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Manatū Mō Te Taiao

Projected Balance of Emissions Units During the First Commitment Period of the Kyoto Protocol

New Zealand Government

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Contents

Tables

Figures

1 Executive Summary

This report updates New Zealand's projected quantity of emissions and removals of greenhouse gases during the first commitment period (2008–2012) of the Kyoto Protocol. The report is known as the net position report. The projected quantity of emissions and removals is a core component of New Zealand's projected financial surplus or deficit over the first commitment period of the Kyoto Protocol. The other components are the international price of emissions units and the exchange rate between the New Zealand and United States currencies.

The report is a compilation of projections by sector from across government. Agricultural and forest sink projections are provided by the Ministry of Agriculture and Forestry, energy (including transport) and industrial processes projections are from the Ministry of Economic Development, and waste and solvent emissions projections are from the Ministry for the Environment. The Ministry for the Environment calculates the projected balance of units using the projected emissions and removals by sector.

This report includes the effects of refinements in modelling process and updated assumptions on variables such as economic growth, population growth and oil prices as at May 2007. The projections use the information from the latest national inventory of greenhouse gas emissions and removals submitted to Secretariat of the United Nations Framework Convention on Climate Change (the Convention) on 4 May 2007 (MfE, 2007*a*).

The projections reported in this document reflect the government's agreed policies as at the end of April 2007. New policies which have been included since the 2006 net position report are the biofuels sales obligation and the solar hot water programme.

The net position report provides a projection of greenhouse gas emissions for the first commitment period of the Kyoto Protocol relative to total emissions in the base year of 1990. In comparison, the national inventory of greenhouse gas emissions and removals provides a record of New Zealand's actual greenhouse gas emissions and removals from 1990–2005. A key difference is that the net position report is based around Kyoto Protocol accounting rules for land use, land-use change and forestry, whereas the national inventory adheres to the reporting requirements for inventories under the Convention.

2007 results

As at May 2007, New Zealand's net position is projected to be a deficit of 45.5 million units[1] over the first commitment period of the Kyoto Protocol.

The May 2007 projection shows a change from previous projections. In May 2006, the most likely estimate for the projected net position was a deficit of 41.2 million units. There were four key changes to the components of the net position estimate between the 2006 estimate and the 2007 estimate:

1 One emissions unit is equivalent to one tonne of greenhouse gas emissions converted to carbon dioxide equivalent by the global warming potential.

- New Zealand's assigned amount increasing (1.9 million units) due to improvements in New Zealand's Greenhouse Gas Inventory. Increasing the assigned amount lowers the net position deficit.
- New Zealand's agriculture greenhouse gas emissions are now projected to be 4.3 million tonnes carbon dioxide equivalent higher than projected in 2006. This is mainly attributable to projected increases in dairy cow numbers as a consequence of higher world commodity prices for dairy products.
- New Zealand's emissions from energy are now projected to be 1.5 million tonnes carbon dioxide equivalent higher than projected in 2006 due to the expected higher level of dairy processing.
- New Zealand's transport emissions are projected to be 1.3 million tonnes carbon dioxide equivalent higher as a result of integrating the more comprehensive vehicle fleet emissions model to project transport emissions.

The Ministry of Agriculture and Forestry has provided a most likely scenario for deforestation of 21.0 million tonnes carbon dioxide. This scenario is based on the government's current policy to cap the Crown's deforestation liability for pre-1990 forests at 21.0 million tonnes carbon dioxide. A deforestation survey undertaken in 2006 indicated that deforestation is likely to exceed the 21.0 million tonne cap in the absence of policy interventions under current market conditions. The 2006 deforestation intention survey indicated that forest owners currently intend to deforest about 50,000 hectares during the first commitment period of the Kyoto Protocol. This area would generate deforestation emissions of approximately 41.0 million tonnes carbon dioxide. If the upper deforestation emissions value is assumed, the projected net position deficit increases by 20 million units to a deficit of 65.5 million units. This report presents both values for deforestation during the first commitment period.

Uncertainty

There is still a great deal of uncertainty as to what the final balance of units or net position will be during the first commitment period. The government's climate change policy is continuing to develop. It will not be until the national greenhouse gas inventory covering the first commitment period of the Kyoto Protocol is accepted as final by the compliance committee of the Kyoto Protocol, when New Zealand will actually know the true value of the net position. The uncertainty around the net position estimate is large. The most significant source of uncertainty is attributable to the values used for forest sinks and this will continue to be the case until the Land Use & Carbon Analysis System being developed by the Ministry for the Environment becomes operational.

Three scenarios are used to quantitatively assess uncertainty about each sector projection. The variables used in the scenarios represent the best available knowledge as at the time of projection. The most likely scenario represents what is considered the most likely outcome of projected emissions, reductions from fully implemented policies and removals via forest sinks. It is highly unlikely that all upper or all lower situations will occur together, for this reason totals are not reported.

High uncertainty reflects the difficulty in modelling the complex relationships of the New Zealand energy sector, projecting agricultural markets and animal productivity, and projecting removals from forest sinks prior to the Land Use & Carbon Analysis System becoming operational. The projected value of the net position will continue to change as projection models are further refined, assumptions are updated and the interpretation of the Kyoto accounting rules are applied in practice.

Review

Audit New Zealand will conduct an annual audit of the net position estimate. This year AEA Technology will perform a periodic review of the net position. AEA Technology is the same independent, UK-based consulting firm that completed the 2005 net position review.

2 Introduction

The Kyoto Protocol (UNFCCC, 1998) commits Annex I[2] Parties that have both signed and ratified the Protocol to limit or to take responsibility for their greenhouse gas emissions. Annex I Parties in Annex B of the Protocol must put in place domestic policies and measures to address emissions or take responsibility for emissions in excess of their commitment. The individual emissions targets of Annex I Parties were intended to equate to a total reduction in greenhouse gas emissions of at least five per cent from 1990 emissions levels in the period from 2008 to 2012 (the first commitment period of the Kyoto Protocol).[3] Emissions may also be offset by increasing the amount of greenhouse gases removed by carbon "sinks," eg, forests planted since 1990. New Zealand has committed to reducing its average net emissions of greenhouse gases over the first commitment period to 1990 levels or to take responsibility for the difference. New Zealand can meet its commitment through emissions reductions (for example introducing biofuels sales obligations) and use of the Kyoto Protocol flexibility mechanisms such as carbon trading, Joint Implementation, the Clean Development Mechanism, and offsetting increased emissions against carbon dioxide removed by forests.

This report projects New Zealand's emissions and removals of greenhouse gases during the first commitment period of the Kyoto Protocol. The projection follows New Zealand's annual inventory to the United Nations Framework Convention on Climate Change (the Convention) and considers emissions and removals of the gases carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. Global warming potentials are used to convert each of the gases to a carbon-dioxide equivalent (CO_2-e). The global warming potential values used in this report are from the Intergovernmental Panel on Climate Change Second Assessment Report (IPCC, 1995) as per the Convention reporting guidelines.

This report is a compilation of sectoral projections from across government. Agricultural and forest sink projections are provided by the Ministry of Agriculture and Forestry, energy (including transport) and industrial processes projections are from the Ministry of Economic Development, and solvents and waste projections are from the Ministry for the Environment. The Ministry for the Environment combines the sectoral projections to create the projected balance of units over the first commitment period of the Kyoto Protocol.

2 Annex I Parties are industrialised countries that have signed and ratified the United Nations Framework Convention on Climate Change and are listed in Annex I of that document.

3 Note that the calculation of five per cent includes the USA and Australia, which have not ratified the Kyoto Protocol.

2.1 National trends in New Zealand's emissions

The net position uses the information from the latest national inventory of greenhouse gas emissions and removals submitted to the United Nations Framework Convention on Climate Change Secretariat on 4 May 2007 (MfE 2007*a*).

In 1990, New Zealand's total greenhouse gas emissions (excluding the land use, land-use change and forestry sector) were equivalent to 61.9 million tonnes carbon dioxide equivalent. In 2005, total greenhouse gas emissions were equivalent to 77.2 million tonnes carbon dioxide. This equates to a 15.3 million tonnes carbon dioxide equivalent (24.7 per cent) rise in greenhouse gas emissions since 1990 from the five sectors listed in Annex A to the Kyoto Protocol (see Box 1, Section 3). Table 1 presents details of emissions by sector for 1990 and 2005.

Table 1: Annual sectoral emissions of greenhouse gases in 1990 and 2005

Sector	1990 Mt CO_2-e	Share of 1990 emissions %	2005 Mt CO_2-e	Share of 2005 emissions %	Change from 1990 Mt CO_2-e	Change from 1990 %
Agriculture	32.5	52.5	37.4	48.5	4.9	15.2
Energy (including transport)	23.6	38.1	33.5	43.4	9.9	42.0
Industrial processes	3.3	5.3	4.3	5.6	1.0	31.8
Waste	2.5	4.0	1.8	2.4	–0.6	–25.9
Solvents	0.04	0.1	0.05	0.1	0.0	16.4
Total	**61.9**	**100.0**	**77.2**	**100.0**	**15.3**	**24.7**

Source: Ministry for the Environment (2007*a*)

Note: One emissions unit is equivalent to one tonne of greenhouse gas emissions converted to carbon dioxide equivalents by the global warming potential.

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)	Energy	**Fuel combustion**
Methane (CH_4)		Energy industries
Nitrous oxide (N_2O)		Manufacturing industries and construction
Hydrofluorocarbons (HFCs)		Transport
Perfluorocarbons (PFCs)		Other sectors
Sulphur hexafluoride (SF_6)		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 Net Position Compliance Equation

The maximum amount of emissions (measured as the equivalent in 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".

Parties may increase their emissions over their Assigned Amount by increasing the amount of greenhouse gases removed from the atmosphere by so-called carbon "sinks" in the land use, land-use change and forestry sector. However, only certain activities in this sector are eligible. These are afforestation, reforestation and deforestation since 1990 (Kyoto Protocol Article 3.3) and forest management, cropland management, grazing land management and revegetation (Kyoto Protocol Article 3.4). The removal of greenhouse gases from the atmosphere through eligible sink activities minus any deforestation emissions generate Removal Units (RMUs) commonly referred to as carbon credits.

An Annex I Party to the Kyoto Protocol must hold sufficient Assigned Amount Units (AAUs) during the first commitment period of the Kyoto Protocol 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 emissions through the mechanisms under the Kyoto Protocol's flexibility provisions. Flexibility provisions include the Clean Development Mechanism, Joint Implementation and trading of units between Annex 1 Parties. The Kyoto compliance equation may be simplified as described in Box 2.

The projected net position over the commitment period of the Kyoto Protocol (2008–2012) is based on projected emissions, estimates of New Zealand's assigned amount units, the projected removal units generated from forest sinks, and any emissions units allocated to projects such as those awarded under the Projects to Reduce Emissions programme.

Box 2: Kyoto compliance equation

Sum of all emissions from 2008 to 2012 from:

energy (including transport)

industrial processes

solvents and other product use

agriculture

waste

≤

5 times the emissions in 1990 (known as the assigned amount or AAUs)

Plus

Removals of carbon dioxide via forest sinks (RMUs)

New Zealand awarded assigned amount units[4] to projects under its climate change programme "Projects to Reduce Emissions". The net position accounts for awarded units by subtracting units awarded to projects 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.

3.1 New Zealand's assigned amount

Under the rules of the Kyoto Protocol, the inventory submitted with the initial report calculates the assigned amount. The initial report undergoes an in-country review. Once the international review is finalised and approved through the Kyoto Protocol Compliance Committee, New Zealand's assigned amount is set for the first commitment period of the Kyoto Protocol.

New Zealand submitted its initial report on 31 August 2006. New Zealand's in-country review took place in February 2007. The outcome of this review should be finalised during 2007.

The number of assigned amount units is equal to five times the emissions reported for New Zealand's base year of 1990. The emissions in 1990 were 61.9 million tonnes carbon dioxide equivalent (rounded to one decimal place). Each emissions unit is equal to one tonne of greenhouse gas emissions, converted to carbon dioxide equivalents using the global warming potential for each greenhouse gas (IPCC Second Assessment Report, 1995). This equates to 309.5 million assigned amount units over the first commitment period.

4 Project participants have the option to request Emission Reduction Units (ERUs) in place of Assigned Amount Units.

4 Projected Emissions over the First Commitment Period of the Kyoto Protocol

4.1 Projected balance of units

As at May 2007, New Zealand's net position is projected to be in deficit by 45.5 million units over the first commitment period of the Kyoto Protocol (Table 2). Three scenarios are used to quantitatively assess uncertainty about the projection for each sector. The variables used in the scenarios represent the best available knowledge as at the time of projection. The most likely scenario represents what is considered the most likely outcome of projected emissions for each sector, and removals via forest sinks. It is highly unlikely that all upper or all lower outcomes will occur together.

The Ministry of Agriculture and Forestry has provided a most likely scenario for deforestation of 21.0 million tonnes carbon dioxide. This scenario is based on the government's current policy to cap the Crown's deforestation liability for pre-1990 forests at 21.0 million tonnes carbon dioxide. A deforestation survey undertaken in 2006 indicated that deforestation is likely to exceed the 21.0 million tonne cap in the absence of policy interventions under current market conditions. The 2006 deforestation intention survey indicated that forest owners currently intend to deforest about 50,000 hectares during the first commitment period of the Kyoto Protocol. This area would generate deforestation emissions of approximately 41.0 million tonnes carbon dioxide.

If the upper deforestation scenario of 41.0 million tonnes carbon dioxide is used in determining the deficit on the Crown's accounts the deficit will be 65.5 million units.

Table 2: Projected balance of emissions units over the first commitment period (million emissions units)

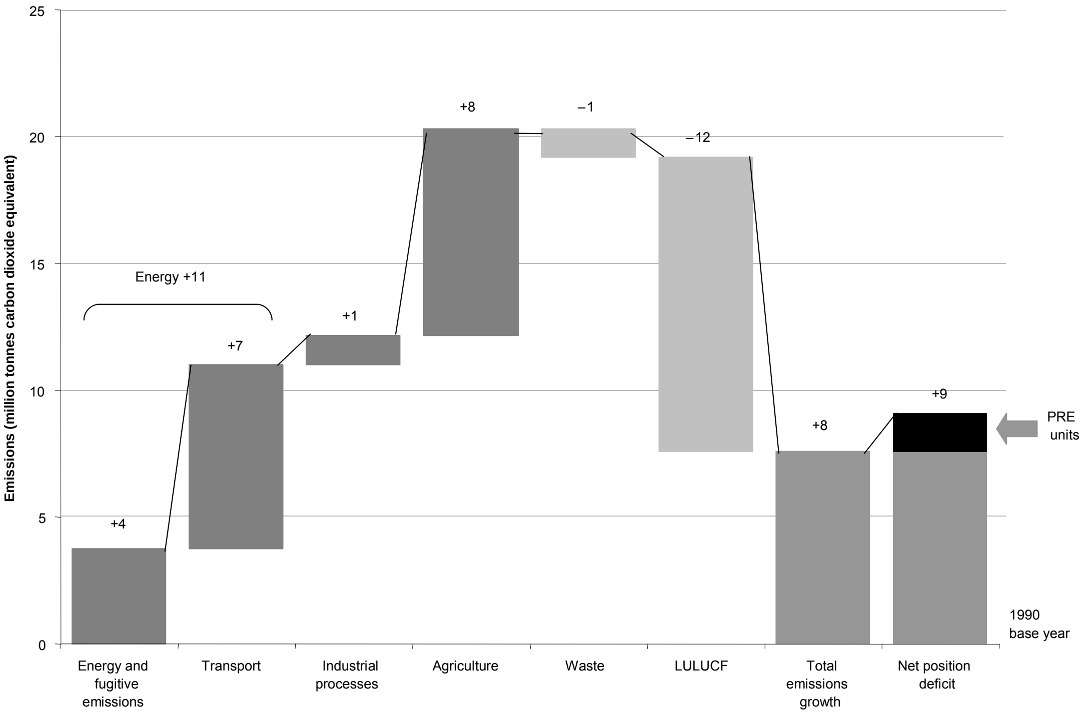
			Upper scenario	Most likely scenario	Lower scenario
Emissions					
a.	**Projected aggregate emissions**			**405.4**	
Energy (excluding transport)			103.0	92.8	86.1
Transport			84.7	80.1	76.7
Industrial processes			22.3	22.2	22.1
Solvent and other product use			0.3	0.3	0.3
Agriculture			228.3	203.1	180.0
Waste			7.3	7.0	6.7
b.	**Assigned amount units**	**AAUs**	**309.5**	**309.5**	**309.5**
c.	Emissions to be covered (b–a)			–96.0	
Projection of removal units					
d.	Removals via forests		57.0	79.0	119.3
e.	Deforestation emissions		–41.0	–21.0	–21.0
f.	**Net removals via forests (d+e)**	**RMUs**	**16.0**	**58.0**	**98.3**
g.	Balance (c–f)			–38.0	
h.	AAUs allocated to projects		7.5	7.5	7.5
Balance of units (g–h)				**–45.5**	

Note: One emissions unit is equivalent to one tonne of greenhouse gas emissions converted to carbon dioxide equivalents by the global warming potential.

Total emissions of greenhouse gases for the Kyoto Protocol commitment period are projected to be 405.4 million tonnes carbon dioxide equivalent. The total for modelled projections of emissions over the first commitment period equates to average annual emissions of 81.1 million tonnes carbon dioxide equivalent (Figure 2).

Figure 1 shows the change in average annual emissions from 1990 to 2010 by sector and in total. The average annual value of the net position during the first commitment period of the Kyoto Protocol (2008–2012) is also shown, and includes an estimate of the average annual value of units awarded under the Projects to Reduce Emissions (PRE) programme.

Figure 1: Projected annual average emissions and net position deficit for 2010



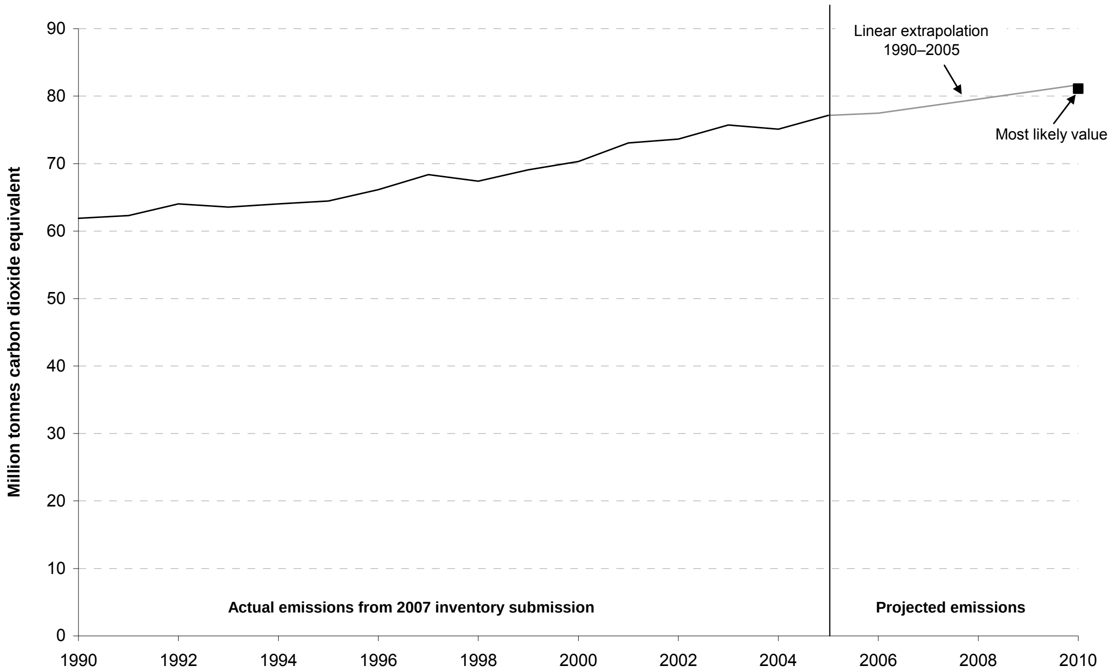
Note: Land use, land-use change and forestry (LULUCF) assumes deforestation emissions of 21.0 million tonnes carbon dioxide for the five-year period 2008 to 2012.

Note: Energy and fugitive emissions does not include transport.

Note: Figures may not add due to rounding.

Emissions projections for each sector are based on detailed sectoral modelling. A simple linear extrapolation of total emissions has been included in Figure 2. This extrapolation projects total annual emissions to be 81.7 million tonnes carbon dioxide equivalent. This is close to the modelled projection for total annual emissions and provides some assurance of the validity of the modelling process for projecting total national emissions (excluding deforestation).

Figure 2: Projected emissions for 2010, total emissions reported in the national inventory from 1990–2005 and a linear extrapolation of previous emissions



Note: Excludes emissions from deforestation.

Table 3: Projected emissions of gases and sources listed in Annex A of the Kyoto Protocol over the first commitment period (million tonnes carbon dioxide equivalent)

	Upper scenario	Most likely scenario	Lower scenario
Emissions			
Projected aggregate emissions		**405.4**	
Energy (excluding transport)	103.0	92.8	86.1
Transport	84.7	80.1	76.7
Industrial processes	22.3	22.2	22.1
Solvent and other product use	0.3	0.3	0.3
Agriculture	228.3	203.1	180.0
Waste	7.3	7.0	6.7

Note: 1 million tonnes is equivalent to 1,000 gigagrams.

4.2 Assumptions

Model inputs and outputs are co-ordinated across departments to provide consistency with the assumptions. For example, the Ministry of Agriculture and Forestry's dairy herd projections are an input to the Ministry of Economic Development's energy demand module for dairy processing.

In previous years, macroeconomic assumptions such as economic and demographic change were based on Treasury's Half Yearly Economic and Fiscal Update.

These assumptions were formulated in November 2006. Since then, agricultural commodity prices have changed significantly. On 23 May 2007, as a result of rapidly changing and buoyant international prices for dairy products, Fonterra announced an increase in the payout to its dairy farmers for milk solids of 27 per cent. This increase, along with changes in other agricultural commodity prices, was expected to make a material difference to projections of livestock numbers and hence possible total emissions.

A decision was made to make use of the newer price and exchange rate assumptions (as in the Ministry of Agriculture and Forestry's Situation and Outlook for New Zealand Agriculture and Forestry publication and Treasury's Budget Economic and Fiscal Update) to derive livestock projections and agricultural emissions. The forecast in total agricultural emissions did not change significantly as the increase in dairy cow numbers due to the high dairy payout was offset by a decrease in the sheep flock.

The deficit of emissions units is calculated using crown accounting standards and does not include the effects of policies that have not been agreed through Cabinet by the end of April 2007. Policies included in this net position report include the biofuels sales obligation and the solar hot water programme. The effects of the Projects to Reduce Emissions programme on the net position are modelled as part of the energy emissions projection by the Ministry of Economic Development, using their Supply and Demand Energy Model (SADEM).

4.3 Accounting for uncertainty

Projections of emissions and removals via sinks are broken down by sector (Table 2). The net position compliance equation as described in Section 3 is also calculated in Table 2. The projections are estimates of future values and are inherently uncertain. The projected net position is expected to continue to change every year when the net position is updated. To accommodate this uncertainty upper and lower emissions projections have been provided for each sector. The uncertainty is shown by each sector in Figure 3. The bars in Figure 3 show the range between the upper and lower emissions scenario outcome. Bars to the left of the zero axis show the range between the most likely scenario and the high emissions scenario for each sector. Bars to the right of the zero axis show the range between the most likely scenario and the low emissions scenario for each sector.

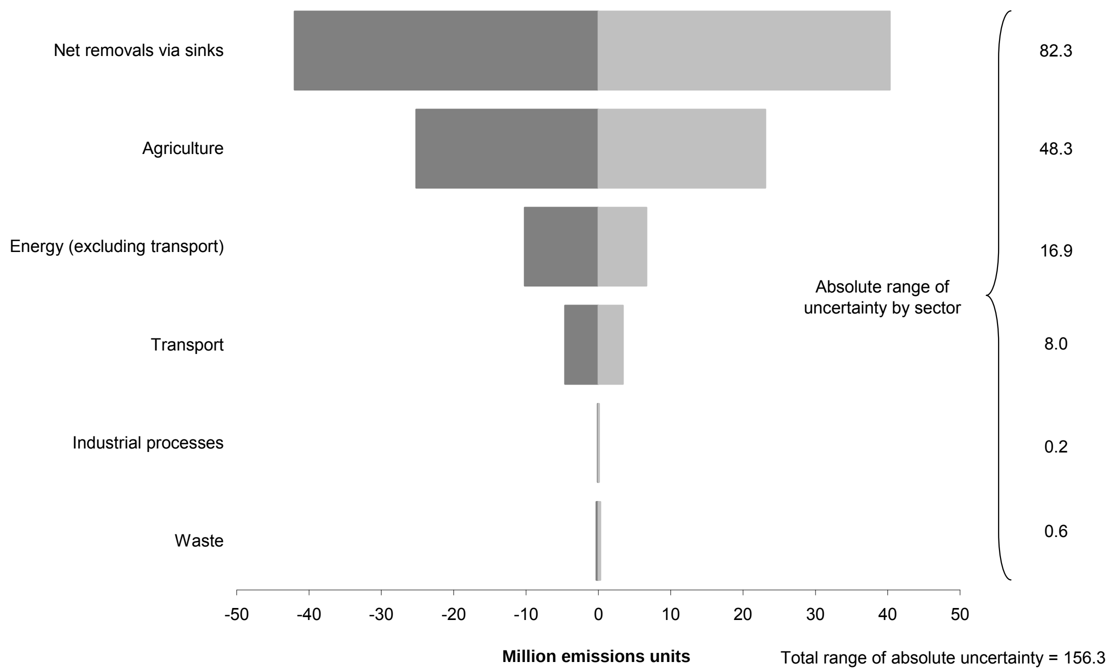
- **Agriculture:** upper and lower emissions projections for the first commitment period are based on variations in commodity prices combined with high and low emissions factors for dairy cattle, beef cattle, sheep and deer.
- **Energy transport and industrial process:** upper and lower emissions projections for the first commitment period are based on variations in macroeconomic factors, levels of production and consumption, and outcomes of policy measures.
- **Net removals** from land use, land-use change and forestry: upper and lower projections for the first commitment period are based on variations in future deforestation and afforestation rates. In addition, upper and lower projections are calculated to allow for measurement and scientific uncertainty.
- **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 policies.

It is highly unlikely that all upper or all lower situations will occur together. In previous net position reports (May 2005 and May 2006) a repeated sampling technique (also known as a Monte Carlo simulation method) was used to quantify the uncertainty about the most likely outcome.

A Monte Carlo simulation method was applied by the Ministry for the Environment in the 2005 and 2006 net position reports to weight the uncertainty from each sector to total uncertainty in the net position. There is debate as to whether the Monte Carlo method is suitable tool for modelling emissions projections uncertainty for New Zealand, because of the limited number of modelled projections and because there are unknown factors such as the result for land use, land-use change and forestry where the end result will have a dominant effect on the final net position.

The AEA Technology review team, reviewing the 2007 net position have been asked to provide guidance on how best to treat this uncertainty.

Figure 3: Uncertainty ranges for impact on net position by component



4.4 Reconciliation with 2006

Table 4 compares the net position from May 2005, the interim update to the net position reported in the Crown Financial Statements in December 2005, the May 2006 net position and the current estimate of the net position for 2007.

Table 4: Reconciliation of previous projections of the most likely balance of emissions units (million tonnes carbon dioxide equivalent)

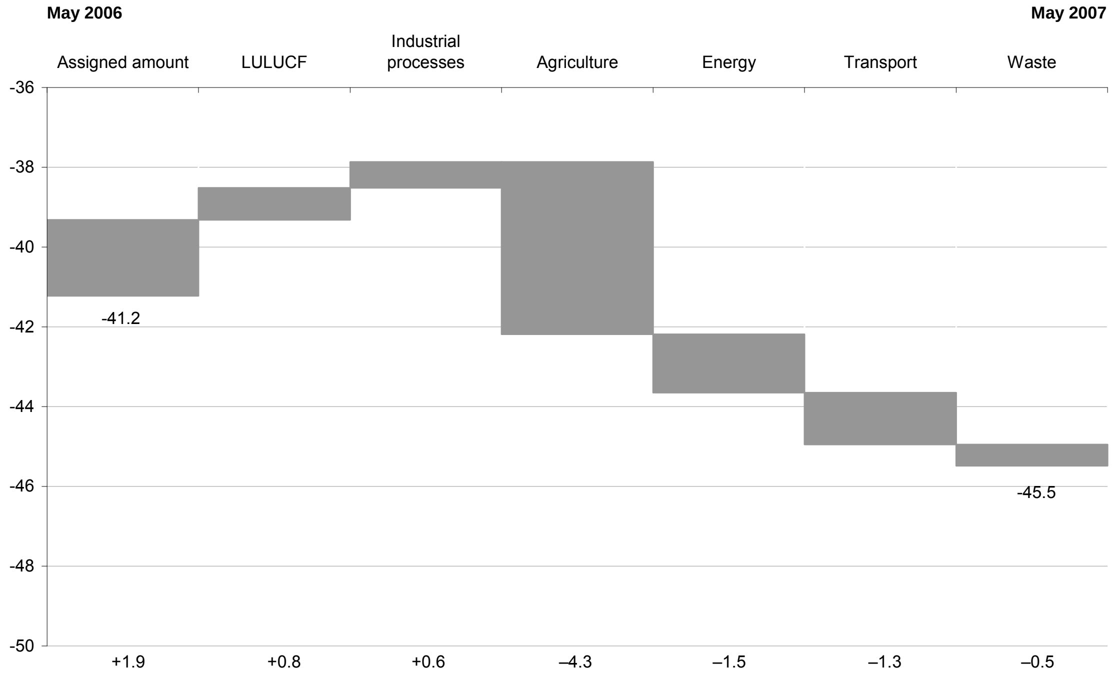
		May 2007	Change	May 2006	Change	December 2005	Change	May 2005
Projection of assigned amount units								
a. Projected aggregate emissions		405.4	7.0	398.5	–16.3	414.8	13.1	401.7
Energy (excluding transport)		92.8	1.5	91.3				
Transport		80.1	1.3	78.8				
Industrial processes		22.2	–0.6	22.9				
Energy (including transport) and industrial processes		195.1	2.1	193.0	–14.5	207.5	13.1	194.4
Solvent and other product use		0.3	0.0	0.3	0.3	0.0		0.0
Agriculture		203.1	4.3	198.8	–3.2	202.0		202.0
Waste		7.0	0.5	6.5	1.2	5.3		5.3
b. Assigned amount units	**AAUs**	309.5	1.9	307.6	0.0	307.6		307.6
c. Emissions to be covered (b–a)		–96.0	–5.1	–90.9	16.3	–107.2	–13.1	–94.1
Projection of removal units								
d. Removals via forests		79.0	0.8	78.2	1.0	77.2		77.2
e. Deforestation emissions		21.0	0.0	21.0	0.0	21.0	14.7	6.3
f. Net removals via forests (d+e)	**RMUs**	58.0	0.8	57.2	1.0	56.2	–14.7	70.9
g. Balance (c–f)		–38.0	–4.3	–33.7	17.3	–51.0		–23.2
h. AAUs allocated to projects		7.5	0.0	7.5		7.5		7.5
Monte Carlo differences		0.0	0.0	0.0	5.5	–5.5		–5.5
Balance of units (g–h)		**–45.5**	**–4.3**	**–41.2**	**22.8**	**–64.0**	**27.8**	**–36.2**

Note: One emissions unit is equivalent to one tonne of greenhouse gas emissions converted to carbon dioxide equivalents by the global warming potential.

Note: Net removals via forests offset emissions and reduce the deficit on the net position.

Emissions projections in some sectors are higher while other sectors are lower; however the net effect is that emissions are projected to be higher during the first commitment period than reported in the Crown Financial Statements since May 2006. Figure 4 tracks the changes to the net position by component and shows how changes in each component have affected the final net position value since the May 2006 net position report.

Figure 4: Changes to the net position from 2006 (million tonnes carbon dioxide equivalent)



5 Sectoral Emissions

5.1 Agriculture

5.1.1 Sector coverage

Emissions of methane and nitrous oxide are produced when biomass (organic matter) is consumed, decays or is burnt. Naturally occurring emissions are modified by human activities such as cultivation, addition of nitrogenous fertilisers, farming of livestock, deliberate burning, or flooding. New Zealand has five subsectors within agriculture that produce greenhouse gas emissions. The subsectors are:

1. **Enteric fermentation** is a by-product of digestion by ruminant livestock. This is New Zealand's highest single emissions category, contributing 31 per cent to total national emissions in 2005.
2. **Agricultural soils** emissions are associated with the application of nitrogenous fertilisers, animal wastes deposited to agricultural soils, and the use of nitrogen fixing crops. Emissions can be direct from the soil, and indirect through atmospheric deposition, leaching and run-off.
3. **Manure management** produces emissions from decomposition of animal waste held in manure management systems (eg, stored in ponds).
4. **Savanna burning** emissions are from the controlled burning of tussock grasslands. The amount of tussock burned has been steadily decreasing since 1959.
5. **Burning of agricultural residues** emissions are from field burning of crop residues, including barley, wheat and oats.

5.1.2 Projected emissions

Total emissions from the agriculture sector are projected to range from 180.0 million tonnes carbon dioxide equivalent to 228.3 million tonnes carbon dioxide equivalent over the first commitment period of the Kyoto Protocol, with a most likely value of 203.1 million tonnes carbon dioxide equivalent. Average annual emissions over the first commitment period are projected to range from 37.5 million tonnes carbon dioxide equivalent to 45.7 million tonnes carbon dioxide equivalent with a most likely value of 40.6 million tonnes carbon dioxide equivalent.

Agriculture emissions projections are driven by future values for:

- animal numbers by species: dairy cattle, beef cattle, sheep and deer in 2010 using the Ministry of Agriculture and Forestry's Pastoral Supply Response Model
- rates of methane emissions per animal based on changes in past emissions per animal between 1990 and 2005

- rates of nitrogen output per animal based on changes in past nitrogen output per animal between 1990 and 2005
- level of nitrogen fertiliser use based on an econometric model that projects future use from projected animal numbers, fertiliser prices and other variables (output prices, agricultural productivity growth).

The most likely value for annual emissions at 2010 is 0.86 million tonnes carbon dioxide equivalent higher than was projected in 2006 and 4.30 million tonnes carbon dioxide equivalent higher over the commitment period. The difference between the optimistic and pessimistic scenarios is now 8.39 million tonnes carbon dioxide equivalent compared to 8.40 million tonnes carbon dioxide equivalent in the 2006 forecast estimates.

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

Table 5: Summary of 2007 emission projection scenarios for 2010

		1990	2005	2010		
				Lower emissions scenario	Most likely scenario	Upper emissions scenario
Total projected emissions	Mt CO_2-e	32.50	37.45	36.24	40.62	45.89
Change from 1990	Mt CO_2-e			3.50	8.12	13.16
Change from 1990	percent			10.80	25.00	40.50

Note: Some figures may not add due to rounding.

Source: MAF (2007*a*)

Table 6: Projected most likely animal numbers in 2010

	1990 (000 head)	2010 most likely scenario (000 head)
Dairy cattle	3,391	6,107
Beef cattle	4,597	4,115
Sheep	57,861	37,023
Deer	1,036	1,457

Source: MAF (2007*a*)

The 2007 nitrogen application forecast for 2010 is lower than the 2006 nitrogen fertiliser application forecast (403,709 tonnes). This is due to expected higher real nitrogen fertiliser price relative to agricultural commodity prices. The nitrogen fertiliser model results in 2006 were not price responsive.

Technologies that reduce emissions at an individual animal level may emerge over the next five years. Nitrification inhibitor dicyandiamide is an example of an emerging emission reduction technology that has been shown to reduce nitrous oxide emissions in grazed pastures. Mitigation technologies, such as dicyandiamide have not been factored into the projections as they may not have be widely adopted by 2010 and may be counter balanced by greater improvement in animal productivity growth. Industry strategy plans, particularly in the dairy industry, are seeking production gains of at least three per cent per annum in milk production. Favourable commodity price forecasts suggest that these ambitious growth targets are more likely to be met.

In terms of nitrogen fertiliser usage, future changes such as limitations on nitrogen fertiliser use in some catchments, eg, Lake Taupo and Lake Rotorua, the conversion of pastoral land to forestry, the Dairying Clean Streams Accord, regional council initiatives, industry codes of practice and the increasing price of nitrogen fertiliser are likely to limit another steep upward trend in fertiliser nitrogen usage apparent during the period 1992 to 2003.

On the other hand, the recent increase in commodity prices, particularly for dairy products, is likely to lead to more nitrogen fertiliser being applied. Nitrogen fertiliser still provides the least cost means of securing additional dry matter production. Also the clover root weevil, a pest found in New Zealand in 1996, is reducing nitrogen fixation by clover, New Zealand's main source of nitrogen for pastures. The response of some affected farmers has been to increase the use of nitrogen fertiliser and feed supplements.

5.1.3 Reconciliation with 2006 projection

Assumptions

The increase in emissions compared to the 2006 projections is mainly attributable to the higher forecast of dairy animal numbers as a consequence of current high world commodity prices for dairy products. International spot market prices for whole milk and skim milk powders have increased by over 50 per cent since September 2006, and have led price increases across all dairy commodity groups. Constrained supply of dairy commodities from a number of key exporting countries has been the main cause of the higher prices. Supply of powders onto international markets from the European Union fell due to a switch in production from powders to cheese; changes to the Common Agriculture Policy have driven this. The drought in Australia, which has constrained milk production, has also had a major impact during the past nine months.

Relative to the 2006 net position report, higher commodity prices for dairy products are now expected to prevail during the first commitment period of the Kyoto Protocol.

Method

Changes in estimation methodologies have been implemented to take into account new approaches and information obtained since the last update in May 2006. Overall these methodological changes lead to a reduction of emissions in excess of 1990 levels.

Changes were implemented in two areas:

- the projection of nitrogen fertiliser application in 2010 was based on an improved methodology developed by Ministry of Agriculture and Forestry. The methodology improvement resulted in a lower projection of nitrous oxide emissions
- updating the National Greenhouse Gas Inventory methodology in keeping with the Convention guidance for maintaining "Good Practice". Two changes were implemented in the agricultural section of the National Greenhouse Gas Inventory in 2007, in which the 2005 emission levels are reported. These were:
  - the crop residue burning fraction for 2005 was reduced from 50 per cent to 30 per cent. This change had a minor impact on emissions output
  - the commencement of the period over which animal emissions are reported was changed from a July to June year to a January to December year, commencing in January 1989. Three year averages are used to derive animal populations. This change resulted in an approximate one per cent increase in the 1990 emissions levels for agricultural methane and nitrous oxide.

5.1.4 Uncertainty

These projections are forecasts of future agriculture greenhouse gas emissions. Forecasts are greatly influenced by prevailing conditions. As such these projections need to be assessed within the uncertainties of biological systems affected by climate and 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 however, future changes in projected emissions are inevitable to allow for future changes in economic conditions and other factors.

An assumption implicit in the projections is that the rate of increase in productivity per animal over the next five years will be the same as the rate of increase in animal performance over the past 15 years, and therefore a linear extrapolation of methane emissions per animal is appropriate. It is possible that the rate of increase in animal performance may decline over time. To test this, other non-linear relationships were looked at; however no significant improvement in relationship was gained.

5.2 Energy (including transport) and industrial processes

5.2.1 Sector coverage

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

The transport sector contributes a large portion of all emissions from the energy 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 the two major liquid fuels of petrol and diesel as well as increased use of aviation fuels.

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

Industrial processes contribute around six per cent of New Zealand's total greenhouse gas emissions. There are six major industrial processes that are represented in this sector:

- the reduction of iron and in steel production
- the oxidisation of anodes in aluminium production
- the production of hydrogen
- the calcination of limestone of use in cement production
- the calcination of limestone for lime
- the production of ammonia and urea.

Emissions from the industrial processes sector are dominated by emissions from the metal industry.

5.2.2 Projected emissions

Total emissions from the energy and transport sectors are projected to be 172.9 million tonnes carbon dioxide equivalent for the first commitment period of the Kyoto Protocol.

Table 7: Projected energy and industrial process emissions

	Energy (excluding transport) Mt CO_2-e	Transport Mt CO_2-e	Industrial processes Mt CO_2-e	Total emissions Mt CO_2-e
2008	18.5	15.5	4.4	38.4
2009	18.6	15.8	4.4	38.8
2010	18.2	16.0	4.4	38.7
2011	18.5	16.3	4.5	39.3
2012	18.8	16.6	4.5	39.9
Total first commitment period	**92.8**	**80.1**	**22.2**	**195.1**

Source: MED (2007)

Note: Some figures may not add due to rounding.

For industrial processes the Ministry of Economic Development models carbon dioxide emissions only. Carbon dioxide emissions were increased by 19 per cent to adjust for non-carbon dioxide greenhouse gases. Total emissions from the industrial processes sector are projected to be 22.2 million tonnes carbon dioxide equivalent for the first commitment period of the Kyoto Protocol.

5.2.3 Reconciliation with 2006 projection

Since the 2006 net position report, a number of enhancements have been made in the energy sector (including transport):

- actual data for 2005 and where possible actual data for 2006 has been incorporated
- the 'Other Industrial and Commercial' model has been disaggregated into two separate sectoral models for 'Commercial' and 'Other Industrial'
- demand elasticities have been incorporated into the new 'Commercial' and 'Other Industrial' models
- enhancements have been made to modelling on-road transport, utilising the Ministry of Transport's Vehicle Fleet Emissions Model
- enhancements have been made to the fugitive emissions model.

These enhancements coupled with revised assumptions lead to projected emissions from the energy and transport sectors (excluding industrial processes) being 2.8 million tonnes carbon dioxide equivalent (1.6 per cent) higher than in the 2006 net position estimate.

Table 8: Projected most likely emissions results for the energy sector for 2006 and 2007

	2006 Mt CO_2-e	2007 Mt CO_2-e	Difference Mt CO_2-e
2008	32.7	34.0	1.2
2009	33.5	34.4	0.9
2010	34.1	34.3	0.2
2011	34.6	34.8	0.2
2012	35.1	35.4	0.3
Total for commitment period	**170.1**	**172.9**	**2.8**

Source: MED (2007)

The increase in total greenhouse gas emissions from the energy sector (including transport) is the result of the following changes since net position 2006:

- In the 2007 projected net position, Methanex is assumed to operate until 2009. In the 2006 projected net position, Methanex was assumed to cease production prior to 2008. Methanex's operation during the first commitment period of the Kyoto Protocol increases the projected net position.
- Revised Ministry of Agriculture and Forestry dairy herd projections used in modelling are higher than those used in 2006 net position, resulting in higher projected energy emissions from energy use in dairy processing.

- Enhancements to the 'Other Industrial' and 'Commercial' models have resulted in higher emissions projected from these sectors in the 2007 net position estimate.
- The use of the Vehicle Fleet Emissions Model to enhance on-road transport emissions has increased projected emissions from the transport sector in the projected 2007 net position estimate. The Vehicle Fleet Emissions Model was not used in modelling work for 2006 net position estimate.

A number of factors have contributed to lower emissions from some sectors in the 2007 net position projection, partially offsetting the increase:

- In the electricity sector there is increased certainty on commissioning of new renewables, increased confidence in the availability of gas through the first commitment period of the Kyoto Protocol. Genesis Energy's Energy Efficiency Enhancement Project (known as E3P) is a new gas-fuelled, combined-cycle plant at Huntly and is in the final stages of commissioning. These factors, combined with reducing flexibility in supply of gas result in more gas fired generation relative to coal fired generation.
- The inclusion of recent actual data for air and sea transport has slightly decreased emissions from air and sea transport.
- Enhancements to the fugitive emissions model have led to decreased fugitive emission projections.

For industrial processes the Ministry of Economic Development models carbon dioxide emissions from industrial processes only (Table 9). Total carbon dioxide emissions from industrial processes are provided to the Ministry for the Environment as an input to the modelling of overall greenhouse gas emissions from industrial processes. The Ministry for the Environment increases carbon dioxide emissions by 19 per cent to adjust for non-carbon dioxide greenhouse gases.

Table 9: Projected most likely emissions of carbon dioxide only from industrial processes

	2008	2009	2010	2011	2012	Total for commitment period
Mt CO_2-e	3.7	3.7	3.7	3.8	3.8	18.7

Source: MED (2007)

5.2.4 Uncertainty

The following is a non-exhaustive list of conditions that could affect actual emissions from energy (including transport) and industrial processes for the first commitment period of the Kyoto Protocol:

- overall New Zealand economy performance (rapid growth or recession)
- impact of government policy measures, such as the New Zealand Energy Strategy
- success of various energy efficiency programmes
- fluctuations in international oil, coal and gas prices
- fluctuations in international commodity prices (eg, dairy prices)
- negotiated outcomes between fuel suppliers and electricity generators, who may switch fuels depending upon their price and availability
- emissions from electricity generation may fluctuate from year to year due to changing hydrological conditions
- decisions to build additional renewable plant before 2012
- constraints on gas supplies
- fuel mix for industrial sector expansions
- decisions by industrial consumers to locate operations overseas
- impacts on competitiveness of New Zealand industry due to exchange rate fluctuations (especially dairy and forestry)
- uncertain consumer response to changes of oil price (such as buying smaller size cars, diesel cars, or use of public transport)
- physical disasters impacting energy facilities or major energy consumers, such as major breakdown of electricity generator or major breakdown of high-voltage direct current link that connects the North and South Islands
- pandemic or natural disaster
- the continued operation of the Methanex methanol plant during the first commitment period of the Kyoto Protocol.

In 2007, upper and lower emissions scenarios were run to provide an indication of the range of uncertainty in the projections. Table 10 presents the results of these two scenarios, compared to the 2007 “most likely” scenario.

Table 10: Summary of assumptions and effects of upper and lower emissions scenarios

Scenario	Assumptions	Total emissions from energy (including transport) during the first commitment period of the Kyoto Protocol
Lower emissions scenario	Low GDP growth Low population growth Low exchange rate Low dairy numbers Biofuels obligation exceeded Wet hydrological conditions Methanex not operating Energy efficiency gains increased	162.8 Mt (-10.1 Mt compared to 2007 'most likely' case)
Upper emissions scenario	High GDP growth High population growth High exchange rate No additional gas discoveries Methanex Motonui plant running No energy efficiency and conservation Dry hydrological conditions High dairy numbers No biofuels No solar water heating programme	187.7 Mt (+ 14.8 Mt compared to 2007 'most likely' case)

Source: MED (2007)

The projected balance of emissions from energy (including transport) during the first commitment period of the Kyoto Protocol lies in the range between 162.8 million tonnes carbon dioxide equivalent and 187.7 million tonnes carbon dioxide equivalent with the most-likely scenario of 172.9 million tonnes carbon dioxide equivalent. This compares with a range from 156.2 million tonnes carbon dioxide equivalent to 187.2 million tonnes carbon dioxide equivalent in the 2006 net position report for energy and transport. The overall range in 2007 net position projections has diminished.

5.3 Land use, land-use change and forestry

5.3.1 Sector coverage

As forests grow they remove carbon dioxide from the atmosphere through photosynthetic activity. The Kyoto Protocol provides mechanisms for Parties to account for carbon dioxide removals by forests established on land that was non-forest at 1990. These removal units can be used to offset greenhouse gas emissions from other sectors.

This section provides projected carbon dioxide removals and emissions from New Zealand's land use, land-use change and forestry sector, limited to post-1990 afforestation, reforestation and deforestation activities accounted for under the Kyoto Protocol.

5.3.2 Projected removals and emissions

Carbon dioxide removals (less deforestation emissions) by the land use, land-use change and forestry sector for the first commitment period of the Kyoto Protocol are projected to be in the range of 16.0 to 98.3 million tonnes carbon dioxide equivalent. The base scenario is projected to be a net removal of 58.0 million tonnes carbon dioxide equivalent.

The key assumptions used in these projections are:

- future rates of deforestation
- forest growth rates
- the proportion of afforestation since 1990 which may be ineligible Kyoto forest because some may have been over-planted onto land which was already defined as forest
- the loss of soil carbon following afforestation of grassland
- future afforestation rates.

The projections also include error bounds around the existing area of Kyoto forests.

Table 11 provides a breakdown of the major contributing factors on which the removal and emission projections are based.

Table 11: Land use, land-use change and forestry projected carbon dioxide removals and emissions (million tonnes carbon dioxide equivalent relative to the most likely scenarios)

Contributing factor	High emissions	Most likely	Low emissions
Total removals from simulations in combined model[1]	57	79	119.3
Less deforestation emissions[2,3]	-41	-21.0(cap)	-21.0(cap)
Removals less deforestation emissions	16	58	98.3
Removals based on afforestation only			
Kyoto planted forest carbon dioxide removals (based on existing 680,900 hectares)	96.8	96.8	96.8
Future afforestation (2007 to 2012) (0, 5,000, 20,000 hectares/year)	0	0.9	1.9
Adjustment factors (see assumptions below for further details)			
Area of Kyoto forest planted between 1990 and 2006 ± 5%	-4.8	0	4.8
Kyoto forest growth rates	-9.8	0	28.4
Soil carbon change with afforestation	-11.3	-3	0
Ineligible afforestation	-20.5	-15.7	-7.8
Total removals from simulations in combined model[1]	57	79	119.3

1 The combined model results account for interrelationships between adjustment factors (forest area, growth rates, soil carbon changes, ineligible afforestation, and scrub clearance during site preparation). The removals attributed to each factor are not additive, because some factors are correlated. For example, the impact of soil carbon decline due to afforestation is –3.0 Mt CO_2 under the most likely new planting assumption, but falls to –2.5 Mt CO_2 under the most likely ineligible afforestation scenario, because the area planted is reduced. Three separate simulations were run using all of the high emissions, most likely emissions and low emissions assumptions respectively to produce the combined model results.

2 Current government policy as at March 2007 is to cap its liability for deforestation of pre-1990 forests at 21.0 Mt CO_2-e.

3 41.0 Mt CO_2-e represents 50,000 hectares which is the base scenario from a deforestation intentions survey carried out in late 2006. An "accelerated deforestation and more" scenario presented in the deforestation report was 65,000 hectares or 53.3 Mt CO_2-e.

5.3.3 Deforestation

Emissions from forecast deforestation for the period 2008 to 2012 are currently projected to be in the range of 21.0 to 41.0 million tonnes carbon dioxide equivalent. The government is currently consulting on policy options to manage deforestation. As at March 2007, in the absence of any new deforestation policy decisions, the 2002 government stated policy[5] of capping the Crown's liability for deforestation of pre-1990 forests at 21.0 million tonnes carbon dioxide equivalent has been used for the most likely and low emissions scenarios in these projections.

[5] Historically, little plantation forest deforestation has occurred in New Zealand. In 2002 the government's publicly stated deforestation policy was to cap liabilities that it would accept for pre-1990 forests at 21.0 million tonnes carbon dioxide equivalent the first commitment period of the Kyoto Protocol. If deforestation looked likely to occur at levels above expectations the government would consider its policy options to manage deforestation emissions within the cap.

Deforestation rates will have a substantial effect on New Zealand's net position during the first commitment period of the Kyoto Protocol. If there are no policy measures put in place to manage the government's liability within the cap then the level of deforestation emissions is likely to be significantly higher than 21.0 million tonnes carbon dioxide.

Furthermore, if the government did not implement policies to manage deforestation in the first commitment period it is likely that some forest owners may bring future (post-2012) deforestation forward into the first commitment period if they believed that post-2012 policy measures to control deforestation were likely to be introduced. A 2006 deforestation intentions survey indicated that between 17,000 and 37,000 hectares of plantation forest was intended to be deforested over the period 2013–2017. Clearly any deforestation brought forward into the first commitment period of the Kyoto Protocol would further increase deforestation emissions beyond the high emissions scenario presented in this report.

5.3.4 Afforestation

The most likely scenario assumes annual afforestation of 5,000 hectares. The low emissions scenario assumes average afforestation of 20,000 hectares per year for the first commitment period of the Kyoto Protocol. The high emissions scenario assumes no further afforestation occurs after 2006. Table 12 below shows the annual afforestation rates used in the 2007 projections.

Table 12: Land use, land-use change and forestry sector future plantation afforestation (hectares)

Calendar year	High emissions	Most likely emissions	Low emissions
2007	0	5,000	7,500
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

5.3.5 Reconciliation with 2006 projection

The most likely scenario of projected net removals of 58.0 million tonnes carbon dioxide equivalent is very similar to the 2006 most likely scenario of 57.2 million tonnes carbon dioxide equivalent.

Removals (less deforestation emissions) have decreased for both the high and low emissions scenarios. For the low emissions scenario the deforestation cap of 21.0 million tonnes carbon dioxide equivalent has been used. In 2006 the low scenario used was 6.3 million tonnes carbon dioxide equivalent for deforestation emissions. The high scenario for deforestation emissions is 41.0 million tonnes carbon dioxide equivalent based on the 2006 deforestation intentions survey results.

Estimates of net removals for the high emissions and low emissions scenarios in 2007 have also changed since 2006 due to an allowance being made for the uncertainty of New Zealand's Kyoto forest area.

5.3.6 Uncertainty

The land use, land-use change and forestry projections need to be used with an understanding of the large uncertainties they contain. These uncertainties are due to the complexity of projecting biological systems which are inherently variable and are also affected by changing economic conditions. These projections are based on currently available information and the current state of scientific knowledge. Every effort has been made to provide the best projections at this time however, future changes in projections are inevitable as economic conditions change, and as new scientific knowledge and improved information become available.

Net removals by the land use, land-use change and forestry sector (that is, removals by post-1990 forests minus deforestation emissions) for the Kyoto Protocol commitment period are projected to be in the range of 16.0 to 98.3 million tonnes carbon dioxide equivalent. The land use, land-use change and forestry sector projections have the largest uncertainty of the five sectors in the net position report.

Table 13: Land use, land-use change and forestry projected carbon dioxide removals and emissions during the first commitment period (million tonnes)

Contributing factor	High emissions	Most likely	Low emissions
Total removals from simulations in combined model[1]	57	79	119.3
Less deforestation emissions[2,3]	-41	-21.0 (cap)	-21.0 (cap)
Removals less deforestation emissions	16	58	98.3

1 The combined model results account for interrelationships between adjustment factors (forest area, growth rates, soil carbon changes, ineligible afforestation, and scrub clearance during site preparation). The removals attributed to each factor are not additive, because some factors are correlated.

2 Current government policy as at March 2007 is to cap its liability for deforestation of pre-1990 forests at 21.0 Mt CO_2.

3 41.0 Mt CO_2 is based on 50,000 ha deforestation which is the base scenario from a deforestation intentions survey carried out in late 2006. For a description on the deforestation intentions survey results refer to Manley, 2006. Details on the calculation of deforestation emissions are available later in this report and in Wakelin et al, 2007.

5.4 Waste

5.4.1 Sector coverage

Greenhouse gas emissions arise from three waste sector sources – solid waste disposal sites, domestic wastewater treatment plants and industrial wastewater treatment plants.

Waste sector emissions in 2005 are now 0.6 million tonnes carbon dioxide equivalent (25.9 per cent) below the 1990 baseline value of 2.5 million tonnes carbon dioxide equivalent.

The reduction in emissions from 1990 to 2005 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.

5.4.2 Projected emissions

Emissions from the waste sector over the first commitment period are expected to range between 6.7 million tonnes carbon dioxide equivalent and 7.3 million tonnes carbon dioxide equivalent. Projected annual emissions for 2010 are expected to lie between 1.34 million tonnes carbon dioxide equivalent and 1.45 million tonnes carbon dioxide equivalent per annum with a most-likely value of 1.4 million tonnes carbon dioxide equivalent.

Since 1990, there has been a large decrease in emissions 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 sectoral emissions despite increasing solid waste volumes and increases in emissions from wastewater treatment.

5.4.3 Reconciliation with 2006 projection

Projected emissions from the waste sector have increased 0.5 million tonnes carbon dioxide equivalent from the 2006 projections due to:

- emissions from wastewater treatment have been revised upwards due to methodological improvements resulting in an increased methane emissions factor
- assumptions regarding the impact of the New Zealand Waste Strategy.

5.4.4 Uncertainty

Upper and lower emissions projections for the first commitment period are based on variations in the outcome of existing waste minimisation and management policies.

5.5 Solvents and other products

5.5.1 Sector coverage

This sector reports emissions from the evaporation of volatile chemicals when solvent based products are exposed to air, during processes such as chemical cleaning substances used in dry cleaning, printing, metal degreasing and a variety of industrial and household uses. Also included are emissions from paints, lacquers, thinners and related materials.

The sector is a minor contributor to New Zealand's total greenhouse gas emissions, being responsible for just 0.03 million tonnes carbon dioxide equivalent of emissions (less than 0.1 per cent of total emissions).

5.5.2 Projected emissions

Emissions from the solvents and other product use sector is estimated by a simple linear extrapolation of emissions reported in the greenhouse gas inventory from 1990 to 2005. Total emissions are projected to be 0.3 million tonnes carbon dioxide equivalent during the first commitment period of the Kyoto Protocol.

5.5.3 Reconciliation with 2006 projection

Changes in projected emissions from solvents and other products cannot be observed at the one decimal place level of reporting.

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Annex A: Agriculture Emissions Projections provided by Ministry of Agriculture and Forestry

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 uncertainties that exist. This uncertainty is due to the complexity of forecasting biological systems which are inherently variable and are affected by climate and changing economic conditions. While every effort has been made to provide the best projections as at June 2007, future changes in projections are inevitable to reflect changes in economic conditions, international commodity prices and exchange rates.

Table A1: Summary of 2007 annual emission projection scenarios for 2010

	1990 Baseline (*Mt CO_2-e)	2005 Most current (Mt CO_2-e)	2010 Lower scenario (Mt CO_2-e)	2010 Most likely (Mt CO_2-e)	2010 Higher scenario (Mt CO_2-e)
Total projected emissions	32.50	37.45	36.00	40.62	45.66
Projected emissions above 1990			3.50	8.12	13.16
Per cent change from 1990			10.8	25.0	40.5

Figures based on 2005 National Greenhouse Gas Inventory methodology.

* Million tonnes carbon dioxide equivalents.

* Figures may not add due to rounding.

Summary

Total emissions from the agriculture sector are projected to range from 180.00 Mt CO_2-e to 228.30 Mt CO_2-e over the first Commitment Period (2008–2012) of the Kyoto Protocol, with a most likely value of 203.10 Mt CO_2-e. Average annual emissions over the first commitment period are projected to range from 37.45 Mt CO_2-e to 45.66 Mt CO_2-e with a most likely value of 40.62 Mt CO_2-e.

The most likely value for annual emissions at 2010 is 0.86 Mt CO_2-e higher than was projected in 2006 and 4.30 million tonnes higher over the Commitment Period. The difference between the lower and higher scenarios is now 9.66 Mt CO_2-e compared to 8.40 Mt CO_2-e in the 2006 forecast estimates.

The increase in emissions compared to the 2006 projections is mainly attributable to the higher forecast of dairy cow numbers as a consequence of current high world commodity prices for dairy products. The projected impact of the improved dairy payout announced in May 2007 has been taken into account in these projections.

These projections are forecasts of future agriculture greenhouse gas emissions. Forecasts are greatly influenced by prevailing conditions. As such these projections need to be assessed within the uncertainties of biological systems affected by climate and 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 June 2007 however, future changes in projected emissions are inevitable to allow for future changes in economic conditions and other factors.

Introduction

These projections are based on the methodologies used in the National Greenhouse Gas Inventory submitted to the United Nations Framework Convention on Climate Change (UNFCCC) annually and on econometric and physical models developed by the 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:

- animal numbers by species: dairy cattle, beef cattle, sheep and deer in 2010 using the the Ministry of Agriculture and Forestry Pastoral Supply Response Model (PSRM)
- ruminant methane emissions per animal based on changes in past emissions per animal between 1990 and 2005
- nitrogen output per animal based on changes in past nitrogen output per animal between 1990 and 2005
- nitrogen fertiliser use based on an econometric model that projects future use from projected animal numbers, fertiliser prices and other variables (output prices, agricultural productivity growth).

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

The table below provides a summary of the forecasts developed last year (2006) for the net position for agriculture in 2010. The 1990 baseline emissions are slightly different between the two net projection years due to improved methodologies.

Table A2: A summary of 2006 projection scenario emissions for 2010

	1990 Baseline (*Mt CO_2-e)	2010 Lower scenario (Mt CO_2-e)	2010 Most likely (Mt CO_2-e)	2010 Higher scenario (Mt CO_2-e)
Total projected emissions	32.12	36.06	39.76	44.45
Projected emissions above 1990		3.94	7.64	12.33
Per cent change from 1990		12.3	23.8	38.4

* Million tonnes carbon dioxide equivalents.

The significant increase in payout to dairy farmers announced by Fonterra in May 2007 necessitated a reanalysis of the projections.

Changes in methodology since last year's assessment

Changes in estimation methodologies have been implemented to take into account new approaches and information obtained since the last update in May, 2006. Overall these methodological changes led to a reduction of emissions in excess of 1990 levels.

Changes were implemented in two areas:

- The projection of nitrogen fertiliser usage in 2010 was based on an improved methodology developed by the Ministry of Agriculture and Forestry. This resulted in a 6 per cent increase in nitrogen fertiliser use projections.
- Updating of the National Greenhouse Gas (GHG) Inventory methodology in keeping with UNFCCC guidance for maintaining "Good Practice". Two changes were implemented in the agricultural section of the National Greenhouse Gas Inventory in 2007, in which the 2005 emission levels are reported. These were:
  - The crop residue burning fraction for 2005 was reduced from 50 per cent to 30 per cent based on updated expert advice. This change had a minor impact on emissions output.
  - The commencement of the period over which animal emissions are reported was changed from a July to June year to a January to December year, commencing in January 1989 as three-year averages are used to derive animal populations. This change resulted in an approximate 1 per cent increase in the 1990 emissions levels for agricultural methane and nitrous oxide.

Development of the most likely scenario

Projections of most likely animal population in 2010

The PSRM is used to obtain projected animal numbers. It is also currently used for livestock projections that contribute to the New Zealand Treasury's twice yearly economic and fiscal updates. PSRM is a system of equations that capture the biological and market behaviours of the New Zealand pastoral sectors (dairy, beef, sheep, and deer). Changes in livestock inventory are derived from exogenous shocks to the model that includes real farm-gate prices and weather.

Baseline scenario

The Ministry of Agriculture and Forestry livestock forecasts provide farm-gate price forecasts out to 2020. These forecasts take into account the macro-economic assumptions (eg, economic growth, exchange rate, inflation) provided by Treasury's Budget Economic and Fiscal Update (BEFU) 2007 and the international supply and demand factors which subsequently affect international commodity prices. The significantly higher dairy farm product price, announced by Fonterra in May 2007, was used to derive the model projections.

The weather variable in the PSRM uses the Daily Soil Moisture Deficit (DSMD) series supplied by the National Institute of Water and Atmospheric Research. For the forecast period (2007–2020), DSMD uses the average value over the 1973–2006 period.

The price assumptions are exogenous in PSRM. Information from experts in the forestry sector suggests that land conversion to forestry only marginally impacts on the pastoral sector.

Table A3: Projected most likely animal numbers in 2010

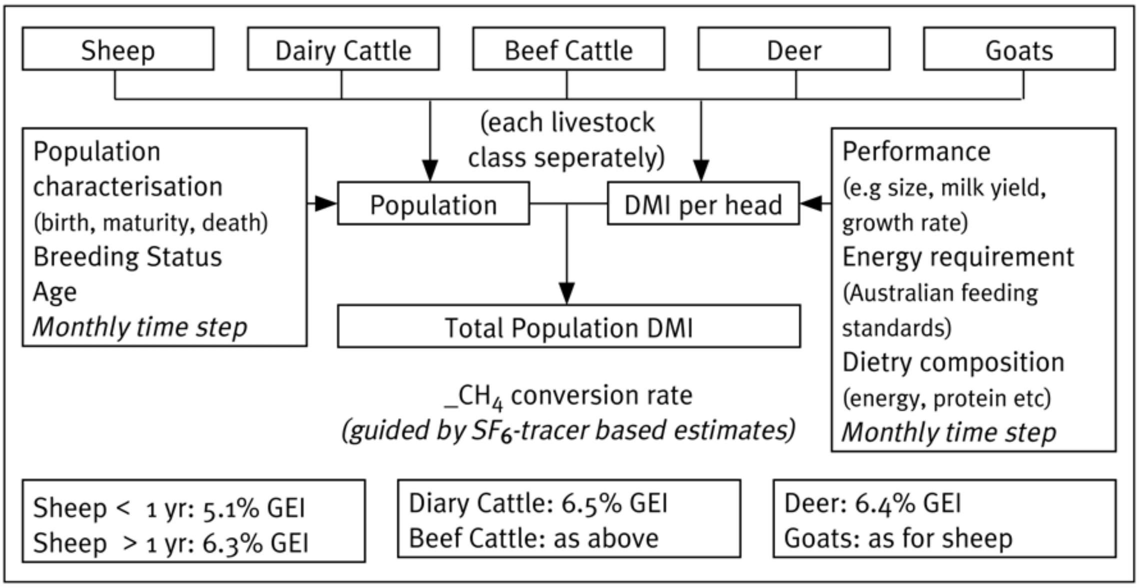
	1990 baseline (000)	2010 most likely scenario (000)
Dairy cattle	3,391	6,107
Beef cattle	4,597	4,115
Sheep	57,861	37,023
Deer	1,036	1,457

Projections of ruminant methane emissions

Projections of methane emissions per animal in 2010 are derived from linear trends of the methane emissions per animal from 1990 to 2005 and then extrapolated to 2010 (Table A4). The 1990–2005 values are those used in the national greenhouse gas inventory.

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 A1).

Figure A1: Model for deriving ruminant methane emissions (Clark *et al*, 2003)



DMI: Dry Matter Intake
GEI: Gross Energy Intake

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 deer, beef and dairy cattle, 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.

Table A4: Estimated per animal methane emissions in 1990 and 2005, and projected most likely methane emissions per animal in 2010

	1990 (kg CH_4/head/annum)	2005 (kg CH_4/head/annum)	2010 projected (kg CH_4/head/annum)
Dairy cattle	70.11	78.72	82.35
Beef cattle	51.23	57.49	59.53
Sheep	9.25	11.01	11.71
Deer	19.23	21.90	23.33

Methane from ruminant animal waste

Methane emissions also arise from faecal material deposited on pasture and, in the case of lactating dairy cows, from animal waste management systems. The projected methane emissions factor for each animal species in 2010 is derived from the trend over time from 1990 to 2005 (Table A5).

Table A5: Estimated per animal waste methane emissions in 1990 and 2005, and projected most likely methane emissions from animal waste in 2010

	1990 (kg CH_4/head/annum)	2005 (kg CH_4/head/annum)	2010 projected (kg CH_4/head/annum)
Dairy cattle	2.920	3.350	3.470
Beef cattle	0.624	0.701	0.725
Sheep	0.090	0.109	0.116
Deer	0.175	0.198	0.211

Projections of 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 from linear trends of nitrogen output per animal using data in the national inventory for the period 1990 to 2005 (Table A6). Nitrous oxide emissions are then calculated using the methodology used for the national greenhouse gas inventory.

Table A6: Estimated per animal nitrogen output in 1990 and 2005, and projected most likely nitrogen output per animal in 2010

	1990 (kg N/head/annum)	2005 (kg N/head/annum)	2010 projected (kg N/head/annum)
Dairy cattle	104.90	115.91	120.24
Beef cattle	66.16	74.28	76.97
Sheep	12.60	15.18	16.15
Deer	25.10	28.65	30.64

Projections of nitrogen fertiliser use

A new model has been developed for projecting nitrogen fertiliser usage. The new model better reflects the factors that influence nitrogen fertiliser use on farm (see Austin *et al*, 2006). Compared with the nitrogen fertiliser model used for the 2006 net projections (which only took into account dairy cow and heifer numbers), the new model takes into account the impacts on nitrogen fertiliser use of changes in the price of nitrogen fertiliser, product output prices, and agricultural productivity growth. This model is incorporated into the PSRM to produce the most likely, high, and low forecasts for nitrogen fertiliser use.

The projected most likely volume of nitrogen fertiliser usage in 2010 is **427,655** tonnes N.

The most likely nitrogen fertiliser use forecast for 2010 is higher than the 2006 net projection nitrogen fertiliser use forecast (403,709 tonnes). This is mainly due to higher dairy prices leading to higher composite output prices and higher dairy cow numbers.

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, horses, goats, pigs, and poultry. This was also the case for nitrous oxide emissions from crop stubble burning, savannah burning and nitrogen fixing crops. These emission sources make up less than 1.5 per cent of agricultural sector emissions in 2005. There was no basis to assume that any of these emission sources would be significantly different 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 2005 inventory emission values were used for the 2010 projections.

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 for animal numbers, methane emissions per head, nitrogen output per head and nitrogen fertiliser use. These two scenarios give an estimate of the values of the upper and lower bounds of future projected emissions at the 95 per cent confidence level.

Animal numbers

To derive livestock forecasts for different scenarios, exogenous price uncertainty is introduced into the PRSM model. Price uncertainty is introduced into the simulation through specifying the possible movements in commodity prices for the forecast period. Variation of prices (or the standard deviation of the 95 per cent confidence level) 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 the movement in prices (Table A7).

Table A7: Lower and higher scenarios of animal number projections in 2010

	Lower 2010 (000)	Most likely 2010 (000)	Higher 2010 (000)
Dairy cattle	5,806	6,107	6,409
Beef cattle	3,578	4,115	4,651
Sheep	34,350	37,023	39,678
Deer	1,110	1,457	1,907

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 2005. 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: Lower and higher scenarios of per animal methane projections in 2010

	Lower 2010 ($kgCH_4$/head/annum)	Most likely 2010 ($kgCH_4$/head/annum)	Higher 2010 ($kgCH_4$/head/annum)
Dairy cattle	80.90	82.35	83.79
Beef cattle	58.53	59.53	60.52
Sheep	11.46	11.71	11.96
Deer	22.58	23.33	24.08

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 2005. This provided an upper and lower bound for projected nitrogen output per head in 2010 (Table A9).

Table A9: Lower and higher scenarios of per animal nitrogen output projections in 2010

	Lower 2010 (kg N/head/annum)	Most likely 2010 (kg N/head /annum)	Higher 2010 (kg N/head/annum)
Dairy cattle	118.20	120.24	122.29
Beef cattle	75.48	76.97	78.46
Sheep	15.74	16.15	16.56
Deer	29.75	30.64	31.54

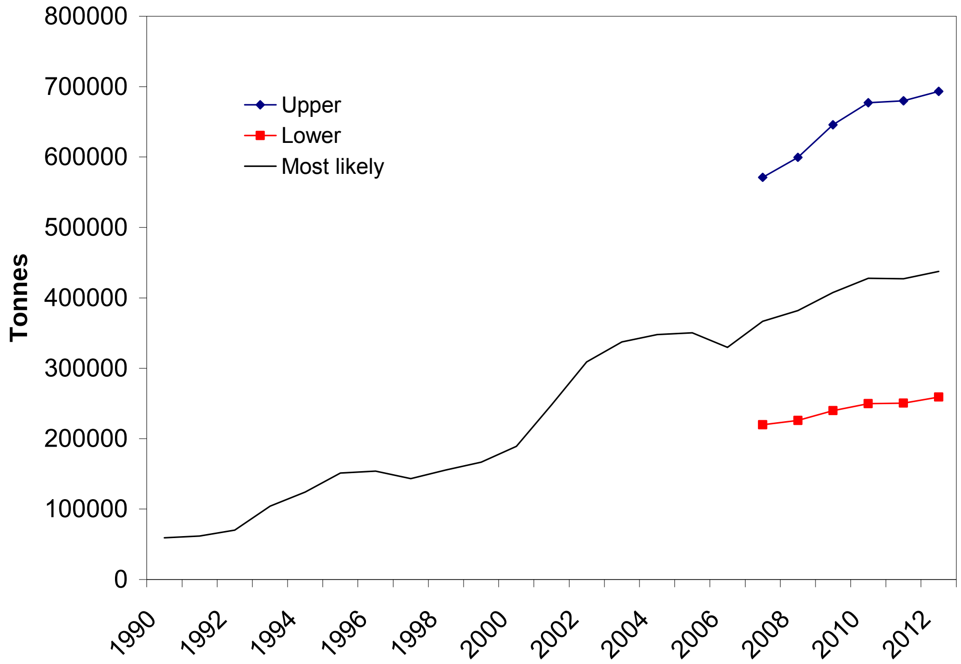
Nitrogen fertiliser

Lower and higher scenarios for future nitrogen fertiliser use were obtained from the lower and higher projections of dairy animal numbers derived within the PSRM model. These are presented in Table A10 and Figure A2.

Table A10: Lower and higher bounds of projected nitrogen fertiliser use in 2010

Lower 2010 (tonnes N per annum)	Most likely 2010 (tonnes N per annum)	Higher 2010 (tonnes N per annum)
249,820	427,655	677,048

Figure A2: Nitrogen fertiliser use forecast



Impact of recent changes in dairy payout prices

The significant increase in payout to dairy farmers announced by Fonterra in May 2007 necessitated a reanalysis of the projections using June 2007 prices. Earlier analysis used Treasury Half Yearly Economic and Fiscal Update in December 2006. **(**HYEFU06).

The outcome resulted in a small change in emissions, but a rebalancing of animal numbers with greater dairy animal numbers and significantly fewer sheep. There were smaller increases in beef and deer numbers (Table A11).

Table A11: Change in projected animal numbers due to increased dairy payout

	Forecasts of most likely animal numbers to 2010 using HYEFU06 prices (000)	Forecasts of most likely number to 2010 using June 2007 prices* (000)
Dairy	5,932	6,107
Beef	4,029	4,115
Sheep	40,242	37,023
Deer	1,365	1,457

* Treasury BEFUO7 assumptions and MAF Situation and Outlook for NZ Agriculture and Forestry 2007 price assumptions.

Overall assumptions and limitations of the projections

These projections need to be assessed within the uncertainties of biological systems and economic circumstances of the agricultural industry, which is largely driven by overseas markets. For example, an assumption implicit in the projections is that the rate of increase in productivity per animal over the next five years will not be dissimilar to the rate of increase in animal performance over the past 15 years, and therefore a linear extrapolation of methane emissions per animal is appropriate. It is possible that the rate of increase in animal performance may decline over time. To test this, other non-linear relationships were looked at; however no significant improvement in relationship was gained. However, the current per animal productivity of New Zealand dairy cows is significantly lower than European and American animals, and has a significant way to go before it reaches these productivity levels.

Mitigation technologies that reduce emissions at an individual animal level may emerge over the next five years. These include products such as the nitrification inhibitor dicyandiamide (DCD) that has been shown to reduce nitrous oxide emissions in grazed pastures. None of these mitigation technologies have been factored into the projections as they may not be widely adopted by 2010 and may be counter balanced by greater increases in animal numbers and 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 met.

In terms of nitrogen fertiliser usage, future changes such as limitations on nitrogen fertiliser use in some catchments, eg, Lake Taupo and Lake Rotorua, the conversion of pastoral land to forestry, the Dairying Clean Streams Accord, regional council initiatives, industry codes of practice and the increasing price of nitrogen fertiliser, are likely to limit another steep upward trend in fertiliser nitrogen usage apparent during the period 1992 to 2003.

On the other hand, the recent increase in commodity product prices, particularly for dairy products, is likely to lead to more nitrogen fertiliser being applied. Nitrogen fertiliser still provides the least-cost means of securing additional dry matter production. Also the clover root weevil, a pest found in New Zealand in 1996, is reducing nitrogen fixation by clover, New Zealand's main source of nitrogen for pastures. The response of some affected farmers has been to increase the use of nitrogen fertiliser and feed supplements.

References

Austin D, Cao K, Rys G, 2006. *Modelling Nitrogen Fertiliser Demand in New Zealand.* Paper presented at the New Zealand Agricultural and Resource Economics Society conference, Nelson.

Clark H, Brookes I, Walcroft A, 2003. *Enteric Methane Emissions for New Zealand Ruminants 1990–2001 Calculated Using an IPCC Tier Two Approach.* Report prepared for the Ministry of Agriculture and Forestry by AgResearch Ltd.

Ministry of Agriculture and Forestry, 2007. *Briefing on Methodology for Forecasting Livestock Numbers and Nitrogen Fertiliser Use*, 8 pp.

Annex B: Energy and Industrial Processes Emissions Projections provided by Ministry of Economic Development

1 Introduction

1.1 Scope coverage of emissions

This report covers emissions from energy (including transport) and industrial processes. Total greenhouse gas emissions from the energy sector are calculated by the Ministry of Economic Development. For industrial processes carbon dioxide estimates by the Ministry of Economic Development are supplemented by Ministry for the Environment estimates of other associated greenhouse gas emissions.

1.2 Recent trends

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

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

The transport sector contributes a large portion of all emissions from the energy 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 the two major liquid fuels of petrol and diesel as well as increased use of aviation fuels.[6]

Industrial processes contribute around six per cent of New Zealand's total greenhouse gas emissions. There are six major industrial processes that are represented in this sector:

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

The industrial processes sector is dominated by emissions from the metal industry.

6 *New Zealand's Greenhouse Gas Inventory 1990–-2004*, New Zealand Climate Change Office, April 2006, http://www.climatechange.govt.nz/resources/reports/nir-apr06/html/page5.html

1.3 Key drivers of emissions

In general, changes in energy emissions in New Zealand tend to be closely 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 from both coal and gas in a 'dry' hydro year. The reverse occurs in a 'wet' hydro year. This is a different trend to the steady increase in emissions from coal and gas fuelled electricity generation found in many other countries.

Fluctuations in the price of oil products have only a limited impact on changes in the level of greenhouse gas emissions in New Zealand. While there is a historic relationship between transport fuel prices and fuel consumption in New Zealand, consumption volumes change relatively little as a result of a change in fuel price. For example, recent government energy forecasts in New Zealand have used long run price elasticities of demand of 0.19 for petrol and 0.13 for diesel.[7]

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). 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.

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.

Modelling carbon dioxide (CO_2) emissions from combustion is fairly straightforward, since the output of CO_2 depends only on the amount of each type of fuel being burned. Emissions of other greenhouse gases and of CO_2 from non-combustion activities are more complicated to estimate. They depend both on the amount of fuel and on the way the fuel is used.[8]

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7 *Costs and Benefits of Mandatory Biofuel Blends in Transport Fuels*, NZIER (report prepared for MED), http://www.med.govt.nz/templates/MultipageDocumentPage____8072.aspx, 2004.

8 *New Zealand's Energy Outlook to 2030*, MED, September 2006, p 11.

2.2 Improvements to modelling since net position 2006

Since the net position 2006 report, a number of enhancements have been made:

- actual data for 2005 and where possible actual data for 2006 has been incorporated
- the 'Other Industrial and Commercial' model has been disaggregated into two separate sectoral models for 'Commercial' and 'Other Industrial'
- demand elasticities have been incorporated into the new 'Commercial' and 'Other Industrial' models
- enhancements have been made to modelling on-road transport, utilising the Ministry of Transport's Vehicle Fleet Emissions Model[9]
- enhancements have been made to the fugitive emissions model.

2.3 Specific assumptions

This section provides a brief overview of the key assumptions used. Where possible, an effort has been made to align modelling assumptions across government, and with the assumptions underpinning the New Zealand Energy Strategy (NZES). Macroeconomic inputs are in line with Treasury projections, dairy herd projections are supplied by Ministry of Agriculture and Forestry and price assumptions for fuel commodities are consistent with those used in NZES.

2.3.1 Key assumptions for the net position 2007 most-likely scenario

Table B1: Key assumptions for the net position 2007 most-likely scenario

Year	Economic growth (GDP real) Per cent per annum	Exchange rate NZ$/US$	Oil prices $US/bbl
2006	1.5	0.666	60
2007	2.3	0.634	60
2008	2.9	0.600	60
2009	3.2	0.572	60
2010	3.0	0.548	60
2011	2.7	0.543	60
2012	2.4	0.543	60

2.3.2 Coal

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

2.3.3 Gas

Gas is assumed to be readily available in the CP1 period.

Gas prices are determined within SADEM, and increase in response to depleting domestic reserves.

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9 *New Zealand's Energy Outlook to 2030*, MED, September 2006, p 11.

2.3.4 Methanex

Methanex is the gas-to-methanol operation in Taranaki. Based on recent experience Methanex's smaller Waitara Valley plant is assumed to continue operating until 2009.

The continuing operation of the Methanex plant is a specific change from net position 2006 assumptions.

2.3.5 Energy efficiency measures

Energy efficiency policies that have been fully implemented include energy efficiency improvements driven by the existing National Energy Efficiency and Conservation Strategy (NEECS), local government initiatives, and the energy-intensive business programme. As in the net position 2006 report, and based on the AEA Technology 2005 review, energy efficiency gains are explicitly represented within the SADEM energy projection.

Residential energy efficiency improvements were estimated to provide 1.70 PJ of energy savings per year and other industrial and commercial sectors were estimated to achieve 2.34 PJ of energy savings per year during the first commitment period.

2.3.6 Fossil fuels levy

A fossil fuels levy is not modelled. This is consistent with net position 2006 reporting.

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. The majority of the eligible projects are in the electricity generation sector.

In consultation with the Electricity Commission, only plants which are sufficiently advanced[10] are included – in that they are likely to be installed and in operation over the commitment period – regardless of whether they qualify for PREs or not.

2.3.8 Heavy industries

The heavy industries section is under continuing review[11] and sector specific discussions take place at various times. Assumptions of specific relevance are:

- steel – assume constant production
- aluminium – assume constant production
- petrochemical – limited methanol production will continue into the First Commitment Period (CP1); ammonia and urea production forecasts have not changed since net position 2006

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[10] Based on economics, resource consent status, and discussions with industry players.

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

- forestry – the energy demand projections for pulp and paper, sawmill, and panel products have been incorporated from the heavy industry report[12]
- Dairy – the dairy model takes in livestock projections (provided by the Ministry of Agriculture and Forestry) and projects the energy required to process the resulting milk solids from the number of given livestock. This is discussed further in section 2.3.12.

2.3.9 Other transformation

Refinery expansion from 2009 is included. This is consistent with net position 2006.

2.3.10 Solar water heating

An approximate saving of 2,100 kWh[13] per unit per year is assumed for net position 2007. The number of installations per year over the first commitment period as a result of the government's programme is estimated as follows.[14]

Table B2: Number of installations per year over first commitment period

Year	Number of additional units installed	Total energy savings (GWh)
2007/2008	5,000	10.5
2008/2009	6,000	12.6
2009/2010	7,000	14.7
Total	18,000	37.8

As discussed in section 3.1.2, the government's programme is currently 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.

2.3.11 Biofuels sales obligation

In deriving the emissions expected from land transport we assume that the government's proposed biofuel sales obligation levels are met.[15] This obligation will require that biofuel sales achieve yearly mandatory levels from 2008, reaching at least 3.4 per cent of total diesel and petrol sales by 2012. For modelling purposes it is assumed that this fuel will be used by the transport sector and that the tail-pipe CO_2 emissions produced from this fuel will not be counted for the net position. However, CH_4, and N_2O emissions produced from this fuel will be counted for the net position.

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

[13] 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.

[14] Based on Proposed Programme to Increase the Uptake of Solar Water Heating, and advice from EECA.

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

Further assumptions include:

- bio-diesel is assumed to supply 70 per cent of the sales obligation as it is expected that this fuel will be the most economic over this timeframe[16]
- all biofuel will be produced domestically
- domestic biofuel production will produce additional energy demand and emissions which are accounted for in the net position. These emissions are modelled as being equivalent (on a fossil fuel basis) to 54 per cent additional for bio-diesel and 11 per cent additional for bio-ethanol.[17]

2.3.12 Dairy herd numbers

Dairy herd numbers are based on the Ministry of Agriculture and Forestry's medium growth scenario projections.[18] SADEM uses the Ministry of Agriculture and Forestry's dairy projections as an input into calculating the growth of the productive dairy herd. the Ministry of Agriculture and Forestry's dairy projections have been revised since 2006, increasing energy demand for the dairy sector during CP1. Overall, the increase in projected figures has resulted in a 19.35 per cent increase in energy demand for the dairy sector during CP1, from 153 PJ to 183 PJ.

2.3.13 Transport model

In the net position 2006 report, projections of energy use in land transport were generated by SADEM. SADEM contains separate models for energy and fuel use in land (ie, motor vehicle and rail), sea and air transport. All of these models operate in a 'top-down' manner, and make projections of future demand by fitting relationships between historical fuel use, GDP, and fuel price.

In net position 2007, the Vehicle Fleet Emissions Model (VFEM) has been used to enhance the SADEM projections. The VFEM is capable of modelling changes to New Zealand's on-road vehicle fleet, including the number of vehicles, kilometres travelled per vehicle and average fuel economy. This more detailed modelling adds a level of refinement to estimates of on-road transport energy demand. It also allows an improved estimate to be made of the fuel used by 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.

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16 Fuels and Crown Resources, MED.

17 Enabling Biofuels: Biofuel Economics 2006 COVEC report for MoT, http://www.mot.govt.nz/assets/NewPDFs/Covec-Biofuels-Economics-Final-Report-16.06.06.pdf

18 Supplied by Ministry of Agriculture and Forestry.

2.3.14 Commercial and other industrial models

In 2007, SADEM includes separate models for the commercial and other industrial sectors.

Table B3: Energy demand sectors and modelling techniques

Major demand sector	Sub-sector	Model	Net energy (PJ 2010)	Percentage
Residential demand	Residential	Multivariate, GDP, price, heating and cooling degree days, lagged demand	59.0	10.9
Industrial and commercial demand	Forestry	Industry specific forecasts	49.6	9.2
	Petrochemicals and refining	Company forecasts	17.4	3.2
	Metals	Industry specific forecasts	39.9	7.4
	Dairy	MAF forecasts (as input)	31.8	5.9
	Other industrial	Multivariate, GDP, lagged demand	49.6	9.2
	Commercial	Multivariate, GDP, lagged demand	46.8	8.7
Transport demand	Land	On-road: VFEM MoT/MED forecast Off-road: Multivariate	216.2	40.1
	Sea	Ordinary least squares	11.4	2.1
	Aviation	Ordinary least squares	17.7	3.3
Total			539.5	100.0

3 Policies

3.1 New policies in place

Since the net position 2006 report, the government has introduced two new policy measures that are likely to have an impact mainly on emissions from the transport and stationary energy sectors.

3.1.1 Biofuels sales obligations

During February 2007, Cabinet agreed that an obligation would be placed on oil companies to supply biofuels equal to a proportion of their sales of petrol and diesel. Introduced progressively from April 2008, the sales obligation will increase to 3.4 per cent of petrol and diesel sold by oil companies by 2012. The obligation is on a calendar year basis, and for the first year applies only to the nine months from 1 April to 31 December. For the first two years, companies will be allowed to carry their obliged sales forward into the following year. The carrying forward of obliged sales may incur a 5 per cent penalty at the discretion of the Minister of Energy. Companies not meeting their obligations will face financial penalties.[19]

[19] Biofuels Sales Obligation, CAB Min (07) 4/2, http://www.mot.govt.nz/biofuels-440-index/

The volume of biofuel sales required is dependent on a decision by the Environmental Risk Management Authority (ERMA) on the requirement for double containment storage tanks for ethanol/petrol blends.[20] On 16 May 2007, ERMA announced that it had relaxed the rules for storing petrol ethanol blends of up to 10 per cent ethanol by removing the requirement that the fuel must always be stored in double-skinned underground tanks.[21]

3.1.2 Solar water heating programme

In November 2006, the government agreed to a five-and-a-half-year solar water heating programme. The programme includes investment of $15.5 million for the first three and a half years in addition to existing funding already provided through the Energy Efficiency and Conservation Authority. Funding levels for the final two years will be decided after a review in 2009.

The proposed programme will increase demand through information, demonstration and promotional programmes, and direct financial incentives. This will be supported by measures to strengthen the industry's ability to respond to increased demand by delivering quality, cost-effective installations. The programme includes:

- providing independent information to help consumers decide whether solar is suitable for them, and what kind of system they need
- motivating demand through promotion
- improving quality and cost effectiveness by working with industry including setting standards and encouraging training opportunities
- providing financial assistance to home owners
- putting more solar water heating systems into government buildings
- encouraging new ideas through an Innovation Fund.

This overview of the programme refers only to the first three and a half years, although it is likely that many of these activities would be continued into the final two years.[22]

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[20] *Enabling Biofuels: Biofuel distribution options*, Hale & Twomey (for Ministry of Transport), March 2006, http://www.transport.govt.nz/assets/NewPDFs/Biofuels-Distribution-Report-Final.pdf, p i.

[21] ERMA New Zealand relaxes rules on storage of petrol-ethanol http://www.ermanz.govt.nz/news-events/archives/media-releases/2007/mr-20070516.html.

[22] EECA, http://www.eeca.govt.nz/renewable-energy/solar/programme-outline.html.

3.2 Impact of policies on net position

Only policies on which Cabinet has made a substantive decision prior to 28 February 2007 have been considered.

Table B4: Expected impact of government policies

Policy	Expected impact during CP1
Projects to reduce emissions	A reduction in emissions from the energy sector, particularly from electricity generation. PREs provide incentives to build renewable generation sources.
NEECS measures	A reduction in emissions from the residential, commercial and other industrial sectors.
Biofuels sales obligation	An overall reduction in CO_2 emissions from the transport sector. This may be partially offset by the additional fossil fuel energy required to produce biofuels.
Solar water heating programme	A reduction in emissions, by reducing residential demand for electricity.

4 Emissions projection

4.1 Total emissions by sector, net position 2007

Total emissions from the energy and transport sectors are projected to be 172.9 Mt of CO_2 equivalent for the first Kyoto Commitment Period.

Table B5: Emissions (kt CO_2 equivalent)

Year	Energy (excluding transport)	Transport	Industrial processes	Total
2008	18,509	15,463	4,384	38,356
2009	18,645	15,760	4,415	38,819
2010	18,240	16,046	4,445	38,731
2011	18,543	16,260	4,473	39,276
2012	18,847	16,572	4,499	39,918
Total CP1	**92,783**	**80,101**	**22,217**	**195,101**

For the industrial processes, the Ministry of Economic Development models carbon dioxide emissions from industrial processes only. Total CO_2 emissions from industrial processes are provided to the Ministry for the Environment as an input to the modelling of overall greenhouse gas emissions from industrial processes. The Ministry for the Environment increases carbon dioxide emissions by 19 per cent to adjust for non-carbon dioxide greenhouse gases. CO_2-e emissions from the industrial processes are included in the table above.

Table B6: Carbon dioxide emissions from industrial processes

Year	Industrial processes (kt CO_2)
2008	3,684
2009	3,710
2010	3,735
2011	3,759
2012	3,781
Total CP1	**18,670**

4.2 Total emissions for energy and transport sectors (excluding industrial processes)

Net position 2006 (most-likely case) versus net position 2007 (most-likely case), 2008–12

Projected emissions from the energy and transport sectors (excluding industrial processes) are 2.8 Mt of CO_2 equivalent (or 1.6 per cent) higher than in the net position 2006 most likely scenario.

Table B7: Emissions (kt CO_2 equivalent)

Year[1]	2006 net position (mid-case)	2007 net position	Difference
2008	32,733	33,972	1,239
2009	33,480	34,405	925
2010	34,129	34,286	157
2011	34,640	34,803	163
2012	35,137	35,419	282
Total CP1	**170,119**	**172,884**	**2,765**

The increase in total greenhouse gas emissions from energy and transport is the result of a number of changes since net position 2006:

- in net position 2007, Methanex is assumed to operate until 2009, which has increased emissions from the petrochemicals sub-sector. In net position 2006, Methanex was assumed to cease production prior to the start of CP1
- revised Ministry of Agriculture and Forestry dairy herd projections used in modelling are higher than those used in net position 2006, resulting in higher emissions from the dairy sector
- enhancements to the ‘Other Industrial’ and ‘Commercial’ models since net position 2006 have resulted in higher emissions from these sectors in net position 2007
- the use of the Vehicle Fleet Emissions Model (VFEM) to enhance on-road transport emissions has increased emissions from the transport sector in net position 2007. VFEM was not used in modelling work for net position 2006.

A number of factors have contributed to lower emissions from some sectors in net position 2007, partially offsetting the increase:

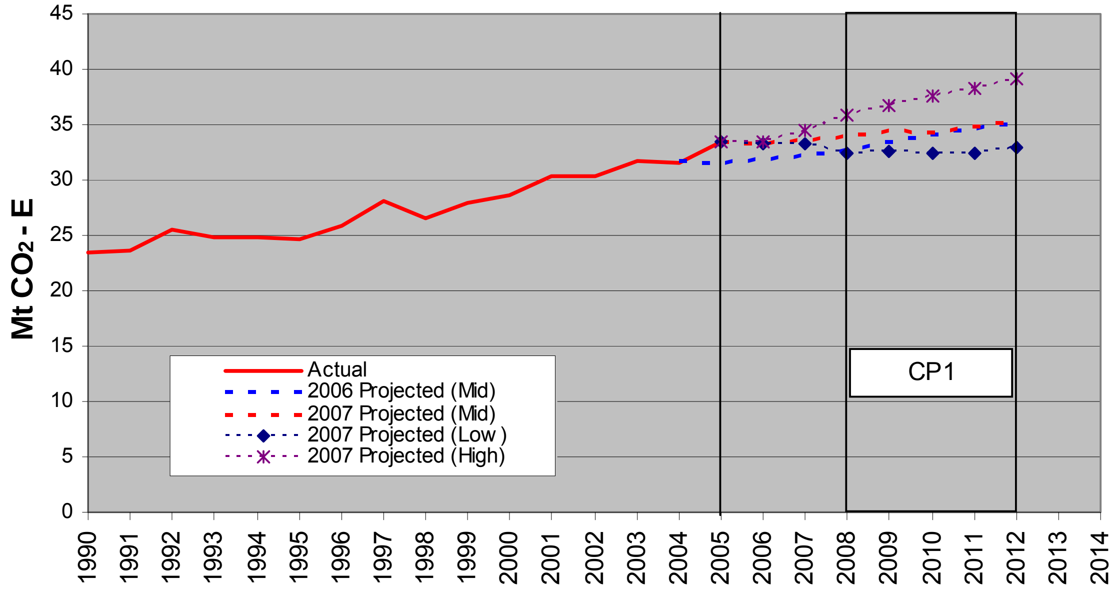
- in the electricity sector there is increased certainty on commissioning of new renewables, increased confidence in the availability of gas through CP1, and E3P (the new gas-fuelled combined cycle plant at Huntly) is in the final stages of commissioning. These factors, combined with reducing flexibility in supply of gas result in more gas-fired generation relative to coal-fired generation
- the inclusion of recent actual data for air and sea transport has slightly decreased emissions from these sectors
- enhancements to the fugitive emissions model have led to decreased emissions from this sector.

Emissions from energy and transport (excluding industrial processes)

Net position 2006 (most-likely case) versus three scenarios of net position 2007, 1990–2012

The figure below shows the result of net position 2007 projections compared to the net position 2006 most likely scenario. The graph also includes the low and high scenarios for net position 2007 discussed in section 4.4.

Figure B1: Emissions from energy and transport (excluding industrial processes)



Note that actual emissions in 2005 were higher than an expected average due to relatively dry hydrological conditions and consequently higher thermal electricity generation.

4.3 Uncertainty reporting and sensitivity analysis

The following is a non-exhaustive list of conditions that could affect actual outcomes for the First Commitment Period (CP1) of the Kyoto Protocol to the United Nations Framework Convention on Climate Change:

- overall New Zealand economy performance (rapid growth or recession)
- impact of government policy measures, such as the New Zealand Energy Strategy
- success of various energy efficiency programmes
- fluctuations in international oil, coal and gas prices
- fluctuations in international commodity prices
- negotiated outcomes between fuel suppliers and electricity generators, who may switch fuels depending upon their price and availability
- emissions from electricity generation may fluctuate from year to year due to changing hydrological conditions
- decisions to build additional renewable plant before 2012
- constraints on gas supplies
- fuel mix for industrial sector expansions.
- decisions by industrial consumers to locate operations overseas
- impacts on competitiveness of New Zealand industry due to exchange rate fluctuations (especially dairy and forestry)
- uncertain consumer response to changes of oil price (such as buying smaller size cars, diesel cars, or use of public transport)
- physical disasters impacting energy facilities or major energy consumers, such as:
  - major breakdown of electricity generator
  - major breakdown of HVDC link
- pandemic or natural disaster
- the continued operation of the Methanex methanol plant during CP1.

In 2007, ‘high’ and ‘low’ emissions scenarios were run to provide an indication of the range of uncertainty in the projections. The table below presents the results of these two scenarios, compared to the 2007 ‘most likely’ scenario.

Table B8: 'High' and 'low' emissions scenarios compared to 2007 'most likely' scenario

Scenario	Assumptions	Total emissions from energy and transport during CP1 (CO_2 – e)
Low emissions scenario	• Low GDP growth • Low exchange rate • Low population growth • Low dairy numbers • Methanex not operating • Biofuels obligation exceeded • Energy efficiency gains increased • Wet hydrological conditions	162.8 Mt (–10.1 Mt compared to 2007 'most likely' case)
High emissions scenario	• High GDP growth • High exchange rate • High population growth • No additional gas discoveries • High dairy numbers • Methanex Motonui plant running • No biofuels • No energy efficiency and conservation • No solar water heating programme • Dry hydrological conditions	187.7 Mt (+ 14.8 Mt compared to 2007 'most likely' case)

These results are also shown previously in Figure B1. This compares with a range from 156.2 Mt to 187.2 Mt in net position 2006. The overall range in net position 2007 projections has diminished and the projected upper bound has remained about the same.

In conclusion, the projected balance of emissions from energy and transport during the first commitment period (2008–2012) lies in the range between 162.8 and 187.7 with the most-likely scenario of 172.9 million tonnes of carbon dioxide equivalent.

Annex C: Land Use, Land-use Change and Forestry Sector provided by the Ministry of Agriculture and Forestry[23]

Disclaimer: This report contains forecast projections of carbon dioxide removals and emissions by the land use change and forestry sector. These projections need to be used with an understanding of the uncertainties that exist. This uncertainty is due to the complexity of forecasting biological systems which are inherently variable and are affected by climate and changing economic conditions. The projections are based on the best information currently available and the current state of scientific knowledge. While every effort has been made to provide the best projections as at March 2007, future changes in projections are inevitable with changes in economic conditions, improved information and new scientific knowledge.

Summary

This report provides forecast 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-1990 afforestation, reforestation and deforestation activities accounted for under the Kyoto Protocol.

The projections cover the First Commitment Period (2008–2012) of the Kyoto protocol. The key use of the LULUCF projections is as an input to the "2007 Projected Balance of Emissions Units" report produced by the Ministry for the Environment. The Ministry for the Environment's report is known as the "net position" report and brings together the projected quantity of greenhouse gas (GHG) emissions and removals from all sectors of the economy. The net position report is a core component of the New Zealand Government's projected financial position over the First Commitment Period of the Kyoto Protocol.

These projections are forecasts of future CO_2 removals and emissions by the LULUCF sector. Forecasts are greatly influenced by prevailing conditions. These forecast projections need to be used with an understanding of the uncertainties they contain. These uncertainties are due to the complexity of forecasting biological systems which are inherently variable and affected by climate and changing economic conditions. These projections are based on currently available information and the current state of scientific knowledge. Every effort has been made to provide the best projections as at March 2007, however future changes in projections are inevitable to allow for future changes in economic conditions, improved information and new scientific knowledge.

Net removals by the LULUCF sector (that is, removals by post-1990 forests minus deforestation emissions) for the period 2008 to 2012 are projected to be in the range of 16.0 Mt CO_2 to 98.3 Mt CO_2. The base scenario is projected to be 58.0 Mt CO_2 which is very similar to the 2006 base scenario projection of 57.2 Mt CO_2.

[23] For the forestry sector this report only covers Article 3.3 which includes post 1990 afforestation and all deforestation.

Table C1: LULUCF projected CO_2 removals and emissions (Mt) in CP1 (2008–2012)

Contributing factor	Pessimistic scenario	Base scenario	Optimistic scenario
Total removals from simulations in combined model[1]	57.0	79.0	119.3
Less deforestation emissions[2 3]	–41	–21.0 (cap)	–21.0 (cap)
Removals less deforestation emissions	16.0	58.0	98.3

1 The combined model results account for interrelationships between adjustment factors (forest area, growth rates, soil carbon changes, ineligible afforestation, and scrub clearance during site preparation). The removals attributed to each factor are not additive, because some factors are correlated.

2 Current government policy as at March 2007 is to cap its liability for deforestation of pre-1990 forests at 21.0 Mt CO_2.

3 41.0 Mt CO_2 is based on 50,000ha deforestation which is the base scenario from a deforestation intentions survey carried out in late 2006. For a description of the deforestation intentions survey results refer to Manley, 2006. Details on the calculation of deforestation emissions are available later in this report and in Wakelin et al, 2007.

Estimates of net removals for the pessimistic and optimistic scenarios in 2007 have changed since 2006 due to an allowance being made for the uncertainty of New Zealand's Kyoto forest area. Net removals in the optimistic scenario have dropped because expected deforestation emissions have increased. In 2006, 6.3 Mt CO_2 was used for the optimistic deforestation scenario. In the 2007 projections, the deforestation cap of 21 Mt CO_2, set by government in 2002, has been used for both the base and optimistic scenarios.

If policy measures are not implemented to manage the government's deforestation liability within the deforestation cap of 21 Mt CO_2 during CP1, the government's deforestation liability is likely to increase by a further 20 Mt CO_2 to reach 41 Mt CO_2. This pessimistic deforestation scenario assumes 50,000 hectares will be deforested during CP1 based upon forest owners' actual intentions as reported in a survey completed for the Ministry of Agriculture and Forestry (Manley, December 2006). Furthermore, if the government does not implement policies to manage deforestation in CP1 but signals that it may do after CP1, it is likely that forest owners would bring additional deforestation plans forward into CP1. Clearly any additional deforestation brought forward into CP1 would further increase deforestation emissions beyond the pessimistic deforestation scenario.

The LULUCF projections are very uncertain with a range of 16.0 Mt CO_2 to 98.3 Mt CO_2. This uncertainty is caused by measurement uncertainty and information gaps, scientific uncertainty and to account for possible future changes in government policy. Uncertainty has been incorporated into the LULUCF projections through the use of scenarios. These scenarios are described in detail later in this report. Overall the LULUCF sector projections are the least certain of all the sectors in the net position report. Measurement and some scientific uncertainty will be reduced when the Ministry for the Environment's Land Use and Carbon Analysis System (LUCAS) is operational from about 2010.

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

1. afforestation will have little effect on increasing CO_2 removals in CP1 because newly established forests will remove little CO_2 from the atmosphere in their early growth years

2. deforestation rates will have a substantial effect on New Zealand's net position in CP1. The base scenario in these projections uses the deforestation cap of 21 Mt CO_2. If there are no policy measures put in place to manage the government's liability within the cap then the level of deforestation emissions is likely to be significantly higher than 21 Mt CO_2.

Introduction

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

As forests grow they remove carbon dioxide (CO_2) from the atmosphere through photosynthetic activity. The Kyoto Protocol provides mechanisms for Parties to account for CO_2 removals by forests established on non-forested land since 1990. These removal units can be used to offset greenhouse gas emissions from other sectors.

This report provides forecast projections of CO_2 removals and emissions from New Zealand's land use, land-use change and forestry (LULUCF) sector, limited to post-1990 afforestation, reforestation and deforestation activities accounted for under the Kyoto Protocol. These projections form a core component of the New Zealand Government's projected quantity of units over the first commitment period (2008–2012) of the Kyoto protocol. The LULUCF projections from this report feed into the Ministry for the Environment's "2007 net position" report.

The key assumptions used in these projections are:

- future rates of deforestation
- forest growth rates
- the proportion of afforestation since 1990 which may be ineligible "Kyoto" forests because some may have been over-planted onto land which was already defined as forest
- the loss of soil carbon following afforestation of grassland
- future afforestation rates.

The projections also include error bounds around the existing area of "Kyoto" afforestation.

Forestry trends and drivers

Forecasting is a challenging task. Forecasts are greatly influenced by prevailing conditions and those that have recently existed. This section describes the economic and policy environment in which New Zealand forest owners have been operating over the last four to five years. During this period the operating environment has changed substantially. This makes forecasting more uncertain.

The last four to five years have been difficult for the New Zealand forestry sector. A high exchange rate, increasing costs, particularly shipping costs, along with competitive and changing international markets have adversely affected forest growing profitability in New Zealand. Recently international log prices have increased. The outlook for international log prices is good with the Russian Government's decision to increase export duties from the current level of 6.5 per cent to 20 per cent in July, with further increases over the next two years to 80 per cent. Trading conditions and profitability for many domestic wood processors have deteriorated with a high exchange rate and increased log prices.

There has been the largest volume of forest sales since state forest privatisation in the late 1980s. New Zealand's two largest corporate forestry companies (Fletcher Challenge and Carter Holt Harvey) have both been sold to private investors. The pattern of forest ownership has changed rapidly. Before being purchased by the Rank Group, Carter Holt Harvey sold around 100,000 hectares of forest to Matariki Forests (a consortium of Rayonier, AMP and Deutsche

Bank Infrastructure managed funds). In late 2006, the Rank Group sold almost all of the remaining Carter Holt Harvey forest estate to Hancock Natural Resource Group. Superannuation funds and timber investment management organisations (TIMOs) have purchased large areas of plantation forests in New Zealand. TIMOs now own more than a third of the total planted forest area in New Zealand.

There is now greater separation between forest ownership and land ownership than has been the case historically. Land owners are looking to realise some of the increased land value through forest land sales. In some locations, pastoral farmers are willing to pay higher prices for land than commercial forest owners resulting in a change in land use from forestry to agriculture.

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

- a major decline in the rate of afforestation; afforestation has fallen from a 30-year annual average (1976 to 2005) of 42,000 ha to just 5,000 ha in the year to December 2006
- the new phenomenon of deforestation where plantation forest land is converted to alternative land uses, particularly pastoral grazing. In the year ended March 2006, an estimated 12,900 hectares of deforestation occurred. This was predominantly in the Central North Island and Canterbury regions. Prior to 2004 little plantation deforestation occurred.

A number of climate change policy discussion documents were released for public consultation in late 2006 including *Sustainable Land Management and Climate Change – Options for a Plan of Action*. Submissions on this discussion document closed on 30 March 2007.

These forecasts do not account for any future climate change and forest policies. The projections are based on the prevailing policy settings as at March 2007.

Modelling methodology

This report provides scenario-based forecasts (projections) of removals and emissions for the LULUCF sector for the period 2008 to 2012. The projections are based on the best available information as at March 2007.

Projected removals from the LULUCF sector are based on data and assumptions from the Ministry of Agriculture and Forestry (MAF) and the Ministry for the Environment (MfE). The carbon modelling was undertaken by Ensis (formerly Forest Research). 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 Ensis and Landcare Research.

In order to incorporate scientific uncertainty, knowledge gaps and the range of possible future outcomes (particularly for afforestation and deforestation), a scenario-based approach has been used. The scenarios presented are labelled pessimistic, base and optimistic. These scenarios are today’s best attempt to cover the likely range of major contributing factors to estimating LULUCF sector removals and emissions based on the current economic environment, policy settings, knowledge of land-use patterns, and the state of scientific knowledge.

The projected forest sink removals were calculated using a spreadsheet simulation model of the Kyoto 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 Kyoto forest stand. To calculate the carbon stock in a given year, values in the yield table are multiplied by the net stocked forest area at the corresponding age, and then summed. The distribution of areas by age class is defined by the new planting rate – the simulation advances these areas through annual time periods (1990 to 2012). Net carbon uptake is calculated as the stock change in the first commitment period (2008–2012). A more detailed model description is available in Annex 1.

Projection results

Table C2 below provides a breakdown of the major contributing factors on which the removal and emission forecasts are based.

Table C2: LULUCF projected CO_2 removals and emissions (Mt) in CP1 (2008–2012)

	Pessimistic scenario	Base scenario	Optimistic scenario
Contributing factor			
Total removals from simulations in combined model[1]	57.0	79.0	119.3
Less deforestation emissions[2 3]	–41	–21.0 (cap)	–21.0 (cap)
Removals less deforestation emissions	16.0	58.0	98.3
Removals based on afforestation only			
Kyoto planted forest CO_2 removals (based on existing 680,900 ha)	96.8	96.8	96.8
Future afforestation (2007 to 2012) (0, 5,000, 20,000 ha/yr)	0	0.9	1.9
Adjustment factors (see assumptions below for further details)			
Area of Kyoto forest planted between 1990 and 2006 ± 5%	–4.8	0	4.8
Kyoto forest growth rates	–9.8	0	28.4
Soil carbon change with afforestation	–11.3	–3.0	0
Ineligible afforestation	–20.5	–15.7	–7.8
Total removals from simulations in combined model[1]	**57.0**	**79.0**	**119.3**

1. The combined model results account for interrelationships between adjustment factors (forest area, growth rates, soil carbon changes, ineligible afforestation, and scrub clearance during site preparation). The removals attributed to each factor are not additive, because some factors are correlated. For example, the impact of soil carbon decline due to afforestation is –3.0 Mt CO_2 under the base new planting assumption, but falls to –2.5 Mt CO_2 under the base ineligible afforestation scenario, because the area planted is reduced. Three separate simulations were run using all of the pessimistic, base and optimistic assumptions respectively to produce the combined model results.
2. Current government policy as at March 2007 is to cap its liability for deforestation of pre-1990 forests at 21.0 Mt CO_2-e.
3. 41.0 Mt CO_2-e represents 50,000 ha which is the base scenario from a deforestation intentions survey carried out in late 2006. An "accelerated deforestation and more" scenario presented in the deforestation report was 65,000 ha or 53.3 Mt CO_2-e.

Removals from the LULUCF sector for the period 2008 to 2012 are projected to be in the range of 16.0 Mt CO_2-e to 98.3 Mt CO_2-e. The base scenario is projected to be 58.0 Mt CO_2-e.

Model assumptions

Future afforestation (plantations)

The average new planting rate over the last 30 years has been 42,000 hectares per year. In the period 1992 to 1998 new planting rates were high; during this period new planting averaged 69,000 hectares per year. Since 1998 new planting has declined. Afforestation in 2006 was 5,000 ha.

Figure C1: New forest planting (1920 to 2006)

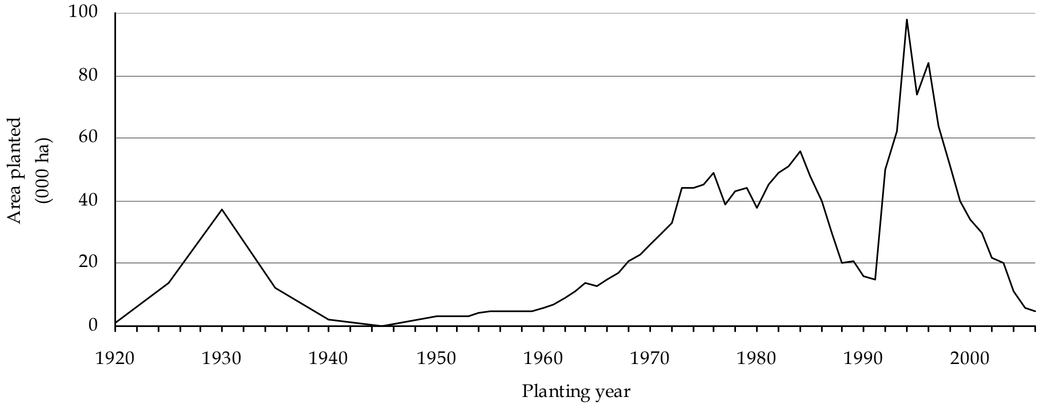


Table C3 below shows the afforestation rates used in the 2006 projections.

Table C3: Future plantation afforestation (hectares)

Calendar year	Pessimistic	Base	Optimistic
2007	0	5,000	7,500
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 **base** scenario assumes annual afforestation of 5,000 hectares. The **optimistic** scenario assumes average afforestation of 20,000 hectares per year between 2008 and 2012. The **pessimistic** scenario assumes no further afforestation occurs after 2006. These afforestation rate assumptions are the same as last year.

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, the 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.

Growth rates (plantations)

The **base** scenario uses a national carbon yield table developed from the National Exotic Forest Description (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-1990 plantation stands have higher growth rates than earlier plantings.

Analysis of forest growth data suggests that fully stocked stands planted after 1990 show a 15–35 per cent improvement in productivity over stands currently being harvested, as a result of genetic improvement, better site quality and improved forest management. The upper end of this range was used to develop the **optimistic** 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 optimistic 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 **pessimistic** 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 2006 projections. The growth rate scenarios are broadly indicative only. Accurate estimation of forest CO_2 removals requires representative sampling of "Kyoto" forests. A statistical representative sample plot network is 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. Estimates of LULUCF CO_2 removals from the LUCAS are expected to be available from 2010.

Changes in soil carbon

Soil carbon levels are a function of climate, land use and soil type. Most pasture to radiata pine afforestation occurs on erosion-prone hill country where soil properties are inherently variable, including that of soil carbon. Work is currently underway to improve New Zealand's approach to determining change in soil carbon with afforestation.

At present New Zealand uses two methods to estimate the change in soil carbon with afforestation:

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

The first method for estimating soil carbon change with afforestation is the analysis of the soil-paired plot database – a cache of purpose-collected data intended to be used as validation of the SCMS estimates. Analysing data from the soil-paired plot database in those localities where afforestation has taken place provides an estimate of soil carbon loss of 4.7 ± 2.6 tC/ha. This is used for the **base** scenario. This dataset contains several outliers, all of which indicate substantial carbon losses. If these outliers are excluded from the calculation of soil carbon change with afforestation, the estimate becomes a gain of 0.2 ± 2.5 tC/ha (95 per cent confidence level). While excluding these outliers is consistent with the approach of excluding sites where erosion affected the forest site more than the pasture site, exclusion of these plots needs more analysis. For this reason the **optimistic** scenario assumes no soil carbon change.

The second estimation method is the New Zealand Soil Carbon Monitoring System (SCMS) – 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 and the system has been described in peer-reviewed, international journals. Recent scrutiny of the model predictions for localities where most of the pasture to radiata pine land-use change occurs, has led the developers and officials to suspect that the predicted soil carbon reduction associated with afforestation is overstated. The limited number of historic soil data in such localities (erosion-prone hill-country) is the prime reason for these views. It is because of this issue that the estimate produced by the SCMS (a loss of 18 ± 11 tC/ha) is considered to be the most **pessimistic** estimate of likely soil carbon change with afforestation. The difference between the estimate provided by the soil-paired plot database and that derived from the SCMS provides a strong case for accepting the SCMS value as the most pessimistic estimate.

The pessimistic estimate has changed from that used for the 2006 projections as additional plots from a Marlborough study have been added to the dataset and plots also included in the paired sites database have been excluded from this calculation.

Ineligible planting

Initial investigation has indicated that some plantation afforestation since 1990 may have occurred on land that, from a definitional perspective, already met the New Zealand Kyoto adopted forest definition. Under carbon accounting rules, any land planted after 1990 where the land was already ‘forest land’ under the Kyoto forest definition, does not qualify as “Kyoto” forest.

The estimates of the proportion on “ineligible” exotic forests used in the 2006 LULUCF projections were 16 per cent (base), 8 per cent (optimistic) and 21 per cent (pessimistic). These have been used again in the 2007 projections.

The base and pessimistic 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-1990 forest planted into possible forest land being: nationally 16 per cent; Marlborough region 21 per cent; and the Gisborne region 15 per cent. Some anecdotal information at the time suggested that the levels could be as low as 8–10 per cent, and this was used for the optimistic figure. These estimates were made at a time when it had not been decided how New Zealand was going to interpret, and map, the Kyoto forest classes as defined in the Marrakech Accords (which defines the Kyoto forest definition).

Table C4: Percentage of existing forest (shrubland) ineligible under the Kyoto Protocol

	Pessimistic	Base	Optimistic
Percentage of afforestation since 1990 planted onto shrublands that could meet New Zealand's Kyoto Forest definition	21%	16%	8%

Forest industry commentators have expressed the view that the proportion of "ineligible" Kyoto forests is too high. However, to date no further quantitative information has become available to provide improved estimates of the area of forest over-planting. In light of this, these projections use the 2006 scenarios again in 2007. Indications from further preliminary analysis suggest that the proportion of ineligible forests may be reduced once further land-use mapping for the LUCAS has been completed.

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, the carbon stock change due to afforestation must be accounted for. An allowance has been made for this in the combined model results.

Future deforestation (plantations)

Emissions from forecast deforestation for the period 2008 to 2012 are currently projected to be in the range of 21.0 Mt CO_2-e to 41.0 Mt CO_2-e. The government is currently consulting on policy options to manage deforestation. In the absence of any new deforestation policy decisions as at March 2007, the 2002 government-stated policy[24] of capping the Crown's liability for deforestation of pre-1990 forests at 21.0 Mt CO_2-e has been used for the **base** and **optimistic** scenarios in these projections.

The relatively new trend of not replanting forest after harvesting, and in some cases converting immature forest to pasture, started on a larger scale in 2004. New Zealand has always had relatively dynamic land-use change patterns so changes in land use are not unusual. However, the scale of conversion of planted production forest land has been greater than anticipated. The 2006 NEFD survey estimated that 12,900 hectares of forest clear-felled in the year ended March 2006 will not be replanted. This area represents 33 per cent of the area harvested, and compares with historical information indicating that only about 2 to 5 per cent of the area harvested had not been replanted prior to 2004.

The government is currently reviewing submissions received as part of its consultation process associated with the *Sustainable Land Management and Climate Change* consultation document. It is anticipated that decisions on deforestation policy options will be made by the government later this year. The broad deforestation policy options proposed in the 'Plan of Action' consultation document were:

[24] Historically, little plantation forest deforestation has occurred in New Zealand. In 2002, the government's publicly stated deforestation policy was to cap liabilities that it would accept for pre-1990 forests at 21 Mt CO_2 over the first commitment period (2008–12). If deforestation looked likely to occur at levels above expectations the government would consider its policy options to manage deforestation emissions within the cap.

- a flat charge on land use change from forestry
- a tradeable permit regime
- passing legislation to prevent deforestation of land unless government approval has been granted
- RMA controls on deforestation.

The government's previously stated decision to cap its deforestation liabilities at 21 Mt CO_2 has been used for the **base** and **optimistic** scenario. This is a change from the 2006 report when – 6.3 Mt CO_2 was used for the optimistic scenario, representing a reversion to historic deforestation rates.

The **pessimistic** scenario assumes an emission liability of 41.0 Mt CO_2. This scenario is based on a deforestation intentions survey completed for the Ministry of Agriculture and Forestry in December 2006. The results from this survey indicated that under current conditions forest owners intended to deforest about 50,000 hectares during the first commitment period (2008–12). The calculation of 41.0 Mt CO_2 is based on all deforestation being mature forest and all emissions being instantly emitted. This is up slightly on the value of 38.5 Mt CO_2 used in the 2006 projections.

Deforestation of 50,000 hectares during CP1 was the base scenario presented in the 2006 deforestation intentions survey. An "accelerated and more" scenario of 65,000 hectares deforestation in CP1 was also presented in this report. This assumed that the rate of deforestation for two large conversion projects was increased, as was the level of deforestation by small forest growers. If the "accelerated and more" scenario was used as the pessimistic scenario in this report it would increase deforestation emissions from 41.0 Mt CO_2 to 53.3 Mt CO_2.

Furthermore, if the government does not implement policies to manage deforestation in the first commitment period it is likely that some forest owners would bring future (post-2012) deforestation forward into the first commitment period if they believed that post-2012 policy measures to control deforestation were likely to be introduced. The 2006 deforestation intentions survey indicated that between 17,000 and 37,000 hectares of plantation forest were intended to be deforested over the period 2013–2017. Clearly, any deforestation brought forward into CP1 would further increase deforestation emissions beyond the pessimistic scenario presented in this report.

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 report (2001) provided estimates for the area of clearance of indigenous forest and scrub between 1989/90 and 1996/97. To estimate clearance between the two periods, visual interpretation of ground cover was completed for satellite images taken at the two time periods. 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 the area of indigenous forest cleared was 1,809 hectares or 0.03 per cent of the total area of indigenous forest as at 1996. The area of scrub removed was 1,409 ha or 0.05 per cent of the total area of scrub as at 1996.

It is thought that under current legislation (eg, Resource Management Act 1990, 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. Although until improved national mapping of forest area change is available the actual level of indigenous forest and shrub land clearance is currently uncertain and will not be known until the LUCAS is operational from 2010.

Data limitations

There are acknowledged weaknesses in some of the data used in the LULUCF sector projections due to a lack of current knowledge and scientific uncertainty. With funding confirmed for the further development of the Land Use and Carbon Analysis System (LUCAS) in August 2005, the Ministry for the Environment commenced implementing the LUCAS during the 2005/06 year. The LUCAS is being designed to provide more robust LULUCF sector 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. A lack of support from forest owners has delayed the installation of forest carbon inventory plots in their forests. This has delayed the implementation of some LUCAS work streams, in particular the establishment and measurement of sample plots across planted "Kyoto" forests. Delays in implementing the LUCAS will mean it may take longer to reduce the uncertainty for estimating and projecting LULUCF CO_2 removals and emissions.

Because the LUCAS is not yet generating data, existing forest resource information such as the NEFD database and Land Cover Database (LCDB) continue to be used for projecting LULUCF carbon dioxide removals. It is important to note that the NEFD database was designed to forecast future wood supply and is not designed for forest carbon accounting purposes. This means that some of the information required for carbon accounting purposes is **not** currently available. The NEFD describes the pre-1990 forests, where the ownership is dominated by larger forest growers' forests, reasonably well. NEFD information on the plantation forests established since 1992 by a large number of smaller-scale forest owners is of poorer quality. In addition there is relatively scant information on New Zealand's 6.5 million hectares of indigenous forest and 2.6 million hectares of shrubland.

Review of past projections

The 2005 greenhouse gas projections were subject to a number of reviews. The most comprehensive review was undertaken by AEA Technology from the United Kingdom. While the AEA Technology review identified a number of improvements which could be made in producing future projections, most of which have been incorporated in producing this year's projections, the overall finding of the review was that "the methodologies employed to project emissions and sinks across the different sectors [are] generally sound and reasonable in their approach". The review 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 provided a number of useful suggestions for improving the accuracy and robustness of future forecasts. They recognised that many of their recommendations built upon improvements already in train. The key conclusions for the AEA Technology LULUCF 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-1990 forest planting at a national scale into existing shrublands that meets 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."

Work has been completed to address two of the key issues identified above. A report has been produced looking into the financial returns from forestry and its relationship to forestry planting rates. This report is available on the Ministry of Agriculture and Forestry's website. In 2005 and 2006, deforestation surveys were also completed looking at where deforestation is taking place and why. The results of these surveys have been incorporated in these projections. A summary of the 2006 deforestation report is also available on the Ministry's website.

Current policies

The Permanent Forest Sinks Initiative

The Permanent Forest Sink Initiative (PFSI) provides an opportunity for landowners to establish permanent forest sinks and obtain tradable Kyoto Protocol compliant emission units in proportion to the carbon sequestered in their forests. New forests established under the PFSI will still be young even at the end of CP1 (2012) so will only be removing a small amount of CO_2. As credits for PFSI forests will be devolved to forest owners, new PFSI forests will not affect the Crown's balance of units.

There is the potential for existing Kyoto-compliant forests to move into the PFSI allowing the forest owner to receive Kyoto Protocol compliant emission units. Any existing Kyoto-compliant forests that are moved to the PFSI will result in the devolution of emission units and the removal from the Crown's balance of units. There is currently insufficient data to identify the area of existing Kyoto forest that may move into the PFSI, however only exotic forest planted since 17 October 2002 will be eligible.

Accounting for Article 3.4 forest management

New Zealand has made the decision not to account under Article 3.4 of the Kyoto Protocol. New Zealand had the option of electing which additional Article 3.4 land use, land-use change and forestry activities, if any, it wished to account for in the first commitment period. Forest management is one such activity that could have been included under Article 3.4.

Under Article 3.4, New Zealand would have to account for carbon stock and carbon stock changes in New Zealand's indigenous forests as well as its pre-1990 planted forests. At present, there is uncertainty in the data on carbon stock changes in New Zealand's indigenous forests. Available data suggest that the carbon stocks are likely to be in a steady state or possibly in slight decline. An assessment in 2006 of the significance to New Zealand of Article 3.4 forest management activities concluded that the balance lay somewhere between –92 to 11 Mt CO_2-e over the first commitment period. If New Zealand decided to account for forest management under Article 3.4, it would also be subject to a cap restricting the maximum amount of carbon dioxide removals it can claim in the first commitment period to 3.7 Mt CO_2. Under Article 3.4 potential emissions and the related liabilities would remain uncapped. There would also be substantial costs incurred in measuring New Zealand's entire forest estate to secure a maximum of 3.7 Mt CO_2 over the first commitment period.

New policy proposals

Sustainable land management and climate change consultation

At the time of producing these projections the government had just completed a public consultation round on its proposed options for a plan of action on climate change in the land management sectors. This plan of action covers how the agriculture and forestry sectors could work with the government to adapt to climate change; capitalise on business opportunities arising from climate change; reduce greenhouse gas emissions from land-based activities; and create carbon sinks. The broad options in the plan of action for forestry are outlined below.

To encourage afforestation:

- an afforestation grant scheme where growers who establish new post-2007 forests could tender to receive an afforestation grant. Grants would be awarded based on highest expected carbon storage for the lowest tender grant rate. Sites with more co-benefits such as erosion control, watershed management and mitigation of nitrate leaching could be given higher priority in the allocation of grants
- giving growers a choice between being part of the afforestation grant scheme or devolution of the relevant sink credits and their associated liabilities for new post-2007 forests. Devolution of credits and liabilities would operate in a similar manner to the Permanent Forest Sink Initiative.

Both of these would work alongside the current Permanent Forest Sink Initiative.

For discouraging deforestation of non-Kyoto forests:

- 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; 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)
- RMA 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.

Under these options, the government could carry a portion of the deforestation costs incurred under the Kyoto Protocol by setting a threshold below which the policy would not apply. Under the flat charge option, the government could carry a portion of the cost through setting the expected international price of carbon.

The above are a range of potential climate change policy options for the land-use sectors. The government is currently analysing submissions following the consultation round on these options and is continuing to consider the policy options. Until specific policy measures are agreed and implemented it is not possible to include them in the LULUCF projections.

The choice and effectiveness of deforestation policy will have a material effect on New Zealand's net position in CP1 (and beyond) while any new afforestation policies will have negligible impact in the short term but will increase CO_2 removals over a longer period of time.

Reconciliation with 2006 projections

Table C5: LULUCF projected CO_2 removals and emissions (Mt) in CP1 (2008–2012)

	Pessimistic scenario 2007	Optimistic scenario 2007	Base scenario 2007	Base scenario 2006
Contributing factor				
Total removals from simulations in combined model[1]	57.0	119.3	79.0	78.2
Less deforestation emissions[2 3]	–41	–21.0 (cap)	–21.0 (cap)	21.0 (cap)
Removals less deforestation emissions	16.0	98.3	58.0	57.2
Removals based on afforestation only				
Kyoto planted forest CO_2 removals	96.8	96.8	96.8	96.6
Future afforestation (2007 to 2012) (0, 5,000, 20,000 ha/yr)	0	1.9	0.9	1.2
Adjustment factors (see assumptions below for further details)				
Area of Kyoto forest planted between 1990 and 2006 ± 5%[4]	–4.8	4.8	0	na
Kyoto forest growth rates	–9.8	28.4	0	0
Soil carbon change with afforestation	–11.3	0	–3.0	–3.0
Ineligible afforestation	–20.5	–7.8	–15.7	–15.5
Total removals from simulations in combined model[1]	**57.0**	**119.3**	**79.0**	**78.2**

1 The combined model results account for interrelationships between adjustment factors (forest area, growth rates, soil carbon changes, ineligible afforestation, and scrub clearance during site preparation). The removals attributed to each factor are not additive, because some factors are correlated. For example, the impact of soil carbon decline due to afforestation is –3.0 Mt CO_2 under the base new planting assumption, but falls to –2.5 Mt CO_2 under the base ineligible afforestation scenario, because the area planted is reduced. Three separate simulations were run using all of the pessimistic, base and optimistic assumptions respectively to produce the combined model results.

2 Current government policy as at March 2007 is to cap its liability for deforestation of pre-1990 forests at 21.0 Mt CO_2-e.

3. 1.0 Mt CO_2-e represents 50,000 ha which is the base scenario from a deforestation intentions survey carried out in late 2006. An "accelerated deforestation and more" scenario presented in the deforestation report was 65,000 ha or 53.3 Mt CO_2-e.

4. Uncertainty in the area of Kyoto forest planted was not included in the 2006 report.

The base scenario is very similar to that presented in 2006. While uncertainty in the area of Kyoto forest planted between 1990 and 2006 has been introduced under the base scenario, the adjustment in the area of Kyoto forest is 0. Introducing this uncertainty has widened the gap in total removals between the optimistic and pessimistic scenarios.

Removals less deforestation emissions have decreased for both pessimistic and optimistic scenarios from 2006 with the cap of 21 Mt CO_2-e now being used for deforestation emissions under the optimistic and base scenarios, and 41 Mt CO_2-e being used for the pessimistic scenario. This follows work in 2006 looking at deforestation intentions of forest owners.

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Annex 1: Description of the LULUCF net position models

1 Model for projecting net removals

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 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 1990 and any land deforested over the first commitment period of the Kyoto Protocol (CP1). 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.[25]

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

Methodology used in this report

Projected removal units from afforestation and reforestation since 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 NEFD regional yield tables. The national carbon yield table provides carbon stock estimates by age on a per hectare basis for all non-soil 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. This approach is the same as that employed by routinely-used forest estate planning simulators, such as IFS (Interactive Forest Simulator, Garcia 1979).

The calculation of annual carbon stocks from the national carbon yield table and annual afforestation areas is illustrated in Figure C2, for the period 1990–1992. It is assumed that the carbon stock in the year of planting is zero. Annual stocks are calculated for each age class and summed over all age classes to give the total annual stock. Net removals are calculated as the annual change in stocks.

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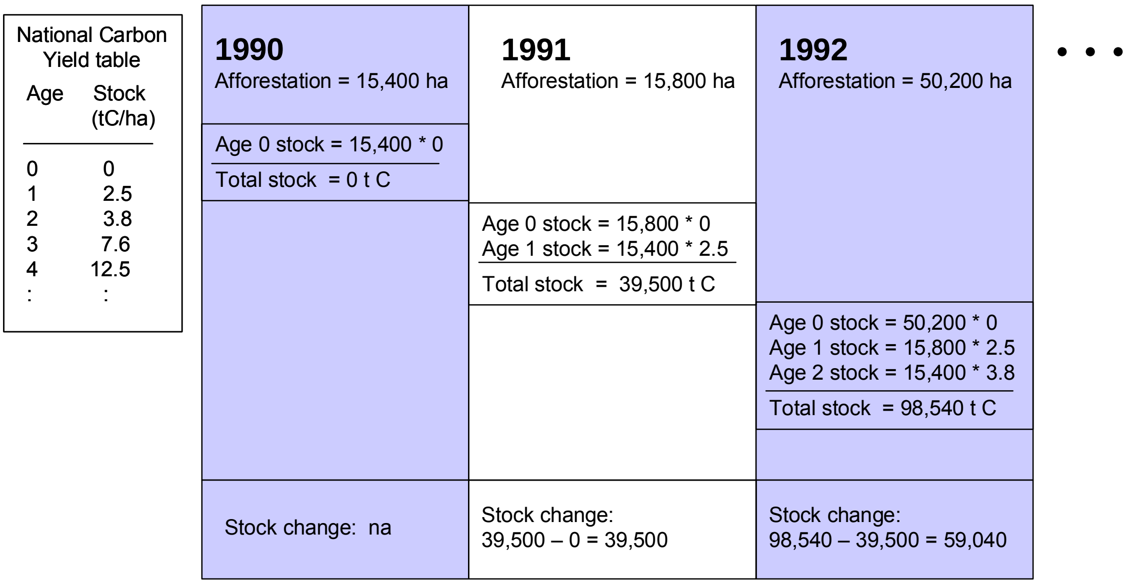
[25] Either measurement may be replaced with modelled stocks if necessary.

Figure C2: Example calculation of annual carbon stocks from the national carbon yield table and annual afforestation areas



Soil organic carbon stocks are estimated in the same way, except that a separate national soil carbon yield table is prepared which 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 since 1990. 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. The 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.

The model

Three Microsoft Excel spreadsheets are used to calculate carbon removal and emission units.

Afforestation calculations

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

The spreadsheet allows combinations of post-1990 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.

Soil carbon calculations

This 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.

Deforestation calculations

This 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. 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.

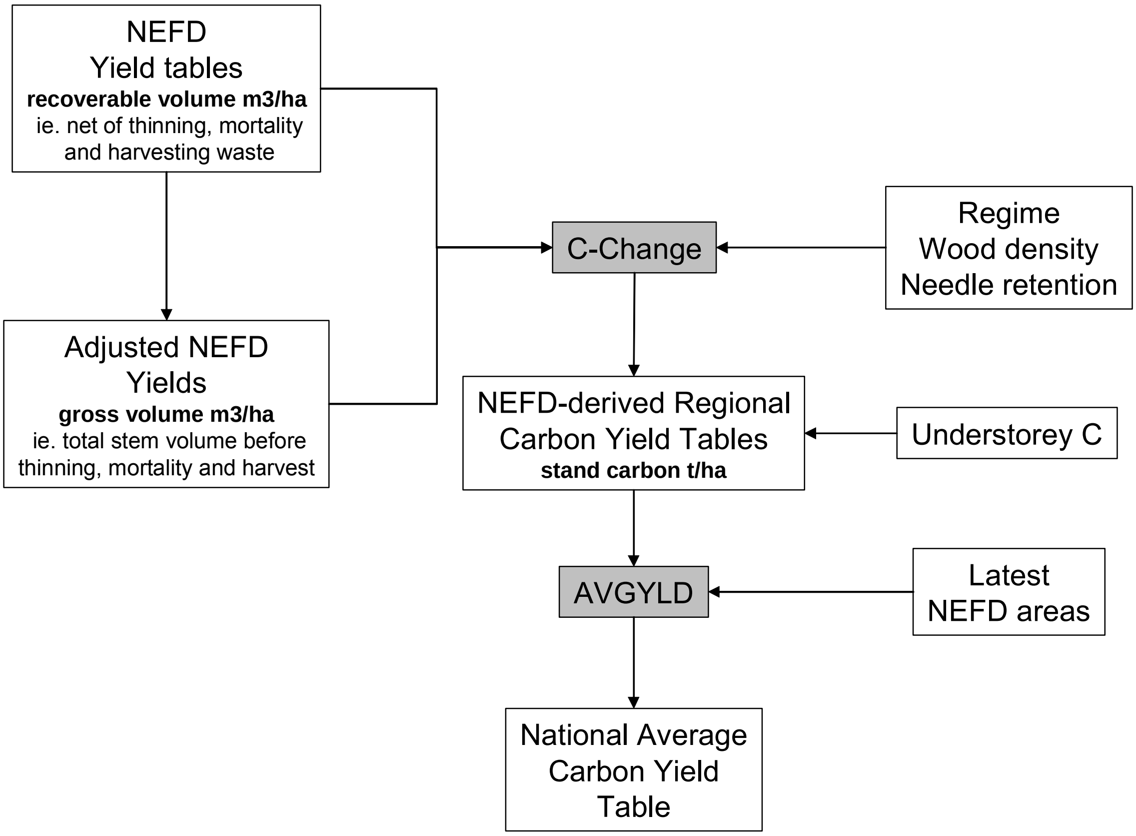
Projected removal units are calculated as the sum of annual emissions over the commitment period. Emissions and removals associated with post-deforestation land uses (ie, agriculture and lifestyle blocks/settlements) are not modelled, including changes to the soil organic carbon pool on this land.

Both removals and emissions are 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.

2 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 2005 UNFCCC planted forest carbon inventory (Wakelin and Paul 2007). The process used to construct the yield tables is outlined in Figure C3.

Figure C3: Deriving the national average yield table



NEFD volume yield tables

NEFD yield tables are prepared periodically to support wood supply modelling carried out by the Ministry of Agriculture and Forestry (MAF). The latest set of yield tables (MAF 1996b, replacing the MAF 1992 set) 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.

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 et al (2005). The two main steps are:

1) Convert NEFD yields net of mortality to gross yields.[26]
2) Use C_change to firstly convert stem volumes to stem biomass, and then to convert stem biomass to stand biomass.

[26] Gross yield is stem volume before thinnings and mortality are removed.

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 data held by Ensis 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

Area-weighted national average yield table

A national aggregate age class distribution was produced by using the IFS/FOLPI 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.

Issues

The assumption made is that the national average carbon yield table will be representative of stands planted since 1990. Obviously the growth of individual stands will vary. The applicability of the national average yield table is discussed further in the growth rate section earlier in this report.

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

- yield tables are prepared as a basis for wood availability studies, so the focus is on yields at the range of rotation ages modelled (20–40 but more typically 26–30)
- the main focus of the company yield tables that are used to compile the NEFD yield tables is around 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, production-thinned Douglas fir in East Cape and southern North Island have been assigned the Douglas fir waste-thinned yield table from their respective regions
- 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.

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

Annex D: Waste Emissions Projections provided by Ministry for the Environment

Introduction

Greenhouse gas emissions arise from three waste sector sources, being emissions from solid waste disposal sites and from domestic and industrial wastewater treatment plants.

Emissions from solid waste disposal sites comprised 79 per cent of the emissions from the waste sector in 2005. 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 21 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.

Recent trends

Waste sector emissions in 2005 are now 0.647 million tonnes of carbon dioxide (Mt CO_2e) below the 1990 baseline value of 2.493 Mt CO_2e, a reduction of 25.9 per cent.

This 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.

Modelling

Description of method

The emissions from solid waste disposal are projected using the methodology and variables used in *New Zealand's Greenhouse Gas Inventory 1990–2005* (MfE, 2007). 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 is 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 CH4 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 complied 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 Treasury's December 2006 Half Year Economic and Fiscal Update model results. Other variables remain constant at the values reported in the latest national inventory (MfE, 2007).

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 using a linear projection of emissions from 1990 to 2003 (r2 = 0.96). Emissions are projected to be 0.39 Mt CO_2e for 2010. This is an increase of 0.06 Mt CO_2e from the 2006 net position report and reflects an improved methodology for estimating the biodegradable organic content of domestic and commercial wastewater.

Policies

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.

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_2e, 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_2e, 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.

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_2e, 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 6.5 Mt CO_2e.

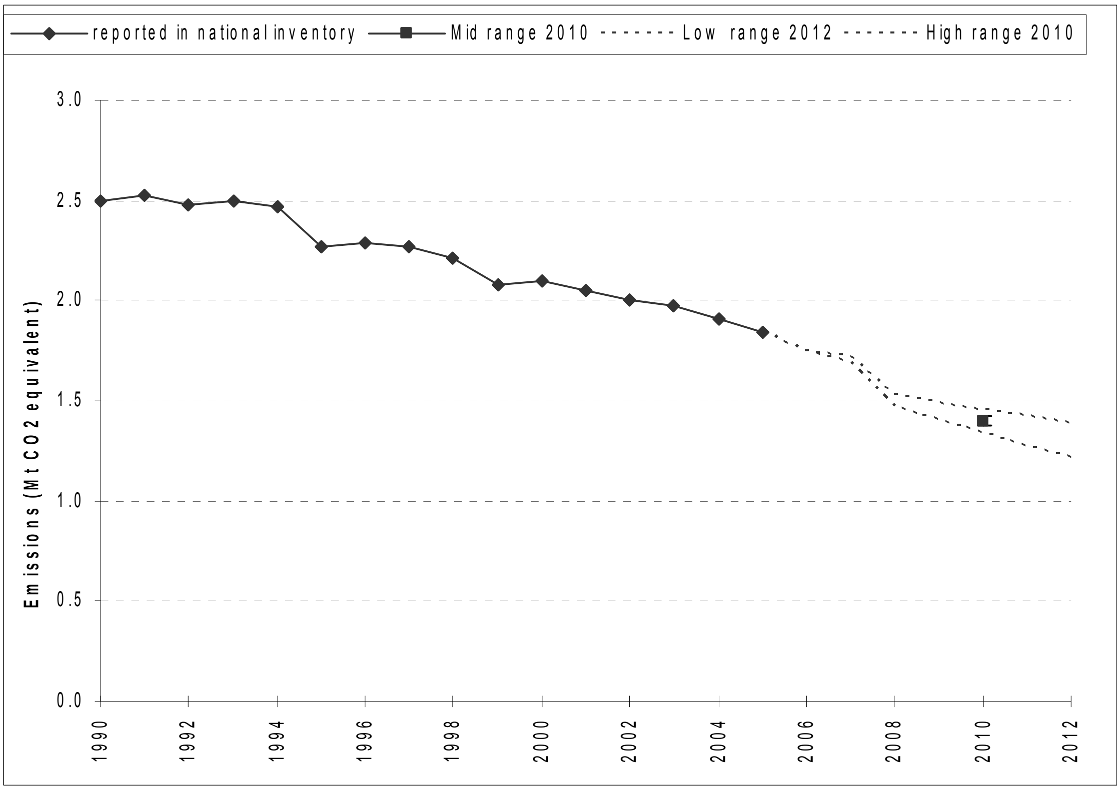
Projection

Total emissions

Emissions from the waste sector over the first commitment period are expected to range between 6.7 Mt CO_2e and 7.3 Mt CO_2e. Projected annual emissions for 2010 are expected to lie between 1.34 Mt CO_2e and 1.45 Mt CO_2e per annum with a most likely value of 1.4 Mt CO_2e.

Figure D1 shows that since 1990 there has been a large decrease in emissions 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 sectoral emissions despite increasing 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)



Reconciliation with 2006 projection

For the period 2008 to 2012, projected emissions from the waste sector have increased 0.5 Mt CO_2e from the 2006 estimates due to several factors:

- as discussed above, emissions from wastewater treatment have been revised upwards due to methodological improvements resulting in an increased methane emissions factor
- adjustments to assumptions regarding the impact of the New Zealand Waste Strategy.