period (for converted pasture and planted forest combined) and confirmed by the sum of emissions over the same period.

A1.3.3 Deforestation calculations

The third spreadsheet models variations in deforestation rate and alternative treatments of post-deforestation residues. It is assumed that deforestation occurs in pre-1990 planted forests following a normal harvest at age 28 years. The merchantable stem component is modelled as an instantaneous emission of carbon, but tracked separately from harvest residues. The latter may be emitted instantly, or allowed to decay under alternative decay rates. In addition, the proportion of instantly emitted versus decaying residues can be adjusted.

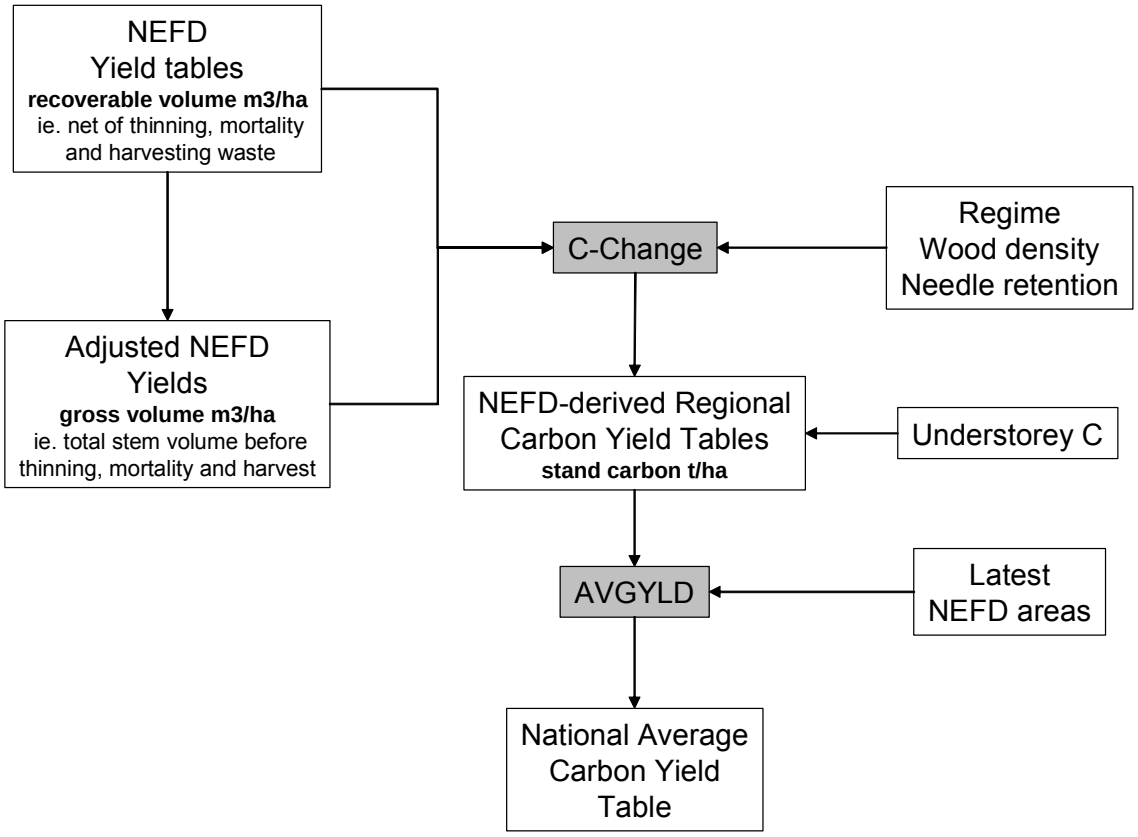
Projected removal units are calculated as the sum of annual emissions over the commitment period. Emissions and removals associated with land uses after deforestation (ie, agriculture and lifestyle blocks/settlements) have not been modelled.

Removals and emissions are both calculated in the three spreadsheet models described above based on stock differences, where the stock is the product of areas multiplied by yield table values. The estimates of afforested and deforested areas are key variables, as are the values in the carbon yield table, which is described in the next section.

A2 National average carbon yield table

Projected removal units are calculated using a national area-weighted average carbon yield table for New Zealand's planted forests. This yield table formed the basis for the 2006 UNFCCC planted forest carbon inventory (Wakelin, 2007). The process used to construct the yield tables is outlined in Figure C7.

Figure C7: Deriving the national average yield table



A2.1 NEFD volume yield tables

National Exotic Forest Description yield tables are prepared periodically to support wood availability modelling carried out by the Ministry of Agriculture and Forestry. The latest set of yield tables (MAF 1996) was used for both the 1996 and 2000 Wood Supply Forecasts. The yield tables have been reviewed (eg, Jaakko Poyry Consulting, 2003; Manley, 2004) and a new set is in preparation.

A2.2 Regional carbon yield tables

The process used to derive a carbon yield table for each NEFD yield table is described in more detail in Wakelin (2007). The two main steps are:

1. Convert NEFD yields net of mortality to gross yields.
2. Use C_Change to firstly convert stem volumes to stem biomass, and then to convert stem biomass to stand biomass.

The first step is required because C_Change requires both gross and net increments as inputs. Gross volume increment is used to calculate total dry matter production; the difference between gross and net volume is used to derive carbon in annual tree mortality, and the resulting dead carbon is added to the dead component carbon stock. An analysis of Permanent Sample Plot (PSP) data held by Scion was made to determine the relationship between net and gross volume for each broad NEFD regime. The PSP data was also used to determine pruning and thinning schedules for each regime.

Inputs to C_Change include the NEFD stem volume yield tables, wood density classes for regions and species, and silvicultural regime details. C_Change is used to:

- derive stem wood biomass increment from volume increment and density
- apply an increment expansion factor to convert this to total carbon fixed
- partition the total carbon to live biomass pools
- calculate transfers from live to dead pools from mortality functions and regime details (ie, pruning/thinning)
- apply decay functions to estimate carbon loss from dead pools.

The output from C_Change is a carbon yield table corresponding to each of the 89 NEFD crop types, with estimates of carbon per hectare by age class for each pool.

Note that these carbon yield tables assume:

- volume growth that is species-specific, based on the species and species groups used in the NEFD yield tables
- broad wood density classes differentiated by species (and by region for radiata pine)
- regime assumptions (particularly initial and final stocking) that are based on radiata pine PSP data
- carbon partitioning based on radiata pine relationships, as data for other species is limited.

A2.3 Area-weighted national average yield table

A national aggregate age class distribution was produced by using the IFS/FOLPI software utility AVGYLD (FRI, 1995) to calculate an area-weighted national crop type yield table and associated age class distribution from the individual NEFD crop types as at 1 April 2005.

A2.4 Issues

The underlying assumption is that the national average carbon yield table is representative of stands planted since 1 January 1990. Obviously the growth of individual stands will vary (see growth rate section earlier in this report).

The main problem with using the NEFD yield table as the basis for carbon yield tables arises from the relatively narrow focus of the NEFD Steering Committee. Yield tables are:

- prepared as a basis for wood availability studies, ie, yields at the range of rotation ages modelled (20–40 but more typically 26–30 years)
- based mainly on areas that will be harvested in the short to medium term from the large forest owners' resource.

This means that:

- yields and increments may not be accurate at other ages – for instance, NEFD yield tables may over-predict yield (and therefore carbon) at young ages
- yield tables do not necessarily reflect future growth rates
- yields may not be applicable to the small growers' estate
- the yield tables were prepared in 1995 for the NEFD crop types that existed at that time. Suitable yield tables do not exist for some of the crop types found today – eg, for production-thinned Douglas-fir, the waste-thinned yield table had to be used in East Cape and southern North Island
- regime differences may not be explicitly captured in the yield tables at the time of silviculture, unlike yield tables produced using a stand growth simulation model.

Nevertheless, the NEFD yield tables are likely to remain the best published source of growth data suitable for national carbon modelling purposes until LUCAS is fully implemented.

Ministry for the Environment
Manatū Mō Te Taiao

Appendix D: Waste Sector Emissions Projections

New Zealand Government

Contents

1 Introduction

Greenhouse gas emissions arise from three waste sector sources: emissions from solid waste disposal sites (landfills), from domestic and industrial wastewater treatment plants, and from solid waste incineration.

Emissions from solid waste disposal sites comprised 79 per cent of the emissions from the waste sector in 2006. These emissions are the result of anaerobic decomposition of organic matter: primarily garden, food, paper, textile and timber waste. The net amount of emissions produced depend on many factors including the composition of solid waste to landfill, waste disposal practices, and the efficiency of any landfill gas collection system.

Wastewater treatment processes produced 20 per cent of emissions from waste. Both methane and nitrous oxide are emitted through treating domestic, commercial and industrial wastewater. Factors influencing the amount of emissions include the type of treatment process, the volume of wastewater and the nitrogen content, and whether any resulting emissions are flared.

Emissions from solid waste incineration produced less than one per cent of waste sector emissions in 2006. These emissions include carbon dioxide (from combusting materials with some fossil fuel content, such as plastics), nitrous oxide and methane. The emissions arise from hospital and quarantine waste incineration. There has been a significant decrease in incineration emissions since 1990 due to the implementation of national regulations controlling air quality effects and the availability of alternative treatments such as steam sterilisation.

1.1 Recent trends

Waste sector emissions in 2006 were 1.858 million tonnes of carbon dioxide equivalent (Mt CO_2-e). This is a reduction of 0.648 Mt CO_2-e (25.9 per cent) below the 1990 baseline value of 2.506 Mt CO_2-e.

This reduction has occurred across all waste sub-sectors. The largest reduction has occurred in the solid waste disposal on land category as a result of initiatives to improve solid waste management practices and increase landfill gas capture rates in New Zealand. Improvements in wastewater treatment technologies and solid waste incineration practises have resulted in smaller inventory reductions.

2 Modelling method

The emissions from solid waste disposal are projected using the methodology and variables used in *New Zealand's Greenhouse Gas Inventory 1990–2006* (MfE 2008a). The methodology uses data specific to New Zealand on waste generation rates, waste composition, percentage of waste disposed to types of landfills, and landfill gas extraction and combustion. Data on waste generation has not been collected routinely in the past; however, all assumptions have been clearly expressed in the national inventory and reviewed by international experts.

The national inventory uses a Tier-2 model to estimate gross methane emissions from solid waste disposed to landfills. This methodology is recommended by the Intergovernmental Panel on Climate Change (IPCC) and assumes that the degradable organic components in waste decay slowly throughout a few decades. Emissions of methane are highest in the first few years after the waste was disposed, then gradually decline.

The methodology requires an estimate of solid waste generated per capita. This data has been compiled through the landfill surveys in 1995 and 2002. Other limited data sets exist for waste composition and have been used. The only variable input into the projections methodology is that of national population, which determines the total volume of waste to landfills. The projection used is from Statistics New Zealand's National Population Projections (2006 base, series 5). Other variables remain constant at the values reported in the latest national inventory (MfE, 2008).

Projected effects of the New Zealand waste strategy are deducted from the modelled gross methane emissions. The effects of the national environmental standard for landfill gas collection are also deducted from the remaining emissions, and were estimated using a survey of landfill operators in 2005 (Waste Management, 2005).

Emissions from wastewater treatment have been estimated using a combination of country specific methodologies and IPCC good practice models. Emissions are sourced from anaerobic treatment of domestic, commercial and industrial wastewater in municipal and some industrial treatment plants. Some larger treatment facilities flare the resulting methane. Projected emissions for 2010 were estimated by pro-rating the 2006 emission values against projected population, using the same Statistics NZ data as in the projections of solid waste described above. Emissions are projected to be 0.35 Mt CO_2-e for 2010. This is a decrease of 0.04 Mt CO_2-e from the 2007 Net Position report, which reflects an improved methodology for estimating emissions from industrial wastewater treatment.

Emissions from solid waste incineration were estimated and reported for the first time in the latest national inventory (MfE, 2008). IPCC 2006 good practice guidance was followed. Emissions of carbon dioxide, nitrous oxide and methane are sourced primarily from the burning of quarantine and hospital waste. There were 10 such incinerators emitting such gases at the start of 2006. Carbon dioxide is counted in the inventory where materials with a fossil fuel origin are burnt. Projected incineration activity was assessed through obtaining expected activity estimates from individual incinerators. Emissions are projected to be 1.44 Mt CO_2-e for 2010.

3 Policies

3.1 Policies in place

The effects of the New Zealand Waste Strategy and the National Environmental Standard for Landfill Gas Collection are included in the total emissions from the waste sector. These are currently the only policies directly affecting emissions from the waste sector. Emissions from solid waste disposed on land are proposed to enter the scope of the New Zealand emissions trading scheme from 1 January 2013.

3.2 The New Zealand Waste Strategy

The New Zealand Waste Strategy was launched in March 2002 with the objective of moving towards zero waste by 2010. The strategy extends to all waste streams including landfill waste, mine and quarrying waste, and sewage. In the initial estimate of emissions over the first commitment period, the New Zealand Waste Strategy was projected to deliver an estimated reduction of 2.4 Mt CO_2-e, or 13.5 per cent, in gross emissions from solid waste disposal sites. This projection is retained as the optimistic value. The most likely estimate is that 75 per cent of the reduction occurs, ie, 1.8 Mt CO_2-e, with a pessimistic value assuming 50 per cent of the reduction. The impacts of the New Zealand Waste Strategy are applied to the data progressively, with a two per cent impact in 2008 to a maximum of 13.5 per cent by 2012 in the optimistic scenario.

3.3 The National Environmental Standard for Landfill Gas Collection

A National Environmental Standard for Landfill Gas Collection and Destruction was introduced under Sections 43 and 44 of the Resource Management Act (RMA) to be applied to landfills that will accept over one million tonnes of refuse throughout their design life (MfE 2004).

Landfill gas collection estimates were updated for the 2004 Inventory by Waste Management in 2005. The consultants projected that 7.4 Mt CO_2-e, or 55 per cent, of gross emissions from solid waste disposal sites would be collected by landfill gas systems over the years 2008 to 2012. These estimates did not include the effects of the New Zealand Waste Strategy on gross emissions. Consequently, the landfill gas collection estimates were reduced by the same proportions used to reduce gross emissions. The most likely scenario now holds that landfill gas collections systems will reduce gross emissions by 6.8 Mt CO_2-e over 2008 to 2012

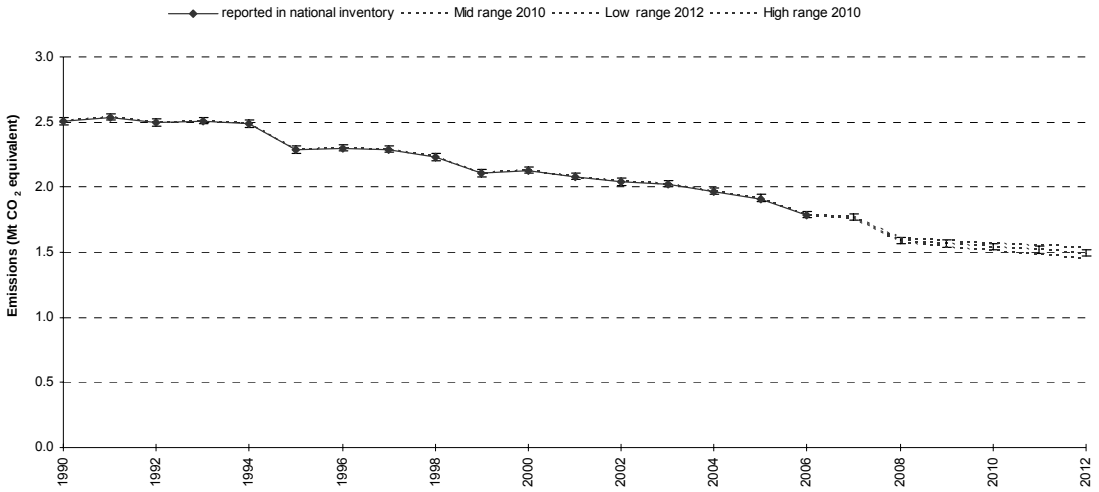
4 Projection

4.1 Total emissions

Emissions from the waste sector over the first commitment period are expected to range between 7.8 and 7.5 Mt CO_2-e. Projected annual emissions for 2010 are expected to lie between 1.56 Mt CO_2e and 1.51 Mt CO_2-e per annum with a most likely value of 1.54 Mt CO_2-e.

Figure D1 shows that since 1990 there has been a large decrease in emissions which, as explained above, is primarily due to decreased waste volumes and less organic matter entering landfills. The New Zealand Waste Strategy (MfE 2002) and National Environmental Standard for Landfill Gas Collection and Destruction are projected to further decrease waste sector emissions despite expected increases in solid waste volumes and increases in emissions from wastewater treatment.

Figure D1: Projected annual emissions for 2010 and the inventory time series of emissions from the waste sector (million tonnes carbon dioxide equivalent)



4.2 Reconciliation with 2007 projection

For the period 2008 to 2012, projected emissions from the waste sector have increased 0.7 Mt CO_2-e (10 per cent) from the 2007 estimates due to several factors:

- inclusion in the estimates, for the first time, of emissions from solid waste incineration. These emissions are projected to have decreased 86 per cent from 1990 levels by 2010
- methodological changes in modelling emissions from industrial wastewater treatment
- adjustments to assumptions regarding the composition of solid waste disposed to landfills since 2003 leading to a higher emission factor per tonne of waste
- correcting an overstatement in the estimates of landfill gas collection.

5. References

MfE 2002. The New Zealand Waste Strategy: Towards zero waste and a sustainable New Zealand. Wellington, Ministry for the Environment.

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