New Zealand
Climate Change Programme

RESPONDING TO CLIMATE CHANGE

A Discussion of Options for New Zealand

MINISTRY FOR THE ENVIRONMENT
MANATŪ MŌ TE TAIAO
1990

Responding to Climate Change: A Discussion of Options for New Zealand

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A note about the New Zealand Climate Change Programme:

The New Zealand Climate Change Programme, with the Secretary for the Environment as Chairman of the Steering Committee, was convened in 1988, to collate and coordinate information and advise the Government on how New Zealand should respond to climate change.

The work has been carried out by three working groups - Facts, Impacts, and Policy.

This report was prepared by the Policy Working Group.

Other publications issued under the auspices of the New Zealand Climate Change Programme are:

Climate Change in New Zealand. Report prepared by the Royal Society of New Zealand. Royal Society of New Zealand, Wellington, 1988. 28 p. $9.95 *(Available from the Royal Society)*

New Zealand Climate Report 1990: Report Prepared by the New Zealand Climate Committee of the Royal Society of New Zealand as a Contribution towards the Climate Change Programme of the New Zealand Government. Royal Society of New Zealand, Wellington, 1990. 28 p. $15.00 *(Available from the Royal Society)*

Climatic Change: A Review of Impacts on New Zealand. Report prepared by the Impacts Working Group of the New Zealand Climate Change Programme. Ministry for the Environment, April 1990. 32 p. $5.00. (Summarises the report immediately following.)

Climatic Change: Impacts on New Zealand - Implications for the Environment, Economy, and Society. Report prepared by the Impacts Working Group of the New Zealand Climate Change Programme. Ministry for the Environment, Wellington, May 1990. 256 p. $30.00

Foreword

Global climate change threatens the existence of the world as we know it. Although nothing is certain except that greenhouse gases are increasing in the atmosphere, studies suggest that ecological systems could be disrupted, with major impacts on human economies and societies.

If we ignore this threat, it is at our own peril. In spite of the uncertainties, it would be irresponsible not to act. If we wait for conclusive proof, it may be too late. So what must we do?

Many aspects of climate change create difficulties in making decisions:

- its global scale;
- its uncertainty;
- the variety of causes and complex interactions between them;
- the need to cope with wide ranging consequences *and* at the same time tackle the causes;
- the need to involve *everyone* in responding.

In responding to the causes and impacts of climate change, it is for us all to bear in mind that any solutions will require global effort and cooperation. The key to the success of any policies New Zealand may adopt will ultimately be international cooperation.

Despite the difficulties, the international community is working rapidly towards agreements on how to control the causes and effects of climate change.

The New Zealand Climate Change Programme has also been considering the issues of how to prevent further build-up of the gases that cause the problem, and how to respond to the impacts of climate change as they occur.

This discussion document is a first attempt at addressing the issues. It sets out an array of possible responses. Some options may turn out to be impracticable or too costly to pursue further. Others could be adopted with little cost and considerable benefit. The task for Government is to develop the best grouping of options to respond to the complex issues involved.

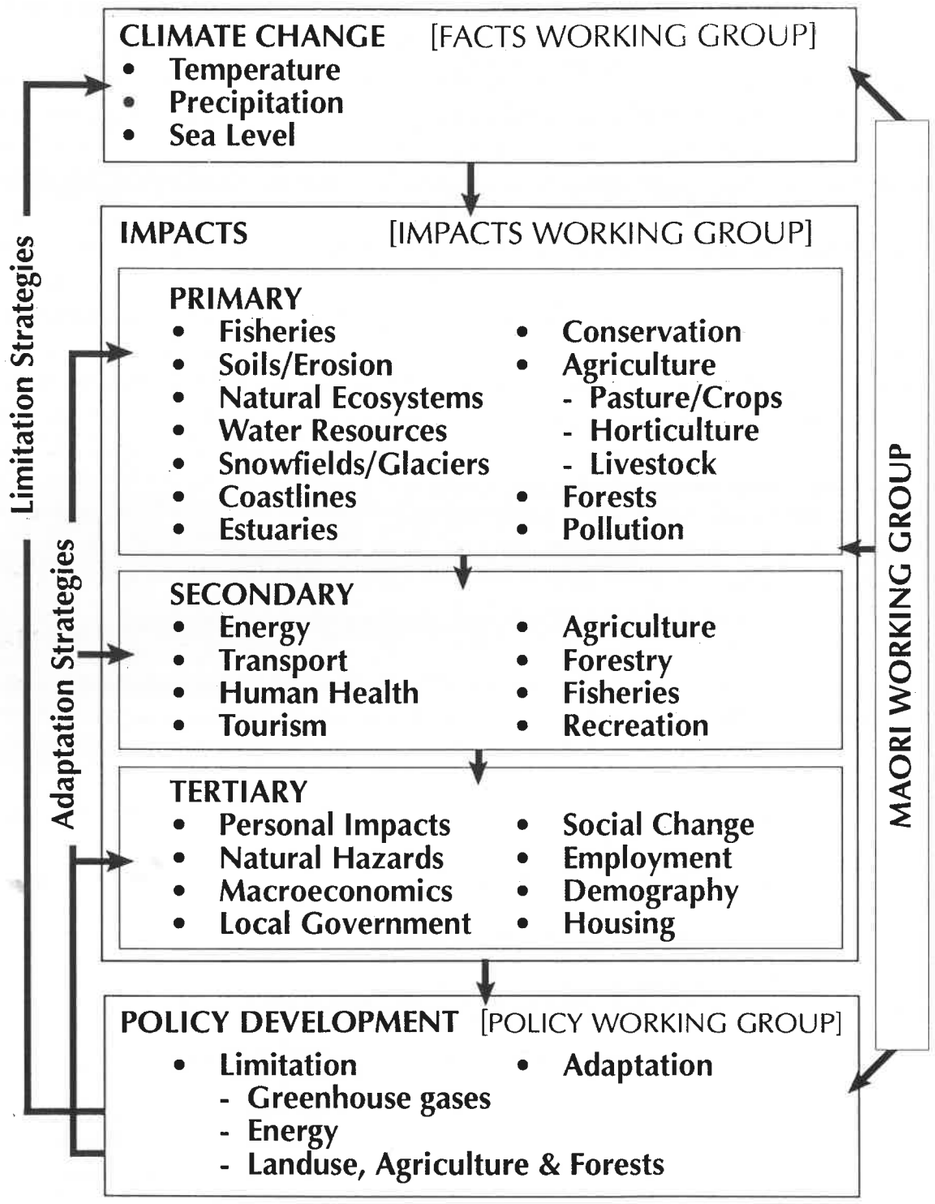
Many choices lie ahead, for which we must all share some responsibility. The Government invites your views on what must be done.

Rt Hon. Geoffrey Palmer
Prime Minister and Minister for the Environment

Wellington, May 1990

Closing Date for Public Submissions
8 June 1990

New Zealand Climate Change Programme



Preface

In 1988, after a conference on "Climate Change: The New Zealand Response", the Government decided that New Zealand required a coordinated programme for responding effectively to an issue which had potential widespread implications for the land and people. This decision led to the establishment in June 1988 of the New Zealand Climate Change Programme.

The challenge for the New Zealand Climate Change Programme was to report to Government on: the scientific basis for predictions of climate change; the possible impacts of climate change on physical and biological systems, on the economy, and on society; and how New Zealand might respond to climate change. Three working groups on climate change were set up under a Steering Committee chaired by me. A fourth working group, the Maori Working Group, was established to advise on matters relevant to Maoridom, and to ensure that policy recommendations took account of Maori concerns and were in accord with the Treaty of Waitangi.

Preparation of this document was carried out by the Policy Working Group of the New Zealand Climate Change Programme, chaired by Judy Lawrence and Jane von Dadelszen. The group has members from 18 Government departments, as well as representatives of the Facts, Impacts, and Maori Working Groups. To assist the preparation, four working subgroups were also established to develop material on: the greenhouse gases; energy; agriculture, forestry, land use, and industry; and adaptation. These subgroups comprised members of the Policy Working Group and expert help commissioned from outside agencies. Ministry for the Environment staff convening the four subgroups were, respectively, Helen Plume, Jane Sheldon, Martin Petrie, and John Campbell. Jane von Dadelszen and Chris Livesey developed the generic options. Significant input was also provided by the Maori Working Group, particularly Tim Fraser from the Ministry for the Environment and Nici Gibb and Tikitu Tutua-Nathan of Manatu Maori.

I would like to thank all those involved for their hard work in producing such a comprehensive discussion document. I am sure it will stimulate debate and discussion and assist the Government in choosing the most appropriate actions for New Zealand to take.

Roger Blakeley
Secretary for the Environment and
Chairman of the New Zealand Climate Change Programme Steering Committee

Wellington, May 1990

Aim of this Publication

This document provides a review of possible ways in which the Government might respond to the issues surrounding climate change.

The options described here are simply options. They do not represent a statement of Government policy. Before taking any decisions, the Government first wants to have public views on the appropriateness and feasibility of the options, including:

- **which group or basket of options is favoured;**
- **comments evaluating the options;**
- **combinations of options that might help to achieve particular targets in limiting emissions of greenhouse gases;**
- **the appropriateness of criteria (suggested at the end of sections 3 and 4) for evaluating options to limit the causes of greenhouse gas accumulation and to adapt to the changes that may already be taking place.**

Submissions must be received by the Ministry for the Environment by noon on 8 June 1990.

Address submissions to:

Ministry for the Environment
PO Box 10-362
Wellington **Attention Iain McGlinchy**

The timetable for public input is:

This policy discussion document released	**4 May 1990**
Public submissions close	**8 June 1990**
Policy Working Group reports to Government	**July 1990**

Contents

1. Climate Change

1.1 What Is Climate Change?

Throughout the history of the earth the climate has been changing. What is happening now, however, is that we are hearing more and more about "the greenhouse effect". This greenhouse effect is a natural phenomenon, in which gases and small particles trap the sun's heat and in that way maintain a temperature which is suitable for life. Concern now is that human activities have affected the atmosphere and are intensifying the greenhouse effect, leading to climate change more rapid than has been experienced before.

The heat-retaining greenhouse gases include water vapour, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and tropospheric ozone (O3). They have maintained a delicate balance of incoming solar radiation and outgoing heat radiation for millions of years. Over the last two centuries, however, human activity has altered this balance by dramatically adding to the amounts of these gases, and by introducing new artificially created "super absorbent" greenhouse gases such as chlorofluorocarbons (CFCs) and halons.

If current trends in atmospheric accumulation of these gases continue, the total concentration of greenhouse gases by the mid 21st century could be double what it was before the industrial revolution. Computer models set up to calculate the possible changes indicate that such a doubling could result in temperatures changing at a rate beyond anything which the earth's ecosystems have experienced for many millennia.

Estimates of the likely rises in temperature are continually being revised as new information comes to hand, and their accuracy will improve as computer models are refined. The latest estimates of the New Zealand Climate Change Programme's Facts Working Group suggest air temperatures around the world have risen by about 0.5°C during the last 50 years. The Facts Working Group consider that, if greenhouse gases are the dominant factor in inducing climate change, then the most likely prospect is for accelerated warming. If this is the case, temperatures in New Zealand by the year 2025 could average 0.5-1.0°C higher than at present, and by the year 2050 perhaps 1.0-2.0°C higher than at present.

Such heating-up might lead to more than just warmer temperatures. Along with alterations in atmospheric circulation, there could be changes in wind patterns, and changes in the frequency, intensity, and duration of storms, rainfall, and other aspects of weather. There are many unknowns, and many assumptions have been made. Computer models indicate that if changes occur as a result of human activity, we will probably start to notice them around the year 2000.

Another possibility is sea level rise, as a result of the thermal expansion of seawater, plus increased melting of alpine glaciers and snowfields. The Facts Working Group considers the most likely mean sea level change in the New Zealand region, consistent with the expected temperature changes, to be a rise above present levels of 7-17 cm by 2025, and 17-35 cm by 2050.

1.2 Greenhouse Gases

The most plentiful and best known of the greenhouse gases is carbon dioxide. This is thought to be responsible for about half the present human-generated intensification of the greenhouse effect. Of the other trace gases in the atmosphere which contribute to the greenhouse effect, the main ones are methane (CH4), nitrous oxide (N2O), and the chlorofluorocarbons (CFCs). New Zealand's relative contribution to long-term global warming, through its output of each of these gases, is set out in Table 1.

Table 1: *New Zealand's Annual Output of Greenhouse Gases: 1989 (The contribution to long-term warming (500 years) is calculated as a percentage)*

Gas	Human Induced Emissions 1989 (thousand tonnes)	"Impact" Factor	Carbon Dioxide Equivalent (per million tonnes gas)	Percent of New Zealand Contribution
CO2	26 200	1	26	43
CH4	1 600	9	14	23
N2O	45	190	9	15
CFC-11	1	1 500	1.5	2
CFC-12	1	4 500	4.5	7
Others: (Includes O3, H2O, CO, other CFCs, SO2, halons)				>10

Notes to Table 1:

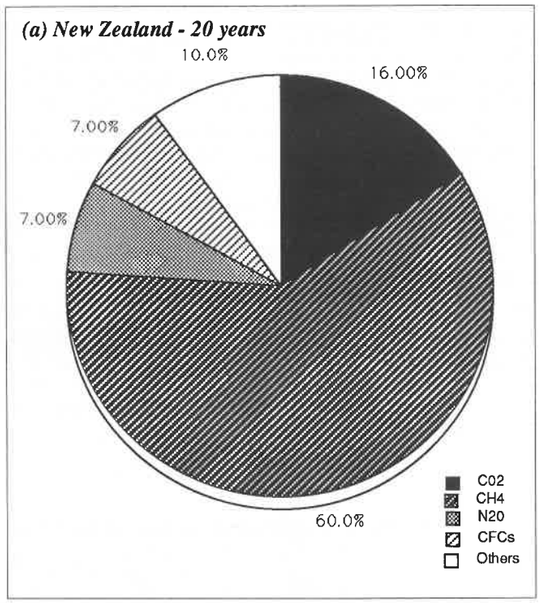
1. **Impact factor** considers the cumulative global warming from an instantaneous injection of 1 kg of each gas today, relative to an equivalent injection of carbon dioxide. The cumulative contribution through the next 500 years is considered. These figures represent the best understanding currently being discussed by the Intergovernmental Panel on Climate Change (IPCC).
2. **Carbon dioxide equivalent** refers to an estimate of the mass of carbon dioxide that would need to be emitted to have the same warming potential as the current New Zealand annual emission of each listed greenhouse gas. For example, the 1000 tonnes of CFC-12 emitted has the same cumulative greenhouse effect as 4,500,000 tonnes of CO2.
3. **The data in Table 1** contain uncertainties about emissions and relative greenhouse warmings. Further research will within the next few years refine the values.

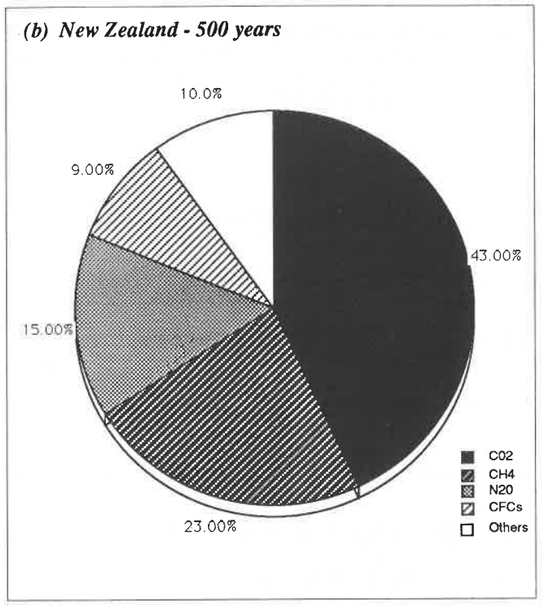
The percentage contributions for long-term warming shown in Table 1 are also represented in Figure 1, alongside the percentage contributions for short-term warming (the cumulative effect through the next 20 years). Global charts are included for comparison.

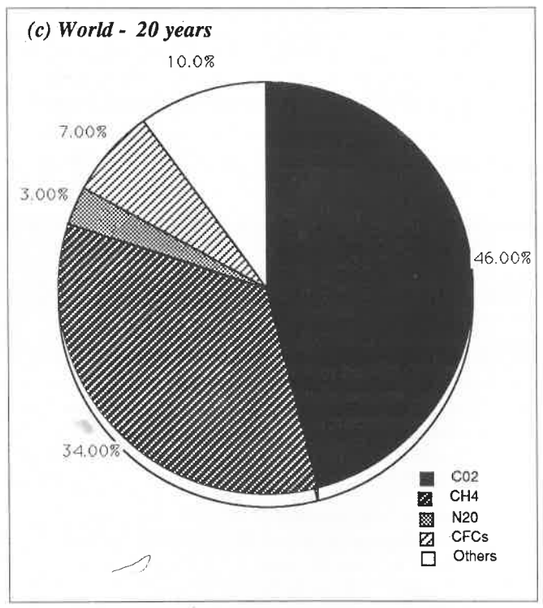
Figure 1 illustrates how the contributions to global warming of the different gases change over time. The charts show the cumulative warming effect of the 1990 emissions of each of the gases, calculated for 20 years and 500 years in the future. Gases that have a relatively short atmospheric lifetime (e.g. methane) have a more significant contribution in the short term, compared with gases that have a longer atmospheric lifetime (e.g. carbon dioxide).

Government policy responses will need to take both the short- and long-term warming potential into account.

The Intergovernmental Panel on Climate Change (IPCC) have







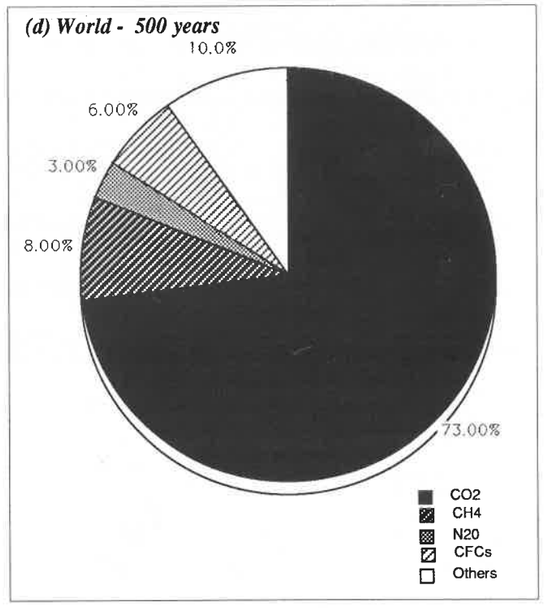


Figure 1: *The net cumulative warming effect of each of the major greenhouse gases released in 1990, calculated over (a) 20 years and (b) 500 years, for New Zealand's contribution; and for the combined international contribution over (c) 20 years and (d) 500 years. The calculations used for these diagrams are based on figures produced by the Intergovernmental Panel on Climate Change to indicate trends in greenhouse warming potential.*

been examining the necessary reductions in amounts of human caused emissions necessary to stabilise concentrations of the gases at present-day levels. Their draft findings are:

Carbon dioxide	60-80%
Methane	15-20%
Nitrous oxide	70-80%
CFC-11	70-75%
CFC-12	75-85%
HCFC-22	40-50%

1.3 Impacts of Climate Change

The possible impacts of climatic change on New Zealand are discussed in a companion to this discussion document entitled "Climatic Change: A Review of Impacts on New Zealand", which summarises a fuller report "Climatic Change: Impacts on New Zealand - Implications for the Environment, Economy and Society". Both reports were prepared by the Impacts Working Group.

The Impacts Working Group used two scenarios of possible future climates for New Zealand in the year 2050 to explore the likely consequences or impacts. The scenarios were based on the Facts Group's initial (1988) "best guesses". They are not predictions of the future state of the atmosphere and the climate of earth, but a description of two future states selected from a number of possibilities. The level of scientific uncertainty remains high, hence the suggested impacts indicate not what will happen but what could happen if the scenario of plausible climatic conditions eventuates.

By the year 2030, it is estimated that concentrations of greenhouse gases will have reached the equivalent of a doubling of the carbon dioxide levels that existed before the industrial revolution. The climate would take a further two decades beyond 2030 to adjust to the change in atmospheric composition, and the date of 2050 was chosen to reflect that time lag. The date is arbitrary, particularly as the composition of atmospheric trace gases is likely to continue to alter after 2030.

The postulated climatic changes, brought on by greenhouse warming, would proceed at rates greater than experienced under natural conditions. The nature and rate of change, rather than change itself, would have the greatest impacts on the land and people.

The impacts would depend on the characteristic life cycle or time scale of a particular aspect of the environment or society. Many areas of society would be able to respond successfully to the magnitude and rate of climate change described in the scenarios. Their adjustments would not be without cost but might be imperceptible and could be achieved through the normal course of technological and social change. The greatest uncertainty is the possibility of changes in the frequency or severity of "extreme events", such as floods and droughts. If climate change resulted in a real or perceived increase in such events, then any impacts on society and the economy could be disproportionately great.

Particular areas where the impacts would be noticeable and severe are the public estate and Maori lands - the coastline, natural resources, and native plants, animals, and ecosystems. Particular sectors of the population which would suffer most would be those which are already socially and economically vulnerable.

Carbon Dioxide

Concentrations of carbon dioxide in the atmosphere have been steadily increasing over the last 200 years. The pre-industrial level of carbon dioxide is estimated to have been 270 ppm compared to the present day level of 350 ppm. This is expected to rise to 450 ppm by the year 2030, although some researchers are suggesting such a level could be reached much earlier. Most of the increase is due to the combustion of fossil fuels (oil, gas, and coal), which has risen with the advance of industrialisation. The burning of large tracts of forest to clear land for development is also responsible for a significant amount of carbon dioxide entering the atmosphere.

Not all the carbon dioxide which is produced stays in the atmosphere. Natural ecosystems, particularly the oceans, are able to absorb approximately 50 percent of the excess carbon dioxide which is produced by human activities. It is the other 50 percent which remains in the atmosphere that is causing concern.

New Zealand's production of carbon dioxide is set out in Table 2.

Table 2: New Zealand's Production of Carbon Dioxide: 1989

Carbon dioxide source	Carbon dioxide per year (million tonnes)	Equivalent carbon per year (million tonnes)
Liquid fuels, oil	10.45	2.85
Electricity production	3.63	0.99
Natural Gas	2.86	0.78
Synfuel	2.23	0.61
Coal and lignite	4.03	1.10
Wood fuels*	1.76	0.48
Lime production (g)	0.55	0.15
Cement production (g)	0.55	0.15
Aluminium production (g)	0.37	0.10
Steel production (h)	1.24	0.33
Landfill gas (f)	0.55	0.15
LPG	0.37	0.10
Total	26.28	7.16

*** Wood fuels and landfill gas are not included in the Table 2 total as they represent carbon recently removed from the atmosphere.**

Data in Table 2 are from reference source (a), except as noted by other alphabetical references shown in parentheses.

To give a broader picture, Table 3 shows the carbon dioxide emission rate per unit of energy; and Table 4 is a breakdown of carbon dioxide emissions from the energy sector.

Table 3: Carbon Equivalent Emission Rates from Consumer Energy in New Zealand

Energy source	Carbon dioxide emission rate (kilograms of carbon per gigajoule of energy)
Natural gas (reticulated)	15.0
Oil products (average)	19.0
Coal	25.4
Electricity:	
Natural gas	14.8
Coal	25.5
Oil	19.0
LPG (includes flaring)	18.6
CNG (includes compressor energy)	15.2
Petrol	18.3
Synthetic petrol	31.2

Data in Table 3 are from reference source (a).

Table 4: Carbon Dioxide Emissions from the Energy Sector in New Zealand

Sector	Solid fuels	Liquid fuels	Gas	Total
	(million tonnes of carbon per year)			
Electricity generation	0.17	0.01	0.88	1.06
Industrial	1.13	0.39	0.57	2.09
Commercial	0.08	0.16	0.12	0.35
Domestic	0.26	<0.01	0.07	0.34
Transport	<0.01	2.63	0.07	2.70
Petrol production			0.35	0.35
Methanol production			0.13	0.13
Total	1.64	3.19	2.19	7.02

Data in Table 4 are from reference source (e).

To put New Zealand's production of carbon dioxide in the global context, Table 5 lists, in 1986 figures, the carbon dioxide emissions of selected countries. It should be emphasised that, although New Zealand ranks 62nd for total emissions of carbon dioxide, not much higher than the global average, this position changes to 40th in the world on a per capita basis, which places New Zealand in the industrialised group of nations.

Table 5: Carbon Dioxide Emissions of Selected Countries: 1986

Country	Total carbon dioxide emissions (million tonnes carbon per year)	Per capita carbon dioxide emissions (tonnes carbon per year)	Rank total	Rank per capita
USA	1201.62	5.01	1	5
USSR	1010.80	3.59	2	13
China	554.35	0.53	3	73
Japan	256.08	2.11	4	28
West Germany	186.27	3.07	5	17
UK	166.20	2.94	6	19
India	144.33	0.19	7	95
Poland	124.48	3.32	8	16
Canada	105.20	4.09	9	9
France	98.36	1.79	10	35
Australia	61.26	3.85	16	11
NZ	5.45	1.63	62	40
World	5510.82	1.14		

Data in Table 5 are from reference source (d), as cited by reference source (b).

Methane

Present concentrations of methane are about 1.7 ppm and are increasing at about 0.9% per year. Previously, methane concentrations had remained roughly constant, at 0.6 ppm, from the time of the last ice age up to the 18th century. The amount of methane in the atmosphere is growing steadily, at about 1% per year. The level is expected to rise to 2.3 ppm by 2030.

Methane is produced naturally by the breakdown of vegetation in processes where the supply of oxygen is limited - rotting, digestion, and burning. The principal sources of atmospheric methane are thought to be enteric fermentation in ruminant animals, release by rotting vegetation in rice paddies, and biomass burning. Lesser amounts are released during the mining of coal or the extraction of other fossil fuels, and by the natural processes in wetlands. New Zealand's production of methane in 1989 is set out in Table 6.

It should be noted that there are large uncertainties in the figures in Table 6 quoted for methane production. At this point, it would be more accurate to represent the emissions as ranging between 1.2 and 2.0 million tonnes methane per year (0.9 and 1.5 million tonnes carbon per year).

Table 6: New Zealand's Production of Methane (1989): By Source

Source	Methane production per year (million tonnes)	Equivalent carbon per year (million tonnes)
Livestock	1.2	0.9
Landfill gas	0.3	0.2
Natural gas and oil	0.01	0.01
Coal mines	0.01	0.01
Wetlands	0.08	0.06
Fossil fuel burning	negligible	negligible
Biomass burning	negligible	negligible
Total	1.6	1.2

Data in Table 6 are from reference (c).

Table 7: Estimated Annual Production of Nitrous Oxide

(The figures quoted for gas exclude methanol production, synfuels and petralgas)

		Nitrous oxide production (tonnes per year)
ENERGY SECTOR (e)		
Coal		
Electricity	100)	260
Industrial	110)	
Commercial	30)	
Domestic	20)	
Oil		
Refining	10)	250
Diesel	200)	
Petrol	40)	
Gas		
Electricity	430)	690
Industrial	220)	
Commercial	10)	
Transport.	30)	
Wood		
Wood-fired boilers		130
Energy Total		1330
AGRICULTURAL SECTOR (h)		44,000
COMBINED TOTAL		45,330

Data in Table 7 are from reference sources (e) and (h), as indicated.

Nitrous Oxide

Nitrous oxide is produced naturally by microbial production in soils and oceans. Pre-industrial levels are estimated to have been 0.285 ppm. This is rising at about 0.2% per year, the increase caused by the combustion of fossil fuels and the application of nitrogenous fertilisers, and other pasture management techniques. By the year 2030 the concentration is estimated to be in the range of 0.350 to 0.450 ppm. In New Zealand in particular livestock and pasture management practices are thought to make a major contribution to nitrous oxide output. New Zealand's annual production of nitrous oxide is set out in Table 7.

It should be noted that the figures in Table 7 are estimates, and that there is considerable uncertainty in the agricultural sector contribution. Some researchers in this field suggest that this figure should be about four times higher, whereas others are suggesting that a much lower figure is more likely.

CFCs

CFCs (chlorofluorocarbons) are well known for the effect they have on stratospheric ozone. CFCs are also very effective greenhouse gases and, together with halons, are estimated to make a 10 percent contribution to overall global warming (see Figure 2). CFCs are used for a wide variety of purposes such as in refrigeration and air conditioning, expanding foams, cleaning electronic components and metals, and as aerosol propellants. CFCs were first developed in the 1920s and do not occur naturally in the environment.

The Montreal Protocol, which calls for a 50 percent reduction in the use of CFCs by the year 2000, has been ratified by about 50 countries. The Ozone Layer Protection Bill, currently before the New Zealand Parliament, goes much further than the Montreal Protocol. It is intended virtually to phase out CFC and halon use by the year 2000, as illustrated in Figure 2.

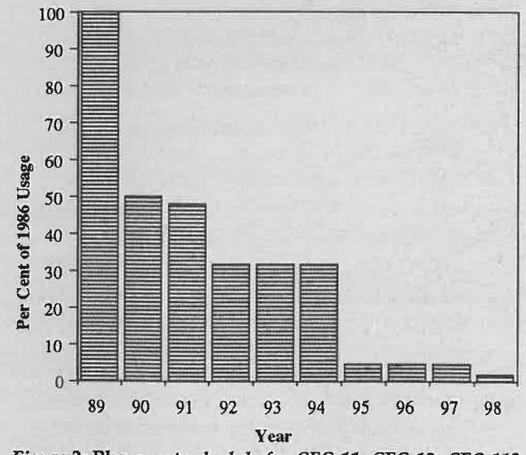


Figure 2: Phase-out schedule for CFC-11, CFC-12, CFC-113, CFC-114, CFC-115, halon 1211, halon 1301, and halon 2401. The usage is estimated to be equicalent to or slightly higher than that for 1986.

This discussion document does not include any policy options for CFCs as it is considered that these are covered adequately by the measures already proposed in the legislation.

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(a) Eden Resources, 1990. The greenhouse issues of natural gas use in New Zealand. Report to the Gas Association of New Zealand. Eden Resources, Wellington, February 1990.

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(e) Ministry of Energy

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(h) Ministry for the Environment calculation.

2. Framework for Policy Development

2.1 Principles

Change in the world's climate has both a domestic and an international context, because the consequent impacts may be distant in both place and time from the causes. Put more simply, we're all on the same planet. Any policies to counter the problems must therefore have reference to wide political and social frameworks here in New Zealand and worldwide. Differing cultural perspectives on what is happening to our environment, the need to ensure that the costs of climatic changes will not be borne by those who can least afford them, and responsibilities under the Treaty of Waitangi are all relevant.

To guide the preparation of this document and provide a framework for advice to Government ministers, the Policy Working Group agreed to a set of principles (see below).

Guiding Principles for New Zealand Climate Change Programme

Global context

- The atmosphere and other environmental resources are vital to all life.
- Policy should recognise that human-induced climate change may occur in addition to the long-term and short-term fluctuations in climate caused by natural processes.
- The potential effects of climate change constitute a global problem, and New Zealand is part of the global physical and biological system. Causes, consequences, and appropriate responses should be considered in the context of these global systems and recognise that the impacts of actions may be distant from these actions.
- The South Pacific region is particularly vulnerable to the impacts of climate change. When New Zealand policy responses are considered in their global context, particular attention should be paid to the relevance of this policy to the South Pacific. Policy development should reflect our obligations to share information. In addition policy options that are easily transferable to the South Pacific should be encouraged.
- National strategies and temporary responses to the problem should be compatible with global responses while at the same time reflecting New Zealand's international responsibilities and unique situation with regard to location, climate, natural environment, economy, and society.

Long term

- Policy should recognise that climatic change is ongoing. Although scenarios of potential impacts have been developed there is no expectation of reaching a state of equilibrium by 2030 or 2050 unless action is taken to limit greenhouse gas emissions. Even if limitations occur, lags in past emissions may result in further climate change.
- Any actions undertaken in the present will have consequences far into the future. In evaluating policy response options, substantial weighting should be given to the long term.
- Any development should be sustainable in the long term - that is, it should recognise that continuing development is required to meet the needs of present generations but should not compromise the ability of future generations to meet their needs as far as these can reasonably be anticipated.

Treaty of Waitangi

- Policy must not conflict with or compromise the Treaty of Waitangi.
- Policy should ensure the continued protection of Maori physical, cultural, and spiritual needs as guaranteed by the Treaty of Waitangi.

Social equity and values

- Policy should attempt to promote social equity and ensure that it does not create or exacerbate social inequalities.
- Policy should ensure the continued protection of all people's social, physical, cultural, and spiritual needs.

Participation of all people

- Central and local government, organisations and enterprises, and every person should treat climate change as a priority issue and play their part in addressing the problem.
- The process of policy development should encourage participation by all people. Public debate should be an integral part of policy formulation, and the form of consultation used should be culturally appropriate, so that full participation is possible.
- Public information should be provided to enable every person to participate equitably in responses to the problem. Information and education campaigns should be culturally sensitive to ensure that all the diverse ethnic groups represented in New Zealand are able to participate.
- Policies should welcome and encourage non-governmental responses to the issue, including re-

sponses from industry and voluntary, professional, or Maori groups.

Policy outputs

- **Policies should primarily stress and actively promote the limitation or reduction of greenhouse gas sources and encourage the enhancement of sinks for these gases. Policies should also limit the emission of other materials that have the potential to modify climate.**
- **Policies should also promote appropriate adaptations to anticipated impacts.**
- **Policy options should be flexible in recognition of the uncertainties associated with climate change and should include the possibility of some temperature cooling as well as warming.**
- **The biological, physical, social, economic, cultural, and institutional implications of policy options should be examined as the policy is developed.**
- **Policies should take into consideration the broad range of national concerns and interests, including economic growth, international competitiveness, quality of life, and Maori cultural and spiritual values.**
- **Policy options should promote the efficient use of resources.**
- **Policy options with other benefits besides adapting to or limiting climate change should be promoted where possible, and the other benefits should be promoted alongside their contribution to the climate problem.**

2.2 Treaty of Waitangi

Te Tiriti-O-Waitangi guaranteed tino rangatiratanga to the chiefs and hapu of Aotearoa over their physical and cultural resources. In addition to reference to the Treaty in the principles that were established to guide the Policy Working Group, there were also the terms of reference for the New Zealand Climate Change Programme's Maori Working Group, which included the following statement in regard to Te Tiriti-O-Waitangi:

> "To ensure that any response to the ramifications of climate change are in accord with the obligations of the Treaty of Waitangi".

Under Te Tiriti, the Maori retain rangatiratanga over their lands, forests, fisheries, and other taonga. It follows from this that the Crown must provide for appropriate Maori participation in the development and implementation of Government policy such as that relating to the New Zealand Climate Change Programme. Appropriate Maori participation means participation on terms acceptable to both parties to the Treaty.

In the context of the Treaty, the setting up of the Maori Working Group and its role in policy development must be seen as a *first step* along the way to meaningful direct consultation with tangata whenua. The Maori Working Group, which to date has been the main source of providing a Maori perspective, makes no claim to speak for Maori. The group also acknowledges that time constraints on the process of developing options for action have meant that it was not possible to have hapu and iwi input before the publication of this present document.

The importance of ensuring cultural balance in the programme cannot be overemphasised. The Treaty of Waitangi represents an undertaking to recognise and accept traditional forms of Maori knowledge. Such knowledge, combined with Western science, will extend the information base on climate change. The Maori view of the environment - and thus their view on what steps should be taken in response to Climate Change Programme information - is ecocentric, culturally and spiritually integrated, and holistic. This standpoint gives rise to different perspectives and different priorities, all deriving from a distinct "view of the universe" - expressed in part through the Maori cultural concept of kaitiaki (guardianship). Recognising and providing for the body of Maori knowledge should therefore be a priority. (See "Taonga Tuku Iho", *in* "Climatic Change: Impacts on New Zealand", page 4.)

Throughout the process of the New Zealand Climate Change Programme so far, recognition of Te Tiriti-O-Waitangi has been paramount, and will continue to be so. One possible way of ensuring appropriate Maori input may be to create and supply resources for "response groups" within hapu and iwi, which would assess information on impacts and provide a spiritual and cultural dimension, as well as an appropriate expression of rangatiratanga.

2.3 International Response to Climate Change

Climate change is a worldwide problem and therefore requires a response from the entire international community. To be successful, any international response or responses will require the negotiation and acceptance by all nations of agreements dealing with difficult and politically contentious issues such as energy, development, finance, and population. Such negotiation and agreement will almost certainly be the most complex and ambitious ever undertaken. Attitudes and assumptions long held to be unchallengeable will be challenged, not least in the process of establishing new global institutiuons with wide-ranging powers.

As a matter of course, New Zealand will be devoting more and more attention to the international aspects of the climate change problem, including:

- participation in the negotiation of a Convention on Climate Change which is likely to result from the consideration of the IPCC report by the 45th United Nations General Assembly in October 1990, together with recommendations from the Second World Climate Conference, to be held in Geneva in November 1990;
- further participation in Montreal Protocol negotiations on limiting ozone-depleting substances;
- continued participation in the ongoing scientific and technical work within the IPCC and through the International Geosphere-Biosphere Programme (IGBP).

For New Zealand, there is a further international dimension. Although the impacts of climate change on New Zealand itself may be significant, it is clear that many of our island neighbours in the Pacific stand to suffer much greater consequences. Given the small land area of many of these islands and their vulnerability to destructive tropical cyclones, the effects of climate change could be devastating.

At meetings of the South Pacific Forum and the Intergovernmental Panel on Climate Change, New Zealand and Australia have emphasised the concerns of the South Pacific island countries over the likely impacts of climate change. As the process of international negotiation relating to emissions of greenhouse gases intensifies, it will be increasingly difficult for the South Pacific island countries, with their limited resources, to participate. They will consequently be looking to New Zealand for increased support and assistance.

The New Zealand Climate Change Programme recognises the value of traditional Maori forms of knowledge of the environment. This has implications for a Maori role in the international response to climate change. The Maori, as tangata whenua, have particular links with the rest of Polynesia, for example, and may therefore have an important role in climate change initiatives in the South Pacific and elsewhere, including liaison and attending international meetings.

It is already clear that a major feature of forthcoming international negotiations on the reduction of greenhouse gas emissions will be the differing standpoints of the developing countries and the developed countries. The developing countries fear that controls on emission will preclude their aspirations to "advance" their levels of development and will "lock in" forever the existing disparities in global wealth. The developed world, on the other hand, is concerned to ensure that any economic interventions that may prove necessary to counter the problems do not cripple international trade and economic growth.

New Zealand, as a small developed country, has a tradition in international negotiations of being able to assist in bridge building between the rich and poor nations. There is often a risk that the trade and economic interests of the smaller developed countries could be jeopardised. We therefore have our own economic future on the table as much as any other country participating in the negotiating process.

2.4 Why New Zealand Must Respond to Climate Change

Immediate attention must be given to limiting the build-up of greenhouse gases. The longer the delay, the greater will be the concentration of greenhouse gases in the atmosphere, and the greater the potential for climate change. We can't afford to wait for all the scientific arguments to be resolved before taking steps to resolve the problems.

Many nations are already examining the issue and considering responses. The Netherlands, for example, has set targets for stabilising emissions at 1989 levels. Other countries are aiming for percentage reductions in emissions - Denmark, for example, is aiming for a 20% reduction in emissions by 2005. Through the Australia and New Zealand Environment Council (ANZEC), the environment ministers of Australia and New Zealand have agreed to investigate ways of achieving limitations on emissions of greenhouse gases - looking at targets of up to 40% of the 1988 levels of emission, as well as considering what the impacts of implementing such targets might be.

Changes made in New Zealand to limit the build-up of greenhouse gases will however lead to only a small reduction when considered in a worldwide context. All countries must therefore act responsibly, and soon, if the problem is to be tackled effectively. Although this country's emissions are not as high on a per capita basis as those of some industrialised countries, they are above the international per capita average. In addition, many of our practices are not as efficient as they might be. There are no grounds for complacency.

The historical contribution of many developed countries to greenhouse gas build-up has been through their industrial processes. New Zealand's contribution over the last 200 years has been principally through its activities in deforestation, along with its use of fossil fuels and an increase in its agriculture. Together, these activities have brought considerable benefits to society, but the practices in these areas now need to be re-examined with respect to greenhouse gas emissions. For instance, much of New Zealand's forest has been burnt or felled and, although through current forestry activities the country may currently be a net absorber of carbon dioxide, the overall effect has been the loss of long-term stored carbon from forests to the atmosphere.

There are many potential efficiency improvements relating to fossil fuels and agricultural practices that would have considerable benefits besides reducing greenhouse gas emissions. For example, increased energy efficiency would help to reduce global emissions of greenhouse gases and also cut fuel use and consequently operating costs.

Policy responses that have climate change benefits and other benefits could ensure that costs are minimised, whatever the actual climate change outcome, thus keeping New Zealand's options open at this stage. For example, whether or not climate change occurs as suggested, there will be benefits to New Zealand from policies that encourage wise use of energy resources and environmentally sound management of water and soil resources.

New Zealand, despite being a small country, can make a contribution to international action on this issue by setting an example through its development of a policy to cut back emissions in a responsible manner. Our effectiveness in encouraging other nations to limit their emissions is likely to depend on the example we set by our own actions.

It is clear that the Government's first consideration of climate change policy will not be the end of the response process. There will be a continuing need to review and respond as new information becomes available. New Zealand's response is likely to be part of a global initiative, and there will be many years of further work examining climate change, its impacts, and possible responses before a sustainable global ecosystem can be achieved.

Submissions on future work and where and how it might be organised would be welcomed.

2.5 Types of Policy Response

Climate change can be responded to in two ways - by limiting the build-up of greenhouse gases, and by adapting to the effects of the build-up.

Limitation responses are directed at the causes of global climate change and include measures to reduce the build-up of greenhouse gases. The goal would be to reverse the trend in gas build-up, reduce the rate of atmospheric warming, and possibly stabilise temperatures at some time in the future. Such preventive measures would include options for both the reduction of emissions of greenhouse gases and also an increase in "sinks" or natural stores for these gases.

Adaptive responses would be directed at the possible consequences of global climate change and would include measures to anticipate and deal with the effects of greenhouse warming. The goal would be to ensure climatic impacts had minimum consequences.

The two approaches to making responses, although discussed separately in sections 3 and 4 of this document, will both be necessary.

Figure 3 illustrates the relationship between the types of policy response and climate change.

Many adaptations will take place without deliberate policy initiatives, simply because people will have to cope with any impacts that occur. It is in people's immediate interest to do so, as they will be directly affected. On the other hand, those who are responsible for generating greenhouse gases are often not directly affected by those actions and are less likely to act independently to limit gas build-up. Although it may be in the public and global interest to reduce greenhouse gases, it is often of little apparent benefit to the individual producer of the gases.

Policies for reducing emissions of greenhouse gases could appropriately be initiated by central government or as part of international agreements. Adaptive responses, however, are most likely to be initiated locally - by local government, companies, iwi, or individuals.

If New Zealand is to respond effectively to climate change, both the short- term and long-term implications will need to be addressed. As indicated in section 1.2, the relative significance of methane and carbon dioxide as a cause of the problem varies with time. In addition, both the limitation of greenhouse gases and the necessary adaptation to their effects will be required. Consequently, a basket of options is needed, dealing with limitation and adaptation, in both the short and long term. Such options are described in sections 3, 4, and 5.

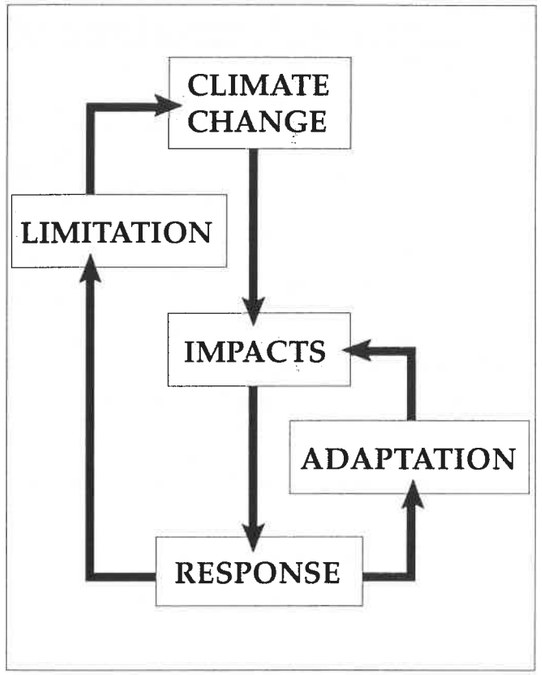

Figure 3: *The relationship between types of policy response and climate change.*

3. Limiting Emissions of Greenhouse Gases

This part of the publication identifies a wide range of policy options for reducing greenhouse gas emissions and enhancing sinks or natural stores for greenhouse gases.

The options are not mutually exclusive, and should be considered together, with the aim of identifying the best basket of options that could give the greatest benefits in terms of greenhouse gas reduction, while at the same time giving such incidental yet highly desirable benefits as reducing energy use, fossil fuel use, pollution, and operating costs.

The possible ways of limiting greenhouse gas emissions are considered under three headings:

1. generic or broad policy options which could influence many sectors;
2. policy options in energy and transport;
3. policy options in agriculture, forestry, land use, and industry.

3.1 Limitation Options - Generic

Social and Behavioural Measures

1. Public education

There is general public interest in "green" behaviour, which needs to be capitalised on and maintained.

Public education could encourage people to take voluntary steps to limit greenhouse gas build-up. However, as some actions on the part of the public are likely to have greater effectiveness than others, it will be essential to ensure that any campaigns are well planned and well targeted. In addition, an important aspect will be sensitivity to cultural differences to ensure that all ethnic groups in New Zealand are able to participate.

The communication media suitable for an educational campaign include advertising, books and pamphlets, news coverage and features in the press, radio and television programmes, public meetings, community action programmes, and utilising networks developed for other purposes. The method will depend on the target audience and the money and staff available. Poor funding can result in an ineffective campaign.

At present no single institution has responsibility for environmental public education, and the work is undertaken by a number of agencies, including non-government organisations, local authorities, the Ministry for the Environment, and the Department of Conservation. If a public education policy were to be adopted there would be a need for an identified coordinator.

Public education would assist the implementation of other strategies adopted to limit greenhouse gas emissions. There would also be a spin-off for the adaptive responses discussed in section 4, as people would be better informed and better able to make rational choices in response to impacts. There are other benefits in the public being informed about environmental issues and the relationship between these issues and their own behaviour. Behaviour learnt in response to climate change and the limitation of greenhouse gases might also be applied when other environmental problems were identified.

Public education is more likely to receive widespread support if adopted in conjunction with other "harder" options.

Advantages of public education are that the campaigns are practical and could be implemented within a reasonable time. The main drawbacks are the cost of undertaking an effective programme and the need to establish a recognised institution with responsibility for assisting and co-ordinating campaigns.

2. School-based education

Education of children through the school curriculum could be expected to achieve similar outcomes to general public education campaigns. The goal would be to influence directly the behaviour of children, and indirectly that of their parents, leading them to adopt habits to assist in reducing the build-up of greenhouse gases. In this way there is potential to change the behaviour of the next generation of adults, and to reach a wide cross section of the community, as adults learn from their children. Although the effects of such behavioural changes on global climate change are hard to quantify, they could be similar to those of a a public education programme, but might take longer to have an impact.

As with campaigns targeting the general public, there would be spin-off benefits.

The practicality of school-based education will depend entirely on how easily it fits into existing educational programmes. There are a number of areas throughout the curriculum where this could occur - for example in science, social studies, geography, horticulture, and economics. The costs would be in the production of materials and in staff and teacher training.

3. Green consumerism

In the last few years there has been a steady rise in green consumerism. People in many developed countries have been interested in purchasing goods that do not cause environmental harm, and governments have shown a readiness to encourage this. New Zealand is investigating ways of labelling goods to indicate their "friendliness" to the environment.

This approach would contribute to limiting greenhouse gas emissions through a voluntary market response to labelling. Success here would depend on: the amount of choice consumers had in relation to products; how easily consumers understood "greenhouse friendliness"; availability of alternatives to "unfriendly" goods; the relative costs of alternatives; and how widely the strategy was adopted.

Green consumerism could both influence consumer behaviour and also send strong signals to industry. Quick implementation is feasible and the impact could be swift.

An additional benefit would be heightened public awareness of the contribution of everyday products to the causes of global climate change. Such awareness helps to drive home the interdependence of society, the economy, and the environment. There would be opportunities for companies to increase sales of greenhouse friendly goods, and possibly even capitalise on export markets with a "clean green New Zealand" image.

The main costs of this option are in running a scheme to set standards for and monitor environmentally friendly labelling. There could be price rises to consumers if the costs of the scheme were passed on to purchasers.

Since green consumerism is an idea that already has wide public acceptance, this is a practical option which could be implemented relatively easily. It is unclear at present what

effect such a scheme would have on global climate change. It is an option that would probably work best as an incentive for other policy options to limit greenhouse gas build-up.

4. Community action

Community action is usually initiated by concerned citizens or through environmental groups. Such initiatives can however be assisted by provision of information or funding, whether government or private sponsorship, to enable community based groups to undertake campaigns. The support could be financial or could take the form of information, strategy advice, joint seminars, or regular meetings. The groups involved could be professional associations or community or environmental groups.

When grassroots groups and policy makers work together, they can avoid duplication of resources and avoid conflict between their groups.

There would be costs in time and money if assistance was provided to groups. There would also be the costs of potential conflict if the objectives between a sponsor and sponsored groups differed. Sponsors might feel that the community members wanted "to go too far". Another risk is that community action could concentrate on particular targets which had not been adopted as responses because their costs outweighed their benefits.

Community action could produce outcomes similar to those of green consumerism - with products or processes which aided greenhouse gas limitation being favoured over those that did not. Again it is extremely difficult to quantify the actual achievable reduction in gas concentration, although it is likely to be smaller than for the options 1, 2, and 3 above, unless the community action was widespread.

Planning Measures

5. National policy statements

The Resource Management Bill provides for the Minister for the Environment to issue national policy statements on matters of national significance that are relevant to achieving the purpose of the Bill. Regional policy statements would not be permitted to conflict with national policy statements - with regional and territorial authorities being required to state what action they proposed to take once a national policy statement was produced. National policy statements on global climate change might be an effective means of achieving desired outcomes. They could be issued progressively as policy was developed.

An initial national policy statement could state that the Government accepted the need for New Zealand to reduce its contribution to the build-up of greenhouse gases in the atmosphere. Performance standards could ensure no plans or consents under the Resource Management Act significantly increased the annual human-induced emissions by New Zealand of any particular greenhouse gas, or reduced net sinks for any such gas.

This type of national policy statement would ensure that decisions on the desirability of proposals with significant implications for the build-up of greenhouse gases in the atmosphere were made on the basis of national rather than regional considerations. The national policy statements would also complement other policies to limit emissions.

The major direct costs would be in the provision of central government resources that would be needed to develop, communicate, and implement the policy statements.

6. Call-ins under the Resource Management Bill

The Resource Management Bill makes provision in clause 121 for consent applications of national significance to be called in by central government. This allows for decisions by the Minister for the Environment within a national context. Where appropriate national policies were not yet in place, the call-in provisions could be used. The criteria for deciding to call in a particular proposal could be similar to those suggested for the national policy statements above.

The costs of using call-ins would be in central government resources and setting up a Board of Inquiry to advise the Minister, as provided for in the Resource Management Bill.

7. Regional policy statements

Regional councils could include in their regional policy statements the objective of limiting net greenhouse gas emissions. Councils could then both take action themselves to limit emissions directly and also take action to encourage others to limit emissions.

The councils could also identify specific actions to reflect many of the policy options discussed here.

The choice of how each region went about achieving the overall objective would lie with the region itself. Consistent with the philosophy of the Resource Management Bill, regions could take regionally appropriate initiatives.

The main costs associated with this option would be the regional government resources involved in implementing, communicating, and enforcing the relevant aspects of the policy statement or plan. The main benefits would be in the autonomy given to the different regions to develop policies appropriate to their needs.

8. Quantitative national targets

The Government could establish quantitative targets for the reduction of New Zealand's net contribution to the build-up of greenhouse gases. Such targets would provide goals for New Zealand and assist in implementing international agreements to which New Zealand might become a party.

A national policy statement under the Resource Management Bill might be the most appropriate means of setting such targets, so that regions took the targets into account and were not out of step with them. In particular it would ensure that greenhouse gases were taken into account when consents were granted and plans made under the Resource Management Bill.

Quantitative targets would be useful only for those greenhouse gases for which reasonably reliable figures on current emissions were known.

Financial, pricing, and other market measures

9. Placing charges on greenhouse gas emissions or sources of greenhouse gas emissions

Government could place charges either on emissions, or on the use of sources of greenhouse gases. Each emitter would pay charges related to the level of emission or the level of use of the source material. In the latter case, a specific instance would be a charge based on the carbon content of fossil fuels.

Charges on greenhouse gas emissions would increase the costs to emitters. Depending on the degree to which these costs were passed on to final consumers, the charges would increase the price to consumers of goods and services involving the emission of greenhouse gases, or reduce the profitability of the producer. In either instance, they would provide incentives to reduce emissions of greenhouse gases.

Experience with other charges indicates that although a small cost increase may produce the desired response in the short term, it ceases to be effective relatively quickly. This suggests that such charges would have to be large. They could start off at a modest level and be progressively increased over a number of years. Charges on their own, without accompanying regulatory controls, are likely to be an unreliable means of for limiting emissions to specific levels.

Practical considerations limit the applicability of charges on emissions to sources where:

- a reasonable estimate can be made of the level of emissions;
- there is some certainty about what the response to the charge will be;
- the cost of collecting the charge is not too high.

Areas where such charges might be applied are:

- industrial plants;
- waste disposal in landfills;
- vehicles (in association with warrant of fitness testing);
- forestry harvesting operations.

Practical considerations would also limit the applicability of charges on the use of source material to specific categories such as fossil fuels, nitrogenous fertilisers, and bulk imports of CFCs.

Apart from their benefits in terms of reducing greenhouse gas emissions, charges on fossil fuels or emissions from burning fossil fuels would provide an incentive for increased efficiency in fossil fuel usage, for the substitution of other fuels for fossil fuels, and for the further development of energy sources other than fossil fuels. To the extent that charges resulted in increased energy prices, they would provide an incentive for increased energy efficiency and energy conservation.

Charges of this nature are consistent with the "polluter pays principle". Some people oppose such charges on the grounds that they legitimise pollution, with firms and consumers buying the right to pollute. In fact, charges are no different in this respect from regulations: both legitimise a limited amount of pollution.

One of the greatest benefits of charges is that, relative to subsidies or regulation, they reduce the economic cost of pollution control because they encourage the abatement of pollution to be carried out by those who can do it at least cost.

The significant amount of revenue that these charges would raise could be used for:

- funding subsidies for additional expenditure to reduce emissions (option 10 below);
- the creation of sinks for greenhouse gases (option 12 below);
- funding for regional action (option 7 above);
- providing compensation for those adversely affected by climate change;
- funding contributions that New Zealand might make to international funds set up to deal with international aspects of the greenhouse effect. The Government has accepted in principle (in the Hague Declaration) that countries which will bear unreasonable burden in adjusting to measures necessary to protect the atmosphere should receive reasonable compensation;
- unrelated purposes, including the reduction of other taxes.

Whether and to what extent such charges would adversely affect the Government's economic and social objectives, including growth and employment, would depend in large part on:

- the level of charges;
- how rapidly they were introduced;
- the extent to which they were borne by consumers or producers;
- what the revenue was used for.

A potential drawback is that unilateral introduction of charges by New Zealand could reduce our international competitiveness. The charges would be less likely to cause disruption to our international trade if they were introduced within the context of an internationally agreed system. Work is under way internationally, in fora such as the IPCC and the OECD, examining the use of charges as a means of limiting the build-up of greenhouse gases.

Administering a system of charges on emissions would probably cost a substantial amount because of the amount of measurement and monitoring required. Administering a system of charges on source materials would be less costly.

Research is required into the level of charge necessary to be effective, the likely effects of such charges on the economy, and complementary policies that would lessen any undesirable effects. For charges on sources of greenhouse gases, research is needed on the relative advantages and disadvantages of collecting the charges from producers or consumers.

As some sources of greenhouse gas emissions are in Maori ownership (coal) and others are currently subject to claims to the Waitangi Tribunal (oil and gas), appropriate consultation should take place with tangata whenua.

Charges on fossil fuels are in place or being seriously considered in a number of developed countries, but mainly for revenue-generating purposes.

10. Subsidies for additional expenditure that reduces emissions

Subsidies could be used as incentives to encourage emitters to reduce their emissions. Payments would be made available to assist emitters meet the costs of taking specified actions that would reduce their emissions.

Effective subsidies are likely to require significant government funding, both for administration and for the incentives themselves. However subsidies could be funded from charges or taxes such as those outlined in option 9 above, thereby eliminating the direct costs to government.

It is often difficult to target subsidies efficiently so that they are paid only when they are needed. Subsidies that are introduced without specifying that they are for a limited period only are often difficult to eliminate.

11. Tradeable emission permits

Under a system of "tradeable" emission permits, permits to emit specified amounts of greenhouse gases over a specified time would be issued by the Government, an appropriate international body, or both. One of the requirements for carrying on certain activities would be that sufficient permits would have to be held to cover the emissions produced. The permits would be able to be bought and sold. Ideally, the permits would be denominated in GWP (greenhouse warming potential) units, so that they could be used by any activity that required them.

With tradeable emission permits, emissions of greenhouse gases from those areas in which permits were required could be limited to any predetermined level. Mechanisms would be provided whereby the issuing authority would be able to increase or decrease the total GWP value of the permits in the market in accordance with the desired level of emissions.

Such a system would enable New Zealand to limit its emissions to the desired level, without the Government's having to make many judgements about which particular enterprises or people should be able to emit how much greenhouse gas. It would initially be necessary to allocate enough permits to ensure the short-term continuation of present levels of economic activity, with the reduction in permits being phased-in to allow reasonable time for changes in practices and technology.

The ideal would be for every country to have a national system operating within a global system. In this way, global emissions of greenhouse gases could be limited to whatever level the international community agreed was compatible with sustainability.

Practical considerations limit the applicability of tradeable permits for emissions to sources where a reasonable estimate can be made of the level of emissions. Areas in which they might be applied are:

- industrial plants;
- waste disposal in landfills;
- vehicles (in association with warrant of fitness testing);
- importation of bulk CFCs;
- forestry operations.

The permits could also possibly be applied to the mining and importation of fossil fuels and to the manufacture or importation of nitrogenous fertilisers.

An important associated issue is how, and to whom, the permits should initially be given or sold. One possibility would be for the Government to sell them, in which case a benefit to the Government would be a significant amount of revenue. Such revenue could be put to the same sort of uses as outlined in option 9, dealing with charges.

To the extent that the permits applied to emissions of carbon dioxide from the burning of fossil fuels, the permit system would also provide an incentive for increased energy efficiency and energy conservation, and for the further development of renewable energy sources.

A system of tradeable permits is consistent with the polluter-pays principle.

A major benefit of tradeable permits in comparison with regulation or subsidies would be a reduction in the economic cost of pollution control, because the permits would encourage the reduction in emissions to be done by those who could do it at least cost.

Whether and to what extent such charges would adversely affect the Government's economic and social objectives (including growth and employment) would depend in large part on factors such as:

- the level of reduction in emissions required;
- how rapidly these reductions were to be achieved;
- whether or not the permits had to be bought initially;
- the nature of any controls over the proportion of the available permits that could be held by any one company or industry;
- the extent to which increased costs were borne by consumers or producers;
- what any revenue coming to the Government was used for.

Unilateral introduction of a system of tradeable permits by New Zealand could reduce our international competitiveness. Work is under way internationally, examining the use of tradeable permits to limit the build-up of greenhouse gases.

The costs of running the system once it was established could be less than for a system of charges on emissions, although it would involve similar costs for measurement, monitoring, and policing.

12. Expenditure/subsidies for creating sinks for greenhouse gases

Government could provide funding for the creation of additional sinks for greenhouse gases. The most obvious way of creating sinks is through afforestation.

Government could either create its own sinks or could assist other parties to create sinks. There are a number of issues relevant to these options: what form of control there should be over what can be done with a sink once it has been created; and whether funds available for creating sinks should also be available for compensating parties who do not destroy sinks.

In general, the advantages and disadvantages of subsidies for creation of sinks are similar to those noted under option 10.

As a way of increasing the efficiency of any funding for sink creation, Government could provide the funding to an appropriate organisation and, by requiring that organisation to seek competitive bids for sink creation work, ensure that the least-cost options were funded.

Legislative and Regulatory Measures

13. Limiting net emissions or net reductions in sinks by legislation

Legislation could be used as a policy instrument to achieve a reduction in emissions.

This option is rather cumbersome as a generic option. However some of the more specific options might be implemented through modifications to existing legislation.

The suggestion for energy efficiency legislation is discussed in more detail in option 65.

14. Limiting net emissions or net reductions of sinks by regulation

There are two approaches within this option. In some cases they may be complementary. The first is setting a standard such as a maximum for net carbon dioxide emissions per unit of useful energy generated in a power plant. The standard could be set by central, regional, or local government, using an appropriate mechanism under the Resource Management Bill. Similar minimum standards could be developed in other areas, for example methane emissions from landfills.

The other approach is the best practicable option (BPO). This would be applicable to sources of greenhouse gases requiring a resource consent under the Resource Management Bill. Under BPO, proposals are required to meet the highest possible environmental standards, given the current state of technology, other environmental and social impacts, and economic considerations. Proposals are treated case by case at the regional or local government level and are subject to any applicable minimum standards. A national policy statement on greenhouse gases would ensure that greenhouse gas reduction was included as a relevant factor under BPO.

With either the minimum standards approach or the BPO approach, the creation of additional sinks as part of the total proposal or policy could bring the net emissions or the net destruction of sinks to an acceptable level.

The cost to government (central, regional, and local) of this option would lie first in developing a practical system, and then in the ongoing assessment of proposals, monitoring, and enforcement. Depending on the level of the standards set and on the structure of the industries affected, there could be increased costs for producers or consumers.

The effectiveness of this option would depend on factors such as how widely it was applied, how much reduction in net greenhouse build-up could be achieved through BPO, and how well it was monitored and enforced.

15. Mandatory offsets for carbon dioxide

This policy option is a particular variant of the more general option of setting standards for greenhouse gas emissions. The standard set in this case is zero net emissions over a time period that includes the life of the plant or the activity.

Central, regional, or local government could require that policies or proposals that would increase New Zealand's human-induced emissions of carbon dioxide by more than some specified amount must undertake, as a condition of approval, to ensure that sinks were provided that would remove from the atmosphere the net addition of carbon dioxide attributable to the policy or project. A similar requirement could be placed on policies or proposals that reduced sinks for carbon dioxide by more than a specified percentage of New Zealand's human-induced emissions of carbon dioxide.

Afforestation is the most obvious potential offset, but it may not be easy to reach agreement on issues such as how much forest constitutes an acceptable offset for a tonne of carbon dioxide, or what can or cannot be done with the forest when it is mature.

As an alternative to actually creating the offset, the applicant might be permitted to make a payment, to an appropriate body, of an amount equivalent to the cost of creating the offset.

3.2 Limitation Options - Energy

Introduction

The generic options presented in section 3.1, such as education, regulatory approaches, economic measures, and planning tools, could be complementary to the specific energy options presented in this section.

In addition, energy options need to be considered alongside the agriculture and forestry options. Indeed, a "basket" of options could be the most appropriate strategy in order to achieve greenhouse gas reduction and stabilisation.

Many of the options in this section are concerned with reducing energy demand, for which considerable potential exists in New Zealand through efficiency measures that do not require a reduction in the level of energy services and do not involve untried or dangerous technologies. However, barriers exist to the uptake of cost-effective efficiency measures, for example:

- a lack of access to investment capital;
- a lack of specific easily obtained information for users;
- efficiency measures seem to be peripheral to the main interests of most consumers.

Furthermore, substantial national energy savings require a large number of small and disaggregated actions. Any attempt to increase energy efficiency within New Zealand should have regard to these considerations.

The following points are important with respect to reductions in energy demand and the effect of reduced energy demand on greenhouse gas emissions. In New Zealand, hydro produces approximately 80% of total electricity, which is generally the base load. Huntly thermal power station (able to use both gas and coal) also provides base load as well as peak load. However, thermal power stations generally provide peak load (between approximately 6 a.m. and 9 p.m.). Electricity at the margin is therefore about 95% thermal,* so a reduction in electricity use would reduce greenhouse gas emissions from power stations, as long as the saved energy was not used elsewhere. Saving hydro-electricity means that more "clean electricity" is available to meet new demand or to substitute for energy derived from fossil fuels.

A reduction in the direct use of coal, gas, and petroleum products would reduce greenhouse gas emissions. Inter-fossil fuel substitution could also reduce emissions, e.g. if gas (in the form of CNG) were used to replace petrol. Although reductions in emissions may be achieved through increases in efficiency or inter-fossil fuel substitution, it is important to remember that these reductions can be negated through increases in energy demand.

The objective of reducing *and stabilising* greenhouse emissions should therefore be kept in mind. For example, energy efficiency measures serve to reduce energy demand. They may not necessarily stabilise energy demand. If that is the case, how does New Zealand meet a slowly increasing energy demand without increasing emissions? Stabilisation of emissions requires consideration of long-term solutions.

Substituting renewable energy sources (e.g. solar energy and biogas) for fossil fuel is potentially a long-term option. Although energy from biomass still produces greenhouse gases, the fact that it is a renewable resource means that there is the potential to balance carbon dioxide emissions through the carbon sink (biomass) being continually renewed.

Finally, it should be noted that many of the suggestions in this section on energy may already be occurring to a certain degree. For example, the Energy Management Group within the Ministry of Commerce is already promoting energy efficiency in New Zealand. The group's varied activities include a Government Shared Savings Programme (promoting energy efficiency within Government), a Demonstration Programme, and dissemination of information through the publication "Energy Management News". Electricorp Marketing (a part of Electricorp NZ) also has an Energy Management Unit. Activities that are already occurring are included in this section of the publication because of the need to emphasise the importance of their continuation or because the activity in question needs to be given greater priority.

Energy Supply

16. Energy efficiency as a means of electricity supply

At present, there are various barriers to the uptake of energy efficiency as a means of supply. It is important to address barriers because increased energy efficiency could safeguard against unnecessary expansion of electricity supply in the future. This is an important consideration, as an additional thermal power station would increase New Zealand's green-

* Ministry of Energy, "Energy Issues 1986", Government Print, Wellington.

house gas emissions substantially. For instance, it has been estimated that a proposed 1000 MW power station at Bream Bay would increase New Zealand's carbon dioxide emissions by 30%.*

A major barrier to energy efficiency as a means of supply is the actual structure of the electricity industry, with two characteristics in particular creating the barrier: a monopoly over generation and dislocation between the generator and consumers.

A generation monopoly tends to result in a supply-driven market; for example, without competition, the cost of new supply can be easily passed down to the consumer. This allows the monopoly generator to build generation capacity ahead of demand, thus maintaining surplus capacity which helps the monopoly maintain its position in the market. Maintaining a monopoly therefore tends to counteract the use of energy efficiency as a means of supply. Another outcome of a supply-driven market in New Zealand is the "Fourth Tariff" option, which provides an incentive for distributors to keep expanding their sales as tariff concessions are given based on *growth* in electricity purchases.

Lack of direct commercial contact (dislocation) between the generator and consumer comes about because the generator sells electricity to the distributor, who then sells it to the consumer. In some countries, electricity companies are involved in innovative financial arrangements with customers in order to bring about energy management - it has even been known for companies to invest in energy saving equipment and instal it free on their customers' premises, because it is cheaper than building the next power station. In New Zealand, distributors have no incentive to do this because they do not save the high capital cost of the next power station, but only the averaged bulk tariff.

Restructuring the electricity industry into a number of vertically integrated companies (companies with interests in both distribution and generation) could provide a competitive structure which would help bring about investment in energy efficiency. The objective of the restructuring would be to ensure that there were direct links between generators and consumers; and that real competition existed, with supply responding to demand, rather than supply driving demand. Competition would also encourage the industry to investigate alternative means of supply. It would be necessary for the Commerce Commission to ensure that the companies did not gradually coalesce over time.

Energy efficiency as a means of supply could also be encouraged through legislation which sets parameters (e.g. requiring electricity producers or suppliers to act responsibly with regard to the greenhouse effect), or sets specific objectives (e.g. requiring a reduction in greenhouse gas emissions by X amount), or designates "tools" to be used by commercial generators or suppliers (e.g. the use of least-cost planning and life-cycle costing and the creation of tariff structures which would encourage investment in energy efficiency).

The major costs associated with investment in energy efficiency would be the initial capital costs. However, these should appear in a more favourable light when compared to the costs of new supply. An additional benefit of the option would be its contribution to the development of a market in energy efficiency in New Zealand. Research has shown that the development of such a market would create a substantial number of jobs.*

17. Electricity tariff structures to create incentives for energy management

Increased energy efficiency is an important method of reducing greenhouse gas emissions. However, tariff structures exist in New Zealand which penalise distributors if they reduce electricity sales. Instead, tariff structures could be used to encourage energy efficiency.

For example, when distributors need to purchase electricity to meet new additional loads, they could purchase this load at the long-run marginal cost (LRMC), which is indexed to how the load shortens the time until a new power generation source is needed. An incentive could be created for distributors to undertake or encourage energy management amongst their clients, by the tariff for the new load being reduced as the distributor decreases its load through energy management. This tariff structure would help end-users to face the real cost of energy consumption, while at the same time providing an incentive for energy management, as opposed to building new generating plant.

The restructuring of the electricity industry, outlined in option 16, could provide an institutional framework conducive to the creation of tariff structures which encourage energy efficiency.

18. Technical efficiency of energy production and distribution.

This option holds various implications for climate change. With respect to coal-fired power stations, it would result in the use of less coal to produce the same amount of energy, with a subsequent reduction in greenhouse emissions from the coal-fired stations. The same would apply to gas-fired stations. Improving the efficiency of hydro-stations would mean that more "clean" electricity was available to take the place of fossil fuel itself or electricity derived from fossil fuel.

This could be considered a practical option because it is concerned with improvements in efficiency only where "practicable". Such improvements could be identified through energy audits and the use of life-cycle costing.

The restructuring of the electricity industry, outlined in option 16, could provide an institutional framework conducive to efficient supply.

19. Maui gas "take-or-pay" agreement

In New Zealand, the Maui gas "take-or-pay" agreement between the Government and Shell BP Todd means that the Government is under contract to take a particular quantity of gas, or pay for it, regardless. This has set up particular incentives in the gas market, driving Maui gas depletion policy, pricing, and the operation of the Motonui gas-to-gasoline plant. If, on the other hand, the rate of depletion was linked to the objective of reducing greenhouse gases, the amount of gas used would depend on how natural gas (which has the least greenhouse gas potential of all the fossil fuels) could efficiently substitute for coal and oil. The outcome of the present contractual arrangement could be that New Zealand might never optimise its contribution to the reduction and stabilisation of greenhouse gas emissions.

*Wright, J, Baines, J, and Williamson, A.: "The future of Thermal Power Stations in New Zealand". Centre for Resource Management, University of Canterbury and Lincoln College, Feb 1990.

*Thompson, M.A. "Job Creation and Energy Management Programmes", N.Z. Institute of Economic Research (Inc.), 1988.

An assessment of the significance of the contractual agreement for greenhouse gas emissions and limitation policies could result in a possible renegotiation of the contract. However, any renegotiation would have to be mutually agreed to by all parties to the contract.

20. Motonui gas-to-gasoline plant

The Motonui gas-to-gasoline plant uses 37.5% of the gas from the Maui field, and *50% of the gas' s energy is lost* in converting it into petrol. The conversion inefficiency means that 1 litre of synthetic petrol produces 40% more carbon emissions than normal petrol, and twice as much as CNG, for the same distance travelled. If synthetic petrol used in New Zealand was replaced by CNG, New Zealand's total carbon dioxide emissions would be reduced by approximately 5%. From the perspective of reducing greenhouse gas emissions, gas would be better utilised as a substitute for coal and oil, because gas, per unit of energy, produces lower greenhouse gas emissions compared to other fossil fuels.

In addition, the processing cost of synfuel is around 70 cents a litre, whereas conventional petrol coming out of a refinery costs about 28 cents. The extra cost is picked up by the tax payer.

The Crown owns 75% of the plant, and Mobil 25%, and Mobil is guaranteed a 16% return on its investment by the Crown. An assessment of the significance of the contractual agreement for greenhouse gas emissions and limitation policies could result in a possible renegotiation of the contract. However, any renegotiation would have to be mutually agreed to by all parties to the contract.

This option has implications for Maori, because reducing production would mean that less waste from the production plant would be disposed of through the Waitara outfall into the sea and traditional fishing grounds.

21. Institutional arrangements governing gas exploration

In a fossil fuel based society, gas is the least greenhouse gas intensive of all the fossil fuels. If society chooses to remain fossil fuel based, it is important, from the standpoint of considering greenhouse gas, to maintain an adequate supply of gas to *substitute* for oil and coal.

At present, the primary drive behind petroleum exploration is oil (and the international price of oil), with gas a secondary consideration. Thus, gas is linked to oil (which emits more greenhouse gas per energy unit). The institutional arrangements governing the petroleum industry should be reviewed in the light of this dilemma.

Furthermore, there is no arrangement for discouraging the flaring of gas during the technical assessment of petroleum discoveries. It is estimated that more gas was flared at the Waihapa discovery over a 12-month period than was used by the entire household gas market. Re-injection of gas should also be discouraged, because the gas cannot be retrieved after re-injection.

22. Pricing, allocation, and depletion of energy resources

The primary resource owner in New Zealand is central government, which therefore plays a major role in determining the development of oil, coal, gas, hydro-electricity, and geothermal projects. Development of all these resources affects, positively or negatively, the production of greenhouse gases. A proper pricing and allocation regime is therefore a necessary underpinning for any other greenhouse policy. If greenhouse gas intensive resources are priced too low, the incentive is to increase consumption of such resources.

Depletion rates of energy resources are also a major consideration with respect to climate change objectives that seek to reduce and stabilise greenhouse gas emissions.

These issues could be addressed through mechanisms available under the Resource Management Bill.

As Maori own or are challenging the ownership of energy resources, the Treaty of Waitangi has implications for this option.

23. National policy on thermal power generation

A 1000 MW thermal power station such as the one proposed at Bream Bay would increase New Zealand's carbon dioxide emissions by 30%. If New Zealand decided to reduce its emissions through energy management, this one event (a new power station) could negate any such reductions. This should be seriously considered before any climate change strategy is put in place.

A thermal power station policy could prohibit the building of any new thermal generating plant (other than on-site co-generation plant), unless a corresponding amount of old thermal plant was being retired. On the other hand, owners of new thermal power stations could be required to provide an equivalent sink for the duration of the power station's life. These options would *maintain* the present level of emissions from thermal plant. Other measures would be necessary if emissions from thermal power plant were to *decrease*. For instance, any new thermal plant could be required to be more efficient than the plant (of the same or less capacity) that is being retired to make way for the new plant. Another approach would be to phase out thermal generation as old plant was retired.

24. Corporate responsibility

Outcomes which could be considered "responsible" might include: companies providing funds for research into the generation of energy from renewable resources (e.g. solar thermal supply) or research on efficient technologies (e.g. more efficient motors); the electricity industry using energy efficiency as a means of supply; companies investing in the provision of carbon sinks.

The essence of this option involves a changing of the attitudes of companies so that their objectives include good environmental outcomes. Government could play a role in persuading companies to develop these ideas. Rethinking the objectives of companies could also be a task for universities, with environmental ethics an important aspect of commercial and business management degrees.

A requirement for members of the energy industry to act responsibly with regard to the greenhouse effect could also be covered by including in the Companies Act and the State Owned Enterprises Act a requirement for companies to be environmentally responsible.

This option would probably not have an immediate substantial effect on greenhouse gas emissions, but it would have a gradual effect. It would also help safeguard against future environmentally irresponsible behaviour and would thus be important with regard to stabilising greenhouse gas emissions.

25. Renewable energy resources

Biomass as a source of energy can be beneficial with regards to the greenhouse effect, because carbon emissions can be

balanced by the uptake of carbon in the formation of biomass. Other renewable sources of energy, e.g. wind and solar, do not involve emissions, apart from those associated with the production and maintenance of the equipment.

Renewable sources of energy would become more economically viable if the environmental impacts of energy supply and use were included in prices. Direct government funding of projects involving the supply of energy from renewable resources, e.g. wind farms, could also be a means of making renewable sources of energy more economically viable. Research, development, and demonstration would also be important if there was to be any increase in the uptake of renewables-based sources of power. Research could be partly or fully Government funded in an effort to lay the foundations for a New Zealand renewables technology industry.

This option would not reduce greenhouse gas emissions immediately but would pave the way towards a transition to renewables which would help reduce and stabilise New Zealand's emissions in the long term.

The Treaty of Waitangi would have implications for this option, because of the use of land and rivers.

Transport Sector

26. Vehicle emission standards

This option is particularly relevant to older cars. Tune-ups would reduce emissions of carbon dioxide, hydrocarbons, and carbon monoxide. Carbon monoxide competes with methane (another greenhouse gas) for hydroxyl radicals, prolonging the life of methane in the atmosphere. Carbon monoxide is also eventually converted to carbon dioxide. Hydrocarbons react with nitrogen oxides and oxygen to form tropospheric ozone - another greenhouse gas. If all petrol vehicles were adequately tuned, total fuel savings of around 4% (a conservative estimate) could be achieved.* This translates into a 1% reduction in total carbon dioxide emissions, and a 0.5% reduction in total greenhouse gas emissions

Most older cars could meet an emissions test relatively easily - in some cases more easily than new, more technically complicated cars.

This is a practical option because it could be implemented through the Warrant of Fitness requirement for vehicles, at relatively little cost. Furthermore, vehicle owners might benefit from fuel savings. However, there could be inequitable economic impacts, because the less wealthy might own vehicles which were unable to pass an emissions standard.

27. Rebates for old vehicles

If the NZ vehicle fleet in general became more fuel efficient, greenhouse gas emissions from the transport sector would be reduced. Encouraging old inefficient vehicles to be taken off the road could help the vehicle fleet become more efficient.

This option requires financial commitment, as it involves a rebate when the vehicle is eventually "retired". The rebate could be funded through a deposit which is paid at the time of registering a new car and obtaining a number plate with the deposit remaining with that particular number plate throughout the life of the vehicle. Demand for spare parts for old vehicles still on the road would give owners additional income.

It would be important to verify how this option would interact with the New Zealand vehicle wrecking industry, as well as the amount the rebate would have to be set at to provide an incentive for people to take old inefficient vehicles off the road.

* Report of the NZ Motor Vehicle Exhaust Emissions Investigation Committee to the Ministers of Health and Transport, 1978.

28. Fuel efficient speed limit

This option could be implemented by lowering the present open-road speed limit to 80 km per hour. This should decrease the amount of petrol used per trip, which in turn should reduce greenhouse gas emissions per trip. A reduction in speed from 100 to 80 km per hour could result in fuel savings of somewhere between 20 and 30%.

As with all regulations, the difficulty lies in consistent enforcement, i.e. a traffic officer would not be placed every 100 metres on every road in New Zealand. It has been pointed out, however, that a lowering of the speed limit would result in a reduction of the average speed of motorists. Regulation should be supplemented by a constant education programme, although this would require Government resources.

Although the option would be relatively easy to implement, it might not result in a substantial reduction of greenhouse gas emissions because of the difficulties associated with complete and constant enforcement.

29. Fuel efficient driving of vehicle fleets

Vehicle fleets could be targeted (instead of vehicles in general) through a nationwide education campaign aimed at vehicle fleet owners.

As well as requiring drivers to drive at lower speeds, the campaign could involve fuel-efficient driving, whereby drivers were taught to execute gear changes and use acceleration rates which were fuel efficient.

This option should result in a reduction in petrol use and therefore a reduction in greenhouse gas emissions. However, it is difficult to estimate the exact savings in fuel consumption because of the variation among drivers. The fuel economy of two drivers driving at the same speed can vary by up to 20%.

This option should be practical, as owners of vehicle fleets could experience substantial financial savings (compared to the owners of individual cars), providing an incentive for them to engage in the programme.

30. Fuel efficient vehicles

If more fuel efficient vehicles were used than at present, there could be an overall reduction in petrol use and, subsequently, a reduction in greenhouse gas emissions. For example, a target of an increase by 50% in fleet average economy (from the present 30 mpg to 45 mpg) by 1995 would allow sufficient time, with the present rate of turnover of the fleet, to meet a target of a 30% reduction in carbon dioxide levels from vehicles by 2005. This translates into a reduction in total carbon dioxide emissions by around 8%, and a reduction in total greenhouse gas emissions by about 3%.

The Government could introduce legislation along the lines of the Corporate Average Fuel Economy (CAFE) regulations applied in the United States. The CAFE regulations set fuel economy targets for the average of the total fleet of vehicles sold by any one manufacturer. The present US level is 27 miles per US gallon, so that a manufacturer who sells 10,000 cars with an average economy of 29 miles per gallon can also sell 2000 cars with an average economy of 17 miles per gallon to produce a total fleet of 12,000 cars averaging 27 mpg. Details of how a CAFE standard could be implemented in New Zealand would have to be developed through industry/Government discussions.

Another way of achieving the objective of bringing more fuel-efficient cars on to the market would be to introduce a differential tax based on relative fuel efficiencies. The result should be similar to the CAFE-type approach - a price gap opening up between efficient and inefficient vehicles.

This should be a practical option because fuel-efficient cars already exist and fuel savings should provide an incentive for people to buy them - especially if a price differential existed. Furthermore, the CAFE approach does not ban the sale of inefficient vehicles, it simply requires that such sales are balanced by the sale of super-efficient vehicles.

An option such as this, which aims to increase the availability and the attractiveness of efficient cars, should take into consideration the possibility that the enhanced performance of such vehicles could result in fuel savings through efficiency being offset by increased use of the vehicle by the driver. This implies the need to implement complementary policy aimed at reducing the use of private vehicles and distances travelled.

31. Consumer information

Informed buyers might choose more efficient vehicles, which could result in an overall increase in efficiency of the vehicle fleet.

Information could be made available through the "green labelling" of cars. As with all labelling, this should state both the fuel consumption and how it compared with the standard for the fleet average as well as how it compared with the fuel consumption of the most efficient car of that engine size currently on the market. It could also give a greenhouse impact rating. However, there would be a need for constant public education so that the customer was constantly aware of the reason for making "good" choices.

This option would be following the developing trend of green marketing - with potential benefits for both the consumer and producer - and should therefore be considered a practical option, given today's increasing green consumerism.

This option could be considered as complementary to CAFE standards, because it provides the consumer with information on what the market can provide.

32. Business tax provisions and allowances

This could encourage the use of more fuel efficient vehicles, which would mean less petrol consumption and therefore a reduction in greenhouse gas emissions.

It would necessitate the development of a vehicle efficiency-rating system, so that the relative efficiency of vehicles was identifiable. However, this could be achieved through implementing emission standards. Ensuring that businesses were telling the truth about the efficiency of their vehicles could be difficult to establish unless the Inland Revenue Department had access to a data base which listed vehicle owners and the rating of their vehicles as defined during a Warrant of Fitness emissions test. This option would therefore necessitate a national data base, as well as other enforcement mechanisms. Furthermore, unless the new taxation laws strongly favoured efficient vehicles, this option might provide businesses with little incentive to change - even if enforcement was possible.

This option might not be considered an initial priority in the development of a more fuel-efficient vehicle fleet. Options such as the CAFE standard, standard emission tests, and green labelling of vehicles might be considered more of a priority, with this option further developed if additional incentives for change were necessary.

33. Vehicle registration fees

Registration fees could be structured so as to encourage the use of more fuel-efficient vehicles, which would mean less petrol consumption and therefore a reduction in greenhouse gas emissions. The option could be implemented by considering registration fees as a vehicle-efficiency tax rather than a vehicle-owner tax.

Such a move would necessitate the development of a vehicle efficiency rating system. However, this could be achieved through implementing emission standards. Ensuring that people were correctly reporting the efficiency of their vehicles could be difficult to verify unless the administrative agency had access to a data base which listed vehicle owners and the rating of their vehicles as defined during a Warrant of Fitness emissions test. This option would therefore necessitate a national data base as well as other enforcement mechanisms.

Unless the new registration fees strongly favoured efficient vehicles, this option might provide people with little incentive to change - even if enforcement was possible. Furthermore, the less wealthy might already be experiencing inequitable impacts from the establishment of emission standards (which would have to be implemented prior to the implementation of this option), and the application of this option would be an additional burden. The option might therefore not be considered an initial priority in the development of a more efficient vehicle fleet. Options such as the CAFE standard, standard emissions tests, and green labelling of vehicles might be considered more of a priority, with this option further developed if additional incentives for change were necessary.

34. Pre-heating vehicle engines prior to starting

Pre-heating car engines, through the use of engine block heaters that can be plugged into power points, can save up to 50% of fuel consumption on short city trips. Putting this procedure into practice should therefore translate into a reduction in greenhouse gas emissions.

For this option not to generate additional electricity demand, it would be necessary to make efficiency gains in electricity production and/or use. However, because this would be a purely voluntary measure, involving time and effort on the part of the driver, the impact it could have on greenhouse gas emissions would probably be minimal. This option might therefore not contribute significantly to greenhouse gas reductions.

35. Integrated transportation planning

Transportation planning is not a process which can be separated from other planning processes for two main reasons:

- Transportation development options are usually to some degree interchangeable with other options, particularly land use options, e.g. instead of a six-lane motorway a lesser road could be built in conjuction with settlement/development constraints.
- Transportation options must serve objectives that are not isolated from other objectives, i.e. transport planning necessarily serves economic, social, environmental, and energy goals - roads are not built simply for the sake of building roads. The planning process therefore considers a wide range of implications of transportation development - e.g. economic, social, environmental, energy - in both the short and long-term. It also considers the implications not just for the immediate locality, but over a wider area. In fact, the transportation planning process should be guided by a

set of principles such as those devised for the Resource Management Bill.

Transportation planning is concerned with the identification and evaluation of options for development (expenditure) across all transport modes (road, rail, shipping, and air), as well as within modes. Such planning should also identify and evaluate inter-modal options (e.g. a combination of road and rail).

Integrated transportation planning is already occurring on an ad hoc basis. However, for effective planning, an obligation in law should be placed on regional and national government agencies to produce transportation plans and policies. Furthermore, Transit New Zealand could require specific levels of transportation planning as a prerequisite to regional councils submitting land transport programmes. Such a requirement would need at least a year's notice for effective implementation.

Responsible transportation planning would have gradual long-term effects. Although it would not cause an immediate reduction in greenhouse gases, it would be an essential part of any long-term strategy to reduce and stabilise greenhouse gas emissions.

36. Efficient modes of transport

All modes and uses of transport have different energy efficiency performance. For example, rail locomotives have the potential for significantly lower fuel use per tonne kilometre than trucks.

Benefit/cost calculations on alternative modes and uses of transport are typically complex. This kind of analysis should be an inherent part of comprehensive transportation planning (see option 35).

37. Urban driving

Town planning can help replace some private car use by public transport through:

- residential consolidation to achieve higher population densities along public transport routes;
- grouping of employment places and other destinations around public transport nodes;
- restricting parking spaces where public transport is available and avoiding the widening of the roads as soon as they reach capacity.

Reducing the overall number of private vehicles on the road, and substituting them with efficient public transport would reduce New Zealand's greenhouse gas emissions.

Town planning could help reduce vehicle trips through:

- encouraging dispersed locally based employment in lower-density areas between rail corridors, and by clustering shops, schools, recreational facilities in order to encourage multipurpose trips.
- improving facilities for cyclists and pedestrians.

Responsible town planning should have gradual long-term effects. Although the implementation of such planning may not cause an immediate reduction in greenhouse gases, it is an essential part of any long-term strategy to reduce and stabilise greenhouse gas emissions. If urban driving was reduced by 50%, transport sector emissions should reduce by 25%, and New Zealand's total carbon dioxide emissions by 10%. Total greenhouse gas emissions should reduce by 4%.

38. Staff transport

Provision by organisations of transport for their staff to and from employment could result in a reduced number of vehicles on the road and therefore a reduction in greenhouse gas emissions.

However, this option would have an effect only if taken up by firms which provided parking space for private vehicles (or firms which were located in an area that had plenty of parking) and had large numbers of employees who started and finished at the same time. (If parking space was not provided or available, employees might already be travelling by public transport.) This option, in the New Zealand context, would probably not have a significant impact on greenhouse gas reductions.

39. Company cars

According to an Auckland Regional Authority survey, during the morning peak hour traffic, 45% of cars crossing the harbour bridge are company cars. In the 1986 census, company cars were the second most popular mode of transport to work, comprising 12% of the survey. If company cars were reduced in number, executives might be more inclined to catch public transport, lowering the number of cars on the road and resulting in a reduction of greenhouse gas emissions.

Companies could be encouraged to reduce cars through taxes levied on every additional car over a specified number.

There could be difficulties in implementing this option because there would be a need to verify the number of company cars that a business owned. An effective level of taxation would also have to be set.

40. Trading distances

"Trading distance" is the distance travelled by buyers and sellers. A reduction in trading distances travelled should result in less fuel being burnt, with a subsequent reduction in greenhouse gas emissions.

This option could be implemented through the creation of an electronic broker service supplying information to buyers and sellers on what goods and services were available and where they were located.

Research is needed to investigate the potential of such a service for reducing greenhouse gas emissions. Research is also needed to ascertain whether such a service could be cost effective in New Zealand and thus an attractive proposition for private sector investment.

41. Full-loading of vehicles

The full loading of vehicles would mean that the available loads for cartage would be driven around by fewer vehicles. This could contribute to a reduction in greenhouse gas emissions due to less fossil fuel being burned.

Commercial carriers have an incentive to seek a return load if they have knowledge of the requirement, i.e. the more loads carried in a trip, the greater the profit. Vehicles used by companies to deliver their own goods may not seek a return load unless they are picking up goods required at their companies' plants, as delivery costs, including the cost of the return journey, can be passed on to the customer.

Full loading for all trucks could be encouraged by the creation of an electronic load brokerage scheme, which would provide information as to the location of loads.

Research is needed to investigate the potential of such a service for reducing greenhouse gas emissions. Research is also needed to ascertain whether such a service could be cost effective in New Zealand and thus an attractive proposition for private sector investment.

42. CNG as an alternative to petrol

Carbon dioxide emissions from vehicle engines would be reduced by 33%, assuming engines were properly tuned for CNG use and were fully optimised in each case. This translates into a reduction of New Zealand's total carbon dioxide emissions by approximately 8%, and a reduction in total greenhouse gas emissions by around 3%, if all vehicles were converted to CNG.

Carbon monoxide emissions would also be reduced. Carbon monoxide emissions are important because carbon monoxide interferes with the ability of hydroxyl radicals in the atmosphere to destroy CFCs and nitrous oxide. Carbon monoxide also competes with methane for hydroxyl radicals, thus prolonging the life of methane in the atmosphere.

Although the CNG industry has historically been fraught with difficulties, it is possible for it to regain market strength. Conversions have never been cheaper, and CNG still costs less than petrol and diesel. However, there is a need for the creation of a *development* fund, a co-ordinated marketing strategy, and a stable, long-term pricing regime. Regaining market strength could be further assisted by the introduction of a CAFE-type standard to specify the carbon efficiency of a vehicle fleet. Dedicated CNG vehicles could then be favoured by importers because of their greatly lowered carbon emissions.

Increasing the percentage of CNG vehicles would provide New Zealand with a medium term strategy for substantially reducing greenhouse gas emissions while natural gas lasted. It would also provide a bridge to a long-term strategy in that it would establish the technology and infrastructure for compressed biogas (CBG), which is sustainable.

43. CNG as an alternative to diesel

There would be a reduction in carbon emissions, compared to diesel, if CNG were substituted. Because diesel produces little carbon monoxide, there is hardly any reduction in carbon monoxide emissions by changing to CNG. Furthermore, the advantage of the lower carbon content of CNG is partly offset by a 5% reduction in fuel efficiency. However, improved conversions should be able to reduce efficiency loss.

44. Compressed biogas (CBG)

Greenhouse gas emissions from the use of compressed biogas (CBG) in vehicles is the same as for CNG. However, carbon dioxide emissions can be cancelled out by replanting the material that was harvested to make the biogas. If emissions were balanced by a sink and all vehicles used CBG, New Zealand's total carbon dioxide emissions would be reduced by around 30%, and total greenhouse gas emissions by approximately 12%.

When scrubbed and compressed, CBG can be used in CNG vehicles and dispensed in CNG equipment. It is already produced by some industries for their own use and on some farms, forming a means of waste control as well as providing energy. The aim of the option is to increase the production and use of compressed biogas (CBG) by stimulating both private and commercial production. This could be done by providing information on the production and use of biogas to the farming community and industry; by providing relatively cheap loans to cover the initial capital costs of setting up a digester; by rationalising the commercial prices of all fuels according to their potential to contribute to or help stabilise climate change. Also, further research is needed on the barriers to the production and use CBG.

As energy from biomass offers a long-term solution to energy supply (in terms of energy security, reduced greenhouse gas emissions, and the potential to balance carbon dioxide emissions), the production and use of compressed biogas is an important long-term option for New Zealand. However, if dedicated CBG/CNG vehicles were to be run in both the South and North Islands, CBG would have to be extensively available in the South Island and then in the North Island as natural gas ran out.

The Treaty of Waitangi may have implications for this option, because Crown Land could be used to grow biomass for energy.

45. Methanol/ethanol produced from biomass

When burned, methanol and ethanol produce less carbon dioxide, carbon monoxide, and nitrous oxide and fewer unburnt hydrocarbons than petrol. Furthermore, if methanol and ethanol are produced from biomass, there is the potential to balance carbon dioxide emissions with carbon dioxide uptake through biomass renewal. If emissions were balanced by a sink and all vehicles used methanol or ethanol, New Zealand's total carbon dioxide emissions would be reduced by approximately 30% and greenhouse gas emissions by 12%.

Wood is the most usual biomass feedstock for methanol; and a wide range of crops besides wood can be used to produce ethanol (although beet is considered to be the most viable).

New Zealand studies suggest that a large proportion of this country's fuel needs can be met through alcohol fuels.* However, it is also felt that energy farming for production of fuels should be viewed as competing with *post*-Maui fuel options. Nevertheless, a constant commitment to research, development, and demonstration is needed if energy farming is ever to be incorporated smoothly into any long-term climate change strategy.

As energy from biomass offers a long-term solution to energy supply (in terms of energy security, reduced greenhouse gas emissions, and the potential to balance carbon dioxide emissions), it would be prudent to continue research and demonstration in this area.

The Treaty of Waitangi may have implications for this option because Crown land could be used to grow biomass for energy.

46. Electric vehicles

If electric cars were run on hydro electricity or photovoltaics, greenhouse gas emissions should drop markedly. If *all* vehicles were run on hydro or photovoltaic electricity, New Zealand's total carbon dioxide emissions would decrease by approximately 30% and total greenhouse gas emissions by 12%. However, unless surplus hydro was available at the time the batteries were recharged, there would be an increase in the thermal generation of electricity and thus an increase in emissions from thermal power stations.

An article in the Dominion, 4 January 1990, stated that General Motors were developing an electric powered car with double

* New Zealand Energy Research and Development Committee, Report No. 46, 1979: "The Potential of Energy Farming for Transport Fuels in New Zealand".

the range of most electric vehicles (approximately 160 km).

However, the costs of storing electricity in batteries is currently very expensive - approximately 50 cents per kWh. This suggests that the capital and running costs, in the foreseeable future, would be high compared to fossil fuel powered cars. This is therefore an option for the future. Furthermore, unless the range increases, or the time it takes to recharge a battery decreases, this option would be applicable only to those who drove relatively short distances at a time.

The Treaty of Waitangi would have implications for this option if it resulted in a growing pressure to dam more New Zealand rivers.

47. Hydrogen vehicles

Hydrogen is cleaner burning than other fuels; it releases water and nitrogen oxide. There is no carbon dioxide released, and nitrogen oxide can be controlled to low levels. If all vehicles were run on hydrogen produced from hydro electricity or photovoltaics, New Zealand's total carbon dioxide emissions would decrease by approximately 30% and total greenhouse gas emissions by 12%

Although producing hydrogen from water, via electrolysis, is an established technology, hydrogen powered cars currently being developed in Germany and Japan may only be commercialised within the next decade. This is therefore an option for the future.

Furthermore, unless substantial surplus hydro was available, this option could lead to an increase in the thermal generation of electricity.

The Treaty of Waitangi would have implications for this option if electricity demand resulted in a growing pressure to dam more New Zealand rivers.

Commercial Sector

48. Minor alterations to existing buildings

Because of the long lifetime of buildings, it is important for existing buildings to be made more efficient in their energy use.

It should be possible to reduce the energy used in the heating, ventilating, and air-conditioning system (HVAC) system and in lighting by approximately 20%. This translates into a decrease of New Zealand's total carbon dioxide emissions by around 1% and total greenhouse gas emissions by approximately 0.5%.

This option would be particularly relevant to buildings nearing the end of their life, as it does not involve extensive retrofits. It is an option which could be implemented immediately, reducing New Zealand's energy bill and greenhouse gas emissions.

This option could be implemented on a voluntary basis, with low-interest capital available from Government to be paid back through a shared savings scheme (similar to the Government programme run by the Energy Management Group, Ministry of Commerce). It might also be possible for private financial institutions to become involved.

On the other hand, this option could be a legal requirement, entailing Government administration of the loans and loans schedules.

49. Major alterations to existing buildings

The energy savings through major alterations to existing buildings would be higher than for the option 48. All the changes in option 48 should take place. Additional retrofits might include a natural gas condensing boiler (if a boiler was used), with 20% energy savings. If the heating load was low, then electric heating systems would be the most appropriate and use the least energy. The introduction of a variable air volume (VAV) system could further reduce HVAC energy by an additional 20%. This translates into a decrease in New Zealand's total carbon dioxide emissions by approximately 2% and total greenhouse gas emissions by about 0.9%.

This option would be particularly relevant to buildings with the majority of their life-span left. Given the availability of adequate resources, this is an option which could be implemented immediately, reducing New Zealand's energy bill and greenhouse gas emissions.

Means of implementation are the same as for option 48.

50. New buildings

The energy savings possible in new buildings would be greater than for options 48 and 49, owing to the incorporation of passive solar features. If energy savings of 50% were achieved, this would translate into a decrease in New Zealand's total carbon dioxide emissions by approximately 3%, and total greenhouse gas emissions by approximately 1.4%.

Mandatory energy performance standards would be a major means of implementing this option. Because buildings last a relatively long time, and because retrofits are usually more expensive than incorporating the features in the original building design, energy performance standards are essential for new buildings. However, the standards would have to be updated as technology and techniques developed.

Owners could be more interested in ensuring that their buildings were energy efficient if there were clear incentives to do so. At present, rent is based on location. In order to make owners feel that efficient buildings were beneficial to them (as opposed to the tenants) the tenant should pay more for an energy efficient building. The tenant, however, pays less on energy bills, so that the overall outgoing payment of rent and energy remains the same. This arrangement would need the development of performance standards and probably an arbitrator to negotiate a rent which correctly reflected the energy performance of the building.

This is a practical option. There is a great body of knowledge in New Zealand pertaining to passive solar design and energy management. Because of the length of time that buildings exist, this option is important for any long-term climate change strategy.

51. "Green labelling" of new buildings

The existence of better informed buyers could increase the demand for energy efficient buildings. This would reduce energy demand, with reductions in greenhouse gas emissions as already discussed.

All new buildings could be assigned an energy performance grade, publicising how the building compared with the best available energy efficient building. This would help the market recognise energy efficient buildings. The implications of reduced energy demand on the greenhouse effect could also be included.

Although this option would necessitate the development of energy grades, it should be considered not only practical, but also complementary to the development of energy performance standards, as it provides consumers with information as to what the market has to offer.

52. Energy costs in commercial leases

In general, it would make good sense for the occupiers of buildings to receive and pay their own energy bills. Instead, energy bills are often the responsibility of the owner, who bills the occupier along with the rent. Sometimes, if there is more than one tenant in the building, the energy bills are averaged over all the tenants.

If the energy consumption of a building was easily available for perusal, it could provide an incentive for buyers and tenants to seek out property that had low energy costs, and property owners would have an incentive to reduce energy costs by investing capital into a building. This would help reduce New Zealand's energy demand, with a resulting drop in greenhouse gas emissions.

This is not a significant option on its own, but could form part of any packet of options aimed at increasing energy efficiency.

53. "Energy managers"

If someone was responsible for energy management in a building or buildings, it could result in a reduction in energy demand and a subsequent reduction in greenhouse gas emissions.

This option especially applies to organisations which operate many buildings and are therefore using a lot of energy, as there is the potential not only to pay for the energy manager's salary through energy savings, but to make additional energy savings which are energy profits accruing to the business.

Encouraging the use of energy managers for commercial and industrial buildings should be complementary to any policy pertaining to increasing the energy efficiency of New Zealand.

Government Sector

54. Energy audits and efficiency improvements

Hospitals, schools, State-owned enterprises, and other institutions funded by Government should be included in this option.

All levels of government could develop a greenhouse policy aimed at their own energy use as a means of encouraging energy efficiency improvements. By undertaking energy audits and energy efficiency improvements, New Zealand governments, at national, regional, and local levels, could cut down on operational costs as well as set a good example to the rest of the community.

As with energy efficiency improvements in other sectors, the energy management measures would have to be cost effective, with the initial capital outlay paid back through energy savings.

Industrial Sector

55. Energy efficiency incentives

As with the commercial and government sectors, providing incentives for energy efficiency would involve a reduction in energy demand and therefore a reduction in greenhouse gas emissions. As industry is the most energy intense sector with regard to coal, gas, and electricity, there is a great potential for substantial energy savings and a substantial reduction in greenhouse gas emissions. It has been estimated that cost-effective energy efficiency improvements can achieve a 30% reduction in energy demand within the industrial sector. This translates into a decrease in New Zealand's total carbon dioxide emissions by approximately 9% and total greenhouse gas emissions by approximately 4%.

Energy efficiency improvements, as with other sectors, would have to be cost effective, with the initial capital outlay paid back through energy savings. This is an important option which could be implemented immediately. Not only would it decrease greenhouse gas emissions, it would also help make New Zealand industry more economically efficient and competitive.

56. Technology information

If New Zealand industry is expected to become more efficient, then both industry and the engineering community will need technology information - to help ensure that the most effective technology was being used in the effort to reduce greenhouse gases.

As there are already international networks which supply information on energy efficient technology, e.g. CADDET (Centre for the Analysis and Dissemination of Demonstrated Energy Technologies),* obtaining information in New Zealand is not impossible. For example, the Energy Management Group, Ministry of Commerce, both collects and disseminates information from CADDET. With further resources, the service could be even more effective.

This option necessarily complements policy aimed at improving energy efficiency in New Zealand - especially in the industrial sector.

57. National information networks

Organisations such as the Ministry of Forestry, Ministry of Agriculture and Fisheries, Federated Farmers, and the Automobile Association could be encouraged to use their networks to educate their sectors on the benefits of energy management.

The objectives of the organisations could be expanded to include promoting the efficient use of energy. Using existing networks would be an efficient way of disseminating information on energy management in general, as well as the more specialised information which could be obtained through the previous option.

Although this option on its own would not bring about a substantial decrease in greenhouse emissions, it necessarily complements options 55 and 56.

58. Sale of energy and material wastes

Generally speaking, if "waste" energy is sold and used, and waste material used and/or recycled, less energy should be required overall. However, careful analysis of the energy accounts of recycling would have to be undertaken to make sure that it did not use more energy then it saved.

Although this option could be implemented immediately, given adequate resources, it would not immediately translate into energy savings and a reduction in greenhouse gas emissions, as it would entail finding out what was available for sale or exchange, and then the setting up of an infrastructure (probably at a regional level) to deal with the information. Furthermore, it is difficult to estimate the potential reduction in greenhouse gases. However, minimising waste is an important aspect of a resource efficient society and should be encouraged and developed as a long-term approach to resource use and the reduction and stabilisation of greenhouse gas emissions.

* CADDET are developing a new programme aimed at informing members as to the most effective greenhouse-gas-reducing technology available.

59. Incentives for use of renewable sources of energy and co-generation

Biogas generation is particularly beneficial when the wastes used in its production would otherwise have gone to a landfill and turned into methane which would have escaped into the atmosphere. Instead, biogas generation means that the methane is burnt, thereby producing carbon dioxide, which has a lower greenhouse gas potential than methane. Furthermore, biogas from biomass can be beneficial with respect to climate change, because biomass is a renewable carbon sink - carbon emissions from biomass can be balanced by carbon uptake in the formation of biomass.

Renewables-based technology such as wind and solar power do not produce greenhouse gas emissions (apart from the emissions associated with the production and maintenance of the equipment).

Co-generation is an efficient way of supplying energy, as waste heat, produced in the generation of electricity, is also utilised and not allowed to disperse.

Some farms and industry are already using these methods of generating power. However, there are instances where such means of generation are already cost effective and yet the opportunity is not being taken up. It could also be possible to make these methods of generating power more cost effective on a wider scale. There is also the need for continued funding for research, development, and demonstration.

All of these methods of generating power are important in terms of a long-term strategy for stabilising and reducing greenhouse gas emissions. This is therefore an option which should be given serious consideration.

Domestic Sector

60. Incentives for energy efficiency in the home

Electricity, because it is so widely used in our homes, would be the main energy item saved through the increased efficiency of the domestic sector, although demand for solid fuels (coal and wood) and gas would also be reduced. Low-cost measures would reduce domestic energy demand by about 40%. This translates into a reduction of New Zealand's total carbon dioxide emissions by approximately 2% and greenhouse gas emissions by 1%. More extensive retrofits of houses would reduce domestic energy consumption by 75%, which translates into a reduction in total CO2 emissions by about 3%, and total greenhouse gas emissions by approximately 2%.

There are many cost-effective opportunities in existing houses for improvements in energy efficiency. However, as the monthly domestic energy bill is a small percentage of the running costs of a home, there is less incentive for home owners to pay the initial cost involved in energy efficiency improvements. This option might therefore only contribute to a reduction in greenhouse gas emissions if incentives were set up so that home owners were more inclined to make the initial investment, e.g. through "easy" loans, or by the capital costs being included in mortgage finance.

61. Energy performance standards

The development and application of energy performance standards is a practical solution to increasing the efficiency of new housing. Even if the initial capital cost of the home was slightly higher, the reduction in energy bills should compensate, with the monthly cash flow for the owners being lower. Furthermore, day-to-day living would be more comfortable. There are also health benefits in that houses would be less likely to suffer from damp and condensation.

Energy efficient new homes could be 60% more efficient than standard New Zealand homes.

62. Appliance labelling

An informed consumer would be better placed to make a choice between appliances with regard to the appliance's energy consumption and consequently its contribution to the greenhouse effect.

This option could be implemented through appliance labelling. Labels should compare energy consumption with the minimum standard and the best existing on the market for a comparable item.

63. Mandatory appliance standards

Standards would help ensure against the production of energy inefficient goods. Standards could therefore make a substantial contribution to the reduction and stabilisation of greenhouse gas emissions - especially if the standards were constantly revised over the years.

It should be noted that appliance standards and labelling should be complementary not alternative policy options, as labelling provides consumers with information on what the market has to offer.

64. Voluntary appliance standards

This option would have to be tied to an "environmentally friendly" labelling tactic, with manufacturers who met the standard being able to label their goods as "environmentally friendly".

Success of such a measure would depend on consumers being environmentally aware, which would compel suppliers to produce goods which satisfied environmental concerns.

If resources were going to be used by the Standards Association of New Zealand in developing standards as well as checking voluntary claims of adherence, then to leave the adherence as voluntary could result in a lot of time and effort for little return.

Energy Efficiency in New Zealand

65. Energy Efficiency Act

It can be seen that the potential for increases in energy efficiency is spread over all sectors and consists of many desegregated opportunities. However, total energy savings at the national level and the concomitant reduction in carbon emissions from energy efficiency are substantial.

Given the immense potential of increased energy efficiency for reductions in greenhouse gas emissions, and given the vast array of energy efficiency opportunities and methods of implementing measures, the whole issue of energy efficiency could be housed under one act. Further consideration is needed in order to develop this idea in the New Zealand context.

3.3 Limitation Options - Agriculture, Forestry, Land Use, and Industry

A number of land management and industrial practices give rise to greenhouse gas emissions other than those associated with energy production and use. In some cases, these emissions are believed to be quite significant on a national scale. Conversely, certain practices help to lock away from the atmosphere carbon that would otherwise be available to contribute to global warming. It is therefore important that New Zealand's basket of options for limiting greenhouse gas emissions includes options which involve these sources and sinks.

This section of the publication presents options which consider the sources and sinks of greenhouse gases that are related to land management and industrial practices. These options should be regarded as being complementary to those in sections 3.1 and 3.2 of the discussion document, since New Zealand's response to the climate change issue will need to comprise a range of measures if there is to be any significant reduction in greenhouse gas emissions. In assessing the following options, consideration should therefore be given to their interrelationships with the other options presented in this document.

66. Tree planting, forest regeneration, and conservation of existing forest cover

Forests convert carbon dioxide from the atmosphere into living material of a form which is generally resistant to both decay and consumption by animals. As such, they can effectively act as a sink for carbon which would otherwise be available to contribute to global warming. While all forests store carbon, not all are *net* carbon absorbers. A forest consists of plant material which is growing (i.e. carbon absorption is taking place) and plant material which is decaying (i.e. carbon release is occurring). It is the balance of these two processes which determines whether or not there is any *net* carbon absorption or release. Forests which are *increasing* in biomass are net absorbers of carbon. A variety of factors influence the total amount of, and rate at which, biomass is accumulated (e.g. species, location, management regime).

If the current annual rate of human-derived carbon dioxide emissions in New Zealand is compared with the estimated annual carbon uptake of New Zealand's *exotic* forest estate, it appears that New Zealand is currently in carbon dioxide "credit" (i.e. the rate of uptake currently exceeds the rate of carbon dioxide emissions). As the estate ages however, the rate of biomass accumulation (and hence carbon "capture") slows, and additional plantings would be needed to balance existing human-derived carbon dioxide emissions. Clearly this could not go on indefinitely due to such factors as the amount of land available and the cost involved. Furthermore, from a longer-term global carbon cycling perspective, New Zealand may not be in carbon "credit" at all when it is considered how little of the country's original forest cover remains. Widespread destruction of indigenous forest by humans and introduced pests (e.g. deer and opossums) will have contributed to an upset in the balance of the global carbon cycle (along with similar actions in other countries located in temperate and tropical regions). Rather than just offsetting human-derived carbon dioxide emissions, New Zealand's exotic forest estate must therefore also be regarded as having to compensate for the damage done to the global carbon cycle.

Climate change itself has implications for such factors as biomass accumulation rates and the availability of land suitable for certain forms of tree coverage (e.g. growing trees for commercial purposes). This will, in turn, have implications for such factors as carbon storage, and the domestic and international markets for timber and other tree crops. These factors will need to be taken into account in further policy development.

Trees serve a range of both commercial and non-commercial purposes in New Zealand, hence are managed in a variety of different ways. The way in which this option would be implemented, and the potential costs and benefits associated with it, would therefore depend greatly on the scale of coverage that was considered necessary (in terms of relative carbon dioxide uptake or carbon storage), and the mechanisms used to achieve the target cover (e.g. regeneration of indigenous forest, tree cropping, commercial forestry, amenity plantings, soil conservation plantings). Trees, forests, and commercial forest operations have all featured strongly in New Zealand's history, and continue to play important environmental, social, and economic roles today. New Zealand is well equipped with the appropriate research and management skills to consider implementing such an option.

This option may have significant implications for Maori, both because it may lead to decisions which influence future land use opportunities and because Maori perceptions of indigenous forests differ from those they have for exotic forests. Further development of this policy option must therefore involve full consultation with Maori.

This option is regarded as having the potential to enhance significantly New Zealand's carbon sink in the short to medium term. It must not, however, be regarded as a substitute for reducing gas emissions which result from human activities. Such an approach would not be sustainable in the longer term (for reasons such as cost and land area available to plant trees). This option may help to "buy time" until effective emission reduction methods have been developed.

67. Use of timber

The carbon storage properties of timber grown for commercial purposes can be extended by ensuring that the harvested timber is transformed into durable wood products. Construction timber, and treated posts and poles, are examples of durable wood products in common usage. There may therefore be some greenhouse-related benefits to be gained from encouraging greater use of such products (particularly if they replace the use of "greenhouse-unfriendly" products such as aluminium, cement or steel).

This option is complementary to the previous option, which considers the planting of trees. It is therefore sensitive to the uncertainties of timber supply related to any climate change as described in relation to that option.

Potential costs associated with this option include waste treatment and disposal (associated with timber processing), and increased pressure on the natural resource base (associated with any increase in demand for timber). Additional potential benefits include energy savings and indirect greenhouse gas emission reductions (assuming there is a reduction in the production and use of cement, aluminium and steel).

The potential significance of this option is unclear due to a lack of information on a number of relevant matters (e.g. the potential for increased construction timber use in the commercial and industrial sectors, and the durability of specific types of timber products). It is not considered likely to have the same degree of influence as increasing the amount of growing forest.

68. Production efficiency of livestock management systems

"Ruminants" (animals such as sheep, cows, goats and deer that have a complex stomach which includes a storage compartment known as a "rumen") give rise to greenhouse gas emissions in three ways:

- certain bacteria which live in the rumen produce methane as part of the food digestion process;
- manure from farm animals, which breaks down in the absence of oxygen, results in methane emissions;

- nitrous oxide emissions occur when animal urine is deposited on pasture.

The contribution made by farmed ruminants to total annual greenhouse gas emissions in New Zealand is estimated to be around 32% (excluding the contribution made by any methane which comes from manure that breaks down in the absence of oxygen). By increasing the production efficiency of livestock management systems, it may be possible to reduce these emissions.

There are a number of management techniques which may help increase animal production efficiency, such that any given product output level can be achieved with fewer animals (and hence reduced gas emissions). Examples include: improving brood herd reproductive efficiency (in which case a smaller brood herd would be able to sustain any given level of production); increasing the use of intact males (research has indicated that this would result in faster weight gains and increased feed efficiency); and strategic supplementation of nutrients in areas with seasonal or permanent low quality grazing (which could improve both feed efficiency and animal productivity, such that less methane would be emitted per unit of food consumed and fewer animals would sustain any given level of product output). Research is needed to evaluate these management techniques, and to identify any other ways of increasing animal production efficiency. As such, this option is unlikely to have any influence on gas emissions in the short term.

69. Methane production in farmed ruminants

An alternative method for reducing the emissions of methane that result from the digestion process in farmed ruminents is to modify the process so that methane production is suppressed. Research overseas has attempted to this. The motivation for this research has however been the desire to increase the productivity of livestock management systems through the elimination of the energy "loss" due to methane production rather than for greenhouse-related reasons. The suppression of methane production can therefore be seen to have multiple benefits, including a possible reduction in farmed ruminant numbers through increasing animal productivity. Unfortunately, research carried out to date has failed to identify any effective methods for suppressing methane production.

Because New Zealand's livestock management systems are based on extensive grazing of pasture, measures for suppressing methane production within the rumen are limited to those which do not involve the use of alternative feeding practices (at least in the short to medium term). Examples of techniques which may lead to the suppression of methane production include selective breeding of no/low methane-producing animals, the introduction of genetically engineered bacteria into the rumen to suppress methane production, and dosing animals with methane suppressing chemicals.

This is considered to be a realistic option, with the potential to give rise to significant reductions in greenhouse gas emissions. Its influence is not likely to be felt in the short term, owing to the need for further research.

70. Animal waste disposal practices

Methane is emitted from animal wastes which decompose in the absence of oxygen. Farmed animals, because of their numbers and the ways in which they are managed, are of most significance in this regard. Because animal waste generally decomposes in the open in New Zealand, methane emissions from this source are not likely to be significant. There is therefore little scope for achieving reductions in methane emission through modifying waste handling practices in relation to the majority of farmed animals.

In situations where animal wastes are concentrated (e.g. factory farming of pigs and poultry, or the disposal of dairy shed wastes into ponds or lagoons in which oxygen is absent), there are treatment and disposal techniques available which would not only ensure that methane emissions did not occur but could also provide other environmental and economic benefits (e.g. the waste could be used for fertiliser or to "fuel" biogas generators). Such techniques could be advocated by farm advisory agencies where this was practical.

Nitrous oxide emissions occur when animal urine is deposited on pasture. This source may contribute as much as 14% of total annual greenhouse gas emissions in New Zealand. The mechanisms which give rise to this contribution have not yet been clearly identified, and further research is needed to both clarify this and to confirm the contribution. The nature of this source of emissions, and New Zealand's livestock management systems, means that control over nitrous oxide emissions from animal wastes may be very difficult to obtain. For these reasons, it is considered unlikely that any control will be gained over this source in the short term. Research findings will dictate whether it is practicable to manipulate animal waste disposal practices so as to reduce nitrous oxide emissions in the medium to long term.

71. Arable farming and horticulture

If the proportion of existing farmland used for arable farming and horticulture could be increased, this would reduce the area of land occupied by livestock emitting methane and nitrous oxide and, depending on the crop (e.g. if tree crops were used), might also enhance the carbon sink. Research is required to determine whether any net benefit would accrue (in terms of gas emission reductions) and, if so, what management systems would provide the maximum net benefit. It should be noted that an increased use of nitrogen fertilisers (a source of nitrous oxide emissions) and pesticides is often associated with these land uses, that both tend to involve a high degree of mechanisation, and that carbon dioxide emissions are known to occur from some arable farming systems.

Both arable farming and horticulture are capital-intensive land uses, and have specific site requirements, placing restrictions on further expansion. The area of land potentially available for arable farming and horticulture in the future will also be influenced by any climate change which occurs. Market forces will continue to be the dominant factor guiding decisions on land use.

It should be noted that the use of certain mechanisms to implement this option (e.g. regulation) could have significant implications for Maori in the context of Treaty of Waitangi responsibilities.

In view of the matters discussed above, this option is not likely to make any contribution to the reduction of gas emissions in the short term.

72. Nitrogen fertilisers and lime

It may be possible to reduce greenhouse gas emissions associated with the use of nitrogen fertilisers and lime by modifying either the products or the existing use patterns.

Nitrogen fertilisers are used mainly in the growing of arable and horticultural crops in New Zealand. There is also a limited amount of use in some pastoral systems to stimulate pasture growth at times of the year when symbiotically fixed nitrogen

(i.e. that which is accumulated by legumes and subsequently made available to other plants) is not available in sufficient quantities to meet crop demands.

Nitrogen in the soil (derived from both fertiliser and legumes) can be lost to the atmosphere in the form of emissions of nitrous oxide and other nitrogenous oxides. Research has indicated that there are chemicals that can be added to nitrogen fertilisers which suppress the conversion of plant-available nitrogen to "harmful" gaseous forms. There are also forms of nitrogen fertilisers available that release nitrogen more slowly, with the aim of reducing losses from the soil system. These latter types of fertiliser have additional environmental benefits such as reducing nitrate leaching to groundwater.

It is estimated that the contribution made by nitrogen fertilisers to the total soil-nitrogen pool in New Zealand primary production systems is approximately 3% of that which is contributed by symbiotically fixed nitrogen. The relative contribution of fertiliser nitrogen to total annual nitrous oxide emissions in New Zealand has not been determined, however it is considered likely to be relatively small (in comparison with that associated with symbiotically fixed nitrogen), given its apparently minor role in contributing to the soil-nitrogen pool. As such, neither modifying existing use patterns nor the product may be effective in achieving significant direct reductions in nitrous oxide emissions. Further research is however required to confirm this.

Lime is applied to soil in agriculture to raise soil pH levels. This can have a range of beneficial effects for crop production. Carbon dioxide emissions occur as calcium carbonate from the lime reacts with acidic soil colloids. The magnitude of emissions from this source has not been determined. Further research is needed before any conclusions can be drawn about the practicability of modifying either existing use patterns or the product in seeking to reduce carbon dioxide emissions from this source.

Aside from direct gas emission reduction benefits, this option might provide a range of additional benefits, including *indirect* greenhouse gas emission reductions. For example, reducing the use of nitrogen fertilisers and lime would also lead to a reduction in emissions associated with the manufacture of these products (although research is needed to determine the significance of this), and would help improve the sustainability of agricultural ecosystems. Alternatively, use of slow-release nitrogen fertilisers might also help reduce nitrate leaching to groundwater (in addition to possibly reducing gas emissions). Attention should be given to these factors when evaluating this option.

73. Soil conservation

There is evidence to suggest that carbon dioxide emissions may be enhanced in areas of cultivated, exposed, and/or eroding soil. It is also known that methane and nitrous oxide emissions are produced from soils which are waterlogged.

Information and advice about soil conservation and "wise" soil management generally (particularly in regard to primary production systems) has long been provided by Government agencies in New Zealand, and public acceptability of its value in maintaining a variety of environmental, social, and economic values is well established. This acceptance could be built on to incorporate the greenhouse-related issues noted in the preceding paragraph. Although further research is required to determine both the relative contribution of this source to greenhouse gas emissions, and the relative effectiveness of various management practices in achieving emission reductions, the greenhouse-related merits of "wise" soil management (particularly in relation to the processes identified above) could be readily incorporated in existing advocacy programmes.

74. Domestic and municipal refuse disposal systems

Refuse disposal in New Zealand generally involves a combination of anaerobic decomposition (i.e. when waste is broken down in the absence of oxygen), aerobic decomposition (i.e. when waste is broken down in the presence of oxygen), and burning, based on simple sanitary controlled landfill techniques. Emissions of methane, carbon dioxide, and possibly also nitrous oxide result from this decomposition process, with methane accounting for approximately 75% of total emissions.

It is believed that this source provides approximately 3% of total annual greenhouse gas emissions in New Zealand at present. Landfill gas quantities are expected to increase in the short term (owing to an increase in the quantity of waste being deposited in landfills which provide conditions that are more conducive to gas production and which have no gas control measures).

Concern over the increasing level of nuisances associated with landfill operations in New Zealand, along with a growing awareness of the need to prevent environmental degradation and provide greater public involvement in landfill siting, has led to an improvement in management standards over recent years. There is also evidence of a growing interest in capturing and utilising gas produced by landfills.

There are a range of additional potential benefits to be gained from *reviewing* existing refuse disposal techniques, including energy and materials savings associated with recycling of such products as paper, glass, metal, and plastics. In combination, these factors could be expected to make a positive contribution to sustainability.

The modification of existing refuse disposal systems is regarded as being a practicable and desirable option to pursue in the short to medium term, although the need for research into alternative disposal techniques and the costs involved in establishing new plants and/or modifying existing plants may mean that emission reductions will not be achieved in the short term. Refuse disposal is already regulated, and the new resource management legislation could be used to ensure that waste handling and disposal systems were fully "environmentally friendly".

The development of a suitable infrastructure to complement any move to a more comprehensive municipal/domestic waste handling and disposal system would be an important component in the success of this option (e.g. the development and use of facilities for the recycling of "waste products" such as paper, glass, and plastic).

75. Sewage treatment and disposal systems

Sewage may break down in either the presence or absence of oxygen (depending on the type of treatment and disposal system), which results in emissions of carbon dioxide and methane respectively. The degree and type of treatment that human-derived sewage receives in New Zealand tends to be related to the population size served (since establishment and operating costs must be met by rates) and the site characteristics.

The relative contribution of this source to total annual greenhouse gas emissions in New Zealand is unknown, however it is considered unlikely that methane emissions would be significant because of this country's small population and the low

number of systems in which oxygen is absent. Further research is required to determine the significance of this source in terms of gas emissions, and hence the value of reviewing existing sewage treatment systems to achieve direct emission reductions.

It should be noted that in some larger scale anaerobic digestion systems (where waste is digested in the absence of oxygen) the methane gas produced is captured and used as an energy source to run part of or the whole plant. For example, in Christchurch methane is used for electricity generation, as fuel for stationary engines driving pumps, for running a fleet of vehicles, and as fuel for the plant's boilers. In this way, not only is the methane captured and prevented from release to the atmosphere, but there are also *indirect* emission reduction benefits associated with the elimination of fossil fuel use in energy production. Smaller anaerobic "biogas generators" operating on much lower volumes of waste (e.g. farm scale) are also available in New Zealand.

In summary then, although the significance of this source in terms of direct greenhouse gas emissions is currently unclear, there appear to be a range of other potential benefits to be gained (including indirect gas emission reductions) from reviewing existing sewage treatment and disposal systems. Such a review would enable other social and environmental matters which are not currently being addressed to be taken into consideration (e.g. recognition of Maori attitudes towards sewage disposal).

Sewage treatment and disposal is a regulated activity, which may make this option more suitable for implementation. As such, an initial response may be to commission an investigation into the likely magnitude of gas emissions from this source (both direct and indirect), and the potential for reducing these emissions (e.g. through the capture and use of gases emitted directly). Cost is likely to be a major factor influencing the time horizon for achieving benefits with this option.

76. Industrial processes

There are a number of industrial processes in which greenhouse gases are given off, other than through the use of fossil fuels as an energy source. Some examples are:

- the production of burnt lime for use in road construction and agriculture, which results in carbon dioxide emissions;
- the production of cement involves burning lime, which results in carbon dioxide emissions;
- the production of aluminium involves the use of carbon electrodes, and carbon dioxide is given off in the course of the process;
- the production of steel involves the use of coal as a source of carbon for reducing iron oxide to iron metal, and the use of lime in the production of slag - both processes giving rise to carbon dioxide emissions.

While each individual source may not make a major contribution to greenhouse gas emissions relative to other sources, the cumulative contribution is more significant. For example, cumulative carbon dioxide emissions from the above sources alone are estimated to contribute approximately 4% of New Zealand's total annual greenhouse gas emissions, *excluding* that which is derived from the generation of energy.

Although contemplating a reduction in the production of these and many other manufactured goods on the basis of greenhouse arguments alone is not likely to be well accepted for economic reasons (particularly in the absence of substitute products), two alternative approaches to reducing gas emissions from this type of source are to either: (i) review existing production technologies; or (ii) investigate alternative more "greenhouse friendly" products to meet the same needs. Because both manufacturers and the general public may stand to benefit from either of these approaches (manufacturers because of the growing concern about "environmentally- unfriendly" products, and the general public because of the implications of climate change), such an option could be jointly funded by both parties. Such research could also seek to address other environmental issues associated with the particular production process (should any exist). The identification of "significant" contributing industries is a fundamental information need.

If cooperation between industry and the public sector can be achieved, then this option could be regarded as practical to pursue in the short to medium term. However, because of the amount of research involved, and the costs associated with converting existing industry/developing new plant, it is considered unlikely that this option would have any significant influence on greenhouse gas emissions in the near future.

3.4 Discarded Options

The following options were initially considered, but were subsequently discarded on the basis that their potential contribution to reducing greenhouse gas emissions was likely to be insignificant:

- reduction of silage production;
- reduction in the burning of agricultural and forestry waste;
- reduction in the extent of asphalt use, or modification to the composition of asphalt.

3.5 Criteria for Evaluating Limitation Options

In evaluating options to limit greenhouse gas emissions it is useful to have a set of criteria against which options can be measured to achieve the best practicable outcomes. It is important to note that "baskets" of limitation options would be envisaged due to the complementary nature of many of them and because limitation and adaptation options are also complementary in nature.

Criteria that could be employed in developing and evaluating the limitation "basket" of options are:

- Level of reduction of greenhouse gas build up;
- Significant additional benefits;
- Costs:
  - costs to Government;
  - costs imposed on sections of the community;
- Cost effectiveness:
  - ratio of costs involved compared to the level of reduction of greenhouse gas build up;
  - ratio of costs involved compared to the total benefits achieved;
- Level of uncertainty relating to costs and benefits;
- Practicability;
- Timing:
  - significance in the long term;
  - ability to be implemented or reduce emissions in the short term;
- Ability to safeguard against future increases in emissions;
- Implications for sustainability;
- Implications for the Treaty of Waitangi (see box below)
- Implications for the growth of the economy;
- Implications for New Zealand's international relations and trade.

Submissions on the appropriateness of such criteria or any additional criteria would be welcomed.

Options that Have Implications for the Treaty of Waitangi and Maori Spiritual and Cultural Values

One of the guiding principles behind the policy options presented in this publication is that policy must not conflict with or compromise the Treaty of Waitangi. All policy options must therefore be examined in terms of the text of the Treaty. This examination requires the involvement of both parties to the Treaty. The following includes a preliminary (and very general) identification of options which could have implications in terms of the Treaty, and would therefore require further analysis. Further implications with respect to the Treaty and Maori spiritual and cultural values will no doubt be identified as the policy process continues.

Article 1 of the Treaty provides the Government with the constitutional right to govern the country and to develop policy such as that of the Climate Change Programme. Article 2 qualifies this by affirming te tino rangatiratanga of the chiefs and hapu over their lands, villages, and all their taonga. "Tino rangatiratanga" includes the concept of hapu and iwi authority and control over their resources. "Taonga" includes tangible and intangible things of cultural or spiritual value. The Waitangi Tribunal, in its Muriwhenua Report (p. 183) explains the Maori text like this:

> **"Though Maori had no concept of ownership as Westerners understand it, in understanding the Maori text in Western terms, full ownership is necessarily implied. They excluded from their important properties, all those outside the kinship group. Maori ranked these properties much higher than mere commodities, holding them with profound spiritual regard for a vast family, of which many are dead, few are living, and countless are still unborn".**

The policy options for which the rangatiratanga provisions of the Treaty have significant implications include:

- **all options affecting the use of energy resources which hapu or iwi have an ownership interest in (including resources which are the subject of claims before the Waitangi Tribunal or direct negotiations between iwi and the Crown, for example, geothermal, coal, oil, and gas);**
- **all options which could have the result of increasing demand for hydro-electricity (the Wanganui River case currently before the Planning Tribunal provides a good example of the need to recognise Maori spiritual and cultural values regarding water, and the impacts of reduced river flow on those values);**
- **all options affecting the use or management of land and forests (this is directly related to hapu and iwi control of their own resources, and input into how other resources are managed);**
- **all options which could have adverse impacts on physical, cultural, or spiritual aspects of water quality, for example, options relating to stormwater or sewage disposal;**
- **all options which would be implemented at a community level (recognition must be made of the hapu as a fundamental organising unit of Maori society).**

Article 3 of the Treaty relates to equity - it guarantees to Maori the same rights and duties as British citizens. Any policy options which could have equity implications will therefore need to be analysed for their impacts on Maori. For instance, the use of economic instruments for the implementation of policy can exacerbate existing inequalities and create new ones. The requirement for equity in education implies that all policy options which involve the dissemination of information should consider how the information can be disseminated in a culturally appropriate way.

In conclusion, if the Government, as a result of the consultation process initiated by this discussion document, decides to implement any of the policy options identified, it is obliged by the Treaty to ensure that its policies:

- **make positive recognition of rangatiratanga;**
- **provide for active protection of taonga;**
- **address equity issues.**

For these obligations to be met requires that the policy options be examined and developed by both parties to the Treaty.

4. Adapting to Climate Change

Section 3 of this document outlines options for limiting greenhouse gas emissions. However, even if all non-natural emissions of greenhouse gas were to be stopped immediately, climatic changes might continue for many decades. The extent of the changes, and the time span over which they are likely to continue, will depend on the effectiveness of limitation strategies and the speed with which they are adopted throughout the globe.

Section 4 discusses how New Zealand might cope with the environmental changes that could result from global warming. The section is divided into four parts:

- discussion of adaptation processes,
- identification of measures that will help this process,
- discussion of the actions that may be required on a sectoral basis,
- criteria for evaluating adaptive responses.

4.1 What Is Adaptation?

Adaptation refers to the ways that people modify their activities to take environmental conditions into account. It reflects culture, society's needs, and environmental conditions. Adaptation to the environment is a process that takes considerable time as communities build knowledge about their environment and modify their activities accordingly. Moreover, it is an ongoing process, as societies and economies change for a whole range of non-environmental reasons.

When we refer to *adaptation to climate change*, our concern is with how people may alter the usual processes of environmental adaptation in order to accommodate the impacts of climate change.

Processes of adaptation

There are two requirements before individuals and decision making bodies can consider adapting to climate change:

- **Awareness of impacts.** This may result from "predictions" or from direct experience. "Predictions" are often published in reports or presented at conferences. It is most likely that this information will be relayed to the wider public through newspapers, radio, and television. Often the information is "interpreted" in such a way that its meaning or balance is altered. Extreme "predictions"often make headlines, while the caveats outlining the degrees of uncertainty associated with them are omitted.

  We do not yet know if climate change impacts are occurring. However, many people attribute unusual weather and extreme events to climate change, even though similar events may have occurred in the past. As a result they may respond in a way that is different from before.
- **Knowing how to respond**. Some responses may be intuitive or developed by decision makers on their own account. For example, a family may decide to sell a waterfront property that they perceive to be at risk and to move inland. But information about many adaptive responses will not be available at the individual level. People may not know about them; understanding some responses may require specialist skills; other responses may not yet be developed. To date, these issues have received little media coverage.

Taking action

Based on their understanding of the impacts and possible responses, individuals, families, business enterprises, and social groupings will take adaptive action where they are able to do so, and, where they perceive this to be in their interests.

This description of adaptation to climate change implies a relatively simple and smooth process. However, it is unlikely to happen in such a satisfactory manner, for a number of reasons:

- decision makers may have limited or faulty understanding of impacts and/ or possible adaptive responses,
- adaptive actions taken by one individual or group may not have benefits for others (for example groynes built to stop beach erosion at one site may cause erosion elsewhere),
- the needs of future generations may not be taken into account,
- there may be cultural constraints (for example, moving away from ancestral lands may not be an option for Maori),
- individuals and communities may not have the resources available to undertake the most desirable adaptations,
- it may be inefficient to implement certain types of adaptive option at the level of individual or community.

Role of government

Despite these problems, people will respond to climate changes as best they can and as they see fit. Government (at each of the local, regional, and central levels) has an interest in ensuring that this process is conducted in an equitable and efficient manner. There are three broad areas of possible government involvement in the adaptive process:

- helping the adaptive process by improving understanding of impacts and response options, and disseminating this information to decision makers,
- providing assistance where individuals, communities or "lower" levels of government do not have sufficient resources to respond effectively,
- ensuring that social, economic, and environmental outcomes determined to be desirable by government are achieved. This may include establishing criteria to assess adaptive responses.

Costs of adaptation

- **A multitude of impacts.** If we take all locations, all animal and plant species, as well as human activities and valued property, it soon becomes apparent that there are a huge number of possible impacts from climate change. In aggregate, the costs of adapting to climate change may be very high.
- **When will adaptation cease to be necessary?** If limitation strategies fail to control greenhouse gas emissions adequately, adaptive actions will not be "one off" events. Some responses will constantly need to be re-evaluated and periodically upgraded or modified. Many responses will require ongoing maintenance. From this perspective, climate change may pose large and growing costs on future generations.
- **Who pays?** The costs of many of the incidental and small scale adaptations that take place will fall on the individuals and communities that enact them. Where the costs of adaptation are very high and individuals lack the resources to take appropriate action, assistance may be necessary.

  One means of funding adaptation may be through charges against greenhouse gas emissions, a form of the polluter pays principle.

Types of Adaptive Response

There are three main ways in which we can respond to the effects of climate change:

- ***Do nothing:*** **In reality this type of option is in effect a decision to wait before doing something. The wait may be until the impact occurs and the response will be forced; or it may be until there is greater certainty regarding the outcomes of climate change. The latter approach carries with it the possibility that impacts will occur before there is deemed to be sufficient certainty upon which to base actions.**
- ***Modify the environment to reduce impacts or enhance benefits:*** **Some adaptations will seek to buffer people from the changes. For example, structural measures, such as sea walls, stopbanks, or changes in design standards for such structures as sewage outfalls or bridges, may serve to offset changes in the physical environment such as flooding and sea level rise brought about by climate change. If climate change is not limited, and it may be some time before total limitation is achieved, if at all, there will be a continuing need to redesign structures to cope with the ongoing change.**

  We may also use biological measures to reduce the impact of climate change on people. For example, afforestation of catchments may reduce peak flood flows and erosion rates; and genetic development of species or varieties better suited to expected conditions may enable certain agricultural activities to continue.
- ***Modify people's activities to reduce impacts or enhance benefits:*** **Rather than fighting the changes that take place, people may seek to live with them. Land use planning may enable avoidance of areas likely to be rendered more flood prone or liable to coastal erosion. In such areas that are already occupied, improved warning systems and public awareness of personal responsibilities for when disaster strikes may also be necessary. Methods of managing our resources may also need to be altered. For example, shortening rotations of forests may enable greater yields to be gained, and some annual crops may be able to be planted earlier where spring weather conditions improve.**

4.2 Measures That Will Help the Adaptation Process

77. Greater certainty about climate change

Most scientists agree that global warming will occur, but there is less consensus about likely rates of change and changes to other climatic variables. The key to improved understanding is through modelling the global climate - a very expensive process. Currently modelling work is being carried out in Australia, with New Zealand participation. Obtaining output that is pertinent to New Zealand will depend on the level and commitment of New Zealand involvement.

For successful adaptation, it will be necessary to know what the impacts will be at specific sites. Information about climate change at the regional level within New Zealand will also be necessary.

- **International scientific liaison.** The participation of scientists in international projects and conferences on climate change will help New Zealand keep abreast of major developments in understanding climate change processes. In particular, cooperation in global work on modelling climate change and cooperation in South Pacific regional modelling incorporating New Zealand is of great importance. Indigenous knowledge should not be overlooked, and there is a need for the involvement of tangata whenua in conferences and international networking on climate change.
- **Climate change research.** Continued research into climate change by New Zealand scientists is necessary. From this perspective there is a need for continued monitoring (see section 6) and the improvement of historical climate records.
- **Regular climate change updates.** As new climate change findings at the global level come to hand it is important that their implications for New Zealand are investigated and, where possible, translated into descriptions or scenarios of possible regional impacts within New Zealand.

78. Further impact studies

The Impacts Working Group stresses the lack of certainty and detail in its scenarios of climate change effects. To a large extent, improved understanding of impacts will depend on there being greater certainty about climate change. But there is also a need to understand better the links between climate and other environmental factors, as well as economic and social activities.

- **National impact studies.** As more detailed and certain information about climate change becomes available there may be a need to review or update the existing impact work.
- **Sectoral impact studies and climate sensitivity studies.** There is a need to identify further the relationships between climate and species and between climate and economic activities. Our understanding of climate change impacts on some sectors is still weak, and a major priority is better understanding of the links between likely climate impacts and social and economic processes.
- **Regional impact studies.** There will be a need for regional studies to identify impacts in greater local detail than national studies would identify. In most instances the "unit of impact" and "unit of adaptation" will be at the local level where issues such as how a specific beach responds to rising

sea level, how the climate of a single valley used for a certain type of agriculture changes, what happens to the flood regimes of individual rivers, and what the impacts are on any particular small town faced with changing agriculture in its hinterland are important.

79. Monitoring

Monitoring will help us confirm the nature of "postulated" impacts and give us a better understanding of the rates involved in the change. This will enable planners to have more accurate indications of when adaptive strategies should be implemented, and of what type of strategy is likely to be appropriate.

- **Tangata whenua.** The New Zealand environment has been monitored by the tangata whenua since long before the arrival of the earliest European explorers. Maori traditional forms of knowledge and lore provide a valuable source of information on past and ongoing changes to the environment. In attempting to clarify further impacts arising from climate change, Maori traditional forms of knowledge should be accepted, along with conventional scientific methodologies. There is a need to develop culturally acceptable ways in which this knowledge can be used. (Refer to Section 5, Adapting to Climate Change, by the Maori Working Group.)
- **National monitoring network.** There would be considerable duplication if the responsibility for monitoring were to lie at the regional or local level. One approach is to establish a network of key indicators for monitoring climate change in New Zealand. In addition to identifying key indicators of change, it will be important to develop appropriate measures which are sensitive to the changes that are likely to occur.
- **Local and regional monitoring.** There will also be a need to monitor change at the local level - the beach, the river, the valley, or the town. This will assist decisions on specific impacts.
- **Current monitoring activities.** The monitoring of climate change impacts need not be based on new activities. Where monitoring programmes already exist they should be utilised.
- **Monitoring decisions.** In deciding what are the main components of a national programme for monitoring climate change impacts, it may be appropriate to establish an official group representing tangata whenua, scientists (climate and impacts), and those likely to be responsible for initiating responses (e.g. local government).

80. Developing and evaluating adaptive responses

Development of responses will require money, facilities, scientific skills, and means of evaluation and testing. In many instances, even if implementation of responses is appropriate at the non-governmental level, there will be a need for government involvement at the development or evaluation stage.

- **Evaluation of existing adaptations.** There is a need to know to what extent current processes of adaptation will be appropriate under the changing conditions that are anticipated. This work would also enable the identification of key areas where further development of adaptive options is necessary.
- **Development of adaptive options.** Many activities that may be envisaged under this heading may already exist, but with different aims and goals. An example is genetic development of crops to improve productivity, which may also help develop strains more suited to new conditions. The costs of developing new options may be high.
- **International liaison and evaluation of overseas options.** It may be that as a result of climate change some areas of New Zealand will become similar to existing areas overseas. Evaluation of overseas responses may yield useful ideas for application in New Zealand. There is also likely to be an international effort to find ways of accommodating changing environmental conditions. New Zealand will have an interest in the outcomes of this work and, where applicable, may contribute to it as well.
- **Decision making methodologies.** Because climate change is unpredictable there are likely to be a number of difficulties in assessing relative costs and benefits. Methods for making decisions under conditions of uncertainty need to be identified and disseminated.

81. Dissemination of information on likely impacts and responses

The purpose of information dissemination is to ensure that decision makers are aware of the likely impacts and the adaptive responses which they might choose from. There will be a need to target audiences according to the type of decision making activity they are engaged in.

- **Dissemination of information about climate change processes.** With the wide disparity in public reporting on the greenhouse effect there is a need for people to be provided with a balanced view of scientific developments as they come to hand. An awareness of the processes will help decision makers place "predictions" about impacts in context.
- **Dissemination of information about impacts.** Decision makers will need to have knowledge of how their lives, businesses, or other responsibilities may be affected by change. Information from impacts studies and monitoring should be made generally available and accessible, including being presented in non-technical language. There will also be a need to disseminate information on impacts to specific sectors and localities. Clear ways of presenting the degree of uncertainty associated with the information that is disseminated will also need to be developed.
- **Dissemination of information about responses.** There will be a need to target audiences based on the types of response. Examples include the general public, farmers, engineers, planners, and developers.

4.3 Sectoral Responses

Section 4.3 lists examples of possible responses, on a sectoral basis, but is intended to be indicative rather than exhaustive. Impacts will vary greatly from place to place, and in many instances responses will differ according to location.

82. Natural ecosystems

The Impacts Working Group found that natural ecosystems are likely to be most vulnerable to climate change. Natural species may be directly affected by changes in climatic conditions, or indirectly through changes in habitat. In addition to the value of natural ecosystems in their own right, impacts upon them may also affect patterns of human recreation. Responses to climate change in managing nature fall into three categories:

- **Management of threats to nature.** Measures to reduce the effects of change on natural ecosystems may include:
  - managing water levels and flows,
  - managing animal and plant pests,
  - managing fire and erosion risk.

There may be a need to determine critical areas for protection.

- **Making new habitat available.** Where change cannot be prevented it may be necessary to relocate species according to their climatic and other environmental requirements. This option raises a number of issues.
  - land and water resources will have to be allocated for new uses, and perhaps at the expense of the existing activities that they support,
  - the choice of new locations will have to take into account the fact that climate change is likely to continue, and therefore query to what extent, or for how long, the new habitat will be sustainable,
  - the means of relocation needs to be considered. Species may be directly relocated as in tree planting programmes, or they may be left to migrate where possible. This process may be enhanced by setting aside land as wildlife corridors or safe migration routes.
- **"Emergency" responses.** There may be a need, where species are endangered and other measures are not practical or are failing to succeed, to establish gene banks and seed sources (nurseries).

83. Agriculture

The main effect of climate change on agriculture will be a southward and upward shift in agricultural zones. As a consequence, some areas will no longer be suited to their current activities. Other areas may find themselves better suited, or new opportunities may arise. The patterns of extreme events such as drought and flooding may also change. There is a need to identify the most vulnerable crops and activities through sensitivity studies and by mapping shifts in agricultural zones. This will enable targeting of areas and activities where responses will be necessary. Most of the changes that will need to take place will be at the level of the individual farms or the industries that support them.

- **Greater diversity of farming systems.** Mixed farming with a range of crops, including crops with wider environmental tolerances and newly introduced ones that may be more compatible with changed conditions, reduces the vulnerability associated with dependence on a single crop.
- **Relocation.** There may be a need for a shift in the location of various types of agricultural activities. In general this shift will be southward and to higher altitudes. Identification of areas best suited for relocation will be necessary, while taking into account that conditions will probably continue to change.
- **Change timing of activities.** Climate change may result in warmer conditions and longer growing seasons. Farmers may take advantage of this by changing the timing of planting of annual crops or of livestock operations such as lambing.
- **Pest and disease control.** Changes in climate may lead to a number of plant and animal pests that were not normally found in New Zealand. Others that are already here may be favoured by warmer conditions. There may be a need for increased border surveillance, and increased control on the farm. The environmental implications of some measures may need to be taken into account.
- **Long term adjustment of agricultural infrastructure.** As agriculture changes in response to climate change there will be a need for accompanying changes in the infrastructures and industries that support, or are based on, agriculture in different regions.

84. Forestry

Climate change may result in increased productivity of forests. It is possible that competitors on world markets will also increase their production. The forestry industry may be adversely affected by new pests, diseases, and weeds, or increased activity from such problems with these that currently exist. In addition, the likelihood of more tropical cyclones reaching New Zealand may result in serious losses from wind damage, while increased frequency of droughts in eastern areas may increase risk of forest fires.

- **Shorter rotations to take benefit from increased growth rates.** If yields increase it may be possible to shorten the rotations of forests so as to enable more frequent harvesting. The implications with respect to wood quality are however not yet fully understood.
- **Planting new species or varieties.** Given the relatively long rotations involved in forestry, accommodation of new species or varieties may be achieved with little disruption.
- **Disease, pest, and weed control.** This may be achieved through changes in management practices, the use of sprays and pesticides, monitoring programmes, and border control. The costs of these activities may be significant.
- **Reducing fire risk and dealing with wind throw.** Gains in productivity may also be offset by increased fire and wind throw risk in some areas. Implementation of management practices to reduce these risks may be necessary.

85. Coastal management

One of the most commonly discussed consequences of climate change is rising sea level. Other important influences on the coast which may also be modified by climate change include the direction waves come from, storminess, and sediment supplies. Consequences of climate change for coasts include increasing erosion, increased incidence of coastal flooding, and inundation of some areas. Response to the coastal effects of climate change may be grouped into three broad areas:

- **Avoidance of vulnerable areas.** These measures reduce the potential for losses by modifying people's behaviour and activities. There are many ways in which the avoidance option can be applied, including:
  - Limiting future development in vulnerable areas,
  - Compensation for damage to existing structures,
  - Abandonment and resettlement.
- **Protection from change.** Where levels of investment are very high, where coastal resources are highly valued, or where there are large population concentrations, there may be a need to protect existing settlements from the changes that are taking place. This may be achieved through the application of "hard structural" options such as dykes, seawalls, groynes, breakwaters, and the like, and "soft structural" measures such as beach replenishment and dune building. Many structural measures may be of considerable cost and may become inadequate if climate change is not sufficiently countered and sea level continues to rise.
- **Living with change in vulnerable areas.** Where the costs of protection are prohibitive and abandonment is not practical, it may be necessary to develop strategies to enable continued occupation in a manner that is consistent with the changes that take place. Examples of such strategies include: elevated buildings (perhaps with standards for minimum floor levels); infrastructure modifications, such as raising piers and wharves, bridges, transport links and altering drainage systems; the use of salt-tolerant crops

where salinisation occurs; and appropriate civil defence and recovery strategies for areas that are likely to be exposed to frequent flooding. In addition, there may be a need to review laws on riparian rights in areas where rapid erosion is taking place.

86. Water management

Water resources impinge on a number of sectors of economic activity, including electricity generation, urban and industrial water supply, drainage and sewerage, irrigation, waste disposal, and flood hazard management. The impacts on these activities are likely to be highly variable. Floods may cause more severe disruption more frequently, irrigation may become more necessary and more costly in some areas, and in many areas impacts on water supply may be largely beneficial, with the main exception being those areas dependent on groundwater supplies in coastal areas. Drainage systems may also become inadequate in the face of increased storm runoff.

- **Water supply.** In many instances water supply may be enhanced because of increasing rainfall. However, in those areas where droughts are likely to become increasingly common and severe, increased reservoir capacity may be required. Where communities are dependent upon groundwater supplies that may become prone to saltwater contamination, new sources of supply may be required.
- **Management of extreme events.** Measures that may be incorporated to enable communities to cope with extreme events include:
  - land use zoning to avoid areas that are likely to become prone to increased frequency or severity of flood events,
  - increasing public education to provide the population with skills to survive disasters caused by extreme events,
  - maintaining and, where necessary, improving warning systems.
- **Irrigation.** In areas where droughts may occur with greater severity and magnitude, irrigation schemes may need to be initiated or upgraded. There may be instances where the costs of doing so are excessive, and land use changes may be necessary.
- **Skifield management.** Many skifields may be forced to close, while in others snowmaking facilities may be required. The costs of skifield operation may increase if relocation to higher elevations is necessitated.

87. Health

Climate change may affect health directly by causing heat stress (although cold related health risks may be reduced) and indirectly by creating conditions suitable for new diseases, including those carried by insects and animals and those related to the possible failure of health related infrastructure such as sewage disposal. Problems such as the latter may be dealt with in the way we manage water and coastal resources (see previous paragraphs), but there may be a need for specific adaptive actions as follows:

- **Border control and elimination procedures.** It is important that medically significant insects and animals are prevented from coming into New Zealand, and that those existing ones, which may flourish under the scenarios of changed climatic conditions, are eliminated, controlled or contained.
- **Education programmes to alert people to health risks and measures for self protection.** With a likely increase in periods of hot weather, there may be a need for people to be informed as to how they may best cope. Such information may be targeted at "at risk" groups such as the elderly, and may be combined with adequate warning systems.
- **Air pollution control.** In areas where air pollution may increase as a result of climate change there may be a need to control emissions of air pollutants further.

88. Social Impacts

The social impacts of climate change are indirect, and at this stage are poorly defined. In particular, at the level of specific communities it is difficult to point out where impacts will fall.

However, there are some general considerations that may be taken into account:

- groups that are already socially and economically disadvantaged will be most severely impacted,
- change, in general, tends to disrupt communities,
- the speed of change is significant.

A number of measures may be undertaken to reduce the hardships that might occur to those who are negatively affected by climate change. These measures may include:

- Assistance with relocation and housing,
- Assistance in coping with unforeseen events,
- Strengthening of formal and informal support networks,
- Financial assistance to voluntary social services.

89. International considerations: refugees, trade, and aid

Impacts of climate change that take place outside New Zealand may also have indirect impacts upon New Zealand. These include increasing incidence of disasters, many of which will fall upon highly populous and poor nations.

Even slight changes in the productivity of primary industries in overseas nations may have significant effects on the markets in which New Zealand, in relative terms a very small player, trades. If our productivity increases, but is matched by similar overseas increases, any gains may be offset, or even reversed.

In the longer term, consideration may need to be given to the resettlement of "environmental refugees" from places rendered uninhabitable by climate change impacts. In the South Pacific region there is the possibility that atoll communities may be particularly at risk, and globally there are massive populations in prone areas such as the deltaic regions of Asia, including Bangladesh.

- **Increased foreign disaster assistance.** In the South Pacific region, where New Zealand has a prominent role in disaster relief, tropical cyclones may occur with greater frequency. There may be a need to reassess New Zealand's activities in this regard.
- **Monitoring international trade.** There will be a need to monitor production and trade trends in those commodities that New Zealand produces and which may be affected by climate change.
- **Development of immigration policy on environmental refugees.** New Zealand may choose to accept people displaced by climate change impacts, especially those from neighbouring countries. An international agreement on countries' obligations to accept environmental refugees could be drawn up in order to ensure recipient countries assumed a fair share of the burden. There would be a need for the involvement of tangata whenua in the development of such policies.
- **Development of social support systems for refugees.** While systems exist for assisting political refugees in New Zealand, they would need to be significantly expanded and modified if New Zealand were to accept large numbers of environmental refugees who might have special and costly needs such as health care.

4.4 Criteria for Evaluating Adaptive Responses

Not all possible responses will be beneficial, and some may be counterproductive. A number of criteria may be used to evaluate adaptive options.

Effectiveness

The adaptive action must serve the purpose to which it is aimed, whether to reduce climate change impacts or to ensure that any opportunities can be maximised. This requires careful consideration, as initial options may prove on closer examination to be inappropriate.

In assessing the effectiveness of the responses it is important to consider the long-term outlook, especially with respect to the likelihood that climate change may continue for some time yet. For example, building stopbanks to protect areas from increased flood heights may encourage further development in areas that may be subject to even greater flood levels in the future.

Non-climate-change benefits

Adaptive measures that would yield positive outcomes irrespective of climate change are especially attractive, given the uncertainties that exist. In general terms, measures that promote sustainable development of resources and reduce environmental vulnerability fall into this category.

Responding to multiple impacts

There may be a number of impacts where similar adaptive responses may be appropriate. Where this is so, the feasibility of combining responses needs to be considered. For example, adjusting or extending current border control policies may serve as a response to problems of introduced pests and diseases in a number of sectors, including health, forestry, agriculture, and conservation.

Costs of adaptation

The costs of adaptive options will vary greatly according to the scale of the response and the nature of the impact being adapted to. However, because of the great uncertainty relating to the costs of impacts of climate change (i.e., if we "do nothing"), and because the costs may well be greater for future than for contemporary generations, it is extremely difficult to compare the costs of adaptation against the costs of impacts.

Many responses will be extremely expensive. Abandonment of land affected by sea level rise, or of farms that have become unproductive, are responses that may involve massive individual costs. However, protection of the same land by engineering works may also be extremely expensive for local or regional governments to carry out.

Environmental implications

Many adaptations to climate change may incorporate physical measures that seek to modify the character of the change. There is a need to ensure that these measures are environmentally acceptable. For example, the construction of groynes may preserve a beach in one area while hastening coastal erosion further along the coast; and increased use of sprays in response to new pests may result in increasing concentrations of chemicals in natural ecosystems.

Treaty implications

Adaptive responses to climate change should not be in conflict with the Treaty of Waitangi. As many impacts are related to the natural ecosystem, water resources, and the coast, many adaptive responses are likely to have Treaty implications.

For example, protection of land from sea-level rise may result in loss of wetlands and their associated aquatic resources, which may be highly valued by the tangata whenua. On the other hand, there will be a need to consider non-market values when assessing the need to protect land which is culturally significant.

Social implications

The Impacts Working Group concluded that many of the impacts of climate change would fall most heavily on those sections of the community who were already disadvantaged and lacked the resources to respond themselves. Many adaptive options may themselves result in adverse social outcomes. These may include problems associated with unemployment, relocation, or exposure to deteriorating living conditions - such as may result from increased experience of flooding.

Non-climate-change policy development

There is a need to avoid increasing our vulnerability to likely climate change impacts. Many decisions and actions are being taken, and will be taken, that do not take the likelihood of climate change into account. There may be a need to review procedures at government level to ensure policy development considers this likelihood where appropriate.

5. Adapting to Climate Change - Maori Perspectives
Prepared by the Maori Working Group

5.1 Introduction

Change and adaptation to change is an integral part of Maori history. The oral tradition of creation tells of a universe of constant change, which Maori Marsden (1988) describes as "a world comprised of a series of interconnected realms separated by aeons of time from which there eventually emerged the natural world". From the creation of the natural world and the arrival of Iwi Maori in Aotearoa, to the arrival of European settlers over the past 150 years, adaptation to change has become a major aspect of contemporary reality for Maori. In the course of Maori presence on this land, Maori have developed a detailed knowledge of the environment, and sensitivity to its many changes, through a close interaction with the natural world.

The Maori Working Group, in presenting the following policy options in response to climate change, has drawn on these two factors:

i) recognition of traditional forms of Maori knowledge, and

ii) recognition of iwi, hapu, and whanau.

The policy options presented are responses to potential changes which may significantly impact on Iwi Maori. In particular, the importance of coastal areas for the provision of kaimoana, the need for protection of native species, and the spiritual and economic significance of iwi or hapu links with ancestral lands and waters are recognised as areas which could be especially vulnerable to the impacts of climate change.

However, the policy options are not *solely* relevant and applicable to Maori. Nor are they just relevant to climate change. The Maori Working Group presents these proposals as having the potential to apply to all people of Aotearoa. The proposals would benefit Iwi Maori and the general population of Aotearoa, whether or not the postulated climate changes eventuated.

5.2 Policy Options

90. Development of comprehensive community systems of support

Climate change could bring a greater incidence of "extreme events" or natural disasters such as floods and cyclones. Even if the overall change in climate is minimal, it will be the extreme events which have the greatest impacts - environmentally, culturally, socially, and economically. As Maori experiences following the Edgecumbe earthquake and Cyclone Bola show, the local marae and the support offered by whanau groups are invaluable in the event of a natural disaster. From these observations, several policy suggestions flow:

- more formal recognition and resourcing of the role which already exists for the marae in civil defence,
- closer links between civil defence authorities and marae,
- looking at whanau as a model for the establishment of support groups in the event of natural disasters. Such groups would best be established on the initiative of the hapu, iwi or community concerned,
- educational efforts to inform marae-based groups and other support groups of natural hazards and potential responses to disasters (a community with greater awareness of likely impacts will be in a better position to respond).

91. Acknowledgement of traditional forms of knowledge and monitoring of environmental change

To respond adequately to change, we have to know what sorts of changes are happening, and anticipate them as much as possible. This requires close monitoring of the environment.

Often those people who will be the most effective monitors of the environment will be those who have local knowledge of a particular area, and a continuing interactive relationship with the area. Maori knowledge of the environment fits this pattern. A detailed base of knowledge is learned through interaction with the environment, and passed on through the generations. Many examples of this type of knowledge are included in the reports of the Waitangi Tribunal. For example, in the Manukau Claim (WAI 8, 1985), kaumatua recalled how the murky waters of the Manukau were once crystal clear and the thick mud once firm white sand. It was said that siltation was first noticed in the 1940s, when a creeping black sand started moving across the harbour. However, the Auckland Harbour Board had not noticed any marked sedimentation "at least in the navigational channels and the selected banks that it had surveyed", and scientists had not recognised the problem.

The Maori Working Group therefore recommends that monitoring be carried out in a very broad sense, with recognition and acknowledgement given to local and traditional knowledge of the environment. Coastal regions are identified as areas requiring a particular monitoring effort (for example, monitoring of coastal sand movements) because of their vulnerability to climate change. "Informal" mechanisms for monitoring could be established, whereby hapu, iwi and the general public are given the opportunity to report to a local or regional body on changes to the environment (for example, changes in the distribution or abundance of shellfish). This mechanism might take the form of a central collection area or network where anecdotal and other forms of information can be processed and analysed and fed into a monitoring programme in conjunction with scientific evidence.

92. Tree planting and catchment management

Tree planting is normally viewed as a "limitation option", that is, a policy option designed to reduce the build up of greenhouse gases. However, it can also be viewed as an adaptive option. Increased erosion and increased siltation are two postulated impacts of climate change. Tree planting is a land management practice that can help protect land from erosion, and thereby protect rivers and coasts from excess siltation. On the East Coast, land heavily planted in trees was subject to less damage during Cyclone Bola. Sensible soil conservation techniques are of benefit whether climate change is a factor or not, and can be encouraged at regional government level (for example, by provision of native seedlings, free of charge, to those wishing to plant trees on their properties) and through national or regional policy statements.

Linked to this policy option are the benefits of increasing awareness to broaden people's attitudes as to what are acceptable land use options. Maori have always held that land in bush or regenerating scrub is a viable land use option. Leaving land in regenerating scrub or bush has recently been recognised as an appropriate option in terms of limitation of greenhouse gases (Trees are a sink for greenhouse gases, and the land is not cleared and stocked with ruminants - a source of greenhouse gases.) It is also relatively recently that policy makers and planners have come to realise the value of this land use in terms of wise use of water and soil resources.

93. Protection of native species

There appears to be general agreement that native species could come under further stress as a result of climate change. Several factors contribute to this added stress, including inability of the species to adapt to changing conditions, better conditions for introduced weeds and other pests, disease, and habitat loss. Native species are taonga, and Article 2 of the Treaty of Waitangi applies. While the Treaty obviously cannot protect native species from climate change, it does place an obligation on the Government to ensure that these species are protected as far as possible from the impacts of climate change. It is also in the national interest that native species receive specific protection.

The concern of the Maori Working Group is that in responding to the potential impacts of climate change, resources (finance, research, etc.) will be concentrated on impacts of economic significance. This emphasis could occur at the expense of other affected areas of the environment and society which have a value that cannot always be measured in economic terms. The loss of taonga such as native species is an irreversible loss. Another species cannot act as a substitute (as, for example, replacement of kiwifruit by subtropical fruits in a horticultural area could). Loss of a species from the rohe of one iwi is as significant to that iwi as loss of the species nationally. Having raised this concern, the Maori Working Group recommends that research on native species of cultural importance be encouraged, particularly with respect to:

i) the resilience of those species to change, and

ii) increasing population numbers of endangered native species.

As an added measure for protection of native species and ecosystems, the impacts of climate change should be considered in policies and procedures for dealing with both:

- the deliberate importation of new species of animals and plants (for example, a new exotic species of prawn may not be able to survive in coastal waters at their present temperatures, but could survive if those waters warmed as a result of climate change), and
- the accidental importation of "pests" (which could establish more easily in a warmer climate).

5.3 Conclusion

The policy options discussed above are general in nature, but a number of common strands emerge from them. These are:

i) recognition of the validity of traditional tribal forms of knowledge of the environment,

ii) the need to develop policies which acknowledge alternative value systems not based solely on economic attitudes,

iii) implementation of policies and establishment of structures which enable hapu and iwi to exercise rangatiratanga.

From a Maori perspective, these strands are all concepts which are recognised in the Treaty of Waitangi. Recognition of the Treaty of Waitangi needs to be part of *all* policy proposals in the Climate Change Programme, and the Treaty, which affirms rangatiratanga, should be a criterion under which all policy proposals are analysed.

References

Marsden, Maori, 1988. The Natural World and Natural Resources: Maori Value Systems and Perspectives. Working Paper 29A. Prepared for the Resource Management Law Reform Core Group, Ministry for the Environment.

Waitangi Tribunal, 1985. WAI 8. Finding of the Waitangi Tribunal on the Manukau Claim.

6. Monitoring and Further Research

All policy responses to climate change that we can develop at this stage need to recognise the enormous uncertainty surrounding the problem. It is therefore vital that research and monitoring continue to help clarify the situation.

6.1 Further Research

There are many uncertainties in the collective knowledge on climate change, as identified in this report. This makes policy development difficult, but highlights the need for ongoing research accompanied by the continual updating of policy needs.

Not only are there uncertainties in the estimates of the amounts of greenhouse gases that are produced within New Zealand, but also in the actual contribution these gases make to the enhanced greenhouse effect. Research into the greenhouse gases is ongoing worldwide, but there are some specific areas of work which are more relevant to New Zealand and should be undertaken here. It should also be noted that New Zealand has an important role in the global context because of its unique geographical position.

Policy-related research needs are identified below. The Facts and Impacts Working Groups are also identifying future research priorities in their areas.

Contributions of the different gases, their sources, and sinks

Ongoing research in this area should continue, especially in the area of further refinement of the warming potentials of the different greenhouse gases.

In addition, the following areas of research have been identified:

- the estimated scrub/tree coverage necessary to achieve specific carbon storage targets, using a variety of establishment options and management regimes;
- the durability of a range of commonly used wood products (specifically including timber construction materials), in the context of their carbon storage potential;
- refinement of the carbon storage rates for actively growing indigenous forest (including regenerating scrub) and the commonly grown exotic plantation tree species;
- the carbon storage properties of tree stumps and roots in both indigenous and exotic plantation forest;
- detailed assessment of the relationship between farmed ruminant numbers, types, and management systems, and greenhouse gas emissions;
- refinement of the estimates of the greenhouse gas contribution made by non-farmed ruminants in New Zealand;
- the magnitude of methane emissions resulting from anaerobic decomposition of excreta from farmed ruminants;
- refinement of the estimates of nitrous oxide emissions resulting from the deposition of excreta from farmed ruminant on pasture, and identification of the mechanisms involved;
- the carbon sink potential and net greenhouse value (by comparison with livestock farming) of a range of commonly practised arable farming and horticultural land uses;
- the relative magnitude of nitrous oxide emissions attributable to soil- nitrogen derived from both nitrogen fertilisers and symbiotic fixation;
- the total greenhouse gas emissions associated with the manufacture and use of nitrogen fertilisers;
- the magnitude of carbon dioxide emissions resulting from the use of lime in primary production systems;
- the magnitude of greenhouse gas emissions associated with bare, eroding, and cultivated soils;
- the magnitude of greenhouse gas emissions associated with sewage treatment/disposal;
- identification of industries making a "significant" contribution to total annual greenhouse gas emissions.

Climate models, the extent of climate change, and the rate of change

Research in this area should continue. The following research needs have been identified.

- Improvement of historical climate records;
- Regular updating of New Zealand climate change scenarios as new data at the global level come to hand;
- Derivation of models for the Australia/New Zealand/South Pacific region from the global climate models.

Specific impacts of climate change

There is a lack of certainty and detail associated with the possible effects of greenhouse-induced climate change. For long-term planning in response to climate change these problems will need to be addressed. The following needs have been identified:

- Better understanding of the links between climate and other environmental factors, as well as economic and social activities, is needed.
- Further refinements of impact studies at the national level, enabling better detail and interpretation at the regional level, are required.
- Climate sensitivity studies identifying the relationships between climate and species and between climate and social and economic activities would be of considerable assistance in determining which species and activities are most likely to be affected, either positively or negatively, by climate change.

Policy options, their implementation, and viability

In many instances policy options have been suggested without any information on their viability or on their ease of implementation. The following list contains policy options which require further research in these areas. Comparative evaluations between options in specific areas is also required:

- Development of mechanisms to encourage behaviour changes which help to reduce greenhouse gas emissions.
- The effect of behavioural changes on greenhouse gas emissions.
- The level of charge ("carbon tax") necessary to be effective, the likely effects of such charges on the economy, and complementary policies which would lessen any undesirable effects of such charges.
- The best way to determine the level of emissions from any particular source if emissions charges are to be adopted.
- Investigation into areas appropriate for subsidies to encourage the reduction of emissions of greenhouse gases.
- Alternative ways of initially allocating tradeable emission permits, including the likely effects of each alternative on the economy, and complementary policies that would lessen any undesirable effects.
- Appropriate levels of total greenhouse warming potential (GWP) as a basis for issuing of tradeable permits.
- Research and development in the area of biomass-based fuels, for example, energy farming for methanol and ethanol, or the production of compressed biogas (CBG).
- Research into the barriers preventing private and commercial production of biomass-based fuels.
- Research and development into alternative technologies (for example, solar and wind) and barriers to their uptake at both the commercial and private generation level.
- Research into a system whereby industry can sell "spare" energy and material wastes.
- Development of the idea of using an ascending block tariff at both the retail and wholesale level.
- Development of a set of energy accounts which show where energy is going, what it is used for, and in what quantities, to assist decisions regarding resource use.
- Identification of mechanisms for increasing the area of tree coverage.
- The potential for increasing timber usage in the construction industry, and the mechanisms for achieving this.
- The opportunities for reducing numbers of farmed ruminants without compromising output potential.
- The opportunities for suppressing methane production in farmed ruminants.
- The opportunities for eliminating nitrous oxide emissions which result from the deposition of stock excreta on pasture.
- The area of land suited to arable farming and horticulture which is not currently being used for that purpose.
- The greenhouse-gas-related benefits of using slow-release nitrogen fertilisers.
- Alternative "greenhouse friendly" refuse disposal practices.
- The potential for modifying the production processes of those industries which have been identified as being significant greenhouse gas emitters.

There are almost unlimited possibilities for further research, but some areas are likely to be seen as being of greater urgency as policy is developed. There is also the question of funding, how much should be spent, and the role government funding has in climate change research.

Submissions would be helpful to identify research that needs to be undertaken and, in particular, which areas might have priority.

6.2 Monitoring

There will also be a need to continue monitoring of both climate change itself and its impacts. This is important for gaining an understanding of the rates involved in climate change and in confirming the nature of impacts. In addition, monitoring of the effects of any policy responses undertaken and evaluation of these responses will be necessary. Monitoring climate change, its physical impacts, adaptation and policy responses will require comprehensive information bases to record and analyse this information and other research data.

There are a number of ways this could be done, but in most cases extra resources would be needed. It should be noted that monitoring of physical changes to the environment is already occurring in a number of government agencies, and some research is already being done in the area of key indicators. Expansion of this work will be essential, especially for developing ways to measure societal change and the effects of policy responses which will occur in any case.

In addition, traditional forms of knowledge can make a useful contribution alongside that of conventional "science". Maori have developed forms of knowledge specific to resource management issues based on oral traditions. Such knowledge resides with kaumatua, kuia, and tohunga and has been inherited from tupuna for the benefit of present and future generations. Such lore provides a valuable source of knowledge on changes in biophysical systems. This knowledge is possessed by all those people - Maori and Pakeha - who have maintained long and intimate contact with the environment.

Submissions would be helpful to explore monitoring priorities and to identify existing monitoring that could be useful to the climate change programme.

6.3 Technology Development

The implementation of research results will often require technological development so as to lead to the production of appropriate and marketable products. Research results may be of little value, unless additional resources and effort are applied to their development and industry and the public adopt improved technologies (e.g. more energy-efficient equipment). Much technological development will come from overseas, but New Zealand may also be able to direct resources to areas where this country already has (or can develop) a technological or geographic advantage (e.g. agricultural systems, wind energy). Requirements would include a good research base with a good development capability and organisations with the ability to draw on overseas information and disseminate information in New Zealand.

In particular, it is necessary that New Zealand remain well informed of technology developments overseas in renewable energy, and also maintains domestic "renewables" research and development, particularly in areas where there is already a body of knowledge e.g. CNG technology and how it can interface with compressed biogas (CBG).

Information on cleaner fossil fuel technology also needs to be collected, disseminated, and acted on. One possibility is the formation of an energy/ environment group to keep abreast of the information, disseminate the information and, more important, ensure that each sector is considering the environmental implications of its energy decisions. This group could also work at devising institutional arrangements to facilitate the optimum uptake of technology and of behaviour which is less damaging to the climate.

Technological developments may be crucial to the limitation and adaptation to climate change. Investment in this area may produce financial return and offer opportunities for production of "environmentally friendly" products.

Submissions on appropriate technological developments would be welcomed.

Appendix 1:

Working Groups

The groups and individuals who made direct input to the preparation of this document are listed here.

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Tikitu Tutua-Nathan, Ngati Raukawa, Ngati Awa, Manatu Maori

Appendix 2:

Glossary

atmosphere - envelope of gases which surrounds Earth

biogas generator - a device which produces gas fuel through the decomposition of organic material

biomass - total weight or volume of organisms in a given population

brood herd - animals used for breeding replacement stock

CNG-dedicated vehicle - a vehicle with an engine which is designed to run solely on compressed natural gas (CNG), as opposed to dual-fuel vehicles which run on both petrol and CNG

call-ins - a procedure allowed for under Section 121 of the Resource Management Bill in relation to proposals which the Minister for the Environment considers to be of national significance, whereby the Minister can direct that he/she will make decisions on any particular application, or all applications, for resource consents in respect of that proposal

climate sensitivity studies - a study of the degree to which plants, animals, economic activities and social systems may be affected by climate

compressed biogas - a fuel derived from the decomposition of organic matter

ecosystem - a community of organisms interacting with one another, plus the environment in which they live and with which they also interact

genetically-engineered - a technique in which the genetic make-up of an organism's cells is artificially modified (by humans)

greenhouse warming potential - the relative warming potential of a gas when compared with carbon dioxide

hapu - section of a large tribe, clan, secondary tribe, sub-tribe

hydroxyl radical - a chemical compound found in the atmosphere which contains oxygen and hydrogen

intact males - male animals which have not been castrated

inter-fuel substitution - the substitution of one fuel for another (e.g. CNG for petrol)

iwi - nation, people, tribe

kaimoana - food obtained from the sea (usually shellfish)

kaumatua - elder

kawanatanga - governorship

kuia - old woman

landfill - a refuse disposal technique in which waste is used to fill a hole in the ground

least-cost planning - planning with the aim of obtaining a desired level of output in the least-cost way, in the long-term (e.g. many electricity utilities in the United States combine energy conservation with the planning of energy supplies in order to achieve the lowest-cost system over a twenty year planning period)

life-cycle costing - decisions about investments are not made simply by comparing the initial capital costs of items. Instead, all the costs (capital, operating and maintenance) over the expected life-span of the items in question are estimated and compared.

long-run marginal cost - the cost of producing an extra unit of output in the long-term (where the long-term is defined as the time period during which a firm is able to vary all its factors of production, including plant and machinery, in order to arrive at the most efficient input combination)

marae - customary Maori meeting place

passive solar - design features which improve the thermal properties of a building (e.g. keep it warm in winter and cool in summer) so that energy requirements are minimised (e.g. heaters, lights)

photovoltaics - the technology whereby light is converted into electricity

rangatiratanga - chieftainship, full authority

renewables - a term that distinguishes resources which cannot be depleted (e.g. sun) or can be replaced (e.g. trees) from resources which are non-renewable on a human time-scale (e.g. coal)

shared-savings schemes - a contract whereby financial savings due to increases in energy efficiency are used to pay back a loan which was raised for the purpose of undertaking efficiency improvements. The term "shared" is used because only a portion of the savings are used to pay back the loan, with the remainder of the savings regarded as profit.

sink - natural store which keeps carbon out of the atmosphere

tanagata whenua - "people of the land", the indigenous people of Aoteoroa

taonga - treasured, highly valued possessions

whanau - extended family