Ministry for the Environment
Manatū Mō Te Taiao

Net Position Report 2009

New Zealand's projected balance of Kyoto Protocol units during the first commitment period

Appendices

New Zealand Government

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Appendix A: Agriculture Emission Projections provided by the Ministry of Agriculture and Fisheries

Disclaimer: This report contains projections of greenhouse gas emissions for the agriculture sector. These projections need to be used with an understanding of the significant uncertainties that inevitably arise when forecasting complex biological systems: these are inherently variable as they are affected by an unpredictable climate and changing economic conditions. While every effort has been made to provide the best projections as at March 2009, future adjustments will inevitably reflect changes in climatic conditions, economic conditions, international commodity prices and exchange rates. All values have been rounded to two decimal places.

Summary

The most likely value of *total emissions* from the agricultural sector over the five years of the First Commitment Period (CP1) (2008–2012) of the Kyoto Protocol is projected to be 184.0 million tonnes carbon dioxide equivalents (Mt CO_2-e). The range is projected to lie between 166.0 Mt CO_2-e to 204.8 Mt CO_2-e.

Projected annual emissions during CP1 under the most likely, lower, and upper scenarios are presented in Table A1 below.

Table A1: Summary of annual emission projection scenarios for the First Commitment Period in million tonnes carbon dioxide equivalents (Mt CO_2-e)

Calendar year	Annual emission projections		
	Lower	Most likely	Upper
2008[1]	33.97	34.86	35.77
2009[2]	32.49	36.10	40.17
2010[2]	32.68	37.02	42.11
2011[2]	33.13	37.66	43.08
2012[2]	33.70	38.40	43.67
Total	**165.98**	**184.02**	**204.81**

1 Estimated emissions
2 Projected emissions from the Inventory model

The assigned amount for CP1 is 162.5 (based on the 1990 agricultural emissions baseline of 32.5 Mt CO_2-e, (as confirmed in New Zealand's assigned amount)). The most likely projections for CP1 of 184.0 Mt CO_2-e exceeds the assigned amount by 21.5 Mt CO_2-e. This ranges from an excess of 3.5 Mt CO_2-e to 42.3 Mt CO_2-e under the lower and upper scenarios.

The most likely value for total emissions over CP1 (of 184.0 Mt CO_2-e) is 14.4 Mt CO_2-e lower than was projected in 2008. Major contributions to this reduction are the decline of animal numbers and performance due to the 2008 drought, and the incorporation of new emission factors. Although this is a large difference, the most likely value is within the range of total emissions for CP1 projected in 2008.

Projected future agriculture greenhouse gas emissions are influenced significantly by prevailing conditions. All biological systems are greatly affected by climate, and agriculture is also subject to changing economic conditions, including changing international commodity prices and the New Zealand dollar exchange rate. Every effort has been made to provide projections based on the most up to date information as at March 2009, however, future adjustments are inevitable.

Introduction

Our projections are based on:

(1) the methodologies used in the National Greenhouse Gas Inventory submitted to the United Nations Framework Convention on Climate Change (UNFCCC) annually, and

(2) econometric and physical models developed by the New Zealand Ministry of Agriculture and Forestry (MAF). The inventory methodology conforms to the Good Practice Guidance methodologies developed by the Intergovernmental Panel on Climate Change and adopted by the UNFCCC.

Projections are driven by future estimates of:

- annual animal numbers and animal performance data (milk yield, weights) by species (beef cattle, dairy cattle, deer and sheep) obtained from MAF's Pastoral Supply Response Model (PSRM)
- annual nitrogen fertiliser use obtained from MAF's Nitrogen Demand Model
- annual emissions estimated using the agriculture GHG tier two inventory model.

Two further scenarios of projected emissions for each year in First Commitment Period (hereafter CP1) have also been produced that represent the upper and lower bounds of projected emissions. These present emission estimates using the 95 per cent confidence intervals for the upper and lower bounds of animal numbers, animal performance, and nitrogen fertiliser use.

Changes in methodology since last year's assessment

There have been several significant improvements in the methodology used in this year's projections. They consist of the improvement of the PSRM which was used to forecast animal numbers and performance data, the incorporation of the agriculture GHG tier two inventory model (hereafter inventory model) (Clark et al, 2003) which is currently used to estimate New Zealand's emissions for the National Inventory reported to the UNFCCC. Emission factors have been updated to reflect improved understanding of agricultural ammonia (NH_3), nitric oxide and nitrogen dioxide (collectively referred to as NO_x) emissions under New Zealand conditions. These gases influence measured agricultural emissions as they are an indirect route for nitrous oxide (N_2O) formation.

MAF's PSRM has been improved to include a land use forecast component as well as new variables that feed into the inventory model (eg, milk yield, liveweights). The key outputs of the model are forecasts of animal numbers (which are driven by changes in land use and stocking rates) and animal performance, which are subsequently used as inputs into the inventory model. Animal performance projections are driven by past performances, weather conditions as well as farmgate prices. The new land use component allows for simulations of movements between different land use categories under a constrained total land capacity. It also allows for the inclusion of some land use assumptions used in the Land Use, Land Use Change and Forestry (LULUCF) sector. Exogenous shocks to the model are farmgate prices, net farm incomes, and weather conditions. MAF's Nitrogen Demand Model has also been updated.

Use of the inventory model is the second major methodological change. The ability of the PRSM to predict both animal population and performance makes it possible to use the full inventory model to obtain projections. In the past the PSRM projected animal numbers only and these were combined with projections of GHG emissions per animal. These projections were obtained from regression analysis of the time series of emissions per animal from 1990 to the present. Values reported in the Net Position Report are now consistent with how they are derived in New Zealand's National Inventory. Also, estimates for every year of CP1 can now be obtained rather than projecting the 2010 emissions and multiplying by 5 to obtain the total emissions over the 2008–2012 period.

The use of the inventory model to forecast emissions for every year in CP1 enables the most up to date information available to be incorporated into the projection, reducing the uncertainty bounds determined for the 2008 emissions forecast. Preliminary data from the 2008 agricultural production survey were used for animal population numbers. This data relates to the last half of 2007 and the first half of 2008 and therefore only animal numbers for the last six months of 2008 needed to be forecast. Without this data, the entire year plus six months of 2007 would need to be forecast. Estimates of animal performance for the 2008/09 production season were made using production data up to January 2009. Therefore the estimates on performance data for the calendar year 2008 were based on actual data rather than forecasts.

Nitrous oxide is one of the six greenhouse gases whose emissions are estimated for New Zealand's National Inventory. It is produced by both direct emissions from nitrogen (N) and indirectly where other N forms are first formed before being converting to N_2O. One such indirect path is where NH_3 gas and other NOx are first produced. These gases are then re-deposited on land surfaces elsewhere before being converted to N_2O. The major source of New Zealand's N_2O emissions comes from N excreted by livestock. In order to estimate the indirect contribution to N_2O of N excreted by livestock via NH_3 and NO_x gases, a factor called $Frac_{gasm}$ is used. This represents the proportion of N which is excreted by livestock and is released into the atmosphere as NH_3 and NOx. Currently New Zealand uses the IPCC default value of 0.2 for $Frac_{gasm}$. A MAF contracted report (Sherlock et al, 2008) reviewed the relevant studies on $Frac_{gasm}$ from livestock excreted-N, and found that New Zealand could halve the $Frac_{gasm}$ value to 0.1. This report was internationally peer reviewed. The lower values for $Frac_{gasm}$ has been used and this accounts for 3.8 Mt CO_2-e.

Reduction of nitrous oxide emissions due to application of a nitrification inhibitor has also been incorporated and accounts for a further 0.3 Mt CO_2-e. The application of the nitrification inhibitor dicyandiamide (DCD) to dairy pastures has been shown to reduce nitrous oxide emissions from fertiliser and animal excreted nitrogen on pasture over a five month period in winter. Nitrate leaching is also reduced. A report contracted by MAF on the use of DCD (Clough et al, 2008) developed the methodology for the quantification of the reduced nitrous oxide emissions.

Development of the most likely scenario

Projected animal numbers and nitrogen fertiliser use forecasts

Agricultural commodity prices

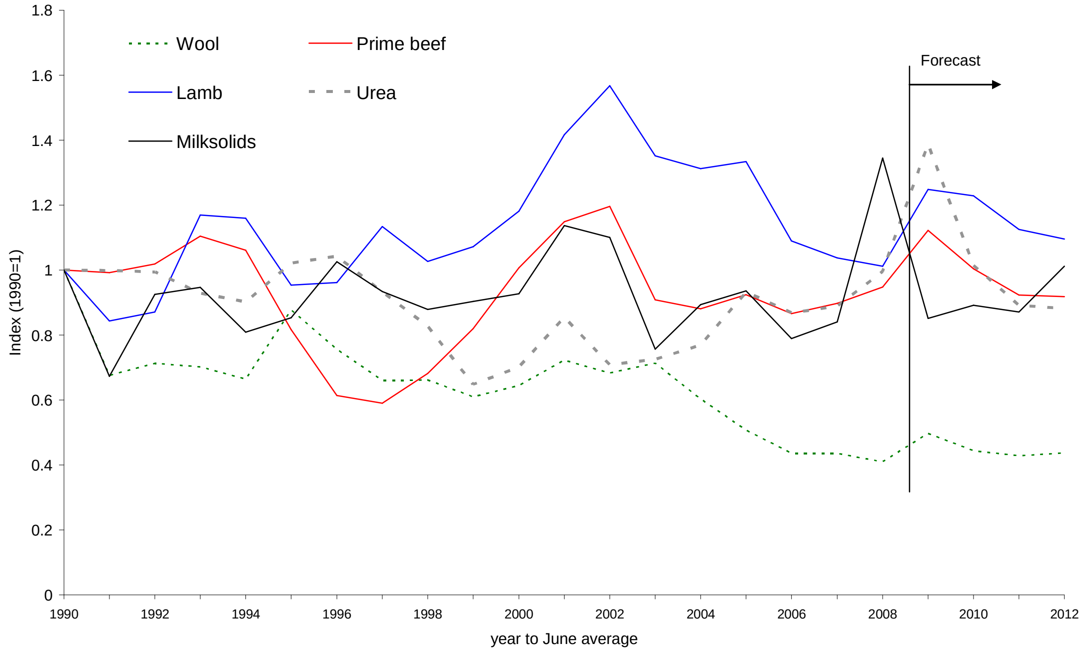
Future numbers of dairy cattle, beef cattle, sheep and deer are driven by changes in land use and stocking rates. Land use changes are modelled using expected changes in farm incomes. Stocking rates are modelled using expected changes in farm-gate prices, animal performance, and weather conditions. MAF estimates key farm-gate prices based on international price movements and the Treasury's assumptions on the future exchange rate and inflation, as published in their 2008 December fiscal and economic update. Figure A1 illustrates MAF's current expectations for key farmgate prices to 2012 in real terms.

In spring 2008, the global financial crises unfolded. The crisis has seen international prices for many commodities receding from their previous high levels and the New Zealand dollar depreciated rapidly against all major trading partners. The New Zealand trade weighted index fell 28 per cent for February 2009, year on year. The significant currency depreciation means New Zealand dollar farmgate prices will increase unless there is a severe fall in international price, as is the case with dairy prices (see Figure A1).

New Zealand dairy prices fell quite spectacularly with very rapid falls in international dairy prices from the peaks of the dairy boom (since August 2008). The average milksolid payout is expected to significantly decline from the peak in the 2007/08 season leading to slower growth in the dairy sector over CP1.

International meat prices followed a different trajectory to dairy; meat prices were poor during the commodity boom but have recently improved due to specific supply constraints. New Zealand meat prices are expected to strengthen over CP1 encouraging a partial recovery in sheep and beef numbers from the drought induced de-stocking of 2008.

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



Animal number forecasts

Since the 2008 net position report, the scale and consequences of the 2008 nationwide drought has become more apparent. The preliminary agricultural production survey results, released on 10 February 2009, provide a comprehensive quantitative description of the drought's impact. Sheep numbers fell by 12 per cent, beef numbers fell by 6 per cent, and deer numbers fell by 13 per cent. Dairy numbers increased by 6 per cent.

Over CP1, dairy numbers are expected to be lower than last year's forecasts due to lower payouts. Projections of sheep and beef numbers, on the other hand, improved from last year's forecasts due to higher prices at farmgate.

Table A2: Animal numbers projections for most likely scenario (000)

Year end 30 June	Beef cattle	Dairy cattle	Deer	Sheep
1990	4593	3441	976	57852
2008[1]	4119	5563	1213	33894
2009[2]	4213	5582	1371	35589
2010[2]	4367	5645	1432	36330
2011[2]	4377	5713	1386	36920
2012[2]	4402	5746	1385	37243

1 2008 is provisional data from the Agricultural Production Survey

2 Projected numbers from MAF's PSRM

Nitrogen fertiliser usage forecasts

The application of nitrogen fertiliser rises in line with improvements in farmgate pastoral output prices, especially the milksolids price, and tends to fall with increases in the price of the fertiliser itself (see Austin *et al*, 2006). The most likely forecast for nitrogen fertiliser use for 2010 is 317,844 tonnes, which is lower than the 2008 forecast of 396,967 tonnes. This difference is largely attributed to lower dairy payouts and higher fertiliser prices over CP1.

Table A3: Projections of nitrogen fertiliser usage for most likely scenario (tonnes)

Year end 30 June	N fertiliser use
1990	59265
2008[1]	349157
2009[2]	349993
2010[2]	317844
2011[2]	297418
2012[2]	330418

1 2008 is provisional data from FertResearch

2 Projected data from MAF's Nitrogen Demand Model

Animal performance forecasts

With genetic improvement and better pasture utilisation, productivity of New Zealand sheep, cattle and deer has increased. This has resulted in increasing amounts of pasture per animal being consumed and consequently more methane and nitrogen in urine and dung being produced. While in years of drought such as 2008/09 animal performance typically dips, the underlying upwards trend is robust and expected to continue in the foreseeable future. In MAF's PSRM model animal performance is modelled as a function of a linear trend of past performance, days of soil moisture deficit and, where statistically significant, farmgate price. Table A4 shows four examples of the performance statistics which are obtained from the PSRM.

Table A4: Example of some of the animal performance data obtained from the Pastoral Supply Response Model

30 June year end	Total dairy milk yields (million litres/year)	Beef bull slaughter weight (kg)	Lamb slaughter weights (kg)	Breeding stag slaughter weight (kg)
1990	2746	275.1	14.1	51.5
2008[1]	3538	299.3	16.5	56.8
2009[2]	3744	308.7	17.6	58.4
2010[2]	3872	313.3	18.0	59.9
2011[2]	3934	319.6	18.0	61.0
2012[2]	3996	321.5	18.2	61.3

1 2008 is data from LIC New Zealand Dairy Stats, and estimate of slaughter weight using MAF slaughter stats

2 Projected data from MAF's Pastoral Supply Response Model

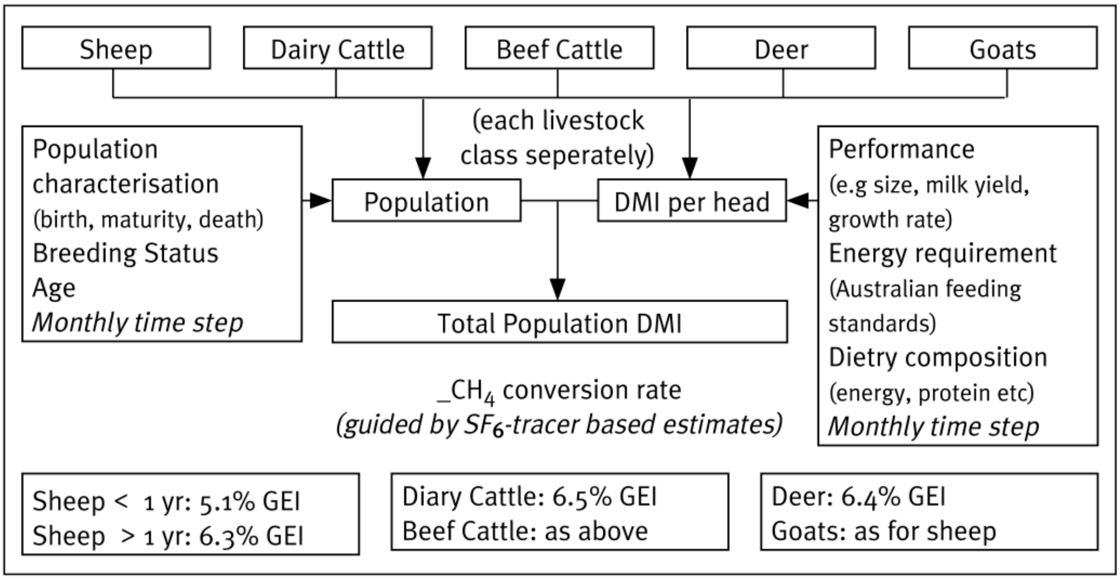
Development of greenhouse gas emission projections: most likely scenario

Projections of enteric methane emissions

Projections of enteric methane emissions for beef, dairy, deer and sheep for each year in CP1 were calculated by running actual data and forecast data from MAF's PSRM through the agriculture GHG tier two inventory model.

The inventory model determines animal feed intakes in monthly time steps for different age classes of each animal species. These are based on the mean national animal performance data 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. Since individual animal performance has been increasing over time (eg, milk yields per cow have risen by approximately 25 per cent since 1990), feed intake and methane emissions per animal have also increased.

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



* GEI = Gross energy intake.

Carbon dioxide equivalents from this enteric methane emission from each main source are shown in Table A5. Methane emissions from enteric fermentation on a per animal bases is shown in Table A6. An overview of the inventory model is shown in Figure A2.

Table A5: Projections of enteric methane emissions from each main source for the most likely scenario and the 1990 baseline (reported in Mt CO_2-e)

Calendar year	Beef cattle	Dairy cattle	Deer	Sheep	Total enteric methane emissions*
1990 baseline**	4.89	5.01	0.38	11.28	21.82
2008[1]	4.93	9.08	0.58	7.95	22.60
2009[2]	5.1	9.42	0.64	8.19	23.41
2010[2]	5.37	9.6	0.68	8.49	24.19
2011[2]	5.5	9.78	0.67	8.71	24.72
2012[2]	5.56	9.92	0.67	8.89	25.11

* Total enteric methane emissions also include emissions from other animal species (goats, horses, pigs, and poultry) for which projections are discussed later.

** 1990 values include all new science and methodologies and therefore are not identical to the 1990 assigned amount

1 Estimated emissions

2 Projected emissions using the Inventory Model

Table A6: Methane emissions from enteric fermentation per animal for 1990 baseline, 2008 estimate and projected most likely scenario values for 2009–2012 (kg CH_4/head/annum)

Calendar year	Beef cattle	Dairy cattle	Deer	Sheep
1990 baseline*	50.74	69.35	18.76	9.28
2008[1]	56.97	77.73	22.72	11.17
2009[2]	57.62	80.36	22.07	10.96
2010[2]	58.55	80.96	22.61	11.12
2011[2]	59.83	81.48	23.12	11.24
2012[2]	60.19	82.19	23.13	11.37

* 1990 values include all new science and methodologies and therefore are not identical to the 1990 assigned amount

1 Estimated emissions

2 Projected emissions using the Inventory Model

Methane emissions from ruminant animal waste

Methane emissions also arise from animal faecal material. This includes material deposited on pasture and, in the case of lactating dairy cows, from animal faecal material collected and treated in waste management systems. The projected waste methane emissions for beef, dairy, deer, and sheep for each year in CP1 were derived by running actual data and forecast data from MAF's PSRM through the agriculture GHG tier two inventory model. Carbon dioxide equivalents from animal waste methane emission from each main source are shown in Table A7. Methane emissions from animal waste on a per animal bases is shown in Table A8.

Table A7: Projections of animal waste methane emissions for the most likely scenario and the 1990 baseline (reported in Mt CO_2-e)

Calendar year	Beef cattle	Dairy cattle	Deer	Sheep	Total waste methane emissions*
1990 baseline**	0.06	0.21	0.004	0.11	0.58
2008[1]	0.06	0.39	0.01	0.08	0.53
2009[2]	0.06	0.4	0.01	0.08	0.55
2010[2]	0.07	0.41	0.01	0.08	0.56
2011[2]	0.07	0.41	0.01	0.09	0.57
2012[2]	0.07	0.42	0.01	0.09	0.58

* Total waste methane emissions also include emissions from other animal species (goats, horses, pigs, and poultry) for which projections are discussed later.

** 1990 values include all new science and methodologies and therefore are not identical to the 1990 assigned amount

1 Estimated emissions

2 Projected emissions using the Inventory Model

Table A8: Methane emissions from waste per animal for 1990 baseline, 2008 estimate and projected most likely scenario values for 2009–2012 in kg CH_4/head/annum

Calendar year	Beef cattle	Dairy cattle	Deer	Sheep
1990 baseline*	0.62	2.89	0.17	0.09
2008[1]	0.70	3.32	0.21	0.11
2009[2]	0.71	3.41	0.20	0.11
2010[2]	0.72	3.43	0.21	0.11
2011[2]	0.73	3.45	0.21	0.11
2012[2]	0.73	3.49	0.21	0.11

* 1990 values include all new science and methodologies and therefore are not identical to the 1990 assigned amount

1 Estimated emissions

2 Projected emissions using the Inventory Model

Projections of nitrous oxide emissions

Nitrous oxide emissions are derived from animal nitrogen output and synthetic nitrogen fertiliser use. Animal nitrogen output is a function of animal feed intake and the nitrogen content of the diet minus any nitrogen stored in animal product (meat, milk etc). Models developed by Clark *et al* (2003) for estimating monthly feed intake also estimate nitrogen output per animal. Projections of nitrous oxide emissions for beef, dairy, deer, and sheep for each year in CP1 were derived by running actual data and forecast data from MAF's PSRM through the agriculture GHG tier two inventory model. Projections of emissions from nitrogen fertiliser use were projected using forecasts of nitrogen use and emission factors that are currently used in National Inventory calculations. (Table A9)

Table A9: Projections of nitrous oxide emissions for each major nitrogen source for the most likely scenario and the 1990 baseline (reported in Mt CO_2-e)

Calendar year	Dung and urine from beef cattle	Dung and urine from dairy cattle	Dung and urine from deer	Dung and urine from sheep	Emission from N fertiliser use	Total nitrous oxide emissions*
1990 baseline**	1.87	2.22	0.15	4.53	0.34	9.4
2008 [1]	1.88	3.90	0.23	3.23	2.00	11.51
2009 [2]	1.94	4.02	0.25	3.43	2.00	11.92
2010 [2]	2.05	4.08	0.27	3.55	1.82	12.05
2011 [2]	2.10	4.14	0.26	3.66	1.70	12.15
2012 [2]	2.13	4.19	0.26	3.74	1.89	12.49

* Total nitrous oxide emissions also include emissions from other animal species (goats, horses, pigs, and poultry), N-fixing crops, crop residues and emissions from burning of savannah and field burning of agricultural residues.

** 1990 values include all new science and methodologies and therefore are not identical to the 1990 assigned amount

1 Estimated emissions

2 Projected emissions using the Inventory Model

Table A10: Nitrogen output per animal for 1990 baseline, 2008 estimate and projected most likely scenario values for 2009–2012 (kg N/head/annum).

Calendar year	Beef cattle	Dairy cattle	Deer	Sheep
1990 baseline*	65.51	103.87	24.88	12.61
2008[1]	73.45	114.14	30.18	15.33
2009[2]	74.29	117.56	29.29	15.53
2010[2]	75.61	118.18	30.03	15.75
2011[2]	77.31	118.87	30.71	15.95
2012[2]	77.81	119.80	30.71	16.17

* 1990 values include all new science and methodologies and therefore are not identical to the 1990 assigned amount

1 Estimated emissions

2 Projected emissions using the Inventory Model

Other animal species and greenhouse gas sources

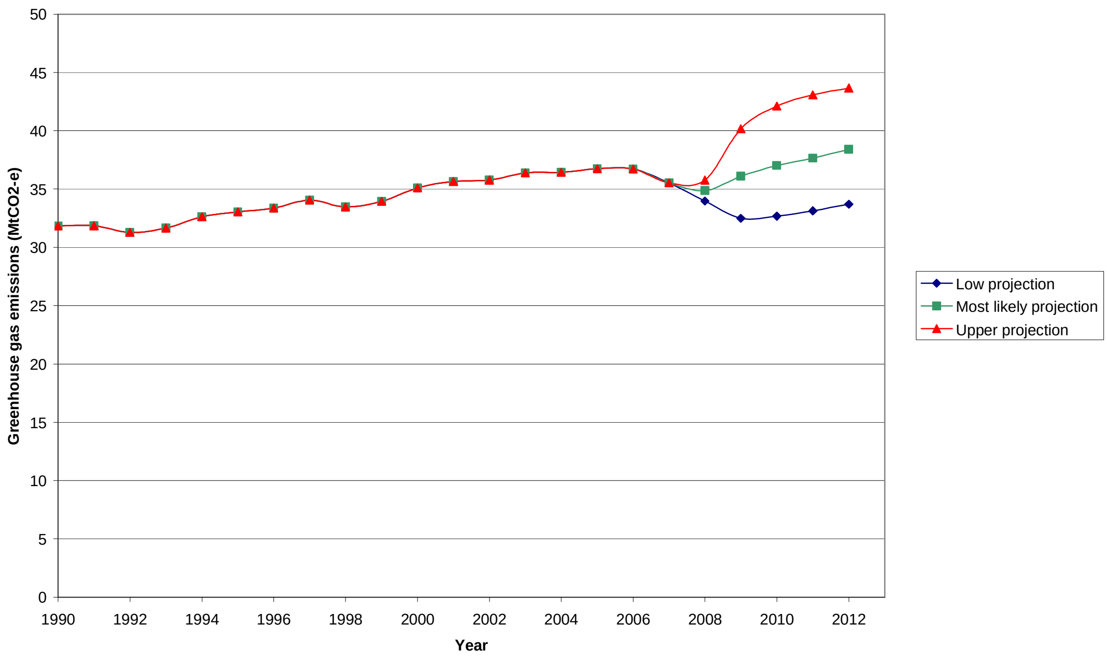
Methane and nitrous oxide emissions of minor animal species present in the National Inventory i.e. goats, horses, pigs, and poultry and nitrous oxide emissions from crop stubble burning, savannah burning and nitrogen fixing crops were forecast based on a rolling three year average method from their actual level of production in 2008. As these sources made up only 1.5 percent of total agricultural emissions in 2007 (0.55 MtCO_2-e), the impact of even large changes in any of these small emission sources on the total national emissions profile would be small.

Development of lower and upper scenarios

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

These calculations attempt to provide a range, with a specified probability, within which future reported emissions estimates should lie. It takes into account the uncertainty around the prediction of the forecasts used to determine the emissions, for example future animal numbers and performance levels. Predictions assume current science and do not account for any future changes in science or methodology.

Figure A3: Projected emissions over CP1



Animal numbers and nitrogen fertiliser usage

Table A11: Projections of animal numbers (000) and nitrogen fertiliser usage (tonnes) for low and high scenarios

Year end 30 June	Beef cattle		Dairy cattle		Deer		Sheep		N fertiliser use	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
2009	3,950	4,475	5,483	5,682	1,141	1,602	29,944	41,723	266,928	447,996
2010	4,116	4,618	5,472	5,818	1,197	1,667	30,087	43,036	219,721	432,873
2011	4,125	4,628	5,518	5,909	1,141	1,632	30,449	43,826	208,050	420,236
2012	4,151	4,652	5,542	5,950	1,140	1,631	30,665	44,240	229,631	478,333

Enteric methane emissions

Lower and upper estimates of enteric methane emissions were obtained from running the inventory model with the lower and upper estimates of animal numbers and performances. This gives a lower and upper bound for projected enteric methane emissions at the 95 percent confidence level (Table A12).

Table A12: Projections of enteric methane emissions for the main livestock industries for the lower and upper scenarios (Mt CO_2-e)

Calendar year	Beef cattle		Dairy cattle		Deer		Sheep	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
2008	4.82	5.04	8.85	9.31	0.56	0.59	7.68	8.23
2009	4.63	5.59	8.94	9.93	0.52	0.76	7.16	9.59
2010	4.86	5.9	8.96	10.28	0.54	0.83	7.22	10.28
2011	4.97	6.05	9.04	10.56	0.53	0.83	7.41	10.60
2012	5.03	6.12	9.14	10.76	0.53	0.83	7.58	10.86

Nitrous oxide emissions

Lower and upper estimates of nitrous oxide emissions were obtained from running the inventory model with the lower and higher estimates of animal numbers and performances. Emissions from nitrogen fertiliser were projected using lower and higher estimates of nitrogen use. This gives an upper and lower bound for projected nitrous oxide emissions at the 95 percent confidence level (Table A13).

Table A13: Projections of nitrous oxide emissions from the main nitrogen sources for lower and higher scenarios (Mt CO_2-e)

Calendar year	Dung and urine from beef cattle		Dung and urine from dairy cattle		Dung and urine from deer		Dung and urine from sheep		Emissions from N fertiliser use	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
2008	1.84	1.92	3.80	3.91	0.22	0.23	3.12	3.34	2.00	2.00
2009	1.76	2.13	3.81	4.05	0.21	0.30	2.89	3.92	1.53	2.56
2010	1.85	2.26	3.81	4.12	0.21	0.33	2.91	4.22	1.26	2.48
2011	1.89	2.32	3.84	4.19	0.21	0.32	2.99	4.35	1.19	2.41
2012	1.92	2.35	3.87	4.24	0.21	0.33	3.06	4.46	1.31	2.74

Overall assumptions and limitations of the projections

All the above projections need to be assessed within the inherent uncertainties of biological systems. Climate shocks such as droughts, and the economic conditions which are largely driven by overseas markets, can rapidly change the circumstances under which the agricultural industry operate over the next few years.

Uncertainty in projections of animal populations and animal performances and of the science underlying measurement methods all attribute to the uncertainty in projections of total emissions.

Emission mitigation technologies such as nitrification inhibitor DCD and improvements in the science behind measuring agricultural emissions ($Frac_{gasm}$) have been incorporated into emission projections. New mitigation technologies and further refinements of measurement methods will bring further changes to these projections.

Adoption of mitigation technologies may be counter-balanced by greater increases in emissions from increases in animal numbers and further improvements in animal productivity growth. Past data on animal productivity growth were used to derive the best fit projection equations for future changes. However, animal performances remained largely dependent on future improvements in technologies and management practices.

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.

Clough, T.J., Kelliher, F.M., Clark, H. and van der Weerden, T.J. 2008. *Incorporation of the Nitrification Inhibitor DCD into New Zealand's 2009 National Inventory*. Prepared for Ministry of Agriculture and Forestry, PO Box 2526, Wellington.

Ministry of Agriculture and Forestry, 2008. *Briefing on Methodology for Forecasting Livestock Numbers and Nitrogen Fertiliser Use*, 8 pp.

Sherlock, R, Jewell P., and Clough, T. 2008. *Review of the New Zealand Specific $Frac_{gasm}$ and $Frac_{gasf}$ Emission Factors*. Prepared for Ministry of Agriculture and Forestry, PO Box 2526, Wellington

[Inconsistent use of punctuation in references above]

Appendix B: Projected Balance of Emissions for the Energy, Transport and Industrial Processes Sectors for the Kyoto Commitment Period, 2008–2012

Short report to Ministry for the Environment, 7 April 2009, prepared by Energy Information and Modelling Group, Ministry of Economic Development.

1 Executive summary

[Inconsistent and incorrect use of capitalisation in the following section (energy sector, industrial processes, most likely, high emission, low emission, transport, urea)]

The Ministry of Economic Development provides projections of emissions from the Energy Sector and Industrial Processes. These projections are based on the energy models maintained and updated by the Energy Information and Modelling Group. This modelling includes co-ordination with the models of the Electricity Commission and the Ministry of Transport and uses inputs from other government agencies including Treasury and the Ministry of Agriculture and Forestry.

In model fitting every effort is made to use preliminary 2008 figures where available. However in some cases energy data and vehicle fleet information for all of 2008 was not available.

This document centres on the Most Likely scenario projection. Both High Emission and Low Emission scenarios are also modelled to allow an estimate of the range of possible outcomes.

Since the 2008 report significant effort has been undertaken to align methodologies used to forecast emissions with those used in the National Inventory calculations allowing greater compatibility between the figures especially at the sub-sector level. In addition we have reconsidered our modelling approach around the treatment of energy efficiency and its expected impact on electricity demand.

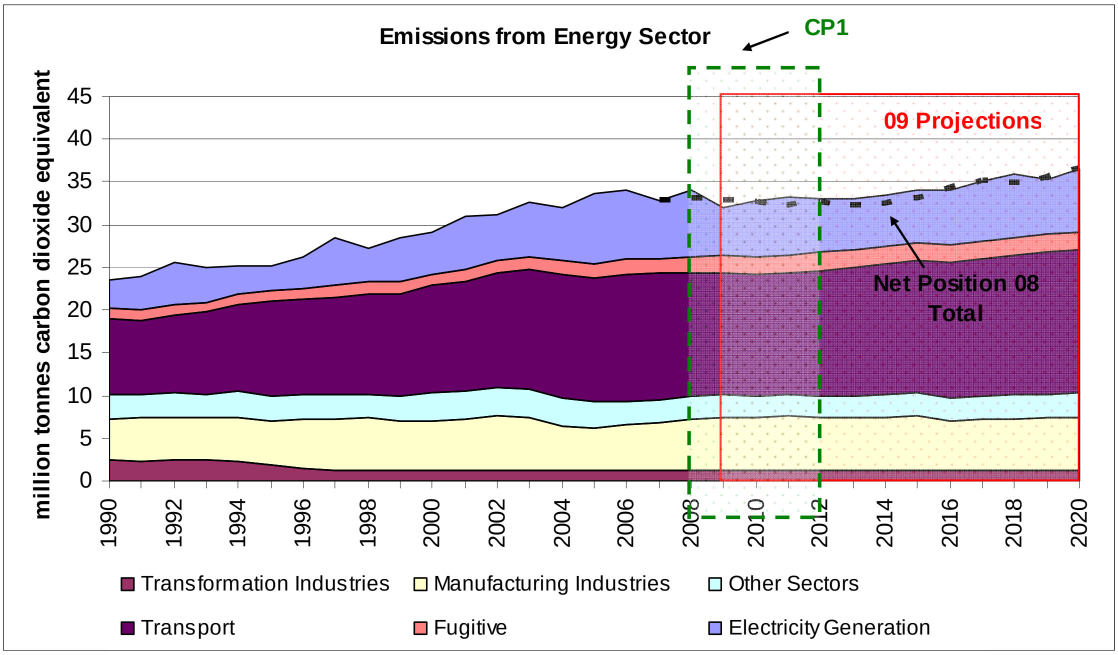
The 2009 projection of total CO_2 equivalent (CO_2-e) emissions from the Energy Sector and Industrial Processes for the first commitment period is 185,620. This is 3 kt CO_2-e lower than the 2008 projection.

Of this total, energy and transport sectors account for 164,913 kt of CO_2 equivalent (CO_2-e) over the first commitment period. This compares to a 2008 projection of 163,651 kt – an increase of 1,262 kt CO_2-e. Industrial Process emissions are projected to be 20,707 kt CO_2-e for CP1. This compares with a 2008 projection of 21,972 kt CO_2-e – a decrease of 1,265 kt CO_2-e.

Significant changes from the 2008 projection are:

- Additional net 600 kt CO_2-e from stationary energy including
  - additional net 150 kt CO_2-e emissions from increased projected electricity demand resulting from model changes including that as to the treatment of future likely energy efficiency improvements
  - additional net 250 kt CO_2-e emissions from the industrial and commercial sector. This results from a re-allocation of 700 kt CO2-e from Industrial Processes relating to the treatment of Urea production[1] less a projected reduced energy demand and emissions of 450 kt CO2-e
  - additional 200 kt CO_2-e increase in fugitive emissions from geothermal electricity generation and from Kapuni gas treatment plant
- a net increase in emissions of 660 kt CO_2-e from Transport comprising
  - additional 1,100 kt CO_2-e resulting from the repeal of the biofuel sales obligation
  - reduction of 440 kt CO_2-e from reduced demand
- a reduction of 1,265 kt CO_2-e in reported emissions from industrial processes comprising a
  - reduction of 700 kt CO_2-e re-allocated to industrial energy emissions
  - further reduction of 565 kt CO2-e in emissions resulting from projected reduction in industrial processing [full stop needed here]

The dry year in 2008 increased electricity emissions by between 0.6 and 1mt in that year however an allowance for a dry year event had been incorporated into the projections made in 2008.



[1] This decrease is a shift of emissions from Industrial Processes to Energy Sector emissions as part of a realignment of methodologies to match those used for National Inventory (see Urea section of Greenhouse Gas Emissions report, p19).

2 Introduction

As a signatory of the Kyoto Protocol New Zealand has accepted as a target that, for the period 2008 to 2012 (the first commitment period) it will reduce its greenhouse gas emissions to the level they were in 1990, or take responsibility for excess emissions.

To monitor progress towards this goal the Ministry of Economic Development projects greenhouse gas emissions that can be expected from the national energy system (including transport) and those from industrial processes.

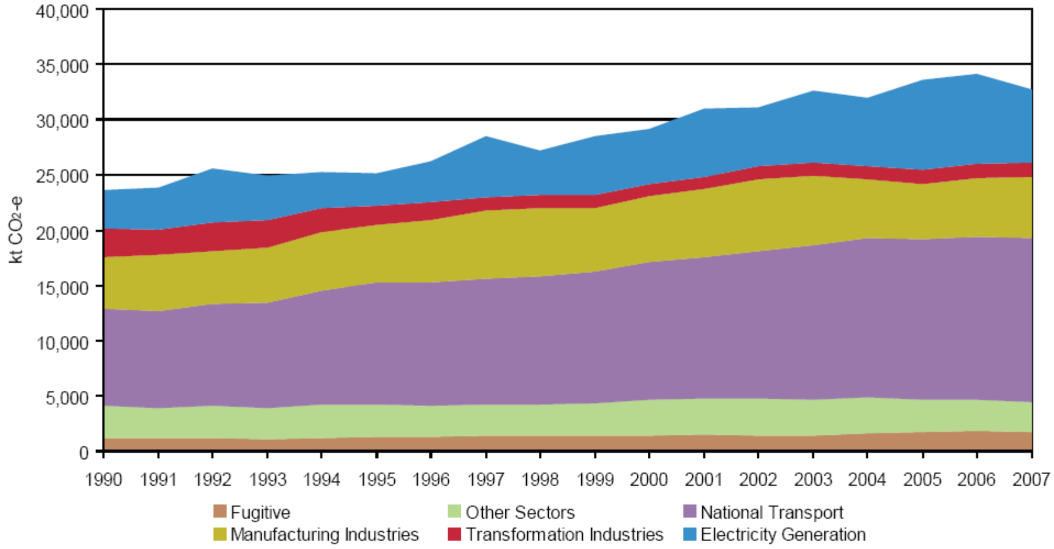
The emission projections are calculated and reported under the framework provided by the United Nations Framework Convention on Climate Change (UNFCCC) and its advisors the Intergovernmental Panel on Climate Change (IPCC).[2] The energy system is defined to comprise the exploration and exploitation of primary energy sources, the conversion of primary energy sources into more useable energy forms in refineries and power plants, the transmission and distribution of fuels and the use of fuels in stationary and mobile applications. Emissions arise from these activities by combustion and as fugitive emissions, or escape without combustion.

Before presenting the updated emission projection this document first presents a brief history of these emissions from 1990 to 2007 and then discusses the policy and economic environment and the relative influences these can be expected to have on the emissions to 2012.

2.1 Historical greenhouse gas emissions

Figure 1.1 below shows the reported emissions from energy for 1990 to 2007 as reported in MED's publication "The New Zealand Energy Greenhouse Gas Emissions 1990–2007".

Figure 1.1: Energy Emissions by Sector (kT CO_2-e)



2 http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

The graph shows total emissions growing 38.7% between 1990 and 2007 with most of this growth occurring in Transport and Electricity Generation. Transport now accounts for 46% of energy emissions and since 1990 these have grown at an average rate of over 3% a year in line with population and economic growth, high growth in the heavy vehicle fleet and with the general trend to larger light vehicles. This growth rate has however slowed appreciably from 2004 in a period of generally higher petrol and diesel prices.

Electricity emissions have also grown and have shown increased variability as Huntly power station has switched between gas and coal and is run harder in dry winters. The drop in 2007 reversed in 2008 as Huntly ran hard on coal for much of the previous winter.

Manufacturing emissions and other sectors are relatively stable and reflect the dominance of a small number of large industrial plants. These emissions had declined since 2002 as a result of Methanex scaling back methanol production. However in October 2008, Methanex restarted production at its Motunui plant and the expected increase in emissions has been included in emission projections in both 2008 and 2009.

Industrial processes contribute around five percent of New Zealand's total greenhouse gas emissions. There are six major industrial processes that are represented in this sector with approximately half of the industrial processes sector emissions from the metals industry.

2.2 Current policy settings

In making this projection the models generally assume future investment in energy supply in line with that observed in the historical period with investment decisions dictated by economics including the constraints required by technical and risk considerations. These investments include those associated with new electricity plant, choice of fuel for industrial applications and vehicle fleet evolution. The latter is an example where straight economic decisions are complicated by the trends and fashion in vehicle choice.

Layered above these influences are the stimulus and requirements of government and international energy policy. The new government has signalled a review of both the New Zealand Energy Strategy 2007 and the Climate Change Response (Emissions Trading) Amendment Act 2008. As these reviews have yet to occur the 2009 projections only include in their modelling the changes in policy setting that the new government have already enacted in the period up to March 2009. These are:

- the repeal of the Biofuel Bill 2008
- the repeal of the Electricity (Renewables Preference) Amendment Act 2008.

In our modelling the first of these measures is found to have a direct effect on the emissions with an additional 1.1M tonnes of CO2-e now expected in the first commitment period.

2.3 Current economic situation

The Net Position 2009 projection has been made in a period of worldwide economic turmoil. New Zealand is already in a technical recession with negative GDP growth being measured in both the July and September quarters 2008. Other countries are similarly in recession including Australia, Japan, USA, United Kingdom and Germany. The experts seem to only agree that the outlook is extremely uncertain.

The current economic situation and its effect on emissions have been modelled to the extent possible. The energy models used are based on calendar year data although in some cases 2008 fourth quarter and final energy demand data was not yet available.

In modelling these projections we draw on the agreed New Zealand government sources for relevant input projections of GDP, exchange rate and international oil price[3]. The first two are sourced from the latest Treasury updates. Treasury provided Economic and Fiscal Forecasts in December 2008[4] however the economic situation has weakened since then and in February the Treasury advised:

> *"The economy is expected to continue weakening in 2009 with a further fall in real GDP predicted for the March quarter. As a result, growth appears to be developing in line with the December Update downside scenario, at least in the near term, with recent international developments pointing to further downside risk."*[5]

Based on this advice Net Position 2009 has used the December update "downside scenario" for inputs on near term GDP and exchange rate. This scenario has GDP growth of 0.4% in 2008 dropping to -0.4% in 2009 but then rebounding to 1.2% in 2010 and 4.4% in 2011. It is worth noting that this projection of economic conditions is for similar levels to those experienced in the 1990-1993 period when greenhouse emissions increased by 6% (although some of these emissions were the result of the dry winter that triggered the 1992 electricity crisis).

It is also worth noting that GDP is not the only key driver in the energy models which determine the level of projected greenhouse emissions. In transport the travel by the light fleet has been found to be driven as much by population growth and fuel price. In the electricity sector movements in demand may not necessarily drive equivalent movements in emissions which depend more on the mix of fuels sourced in production. In a dry autumn/winter, such as in 2008, scarce hydrological conditions will require that fossil fuel sourced generation will be run harder with an ensuing higher level of greenhouse gas emissions [full stop needed here]

The energy models used to form the projection are built up on a sector basis with the relationship between energy demand and economic growth fitted for each sector. Sectors such as transport and residential have historically been found to have low demand elasticity and as a result no dramatic demand reduction is foreseen. Overall, the impact on emissions from energy and industrial processes as a result of the current economic situation is estimated to be a decrease of around 1.5 mt CO_2-e.

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3 http://www.med.govt.nz/templates/MultipageDocumentTOC____28219.aspx

4 http://www.treasury.govt.nz/budget/forecasts/eff2008

5 http://www.treasury.govt.nz/economy/mei/jan09/02.htm

3 Model enhancements

Along with updating historical demand data and the inclusion of preliminary 2008 demand figures significant enhancements have been made to the energy model since the 2008 Net Position forecasts. These include:

- Aligning emission calculation methodologies with those used in the National Inventory especially for transport, cogeneration and industrial processes,
- Revised electricity demand forecasts to better reflect historical annual growth rates by changing the approach taken to model efficiency gains,
- Realigned Heavy Industry demand sub-models to produce internal consistency between models
- Updated assumptions and production forecast for Heavy Industries based on work by Covec and Hale and Twomey.
- Split Other Industrial and Commercial models into Commercial and Light Industry models, where the Light Industry model has two sub-parts, Primary Industries and Other Light Industry.
- Redeveloped biofuels model (although this is not used in 2009 Net Position Modelling) [fullstop needed here]

The implications of the Liquid Fuels Project undertaken late in 2008 have not been included in this work as work is still underway in implementing the recommendations of that work. It is however anticipated that total emissions will not change – only the allocation of emission at the sub-sector level. A quick calculation suggests that ~800kt of emissions (p.a) would be transferred from transport emissions to predominantly Primary Industry emissions. This reflects the fact that there is currently an over reporting of diesel use for transport and an under reporting for use in areas such as agriculture.

4 2009 emissions projections

4.1 Summary by sector

Total emissions from the energy and transport sectors are now projected to be 164,913 kt of CO_2 equivalent (CO_2-e) for the first commitment period. This compares to a 2008 projection of 163,651 kt an increase of 1,263 kt CO_2-e.

Industrial Process emissions are projected to be 20,707 kt CO_2-e for CP1. This compares with a 2008 projection of 21,972 kt CO_2-e a decrease of 1,263 kt CO_2-e.

Year	Emissions (kt CO_2-e)				
	Stationary energy	Transport	Sub-total	Industrial processes	Total
2008	19,666	14,299	33,966	4,007	37,972
2009	17,683	14,331	32,014	3,973	35,987
2010	18,556	14,169	32,725	4,213	36,939
2011	18,825	14,408	33,233	4,254	37,488
2012	18,244	14,731	32,975	4,259	37,235
Total CP1	**92,975**	**71,938**	**164,913**	**20,707**	**185,620**

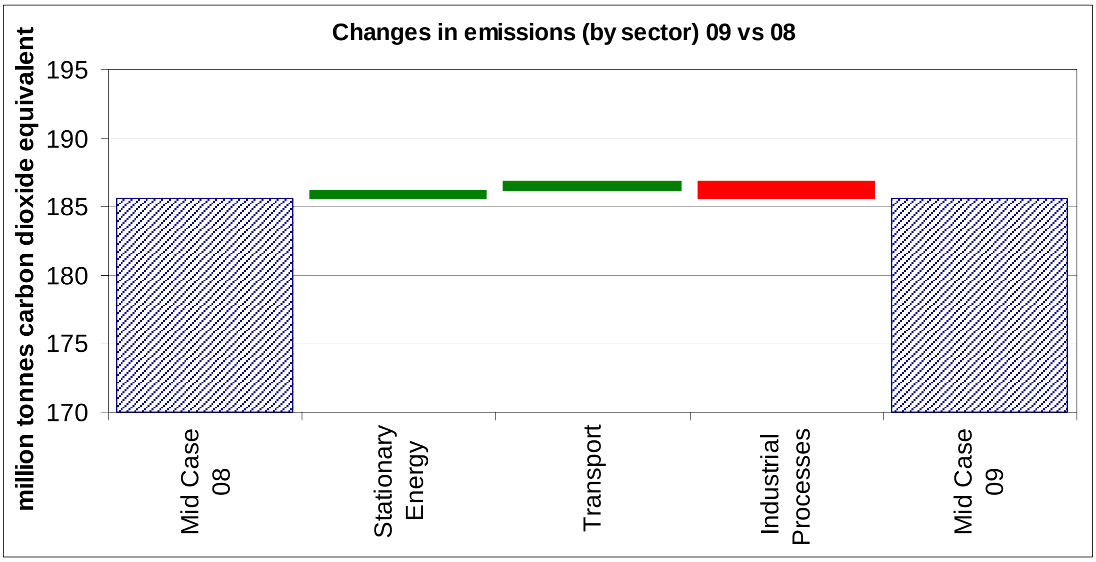
Significant changes from 2008 are:

- Additional net 600 kt CO_2-e from stationary energy including
  - additional net 150 kt CO_2-e emissions from increased projected electricity demand resulting from model changes including that as to the treatment of future likely energy efficiency improvements
  - additional net 250 kt CO_2-e emissions from the Industrial and Commercial sector. This results from a re-allocation of 700 kt CO2-e from Industrial Processes relating to the treatment of Urea production[6] less a projected reduced energy demand and emissions of 450 kt CO2-e
  - additional 200 kt CO_2-e increase in fugitive emissions from geothermal electricity generation and from Kapuni gas treatment plant
- a net increase in emissions of 660 kt CO_2-e from Transport comprising:
  - additional 1,100 kt CO_2-e resulting from the repeal of the biofuel sales obligation
  - reduction of 440 kt CO_2-e from reduced demand
- a reduction of 1,265 kt CO_2-e in reported emissions from industrial processes comprising a
  - reduction of 700 kt CO_2-e re-allocated to industrial energy emissions
  - further reduction of 565 kt CO_2-e in emissions resulting from projected reduction in industrial processing [full stop needed here]

The dry year in 2008 increased electricity emissions by between 0.6 and 1mt, although an allowance for a dry year event had been incorporated into the previous projections.

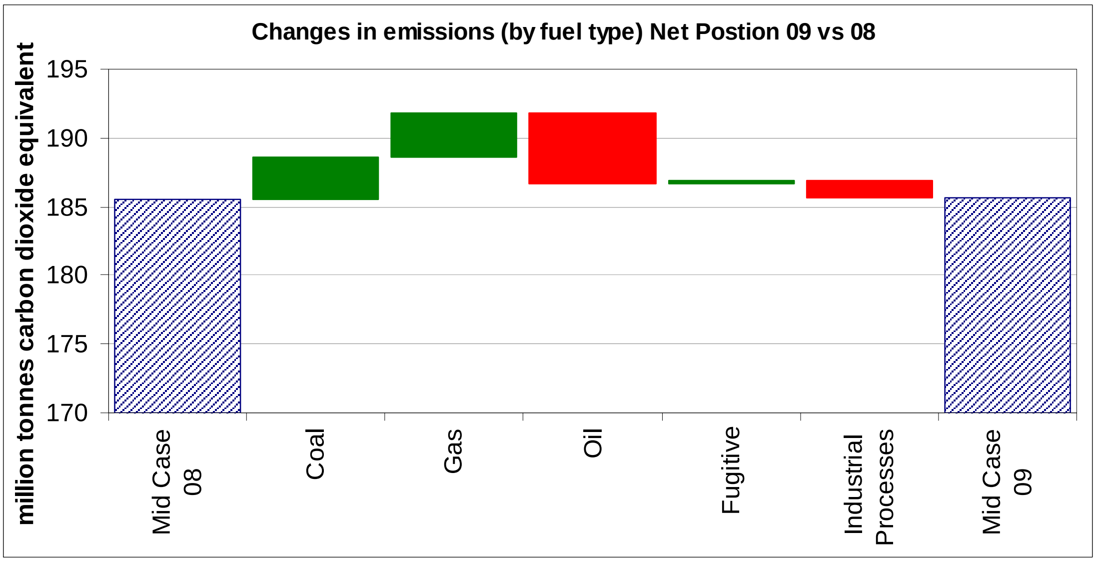
Changes in emissions between the 2008 and 2009 projections by sector (Stationary Energy, Transport and Industrial Processes) are presented in the figure below. Note that some 700 kt CO_2-e of emissions have been reallocated from Industrial Processes to Stationary Energy as part of the methodology realignment.

6 This decrease is essentially a shift of emissions from Industrial Processes to Energy Sector emissions as part of a realignment of methodologies to match those used for National Inventory (see Urea section of Greenhouse Gas Emissions report, p 19).



Changes in emissions by fuel type between 2008 and 2009 projections show a more complicated story than changes by sector.

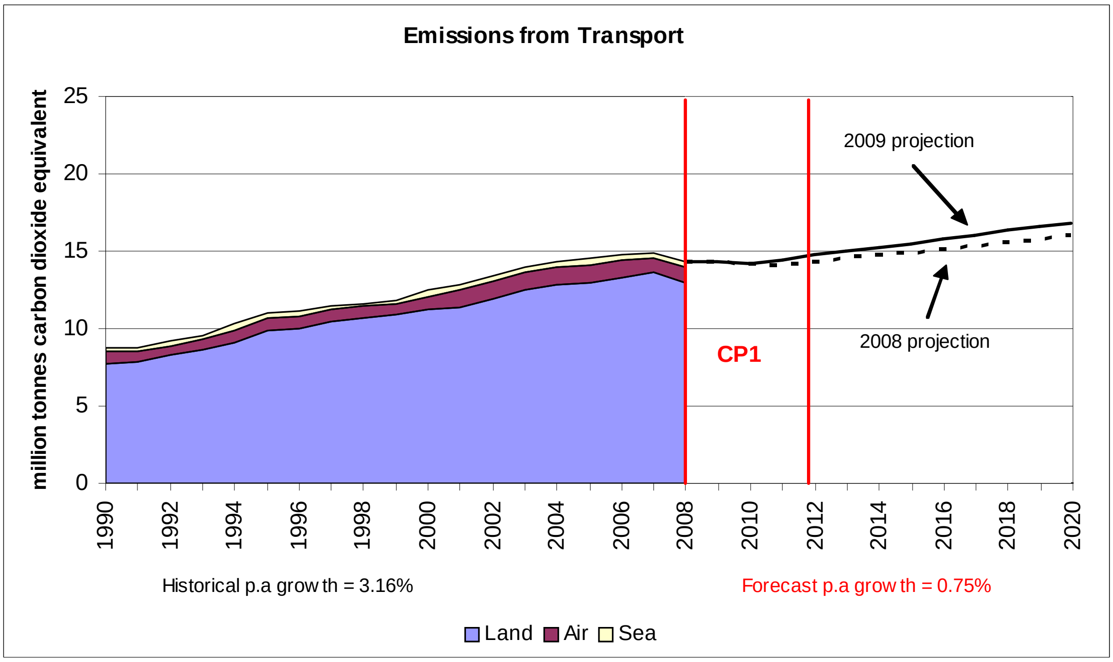
Coal emissions increase due to projected increased electricity generation at Huntly. Gas demand has decreased from both electricity generation and other sectors due to its projected price path and relativity. However the total emissions from gas rise significantly as we now reflect petroleum refining emissions as gas emissions (previously attributed to oil) as per the National Inventory methodology. Thus there is a corresponding drop in emissions from oil. Fugitive emissions increase due to increased geothermal electricity generation and an increase in the expected fugitive emissions from the Kapuni gas treatment plant.



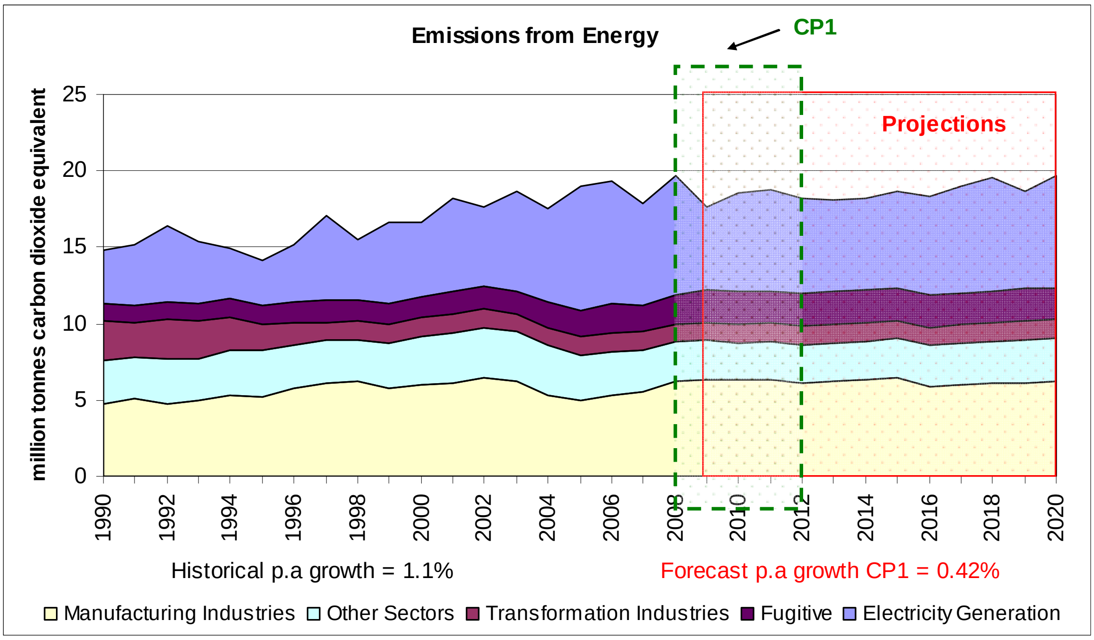
4.2 Emissions – transport (2009 versus 2008)

Projected transport emissions are close to those made last year being just 440 kt CO_2-e higher over the commitment period. This figure reflects the additional emissions with the repeal of the biofuel obligation but with lower emissions and demand expected from the lower GDP projection. The projections made in 2008 successfully predicted the small but unusual downturn in demand for petroleum products in 2008.

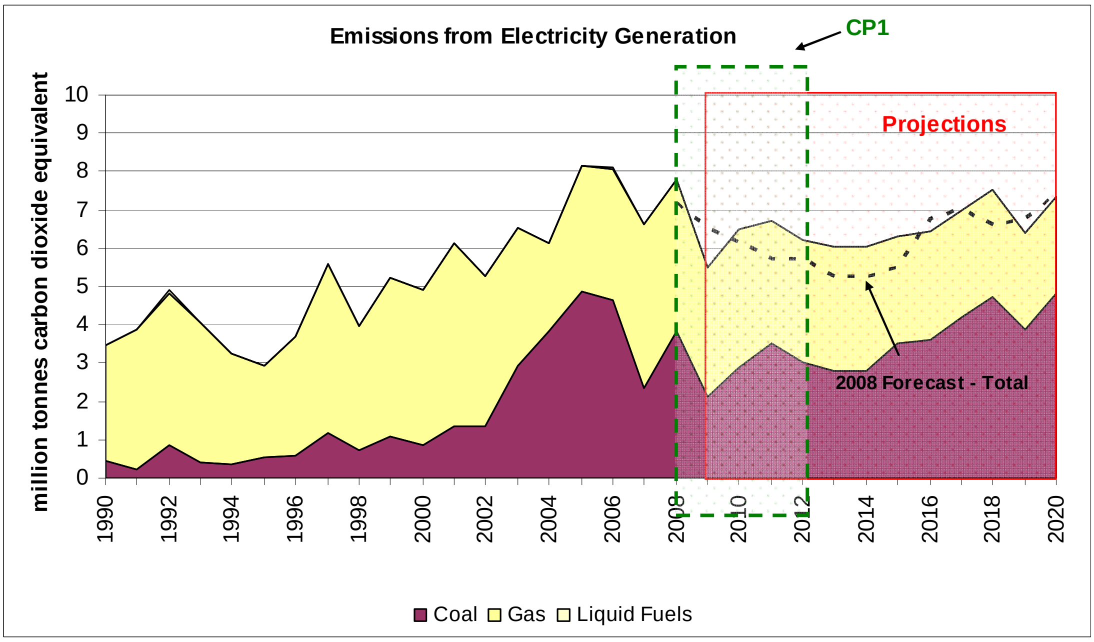
The higher emissions projected in the latter years from 2011 result from the projection now not including any biofuels and some effect from lower oil prices projected to 2020.



4.3 Emissions by sub-sector – stationary energy



4.4 Emissions by sub-sector – electricity



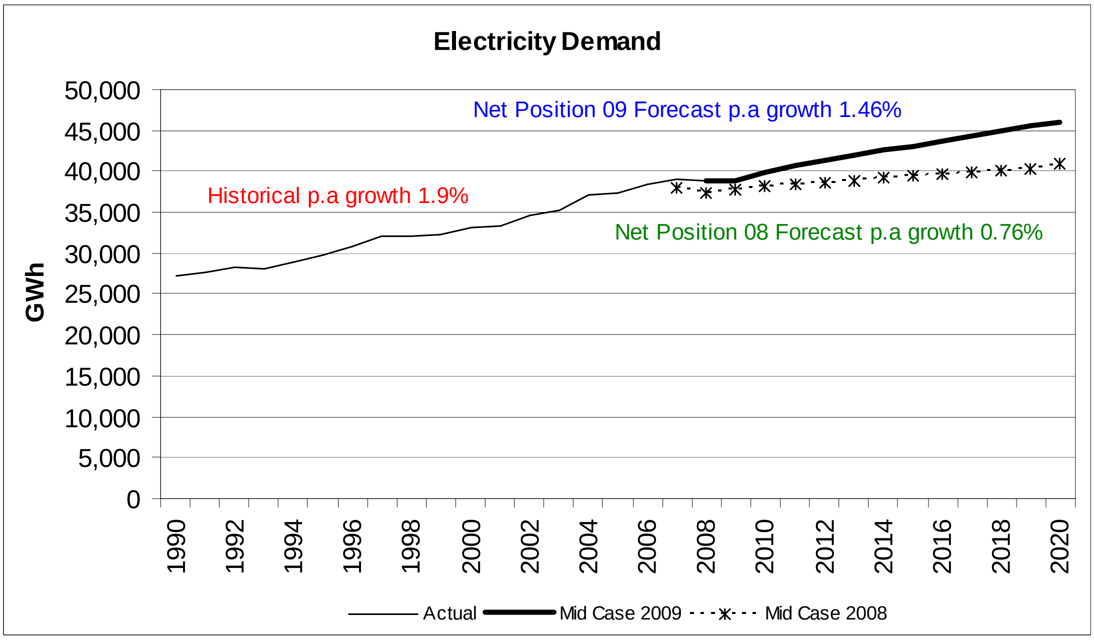
4.5 Electricity demand

Since making the 2008 projections, the method used to project the likely effect of energy efficiency gains has been revised. In 2008 the specific effects of expected energy efficiency measures were modelled in a bottom up manner and subtracted from overall demand growth. While this approach may model the individual expected efficiency measures it risks double-counting the impact of such measures as historical data already includes the net effects of both increasing demand for electrical services and energy efficiency improvements. It is a difficult process to separate out these two effects and to project the future demand for new services.

Thus a simpler approach to projecting future demand growth has been used which is based on fitting models to historical demand by sector. The models produce overall projected annual electricity demand growth of 1.5% to 2020. Average annual demand growth between 1990 and 2008 was 1.9%. The projected rate of increase is lower than the historical figure as heavy industry energy demand growth is expected to be somewhat less in the future compared with the historical average.

At a sub-sector level electricity demand growth (2008 to 2020) is projected as follows:

- Residential 1.3% p.a (driven primarily by projected growth in the number of households).
- Commercial 2.2% p.a (driven primarily by GDP and price forecasts)
- Light Industry 1.6% p.a (driven primarily by GDP and price forecasts)
- Heavy Industry 0.8% p.a (driven by production forecasts) [need fullstop here]



4.6 Electricity generation

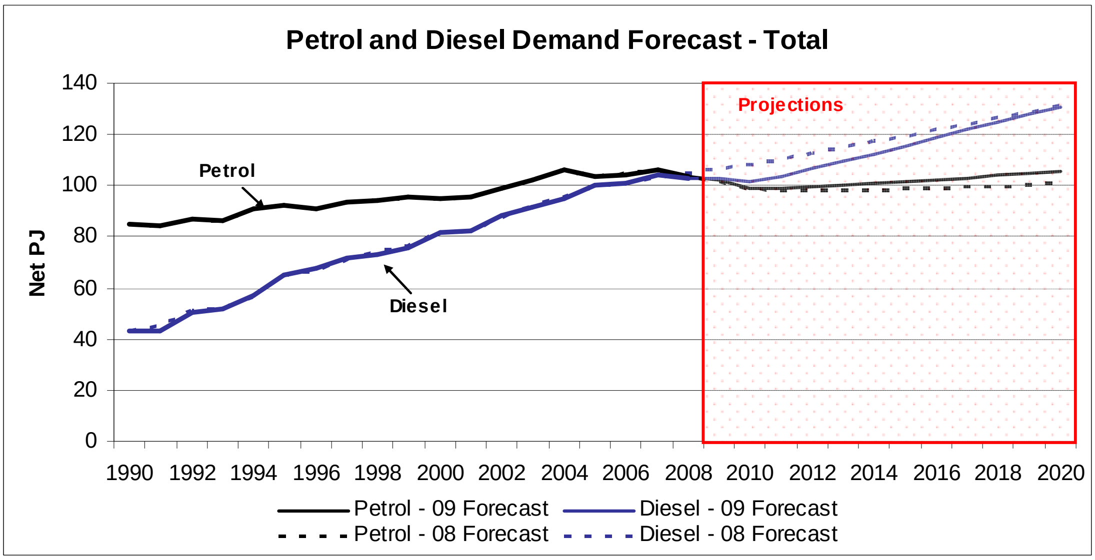
To meet electricity demand, generation was modelled using "GEM". Some key messages from the modelling are:

- Gas prices are projected to rise and from 2011 coal becomes more economic to dispatch than gas. A switching of gas to coal generation results in only a slight increase in emissions since new renewable build keeps total thermal generation relatively constant.
- Rising gas prices also results in new coal plant being built (and no new gas plant) however we do constrain the modelled quantity and timing of new coal build. Unconstrained the model will initiate new coal generation being built almost immediately.
- We assume that the 4 Huntly units move to a dry year reserve role in a staggered fashion – in 2015, 2017, 2019 and 2020. This means that despite new coal being built in 2017 and 2020, overall coal generation does not increase substantially.
- The "lumpy" nature of new investment results in some peaks and troughs in annual emission projections. For example, new hydro and wind in 2019 results in a dip in emissions for that year, and the following year emissions revert to previous levels as thermal generation increases to meet demand growth.

4.7 Petrol and diesel demand

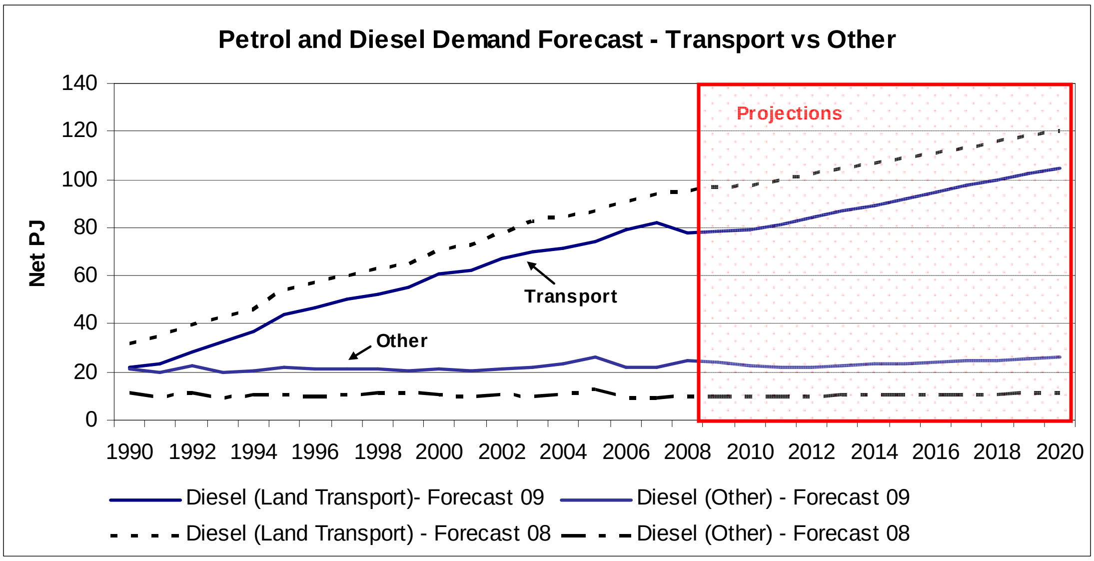
Petrol and diesel demand are modelled through a combination of VFEM forecasts for transport demand and SADEM forecasts for all other petrol and diesel demand (i.e. industry, commercial and residential demand including agriculture).

In terms of energy content, diesel demand is projected to over-take petrol demand in the current year. In terms of litres, diesel is not projected to over-take petrol until approximately 2014.



At the sub-sector level (transport versus other), the revisions to the model methodologies have made a significant improvement to the projections for diesel demand. Historically, SADEM had employed a different definition of transport to that used for National Inventory reporting. This definition of transport had included mobile combustion that occurs off public road (i.e. tractors, trucks, motorbikes etc.). The updated method now allocates all known diesel (and resulting emissions) delivered to off-road users (i.e. agriculture, construction, forestry etc) as being in Other Sectors regardless of whether it is used in mobile or stationary applications. This approach now correctly follows the UNFCCC guidelines.

The effect of this is readily apparent in the figure below with Diesel demand for transport in the 2009 projection being lower than that projected in 2008.



5 Uncertainty – high and low emission projections

Uncertainty is modelled by comparing the Most Likely projection with high and low emissions scenarios. Scenarios are developed by varying a range of model input parameters – in particular the high emissions scenario assumes higher growth in GDP and population, lower oil prices and drier hydrology assumptions (i.e. includes 3 drier years). The historical movements in these inputs have been analysed and the projected path for each has been raised to levels thought close to their potential maximums. This all leads to higher energy and emission projections.

Similarly the low emissions scenario assumes lower GDP and population, higher oil prices and normal hydrology. In addition the assumed emissions price is varied between scenarios – \$50 /tonne in the low scenario and \$15 /tonne CO2-e in the high emissions scenario.

These two scenarios model the variation that may result from the changes in the parameters specified. They do not model the effects of changes not described by the parameters which might well see the emission path move to a greater degree. The risks would now appear to be on the down side to lower emissions as while major emitters may shut down in a short time frame (e.g. Methanex has previously ceased operation at Motunui) it takes a longer period of some years to plan and build additional major emitting plant. These now may not be possible much before the end of 2012.

The tables below shows the range of emissions projected in CP1 for the three scenarios.

	Low case		Mid case	High case	
	% change	kt CO_2-e			% change
Stationary energy	-5.6%	87,733	92,975	99,586	7.1%
Transport	-2.2%	70,388	71,938	73,618	2.3%
Sub-total	**-4.1%**	**158,121**	**164,913**	**173,205**	**5.0%**
Industrial processes	-3.4%	20,006	20,707	21,454	3.6%
Total	**-4.0%**	**178,126**	**185,620**	**194,659**	**4.9%**

	Low case		Mid case	High case	
	% change	kt CO_2-e			% change
Residential	-0.5%	2,579	2,592	2,602	0.4%
Commercial	-1.7%	4,572	4,651	4,716	1.4%
Primary industry	-2.1%	5,306	5,422	5,550	2.4%
Light industry	-1.4%	11,008	11,166	11,331	1.5%
Heavy industry	-4.0%	19,323	20,137	20,698	2.8%
Electricity generation	-11.1%	29,097	32,746	37,750	15.3%
Other transformation	-3.4%	5,733	5,932	6,189	4.3%
Fugitive	-2.1%	10,115	10,330	10,749	4.1%
Transport	-2.2%	70,388	71,938	73,618	2.3%
Sub-total	**-4.1%**	**158,121**	**164,913**	**173,205**	**5.0%**
Industrial processes	-3.4%	20,006	20,707	21,454	3.6%
Total	**-4.0%**	**178,126**	**185,620**	**194,659**	**4.9%**

The variation between the high and low scenario and the most likely projection has reduced from those quoted in 2008. This reflects increased confidence across a range of assumptions leading to more similarity across the 3 scenarios. These include:

- 2008 figures are now (largely) historical so variation is only across the remaining 4 years
- High hydro storage levels in mid-March. Variation in hydrology has the ability to cause the greatest within year swing in emission levels.
- No biofuels are assumed in all scenarios
- Methanex running their Motunui Methanol plant throughout CP1 is assumed in all scenarios
- There is less scope for new electricity generation plant varying between scenarios with plans for new plants already committed to 2010 at least.

Appendix C: Land Use, Land-use Change and Forestry Sector provided by the Ministry of Agriculture and Forestry[7]

Disclaimer: This report contains projected carbon dioxide removals and emissions from exotic planted forests. These projections have significant uncertainties due to information gaps, scientific uncertainty and the complexity of forecasting biological systems which are inherently variable. While every effort has been made to provide the best projections as at February 2009, future changes are inevitable: reflecting likely future changes in economic conditions, improvements in information and new scientific knowledge.

Summary

This report provides projections of carbon dioxide (CO_2) removals and emissions from New Zealand's Land Use, Land-use Change and Forestry (LULUCF) sector, limited to post-1989 afforestation, reforestation and deforestation activities in exotic planted forests as accounted for under the Kyoto Protocol. There is no information on post-1989 afforestation and deforestation of New Zealand's indigenous forests and shrublands. Therefore these activities have not been included in these projections.

The projections cover Commitment Period One (CP1: 2008–2012) of the Kyoto Protocol. The LULUCF projections are an input to the "Net Position Report 2009 – Projected balance of Kyoto Protocol units during the first commitment period" report produced by the Ministry for the Environment. This "net position" report brings together the projected quantity of greenhouse gas (GHG) emissions and removals from all sectors of the economy and is an input to estimating New Zealand's forecast liability or credit under the Kyoto Protocol during CP1.

Net removals by the LULUCF sector (that is, removals by post-1989 planted forests minus emissions from deforestation) for the period 2008–2012 are projected to be between 46 and 108 Mt CO_2. Net removals for the most likely scenario are projected to be 85 Mt CO_2, which is about 18 Mt CO_2 higher than the 2008 most likely scenario projection of 67 Mt CO_2. This increase is mainly due to new information that indicates post-1989 planted forests are growing at faster rates than previously thought. This new growth rate information has come from a preliminary analysis of forest measurements taken from sample plots during 2007 and 2008, as part of a national forest inventory under the Land Use and Carbon Analysis System (LUCAS) programme.

[7] For the forestry sector, this report only covers exotic planted forests accounted under Article 3.3 of the Kyoto Protocol which includes post-1989 afforestation and all deforestation.

The large uncertainty range is mainly due to gaps in information and scientific knowledge. There is also uncertainty about the level of deforestation that will take place between 2009 and 2012 and the emissions forecast to come from this deforestation. Uncertainty has been incorporated into the LULUCF projections through the use of scenarios that represent maximum, most likely and minimum emissions (termed "**upper emissions**", "**most likely**" and "**lower emissions**"; Table C1). Monte Carlo simulation was used to analyse uncertainty in the removals calculation. Measurement error, and uncertainty about the accuracy of growth models, are expected to be further reduced as information from the LUCAS programme is gathered between now and 2012. However, until the LUCAS plots are remeasured at the end of the commitment period, the forests have been mapped, and the final development of methodologies to estimate biomass are in place, the LULUCF projections are likely to remain the least certain of all sectors in the net position report.

Table C1: LULUCF projected CO_2 removals and emissions (in million tonnes) during CP1 (2008–2012). See Table C5 for further detail.

Contributing factor	Upper emissions scenario	Most likely scenario	Lower emissions scenario
Mean CO_2 removals estimated through Monte Carlo simulation	70.2	92.3	115.4
Less deforestation emissions	–24.2	–7.3	–7.3
Net removals (total removals less deforestation emissions)	46.0	85.0	108.1

Projected deforestation areas in CP1 are based on a Deforestation Intentions Survey undertaken between December 2008 and February 2009. The **lower emissions** and **most likely** scenario are based on deforestation forecast under the Emissions Trading Scheme (ETS) policy scenario in the survey. The **upper emissions** scenario is based on forecast deforestation under a No ETS policy scenario.

Introduction

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

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

This report provides projections of CO_2 removals and emissions from New Zealand's Land Use, Land-use Change and Forestry (LULUCF) sector, presently limited under the Kyoto Protocol to post-1989 afforestation, reforestation and deforestation. These projections only cover Kyoto-compliant planted forests.

The six key factors used to estimate these projections are:

- the estimated area of post-1989 planted forests (Kyoto forest area)
- forecast afforestation rates
- forecast deforestation rates of planted forests
- post-1989 planted forest growth rates based on a preliminary analysis of Land Use and Carbon Analysis System (LUCAS) forest inventory measurements
- the proportion of exotic forest area planted since 1 January 1990 that may be "ineligible Kyoto forests" (over-planted onto land which was already defined as forest as at 1 January 1990)
- the potential loss of soil carbon following afforestation of grassland.

Assumptions around the likelihood of these factors in the future provide the range of values for the **upper**, **most likely**, and **lower emissions** scenarios.

Forestry trends and drivers affecting forecasts

Forecasts are greatly influenced by recent historic and prevailing conditions. This section briefly summarises the economic and policy environment the New Zealand forest sector has been operating in.

From 2004 until mid-2008 the New Zealand forestry sector faced a high exchange rate, increasing costs (particularly shipping costs), increasing international competition and changing international markets – all of which impacted negatively on forest-growing profitability. More recently international demand for forestry products has fallen sharply, with lumber exports badly affected by the global economic situation. The domestic forest products market is also forecast to slow further during 2009.

Better returns from alternative land uses, and the greater separation of forest ownership and forest land ownership, have led to the conversion of forest land to other land uses. The area of deforestation accelerated in anticipation that Government climate policy would require forest land owners to pay for deforestation emissions from the start of 2008. A survey of forest owners undertaken between December 2008 and February 2009 indicates that intentions for future land use changes between 2008 and 2020 is forecast to be in the range of 29,000 to 90,000 hectares.

The results of these changes and the perceptions about forestry's future profitability have resulted in:

- a major decline in the rate of afforestation: from an annual average of 38,000 hectares over the last 30 years, to around 2,000 hectares per years in 2007 and 2008. These are the lowest levels of afforestation recorded since 1945.
- forest land being converted to other land uses, particularly dairy farming. It was estimated that approximately 20,000 hectares were deforested in the year ended December 2007, before the Emission Trading Scheme (ETS) legislation was enacted (Manley, 2009). Estimated deforestation for the year ended 2008 under current ETS policy was approximately 3,000 hectares.

Modelling methodology

This report provides scenario-based forecasts (projections) of CO_2 removals and emissions for the LULUCF sector for the period 2008 to 2012. The projections are based on information available as at February 2009 and only cover planted forests.

These forecasts are derived from data and assumptions provided by the Ministry of Agriculture and Forestry (MAF) and the Ministry for the Environment (MfE). The modelling was undertaken by Scion (formerly the New Zealand Forest Research Institute). The underpinning science incorporated in the forest carbon models used in these projections, together with scientific assumptions, come from work carried out by New Zealand's Crown Research Institutes, predominantly Scion and Landcare Research.

Scientific uncertainty, information gaps and the range of possible future outcomes (such as future afforestation and deforestation rates) are reflected in a scenario-based analysis. The scenarios represent the circumstances expected to result in the maximum, most likely and minimum emissions (termed the "**upper emissions**", "**most likely**" and "**lower emissions**" scenarios). The scenarios include the likely ranges of the major contributing factors that influence planted forest LULUCF sector removals and emissions, based on the current economic conditions, policy settings, land-use statistics, and scientific knowledge. More detailed information on these factors are contained in the section on Model assumptions.

The projected post-1989 planted forest removals were calculated using LUCAS field inventory data collected from 273 sample sites. At each sample site 4 sample plots were measured. The sample sites were located on a 4*4km grid laid across New Zealand with sample sites established where the grid intersected with post-1989 planted forest. Because there are still a number of outstanding measurement issues the analysis must be regarded as preliminary at this stage.

The removals calculation methodology used in these projections is based on the design intended to be used by the LUCAS Calculation and Reporting Application. This largely replaces the previous approach used to project CP1 CO_2 removals, which was based on data from the National Exotic Forest Description and models developed for UNFCCC reporting in the early 1990s.

Carbon stocks were estimated from the plot data using an empirical forest growth model – the 300 Index model (Kimberley et al., 2005) and the carbon allocation model C_Change (Beets et al., 1999). The 300 Index model uses the LUCAS inventory data to estimate stem volume growth from establishment to a future harvest age. The C_Change model uses the 300 Index generated stem volumes along with forest management information to estimate forest carbon stocks.

A model that links the 300 Index and C_Change has been developed in Microsoft Excel; this model is called "Forest Carbon Predictor" (Version 2.1).

The change in carbon stock (tonnes C/ha) from 1 January 2008 to 31 December 2012 has been predicted for each LUCAS plot using the Forest Carbon Predictor. From this the average change in carbon stock per hectare was calculated, and multiplied by the estimated total post-1989 planted forest area based on national afforestation statistics collected by MAF. This gives the total forecast change in carbon stock over the commitment period, which is then converted to CO_2-equivalents.

The scenarios modelled included uncertainty around total afforested area, 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 was removed from the calculations.

The spreadsheet simulation model described in previous Net Position Reports was still used as a cross check on the Forest Carbon Predictor model forecasts and also to provide estimates of projected removals from post-2007 afforestation, soil carbon, and deforestation.

Model assumptions

Kyoto forest area

Kyoto forest areas have been estimated from national afforestation statistics collected by MAF. These statistics are based on a combination of:

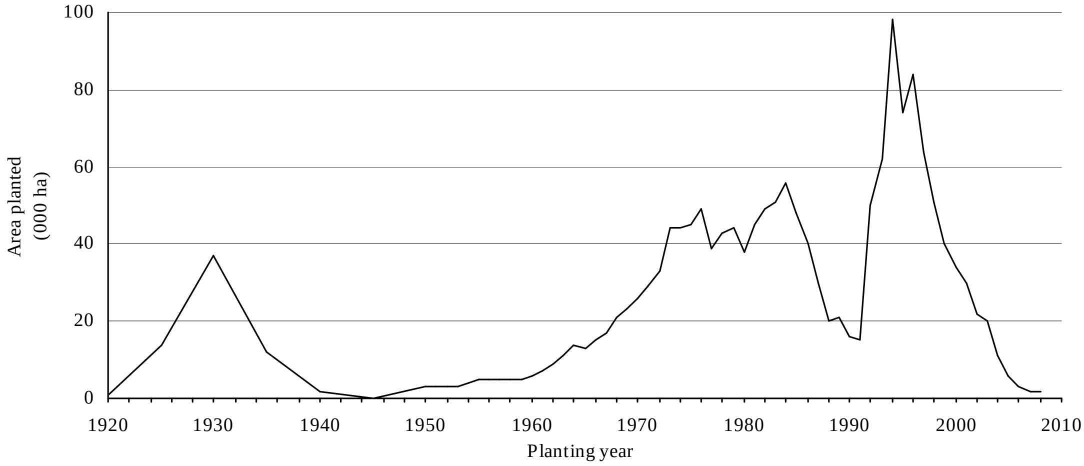
- An annual survey of the number of planting stock sold by forest nurseries (Eyre, 1995). From this survey national estimates of total planting, restocking and new planting are calculated. This survey has been in operation since 1992 and the methodology used was reviewed in 2003 (Manley et al, 2003).
- The National Exotic Forest Description (NEFD) database. The NEFD data is maintained through an annual census of major forest growers and a biennial survey of forest owners with 40 hectares of forest or more. Since the mid-1990's much of the afforestation that has occurred has been by smaller-scale forest owners, many of them new entrants to forest growing. Obtaining complete statistics from these small-scale owners (using postal survey methods) has been problematic.
- Statistics New Zealand estimates of afforestation from the Agricultural Production Survey.
- A small reduction in area to allow for known deforestation of post-1989 planted forest area.

In developing regional wood availability forecasts which are based on NEFD forest areas, the small-scale owner's areas were reduced by 15 percent. This was done because small-scale owner's areas are often reported on a gross area rather than the actual net stocked area basis. For that reason the uncertainty range used for the post-1989 afforestation area (much of which is owned by small-scale owners) was set to ±15 percent.

Future afforestation of exotic planted forests

The average new planting rate over the last 30 years has been 38,000 hectares per year. In the period 1992 to 1998 new planting rates were high, averaging 69,000 hectares per year. Since then new planting has declined, to around 2,000 ha in 2008.

Figure C1: New forest planting, 1920–2008



Source: National Exotic Forest Description (MAF, 2008)

Table C3 shows the afforestation rates used in the 2009 net position projections.

Table C3: Future plantation afforestation (hectares)

Calendar year	Upper emissions scenario	Most likely scenario	Lower emissions scenario
2008	0	2,000	2,700
2009	0	2,000	4,000
2010	0	2,000	5,200
2011	0	2,000	6,500
2012	0	2,000	17,900
Average (2008–2012)	0	2,000	7,300

The **most likely** scenario assumes annual afforestation of 2,000 hectares per year during CP1, based on current afforestation levels.

The **upper emissions** scenario assumes no further afforestation occurs after 2007. This assumption is the same as last year's projections (worst-case scenario).

The **lower emissions** scenario assumes average afforestation of 7,300 hectares per year between 2008 and 2012. These rates are based on the projected afforestation rates estimated by Cairns et al. (2008) at a carbon price of $25 per tonne ($CO_2$ equivalent). Afforestation areas include 1,500 per year afforested through the Afforestation Grant Scheme (AGS). This scheme is currently scheduled to run until 2012. The balance of the area is attributable to the ETS.

Afforestation rates may increase once the forestry schemes (Forestry ETS, Permanent Forest Sinks Initiative (PFSI) and AGS) are fully implemented. There are currently only a small number of participants that have registered in these schemes. However, it is expected that when national climate change policy is fully defined and international carbon market trading is more established, afforestation rates would increase in time. The **lower emissions** scenario takes into account this assumption of increased future afforestation rates, compared with current trends (as at February 2009).

As previously noted, the impact of future afforestation on the amount of CO_2 removed in CP1, is very limited. However, these forests will remove increasing amounts of CO_2 as the forests mature, resulting in larger removals in future commitment periods.

Future deforestation

Since 2004, a clear trend has emerged of not replanting all forest after harvesting and in a number of cases even immature forest has been converted to pasture. These land use changes have been driven by changing commodity prices between forest products and those from competing land uses, particularly diary farming. New Zealand has traditionally had dynamic land-use change that is responsive to price signals, so these changes in land use are not unusual. However, prior to 2002 almost all forest was replanted after harvest.

It has been estimated that approximately 20,000 hectares of plantation forests were deforested in the year ended December 2007 (Manley, 2009). The latest Deforestation Intentions Survey forecast deforestation under three scenarios (Manley, 2009):

a. ETS policy (with deforestation liabilities accruing to the forest owner)

b. Amended ETS policy (offset planting required[8]; no deforestation liabilities for forest owners)

c. No ETS (no deforestation liabilities for forest owners) [fullstop needed here]

The survey results indicated that deforestation between 2008 and 2012 would be approximately 13,000, 27,000 and 34,000 hectares for each scenario respectively. In previous surveys, it was assumed that all deforestation was of pre-1990 planted forest. In this year's deforestation intentions survey forest owners also provided new information on the areas of immature and mature trees that are intended to be deforested. This has allowed a more refined forecast of deforestation emissions. For all the deforestation scenarios it was assumed that 6,000 hectares of immature post-1989 planted forest would be deforested, with the remainder being pre-1990 planted forest.

All deforestation of pre-1990 planted forest is assumed to be mature radiata pine (28-year-old), releasing approximately 800 tonnes of CO_2 per hectare. Deforestation from post-1989 planted forest was assumed to release approximately 280 tonnes of CO_2 per hectare, assuming an average age of 12 years[9].

Deforestation estimates do not include indigenous forest or shrubland that meets New Zealand's adopted Kyoto forest thresholds, as there are currently insufficient national statistics available on the area cleared of either indigenous forest or shrubland (that meets the forest definition). A Landcare Research report provided estimates for indigenous forest and scrub area cleared between 1989/90 and 1996/97, using visual interpretation of ground cover from satellite images (Stephens et al, 2001). Although a complete coverage for New Zealand was not achieved because of insufficient cloud-free images, it was estimated that around 0.03 percent of the total area of indigenous forest and 0.05 per cent of the total area of scrub were cleared between 1990 and 1996.

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8 Under this proposal, an area of planted exotic forest land would not be considered deforested if an "equivalent area of forest" was established elsewhere.

9 This average age was based on expert opinion.

However, it is considered that under current legislation no significant deforestation of indigenous forest is likely. Until improved national mapping of forest area and change is available through the LUCAS programme, the actual level of indigenous forest and shrubland clearance remains unknown.

Growth rates

Forest growth rates used in this report were based on a preliminary analysis of the data collected from LUCAS sample plots established in post-1989 planted forests. These new growth rates replace the NEFD-based yield table used in previous Net Position Reports. The preliminary results from the LUCAS plots indicate that post-1989 planted forests have a higher biomass per unit area compared with the NEFD data. This difference seems to be a result of post-1989 planted forests owned by small-scale foresters having received less intensive forest management and so have higher stockings than those managed by large-scale forest owners. In addition much of the post-1989 planted forest is established on former farm sites, which are likely to be more fertile than traditional forestry sites.

The estimates of the removals of Kyoto forests for the **most likely** scenario were calculated by projecting the carbon stock gain during the commitment period for each plot. Each plot was modelled individually using standardised forest management decision rules (Paul et al, 2009).

The **lower emissions** scenario assumes no silviculture occurs in post-1989 planted forests during CP1 (therefore more forest biomass and removals).

The **upper emissions** scenario was defined by a 10% reduction in the average carbon stock increase. This represents the lower end of the sampling error for the most likely estimate (6%), with additional allowance made for modelling error and greater losses due to wind damage or disease than are assumed by the growth model.

Ineligible planting

Initial research has suggested that a proportion of the post-1989 exotic planting may have occurred on land that already met New Zealand's forest definition due to the presence of indigenous shrubland species that had already reached the Kyoto forest thresholds adopted by New Zealand. Under carbon accounting rules, such land does not qualify as Kyoto forest, as the land was already deemed to be forest land on 31st December 1990.

The estimated proportion of "ineligible" post-1989 planted forests used in the 2006, 2007, and 2008 LULUCF projections were 8 per cent (**lower emissions**), 16 per cent (**most likely**), and 21 per cent (**upper emissions**). The proportions for the **most likely** and **upper emissions** scenarios have been updated to 12 and 16 per cent respectively, based on a preliminary analysis of newly developed datasets of landcover at 1990 (Kirschbaum et al, 2009). These figures represent the best estimates currently available.

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

	Upper emissions scenario	Most likely scenario	Lower emissions scenario
Percentage of post-1989 forest planted into shrublands that could already have met New Zealand's Kyoto forest definition	16%	12%	8%

Confirmed estimates of ineligible post-1989 exotic forest planting will not be available until the LUCAS land-use mapping for the 1990 and 2008 years have been completed and undergone quality assurance. This will provide more definitive data.

Changes in soil carbon

Soil carbon values used in this report are based on the New Zealand Soil Carbon Monitoring System (Soil CMS) model and the soils dataset that will be used in LUCAS.

The Soil CMS model was developed for New Zealand conditions to meet Intergovernmental Panel on Climate Change (IPCC) reporting requirements. This model estimates soil carbon stocks and the forecast change in stock with land-use change (the stock change factor). The Soil CMS model has been determined to be appropriate for meeting soil carbon reporting requirements by an International Review Panel (Ministry for the Environment, 1999) and has been reported in a number of peer-reviewed international scientific publications (e.g. Scott et al, 2002, Tate et al, 2005). With the Soil CMS model, LUCAS uses the Historic Soils dataset which has been extracted from the National Soils Database and five other smaller soils datasets. Future refinements are planned including additional data collection to fill gaps in the current dataset and model refinements to reduce uncertainty.

Initial calculations from the Soil CMS model and Historic Soils dataset predicted a soil carbon loss of 18.4 t C/ha for afforestation. This is assumed to occur over the IPCC default transition period of twenty years. This estimate is assumed to be the **upper emissions** scenario for this year's projections, as it was in the 2008 projections. A review of national and international studies, and process-based modelling, by Kirschbaum et al (2009) – and the expert judgment of researchers and officials – indicated that this initial predicted carbon loss associated with afforestation may be overstated.

Attempts have been made recently to recalibrate the Soil CMS model in a way that better accounts for the broad differences in soil profiles between typical grassland and forest sites, by weighting apparently spatially auto correlated grassland data, and by rejecting grassland sites that are a long way from forest sites. Preliminary analyses based on these approaches indicate mean soil carbon losses of between 8 to 13 t C/ha with afforestation. Further refinement of the spatial auto correlation approach is underway. Based on expert judgement considering all evidence currently available, a soil carbon loss of 11 t C/ha with afforestation was used in the **most likely** scenario.

The **lower emissions** scenario assumes no soil carbon change following afforestation, as in the 2008 projections.

Projection results

Table C5 provides a breakdown of the major contributing factors on which the removals and emissions projections are based. Net removals from the LULUCF sector for the period 2008 to 2012 are projected to be between 46 and 108 Mt CO_2. Net removals for the **most likely** scenario are projected to be 85 Mt CO_2 (compared to 67 Mt CO_2 in the previous year's projection).

Table C5: LULUCF projected carbon removals and emissions (Mt CO_2-e) during CP1: comparison of the 2008 "most likely" projection with the three 2009 scenarios

Contributing factor	2009 projections			2008 projection (most likely scenario)
	Upper emissions scenario	Most likely scenario	Lower emissions scenario	
Removals based on afforestation only				
Post-1989 planted forest CO_2 removals (based on existing 664,000 ha)	109.7	109.7	109.7	95.5
Future afforestation (2008 to 2012): 0; 2,000; 7,300 ha/year	0.0	0.1	0.2	0.2
Adjustment factors (assumptions see text)				
Area of Kyoto forest planted between 1990 and 2007 ± 15%	-16.5	0.0	16.5	0.0
Kyoto forest growth rates	-11.0	0.0	15.2	0.0
Ineligible afforestation	-17.5	-13.2	-8.8	–14.6
Soil carbon change with afforestation	-11.1	-6.6	0.0	–2.9
Mean removals estimated through Monte Carlo simulation	**70.2**	**92.3**	**115.4**	**84.1**
Emissions from deforestation[1,2,3]	-24.2	-7.3	-7.3	-16.9[4]
Removals less deforestation emissions	**46.0**	**85.0**	**108.1**	**67.2**

Notes:

1. The deforestation rates were based on the latest Deforestation Intentions survey results. The **most likely** and **lower emissions** scenarios have estimated deforestation emissions of -7.3 Mt CO_2. This is based on the "Current ETS policy" scenario with 13,000 hectares of deforestation in CP1. The **upper emissions** scenario is based on intended deforestation without an ETS and results in 34,000 hectares in CP1 (-24.2 Mt CO_2).
2. It has been assumed that all forest carbon is instantly emitted upon the deforestation activity taking place.
3. All scenarios include the deforestation of 6,000 hectares of post-1989 planted forest with emissions estimated at approximately 280 t CO_2 /ha (assuming an average age of 12 years).
4. The 2008 projections assumed all deforestation was pre-1990 planted forests and resulted in emissions of approximately 800 t CO_2/ha (28 years old trees). The most likely scenario did not assume all carbon was instantly emitted. Instead, it is assumed that harvesting residues left on site decayed over a 10 year period.

[Remove space in Point 3 above between CO_2 and /ha. Hyphens needed in Point 4 above (28-year-old trees, 10-year period).]

Data limitations

There are acknowledged limitations in the data used in the LULUCF sector projections due to information gaps and scientific uncertainty. MfE commenced the implementation of LUCAS in 2005. LUCAS is being designed to provide more robust inventory data specifically for Kyoto carbon accounting purposes. This is a long-term and large-scale project that will not be fully operational until 2011. LUCAS uses a network of permanent plots across New Zealand's planted and natural forest. This permanent plot network along with national forest mapping has been designed to provide unbiased national estimates of carbon stocks and carbon stock change for New Zealand's forests.

Preliminary analysis of LUCAS sample plots in post-1989 planted forests was used in this report. LUCAS mapping products that will allow the estimation of post-1989 planted forest areas, and land use changes, are not currently complete. Until this information is available, other existing planted forest information such as the NEFD and the Land Cover Databases (LCDBs) will continue to be used for projecting CO_2 removals, even though these data sources were not designed for forest carbon accounting purposes and have known limitations.

The NEFD describes pre-1990 planted forests well (with ownership dominated by large-scale forest growers). NEFD information on plantation forests established by a large number of smaller-scale forest owners since 1992 is of poorer quality. Information on carbon stock changes in New Zealand's 6.5 million hectares of indigenous forest and 2.6 million hectares of shrubland remains scant (Ministry for the Environment, 2004).

Uncertainty analysis

A Monte Carlo analysis was carried out using @Risk software (Palisade Corporation), as in the 2008 projections. The ranges for afforestation factors in Table C5 were represented by triangular probability distributions, with the **upper emission** values set to the 97.5th percentile of the distribution and the **lower emissions** level set to the 2.5th percentile (except for future afforestation where the low value – associated with zero hectares of afforestation – was set as the distribution minimum). The uncertainty analysis used 10,000 iterations to derive the 95th percentile range for CO_2 removals of, which range from 70 to 115 Mt CO_2. Deforestation emissions were then deducted to give an uncertainty range of about 46 to 108 Mt CO_2 (Table C5).

Review of past projections

Since 2005, greenhouse gas projections have been subject to a number of reviews, the most comprehensive being two AEA Technology (United Kingdom) reviews (2005 and 2007). These reviews identified a number of improvements for producing future projections, most of which have been incorporated in the current report. The overall finding of the review of the 2005 projections was that "the methodologies employed to project emissions and sinks across the different sectors [are] generally sound and reasonable in their approach". AEA Technology noted the uncertainties are inherent in all countries' approaches to projecting future greenhouse gas emissions, and that it is "not uncommon" for projections to change on re-analysis. The reviewers recognised that many of their recommendations built upon improvements already in train. AEA Technology's key conclusions for the LULUCF sector review were:

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

Of the four key issues above issues 1 and 3 have been addressed. For Issue 1, a report examining the financial returns from forestry and its relationship to forestry planting rates has been published (Horgan, 2007). This report is available on MAF's website. In respect to Issue 3, deforestation intentions surveys have been undertaken yearly since 2005 (Manley, 2005, 2006, 2008 and 2009), examining major forest owners' deforestation intentions and determining where deforestation is taking place and why. The survey results have been incorporated in the present projections. The 2006 and 2007 deforestation intention survey reports are available on the MAF website.

Issues 2 and 4 are expected to be informed by data and analysis undertaken within the LUCAS programme, though obtaining data for item 4 is very costly since changes are small and highly spatially variable. For further details on LUCAS see http://www.mfe.govt.nz/issues/climate/lucas/.

References

Baisden WT, Beets P, Carran RA, Clark H, Ford-Robertson JB, Francis GS, Maclaren P, Marshall H, Manning MR, Newton PCD, Saggar S, Tate KR, 2001. *An Assessment of the Significance to New Zealand of Article 3.4 Activities under the Kyoto Protocol*. Unpublished contract report prepared for the Ministry of Agriculture and Forestry.

Beets PN, Robertson KA, Ford-Robertson JB, Gordon J, Maclaren JP, 1999. *Description and Validation of C–Change: A model for simulating carbon content in managed Pinus radiata stands*. New Zealand Journal of Forestry Science 29(3): pp. 409-427.

Cairns I, Livesey C and Twaddle D, 2008. *Forestry Mitigation Response and Cost Curves*. Internal report. Ministry for the Environment.

Eyre J, 1995. *Predicting and Measuring New Planting from Nursery Surveys*. New Zealand Journal of Forestry, August 1995, pp 45–46.

FRI (Forest Research Institute), 1995. *IFS/FOLPI Database and Utilities, Interactive Forest Simulator Manual*. FRI Software Series No 19.

García O, 1981. *IFS, an Interactive Forest Simulator for Long Range Planning*. New Zealand Journal of Forestry Science 11: 8–22.

Horgan G, 2007. *Financial Returns and Forestry Planting Rates.* Ministry of Agriculture and Forestry report.

Kimberley, MO, West, GG Dean, MG, Knowles, LR, 2005. *The 300 Index – a volume productivity index for radiata pine*. New Zealand Journal of Forestry 50(2) 13-18.

Kirschbaum M, Trotter C, Wakelin S, Baisden T, Curtin D, Dymond J, Ghani A, Jones H, Deurer M, Arnold G, Beets P, Davis M, Hedley C, Peltzer D, Ross C, Schipper L, Sutherland A, Wang H, Beare M, Clothier B, Mason N and Ward M, 2009. *Carbon stocks and changes in New Zealand's soils and forests, and implications of post-2012 accounting options for land-based emissions offsets and mitigation opportunitie*s. Unpublished contract report prepared for the Ministry of Agriculture and Forestry.

Manley B, Somerville O, Turbitt M and Lane P, 2003. *Review of new forest planting estimates*. New Zealand Journal of Forestry 43 (3).

Manley B, 2005. *2005 Deforestation Survey*. Canterprise, University of Canterbury.

Manley B, 2006. *2006 Deforestation Survey*. Canterprise, University of Canterbury.

Manley B, 2008. *2007 Deforestation Survey*. Canterprise, University of Canterbury.

Manley B, 2009. *2008 Deforestation Survey.* Canterprise, University of Canterbury.

Ministry for the Environment, 1999, *International Review of New Zealand's Carbon Monitoring Project*, ME 340, Wellington.

Ministry for the Environment, 2004, New Zealand Land Cover Database version 2.

Ministry for the Environment, 2008. *Net Position Report 2008: Projected balance of Kyoto Protocol units during the first commitment period. 15 May 2008.*

Ministry of Agriculture and Forestry, 2008. *A National Exotic Forest Description as at 1 April 2007*.

Paul T, Andersen C, Kimberley M and Goulding C, 2009. *Analysis of the 2007-2008 Planted forest Carbon Monitoring System Inventory data of post-1989 forests*. Scion. Unpublished contract report prepared for the Ministry for the Environment.

Scott, NA, Tate KR, Giltrap DJ, Tattershall Smith C, Wilde RH, Newsome PFJ and Davis MR, 2002, *Monitoring land-use change effects on soil carbon in New Zealand: quantifying baseline soil carbon stocks*. Environmental Pollution, 116, S167-S186.

Stephens P, Heke H, Sutherland A, Sheperd S and Pinkney T, 2001. *Estimating Clearance of Indigenous Forest and Scrubland between 1898/90 and 1996/97*. Landcare Research. Unpublished contract report prepared for the Ministry of Agriculture and Forestry.

Tate, KR, Wilde RH, Giltrap DJ, Baisden WT, Saggar S, Trustrum NA, Scott NA and Barton JP, 2005, *Soil organic carbon stocks and flows in New Zealand: system development, measurement and modelling*, Canadian Journal of Soil Science, 85, 481-491.

Wakelin S, 2008. *Carbon Inventory of New Zealand's Planted Forests – Calculations revised in October 2008 for New Zealand's 2007 Greenhouse Gas Inventory*. Scion. Unpublished contract report prepared for the Ministry of Agriculture and Forestry.

[Inconsistent use of punctuation, particularly commas, and capitalisation of titles in references above.]

Annex 1: Description of the LULUCF net position models

Background

Article 3.3 of the Kyoto Protocol allows the net changes in greenhouse gas emissions (by sources) and removals (by sinks) resulting from afforestation, reforestation and deforestation since 1 January 1990 to be used to meet the commitments of Annex B parties. Emissions 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 pools.

The Ministry for the Environment is implementing the Land Use and Carbon Analysis System (LUCAS) so that New Zealand can meet its international obligations for reporting changes in the LULUCF sector under the Kyoto Protocol. The LUCAS programme will report emissions and removals of greenhouse gases across the carbon pools for land use changes since 1 January 1990. Key land use changes include afforestation and deforestation since 1990. The basis for estimating stock changes in the carbon pools will be representative sampling of the Kyoto forest estate taken at the start and the end of CP1[10] and the mapping of land use change from 1990 to 2012.

Summary of changes in the modelling approach used for the 2009 projections

During 2007 and 2008 forest inventory plots have been measured across the post-1989 planted forest estate. This is the first time this national forest inventory data has been available. In order to use this new data a revised approach used to forecast emissions and removals in this 2009 Net Position Report.

Previous approach: Simulation

Up until this year projected removals were calculated using a spreadsheet simulation model of the post-1989 planted forest estate. This previous approach used a carbon yield table derived from the National Exotic Forest Description (NEFD) yield tables. This national carbon yield table provides carbon stock estimates by age on a per hectare basis for the four forest biomass pools. All forest areas planted in the same year were modelled as a single forest area for that planting year. The model tracked these planted areas through time and generated annual estimates of carbon stock by multiplying the area at a given age by the carbon yields per hectare for that age (see Table C6). This approach is the same as that employed by routinely-used forest estate planning simulators, such as the Interactive Forest Simulator (IFS) (FRI, 1995, García 1981).

[10] Missing field measurement may be replaced with modelled estimates as necessary.

Table C6: Calculating annual carbon stocks from forest areas using a national carbon yield table*

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

* Cohorts of planted areas “move down one row in the table” each successive year.

For each Net Position Report, the national average carbon yield table created for the most recent UNFCCC national planted forest carbon inventory has been used (Wakelin, 2008). In previous Net Position Reports, this national average carbon yield table was used to calculate both removals from existing planted forest and future afforestation, as well as emissions from all deforestation.

Revised approach

The modelling approach described above was still used to calculate removals associated with *future* afforestation. The only difference was that a specific post-1989 yield table was derived from the LUCAS plot data for this purpose. This yield table was also used to model deforestation of post-1989 planted forests. The latest NEFD-based national average carbon yield table used in the 2007 UNFCCC planted forest inventory (Wakelin [comma needed] 2008) was only used to model deforestation occurring in the pre-1990 planted forest.

Removals associated with the *existing* post-1989 planted forest as at January 2008 were not estimated using the previous simulation approach. Instead, these removals were calculated directly using the LUCAS plot data, total forest area and the LUCAS methodology described in more detail in the next section (LUCAS method).

There was no change in the way soil carbon changes were modelled.

Table C7 summarises the methods used for each contributing factor in the projections.

Table C7: Summary of the 2009 and previous modelling approaches and source of yield tables

Contributing factor	Previous approach		Revised approach	
	Methodology	Yield table	Methodology	Yield table
Post-1989 planted forests CO_2 removals	Simulation	NEFD-based national average	LUCAS method	Not required
Future afforestation removals	Simulation	NEFD-based national average	Simulation	Derived from LUCAS plots
Area of Kyoto forest planted between 1990 and 2007 ± 15%	Simulation	NEFD-based national average	LUCAS method	Not required
Kyoto forest growth rate – lower emissions	Simulation	300 Index model	LUCAS method with no future thinning	Not required
Kyoto forest growth rate – upper emissions	Simulation	NEFD-based national average minus 10%	LUCAS method minus 10%	Not required
Ineligible afforestation	Simulation	NEFD-based national average	LUCAS method	Not required
Soil carbon change with afforestation	Simulation	Soil carbon estimates	Simulation	Soil carbon estimates
Emissions from deforestation: pre-1990 planted forests	Simulation	NEFD-based national average	Simulation	NEFD-based national average
Emissions from deforestation: post-1989 planted forests	Not modelled[11]	Not required	Simulation	Derived from LUCAS plots

2009 modelling based on LUCAS data and methodology

Post-1989 planted forest CO_2 removals

The projected post-1989 planted forest removals were calculated using LUCAS field inventory data collected from 273 sample sites. At each sample site up to 4 sample plots were measured. The sample sites were located on a 4*4km grid laid across New Zealand with sample sites established where the grid intersected with post-1989 planted forest. There are still a number of outstanding measurement issues that need to be resolved before the analysis of the forest inventory measurements can be finalised. At this stage the analysis must therefore be regarded as preliminary.

The calculation methodology used in these projections is based on the design intended to be used by the LUCAS Calculation and Reporting Application. This largely replaces the previous approach used to project post-1989 planted forests CO_2 removals, which was based on data from the National Exotic Forest Description and models developed for UNFCCC reporting in the early 1990s.

[11] In previous Net Position Reports, there was no information on the area of pre-1990 and post-1989 planted forest forecast to be deforested.

Carbon stocks were estimated from the plot data using an empirical forest growth model – the 300 Index Model (Kimberley et al., 2005) and the carbon allocation model C_Change (Beets et al, 1999). The 300 Index model uses the LUCAS inventory data to estimate stem volume growth from establishment to a future harvest age. The C_Change model uses the 300 Index generated stem volumes along with forest management information to estimate forest carbon stocks. The 300 Index and C_Change have been linked in Microsoft Excel; this model is called "Forest Carbon Predictor" (Version 2.1).

Using the Forest Carbon Predictor the change in carbon stock (tonnes C/ha) from 1 January 2008 to 31 December 2012 has been predicted for each LUCAS plot. From this the average change in carbon stock per hectare was calculated, and multiplied by the estimated total post-1989 planted forest area based on national afforestation statistics collected by MAF. This gives the total forecast change in carbon stock over the commitment period, which is then converted to CO_2-equivalents. Carbon stocks include all living biomass in the crop (planted) trees, dead wood and litter, but exclude soil organic carbon and carbon in the forest understorey.

The scenarios modelled included uncertainty around total afforested area, and the adjustment of forest areas to deduct ineligible forest planted onto existing forest land (ie, shrubland that met New Zealand's forest definition). In the latter case, the over-planted proportion was removed from the calculations.

The scenarios which used this LUCAS method are indicated in Table C7.

2009 modelling using the previous spreadsheet simulation model

The spreadsheet simulation models described in previous Net Position Reports was still used as a cross check on the Forest Carbon Predictor model forecasts and also to provide estimates of projected removals from post-2007 afforestation, soil carbon, and deforestation.

Post-2007 afforestation calculations

Future afforestation is modelled using the spreadsheet simulation model used in previous Net Position Reports. This model multiplies the area of forest planted each year (post-2007) by the appropriate value in the carbon yield table. This is done for each year in the simulation (1990 to 2012). The yield table used was derived by averaging projections made for each LUCAS inventory plot (described in previous section). This was felt to better reflect post-1989 planted forest growth rates than the NEFD-based yield table used previously.

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.

Soil carbon calculations

Soil organic carbon stocks are estimated in a similar way, except that the separate national soil carbon "yield table" reflects changes in soil organic carbon resulting from afforestation of pasture. Both the magnitude of the change in carbon per hectare and the gradual rate of soil carbon change over time (rather than instantly at the time of afforestation) are modelled. Each hectare of land afforested is assumed to start with a high soil carbon stock representing steady-state soil organic carbon under pasture, which then declines before stabilising at a steady-state planted forest level.

Projected removal units are calculated as the soil carbon stock change during the commitment period.

Deforestation calculation for pre-1990 and post-1989 planted forests

Projected emissions from deforestation are determined by estimating the difference between pre- and post-deforestation carbon stocks on land deforested post-1989. Pre-deforestation stocks are calculated by multiplying the area assumed to be deforested by the per hectare carbon stock value in the relevant national carbon yield table at the nominal deforestation age.

For deforestation of post-1989 planted forests the national carbon yield table based on the LUCAS inventory plots was used, assuming an average deforestation age of 12.

For deforestation of pre-1990 planted forest the NEFD-based national carbon yield table developed for the 2007 National Greenhouse Gas Inventory was used, with a 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 spreadsheet model allows either option to be applied, but instantaneous emissions were assumed for this report.

Projected emissions 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) have not been modelled.

Limitations of the analysis

Calculations using the LUCAS plots assume that the measured plots provide an unbiased and statistically representative sample of post-1989 planted forests. Of the 400 planned inventory sites 273 have had field measurements taken. The field data will be supplemented with estimates based on remote sensing data (LiDAR) also collected during 2008. Analysis and quality assurance of the LiDAR data has not yet been completed. Once this analysis has been completed there is likely to be changes to the key estimators that underlie this report.

Of the field plots measured, 18 have been abandoned and 22 have been excluded from the calculations due to unresolved issues with the data. There are also some instances of discrepancies between stand history information provided by forest owners and field observations which still need to be resolved. Once all the data issues are resolved and the analysis finalised, it will undergo a formal independent review. Until this has taken place, the analysis needs to be regarded as preliminary and the results are subject to change.

Non-crop tree vegetation carbon has been excluded from the projections. In previous reports, an allowance was made for emissions from the clearance of scrub vegetation for afforestation, and subsequent CO_2 removals from the growth of understorey vegetation. The simple understorey growth model resulted in about 2% of CP1 removals being attributable to understorey growth, and emissions from scrub clearance were of a similar magnitude. However, data to support these assumptions were weak, and neither has been included in these projections. The assumption used in this report is that there is no net change in non-crop vegetation biomass over CP1 as a result of afforestation or deforestation.

The models used to project forest growth are underpinned by an ongoing research programme and are therefore subject to future change. Currently all forest is assumed to be radiata pine. While radiata pine makes up around 90 per cent of the national forest estate there is are issues with using the functions developed for radiata pine for areas planted in other species. The silvicultural treatment each plot receives in future has the potential to significantly change actual net removals from those projected in this report. In the same way, actual afforestation and deforestation rates may be different from the rates forecast in this report. Finally catastrophic events such as forest loss dues to storms, disease and fire may also impact the uptake and emissions of CO_2 by New Zealand's forests in future.

Annex 2: Forest climate change policy

Introduction

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

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

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

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

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

Development of the Emissions Trading Scheme

After considering feedback from the Sustainable Land Management consultation the Government announced that it would establish a New Zealand Emissions Trading Scheme (ETS). The Government proposed that the ETS would cover all sectors and all gases but the sectors would commence participation within the scheme in a staged manner. Legislation[12] to enact the ETS was passed and came into force on 26 September 2008.

Forestry became the first sector to enter the scheme with obligations and entitlements applying retrospectively from 1 January 2008. For owners of non-exempt pre-1990 planted forests this means that New Zealand units (equivalent to 1 tonne CO_2) need to be surrendered to cover any deforestation emissions since 1 January 2008. Owners of post-1989 planted forests are able to receive New Zealand units if they choose to opt into the scheme (noting that owners who received credits would also be liable for CO_2 emissions from harvesting and other events).

The legislation, as it currently stands, also provides for a free allocation of New Zealand Units to owners of eligible pre-1990 planted forest land as part compensation for the land use restriction placed on this land by deforestation liabilities. A number of deforestation exemptions are also available, for example forest owners with less than 50 hectares of pre-1990 planted forest as at September 2007 can apply to be exempt, as are owners deforesting less than 2 hectares of pre-1990 planted forest during CP1.

2009 review of the ETS

In November 2008, the establishment of a Special Select Committee Review on the Emissions Trading Scheme was announced. The Select Committee is expected to report back by May 2009 in time for amending legislation to be passed in the latter half of 2009. However until the Select Committee and legislative review processes are complete the existing legislation applies. So while, at the time of publishing, the treatment of both pre-1990 and post-1989 planted forest land remains uncertain, the Net Position Report assumes the application of existing legislation.

The main outcomes of the legislation are:

- Post-1989 planted forest owners who opt into the ETS will receive New Zealand Units and therefore the Crown will not be able to use these devolved units to offset increased emissions from other sectors.
- The Crown will also devolve 21 million units (minus an allocation for exemptions) in CP1 to owners of pre-1990 planted forests. It is proposed that an additional 0.8-1 million units are allocated for the removal of “weed” trees.
- Non-exempt owners of pre-1990 planted forest who deforest will be required to surrender New Zealand or Kyoto Units to cover deforestation emissions.

[12] Known as the *Climate Change Response (Emissions Trading) Amendment Act 2008*.

The Permanent Forest Sinks Initiative

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

Accounting for Article 3.4 forest management

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

Under Article 3.4, New Zealand would have to account for carbon stock changes in its indigenous forests as well as its pre-1990 planted forests. At present, carbon stock changes in New Zealand's indigenous forests are not well quantified, although preliminary data suggest that the carbon stocks in these largely old-growth forests are likely to be at steady state (Kirschbaum et al., 2009).

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

Appendix D: Projected Waste Sector Emissions for the First Commitment Period of the Kyoto Protocol

Introduction

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

Emissions from solid waste disposal sites comprised 79 per cent of the emissions from the waste sector in 2007. 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 in 2007. Both methane and nitrous oxide are emitted through treating domestic, commercial and industrial wastewater. Factors influencing the amount of emissions include the type of treatment process, the volume of wastewater and the nitrogen content, and whether any resulting emissions are flared.

Emissions from solid waste incineration produced less than 1 per cent of waste sector emissions in 2007. These emissions include carbon dioxide (from combusting materials with some fossil fuel content, such as plastics), nitrous oxide and methane. The emissions arise from hospital and quarantine waste incineration. There has been a significant decrease in incineration emissions since 1990 due to the implementation of national regulations controlling air quality effects and the availability of alternative treatments such as steam sterilisation.

Recent trends

Waste sector emissions in 2007 were 1.821.8 million tonnes of carbon dioxide equivalent (Mt CO_2-e). This is a reduction of 0.6164 Mt CO_2-e (25.9 per cent) below the 1990 baseline value of 2.438 Mt CO_2-e.

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

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 1990–2007* (MfE, 2009). The methodology uses data specific to New Zealand on waste generation rates, waste composition, percentage of waste disposed to types of landfills and landfill gas extraction and combustion. Data on waste generation has not been collected routinely in the past; however, all assumptions have been clearly expressed in the National Inventory and reviewed by international experts.

The National Inventory uses a MS-Excel model provided by the Intergovernmental Panel on Climate Change (IPCC [comma needed] 2006) to estimate gross methane emissions from solid waste disposed to landfills. This methodology assumes that the degradable organic components in waste decay slowly throughout a few decades. Emissions of methane are highest in the first few years after the waste was disposed then gradually decline.

The methodology requires an estimate of solid waste generated per capita. This data has been 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 projections used are from Statistics New Zealand's National Population Projections (2006 base, series 1, 5 and 9). Other variables remain constant at the values reported in the latest National Inventory (MfE, 2009). Net emissions are projected to be 1.375 Mt CO_2-e for 2010. This is an increase of 0.192 Mt CO_2-e from the 2008 Net Position report and has come about mainly through correcting for an overestimation of projected landfill gas recovery.

Emissions from wastewater treatment have been estimated using a combination of country specific methodologies and IPCC good practice models. Emissions are sourced from anaerobic treatment of domestic, commercial and industrial wastewater in municipal and some industrial treatment plants. Some larger treatment facilities flare the resulting methane. Projected emissions for 2010 were estimated by holding the 2007 emission values constant for all subsectors except commercial and domestic wastewater treatment. It was necessary to hold these values constant because there were no published projections of the necessary activity data. Methane emissions from domestic and commercial wastewater treatment are a function of human population, so this methodology uses the same Statistics NZ data as in the projections of solid waste described above. Emissions are projected to be 0.35 Mt CO_2-e for 2010. This is an increase of 0.04 Mt CO_2-e from the 2008 Net Position report and reflects an improved methodology for estimating emissions from industrial wastewater treatment.

Emissions from solid waste incineration were estimated and reported for the first time in the latest National Inventory (MfE, 2009). IPCC 2006 good practice guidance was followed. Emissions of carbon dioxide, nitrous oxide and methane are sourced primarily from the burning of quarantine and hospital waste. There were 10 such incinerators emitting such gases at the start of 2007. Carbon dioxide is counted in the inventory where materials with a fossil fuel origin are burnt. Projected incineration activity was assessed through obtaining expected activity estimates from individual incinerators. Emissions are projected to be 0.002 Mt CO_2-e for 2010.

Policies

Policies in place

There are three existing policies that are, or will, affect the amount of greenhouse gas emissions from landfills over 2008 to 2012. In addition, emissions from solid waste disposed on land are proposed to enter the scope of the NZ emissions trading scheme from 1 January 2013.

The Waste Minimisation Act 2008

The Waste Minimisation Act was enacted in 2008. This legislation provides for monitoring and reporting of waste disposed and diverted, for the development of producer responsibility schemes, and for the implementation of a national levy on solid waste to fund waste minimisation programmes and infrastructure. There has been no published modelling on the effects of this legislation on any of the variables used in estimating greenhouse gas emissions from landfills. While it is clear that nearly all of the functions of the Act will reduce emissions from landfills, without published and defensible data, the impacts of the Act cannot be built into this report.

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. Targets contained by the Strategy are currently being reviewed in light of the implementation of the Waste Minimisation Act. For that reason, no estimation is included in this report of the possible impact of the Waste Strategy on greenhouse gas emissions from landfills.

In the 2008 Net Position report, assumptions were made on likely reductions in waste volumes, and changes to waste composition from achieving the targets in the Waste Strategy. These assumptions are not included in this report as they are considered to be lacking foundation.

The National Environmental Standard for Landfill Gas Collection

A National Environmental Standard for Landfill Gas Collection and Destruction was introduced in 2004 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.

Landfill gas collection estimates were updated for the 2004 Inventory by Waste Management in 2005. The consultants projected that 7.4 Mt CO_2-e, or 55 per cent, of gross emissions from solid waste disposal sites would be collected by landfill gas systems over the years 2008 to 2012. The consultants used different activity data to develop estimates of gross emissions than used by the latest National Inventory Report. Consequently, the consultant's estimates of recovered methane are probably overestimated. To reduce this problem, the proportion of recovered methane to gross emissions is used in methodology for this report, instead of the consultant's projections of absolute reductions. The most likely scenario now holds that landfill gas collections systems will reduce gross emissions by 7.5 Mt CO_2-e over 2008 to 2012 [full stop needed here]

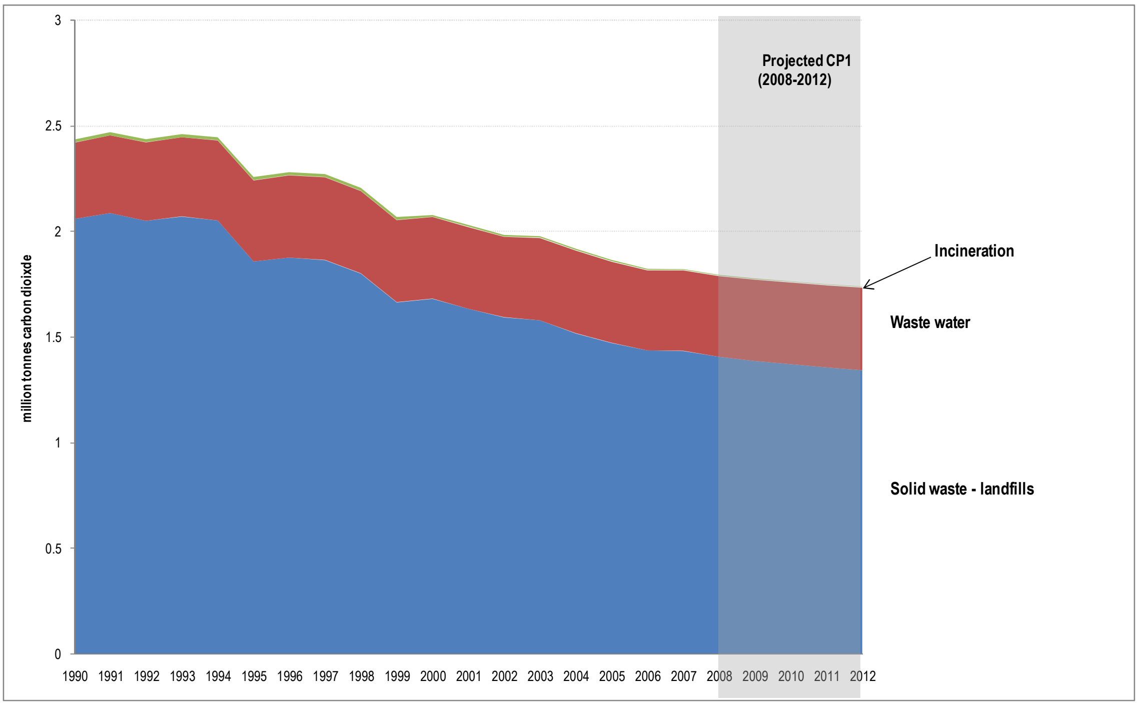
Projection

Total emissions

Emissions from the waste sector over the first commitment period are expected to range between 8.815 Mt CO_2-e and 8.838 Mt CO_2-e. Projected annual emissions for 2010 are expected to lie between 1.762 Mt CO_2e and 1.766 Mt CO_2-e per annum with a most likely value of 1.764 Mt CO_2-e.

Figure 1 illustrates the large decrease in emissions since 1990, which as explained above, is primarily due to decreased waste volumes and less organic matter entering landfills. The possible ranges for projected emissions occur through the use of three population growth scenarios.

Figure 1: Projected annual emissions for 2010 and the inventory time series of emissions from the waste sector (million tonnes carbon dioxide equivalent)



Reconciliation with 2008 projection

For the period 2008 to 2012, projected emissions from the waste sector have increased 1.130 Mt CO_2-e (15 per cent) from the 2008 estimates due to several factors:

- The IPCC 2006 MS-Excel spreadsheet model used to develop estimates of gross and net methane emissions from landfills required changes to various methodological inputs [full stop needed here]
- Methodological changes in modelling emissions from domestic and commercial wastewater treatment. This factor accounts for nearly 25 per cent of the increase.
- Not including any effects of waste minimisation policies, strategies or legislation in the projections of emissions in this report. This factor accounts for over 75 per cent of the increase.

References

IPCC. 2006. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (Eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5. Waste.* IPCC National Greenhouse Gas Inventories Programme. Published for the IPCC by the Institute for Global Environmental Strategies: Japan.

MfE (Ministry for the Environment). 2009. *National inventory of greenhouse gas emissions and removals (in press). Submitted to the United Nations Framework Convention on Climate Change.* 15 April 2009, Ministry for the Environment, Wellington.