Annex 1

Projected balance of units during the first commitment period of the Kyoto Protocol

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Foreword

This report outlines New Zealand's projected balance of greenhouse gas emission units for the first commitment period of the Kyoto Protocol (2008-12).

Given our dependence on agriculture, New Zealand is uniquely dependent for a western nation on our benign climate. If the world does not act to curb climate change, the impacts on our environment, economy and way of life could be severe. Floods and droughts hit our economy hard. A new June 2005 NIWA report shows that in some regions, what is now a one in twenty year drought could become a one in three year event. This is a threat New Zealand can't afford to ignore.

Over the last five years New Zealand has had one of the highest performing economies in the western world. This success brings challenges, such as the need to correct historic underinvestment in infrastructure and to address skills shortages. Greenhouse gas emissions are a further challenge resulting from this success. They are now forecast to be significantly higher than previously, particularly in the transport sector, and New Zealand is now likely to be a net buyer of emissions units in the 2008-2012 period. Although New Zealand's greenhouse gas emissions are only growing at around half the rate of GDP growth, the increase is still significant.

Officials have, appropriately, been conservative in their assumptions. For example, energy demand is assumed to grow steadily, rather than slowing in line with the Government's energy efficiency targets. Relatively low oil prices, and low levels of new natural gas discoveries feature. Officials also assume no gains arise from the agricultural research programme.

Some of the shift in the forecast relates to changes that have been made to the assumptions, measurement and modelling methodology since last year's report. These principally relate to the accounting of forest sinks (particularly scrub), and to changes in the energy sector modelling. Officials advise that given the ongoing revisions underway on the energy sector model, those results should be considered as provisional.

Overall, the significant change since last year's estimate is of concern, and raises questions around the degree of confidence that should be held in the projections. It is essential that estimates of emissions are as robust as possible. I have asked the Chief Executive of the Ministry for the Environment to arrange for an independent review of the assumptions and methodologies employed in this report, to enhance our level of confidence.

What is clear is that New Zealand, like the rest of the world, faces a significant challenge in further de-linking economic growth from that in greenhouse gas emissions. Tackling climate change will not be easy, but it is our obligation to future generations to begin.

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Executive Summary

This report updates New Zealand's projected emissions and removals of greenhouse gases during the first commitment period (2008-2012) of the Kyoto Protocol. The update is based on the latest national inventory of greenhouse gas emissions and removals submitted to the United Nations Framework Convention on Climate Change secretariat on 15 April 2005.

As at May 2005, New Zealand is projected to have deficit of units over the first commitment period of the Kyoto Protocol. The balance of units is projected to range between -11.3 Mt CO_2e (95% CI) under an optimistic scenario and -62.6 Mt CO_2e (95% CI) under a pessimistic scenario. The best estimate of the balance of units is -36.2 Mt CO_2e.

There is a range of 51Mt CO_2e between the optimistic and pessimistic scenarios. This uncertainty reflects the difficulty in modelling the complex interactions of the New Zealand energy sector, projecting agricultural markets and animal productivity, estimating the reductions from the climate change policy package and predicting removals from forest sinks prior to the New Zealand Carbon Accounting System being operational. In addition, a review has highlighted that a number of improvements are required in the model used for CO_2 emissions from the energy and industrial processes sector.

The updated projection shows a substantial decrease from the 32.6 Mt CO_2e surplus in the previous projection (May 2004) and the 55 Mt CO_2e surplus projected prior to ratification of the Kyoto Protocol. The decrease from the 2004 projection is due primarily to an increase in projected energy and industrial processes emissions and a decrease in the removals via forest sinks. The decrease in removals is due to the quantification of previously unknown risks and updating of previous estimates with improved scientific information.

1 Introduction

The Kyoto Protocol commits Parties that ratified the Protocol to individual, legally-binding targets to limit or reduce their greenhouse gas emissions. Parties in Annex I of the Protocol must put in place domestic policies and measures to address emissions or take responsibility for emissions in excess of their target. Emissions may also be offset by increasing the amount of greenhouse gases removed by carbon "sinks", e.g. forests planted since 1990. New Zealand's target in the first commitment period of the Protocol (2008-2012) is 100% of New Zealand's emissions in 1990.

This report projects New Zealand's emissions and removals of greenhouse gases during the first commitment period of the Kyoto Protocol. The projection follows New Zealand's annual inventory to the United Nations Framework Convention on Climate Change and considers emissions and removals of the gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Global warming potentials are used to convert each of the gases to a carbon-dioxide equivalent (CO_2e). The global warming potential values used in this report are from the IPCC Second Assessment Report (IPCC, 1995).

The report is a compilation of sectoral projections from across Government. Agricultural projections are provided by the Ministry of Agriculture and Forestry (MAF), energy and industrial processes projections are from the Ministry of Economic Development (MED) and waste projections are from the Ministry for the Environment (MfE). The MfE combines the sectoral projections to create the projected balance of units over the first commitment period of the Kyoto Protocol.

2 Projected balance of units over the first commitment period of the Kyoto Protocol

The projected balance of units over the first commitment period of the Kyoto Protocol (2008-2012) is based on a straightforward comparison of the projected emissions, New Zealand's assigned amount units, the removal units generated from forest sinks and any liability from the Projects to Reduce Emissions policy (Table 1). In the following sections of this report, additional detail is provided on each of these components.

As at May 2005, New Zealand is projected to have deficit of units over the first commitment period of the Kyoto Protocol. The balance of units is projected to range between -11.3 Mt CO_2e (95% CI) under an optimistic scenario and -62.6 Mt CO_2e (95% CI) under a pessimistic scenario. The best estimate of the balance of units is -36.2 Mt CO_2e.

Three scenarios are used to quantitatively assess uncertainty about the projection. The variables used in the scenarios represent the best available knowledge as at the time of projection. The most-likely scenario represents what is considered the most likely outcome of projected emissions, reductions from policy measures and removals via forest sinks. A pessimistic scenario comprises all pessimistic outcomes, *i.e.* high emissions from all sectors and low reductions from all policies and low removals from sinks. Conversely, the optimistic scenario shows a combination of all optimistic values.

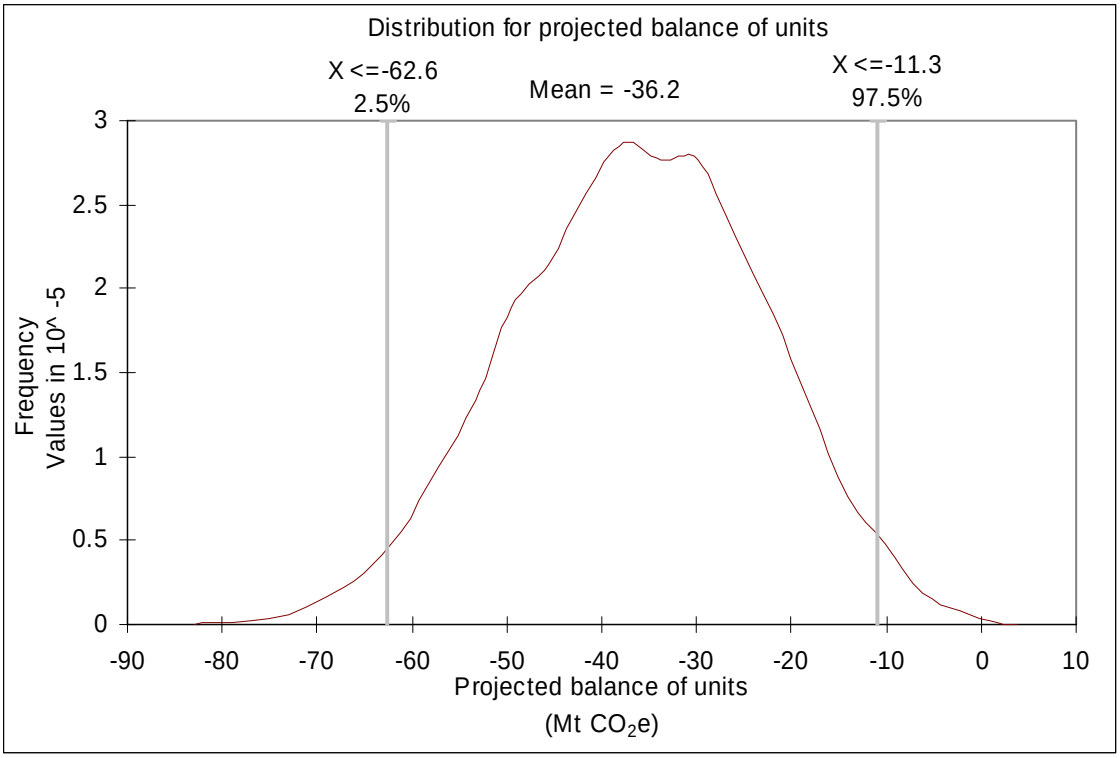
It is highly unlikely that all pessimistic or all optimistic situations will occur together. The uncertainty around the projected balance of units is modelled using a Monte-Carlo simulation. The 95% confidence intervals around the mean are used to represent likely bounds to the pessimistic and optimistic scenarios (Table 1 and figure 1). Triangular probability distributions are used to transform the optimistic and pessimistic values into probabilities.

Table 1: Projected units over the first commitment period (CP1) (all figures Mt CO_2e)

	Pessimistic scenario	**Most likely scenario**	**Optimistic scenario**
a. Projected emissions over CP1	434.0	401.7	377.1
b. Assigned amount units	307.6	307.6	307.6
c. Emissions to be covered (b-a)	-126.4	-94.1	-69.5
d. Removals via sinks	41.8	70.9	90.8
e. Balance (c+d)	-84.0	-22.6	22.0
f. PRE liabilities (e+f)	-7.5	-7.5	-7.5
Balance of units (pure scenarios)	-92.1	-30.7	13.8
Likely balance of units from simulations (95% CI around mean)	**-62.6**	**-36.2**	**-11.3**

There is a range of 51Mt CO_2e between the optimistic and pessimistic scenarios. This uncertainty reflects the difficulty in modelling the complex interactions of the New Zealand energy sector, projecting agricultural markets and animal productivity, estimating the success of the climate change policy package and predicting removals from forest sinks prior to the New Zealand Carbon Accounting System being operational. In addition, a review has highlighted a number of areas where significant improvements are required in the SADEM model used for CO_2 emissions from the energy and industrial processes sector. It is intended that the issues with the SADEM model will be addressed progressively.

Figure 1: Distribution of projected balance of units over the first commitment period of the Kyoto Protocol.



3 Projected emissions over the first commitment period of the Kyoto Protocol

Total emissions over the first commitment period of the Kyoto Protocol are a combination of emissions from the energy and industrial processes sectors, the agriculture sector and the waste sector. Emissions are projected for the mid-point of the first commitment period (2010). This value is multiplied by 5 to obtain total emissions over the first commitment period. The projected emissions include the effect of all policies in the climate change policy package. Three scenarios – a pessimistic, most-likely, and an optimistic scenario are used to assess uncertainty in the projection.

Total emissions of greenhouse gases for the first commitment period are projected to lie between 388.7 Mt CO_2e and 421.1 Mt CO_2e (95% CI), with a mean value of 404.3 Mt CO_2e (Table 2). The total over the first commitment period equates to range in average annual emissions between 77.7 Mt CO_2e and 84.3 Mt CO_2e with a mean value of 80.9 Mt CO_2e (Figure 2).

The mean value for 2010 coincides with a value of 80.7 Mt CO_2e that would be expected from a linear extrapolation of the trend in emissions from 1990-2003.

Figure 2. Projected emissions for 2010, total emissions reported in the national inventory from 1990-2003 and a linear extrapolation of previous emissions.

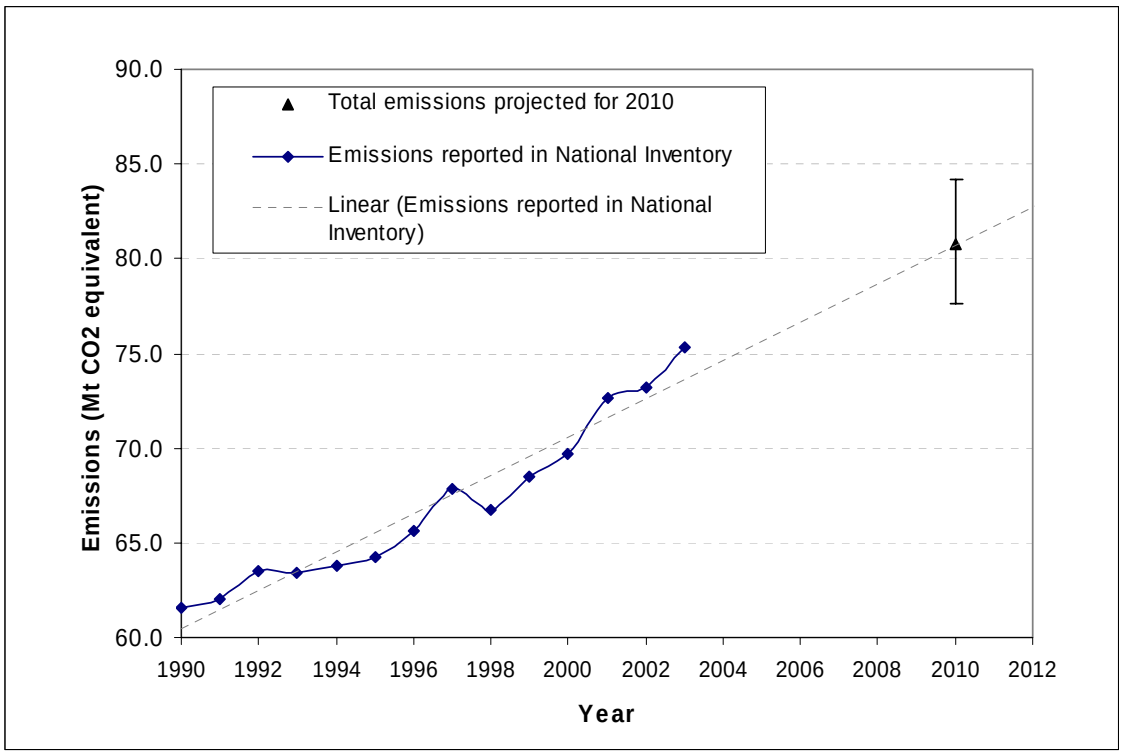


Table 2. Projected emissions of gases and sources listed in Annex A of the Kyoto Protocol over the first commitment period of the Kyoto Protocol.

Sector	**Pessimistic scenario**	**Most-likely scenario**	**Optimistic scenario**
Energy	217.9	194.4	179.7
Agriculture	210.1	202.0	192.4
Waste	6.0	5.3	5.0
Total emissions from scenarios	434.0	401.7	377.1
Likely total emissions from simulations (95% CI around mean)	**421.4**	**404.2**	**388.7**

3.1 Projected emissions from the Energy and Industrial Processes Sectors

The scenarios presented in this report are an interim update on the Ministry for Economic Development's *Energy Outlook 2003* and replace previous projections of CO_2 over the first commitment period of the Protocol. The results are a product of modelling the complex interactions of the New Zealand energy sector. The scenarios are not attempt to project what will actually happen in the energy sector; rather, they provide an indication of a range of possible outcomes under a number of different assumptions.

The interdependence of these and many other factors is a complex issue which is best addressed in a formal, structured manner in order to identify and understand better the interrelationships and dynamics, both within the energy sector and between it and the rest of the economy. This is performed by the Energy and the Environment Group of the Ministry of Economic Development, using its Supply And Demand Energy Model (SADEM).

There are a number of important caveats underlying the analysis. The most significant is that the SADEM model has undergone significant revision and updating since the last Energy Outlook in 2003 and the most recent projections of CO_2 emissions in April 2004. An independent review highlighted areas where significant improvements are required. It is intended that these issues be progressively addressed and the model further revised leading up to New Zealand's 4th National Communication and the next Sustainable Energy Futures Report in mid-2006. The results presented in this report are therefore likely to change as a consequence and should be considered a provisional or interim update on *Energy Outlook 2003*.

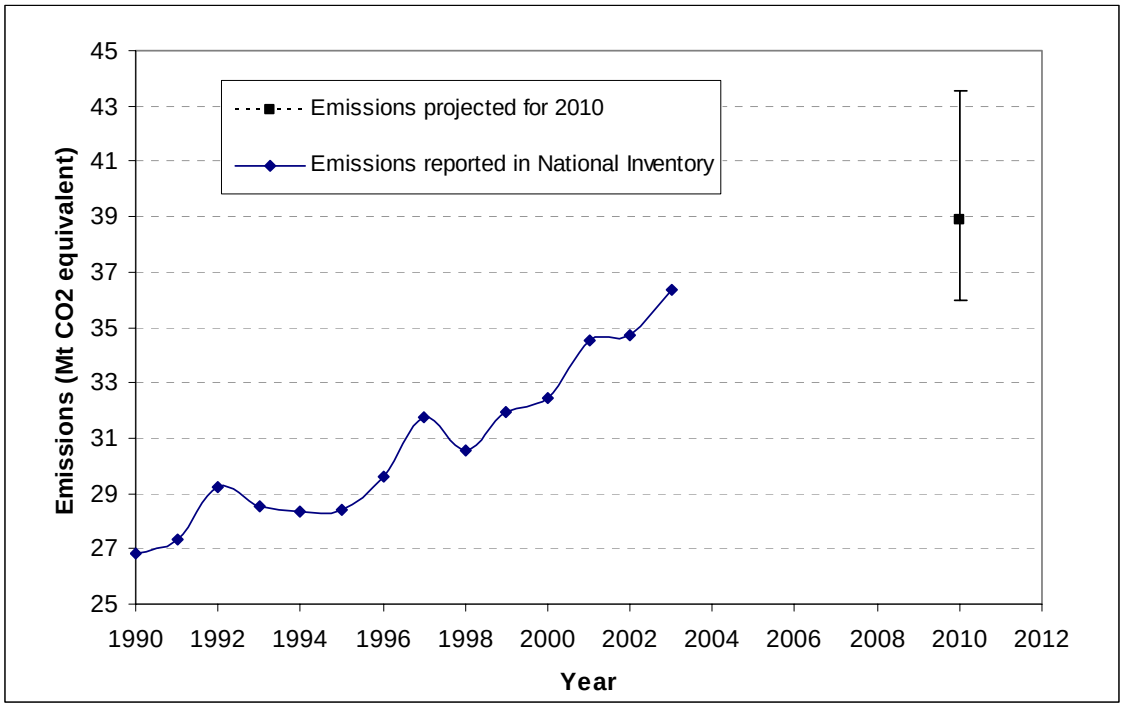
Non-CO_2 emissions from the energy sector are not modelled directly. They are estimated at 5% of the total CO_2 emissions based on the historical relationship between CO_2 and non-CO_2 emissions in the energy and industrial processes sectors.

The projected emissions include the effect of policies in the climate change policy package related to the energy sector. Pessimistic and optimistic emissions projections from the energy and industrial processes sector are based on modelling the effect of plausible high and low values for input variables. The three key underlying variables that were changed to achieve these scenarios were GDP, and oil and coal prices. The values were agreed by the Officials

Committee on Sustainable Energy and officials from the MED and MfE, and represent the best knowledge at the time of projection. The most-likely scenario includes the price effect of a carbon tax, and the effect of the projects to reduce emissions on new electricity generation.

Projected emissions from the energy and industrial processes sector during the first commitment period of the Kyoto Protocol are projected to be between 179.7 Mt CO_2e and 217.9 Mt CO_2e with a most-likely value of 194.4 Mt CO_2e. Average annual emissions are projected to lie between 35.9 Mt CO_2e and 43.6 Mt CO_2e (95% CI) with a most-likely value of 38.9 Mt CO_2e over the first commitment period (Figure 3).

Figure 3. Projected annual emissions from the energy and industrial processes sectors.



3.1.1 The SADEM projections

This section provides a brief overview of the key assumptions used in the SADEM modelling. Detailed information on the SADEM model and projections used in this report can be obtained from the report "*Energy Sector CO2 Projections to 2020 (Interim Update)*" by the Energy and the Environment Group of the Ministry for Economic Development.

Key baseline assumptions

- GDP growth uses Treasury projections out to 2020. The high/low scenario has a +/- 0.7% variance around the projection.
- Oil prices rising from US$32.50/bbl in 2005 to US$40.00/bbl in 2025. The high/low scenario has a -/+ US$10.00/bbl around the 2025 projection.
- Exchange rate of NZ$1.00 = US$0.67 in 2005, and then a constant of NZ$1.00 = US$0.60 from 2006 out to 2025.

- North Island delivered coal prices at a constant $3.75/GJ. The high/low scenario has a -/+ $0.25/GJ variance around this projection. It is assumed South Island coal demand at prices significantly lower than this is minimal.
- New gas available from discoveries averaging 60PJ pa from 2009 onwards.
- Methanex gas to methanol plant to close by mid-2006.
- No EECA/NEECS targets (i.e. no additional energy efficiency)
- A price of $6.50/GJ for gas for electricity generation in 2007.

Major Demand Sectors

Three major energy demand sectors are modelled; residential, industrial & commercial, and transport (Table 3). Each sector has a number of models underlying it. Approximately two thirds of the total energy is modelled using a sophisticated multi-variate approach. About a fifth of the total energy is modelled based on forecasts directly from the industries concerned. The remaining portion is modelled using simple ordinary least square linear regression (OLS).

Table 3: Demand Sectors and Modelling Techniques

Major Sector	Sub-Sector	Model	Net Energy (PJ, 2004)	Percentage
Residential	Residential	Multivariate, GDP, Price, HDD, Lagged Demand	52	10%
Industrial & Commercial	Forestry	MAF forecasts	23	4%
	Metals	Company forecasts	40	8%
	Petrochemicals	Company forecasts	52	10%
	Other Industrial and Commercial	Multivariate, GDP, Price, HDD, Lagged Demand	105	20%
Transport	Petrol (Land)	Multivariate, GDP, Price, Lagged Demand	104	20%
	Diesel (Land)	Multivariate, GDP, Price, Lagged Demand	80	15%
	Aviation	OLS	48	9%
	Sea	OLS	22	4%
	Other	OLS	9	2%
TOTAL			**533**	**100%**

The Carbon tax

The Government has announced that an emissions charge on fossil fuels and industrial process emissions will be introduced in 2007. The charge will approximate the international emissions price and has been set at NZ$15/tonne CO_2.

Projects to reduce emissions

The Projects to Reduce Emissions (PRE) programme is a key part of the Government's climate change policy package. The programme contributes to achieving the outcomes of NEECS including capacity building in renewable energy, and improving energy efficiency, and aims to do this by providing an incentive for projects that reduce emissions below business as usual during the first commitment period of the Kyoto Protocol.

The method used to model the PRE projects installs new generation based on the economics of the different types of generation. PRE units are included as an effective discount on capital costs. This approach means that only 69% of PRE projects are installed (Table 4). This percentage is similar to the April 2004 projection where it was assumed that 60% of PRE projects proceed. The projects modelled include pre-round 1 (already installed) and a proportion of PRE round 1and 2 projects. PRE 3 is not modelled by the SADEM model and consequently any liabilities from PRE3 are not included in the projected balance of units over the first commitment period.

Table 4. Units allocated during the Projects to Reduce Emissions rounds

PRE tender rounds	**Units allocated (M)**
Pre-tender round (actual achieved)	0.76
PRE1 (actual achieved)	3.9
PRE2 (actual achieved)	6.2
Total PRE liability	10.9
Assumed implementation ratio	0.69
Total	**7.5**

3.1.2 Abatement additional to SADEM modelling

The abatement from other policies in the climate change policy package that impact mainly on the energy sector but that are not easily included in the SADEM model are deducted from the SADEM model runs separately. These policies include the National Energy Efficiency and Conservation Strategy (NEECS), local Government initiatives and small to medium enterprises (SME) and business opportunities. The combined effect of these policies is projected to produce abatement ranging between 1.6 and 9.7 Mt CO_2e with most-likely value of 5.0 Mt CO_2e over the first commitment period.

National Energy Efficiency and Conservation Strategy

The NEECS is a package of policy measures and targets that aims to improve energy efficiency by 20 per cent and increase renewable energy sources by 30 PJ by 2012. The Energy Efficiency and Conservation Authority (EECA) have derived an estimate of the impact of NEECS during

the first commitment period based on bottom up assessment of what are reasonable outcomes that could be achieved under the individual NEECS programmes.

A best estimate of the impact of NEECS is projected to be 3.2 Mt CO_2e during the first commitment period (Table 5). If all individual programmes are successfully and fully implemented up to 13 Mt CO_2e of abatement could be achieved. However, for this analysis, it is considered that a more conservative value is obtained by adding in optimistic values for programmes already implemented. This increases the 2.6 Mt CO_2e for the building code, standards and labeling programme to 5.7 Mt CO_2e. A pessimistic scenario of 1 Mt CO_2e abatement is assumed.

Table 5. NEECS programmes included in the average estimate of additional abatement

Programme	**Most-likely estimate Mt CO_2e**
Building code, standards and labeling	2.6
Industrial/commercial energy audits and incentives	0.5
Loans and grants, eg solar water heaters	0.04
Total	**3.2**

Local Government Initiatives

A three year programme, the "Communities for Climate Protection" (CCP-NZ) programme was started in May 2004. It is modelled closely on the Australian "Cities for Climate Protection" programme, which has proven successful in reducing greenhouse gas emissions from councils and communities. As at May, 2005, 15 local authorities have joined the CCP-NZ programme.

The projected abatement is based on the results of CCP Australia. In 2002-2003 year, the programme saved 0.76 Mt CO_2e. In the most recent 3-year period, the programme reduced over 1.2 Mt CO_2e emissions.

CCP-NZ will overlap with some existing polices such as efficiency improvements under NEECS and the New Zealand Waste Strategy. To be conservative it is assumed half of the outcome may be attributable to NEECS and Waste Strategy. The best estimate of abatement from local Government initiatives is 0.3 Mt CO_2e. This is a revision from the previous projection of 0.6 Mt CO_2e, which is retained as the optimistic value. The pessimistic value is assumed to be 0.1 Mt CO_2e.

Small to Medium Enterprises and Business Opportunities

The best estimate of abatement from small to medium enterprises and business opportunities is equal to 1.5 Mt CO_2e. The previous estimate of 3 Mt CO_2e has been retained as the optimistic estimate.

The estimate for this sector is preliminary and is based on a conservative judgement by MfE and EECA that most firms are capable of achieving energy efficiency gains of 5-7 percent through relatively simple measures. If overall efficiency gains of 5 percent were made for fossil fuels and a 7 percent gain for electricity use, and there is a one-to-one relationship between energy savings and emission reductions, then reductions of approximately 300,000 tonnes per year over the first commitment period may be possible. These improvements are not sustainable ad-infinitum.

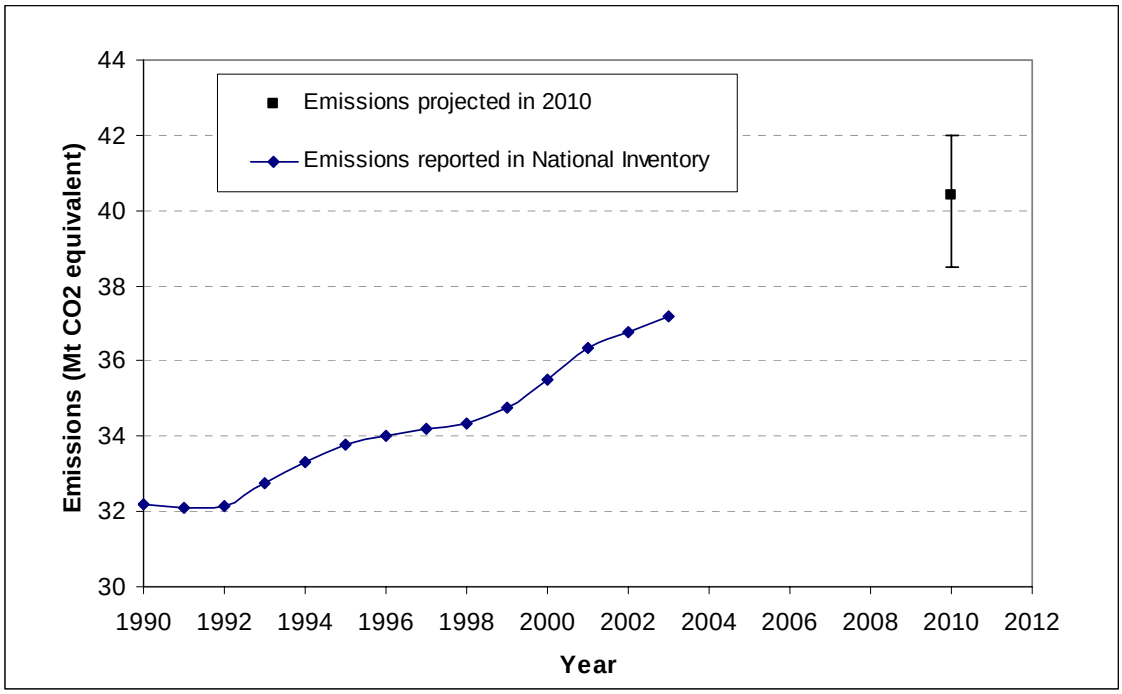
3.2 Projected emissions from the Agriculture Sector

Projections of emissions from the agricultural sector are based on modelling work by the Ministry of Agriculture and Forestry (MAF) and are calculated from total animal numbers, species balance changes, increasing animal performance (liveweight and productivity) and increasing use of nitrogenous fertilisers. Details of the methodology applied to calculate emissions and the assumptions underpinning the high and low scenarios are included in Appendix A.

Emissions from the agriculture sector are projected to range between 192.4 Mt CO_2e and 210.1 Mt CO_2e over the first commitment period. The most likely value is projected to be 202.0 Mt CO_2e. Average annual emissions over the first commitment period are projected to range between 38.5 and 42.0 Mt CO_2e with a most –likely value of 40.4 Mt CO_2e (figure 4).

The potential of technologies to reduce emissions, particularly in the agriculture sector, has not been estimated. There are new products currently entering the market aimed at reducing nitrous oxide emissions from fertiliser and applications of existing bloat chemicals, but for this report the impacts have not been quantified. There are also some prospective technologies that are currently being researched through the Pastoral Greenhouse Research Consortium, a partnership between industry and Government.

Figure 4. Agricultural emissions projected for 2010 and emissions from the agriculture sector as reported in the national inventory.

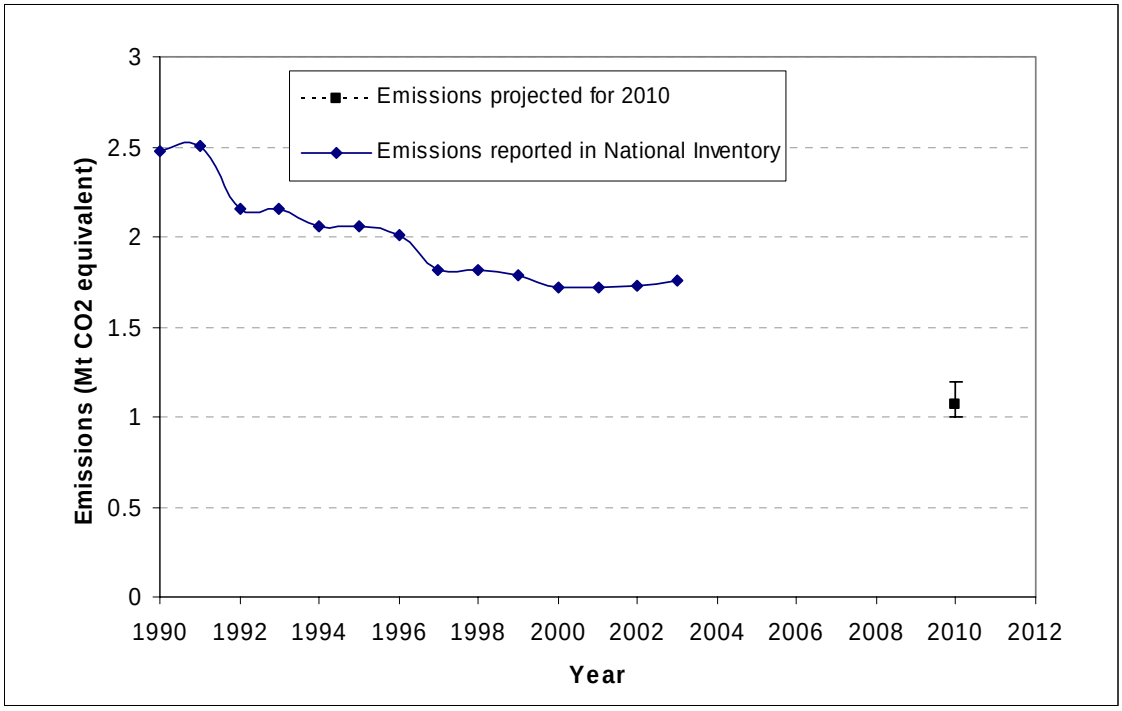


3.3 Projected emissions from the Waste sector

Projected emissions from the waste sector includes emissions from solid waste disposal sites and wastewater treatment plants. The effects of the New Zealand waste strategy and the national environmental standard for landfill gas collection are included in the total emissions from the waste sector.

Emissions from the waste sector over the first commitment period are expected to range between 5.0 Mt CO_2e and 6.0 Mt CO_2e. Projected annual emissions for 2010 are expected to lie between 1.0 Mt CO_2e and 1.2 Mt CO_2e per annum with a most-likely value of 1.1 Mt CO_2e (figure 5). Figure 5 shows that since 1990, there has been a large decrease in emissions due to decreased waste volumes and less organic matter entering landfills. The New Zealand waste strategy (MfE, 2002) and national environmental standard for landfill gas collection and destruction are projected to further decrease emissions from waste.

Figure5. Projected annual emissions for 2010 and the inventory timeseries of emissions from the waste sector.



3.3.1 Waste sector methodology

Solid waste disposal

Emissions from solid waste disposal sites comprise 81% of the emissions from the waste sector. The emissions from solid waste disposal are projected using the methodology and variables used in New Zealand's latest National Inventory of Greenhouse Gas emissions and removals (MfE, 2005). The methodology uses data specific to New Zealand on waste generation rates, waste composition, the percentage of waste disposed to landfills and landfill gas extraction and combustion.

The population projection used is from Statistics New Zealand's projected population 2004-2051 using the 2004 base. The medium fertility, mortality and a net migration of 5000 people is used as the most-likely scenario. Other variables remain constant at the values reported in the latest national inventory (MfE, 2005). Projected effects of the New Zealand waste strategy and the national environmental standard for landfill gas collection are deducted from the modelled emissions.

The New Zealand Waste Strategy

The New Zealand Waste Strategy was launched in March 2002 with the objective of moving towards zero waste by 2010. The strategy extends to all waste streams including landfill waste, mine and quarrying waste, and sewage. In the initial estimate of emissions over the first commitment period, the New Zealand Waste Strategy was projected to deliver an estimated reduction of 5 Mt CO_2e. This reduction was estimated from projected emissions of 12.5 Mt CO_2e over the first commitment period. Since this initial projection, the projected emissions from solid waste disposal sites over the first commitment period have decreased to 7.1Mt CO_2e. Consequently, the amount of projected reduction has been reduced proportionally to 2.8 Mt CO_2e. This projection is retained as the optimistic value. The most-likely estimate is that 90% of the reduction occurs, i.e. 2.6 Mt CO_2e, with a pessimistic value assuming 75% of the reduction.

The National Environmental Standard for Landfill Gas Collection

A national environmental standard for landfill gas collection and destruction has been introduced under Sections 43 and 44 of the RMA to be applied to landfills that will accept over one million tonnes of refuse throughout their design life (MfE, 2004). There is a transitional period to 2007.

The economic analysis of the national environmental standard calculated a reduction of 1.2 Mt CO_2e over the first commitment period. This reduction was based on projected emissions of 9.3 Mt CO2e over the first commitment period. The reduction has been revised proportionally to reflect the decreased waste emissions in the national inventory (MfE, 2005). The updated value is a reduction of 0.9 Mt CO_2e over the first commitment period. A national environmental standard means that no scenario analysis is required.

Wastewater treatment

Emissions from wastewater treatment produce 19% of emissions from waste. The projected emissions for 2010 were estimated using a linear projection of emissions from 1990 to 2003 (r^2 = 0.96). Emissions are projected to be 0.33 Mt CO_2e for 2010.

4 Assigned amount units

The number of assigned amount units is calculated from the most recent national inventory of greenhouse gas emissions and removals (MfE, 2005). In the 2005 submission, the emissions in 1990 were 61.5Mt CO_2e. This equates to 307.6 Mt of assigned amount units over the first commitment period.

The amount of assigned amount units decreased by 0.5 Mt from the previous projection due to the effect of recalculations in the national inventory. Recalculations are improvements in data, emission factors or methodologies that are back-dated from the current inventory to 1990.

5 Removal units from sinks

This report provides an estimate of removals of CO_2 via forest sinks. The projection in this report uses the current inventory methodology and best information available at the time of projection.

A most-likely, pessimistic and optimistic scenario are used to quantify uncertainty around the removals via sinks. The scenarios anticipate the results from when the New Zealand Carbon Accounting System is in operation. It is highly unlikely that all pessimistic or all optimistic situations will occur together and the uncertainty around the projected removals is modelled using a Monte-Carlo simulation. The 95% confidence intervals around the mean are used to represent likely bounds to the pessimistic and optimistic scenarios (Table 6). The change to the New Zealand carbon accounting system will affect all values reported in Table 6.

Table 6. Calculation of projected removal units in CP1 (figures have been rounded).

Projected removal units	Mt CO_2e		
	Pessimistic	Most likely	Optimistic
Total sequestration combined with new planting rates (0, 10k and 30k ha/yr)	91.9	95.3	102.0
Loss of soil carbon with afforestation	-8.6	-2.2	0
Natural scrub meeting Kyoto Forest definition	0	0	3.75
Planted forest not meeting the Kyoto Forest definition	-19.3	-14.7	-7.4
Burning of scrub for forest planting	-1.25	-1.25	-1.25
Deforestation emissions	-21.0	-6.3	-6.3
Total removal units	41.8	70.9	90.8
Likely total removals from simulations (95% CI around mean)	**48.1**	**67.8**	**85.6**

The projected removal units are based on a national radiata pine area-weighted carbon yield table. This yield table has been derived from the National Exotic Forest Description wood volume yield tables and does assume that all planted forests are radiata pine of medium wood density. The same standing stem volumes per hectares are assumed for all forests irrespective of when they were planted. Some experts consider that current carbon sink estimates may be underestimated because most forests planted since the early 1990's have been on more fertile soils with the potential for higher growth rates. There is however, no consensus on this point. A contrary view is that due to the large areas of "non-professionally" managed forests planted since 1990 that the biomass in these forests could be lower because of poorer quality forest management. There also down side risk because 10 percent of New Zealand's planted forest estate is in species other than radiata pine. Generally these other species grow more slowly. No suitable model current exists for alternative species. The Carbon Monitoring System plots and revision of yield tables will help clarify this situation.

The best estimate in the previous projection report was based on a planting rate of 20,000/yr. Current planting rates are around 10,000-15,000 ha/yr. The most likely estimate used in this projection is 10,000 ha/yr. The historical average planting rate is around 40,000 ha/yr meaning that the estimate of 10,000 ha/yr is low in the historical context.

A loss of 2.2Mt CO_2 is included for a loss of soil carbon converting "grassland" to pasture. This is based on research by Landcare Research and Forest Research scientists. Earlier estimates assumed no loss of soil carbon.

There is no projected removal from "Kyoto scrub" that meets New Zealand's proposed definition of forest under the Kyoto Protocol. This definition requires New Zealand to state the minimum area, length (and thus width) of land areas categorised as forest land. The previous estimate was 3.75Mt CO_2.

A loss of 14.7Mt CO_2 is included for forests planted into existing kanuka and manuka forest. Field studies have shown that a proportion of existing planted forests, estimated at up to 16% nationally, were planted in scrub that could meet the definition of forest in the Kyoto Protocol, i.e. the planting was not onto "grassland". The true value won't be known until the New Zealand Carbon Accounting System is in operation. The pessimistic and optimistic estimates use estimates of 21% and 8% of forests being planted in existing forest and 10,000 hectares planted from 2005.

Burning of scrub for forest planting was not included in previous calculations of the balance of units, however this source is included in the change of carbon stocks reported in the national inventory of emissions and removals (MfE, 2005). A constant loss of 1.25Mt CO_2 is used for all scenarios. Use of a constant value implies differing percentages under the optimistic and pessimistic scenarios.

The expected value of emissions from deforestation remains the historical (2-3%) rate of deforestation. This equals a loss of 6.3 Mt CO_2 under the most likely estimate. The minimum amount of deforestation is also set to 6.3 Mt CO_2. Use of a constant value implies differing percentages under the optimistic and pessimistic scenarios. The upper limit is the maximum liability under the deforestation cap. The historic rate of deforestation may not necessarily be an accurate guide of future intentions. Anecdotal information indicates that current and future deforestation is higher than historical levels. A project has recently begun to review methodology options to forecast future deforestation levels.

The projections assume Kyoto accounting rules established for the first commitment period of the Protocol would continue for future commitment periods, for example the "fast growing forest fix" which limits liabilities for Kyoto forests to previous credits claimed. Those countries that will harvest Kyoto forests in the first commitment period need only "pay back" the equivalent carbon units earned in the first commitment period.

The impact of rotation age is most relevant after the first commitment period. The projections assume a rotation age of 28 years. An earlier cut will result in higher carbon emissions during the first commitment period and a later cut would defer carbon emissions. Current forest management trends are toward longer rotations.

5.1 Accounting for Article 3.4 Forest Management

Under Article 3.4 of the Kyoto Protocol, New Zealand has until 2007 to elect which additional Article 3.4 land use, land use change and forestry activities, if any it wishes to account for in the first commitment period. The election of these activities is voluntary for Annex 1 parties. Forest management is one such activity and would include accounting for non-Kyoto forests over the first commitment period. The government has agreed in principle not to account for these activities in the first commitment period. However, a final decision will not be made until closer to 2007, when further information is available.

At present, there is considerable uncertainty in the data on carbon stocks and carbon stock changes for forest land. The available data suggest that carbon stocks are likely to be in a steady state or a slight decline. An assessment of the significance to New Zealand of Article 3.4

forest management activities concluded that the balance lay somewhere between -92 Mt CO_2e to 11 Mt CO2-equivalent over the first commitment period. New Zealand is also subject to a cap for Article 3.4 forest management activities.

Whether New Zealand will be obliged to account for such activities in subsequent commitment periods is a matter for future international negotiations. If New Zealand is obliged to account for pre-1990 forests and these forests are in fact losing carbon, then this would add to New Zealand's emissions liabilities.

6 Reconciliation with previous projections

A comparison of the pre-ratification and 2004 projections is provided in table 7. The decrease in the projected balance of units from the 2004 projection is due to:

1. An increase in projected energy and industrial processes emissions over the first commitment period. This is caused by changes in the modelled emissions and policy measures and changes in the reductions attributed to non-modelled policy measures.

    i. Changes in modelled emissions include updated information from the Maui re-evaluation showing an increase in the long-term price of gas and consequently more coal use in electricity generation, the impact of diesel consumption in excess of the previous projection and an increase in fugitive and industrial processes emissions.

    ii. The new projection also includes changes resulting from modelling reductions from the carbon charge and the Projects to Reduce Emissions policy.

    iii. There were also changes to reductions from non-modelled policy measures, i.e. the NEECS, local Government initiatives and the Small to medium business opportunities.

2. A reduction in the removals via forest sinks due to the quantification of previously unknown risks and updating of previous estimates from improved scientific information.

3. Changes to the liabilities for the "Projects to Reduce Emissions" in the projected balance of units. The 2004 projection included 60% of all 3 PRE rounds as a liability whereas this projection only includes liabilities from the PRE projects modelled in the energy sector. This includes the pre-round 1 and a proportion of PRE round 1and 2 projects. PRE 3 is not modelled and consequently liabilities from PRE3 are not included in the projected balance of units.

Table 7. Reconciliation of previous projections of the balance of units.

	Mt CO_2e		
	2003	**2004**	**2005**
Projected emissions including policies			
Energy and Industrial Processes	161.5	156.4	194.4
Agriculture	189.5	201.3	202.0
Waste	7.5	3.3	5.3
a. Total emissions over the first commitment period	**358.5**	**360.9**	**401.7**
Annual emissions projected for 2010	71.7	72.2	80.9
Latest actual emissions at date of projection	70.2	74.9	75.3
b. Assigned amount	**308.3**	**308.3**	**307.6**
c. Emissions to be covered (b-a)	**-50.2**	**-52.6**	**-94.1**
Removal units			
Sequestration in forests (including new planting)	105.0	97.8	95.3
Loss of soil carbon with afforestation		0	-2.2
Natural scrub meeting Kyoto Forest definition		3.8	0
Planted forest not meeting Kyoto Forest definition			-14.7
Burning of scrub for new planting			-1.3
Deforestation emissions		-6.3	-6.3
d. Total removal units	**105.0**	**95.2**	**70.9**
e. Balance (c+d)	**54.8**	**42.6**	**-23.2**
f. Liabilities to the Projects to educe emissions	**0**	**-10.0**	**-7.5**
Projected balance of units (e +f)	**54.8**	**32.6**	**-36.2***

* The balance of units shown for 2005 is the mean result of the Monte-Carlo simulation. The balance of units from the most-likely scenario is -30.7 Mt CO_2e.

Appendix A. Projections of Agricultural Greenhouse Gas Emissions to 2010

Ministry of Agriculture and Forestry

Introduction

Projections of methane and nitrous oxide emissions to 2010 from the agricultural sector are driven by future estimates of:

- animal numbers by species: dairy cattle, beef cattle, sheep and deer in 2010.
- enteric methane emissions per animal based on annual changes in emissions per animal since 1990.
- nitrogen output per animal based on annual changes in nitrogen output per animal since 1990.
- nitrogen fertiliser use based on annual rates of change of nitrogen fertiliser usage since 1990 supplemented by industry forecasts.

Two further scenarios of projected emissions in 2010 have also been produced. These represent best estimates of the upper and lower bounds of methane and nitrous oxide emissions. The upper and lower bounds have been calculated using upper and lower bounds for both animal numbers and annual methane /nitrogen output per animal.

Development of the 2010 Baseline Projections

Projections of the Animal Numbers

Projections of the livestock numbers for dairy cattle, beef cattle, sheep and deer are undertaken with an econometric model, the Pastoral Supply Response Model (PSRM). The PSRM is an annual time series model that is representative of the biological constraints and investment decisions made by New Zealand farmers. The projections are based predominantly on the provisional June 2004 results of Statistics New Zealand's Agricultural Production Survey. Product prices are those used in MAF projections prepared for The Treasury's Budget Economic and Fiscal Update.

Post-model adjustments are carried out based on known and estimated factors that may reduce the land area available for livestock as follows:

- The removal of South Island high country leasehold areas from livestock farming from June years 2002 to 2013 has an estimated cumulative loss of 0.5 million stock units (SU).
- The annual area of grazing land converted to forestry rises from the current low of 10,600 ha in the year to June 2004 to 18,700 ha in 2010. This compares with MAF's separately provided scenarios of 10,000ha, 20,000 ha and 30,000 ha for June year 2010. It is assumed that these areas displace sheep.
- Anticipated deforestation of an estimated total of 34,000 ha spread over June years 2005 to 2010 in the Central North Island. The land will go mostly into dairy.
- Sheep numbers are adjusted down in 2010 so that total SU of livestock plus the cumulative opportunity loss of SU displaced by forestry are equal to the level as at June 2009. The maximum SU is 97.951 million with 94.384 million from dairy, beef, sheep, deer and goats, and the balance is the cumulative SU displaced by forestry. This ensures that feed demand approximates feed supply over the longer term.

Productivity has improved since 1990 and is expected to increase further in the future. This is revealed in increasing kilograms of milk solids per cow, increasing lambs born per mated ewe and ewe hogget, and heavier carcass weights (particularly for lamb). Productivity increases are accounted for in the emissions model.

Table A1: Projected baseline animal numbers in 2010

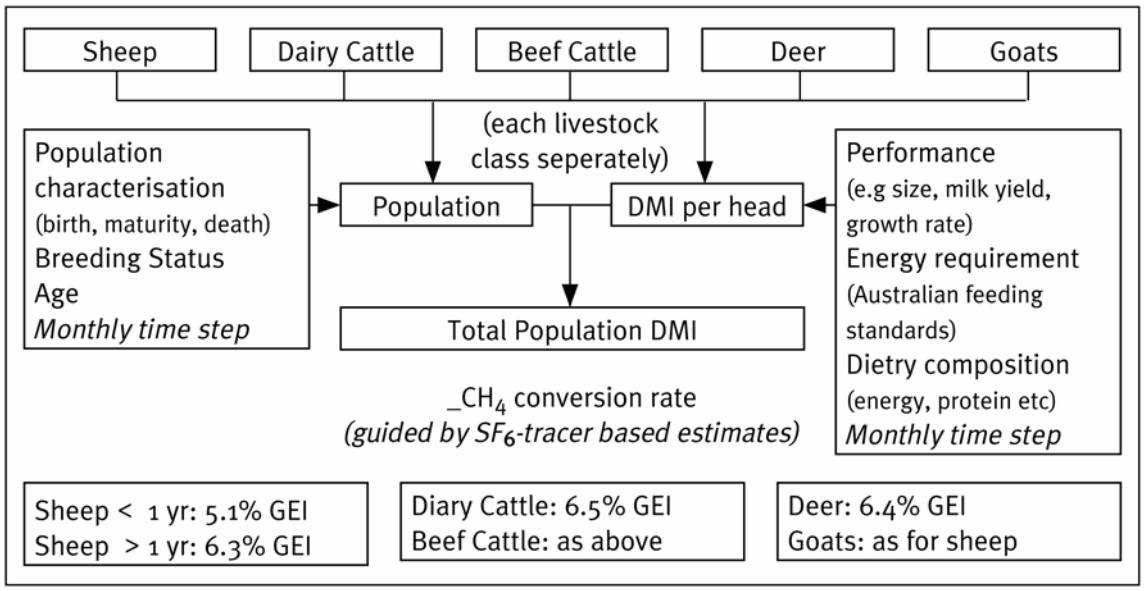
	1990 (000)	**2010 estimated (000)**
Dairy Cattle	3,390	5,605
Beef cattle	4,596	3,841
Sheep	57,850	40,446
Deer	1,035	1,645

Projections of Enteric Methane Emissions per Animal

Projections of methane emissions per animal in 2010 are derived from linear trends of the methane emissions per animal 1990-2003, extended out to 2010.

The per animal emissions used to derive the linear trends are sourced from the current national methane inventory and are calculated using the model developed by Clark *et al* (2003). See Figure one.

Figure A1: Outline of the process used to calculate methane emissions in the national inventory. Taken from Clark *et al* 2003.



The model determines monthly feed intakes for different age classes of each animal species based on the mean national animal performance data derived from national statistics relevant for each species. For example, in dairy cattle, inputs include: animal bred, animal liveweight and milk production per animal, fat %, protein % per animal. 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 SF_6 technique to assess methane emissions in the field. From these estimates of feed intake per animal, and methane produced per unit of intake, an implied annual emission factor has been calculated per animal that takes into account the changes in animal performance over time.

The implied methane emission factors for dairy cattle, beef sheep and deer in 1990 and 2010 along with the correlation coefficient (r) for the linear trend in per animal emissions 1990-2003 are presented in table A2. The data indicate a very strong linear relationship between time and increase in methane emission per animal over the period 1990 to 2003, providing confidence in the projection of emissions to 2010.

Table A2: Annual methane emissions per animal 1990 and 2010, and the correlation coefficient (r) for the linear trend in per animal emissions 1990-2003.

	1990 **kg methane/head/annum**	**2010 estimated** **kg/methane/head/annum**	**Correlation**
Dairy Cattle	70.78	83.91	0.963
Beef cattle	51.04	59.19	0.927
Sheep	8.94	11.60	0.996
Deer	20.96	23.74	0.889

Projections of Nitrous Oxide Emissions

Nitrous oxide emissions from animal excreta are a function of animal feed intake per annum and the nitrogen content of feed minus the nitrogen retained in animal product. Models developed by Clark *et al* (2003) for methane emissions also provide for nitrogen output per animal. Projections of nitrogen output per animal in 2010 were derived from linear trends of the nitrogen outputs per animal using data reported in the national inventory from per animal output from 1990 to 2003. Nitrous oxide emissions in 2010 were then calculated using the methodology used for the national inventory.

Table A3: Annual nitrogen excreta per animal 1990 and 2010 and the correlation coefficient (r) for the linear trend in per animal nitrogen excreta 1990-2003.

	1990 **kg N/head/annum**	**2010 estimated** **kg/N/head/annum**	**Correlation**
Dairy Cattle	106.2	122.7	0.952
Beef cattle	65.2	76.5	0.927
Sheep	12.2	15.9	0.994
Deer	27.4	31.0	0.893

Projection of Nitrogen Fertiliser Use

Nitrogen fertiliser use has increased nearly 6 fold since 1990. Two methods were used to assess projections of nitrogen fertiliser to 2010. The first used projections of nitrogen fertiliser use derived from a linear trend of fertiliser use from 1990 to 2003. The correlation (r) was 0.96. The projected value for 2010 was 433,700 tonnes of nitrogen.

The second method used best fertiliser industry estimates provided through the Fertiliser Manufacturers Research Association which takes into account future exchange rates, agricultural commodity prices, shipping costs and general projected economic circumstances for agriculture. The projected best estimate value for 2010 was 408,500 tonnes.

Because of the large discrepancy, a mean value between these two estimates of 421,100 tonnes was used for estimating nitrous oxide emissions in 2010. This approach is reasonable since future changes such as limitations on nitrogen use in some catchments i.e. Lake Taupo and Lake Rotorua, the continuing conversion of pastoral land to forestry, the Clean Streams Accord and other Regional Council directives on good fertiliser practice are likely to limit the steep upwards trend in fertiliser nitrogen application seen in recent years.

Other Animal Species and Greenhouse Gas Sources

No projections were derived for the emissions of minor animal species present in the national inventory i.e. horses, goats, pigs, and poultry. This was also the case for nitrous oxide emission from crop stubble burning, savannah burning and nitrogen fixing crops. These emission sources make up less that 4 % of the agricultural sector emissions. 2003 inventory emission levels were used for 2010.

Development of the Upper Bounds for 2010 Projections

Introduction

Two future scenarios were developed: a high and low scenario. The high scenario combined the higher projected estimates for animal numbers, methane emission per head, nitrogen output per head and nitrogen fertiliser use. The low scenario combined the lower estimates of animal numbers, methane emission per head, nitrogen output per head and nitrogen fertiliser use. These two scenarios give an estimate of the upper and lower bounds of future projected emissions.

Animal Numbers

A sensitivity analysis was undertaken to provide some high and low projections of livestock numbers. This assumes that the 2004 livestock numbers change by plus and minus 5 percent. The PSRM was then re-run for both and post-model adjustments carried out. The high was allowed to rise to a maximum carrying capacity (including cumulative SU displaced by forestry) of 99.642 million SU which would occur at June 2011. The low was allowed to rise to a maximum carrying capacity of 96.470 million SU which would occur at June 2007. The baseline has a maximum carrying capacity of 97.951 million SU which would occur at June 2009.

Table A4: Upper and lower bounds for animal number projections in 2010.

	Low	Baseline 2010	High
Dairy Cattle	5,519	5,605	5,692
Beef cattle	3,755	3,841	3,932
Sheep	39,966	40,446	40,896
Deer	1,603	1,645	1,688

Methane Emissions per Animal per Year

High and low estimates of methane emission per animal were obtained by calculating the 95% projection interval around the predicted mean values for all years beyond 2003. This gives an upper and lower bound for projected methane emission per head in 2010 (Table A5).

Table A5: Upper and lower bounds for projected methane emissions per head in 2010.

	Low kgCH4/head/annum	Baseline 2010 kgCH4/head/annum	High kgCH4/head/annum
Dairy Cattle	81.56	83.91	86.26
Beef cattle	57.21	59.19	61.17
Sheep	11.53	11.60	11.67
Deer	22.64	23.74	24.85

Nitrogen Excreta Output

High and low estimates of nitrogen output per animal were obtained by calculating the 95% projection interval around the predicted mean values for all years beyond 2003. This provides an upper and lower bound for projected methane emission per head in 2010 (Table A6).

Table A6: Upper and lower bounds for the projected quantity of nitrogen excreted per head in 2010.

	Low kgN/head/annum	Baseline 2010 kgN/head /annum	High kgN/head/annum
Dairy Cattle	119.3	122.71	126.0
Beef cattle	74.0	76.5	79.1
Sheep	15.7	15.9	16.2
Deer	29.6	31.0	32.4

Nitrogen Fertiliser

Scenarios for future nitrogen fertiliser use were based on the variation in nitrogen fertiliser projections provided by the Fertiliser Manufacturers Research Association. These indicated a low scenario of 86,000 tonnes less than the baseline estimate and a high scenario of 28,000 tonnes above the baseline estimate.

Table A7: Upper and lower bounds of projected nitrogen fertiliser use in 2010.

Low Tonnes N per annum	Baseline 2010 Tonnes N per annum	High Tonnes N per annum
335,100	421,100	449,100

Assumptions and Limitations

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

At present animal performance in New Zealand is well below current biological limits and it seems reasonable to assume that the rate of increase in productivity per animal over the next 15 years should be similar to the rate of increase in animal performance over the past 13 years. A linear extrapolation of methane emissions was therefore considered appropriate.

At some stage in the future the rate of productivity increase may well decline due to resource limitation. However, balanced against this are industry strategy plans such as the dairy sector, which seeks to improve productivity in economic farm surplus by 4% per annum which is higher that the historic trend. Factors such as this have not been incorporated into the models. Likewise, mitigation technologies may become available that reduce emissions at an individual animal level over the next 15 years. These include products such as Monensin, a bloat control agent that has been shown to reduce methane emissions, or the widespread adoption of the nitrification inhibitor, DCD which has also been shown to reduce nitrous oxide emissions.

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