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# **Climate Change - a global issue**

## **Is a renewable energy target an effective response for the New Zealand electricity sector?**

A thesis presented in partial fulfilment of the requirements for the degree of  
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at Massey University, Palmerston North  
New Zealand

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# Abstract

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The main objective of this thesis is to investigate the effectiveness of a mandatory renewable energy target (MRET) in reducing greenhouse gas (GHG) emissions from the electricity sector. New Zealand's electricity sector emissions have grown at a rapid rate over the last decade (+19%) due to an increasing reliance on thermal generation plant.

Since the mid 1980's there has been increasing scientific evidence and acceptance that GHG emissions caused by human activity are reducing the amount of solar heat that would otherwise be radiated back out into space leading to climate change.

The Intergovernmental Panel on Climate Change (IPCC) has found new and stronger evidence that most of the observed warming of the past 50 years is attributable to human activities. The IPCC findings show potential for significant changes in temperature (1.4-5.8°C by 2100), rainfall patterns and sea level (9-88cm by 2100) and adverse weather events. This will impact on the global economy, the natural environment and the quality of life for present and future generations.

The Kyoto Protocol is the international vehicle for fighting anthropogenic climate change by reducing GHG emissions. Despite the US withdrawal from the Protocol in 2001, it could still enter into force and countries that ratify it could have legally binding GHG emission responsibilities by late 2002. Domestic policy and legislation presently under development will guide New Zealand's efforts to reduce GHGs and meet its future Kyoto Protocol commitments.

To assess the impact of a possible MRET, a tool was developed which evaluates the effect of five different MRET scenarios on the electricity sector's GHG emissions, the wholesale price of electricity and the level of renewable energy supply. It was found that an MRET is an effective method of reducing GHGs and increasing the level of renewable energy supply, however this effectiveness depends on the level of the target. The higher the target the higher the electricity price, which will also increase if inappropriate investment decisions lead to plant redundancy or oversupply of the market. Implementing energy efficiency measures with an MRET further reduces GHG emissions. If existing renewable generation was prioritised over thermal generation then environmental outcomes are further improved.

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# Abbreviations

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2MTT	Manapouri Second Tailrace Tunnel Project
AA	Assigned Amounts
AAUs	Assigned Amount Units
Annex A	Annex A to the UNFCCC.
Annex B	Annex B to the UNFCCC.
Annex I	Annex I to the Kyoto Protocol to the UNFCCC
Annex II	Annex II to the Kyoto Protocol to the UNFCCC
ARC	Automation and Remote Control (Manapouri)
BAU	Business as usual
CD	Corporate Delivery, Meridian Energy Ltd
CDM	Clean Development Mechanism
CEL	Contact Energy Limited
CERs	Certified Emission Reductions
CH <sub>4</sub>	Methane
CO	Carbon Monoxide
CO <sub>2</sub>	Carbon Dioxide
CO <sub>2</sub> -e	Carbon dioxide equivalent
COP	Conference of Parties
EC	Economic Community
ECNZ	Electricity Corporation of New Zealand
EECA	Energy Efficiency and Conservation Authority
EIA	Enhanced Industry Agreements
EIT	Economies in Transition
ERUs	Emission Reduction Units
EU	European Union
FCCC	Framework Convention on Climate Change
GEF	Global Environment Facility
GEL	Genesis Energy Limited
GEM	Green Electricity Market
GHG	Greenhouse gas
GHGs	Greenhouse gases
GWh	Gigawatt hours (10 <sup>9</sup> watt hours)
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons

IET	International Emissions Trading
INC	Intergovernmental Negotiating Committee for FCCC
IPCC	Intergovernmental Panel on Climate Change
IPCC WG I	IPCC Working Group One
IPCC WG II	IPCC Working Group Two
IPCC WG III	IPCC Working Group Three
JI	Joint Implementation
kWh	Kilowatt hours ( $10^3$ watt hours)
LGNZ	Local Government New Zealand
LNI	Lower North Island
LULUCF	Land Use, Land Use Change and Forestry
MAF	Ministry of Agriculture and Fisheries
MED	Ministry of Economic Development, New Zealand
MEL	Meridian Energy Limited
MEPS	Minimum Energy Performance Standards
MFAT	Ministry of Foreign Affairs and Trade, NZ
MfE	Ministry for the Environment, New Zealand
MOC	Ministry of Commerce, New Zealand
MOT	Ministry of Transport
MRPL	Mighty River Power Limited
MRQ	Mandatory renewables quota
MS	Meridian Solutions, Meridian Energy Ltd
MW	Megawatt ( $10^6$ watts)
N <sub>2</sub> O	Nitrous Oxide
NA	Negotiated Agreement
NEC	National Environmental Standard
NEECS	National Energy Efficiency and Conservation Strategy
NI	North Island
NZ	New Zealand
NGA	Negotiated Greenhouse Agreements
NMVOCS	Non-methane volatile organic compounds
NO <sub>x</sub>	Oxides of nitrogen
NPS	National Policy Statement
NSSCCC	National Science Strategy Committee for Climate Change
NZEM	New Zealand Electricity Market
OECD	Organisation for Economic Co-operation and Development
PFCs	Perfluorocarbons
PJ	Petajoule ( $10^9$ joules)

R&D	Research and Development
REC	Renewable energy certificate
RE	Renewable Energy
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SF <sub>6</sub>	Sulphur Hexafluoride
SG	Strategic Growth, Meridian Energy Ltd
SI	South Island
SOE	State Owned Enterprise
tC	Tonnes of carbon (to convert to tCO <sub>2</sub> multiply by 12/44)
tCO <sub>2</sub>	Tonnes of carbon dioxide (to convert to tC multiply by 44/12)
tCO <sub>2</sub> -e	Tonnes of carbon dioxide equivalent (multiply tGHG by GWP)
TAL	TranAlta Limited (renamed NGC in 2001)
TPK	Te Puni Kokere, Department of Maori Affairs
TRP	Trust Power Ltd
UK	United Kingdom of Great Britain
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention for Climate Change
UNI	Upper North Island
USA	United States of America
VA	Voluntary Agreement
VI	Vertical Integration Model
WEM	Wholesale Energy Market
WMO	World Meteorological Organisation
WOGOCOP	Working Group on CO <sub>2</sub> Policy

### **Units**

k = 10<sup>3</sup>                      e.g. 1,000kg = 1t = 1,000,000 g = 1Mg

M = 10<sup>6</sup>                      e.g. 1 Mt = 1,000 kt

G = 10<sup>9</sup>                      e.g. 1 Gg = 1 kT

T = 10<sup>12</sup>

P = 10<sup>15</sup>

1 billion = 1,000 million = 10<sup>9</sup>

See Appendix 26 for GHG units of measure.



# Chapter 1

## Introduction

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### 1.1 Background

Scientific evidence has linked greenhouse gas (GHG) emissions resulting from human activities with the risk of increasing global climate change. Since this discovery in the 1980's the environmental and economic effect of climate change and the options to reduce and mitigate its impacts have become an ever-increasing focus of governments and businesses throughout the world. The complexities of the climate system mean the effects of climate change are uncertain and difficult to predict, so scientists continue to grapple with presenting the potential impacts. However those working with the Intergovernmental Panel on Climate Change<sup>1</sup> (IPCC) have agreed that there is potential for significant changes in temperature, rainfall patterns and sea level, which will have far reaching effects on the natural environment and the quality of life for present and future generations.

Increasing levels of greenhouse gases (GHGs) are believed to be responsible for climate change. They reduce the amount of solar heat that would otherwise be radiated back out into space leading to the "enhanced greenhouse effect" (commonly known as the "greenhouse effect") which leads to climate change. Climate change is defined as a change in climate over time whether due to natural variability, or as a result of human activity (IPCC I & II, 2001). The IPCC has also found that there is new and stronger evidence that most of the observed warming of the past 50 years is attributable to human activities. (IPCC I, 2001)

GHGs represent about 0.1% of the atmosphere and include, in order of significance, carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (NO<sub>2</sub>), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF<sub>6</sub>). While GHGs occur naturally, man contributes to their increasing levels in the atmosphere. Man-made or "anthropogenic" sources of these gases include the burning of fossil fuels for thermal generation and transportation, land-use change (such as converting forests to pasture), cropping (such as rice cultivation), waste disposal and industrial practices. Additionally, livestock such as sheep and cows also emit methane as part of their digestive processes.

Since pre-industrial times CO<sub>2</sub> concentrations in the atmosphere have increased by about 28%, CH<sub>4</sub> by 145% and NO<sub>2</sub> by 13% (Controller and Auditor General, 2001). CO<sub>2</sub>

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<sup>1</sup> The IPCC is recognised as the most authoritative and technical voice on climate change.

concentrations alone are expected to increase by up to 250% over pre-industrial levels by 2100.

While GHGs are emitted locally, they have a global impact. However the effect in each region may be different. The term "global warming" is often interchanged with "climate change". However this is inaccurate as in some regions the impact of increased levels of GHGs may actually lead to lower temperatures, therefore the more accurate term climate change will be used throughout this thesis.

International awareness of the causes and effects of climate change lead to the development of the United Nations Framework Convention on Climate Change (UNFCCC) which by October 2000 had been ratified by 186 countries. The objective of the Convention is the stabilisation of GHG concentrations within a time frame that will allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. It is acknowledged that the time frame and identifying appropriate stabilisation levels for each GHG will be a critical factor.

The countries involved in the UNFCCC adopted the Kyoto Protocol in 1997 with the principal aim of reducing GHG emissions. It is now the main international vehicle for addressing climate change issues. The Protocol requires industrialised countries (or Annex I countries<sup>2</sup>) to meet a collective emission reduction target for the six major GHGs of at least an average of 5% below 1990 levels across the first commitment period of 2008-2012. Each country's target or commitment in the Kyoto Protocol recognises the different national circumstances of each signatory, or Party, such as its natural resource endowments and costs of GHG mitigation. Based on this each country is allocated an "assigned amount" which is effectively a right to emit to this level. Each country has a commitment to either reduce emissions to this level or to "take responsibility" for any excess in emissions above this level by purchasing an emission right from other industrialised or developing<sup>3</sup> countries.

Emission rights or "credits" are represented by four types of unit of equal value, each measured in tonnes of carbon dioxide equivalent (tCO<sub>2</sub>-e). The units are: Assigned Amount Units (AAU's), which are allocated to each party to the level of their emission reduction

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<sup>2</sup> Annex I countries are the 26 developed countries and 13 countries with economies in transition to a market economy (generally eastern European countries), as listed in Annex I of the UNFCCC. These are also listed in Annex B of the Kyoto Protocol with emission reduction commitments.

<sup>3</sup> Developing countries are those not listed in Annex I of the UNFCCC or Annex B of the Kyoto Protocol. These countries do not have emission reduction targets.

target; Certified Emissions Reductions (CERs), Emission Reduction Units (ERUs), and sink credits. A sink is any process, activity or mechanism that removes GHGs from the atmosphere e.g. planting forests. The trading of these different "credits" is possible through an international emissions trading system.

Early emission reduction activity is already occurring and an over the counter emissions or carbon trading market already exists and has been developing since the late 1990's. Trades are based on tCO<sub>2</sub>-e reductions. The nominal prices have ranged from NZ\$1.20 to \$19.00 tCO<sub>2</sub>-e since trading began in 1996-7 (Natsource, 2001).

The Kyoto Protocol will become legally binding international law when it has been ratified by at least 55 countries, which represent a minimum of 55% of the total industrialised countries' 1990 CO<sub>2</sub> emissions. Eighty-four countries are signatories or Parties to the Kyoto Protocol and, as at June 1<sup>st</sup> 2001, 34 countries had ratified it. This included only one industrialised country (Romania), the other 33 are Annex II countries that do not have binding targets.

Due to the large number of countries represented at the negotiation table, each with their own agenda the final rules for the Kyoto Protocol are still under development making it difficult for countries with targets to ratify. Two significant events occurred in mid 2001. One was the USA's announcement that it was withdrawing from the Kyoto Protocol due to the unknowns associated with the science of climate change, the potential negative economic impact of the Protocol on its economy and the inequity of developing countries not having emission reduction targets. It was possible that this could have caused irreparable harm to the progress towards the Protocol's entry into force as the US represents over 36% of the industrialised world's emissions. However a reconvening of a meeting of the Parties in Germany in November 2001, led to the Bonn Agreement which required some major compromises but achieved a massive step towards the implementation of the Protocol.

The Bonn Agreement has effectively reduced the emission reduction requirements of the industrialised countries to approximately 2% below 1990 levels. However the major value of the UNFCCC and the Kyoto Protocol is as an indicator of a political will to create change and as a forum for developing further mitigation and adaptation solutions.

In a May 2000 media statement from the Prime Minister of New Zealand, the Government announced its commitment to pass legislation enabling New Zealand to ratify the Kyoto Protocol by mid 2002. Ratification of the Protocol will mean that New Zealand is legally bound to reduce its total GHG emissions to 1990 levels on average between 2008 and 2012 or take responsibility for any excess emissions.

Climate change and climate change policy will have an effect on New Zealand's society and its natural and physical resources. In the spirit of the Treaty of Waitangi, consideration is being given to the cultural and spiritual significance of climate change policy to the Maori people by ensuring that they are consulted throughout the development of this policy. Property rights issues may occur.

The Kyoto Protocol requires New Zealand to show "demonstrable progress" toward meeting its commitment by 2005 but to date it has shown the highest percentage increase of carbon dioxide emissions since 1990 of any OECD country. This is mainly due to increases in emissions from transport and thermal power stations. New Zealand's GHG target will also be challenging because unlike most other countries, the major contribution to emissions is from the agricultural sector, notably methane emissions from livestock. Although methane emissions have declined since 1990 due to a reduction in sheep population, current trends show ruminant livestock numbers are rising, therefore methane reduction cannot be relied upon to offset increasing CO<sub>2</sub> emissions by 2008. The policy responses required to deal with these issues while meeting New Zealand's Kyoto Protocol objectives are challenging and very broad reaching. A "whole of government" approach to this issue is required affecting a wide range of Government Ministries. At present a wide range of policies are under development and consideration. The underlying issues are very complex and sector specific so the electricity sector has been selected as the focus of this research.

The world's electricity sector has particular importance in the climate change debate as it produces over one third of energy-related CO<sub>2</sub> emissions, this is projected to increase at an annual rate of 2.7% until 2020 (IEA, 1998). In New Zealand, the electricity sector's levels of CO<sub>2</sub> emission increased by 19% on a gross basis from 1990 to 1999, due to a 50% increase in thermal generation over the same period (MED, 2000).

The increase in GHG emission from the electricity sector can be reduced in two ways:

- i) existing thermal generation plant needs to be operated more efficiently or switch to fuels with lower emissions (e.g. coal to gas), or
- ii) replace thermal generation with renewable energy supply which does not emit any GHGs during generation. It is particularly important that demand growth is met with renewables if the electricity sector's upward GHG emission trend is to be halted.

If GHG emissions in the electricity sector are to be stabilised or decreased while New Zealand experiences economic growth, lower levels of fossil fuel consumption, and the development

of renewable sources of energy must be encouraged through policy or regulation. These are some of the objectives of the Energy Efficiency and Conservation Act (2000) which requires a National Energy Efficiency and Conservation Strategy (NEECS or the Strategy) to be developed by October 2001. The draft was released in April 2001 and represents the first significant climate change policy development effecting the electricity sector in New Zealand. The Strategy will be finalised by September 2001. The NEECS recommends the use of a renewable energy target and mechanism for increasing the supply of renewable energy as a means of meeting the goal of reducing GHG emissions. The mechanism and tool are still under development however this is where a mandatory renewable energy target (MRET), if implemented, is likely to be applied within New Zealand public policy.

This thesis investigates the effectiveness of a MRET in reducing GHG emissions in the electricity sector. A tool was developed to assess the impact of a MRET under five different target scenarios by considering its effect on the electricity sector's GHG emissions, the wholesale price of electricity and the effectiveness of the target for increasing renewable energy supply.

Meridian Energy Ltd, New Zealand's largest 100% renewable energy electricity generator, has been used as a case study to assess climate change issues, both on a physical and policy level, from the perspective of a major player in the electricity market.

The thesis outlines the major national and international climate change policy developments and related issues up until June 2001. Most of these issues are under either review or development which means this study has been carried out in a time of great uncertainty and due to these dynamic issues the original objectives of this work have evolved as new strategies and policies unfolded.

## **1.2 Research objectives and processes**

The overall goal of this thesis is to identify the issues associated with climate change and its mitigation through the reduction of GHG emissions. An answer was sought for the question “Would the implementation of a mandatory renewable energy target to New Zealand’s electricity sector make a difference?”

The scope of this thesis is very wide taking into account global, national, sectoral and organisational issues relating to climate change.

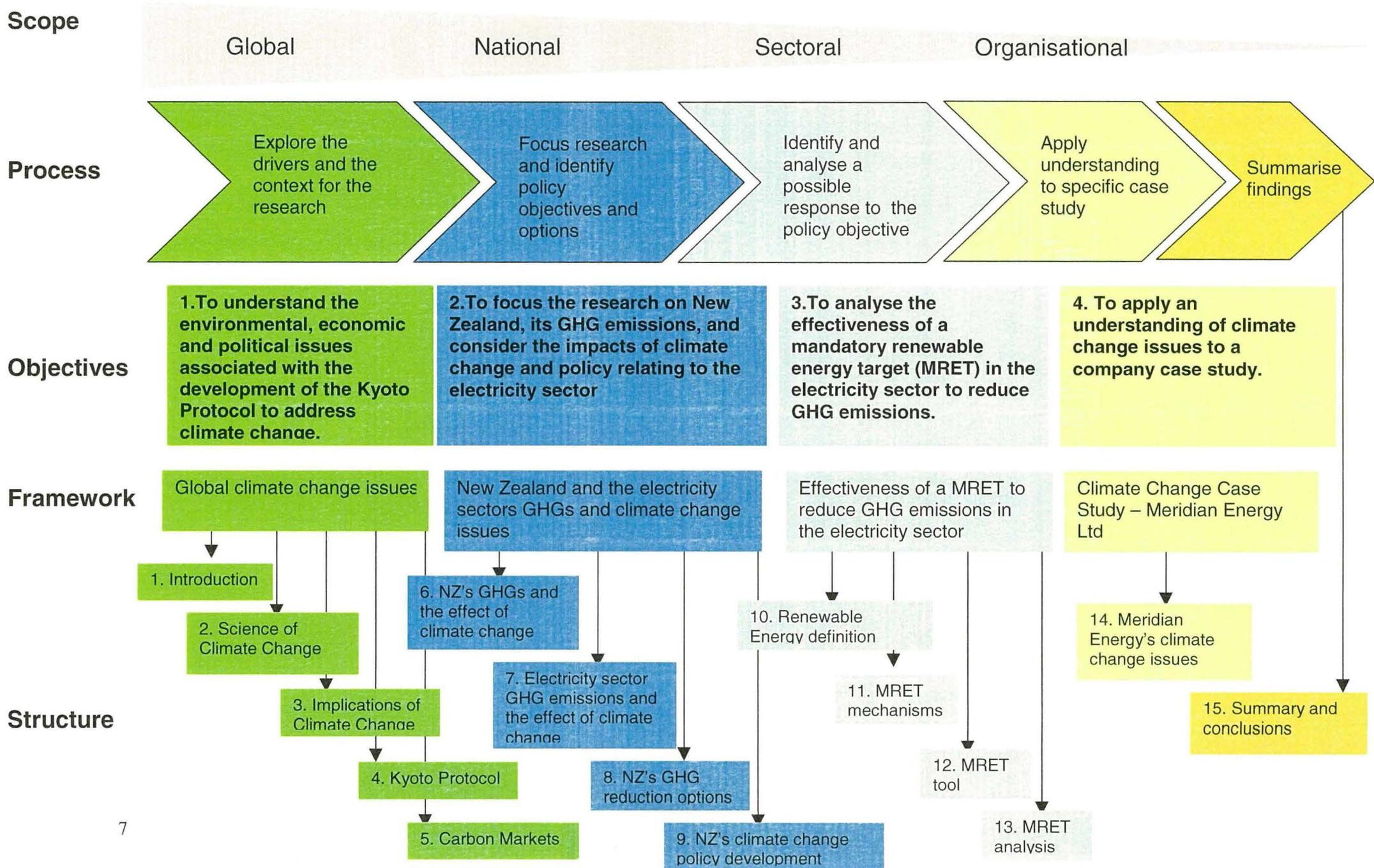
Four steps were taken to address the four main *objectives of this thesis*:

1. This thesis was developed by first exploring the drivers and the context for the research this was to achieve the objective of *understanding of the environmental, economic and political issues leading to the development of the Kyoto Protocol to address climate change*. This is covered in chapters one to five.
2. The research was then focussed and climate change policy objectives identified and options assessed. This was to achieve the objective of *focusing on New Zealand and its electricity sector situation by identifying the level of GHGs, GHG reduction options and possible domestic climate change policy*. This is covered in chapters six to nine.
3. A possible response to the policy objective was identified and analysed. This fulfilled the objective of *analysing the effectiveness of a MRET in the electricity sector to reduce GHG emissions*. This is covered in chapters ten to thirteen.
4. The final objective of *applying an understanding of climate change issues to a company case study* was achieved by exploring Meridian Energy's climate change issues. This is covered in chapter twelve.

The thesis is summarised and conclusions drawn in chapter thirteen.

Figure 1.1 shows a summary of the research objectives and processes.

Figure 1.1: Summary of research objectives and processes





## Section One

### Global climate change issues

*This purpose of this section is to explore the drivers and context of this research. The main driver is the political response to the threat of climate change caused by greenhouse gas emissions from human activities.*

*The context for the research is provided by discussing the environmental, economic and political issues associated with the development of the Kyoto Protocol as a response to climate change.*

- *Chapter 2 explains the causes of climate change and man's contribution to it within a discussion on the science of climate change.*
- *Chapter 3 illustrates the implications of climate change with regards to increasing temperature, sea levels and changes in precipitation patterns.*
- *Chapter 4 discusses Kyoto Protocol, which is the international response to the risk of climate change.*
- *Chapter 5 discusses the carbon market and the price of carbon which is emerging in response to the Kyoto Protocol and other business concerns.*



# Chapter Two

## The Science of Climate Change

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The sun's radiation warms our planet. On average the Earth must radiate back the same amount of energy it absorbs from the sun to prevent changes to the atmosphere and hence the climate. Any alterations in the Earth's ability to achieve this, such as man altering the composition of the atmosphere by increasing greenhouse gas (GHG) emissions, will affect the delicate balance possibly leading to climate change.

The science of climate change is complex and not yet fully understood, however the Intergovernmental Panel on Climate Change (IPCC)<sup>4</sup> collects and analyses all known climate change science to provide the information required for Kyoto Protocol policy maker's considerations. The following chapter provides an overview of the major issues relating to the science of climate change based on information developed by the IPCC.

### 2.1 Climate Change

The scientific understanding of climate change is increasing and the definition of climate change is also maturing. In 1992, the UNFCCC defined climate change as a change of climate, which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time. (UNFCCC, 1992)

The presently accepted IPCC definition is a change in climate change over time whether due to natural variability or as a result of human activity (IPCC, 2001).

The human activities referred to in both definitions are those actions which alter the composition of GHGs in the atmosphere. This research focuses solely on anthropogenic (man-made) aspects of climate change. Table 2-1 details the activities that emit GHGs.

Climate change effects can include temperature rise, sea level rise, changes in precipitation and extreme weather events. Data is available on how the climate has changed in the past from a number of different sources, including assessment of natural phenomenon such as coral and ice core analysis and in more recent times direct measurement techniques. The

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<sup>4</sup> Details of the IPCC can be found in chapter 4.

models and methods used to assess the possible implications of climate change in the future are complex. The future climate change forecasts are based on expectations of future GHG emission levels and other issues that are difficult to quantify with certainty. The IPCC collects and considers all available data when generating its reports. The implications of physical climate change are detailed in Chapter 3.

## 2.2 Greenhouse Gases (GHG)

The thin film of mixed gases that surround the Earth is called the atmosphere. Its composition creates the conditions necessary for the diversity of life on Earth and is mostly made up of nitrogen (78%) and oxygen (21%).

The atmospheric gases that have properties preventing some of the normal radiation of solar heat back into space are called greenhouse gases (GHGs). The GHGs represent only approximately 0.1% of the atmosphere by volume.

In this thesis, the terms “GHGs” and “emissions” describe the six main anthropogenic GHGs referred to in the Kyoto Protocol. In order of environmental significance these are CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, the HFC family, the PFC family and SF<sub>6</sub>.

Each GHG has a global warming potential (GWP) that indicates the degree to which they absorb infrared radiation and its impact on the atmosphere compared to CO<sub>2</sub>. The GWP of CO<sub>2</sub> is defined as 1. Table 2-1 indicates the GWPs of each of the 4 individual gases and 2 families of gases.

There are two other non- Kyoto Protocol GHGs that should be mentioned:

- Water vapour represents approximately 60-70% of the natural greenhouse effect but human activity does not directly affect its atmospheric levels so it is not included in the following discussions.
- Near surface ozone is the focus of the Montreal Protocol rather than the Kyoto Protocol so it will not be included in the following discussions.

Oxides of nitrogen (NO<sub>x</sub>), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOC) are called indirect GHGs as they react to form direct GHGs (i.e. those included in the Kyoto Protocol) in the atmosphere in a short time. These will not be discussed further here despite the fact more information is publicly available about the level of these emissions in New Zealand than the HFC family, the PFC family and SF<sub>6</sub>.

Fine aerosols can also affect the climate but the methods for assessing their impact are still not very reliable so they will not be discussed further.

**Table 2-1: GHGs, their sources and GWPs**

GHG	Chemical Formula	GWP <sup>1</sup>	Anthropogenic sources
Carbon Dioxide*	CO <sub>2</sub>	1	<i>Fossil fuel combustion</i> <sup>2</sup> , land use conversion, industrial processes, biomass burning
Methane*	CH <sub>4</sub>	21	Fossil fuel mining and combustion, <i>ruminant livestock</i> <sup>2</sup> , landfills and other waste disposal, rice cultivation
Nitrous Oxide*	N <sub>2</sub> O	310	<i>Agricultural soils</i> <sup>2</sup> , fertiliser, industrial processes
Perfluorocarbons <sup>3</sup>	PFCs	6,500 – 9,200	Industrial processes, <i>Aluminium production</i> <sup>2</sup>
Hydrofluorocarbons <sup>4</sup>	HFCs	140 – 11,700	<i>Industrial applications</i> <sup>2</sup>
Sulphur Hexafluoride	SF <sub>6</sub>	23,900	<i>Electrical switchgear</i> <sup>2</sup> , aluminium smelting
<p>1. GWP = Global Warming Potential for 100 year time horizon. GWPs vary for different time horizons.</p> <p>2. Principle sources for New Zealand shown in italics.</p> <p>3. PFCs are the family of gases that contain both fluorine and carbon e.g. CF<sub>4</sub> and C<sub>4</sub>F<sub>6</sub>.</p> <p>4. HFCs are the family of gases that contain hydrogen, fluorine and carbon e.g. CH<sub>2</sub>FCF<sub>6</sub> or HFC-134a and C<sub>2</sub>H<sub>4</sub>F<sub>2</sub> or HFC-152a.</p> <p>* For the purposes of the Kyoto Protocol these gases are measured against a 1990 base year while the others can be measured against either 1990 or 1995.</p>			

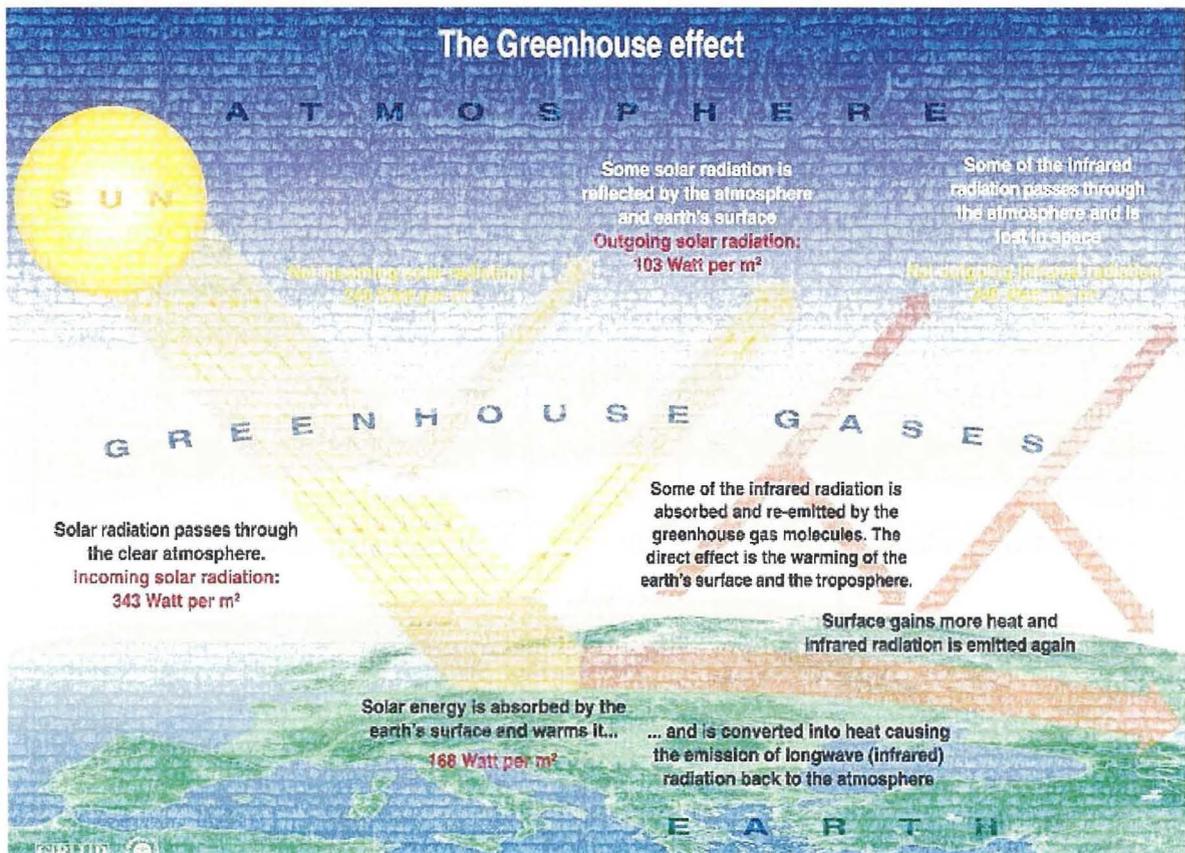
### 2.3 The Greenhouse Effect

The greater the concentration of GHGs in the atmosphere the greater the potential for a warmer planet and changes to the climate. The effect GHGs have on the atmosphere is known as the Greenhouse Effect.

The Earth has a temperature control system that naturally exhibits variations over time. These changes usually take place over thousands of years and the GHGs are critical to this system. On average, approximately one third of the solar radiation that hits the Earth is reflected back

to space. Of the remainder, the atmosphere absorbs some but the land and oceans absorb most. The Earth's surface becomes warm and as a result emits infrared radiation. The GHGs trap the infrared radiation, thus warming the atmosphere, effectively acting as an insulating blanket. The greenhouse effect is a natural process illustrated in Figure 2.1.

**Figure 2-1: The Greenhouse Effect**



(Source: IPCC, 1996)

The models used by the IPCC to simulate the climate of the past incorporate:

- the heating effect of solar radiation;
- heat absorption and reflection by clouds;
- greenhouse gases and suspended particles in the atmosphere: and
- the coupling between oceans and atmosphere (MfE, 2001).

In the natural course of events, GHGs trap energy in the lower atmosphere causing an average temperature increase of approximately  $33^{\circ}\text{C}$ . Radiation from the surface of the Earth and reflection of the incoming sun's radiation by GHGs, clouds and the Earth's surface have an "effective radiating temperature" of  $-18^{\circ}\text{C}$ . This leads to the Earth having a mean temperature of about  $15^{\circ}\text{C}$  (EPA et al, 1996).

Anthropogenic GHGs cause more infra-red radiation to be absorbed than would otherwise occur leading to an increase in the temperature of the lower atmosphere and a heating of the Earth's surface in excess of the balance described above. Effectively more energy is being added to the atmospheric system than is being released. This is known as the “enhanced greenhouse effect” and in common usage has become known simply as the “greenhouse effect”, which describes an effect that is in excess of naturally occurring variances in the atmosphere.

In simple terms when people cut down trees; burn coal, oil and natural gas; raise cattle; or plant rice; CO<sub>2</sub> and other GHGs are released into the atmosphere causing the naturally occurring blanket to become “denser” thus causing changes in the climate.

Some GHGs are removed from the atmosphere due to chemical processes or conversion by the carbon cycle into biomass (e.g. trees, forests) or other biological carbon sinks such as oceans. However, GHGs are accumulating in the atmosphere faster than these natural processes can remove them. Man's deforestation activities are also impacting on the carbon balance.

Human activity over the last two hundred years has measurably changed the composition of the atmosphere as shown in Figure 2.2, these graphs also show the relationship between the increase in the GHGs and human population growth. The graph shows that atmospheric CO<sub>2</sub> levels have increased from approximately 280 parts per million (ppm) in pre-industrial times to about 360 ppm in 2000, this is only 130 years.

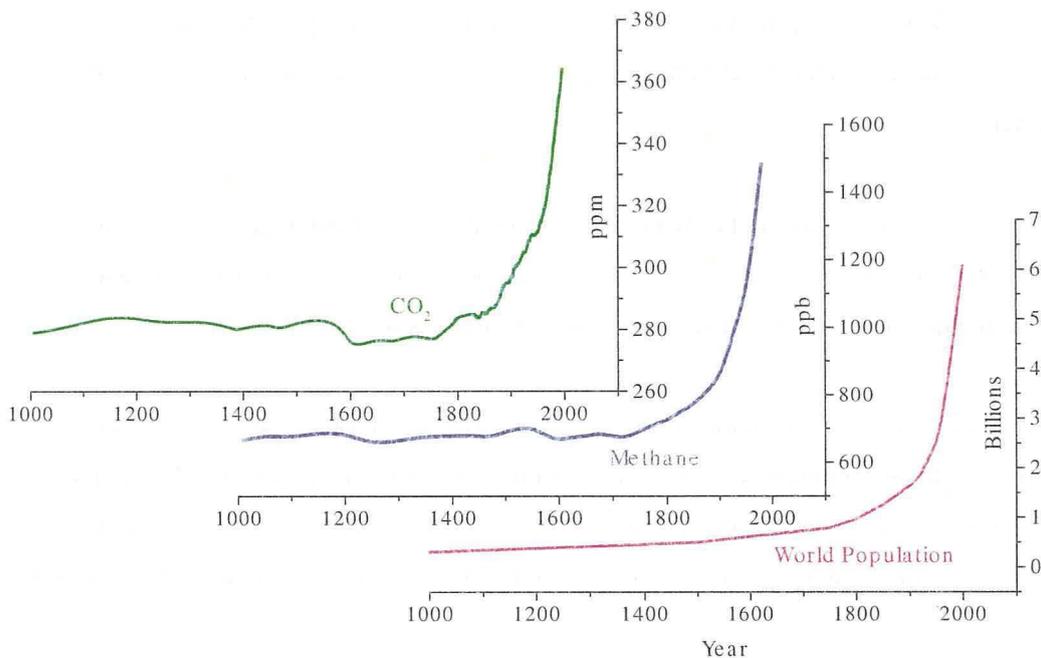
According to the IPCC, CO<sub>2</sub> concentrations are now approaching 370ppm and these levels could reach 540 – 970 ppm by 2100 (IPCC I, 2001). This represents a 90 to 250% increase over pre-industrial times.

It is important to realise that the impacts of GHG emission activities (or the reduction of them) do not have an immediate effect. Even if all anthropogenic emission activities were to cease today it would take at least several decades for the escalation of GHG levels to reduce due to the long atmospheric life time of GHGs. For example the atmospheric life-time of CO<sub>2</sub> is 50 – 200 years, while for some of the perfluorocarbons it can be up to 50,000 years so emission effects are cumulative.

The required response to controlling and mitigating GHG emissions is different to that required for other emissions which impact on the local environment. The reason for this is that no matter where or how GHGs are emitted, they will have an impact on the global

environment and therefore affect the whole world. The effects will however differ depending on locations and sensitivity of different systems to change and adapt.

**Figure 2-2: Global Atmospheric concentrations of CO<sub>2</sub> and CH<sub>4</sub>**



(Source: IPCC I, 2001)

## 2.4 GHG units of measurement

In order to attempt to control or manage the processes that emit GHGs, the emissions must first be measured. The following sections discuss the accuracy of emission estimates commonly called units of measurement.

The three most common units of measure of GHG emissions are:

- tonnes of carbon (tC);
- tonnes of carbon dioxide (tCO<sub>2</sub>); and
- tonnes of carbon dioxide equivalent (tCO<sub>2</sub>-e).

The use of different units of measurement in GHG calculations often causes confusion so it is important that the units are always explicitly stated.

The conversion from tC to tCO<sub>2</sub> is achieved by multiplying by a ratio of the molecular weight of CO<sub>2</sub> over the molecular weight of C i.e.  $\times 44/12 = 3.67$ . The conversion from tCO<sub>2</sub> to tC is conversely by multiplying by  $12/44 = 0.27$ .

All GHG emissions can be converted to tCO<sub>2</sub>-e using the GWP figures as reported in Table 2-1. Each gas has a different impact (and therefore GWP) over different time periods but the IPCC uses 100 year GWP figures so this will also be utilised in this thesis.

In a global sense a tC or tCO<sub>2</sub> is very small so it is more common to report emissions on a kilotonne (10<sup>3</sup> tonne or kt) or megatonne (Mt) basis. Other units are shown in the Abbreviations section in the Preface.

The most common form of GHG emission data is an emission factor, which is used to estimate the amount of GHG emitted when a given quantity of fuel is burnt. It is expressed in terms of the amount of gas released per unit of energy in the fuel. For example, sub-bituminous coal has an emission factor of 91.2 kt CO<sub>2</sub>/PJ. The data used in the calculations in this thesis is discussed further in Chapter 12 and in Appendix 28.

#### 2.4.1 GHG data quality

The most important issue when considering the quality of GHG data is that there are significant uncertainties in the estimates of GHG data available. In brief the estimated uncertainties as reported by the MED (2000) are shown in Table 2-2.

**Table 2-2: Level of uncertainty of estimations of the three main GHGs in NZ**

GHG Emissions <sup>5</sup>	Level of uncertainty
CO <sub>2</sub> emissions	+/- 5%
CH <sub>4</sub> emissions	+/- 50%
N <sub>2</sub> O emissions	+/- 50%

(Source: MED, 2000)

These uncertainties are based on the emission factors and the energy data used. CO<sub>2</sub> has less associated errors as more data exists concerning variability of CO<sub>2</sub> emission factors in New Zealand while non-CO<sub>2</sub> data is based on global averages from IPCC guidelines.

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<sup>5</sup> No information was included in the MED (2000) report about HFCs, PFCs or SF<sub>6</sub>.



# Chapter Three

## The Potential Global Implications of Climate Change

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Climate change has significant implications for the world. Historical climate changes have been assessed in a variety of ways, recent changes are recorded as they occur and future changes are modelled to forecast their magnitude. This information forms the basis of predicting the future impacts on man and other biological systems.

### 3.1 The Possible Implications of Climate Change

The IPCC (1995) published its second major assessment of climate change research in 1995, which was written and reviewed by over 2000 scientists and experts. The report concluded that the balance of evidence suggests that there is a discernible human influence on global climate. This led to considerable controversy as the report itself raised uncertainties relating to this statement.

The IPCC's Working Groups have updated this information in their third assessment report (TAR) in 2001. The major conclusion of the IPCC TAR was that most people would be adversely affected by climate change.

Working Group I assessed the scientific basis of climate change issues and concluded that there is new and stronger evidence that most of the observed warming of the past 50 years is attributable to human activities (IPCC I, 2001). This is indicated by the following findings:

- Temperature rise
  - The Earth's mean surface temperature increased 0.6°C between 1861 and 2000. Comparatively the Earth's climate has been relatively stable since the last ice age with global temperature changes varying less than 1°C over a century during the past 10,000 years (IPCC II, 2000). Eighteen of the world's twenty warmest years in the 20<sup>th</sup> century occurred after 1980, and it is likely that the 1990's was the warmest decade of the last 1,000 years (MfE, 2001).
  - Temperature is predicted to increase by between 1.4°C and 5.8°C by the year 2100 with business as usual (BAU) emission levels.
  - Under BAU, temperature rises are projected to be greater towards the poles and land areas are expected to warm more than oceans especially at high and mid northern altitudes.
- Sea level rise
  - Global mean sea level is estimated to have risen 10-20 cm over the last 100 years.

- Under BAU, the average sea level is projected to rise by about 9-88 cm, in the next 100 years, due to the oceans warming and expanding and increased melting rates of glaciers and ice caps.
- Precipitation
  - Rainfall patterns have changed with more heavy precipitation events.
  - In the future under BAU, precipitation is projected to increase globally, with both increases and decreases locally.
  - Heavy precipitation events will occur even more frequently.
- Under BAU, more extreme weather events are projected to occur such as floods, droughts, heat waves.

So what does this mean? The second IPCC working group explored impacts, adaptation and vulnerability. It predicted that under BAU:

- arid and semi-arid land areas in Southern Africa, the Middle East, Southern Europe and Australia will become even more water stressed than they are today;
- agricultural production in many tropical and sub-tropical countries will decrease, especially in Africa and Latin America;
- the incidence of heat stress mortality and of vector-borne diseases, such as malaria and dengue fever will increase especially in tropical countries;
- tens of millions of people will be displaced by the effect of floods and rising sea levels in small island states and low-lying delta areas; and
- the structure and functioning of critical ecological systems, particularly coral reefs and forests, will change affecting their goods and services which are vital for sustainable development (IPCC II, 2001).

There will also be some beneficial consequences of climate change including:

- increased agricultural productivity in some mid-latitude regions;
- increase water availability in some water scarce regions like some parts of South East Asia; and
- reduced winter mortality in the mid and high latitudes.

IPCC information is used as the basis for this thesis, however there is another group of scientists who provide evidence that the present climate change effects are only due to natural fluctuations. Another group challenges the basic scientific premise on which climate change is analysed. The second group challenges the conclusions arising from the analysis with regards to the expected temperature increase and rising sea levels and the impacts that this will have on water supply, agriculture, plant growth and ecosystems.

## Chapter Four

### The Kyoto Protocol

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The debate over climate change has entered the political arena rather than simply existing in the realms of science. Climate change is a challenging political issue as it is a truly global problem with one tonne of GHG emitted in China having the same impact on the atmosphere as one tonne emitted in America. However, the impacts are going to differ from one region to another and richer countries will be more equipped to adapt to climate change. Despite a lack of complete certainty around the science of climate change, the risks are so significant that politicians throughout the world have adopted the “precautionary approach” by developing international policy to attempt to control and mitigate man's impact on the climate. This process began in the 1980's.

The most significant development in the history of international climate change policy has been the Kyoto Protocol<sup>6</sup> to the United Nations Framework Convention<sup>7</sup> on Climate Change (UNFCCC). The Protocol provides international mechanisms for reducing and mitigating anthropogenic GHG emissions and adapting to climate change. It was adopted at the third conference of parties (COP3) in Kyoto, Japan in December 1997.

Each of the 84 signatory countries or parties has obligations under the Kyoto Protocol which include requirements to:

- report its GHGs by source including the sequestration by sinks;
- provide data to establish its level of carbon stocks at 1990 and enable an estimate of subsequent changes to be made;
- reduce or take responsibility for the emissions of the six main GHGs by an average of 5% below 1990 levels between 2008-2012 (industrialised countries). This collective target is broken down to a specific and differentiated target for each industrialised country; and
- show demonstrable progress towards achieving this commitment by 2005.

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<sup>6</sup> The term Protocol is commonly used for an agreement supplementary to a principle treaty.

<sup>7</sup> The term Convention is commonly used for multilateral treaties that are open to acceptance by a large number of states (or all states). A framework convention establishes its own institutional and decision-making framework for interpreting, developing, and implementing its provision. (Controller and Auditor General, 2001)

In order for a country to ratify, it must implement legislation that enables it to meet its Kyoto Protocol obligations. The minimum would be legislation to:

- set up a national inventory of the six GHGs covered by the Kyoto Protocol;
- a registry for AAUs, CERs, ERUs and sink credits; and
- empower the government to purchase the credits required to take responsibility for any emissions above its target which effectively will ensure that it will be able to meet its Kyoto Protocol obligations.

Each country will also need to develop domestic legislation and regulation to ensure that cost effective emission reductions are carried out by entities that can change emission outcomes within each country's economy.

The Kyoto Protocol will enter into force and become legally binding international law when it is ratified by 55 countries whose emissions total 55% of the 1990 emissions of the industrialised countries that are signatories. When this occurs the Kyoto Protocol is said to be ratified. A country ratifies the Protocol by putting legislation and policy in place that will allow it to meet its Kyoto Protocol commitments.

In this chapter, the groups and organisations that have been instrumental in the development of international climate change policy are described. This is followed by a summary of the major international policy development landmarks, the most significant of these is the Kyoto Protocol, which is discussed in depth.

#### **4.1 Landmarks in the development of international climate change policy**

Table 4-1 indicates the major landmarks in the development of international climate change policy from 1988. The comments in italics are possible developments only. This thesis takes into account developments up until September 2001.

**Table 4-1: International climate change policy development landmarks**

<b>Date</b>	<b>Landmark</b>
1988	World Meteorological Organisation (WMO) and United Nations Environment Programme (UNEP) establish the IPCC. The UN General Assembly discusses climate change for the first time.
1990	The IPCC's First Assessment Report is published recommending the launch of negotiations on a global climate change agreement. The UN General Assembly opens negotiations on a framework convention on climate change and establishes an Intergovernmental Negotiating Committee (INC).

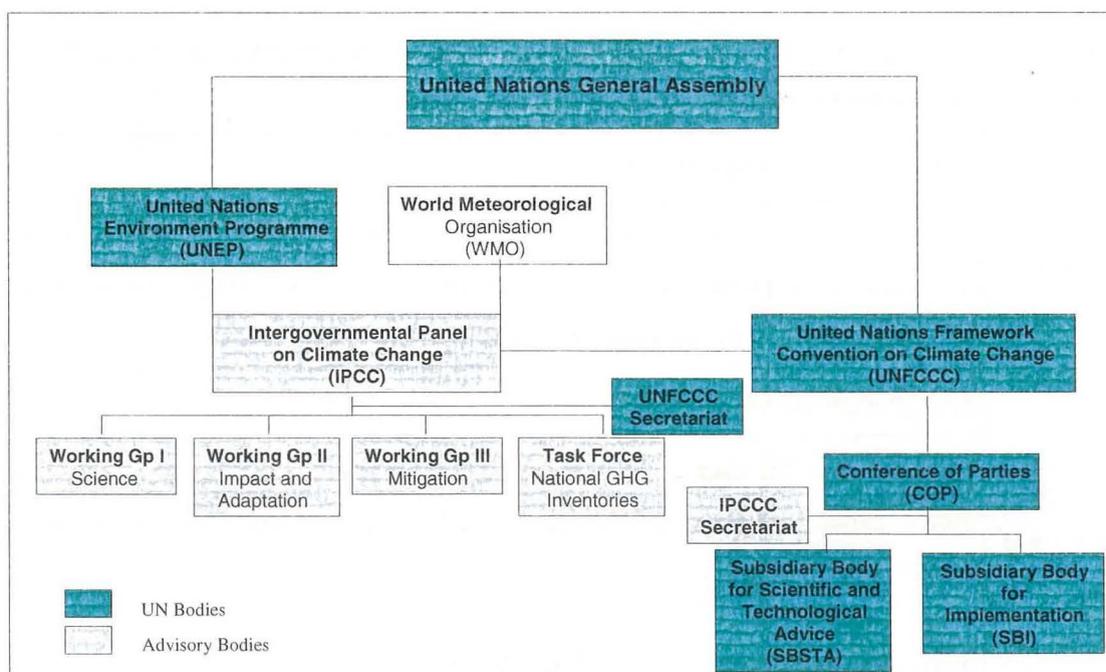
Date	Landmark
9 May 1992	The UN Framework Convention on Climate Change (UNFCCC) is adopted in New York.
4 June 1992	The UNFCCC is opened for signature at the Earth Summit in Rio de Janeiro, Brazil.
21 Mar 1994	The UNFCCC enters into force, after receiving 50 ratifications.
7 April 1995	COP 1 launches a new round of negotiations on a "protocol or another legal instrument", this was known as the Berlin Mandate.
11-15 Dec 1995	The IPCC publishes its Second Assessment Report on the science of climate change. Its findings underline the need for strong policy action.
19 July 1996	IPCC finds that the balance of evidence suggests discernible human influence on climate. This is endorsed by COP2 which decides that targets will be legally binding.
11 Dec 1997	The Kyoto Protocol to the UN Framework Convention on Climate Change adopted by COP3 in Kyoto, Japan.
16 March 1998	The Kyoto Protocol is opened for signature at UN headquarters in New York. Over a one year period, it received 84 signatures.
1998	IPCC third assessment begins.
14 Nov 1998	COP 4 adopts the "Buenos Aires Plan of Action" to strengthen the implementation of the Convention and prepare for the Protocol's entry into force. COP 6 is set as the deadline for adopting many important decisions.
1999	COP 5 in Bonn, Germany.
13 – 24 Nov 2000	COP 6 met in The Hague, the Netherlands, with the goal of taking key decisions on the implementation of the Convention and details of the Protocol. The meeting is adjourned and this objective not met.
March 2001	USA announces that the Kyoto Protocol is fatally flawed.
June 2001	IPCC Third Assessment Reports published.
June 2001	Of the 84 Kyoto Protocol signatories, only 34 had ratified, Romania being the only industrialised country to have done so.
July 2001	COP 6.5 or 6 bis to resume in Bonn, Germany.
<i>Oct 2001</i>	<i>COP 7 in Marrakesh, Morocco.</i>

Date	Landmark
2002	Rio + 10 Earth Summit 2002, ten years on from the 1992 "Earth Summit" in Rio de Janeiro. <i>Goal for ratification of Kyoto Protocol by many signatories including New Zealand.</i>
200?	<i>Possible entry into force of the Kyoto Protocol?</i>
2005	"Demonstrable progress" must be shown by Annex I countries towards meeting their targets. <i>Negotiations begin for the second commitment period targets.</i>
2008 – 2012	<i>First Kyoto commitment period.</i>

## 4.2 Participants in international climate change policy development

The relationships between the most commonly discussed international climate change agencies are shown in Figure 4-2.

**Figure 4-2: Relationship between International Climate Change Agencies**



### 4.2.1 Intergovernmental Panel on Climate Change (IPCC)

The purpose of the IPCC is to assess the state of knowledge of climate change issues including science, environmental and socio-economic impacts and response strategies. It is recognised as the most authoritative scientific and technical voice on climate change, and its findings are central to the COP negotiators. Approximately 400 experts draft, revise and finalise the IPCC

reports and another 2,500 experts participate in the review process. Further details of the make up and purpose of the IPCC and its working groups is shown in Appendix 1.

#### ***4.2.2 United Nations Framework Convention on Climate Change***

The United Nations Framework Convention on Climate Change (UNFCCC) is the foundation of global efforts to combat climate change. It was opened for signature in 1992 at the Rio Earth Summit and entered into force in 1994. 186 countries had ratified or acceded to the Convention by October 2000.

The objective of the UNFCCC is to achieve stabilisation of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner (UNFCCC, 1999).

The Convention sets out some guiding principles including:

- the “precautionary” principle which says that the lack of full scientific certainty should not be used as an excuse to postpone action when there is a threat of serious or irreversible damage;
- the “common but differentiated responsibilities” principle assigns the initial responsibility of combating climate change to industrialised countries because of their historical emissions and their greater capacity to respond;
- the special needs of developing countries; and
- the importance of promoting sustainable development.

In the UNFCCC, the 36 signatories which are industrialised countries or have economies in transition to a market economy are listed in its Annex I (shown in Appendix 2), while 25 developing countries are listed in its Annex II. In this thesis, Annex I countries will be called industrialised countries and Annex II countries will be called developing countries.

Appendix 1 details the structure of the UNFCCC and the commitments and obligations of the Parties to the Convention.

The UNFCCC does not set binding targets or timetables for reducing net emissions, but industrialised countries aimed to lower emissions of anthropogenic GHGs to 1990 levels by the year 2000. Most countries did not meet this commitment.

The adoption of the Kyoto Protocol of the Convention in 1997 led to more defined commitments for industrialised countries which are detailed in Section 4.3.

#### ***4.2.3 Conference of Parties***

The UNFCCC's supreme body is the Conference of the Parties (COP) which represents the 186 states that have ratified or acceded to the agreement. Since 1995 the COP has met regularly to promote and review the implementation of the Convention. It periodically reviews existing commitments in light of the Convention's objectives, assesses new scientific findings and considers the effectiveness of national climate change programmes through national communications. The COP can adopt new commitments through amendments and protocols to the Convention. In 1997 it adopted the Kyoto Protocol.

The next COP will be the seventh session of the COP i.e. COP7. It will be held in Marrakesh, Morocco in November 2001.

#### ***4.2.4 Climate Change Negotiating Groups***

At the six COPs held to date various negotiating groups have emerged, tending to be on a geographical, economic or climate politics basis. The main groups are the Alliance of Small States (AOSIS), the European Union (EU), the Group of 77 and China (G77/China), JUSSCANNZ, the Umbrella Group and OPEC.

Other groups of countries that contribute in a significant manner to climate change issues and discussions are the members of the Organisation for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA). Details of the members of these groups and why they were formed are in Appendix 3.

### **4.3 The Kyoto Protocol**

The Kyoto Protocol is a document made up of 25 articles with 2 annexes as detailed in Appendix 4. The document lays out the objectives of the Protocol, states the emission reduction targets of the parties, defines the methods of meeting the targets, and details the administration of the system including the compliance regime.

The key difference between the Protocol and the UNFCCC is the nature of the targets, the specific wording being "aim to" under the UNFCCC and "legally binding" under the Protocol.

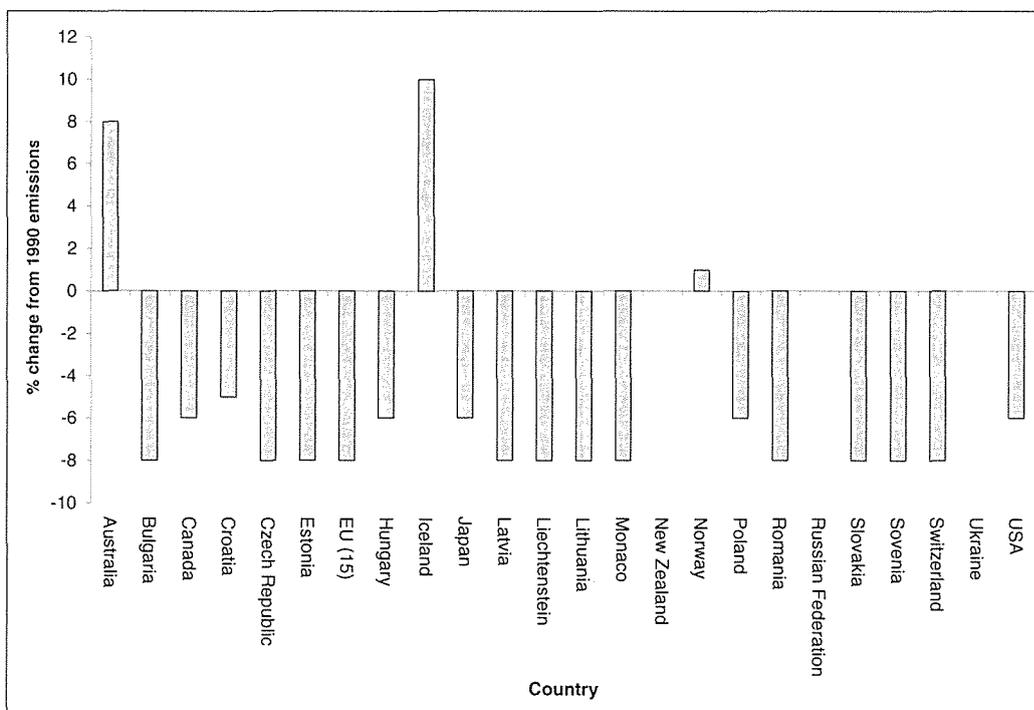
The Protocol strengthens the UNFCCC targets, which were deemed insufficient to address climate change.

Annex B of the Kyoto Protocol lists the targets of the 39 industrialised countries (i.e. those in Annex I of the UNFCCC and 3 others). Annex B is reproduced in Appendix 2. These industrialised countries agreed to collectively reduce their total emissions of the six key GHGs to 5.2% below 1990 levels on average between 2008 and 2012. They emitted 13,728 Mt CO<sub>2e</sub> in total in 1990 (UNFCCC,1997).

This target of an average reduction of 5.2% below 1990 emission levels is broken down into a target for each industrialised country. The targets recognise the parties' different national circumstances, such as their natural resource endowments, reduction possibilities and costs of mitigation. Based on this, each country was allocated an emission target<sup>8</sup> which is indicated as a percentage of total 1990 emissions and is shown in Figure 4.2 and listed in Appendix 2. The target level effectively represents a right to emit to this level.

Countries must either reduce emissions to this level or take responsibility for excess emissions either by carrying out projects that reduce emissions in other countries, by increasing absorption (sequestration) of carbon e.g. by planting trees, or by buying emission rights from other countries. These methods are discussed in Section 4.4.

**Figure 4-2: Kyoto Protocol Targets**



<sup>8</sup> In this thesis, the words “target”, “commitment” and “obligation” are used interchangeably.

New Zealand, Russia and the Ukraine all have a 0% target i.e. their target is to return to (or take responsibility for) the same GHG emission levels as 1990. Only three countries negotiated an increase over their 1990 levels, these were Norway (+1%), Australia (+8%)<sup>9</sup> and Iceland (+10%). Other countries of particular note are the USA with a target of -7% below 1990 levels, Japan and Canada at -6% and the EU, Switzerland and most central and east European states at -8%. Compared to business as usual figures these represent significant reductions for most Annex I countries.

Only industrialised countries and countries in transition to a market economy have been allocated targets, this is in recognition of the fact that most historical and present emissions are due to the action of industrialised countries. It is generally agreed that it should be their responsibility to fund the majority of the mitigation and adaptation measures. At some future time it will be important that developing countries also have commitments as at present there is a direct relationship between economic growth and increases in emissions.

The over-riding outcome of the Protocol is the internalisation of the cost of an environmental externality, being the social cost of carbon in the atmosphere. This has not been included in energy pricing to date. The Kyoto Protocol's success will be based on how effective governments are at implementing policies that meet their commitments. The cost effective achievement of these objectives will be aided by the development of an international carbon trading market which will lead to the discovery of an international price for carbon, this is discussed further in Chapter 5. Polluters in countries that have ratified are likely to be forced or encouraged through policy to include the cost of carbon in their pricing. This will benefit those who do not emit GHGs or who can reduce emissions.

The Controller and Auditor General (2001) gave four facts that are important to understand with regards to the present position on the Kyoto Protocol.

- The Protocol is not yet in force. This will require 55 parties whose emissions represented 55% of the total Annex I 1990 emissions to ratify the Protocol. This requires the governments of these countries to put legislation and regulations in place such that they can achieve the objectives of the Protocol.
- If the Protocol is ratified by sufficient countries to bring it into force the entire international economic structure is likely to change as a result.

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<sup>9</sup> Australia's target of +8% was based on its heavy dependency on fossil fuel with limited opportunity for substitution, fossil fuel intensive export industries, significant transport needs, a population growth much higher than the OECD average and continuing land use change patterns.

- The operation of the Protocol is likely to entail complex measures for international trading in GHGs and carbon sinks that have not yet been agreed.
- There is limited understanding of the Protocol's implications among businesses and the general public in most signatory countries.

#### 4.4 Methods of meeting Kyoto Protocol targets

The intention of the Kyoto Protocol is that emissions should be reduced so countries need to explore and implement a range of cross-economy measures. The Protocol encourages governments to:

- co-operate;
- improve energy efficiency;
- reform the energy and transportation sectors;
- promote renewable energy;
- phase out inappropriate fiscal measures and market imperfections (i.e. subsidies for fossil fuels);
- limit methane emissions from waste management and energy systems<sup>10</sup>;
- protect forests and other carbon sinks.

If the Kyoto Protocol enters into force all industrialised countries that have ratified it will be allocated emission rights or credits based on their agreed targets. These are called Assigned Amount Units (AAUs).

It is unlikely that a country's emissions will match its AAUs using the domestic actions alone. It is also unlikely that this would be the most cost effective approach. For this reason the Flexibility Mechanisms (or implementation mechanisms) are included in the Protocol to assist governments to meet their targets at least cost to their economies. These mechanisms also provide a method for developing countries, which do not have targets, to be involved in the effort to reduce greenhouse gas emissions. This is very important due to the growing size of their economies and the increasing significance of their GHG emissions.

The Flexibility Mechanisms<sup>11</sup> allow emission reduction projects to be hosted by one country and funded by an industrialised country or organisation in another in order to earn credits.

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<sup>10</sup> In New Zealand, the limitation of methane emissions from the agricultural sector will be a significant requirement.

The Flexibility Mechanisms are:

- the Clean Development Mechanism (CDM) for projects in developing countries;
- the Joint Implementation (JI) for projects in another industrialised country;
- the use of carbon sinks; and
- International Emissions Trading (IET) which will allow for trading of credits from a country's initial AAU allocation, from CDM or JI projects or from sink credits.

The options for emission reduction projects are extensive. These could be carried out to reduce domestic emissions or as flexibility mechanism projects. Some examples are:

- energy efficiency projects and renewable energy projects which are proven to offset fossil fuel generating plant;
- fuel switching to lower emitting fuel e.g. Europe's "dash to gas" from coal which has higher emissions;
- changes in agricultural practises (i.e. reducing the depth of tillage reportedly leaves more carbon in the soil);
- forest planting projects which absorb carbon;
- improving industrial processes which cause emissions; and
- altering agricultural feed-stocks to reduce methane emissions from animals (this is still in the research phase).

Demand side projects are also possible but it can be difficult to prove emission reduction ownership. This can also be the case with renewable energy projects if emission reductions happen in a plant not owned by the investor in the renewable energy project.

The "rules" governing the design and operation of the Flexibility Mechanisms are likely to be finalised at COP7 and individual countries need to put domestic policy in place to allow organisations to participate in these projects.

The methods that each country has at its disposal to meet its Kyoto Protocol obligations can be summarised by the equation shown in Figure 4.3.

CERs and sink credits are effectively new credits - they increase the total emissions that are allowable by industrialised countries while ERUs are the AAUs of one industrialised country

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<sup>11</sup> Some consider the bubble mechanism, which allows groups of parties to take on joint targets and allocate the target amongst the group, to also be a Flexibility Mechanism. This mechanism is used by the European Union.

transferred to another industrialised country. The flexibility mechanisms are explored further in the following sections.

**Figure 4-3: Mechanisms for “taking responsibility for” emissions for industrialised countries**

<b>Assigned Amounts</b>	=	<b>Assigned Amount Units</b>	+/-	<b>Emission Reduction Units</b>	+	<b>Certified Emissions Reductions</b>	+	<b>Sink Credits</b>
(AAs)	=	(AAUs)	+/-	(ERUs)	+	(CERs)	+	(Sink credits)
Assigned amount	=	Initial allocation of Assigned Amount based on country's target	+/-	AA's bought or sold via JI projects	+	Created from CDM projects	+	Created from sequestration projects

(Note: The units may be tonnes of carbon (tC) or tonnes of CO<sub>2</sub> (tCO<sub>2</sub>). A reduction of 1tC has the same environmental impact no matter where it occurs i.e. in a developed or industrialised country, however there may be differences in the level of investment required to reduce emissions by 1tC.)

#### 4.4.1 Joint Implementation

Joint Implementation is outlined in Article 6 of the Kyoto Protocol. The purpose is:

*...any Party included in Annex I may transfer to, or acquire from, any other such Party emission reductions units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy,...*

(UNFCCC, 1997)

Industrialised countries are able to carry out emission reduction projects in other industrialised countries and earn emission reduction units (ERUs) equivalent to the reductions due to the project. Though the rules are not yet completely clear for a JI project, they could require:

- the approval of both the investor and host country governments;
- emission reductions to be “real” and permanent. i.e. the “environmental additionality” must be clear, which means the emission reduction must be additional to what would

- otherwise have occurred. This requires the development of baseline emission levels and accurate GHG verification methods; and
- monitoring and verification procedures will need to be in place including the independent certification of emission reductions.

#### **4.4.2 Clean Development Mechanism**

CDM is outlined in Article 12 of the Kyoto Protocol. The purpose is to:

*...assist Parties not included in Annex 1 in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex 1 in achieving compliance...*

(UNFCCC, 1997)

Developing countries do not presently have commitments under the Kyoto Protocol and this remains a contentious issue in international negotiations. It is likely that they will have targets at some time in the future. In the meantime CDM encourages industrialised countries to invest in projects leading to emission reduction in developing countries. These emission reductions can then be credited to the investor country, or shared in part with the host country in the form of Certified Emission Reductions (CERs). There may be lower cost emission reduction opportunities in developing countries. A limited amount of sequestration projects can be carried out by each industrialised country in developing countries to meet their assigned amounts.

CDM encourages the transfer of technology and investment to developing countries in order to aid sustainable development. However, some would argue that it mutes the major environmental focus of the Protocol and tries to meet too many objectives at one time.

CDM is particularly topical because, in theory, CERs from approved CDM projects obtained from January 2000 onward can be "banked" to achieve compliance during the 2008 – 2012 period. This mechanism is one of the major foci of international negotiations at present so countries can begin carrying out CDM type projects. The rules are likely to be similar to JI type projects.

#### **4.4.3 Sink/sequestration Credits**

Sinks are defined in the UNFCCC as

*any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.*

(UNFCCC, 1997)

Sink or sequestration issues are outlined in Article 3.3 and 3.4 of the Kyoto Protocol. As stated in Article 3.3, the purpose is to allow:

*...removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period...*

(UNFCCC, 1997)

Article 3.4 also states:

*... additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to, or subtracted from, the assigned amount for Parties included in Annex I, ...*

(UNFCCC, 1997)

A sink project can be done anywhere. In the country of origin it would be reported in the country's inventory; in another developed country it could earn ERUs for a JI project; or in a developing country CERs could be earned from a CDM project. Property rights over the credits need to be agreed between the counterparties or legislated for.

There is a requirement for the forest establishment or increase in the carbon sink to have occurred since 1990 and independent certification of emission reductions is likely to be required.

#### **4.4.4 Emissions Trading**

Emissions trading is outlined in Article 17 of the Kyoto Protocol. The purpose is:

*...The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions .....,...*

(UNFCCC, 1997)

The definition of the principles, modalities, rules and guidelines for emissions trading are the responsibility of the Conference of Parties and have not been completely finalised.

The second statement of this Article raises the issue of complementarity i.e. the requirement that emissions trading is supplemental to domestic action. Certain groups such as the EU and

various NGOs insist that there must be minimum levels of domestic action achieved prior to the use of emissions trading or the other flexibility mechanisms.

Each country's AAUs can be allocated to entities within a country that would in turn have certain obligations to limit or reduce emissions in some way. When AAUs are allocated to an entity any reduction in their emissions below this allocated amount allows the excess to be traded. Trading of AAUs internationally can occur when the administrative requirements of the system are in place, however some over-the-counter trades based around options are already taking place (see Chapter 5). ERUs and CERs are likely to be fungible (interchangeable) with AAUs so they will all be traded using the same system.

## **4.5 Present status of the Kyoto Protocol**

### **4.5.1 COP 6**

The Sixth Conference of Parties (COP 6) was held in the Hague from the 13-25th November 2001, under the chairmanship of Jan Pronk, the Netherlands Minister of Environment. In the lead up to the event it was seen as the most important session since COP 3 when the Kyoto Protocol was developed and adopted in December 10, 1997. The expectation was that it would meet the objectives of the Buenos Aires Plan of Action, an ambitious programme of work that was agreed to at COP 4 in Buenos Aires in November 1998, and thereby set the stage for entry into force of the Protocol.

Prior to the event, commentators saw that the meeting's success depended on whether it triggered the ratification of the Protocol by developed countries and if it motivated significant action from developing countries to enhance their contributions to the achievement of the UNFCCC objectives.

The major issues under discussion at COP 6 included the Flexibility Mechanisms, compliance, sinks, "land use, land use change and forestry" (LULUCF), monitoring, reporting and review, and developing country issues.

The positions of the different countries and negotiating groups on the major issues is shown in Appendix 5.

In the final hours of COP6, it appeared as though agreement had been reached on several key issues (sinks, supplementarity and some compliance aspects) between the USA and the EU but ultimately the compromise was rejected by the French Presidency, the UK and Germany.

The conference was suspended without reaching agreement on the 25<sup>th</sup> of November. All participants were disappointed at the outcome and stated their commitment to maintain political momentum by reconvening as soon as possible.

The USA requested additional time prior to resuming talks due to the need for its new administration (as of January 2001) to come up to speed. Politically the “failure” of COP6 was seen by many as a missed opportunity because it was the final negotiation led by Clinton’s administration which was seen to be significantly more supportive of the Kyoto Protocol concepts than the incoming Bush administration.

COP6 was reconvened in July 2001 as COP 6.5. The outcome of this meeting is discussed in Section 4.5.3. This research takes into account developments up to COP 6.5.

#### ***4.5.2 Kyoto Protocol “fatally flawed”***

In March 2001, prior to the commencement of COP6.5, President George Bush announced the USA's opposition to the Kyoto Protocol, stating that it was “fatally flawed”, as it would damage the US economy and would not achieve useful environmental outcomes as developing countries do not have emission reduction targets.

Internationally there was an expectation that the Protocol would collapse if the US were to withdraw, however there is still wide international support for the Protocol and its entry into force in 2002. The US decided to participate in COP6.5 to ensure that US trade was not affected and that no precedents were set for other international agreements. They plan to maintain their commitment to the UNFCCC.

The US withdrawal has a significant effect on the “carbon market”. It has changed the balance from a scarce market for emission reductions to one where there is possibly an excess supply from the economies in transition (mostly Eastern European countries) due to the downturn in their economies leading to a significant reduction in emissions since 1990 – often known as “hot air” and also an issues of concern to the USA. This is discussed further in Chapter 5.

#### ***4.5.3 The Bonn Agreement from COP 6.5***

The outcome of COP6.5 in Bonn is now known as the “Bonn Agreement”. It was an unexpectedly good result. The outcome is that there is sufficient information in the Protocol for industrialised countries to consider it to be a “ratifiable” document. This means that there

is now sufficient certainty about the “rules” for parties to implement national policies to meet the Protocol’s objectives. This could lead to the Protocol entering into force in 2002.

The main features of the agreement included the following:

- The right to use sinks to count towards domestic targets, with an annual 1% sink CER limit for CDM projects.
- Development of special carbon sink agreements for countries such as Japan, Russia and Canada.
- A new Special Climate Change fund and an Adaptation Fund have been developed. The former will be supported through replenishment of the Global Environment Fund (GEF), plus bilateral and multilateral channels. The later is to be financed from the share of proceeds on CDM project activities of around 2% and other sources.
- Action under the flexibility mechanisms will be “supplemental to domestic action” but no specific target is suggested but domestic action should be “significant”.
- A commitment period reserve representing 90% of the Party’s AAU or 100% of five times its most recently reviewed inventory is required.
- A fast track procedure for smaller renewable and energy efficiency projects, up to 15 MW and reductions in energy demand by up to 18GWh.
- Exclusion of nuclear power from the CDM and JI projects.
- “Legally binding commitments” would be agreed to after the Protocol is ratified when it will be legally amended.
- The penalty for non-compliance will be the requirement to pay back excess emissions at a rate of 130% (i.e. 1.3 tons for each excess ton of emissions) and the exclusion from international emissions trading.

The concessions around the role of sinks has reduced the actual reduction in GHG emissions down from 5.2% overall to a little less than 2%. Despite this, delegates from the 174 countries represented and environmental groups were virtually unanimous in describing the agreement as an historical event and a critical step in the international efforts to address climate change. America is maintaining its position that the Protocol is not sound policy.

#### ***4.5.4 Will the Kyoto Protocol enter into force?***

The entry into force of the Kyoto Protocol will occur 90 days after parties emitting 55% of Annex I 1990 emissions and a total of a least 55 parties have ratified it. When the required number of countries have ratified the Protocol in their own countries then the Protocol itself is said to be ratified and will enter into force as legally binding international law.

As at June 2001, another 21 countries need to ratify the Protocol and within that group 53.8% of the industrialised countries' 1990 emissions need to be represented in order for it to enter into force.

None of the Annex I countries could block the Protocol alone. However those with a large share of emissions such as the USA (36.1%), the EU (nearly 25%), Russia (nearly 17.4%) and Japan (8.5%) are of crucial importance.

Due to the success of COP 6.5 it is expected that more countries will now ratify in 2002 at the next Earth Summit in Johannesburg, commonly called Rio +10. Delegates at Bonn from Canada, the UK and Japan expressed optimism that ratification of the Protocol could be achieved. Russia is expected to ratify due to the considerable economic value of its "hot air credits". This excess in AAUs can be traded to the Russian's benefit on the international market or used to encourage overseas investment in JI type projects. The EU has often stated that they intend to ratify while the French, Belgians and Danish have already made significant progress towards ratification. Australia will have an election prior to the end of the year so ratification is likely to be an issue as they have concerns about the value of the Protocol if it does not include the USA. In August 2001, the New Zealand government reiterated its policy that it will ratify in September 2002 if Cabinet agrees that the Protocol has become ratifiable.

The agreement in Bonn has triggered major debate in the US Congress about the administration's decision to reject the Protocol and the development of national climate change policy. There are several bills proposed to address climate change, these are likely to be progressed in the next months. On August 1<sup>st</sup> the Senate Foreign Relations Committee passed by unanimous vote a non-binding resolution calling on the Bush administration to propose revisions to the Kyoto Protocol at COP 7 in October or offer an alternative binding agreement. It endorses that an acceptable climate change agreement will need to include developing countries and not harm the US economy, it will need emission reductions to occur in all sectors and be based on flexible international and domestic mechanisms, including emissions trading and carbon sequestration projects.

Despite the US withdrawal, the sentiments (in September 2001) of New Zealand's officials and government Ministers indicate that the Protocol may enter into force as early as September 2002. This is based on an expectation that countries with significant emission levels will ratify at that time including the EU, Canada, Russia, the Ukraine and Japan.



# Chapter Five

## Carbon Markets and the value of carbon

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One of the major outcomes of the political decisions that are being made at an international level relating to climate change is the development of a new commodity and market. This commodity can be generated in a number of different ways but the base "currency" is carbon, hence the term carbon market. It is also commonly called emissions trading.

At present this is a very thin emerging market and there are many names for the tradeable unit - all based either on the reduction of emissions or the sequestration of carbon. It is likely that despite having a common currency, the market will perceive different "qualities" of carbon, which will cause price differentiation. Quality differences occur mainly because of differing levels of certainty regarding buyer's expectation that the emission rights they are purchasing will be useful in mitigating international or domestic responsibilities that may be assigned to them. This is very dependent on the status of policy in the seller country and the level of liability that the seller is prepared to accept.

The development of these markets and indications of the present value of carbon are discussed in the following chapter.

### 5.1 Carbon trading

Despite the lack of definite rules around the Kyoto Protocol, a carbon based commodity market is beginning to emerge. In the absence of national legislation and regulation detailing property rights and methodologies for quantifying emission reductions, the deals that are taking place tend to be on a project basis. These projects have included fugitive gas capture from landfills, fuel switching and co-generation and forest plantation projects.

Despite the absence of firm policies and legislation, companies are hedging their exposure to expected limitations on GHGs, attempting to maximise on potential opportunities and to learn, by carrying out early trades. This indicates that non-Kyoto Protocol drivers, such as OECD domestic trading regimes and corporate voluntary markets, are also significant.

Various schemes such as the Activities Implemented Jointly (AIJ) scheme have been involved in emission reduction projects since the mid 1990s and use similar methodologies as those that may be used for the JI or CDM mechanisms. The World Bank Prototype Carbon Fund is

supported by large companies and governments in order to learn by having involvement in these types of projects (this is often called “learn by doing”).

### 5.1.1 Internal company trading systems

Individual companies, such as BP and Shell, have set up internal trading systems between company divisions, while other companies such as IBM, Johnson and Johnson, and Polaroid have all set GHG emission reduction targets. Examples of company emission levels, targets and methods are illustrated in Table 5-1.

**Table 5-1: Company GHG reduction commitments**

Company	1999 Emissions <sup>12</sup>	Commitment	Internal Trading	CDM/JI
Alcoa	---	25% below 1990 in 2010		
BP Amoco	79.8	Cumulative 2%/year below 1990	Y	Y
Chubu	51.3	0.140 kgCO <sub>2</sub> /kWh in 2005		
DuPont	44.4	65% below 1990 in 2010		
Kodak	---	20% below 1990 in 2004		
Fortum	9	0.5 MtCO <sub>2</sub> below baseline in 2010		Y
IBM	4.1	Cumulative 4%/yr below 1998 until 2004		
Intel	3.3	10% below 1995 in 2010 (PFCs)		
Johnson & Johnson	1.5	7% below 1990 in 2010		
Motorola	---	50% below 1995 in 2010 (PFCs)		
Ontario Pow. Gen.	26	6% below 1990 in 2010		Y
PEMEX	177	-1% per year until 2010	Y	Y
Shell	99	103 Mt CO <sub>2</sub> -e in 2002	Y	Y
Statoil	8.3	1.5 MtCO <sub>2</sub> -e below baseline in 2010		Y
Suncor	5	-1.5/ year until 2002 (-1%/year for 2003-2008)	Y	
Transalta	38.5	None stated	Y	

(Source: Based on Margolick M and Russell D, 2001)

<sup>12</sup> This information source did not provide a unit however it is likely that the units are MtCO<sub>2</sub>-e. It is interesting to note that that some of the companies emit as much as New Zealand does as a country (i.e. 75.4MtCO<sub>2</sub>-e in 1990).

The Partnership for Climate Action, which is managed by the Pew Center for Climate Change in the US, represents companies which emitted an estimated 360 Mt of GHG<sup>13</sup> in 1990 which they plan to reduce to 210Mt by 2010.

### 5.1.2 National trading systems

Governments that have ratified the Kyoto Protocol may assign the responsibility for reducing emissions to entities within their economies that make decisions that impact on the countries emission levels. There are many systems that a government could implement to drive down the emissions in those organisations or sectors and a national emission trading systems allows the least cost reduction opportunities within an economy to be discovered. Domestic emissions trading schemes are operating in some countries as shown in Table 5-2.

**Table 5-2: National trading systems**

Country	Emissions Trading	Allocation	Start-up	Project based mechanisms
EU	Yes	Country specific	2005	2008 latest
UK	Yes	Grandfathering	2001	Yes
France	Yes	Agreements	2003?	Yes
Norway	Yes	G'ring/Auctions	2005 or earlier	Yes
Germany	No	Agreements	-	Later
Denmark	Yes(a)	G'ring	2001	Yes
Sweden	Yes	G'ring/Auctions	2005 or later	Yes
Netherlands	Ongoing Work	Agreements	-	Yes
Finland	Ongoing Work	Agreements	-	Yes
Ireland	Ongoing Work	-	-	Ongoing work
Australia	Yes	G'ring	US dependant	Yes
USA	Yes(b)	G'ring	?	Yes(b)
Canada	Yes	Auctioning/free	US dependant	-
Japan	Ongoing Work	Agreements	-	Yes
New Zealand	Yes	Grandfathering	Not decided	Yes
Russia	No	-	-	Yes
a) Power generating sector only.				
b) Only if ratification and entry into force of the Kyoto Protocol				

(Source: Hasselknippe H et Hoibye G, 2001)

<sup>13</sup> The basis for this unit is not reported i.e. unclear whether it is on a C, CO<sub>2</sub> or CO<sub>2</sub>-e basis.

The cost of production of companies with responsibilities will effectively increase to reflect the price of carbon. To reduce the impact of this additional cost, governments are likely to allocate some of their AAUs to those companies with obligations. There are a variety of different methods that could be used including:

- an auction system, where emitters must purchase credits and therefore the right to emit;
- a grandfathering system where emitters are gifted with credits based on historical emissions levels;
- a hybrid of the two above; or
- based on individual agreements with the government.

A company will need to obtain carbon credits to cover any GHG emissions that exceed the emissions credits that may be allocated by the government. These could be obtained through:

- purchasing carbon credits from emissions trading markets;
- investing in international JI and CDM projects;
- investing in carbon sink projects;
- investing in the energy efficiency and renewable projects which generate credits.

### **5.1.3 International trading systems and carbon prices**

A review and analysis of the emerging international greenhouse market (Natsource, 2001) found that approximately 60 inter-company transactions, involving 55 MtCO<sub>2</sub>-e, had taken place prior to August 2001. This did not include intra-company trades such as those in BP's and Shell's internal trading systems. Most trades have been between buyers and sellers in industrialised countries. The trades involve Verified Emission Reductions (VERs) audited by a third party with a possibility of future government recognition as "credits". Some transactions have involved financial derivatives such as call options.

The nominal prices for inter-company trades have ranged from NZ\$1.40 to \$19.00 per ton of CO<sub>2</sub>-e since trading began in 1996-7. Table 5-3 shows CO<sub>2</sub>-e prices by commodity type.

**Table 5-3: GHG prices per ton of CO<sub>2</sub>-e by commodity type and vintage**

<b>Commodity Type</b>	<b>Vintage Year</b>	<b>NZ\$/tCO<sub>2</sub>-e</b>
Annex I Verified Emissions Reductions (VERs)	1991 - 2007	\$1.40 - \$3.60
Annex I VERs	2008 - 2012	\$4.00 - \$7.10
CDM VERs	2000 – 2001	\$4.20 - \$7.10

<b>Commodity Type</b>	<b>Vintage Year</b>	<b>NZ\$/tCO<sub>2</sub>-e</b>
<b>Compliance Tools</b>		
Dutch Emission Reduction Units (ERUs)	2008 – 2012	\$10.50 - \$19.00
Danish allowances – mid market bid-offer	Av. 2001 – 2003	\$9.50
European ERUs – indicative bids	2008 – 2012	\$16.70 - \$28.57
Australian Early Action AAUs – indicative offers	2008 – 2012	\$14.30 - \$28.60
UK Permits – mid market bid-offer	2003	\$20.20
BP internal allowances – pilot phase	1999	\$23.80 - \$60.00
BP internal allowances – full scale internal trading	2000 – 2001	\$1.20 - \$59.50
Shell internal allowances	2000-2001	\$12.00-\$14.00
<b>Other indicative prices</b>		
Green Warrants (Macquarie Generation to Japanese)	2000 -2001	\$4.80 - \$7.10
New Zealand Modelling exercises	2008-2012	\$13.00 - \$26.00
Expected international price (MfE, 1999)	2008-2012	\$5.00 - \$36.00
Australian modelling (AGO, 1999) (A\$5-\$191) Average A\$30	2008-2012	\$6.00 - \$230.00 Average \$37.00
Possible New Zealand low carbon charge (\$5/tC)	Pre 2008	\$18.30
Forward trading market in New Zealand (actual trades 2001 - \$4/tC)	2008-2012	\$14.66

Based on \$NZ = \$US 0.42, \$NZ = \$A 0.83

(Source: Based on Natsource, 2001)

Different values are attributable to the terms of the contracts rather than a shift in supply and demand. If sellers are prepared to guarantee that VERs will be acceptable by regulatory authorities then higher prices are possible. Buyers generally require proof that sellers own and are authorised to transfer rights to emission reductions. As few governments have established guidelines for setting baselines and monitoring emissions, sellers have defined these for themselves needing only to satisfy potential buyers of their quality. They have tended to be project specific with one base year in the past as far back as 1990.

Waste Management New Zealand has been involved in one deal for the emission reductions associated with one of its landfill sites. Trustpower New Zealand is exploring a feasibility study for a Joint Implementation type project in order to complete the second stage of the Tararua Wind Farm with a consortium from the Japanese Energy Federation. The Japanese have been active in identifying opportunities and have purchased forests in NSW, Australia including the carbon related credits. Other companies have signed memoranda of

understanding with organisations that have abatement opportunities, such as Chinese coal fired electricity generators.

Prices that are being paid remain significantly lower than forecasted prices as total supply has consistently exceeded demand. Prices are also discounted due to the risk associated with policy uncertainty. Risks include:

- the uncertainty surrounding the Kyoto Protocol and potential domestic policies;
- the recognition of specific types of emission reductions and monitoring and verification protocols;
- the flexibility of trading rules; and
- the recognition of early actions.

## 5.2 Potential size of carbon market

Many studies have been carried out with the objective of estimating the cost of meeting the Kyoto Protocol. A variety of approaches and models have been used including general equilibrium, macro econometric and aggregated production/cost function models, each has their strengths and weaknesses. Most have used a top-down economic approach rather than a bottom-up engineering approach. The main findings of these studies are useful for indicating the potential size of the carbon market and the potential value per tonne of carbon (Aslam, 2001). The findings of one study sponsored by the United Nations in 2001 are summarised in Table 5-4. Commentators have stated expectations of the size of the carbon market reaching trillions of dollars. One of the difficulties with these analyses is the use of different assumptions by the researchers.

**Table 5-4: Potential Size of the Carbon Market**

Market Participants	\$tCO <sub>2</sub> -e in 2010 (NPV)	Market Value (approx.)
Abated domestically in industrialised countries	NZ\$50	NZ\$220 billion
JI/IET with industrialised countries	NZ\$24	NZ\$105 billion
CDM/JI/IET including industrialised and developing countries	< NZ\$21	NZ\$70 - S85 billion

(Source: Based on Aslam, 2001)

This study was carried out prior to USA's decision to withdraw from the Protocol process. This withdrawal will significantly decrease demand and therefore the price of carbon. The US

was likely to be a significant net buyer of credits. The countries with economies in transition to a market economy, especially Russia, will be the largest seller of credits due to the downturn in their economies post the 1990 baseline year. They will have the power to control the price of carbon to some extent by managing the availability of the commodity on the market. These excess AAUs can either be traded internationally or used to encourage overseas investment in their country by allocation ERUs to investors in JI type projects. Any excess credits that a country owns can be "banked" until the next period so forecasting the future value will be important for these countries.

The forecasting of the future value of carbon is essential for all entities considering participating in this market. This becomes easier as more certainty develops with the finalisation of the Kyoto Protocol rules and clear indications of the countries that will be involved and the introduction of domestic policy in the participating countries.



## Section Two

# New Zealand and its electricity sector's climate change issues

*The purpose of this section of the thesis is to focus the research by identifying policy objectives and emission reduction options for New Zealand in response to the Kyoto Protocol and the global climate change issues identified in Section One. GHG emission levels are shown and the effects of climate change on the country and industry are discussed. The aspects of New Zealand's policy response which impact on the electricity sector are also discussed.*

- *Chapter 6 has a national focus by exploring New Zealand's GHG emissions and the effect of climate change on New Zealand.*
- *Chapter 7 discusses New Zealand's electricity sector's GHG emissions and the impact of climate change on the sector.*
- *Chapter 8 explores how New Zealand could meet its Kyoto Protocol commitments by concentrating on the GHG reduction options available in the electricity sector.*
- *Chapter 9 assesses New Zealand's climate change policy development and its impact on the electricity industry.*



## Chapter Six

# New Zealand's GHG emissions and the effect of climate change

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New Zealand's total greenhouse gas emissions are small from a global perspective representing around 0.2% of emissions from industrialised countries, however the impacts of emissions from all countries affect its climate, which explains policy makers significant support for an international response.

In 1990, New Zealand emitted 8 tonnes of CO<sub>2</sub> per capita, which was amongst the lowest level of the main industrialised countries, however due to very high CH<sub>4</sub> emissions, New Zealand was the 4<sup>th</sup> highest per capita emitter<sup>14</sup> when taking all GHGs into account at around 20tCO<sub>2e</sub>/capita. This high level of CH<sub>4</sub> emissions leads to considerable challenges for New Zealand's policy makers. New Zealand's Kyoto Protocol commitment is to reduce emissions on average to 1990 levels or take responsibility for emissions in excess of this amount during the first commitment period 2008- 2012. Historic emissions and those expected for the 2008-2012 period are discussed in this chapter.

New Zealand's heavy reliance on climate related income and value streams including life style, agriculture, tourism and hydro-electricity generation means that the impact of climate change could be more significant to New Zealand than other industrialised countries. The potential impacts that have and could occur are discussed in this chapter

### 6.1 New Zealand's GHG emissions in 1990

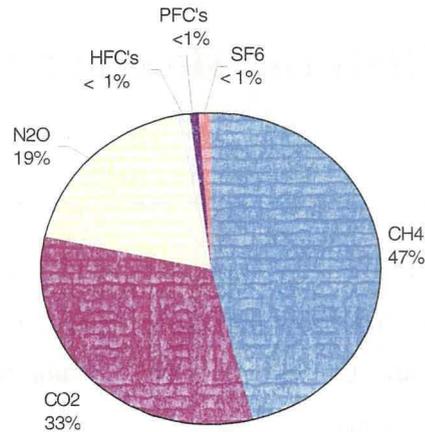
In 1990, the base line year of the Kyoto Protocol, New Zealand emitted 75.4 Mt CO<sub>2</sub>-e of the six gases covered by the Protocol (MfE, 1998). The proportion of each of the emissions is shown in Figure 6-1.

The most recent data indicate that total GHGs have risen by approximately 8% since 1990 and, if nothing is done to reduce emissions, could be more than 15% above our target during the first commitment period from 2008 – 2012 (New Zealand Climate Change Programme, 2001).

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<sup>14</sup> New Zealand has 0.007% of the world's population (Controller and Auditor General, 2001).

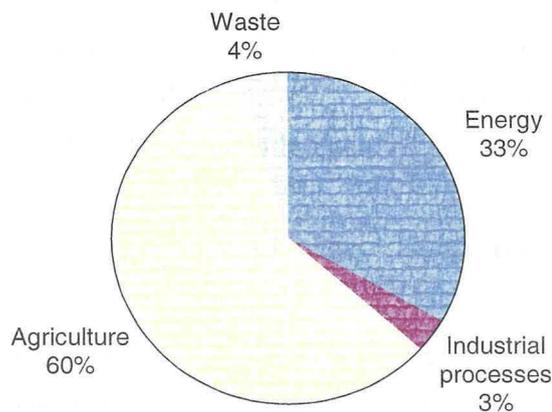
**Figure 6-1: New Zealand's Greenhouse Gas Emissions 1990 (CO<sub>2</sub> equivalent)**



(Source: MfE, 1998)

New Zealand has an unusual emission profile compared to most other industrialised countries because of the large contribution from the agricultural sector (see Figure 6.2 for a sectoral breakdown). The majority of the agricultural emissions are CH<sub>4</sub> mainly released during the digestion processes of sheep and cattle and animal excreta and the use of fertilisers which leads to N<sub>2</sub>O emissions.

**Figure 6-2: Contribution to total emissions by sector (1990)**



(Source: MfE, 1998)

New Zealand has the highest ratio of non-CO<sub>2</sub> emissions to CO<sub>2</sub> emissions of any industrialised country (MfE, 1998). The latest figures (New Zealand Climate Change Programme, 2001) show that the total non-CO<sub>2</sub> emissions are around 1990 levels, despite a large increase in methane emissions from cows (increase by 30%) and a significant decrease from sheep (reduction by 11%).

CO<sub>2</sub> is the second most significant GHG emission and is the most relevant to non-agricultural businesses. Most CO<sub>2</sub> emissions come from energy and industrial processes. Since 1990, there have been substantial increases in CO<sub>2</sub> emissions from the transport sector (36%), manufacturing industries and construction (21%) and thermal electricity generation (54%) (New Zealand Climate Change Programme, 2001). The emissions from the electricity sector are the second largest and the emissions of interest in this study are discussed further in Chapter 7.

## 6.2 New Zealand's forecast GHG emissions between 2008 – 2012

In the future, New Zealand's GHG emissions are expected to grow steadily. However in the medium term this will be offset by considerable absorption, technically referred to as sequestration of carbon, by forests planted after 1990.

Based on MfE expectations in 1998, expected changes in emissions can be summarised as:

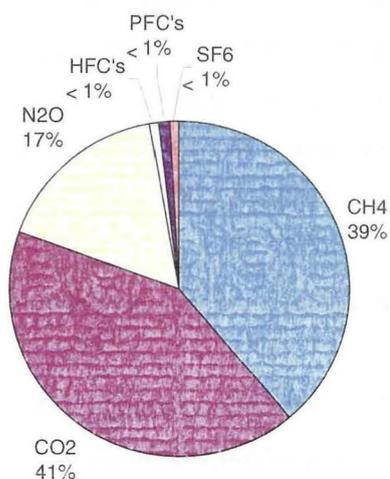
- For the first Kyoto period, CO<sub>2</sub> emissions, are expected to rise significantly mainly due to increased transportation emissions and an increase in the supply of electricity generated by burning fossil fuels (predominantly natural gas).
- Emissions due to methane and nitrous oxide (primarily from the agriculture sector) are expected to drop to 17 million tonnes of CO<sub>2</sub>-e.<sup>15</sup> (This may need to be reassessed due to the upturn in the dairy industry in New Zealand).
- Emissions of SF<sub>6</sub> and HFCs are trending upwards, and PFCs although showing an upward trend from 1995, are expected to remain below 1990 levels through to 2020. Therefore HFCs, PFCs and SF<sub>6</sub> do not change the overall emission profile in any significant way.
- New Zealand will exceed its total GHG emissions by approximately 34 Mt CO<sub>2</sub>e above the amount assigned to New Zealand under the Kyoto Protocol during the first target period.

The expected emission levels of each gas are shown in Figure 6-3.

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<sup>15</sup> This assumption was made prior to the upturn in the agricultural sector, which may mean the decrease in CH<sub>4</sub> is less significant than expected.

**Figure 6-3: NZ's forecast GHG emissions in 2010**



(Source: MfE, 1998)

Table 6.1 shows a comparison between 1990 data and 2008-2012 forecast emissions for New Zealand.

**Table 6-1: New Zealand emissions in 1990 compared to 2008-2012 forecasts**

(Units = MtCO <sub>2</sub> -e)	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	Gross Total	Sinks	Net Total
<b>AAUs for total 1990 GHG emissions levels (MfE, 1998)</b>	25.4	35.8	14.2	75.4		
<b>2008-2012 total target<sup>16</sup></b>	127	179	71	377		377
<b>2008-2012 (forecast)</b>	177	165	68	411	- 130	281
<b>Forecast excess emissions 2008-2012</b>	50	- 14	- 3	34	- 130	<b>- 96</b>

(Source: Based on MfE, 1998)

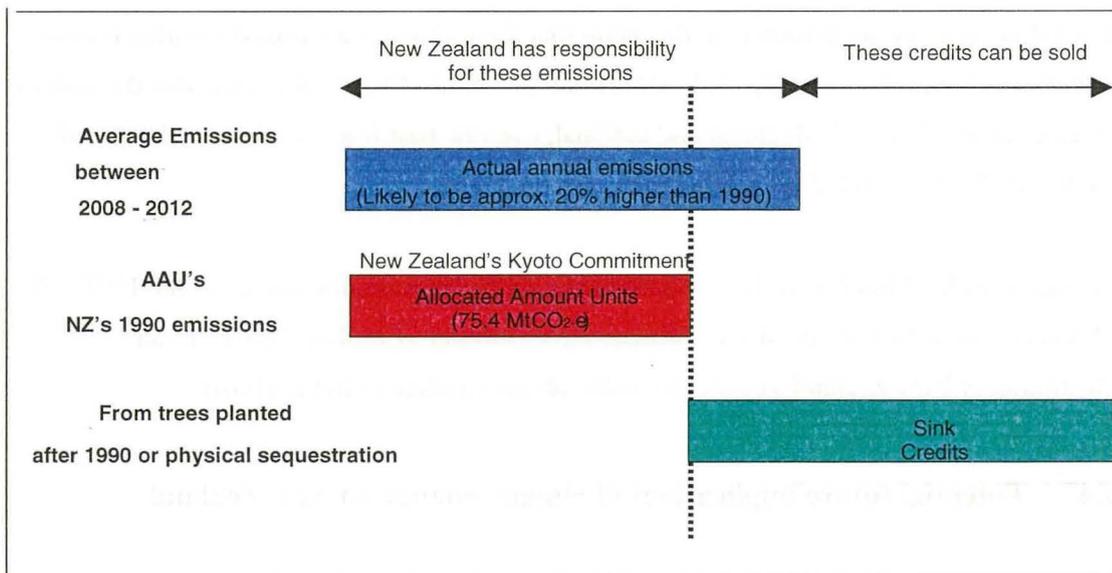
Despite increased emission levels, Table 6.1 shows that New Zealand is likely to have excess emission credits to trade during the 2008-2012 period due to sink credits whose contribution means that net emissions are -96MtCO<sub>2</sub>-e. This means that emissions are 96 MtCO<sub>2</sub>-e less than New Zealand's Kyoto Protocol total emission target from a gross perspective, which could be sold on the international carbon market.

<sup>16</sup> 1990 levels x 5 years (2008 – 2012)

The New Zealand government has stated that it will not use the sink credits to protect emitters from taking responsibility for reducing emissions. Decisions have not yet been made as to the allocation of sink credits though the government has stated that some of them will be assigned to the owners of forest planted after 1990.

New Zealand is likely to exceed its 1990 emission levels by approximately 20% while other industrialised countries could exceed their emission targets by as much as 30% (excluding sinks). New Zealand's situation is different from most other countries as the expectation is that forest sink credits will exceed total emissions for the first commitment period which means that New Zealand may be a net seller of credits, this is illustrated in Figure 6-4.

**Figure 6-4: New Zealand's likely first Kyoto period position**



New Zealand's position in the first Kyoto period (2008-2012) looks satisfactory as a result of sink credits. This may also be the case for the second commitment period, however there is only so much land in pasture, crop and scrub that it is economic to convert to new forest. Therefore taking a longer term view the only approach that will ensure that New Zealand is able to meet subsequent Kyoto targets<sup>17</sup> is to reduce domestic emissions where it is economic to do so. The investments that are likely to significantly impact on New Zealand's long term emission profile are lumpy and have long lifetimes. Therefore it is important that signals are sent as soon as possible to provide sufficient information to the decision makers controlling

<sup>17</sup> Kyoto targets are likely to become tighter and more difficult to achieve in each subsequent commitment period unless a significant scientific breakthrough alters policy makers assessments of the risks. This tightening will ensure that the participants to the Protocol are making a real contribution to the maintenance of the atmosphere and the climate.

these investments. This will help ensure New Zealand's response utilises resources in the most efficient manner.

### **6.3 Has climate change affected New Zealand yet?**

There has been a measurable change in the New Zealand climate over the last 20 years (MfE, 2001). Annual temperatures in the central and eastern parts of the North Island have risen by up to 0.25°C. Recent trends indicate more droughts in the north and east of the North Island, more damaging floods in the west and south of the South Island, fewer frosts nationwide, night time temperatures continuing to rise and stronger westerly winds over southern and central New Zealand. 1998 was the hottest year on record, with an average temperature 0.8°C above normal.

It is not possible to say definitely at this point that these changes are linked to either human activities or naturally occurring cyclical fluctuations in the climate. It is clear that the pattern of temperature change, both global and national, over the past few decades correlates to the predicted effects of global warming.

According to the Ministry for the Environment (1999) the economic impact of the 1997/1998 El Nino event in New Zealand was estimated to be around \$1 billion. This gives an illustration of New Zealand's economic vulnerability to changes in the climate.

### **6.4 Potential future implications of climate change on New Zealand**

While the objective of the Kyoto Protocol and New Zealand's emerging climate change policy is to reduce GHG emissions in the hope of controlling climate change, the level of GHGs are still expected to rise for some time to come. The fact that GHGs exist for a long time in the atmosphere exacerbates the problem. Therefore it is important to assess the implications of climate change so that adaptation options can be considered.

The regional effects of climate change are more difficult to predict. It is expected that New Zealand will face the weather and bio-security issues shown in Table 6.2. The cost and benefits of climate change are unlikely to be spread evenly between different sectors of the economy or different regions.

**Table 6-2: The potential effect of Climate Change on New Zealand**

<b>Weather related issues</b>	<b>Bio-security related issues</b>
-------------------------------	------------------------------------

Weather related issues	Bio-security related issues
<ul style="list-style-type: none"> <li>• Most significant will be changes in the severity and frequency of climatic extremes.</li> <li>• Climate models for the Australia-New Zealand region predict average temperatures to rise between 0.7°C and 3.1°C over the next 100 years.</li> <li>• Changes in rainfall. Climate models predict a decrease in year round rainfall on the east coast of the South Island and in winter rainfall on the east coast of the North Island. Elsewhere, rainfall is predicted to increase.</li> <li>• Changes in wind patterns and strength.</li> <li>• Seasonal snow storage in the South Island is likely to decrease.</li> </ul>	<ul style="list-style-type: none"> <li>• The possible proliferation of existing and introduced pests.</li> <li>• Disease affecting human health.</li> <li>• Effects on agriculture and forestry production.</li> <li>• Extension of existing crops into new production areas.</li> <li>• New crops and crop related industries may become viable.</li> <li>• Rising temperatures and CO<sub>2</sub> may enhance crop and forest growth rates.</li> </ul>

(Source: MAF, 2000)

The potential implications of climate change in New Zealand are significant in terms of cost to the national economy. Whilst these changes are only predicted at this time, it is important that the New Zealand government assesses the risk and acts to implement policies to ensure emissions levels are controlled. While New Zealand's emissions are small from a global perspective, the climate change phenomenon is affected by emissions from all countries reinforcing the need for an international response to emission control and mitigation.



# Chapter Seven

## Electricity sector climate change issues

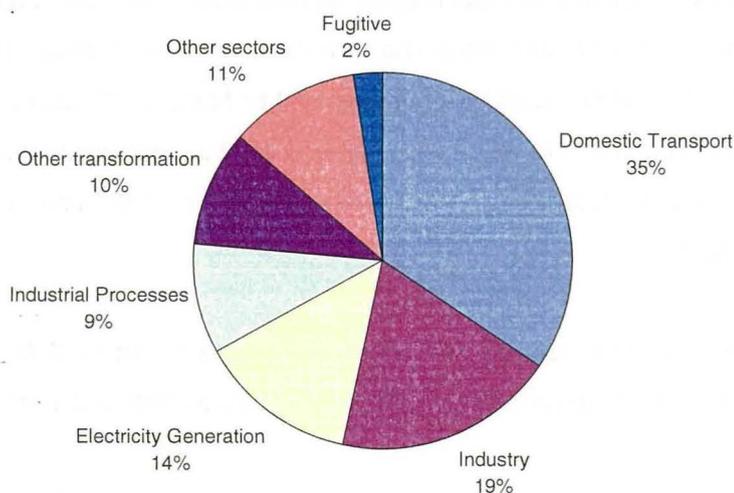
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The world's electricity sector has importance in the climate change debate as it produces over one third of energy related emissions. In New Zealand in 1990, the electricity sector emitted only 4% of New Zealand's total GHG emissions but this represents 14% of all CO<sub>2</sub> emissions in NZ at that time. Whilst not the most significant contributor, emissions from the electricity sector are increasing at a faster rate than any other sector other than transport, therefore the electricity sector is an appropriate focus for this work. This chapter will discuss the emissions from the electricity sector and the implications of climate change on the sector.

### 7.1 New Zealand's electricity sectors GHG emissions

The electricity sector's emissions are primarily CO<sub>2</sub>. The sector contributed 14% of all CO<sub>2</sub> emissions in New Zealand in 1990 as shown in Figure 7-1.

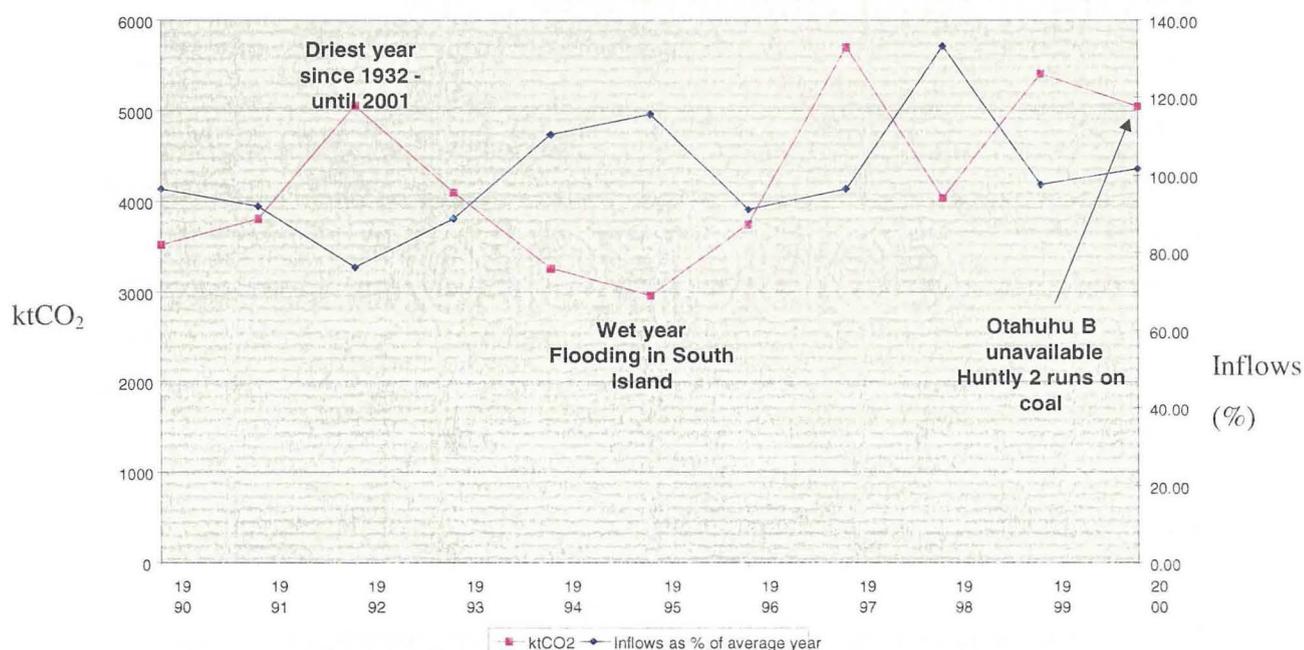
**Figure 7-1: Breakdown of New Zealand energy CO<sub>2</sub> emissions (1990)**



(Source: MfE, 1998)

In 1990, the electricity sector emitted 3.5Mt of CO<sub>2</sub>, by 1999 this had reached 5.4Mt representing a 54% increase. This change is illustrated in Figure 7-2.

**Figure 7-2: Electricity CO<sub>2</sub> emissions and Manapouri/Pukaki inflows (1990 – 2000)**



(Source: MED, 2001 and Meridian Energy data, 2001)

The electricity sectors emissions are variable from year to year depending on the inflows into the hydro lakes and the efficiency and fuel used by thermal generating plant. Figure 7.2 shows the direct relationship between hydro inflows on New Zealand's largest storage lakes and CO<sub>2</sub> emissions from the sector. In dry years the emissions will be higher as thermal plant generates a higher proportion of electricity, in wet years emissions will be lower due to the increased availability of “fuel” for the hydroelectric power stations which provide approximately 70% of New Zealand’s electricity.

It is expected that the electricity sector’s CO<sub>2</sub> emissions will reach 7Mt by 2010. Table 7-1 shows a comparison of the electricity sector’s GHG emissions in 1990 and 1999.

**Table 7-1: Comparison of electricity sector emissions in 1990 and 1999**

Year	CO <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O		Total
	kt CO <sub>2</sub>	kt CH <sub>4</sub>	kt CO <sub>2</sub> -e	ktN <sub>2</sub> O	kt CO <sub>2</sub> -e	ktCO <sub>2</sub> -e	
<b>1990</b>	3,518 (99.79%)	0.159	3.339 (0.10%)	0.0131	4.061 (0.11%)	3,525.4 (100%)	
<b>1999</b>	5,411 (99.75%)	0.234	4.914 (0.10%)	0.0275	8.525 (0.15%)	5,424.4 (100%)	
<b>% increase 1990-1999</b>	65%	68%	-	48%	-	65%	

SF<sub>6</sub> is another electricity sector emission as it is used in transformers as a spark retardant. However it is relatively minor so this work will focus on CO<sub>2</sub> emissions as more opportunities exist to control or reduce this type of emission.

## **7.2 Potential impact of climate change on the NZ electricity industry**

It is difficult to accurately assess the implications of climate change at a global and national level, so attempting to assess these implications on a specific industry is challenging and uncertain. The major potential effects on the NZ electricity industry involve national electricity demand and the industry's ability to supply electricity.

According to IPCC (1998) the potential impacts include:

- Rising temperatures will lead to reduced heating demand in winter and increased air conditioning demand in the summer, however the impact on electricity demand is likely to be relatively small. In fact it could lead to a reduction in the seasonal demand variation that could provide an operational gain for the industry by minimising seasonal peak loads.
- The fact that there is likely to be an increase in weather extremes could decrease the reliability of the system especially due to the high contribution from hydro-electricity. Any changes in rainfall characteristics in hydro-electricity catchments would have impacts on electricity generation operations, as was the case in 1992. This effect has also been illustrated in the winter of 2001.
- Increased temperatures could lead to a reduction in the amount of snow fall, an earlier snowmelt, increased winter run-off and decreased spring run-off. This would reduce spring flood risk and could lead to a more seasonally smooth hydro-electric generation, than at present which has a spring summer peak in the South Island.

Other potential impacts include:

- It is possible that more frequent extreme rainfalls would require hydro-electricity systems to be managed more conservatively to avoid the risk of overtopping the dams in floods and running out of water during droughts.
- Increased sediment transport could accelerate the reduction of storage capacity in the hydro lakes.

- Increased river temperatures could reduce a river's capacity to cool thermal generating plants, which may lead to difficulty in meeting regulatory requirements with regards to downstream river temperatures. The efficiency of thermal generation plants decreases as outlet temperatures increase.
- Transmission losses and line sag will increase with higher ambient temperatures and electricity flow leading to a reduction in the maximum carrying capacity of transmission lines. Transmission volumes are controlled to manage sag safely.

The Ministry for the Environment (MfE) released a comprehensive report on Climate Change Impacts in New Zealand in 2001. Several significant issues were raised with respect to the electricity industry.

- Climate change could play an important role in the South Island based supply of hydro electricity. Expected changes in precipitation varied throughout the country and ranged from -10% in Auckland and Northland to +30% in Southland and inland Otago by 2100. The norm is that river flows in hydro catchments are lowest in winter and rise in spring and summer due to snow melt. However under warmer conditions, there will be increased winter rainfall over the main divide, less seasonal snow storage and a reduced contribution from shrinking glaciers, which may even out the seasonal difference in inflows. This seasonal change in supply will coincide with reduced electricity demand during the winter brought about by warmer conditions.
- Electricity demand models predict that for a warming of about 2° C by 2100, annual average electricity demand would decrease by about 6%. The changes in expected temperature by 2100 varied throughout the country but ranged from +0.6°C in Southland and inland Otago to +2.8°C in Auckland and Northland i.e. an increase in all New Zealand locations. Therefore, future climate change may be expected to bring benefits to hydro electricity supply through reduced summer storage needs and increased generation potential during winter peak demand. The balancing factor to this is that summer demand for electricity could increase through the growing use of air conditioning in buildings.

Based on the information presently available, the predicted effects of climate change on the New Zealand electricity sector could be significant and potentially affect both demand and supply levels.

## Chapter Eight

# New Zealand's Kyoto Protocol commitment and GHG reduction options

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In order to meet its Kyoto Protocol obligations, now and in the future, New Zealand must either reduce emissions significantly below those expected in business as usual forecasts or take responsibility for excess emissions. Each sector within New Zealand has different opportunities and costs associated with emission reductions and different abilities to adapt to climate change. National and international policy makers are firmly focussed on reduction options rather than options for adaptation at this time.

New Zealand's Kyoto Protocol commitments and GHG reduction or mitigation options are discussed in this chapter concentrating on the electricity generation sector opportunities. The methods of taking responsibility for excess emissions using the flexibility mechanisms are also discussed.

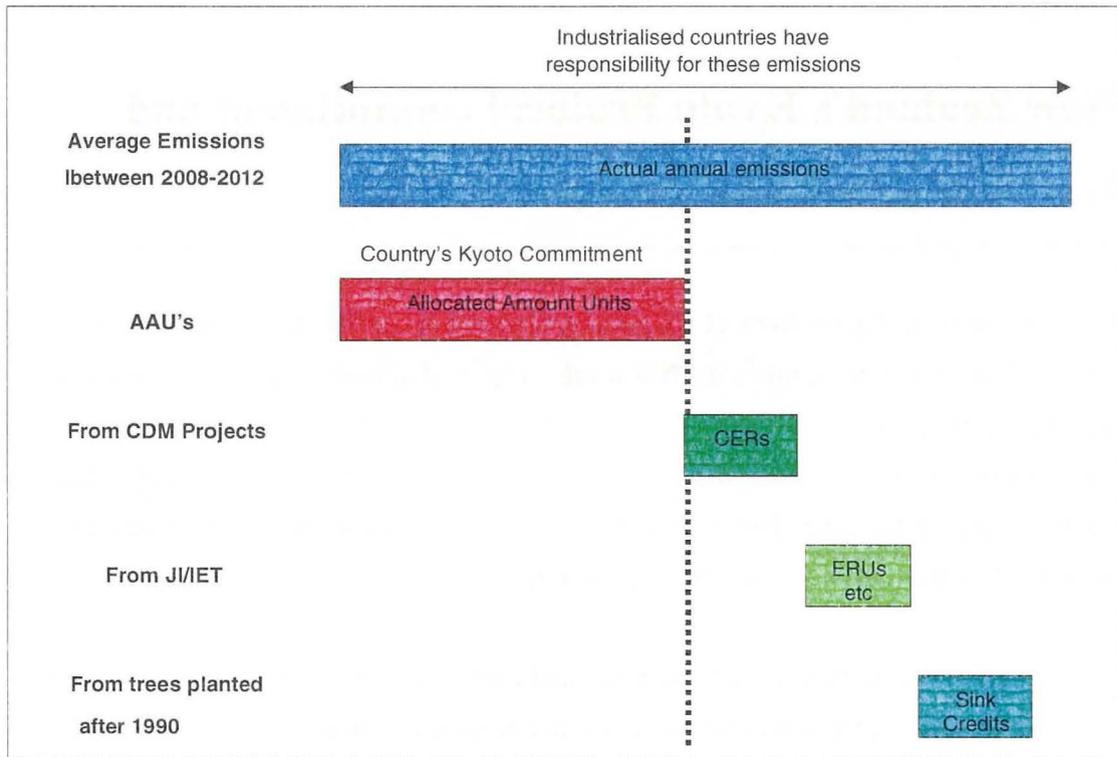
### 8.1 New Zealand's Kyoto Protocol commitment

New Zealand has committed to reduce its GHG emissions back to 1990 levels (approximately 75.4MtCO<sub>2</sub>-e), on average between 2008 – 2012, and to “take responsibility” for any excess emissions over this level. It can do this by purchasing “carbon credits” which could be in the form of AAUs, ERUs, CERs or sink credits.

Figure 8-1 is a pictorial representation of the options to take responsibility that are open to any industrialised country.

If New Zealand's (or any industrialised country's) emissions exceed its Kyoto Protocol obligation, it will be required to pay the penalty outlined in section 4.5.3.

**Figure 8-1: Options for meeting future Kyoto Protocol commitments**



## 8.2 New Zealand’s options for reducing GHG emissions

Each sector has different opportunities available to reduce GHG emissions. Some of New Zealand’s technical mitigation options for each of the 6 main GHGs are shown in Table 8.1.

**Table 8.1: New Zealand's GHG reduction options**

Gas	Mitigation Option
CO <sub>2</sub>	<ul style="list-style-type: none"> <li>• Replace thermal generators with renewable energy</li> <li>• Improve efficiency of thermal generators</li> <li>• Use gas rather than coal</li> <li>• Improve transport networks i.e. reducing road freight</li> <li>• Improve public transport, reduced congestion</li> </ul>
CH <sub>4</sub> Livestock digestive processes	<ul style="list-style-type: none"> <li>• Dose with methane-inhibiting compounds</li> <li>• Modify rumen bacteria via genetic engineering</li> <li>• Improve livestock production through improved genetic characteristics and reproduction rates, using production enhancing agents</li> <li>• Improve nutrition through strategic supplementation</li> <li>• Improve nutritional quality through chemical and mechanical treatment of feed</li> </ul>
Landfills	<ul style="list-style-type: none"> <li>• Better landfill design e.g. lining, capping and moisture control</li> </ul>

<b>Gas</b>	<b>Mitigation Option</b>
<b>CH<sub>4</sub> cont</b> Wastewater  Energy  Animal wastes	<ul style="list-style-type: none"> <li>• Recover and use methane produced</li> <li>• Flare landfill gas</li> <li>• Reduce organic waste in landfills</li> <li>• Mechanical or chemical treatment systems</li> <li>• Aerobic biological systems</li> <li>• Anaerobic biological systems e.g. facultative ponds, septic tanks, sludge digesters</li> <li>• Improve leak detection and pipeline repair</li> <li>• Collect of methane from large underground mines</li> <li>• Use biogas digesters in intensive farming</li> </ul>
<b>N<sub>2</sub>O</b>	<ul style="list-style-type: none"> <li>• Reduce use of nitrogen fertilisers</li> <li>• Reduce stock rates</li> </ul>
<b>SF<sub>6</sub></b>	<ul style="list-style-type: none"> <li>• Use substitutes in low and medium voltage switchgear</li> <li>• Replace leaky switchgear</li> <li>• Improve handling practices to minimise leakage</li> <li>• Substitute sulphur dioxide in magnesium casting</li> </ul>
<b>HFCs</b>	<ul style="list-style-type: none"> <li>• Use substitute in some refrigeration and cooling applications</li> </ul>
<b>PFCs</b>	<ul style="list-style-type: none"> <li>• Use substitutes in some refrigeration and cooling applications</li> </ul>

(Source: Based on MfE, 1998)

The following discussion will concentrate on the mitigation options that exist for the electricity industry.

### **8.3 New Zealand electricity sector's main GHG reduction options**

Appendix 6 provides a brief overview of the electricity industry to provide the context for the remainder of this work.

The main GHG emission from the electricity sector is CO<sub>2</sub> emitted during the combustion of coal and natural gas in order to generate electricity. Natural gas is the most commonly utilised fossil fuel. CO<sub>2</sub> will therefore be the GHG focussed on in this work. Demand side energy efficiency measures will reduce emissions due to a decrease in total electricity generation. However within the electricity generation sector there are two main methods available to reduce or mitigate CO<sub>2</sub> emissions:

1. Projects that improve the efficiency of thermal power use e.g. energy efficiency projects on existing plant or building new plant with better technology such as CCGT or co-generation plants that can be up to 85% efficient due to the use of the waste heat stream. This includes using fuel with lower emission levels, for example using natural gas instead of coal. These projects may make AAUs available for trading i.e. emitters are likely to either be allocated to the generator or they can purchase AAUs or emission rights to cover their emission levels. If this level is reduced due to energy efficiency or fuel switching projects they can sell these AAUs on the emissions trading market.
2. Renewable energy projects emit zero emissions during operation<sup>18</sup> so if a RE plant is built its generation mitigates the emissions that would have resulted if the electricity had been generated using a thermal plant. These projects could earn “project based credits”. If renewable energy projects were done in another industrialised country ERUs could be earned, while in a developing country CERs could be earned. These would be tradeable on the international emissions trading market or could be used to assist New Zealand in meeting its commitments.

The biggest barrier to using renewable energy projects to reduce and mitigate GHG emission in the electricity sector is the difference in cost between efficient gas fired technologies and the more often expensive renewable energy technologies. At present most renewable energy options are more expensive than building combined cycle gas turbine (CCGT) technology or gas fired cogeneration.

At present the electricity wholesale market mechanism does not encourage the least cost production of electricity from an environmental perspective. This is because the social cost of the environmental externality relating to the impact of the GHG emissions is not internalised in the cost of production. If minimisation of greenhouse gas emission was one of the variables that were optimised in the market, then from a carbon content minimisation perspective, renewable generation capacity would be used prior to gas followed by coal fired electricity generation<sup>19</sup>.

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<sup>18</sup> GHGs are emitted during the commissioning of both renewable and thermal generation plant. This varies depending on the raw materials and processes. It is known as embedded carbon and is quantified in life cycle analysis. For this thesis only operating emissions are considered.

<sup>19</sup> It is important that whatever mechanisms are used to drive emission reductions they do not interfere with the operation of the wholesale electricity market that has been set up to achieve the objectives of secure and least cost supply.

Renewable energy electricity generation emits no GHG emissions when operating but a policy mechanism is required to encourage the increase in supply of electricity generation from a renewable energy source, as existing market drivers will encourage new CCGT's to be built rather than a renewable option. One such mechanism that is used throughout the world is the implementation of a Mandatory Renewable Energy Target (MRET) which is described further in Chapters 11-13.



## Chapter Nine

# New Zealand's climate change policy development

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The present Labour Government's existing climate change policy is:

- *A commitment to pass legislation to enable New Zealand to ratify the Kyoto Protocol on climate change by mid 2002.*
- *Development of a comprehensive range of policy measures to ensure that New Zealand is able to meet its commitments under the Kyoto Protocol.*

(Hodgson, 2000)

New Zealand climate change policy has been under development for over a decade.

Legislation is pending that will enable ratification in September 2002, however the policy and mechanisms that will encourage domestic decision makers to reduce emissions is unlikely to be finalised and implemented until 2003 at the earliest.

The comprehensive range of policy measures will show how the government will allocate the responsibility for reducing emissions to the different sectors. The emitters of GHGs and the sectors of the economy that may feel the impact of climate change are not necessarily the same groups. This chapter describes the government's existing and potential energy, electricity and climate change policy which affect the decision making within the electricity sector.

### 9.1 New Zealand climate change policy objectives

The present Labour government's overall objective with respect to the initial Kyoto commitment period is:

*"...to limit greenhouse gas emissions to ensure achievement of New Zealand's Kyoto Protocol obligations in a manner that demonstrates environmental integrity and leadership while keeping as low as practicable the social and economic costs of measures to achieve those obligations"*

(New Zealand Cabinet Minutes, July 2001)

Other Government objectives (MfE, 2001) include:

- show leadership on climate change by ratifying the Kyoto Protocol by mid 2002;
- ensure decisions taken now (e.g. new "capital stock" investments) should take account of future cost of emissions;

- maintain international competitiveness by “bringing other countries with us” and ensure that domestic measures are designed well;
- contributing to the process of international negotiations to encourage the adoption of commitments by other parties so that the objectives of the UNFCCC are advanced;
- ability to show demonstrable progress by 2005.

Appendix 7 provides an overview of the generic instruments available to policy makers which include regulation, economic instruments utilising market mechanisms, financial incentives or subsidies, voluntary agreements, education and information and research. To date only voluntary agreements have been utilised to drive emission reductions. The other policy options that have been considered in New Zealand are presented in the following sections.

## 9.2 New Zealand energy and electricity policy

In October 2000, the Government's energy policy objective was stated as (Hodgson, 2000):

*The Government is committed to a sustainable and efficient energy future. Within this commitment, its overall objective is to ensure the delivery of energy services to all classes of consumer in an efficient, fair, reliable and sustainable manner.*

*The overall outcomes the Government seeks are:*

- *Environmental sustainability, including continuing improvements in our energy efficiency and a progressive transition to renewable sources of energy,*
- *Costs and prices to consumers which are as low as possible, while ensuring that prices reflect the full costs of supply including environmental costs,*
- *Reliable and secure supply of essential energy services,*
- *Fairness in pricing, so that the least advantaged in the community have access to energy services at reasonable prices,*
- *Continued public ownership of publicly owned assets.*

The Government's policy objective for electricity is:

*“...to ensure that electricity is delivered in an efficient, fair reliable and environmentally sustainable manner to all classes of consumer.”*

Environmental sustainability is a key objective and is expected to benefit the environment by:

- encouraging energy efficiency through lower fixed charges;
- encouraging demand side management in the wholesale market;

- providing future electricity prices and information on transmission to promote wise investment;
- promoting distributed generation;
- limiting water and hydro spill; and
- delivery on Electricity Governance Board constitution and monitoring.

Most of these points also address the issue of the mitigation of climate change by reducing GHG emissions, which is a key plank of any sustainable development approach.

### 9.3 New Zealand's climate change policy development

Table 9-1 shows the major climate change policy development landmarks affecting the electricity sector in New Zealand.

**Table 9-1: Summary of New Zealand Climate Change Policy Developments**

<b>Time</b>	<b>Comments</b>	<b>Further information</b>
1990	Government pledges to reduce GHG emissions by 20% by 2005. New Zealand signed the UNFCCC.	
1991	RMA introduced with clause to avoid, remedy or mitigate CO <sub>2</sub> emissions from stationary emitters	Appendix 8
1992	Rio Earth Summit – target reduced to 1990 levels if it could be done without affecting economic growth.	
1994	New Zealand policy package based on stabilising net CO <sub>2</sub> emissions to 1990 levels by 2000. 80% of reduction through forest planting. 20% through energy sector reform, energy efficiency strategy and Voluntary Agreements (VAs) with major emitters driven by the threat of a carbon charge in 1997.	
1995 – 2000	24 VAs signed with large emitters responsible for 47% of 1990 CO <sub>2</sub> inventory with a target of 2.8Mt CO <sub>2</sub> abatement.	Appendix 9
1997	Implementation of carbon charge delayed until after COP 3.	
Dec 1997	Kyoto Protocol adopted at COP 3.	
1998	MfE released a paper on the technical design of a domestic emission trading scheme.	Appendix 10
1998	New Zealand signed the Kyoto Protocol in May.	

<b>Time</b>	<b>Comments</b>	<b>Further information</b>
1998	Electricity Industry Reform Act came into force.	
1999	Treasury releases paper on a low level carbon charge.	Appendix 11
1999	MfE Domestic Climate Change Policy Options Statement released for public consultation.	Appendix 12
May 2000	New Zealand announces its plan to ratify the Kyoto Protocol in 2002 if a ratifiable Protocol emerges from international negotiations. At this time the only industrialised county to ratify is Romania.	
2000	9 official climate change working groups are announced to be convened by the Hon. Pete Hodgson.	Section 9.3.1
Aug 2000	Three climate change papers (prepared in July 2000) released covering, inter alia, price measures such as a carbon charge, Negotiated Greenhouse Agreements (NGAs), and pilot emission trading and non-price and complementary measures.	
Oct 2000	Energy Efficiency and Conservation Act passed requiring the development of a National Energy Efficiency and Conservation Strategy (NEECS) by October 2001.	
Nov 2000	Government takes decisions to expand and strengthen Government Energy Efficiency Leadership Programme seeking overall energy savings of 15% by 2005 in organisations (if energy expenses <\$100,000.	
March 2001	Eight climate change papers (prepared in Feb 2001) released covering pre 2008 price measures, inventory and agricultural issues, 2008-2012 measures, sinks, timelines, consultation, climate change impacts and transport. These provide the most recent information on Cabinets view of climate change policy.	Section 9.3.2
April 2001	Draft NEECS released in order to promote energy efficiency, energy conservation and renewable energy, support papers included background papers on topics including Sustainable Energy Supply	Section 9.3.3 Appendix 14.
April 2001	Auditor General reports that UNFCCC had been ratified with inadequate information e.g. relating to cost increases for fuel, electricity generation and industrial processes.	
Aug 2001	In light of the Bonn Agreement, New Zealand government reiterates its decision to ratify the Kyoto Protocol by September 2002.	

### *9.3.1 Official climate change working groups*

In 2000, nine official working groups were developed to drive the climate change policy progress. These groups and their responsibilities are detailed to indicate the wide ranging impact and scope of climate change policy. They are being directed by a Ministerial Working Group which is led by the Minister of Energy (presently Hon. Pete Hodgson) and made up of Ministers representing the following areas: Energy; Forests; Research, Science and Technology; Environment Industry and Regional Development; Ministers of Finance, Foreign Affairs and Trade, Agriculture and Transport.

The major responsibilities of the working groups include:

1. Non-Price Measures - investigating voluntary agreements/Negotiated Greenhouse Agreements (NGAs), energy efficiency measures, minimum energy performance standards and labelling, demonstration projects, public education, greenhouse gas monitoring, reporting and review. The lead Ministry is MfE.
2. Pre-2008 Price Measures - carbon charges and emissions trading options prior to 2008. The lead Ministry is MED.
3. Post 2008 Emissions - permit allocation and point of obligation, the operation of the market, the size of the market and the timing of its introduction. The lead Ministries are MED and Treasury.
4. Sinks and sink credits - research and development of carbon measurement, accounting and verification and the development of the systems whereby forestry owners will be allocated credit or benefits and to continue to encourage the growth of this sector. Equity between those that own pre-1990 forests and post-1990 forests is an important consideration. The lead Ministry is MAF.
5. Monitoring, reporting and review - provide certainty for the government and emitters. The lead Ministry is the MfE.
6. Business and Economic Development - to explore opportunities for businesses if the Kyoto Protocol is ratified; economic expansion of renewables and energy efficiency technologies and selling New Zealand's expertise in carbon sequestration measurement and accounting. The lead ministry is MED.

7. International Negotiations - a key part of the overall strategy as New Zealand's contribution to the problem (and the potential solution) in real terms is very small so encouraging other country's participation and showing leadership is very important. The lead Ministry is MFAT.
8. Communication and consultation - an essential part of the process for every work stream. This work is led by the Department of Prime Minister and Cabinet.
9. Inquiry into the role of local government in meeting New Zealand's climate change target – carried out by the Local Government and Environment Committee chaired by Jeanette Fitzsimons. Highlights potential opportunities for local government to assist in mitigation processes and feed into the government's policy response process.

The decisions of each of these working groups will impact on the electricity sector in some way. The work relating to non-price measures, pre-2008 price measures and post 2008 price measures are the most significant.

### *9.3.2 Climate change cabinet papers (February 2001)*

Eight Climate Change cabinet papers were prepared in February 2001 and released in March, these provide the most recent information available on the cabinets view on how they wish to see climate change policy developing. (MfE, 2001/1-2001/8)

In response to the Cabinet papers, Cabinet directed officials to report on the development of an overall legislative framework and the clarification of inter-linkages between the elements of a climate change policy package and a national interest analysis by March 2001. As at July 2001, no information relating to this workstream has been released.

The Government has agreed that domestic emissions trading (DET), implemented across a range of sectors, and supplemented with other measures where necessary, will be a central policy measure for meeting New Zealand's Kyoto Protocol target. Moreover, the Government agreed that policies should be developed that aim to establish broadly comparable incentives to reduce emissions across different sectors. Sectors not covered by DET would be subject to additional measures to incentivise the reduction in emissions.

However, the Cabinet papers also note that:

- There are currently few, if any, emission reduction options available for agricultural greenhouse gases that are practicable and cost effective under field conditions;

- Even if all the initiatives currently being considered proved to be cost effective and were introduced, they would not achieve a reduction in road transport CO<sub>2</sub> emissions to 1990 levels, by the commitment period<sup>20</sup>.

If New Zealand is to comply with its intended commitments under the Kyoto Protocol, the implication of these statements is that despite the intention of developing policies that aim to establish broadly comparable incentives to reduce emissions across different sectors, some sectors will be hit more heavily than others. When reviewing where the reductions are going to come from, the only remaining high emitting sectors are the industry and energy sectors.

The pre-2008 measures paper states that cabinet agreed in principle that Negotiated Greenhouse Agreements (NGAs) form part of the pre-2008 policy package, which in total will aim to encourage firms, households and communities to reduce their GHG emissions in the period prior to 2008. Draft generic NGA covering the design options were requested. The paper also noted that NGAs are only likely to be with emitters of a sufficient size and with means to control emissions.

Cabinet agreed that if the tax review results in a decision to introduce a carbon charge, any reduction in emissions achieved by firms as a result of entering into NGAs will be given recognition in the design and application of the charge. The tax review panel is not due to report until September 2001. Further analysis of the rate and corresponding sectoral, distributional and competitiveness impacts of a carbon charge and revenue recycling was called for.

Cabinet also agreed in principle that pilot emissions trading will be further considered after the announcement of the tax inquiry report in late 2001. Officials were directed to develop point of obligation characteristics in consultation with affected parties. Decisions on allocation methods have been deferred.

Provided an international emissions trading system that has environmental integrity emerges it was agreed that New Zealand will participate in this system by allowing domestic entities to buy and sell AAUs on the international market. Officials were also directed to undertake informal consultation with relevant sectors including establishing sector contact groups as appropriate.

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<sup>20</sup> The transport sector currently generates 42.2% of total CO<sub>2</sub> emissions in New Zealand, with road transport alone generating 39% of total CO<sub>2</sub> emitted in New Zealand, and likely to increase by 50% over the next 30 years.

The sinks paper stated that with respect to Kyoto forest sinks some proportion of the additional Assigned Amount Units should accrue to those undertaking the specified activities.

Officials were directed to report on public education and communications campaigns targeted at changing attitudes and encouraging behaviours which prepares New Zealanders for the commitment period.

### ***9.3.3 Draft National Energy Efficiency and Conservation Strategy (NEECS)***

One of the Cabinet decisions resulting from the July cabinet papers was that the NEECS should assist New Zealand in meeting its Kyoto Protocol obligations by reducing CO<sub>2</sub> emissions from fossil fuels and that the use of renewable sources of energy should be promoted as a method of achieving this. This is likely to provide the first certainty with regards to New Zealand's climate change policy.

The Energy Efficiency and Conservation Act 2000 requires a draft strategy to be publicly notified by April 1, 2001 and finalised by October 1<sup>st</sup> 2000. Under the Act the Strategy must :

*“... state the Government's policies in relation to the promotion in New Zealand of energy efficiency, energy conservation, and the use of renewable sources of energy; and the objectives to be pursued to achieve the Government's policies in relation to promotion in New Zealand of energy efficiency, energy conservation and renewable sources of energy<sup>21</sup>.”*

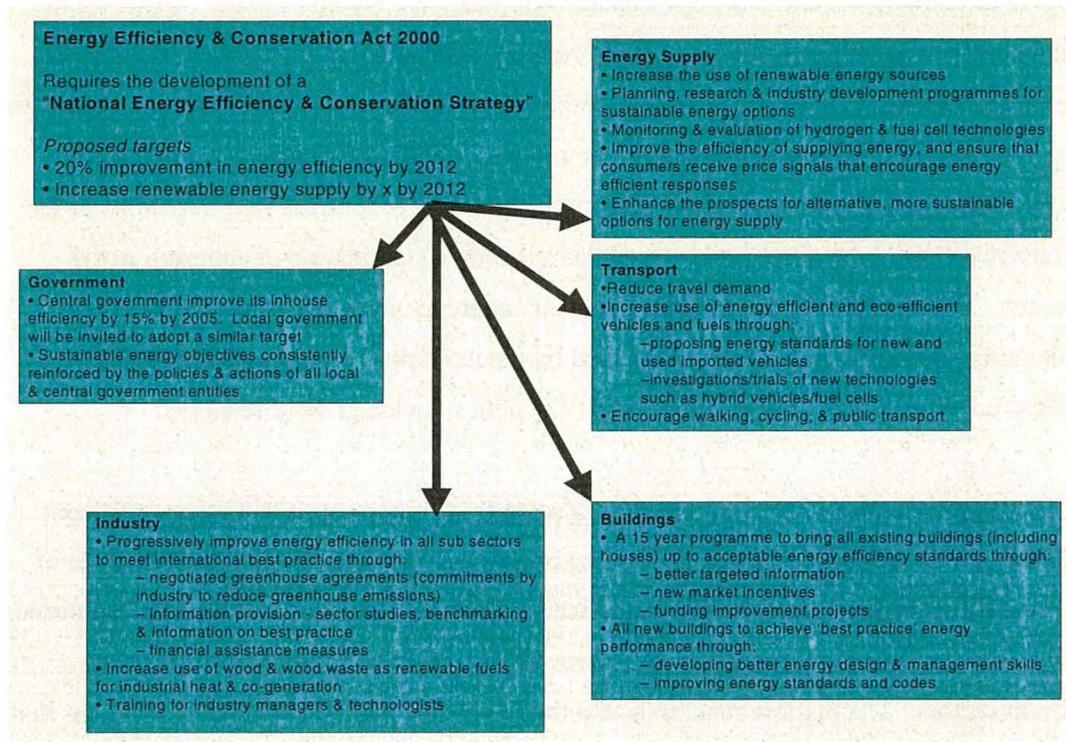
The Strategy must identify the policies, objectives, means and the measurable, practicable and appropriate targets that will be used to promote energy efficiency, energy conservation and renewable sources of energy.

The draft was prepared for the Minister of Energy by the Energy Efficiency and Conservation Authority (EECA) and the MfE and was released prior to April 1<sup>st</sup> for public consultation with submissions accepted until June 1st. The draft strategy is presently being reviewed, amended and appraised by officials and the Minister of Energy prior to adoption by the government by October 1<sup>st</sup> 2001. It will expire on 1 October 2006, but can be altered at any time by the Minister of Energy following new consultation processes. The targets, objectives and means identified are shown in Figure 9-1.

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<sup>21</sup> The definition of renewable energy and the implications of this definition are discussed in Chapter 7.

**Figure 9-1: NEECS Objectives, Targets and Means**



The draft Strategy proposed two targets:

- 20% improvement in energy efficiency by 2012;
- increase in renewable energy supply by an unspecified amount in 2012.

The draft NEECS proposed a mandatory renewable energy target (MRET) as a method of increasing the use of renewable energy sources. This will have a significant impact on the electricity sector and is the focus of Chapters 11-13.

#### 9.4 New Zealand's potential future climate change policy

The underlying question behind many discussions and negotiations on climate change is how the external environmental costs of fossil fuel use can be internalised. The mechanisms that will achieve this are yet to be completely clarified internationally and are wide open for discussion nationally.

Officials and Ministers recognise that New Zealand's contribution to the global problem is very small. Moreover, the cost of New Zealand leading the way could be high. New Zealand's negotiating position is to provide and promote sound information and environmentally credible solutions and to persuade as many countries as possible to join New Zealand in ratifying a Kyoto Protocol that has environmental integrity and politically and economically acceptable rules and processes.

Policy development work is being carried out in the background by officials while politicians continue to publicly declare that New Zealand will ratify the Kyoto Protocol. However no final decisions have been reached as to how New Zealand will meet its targets or what the legislation required for ratification will look like. Consultation has taken place throughout the years with various industry groups and communities. There is little clarity as to how the overall climate change policy package will fit together and despite the best intentions of the various government departments involved there is little co-ordination or cohesion in the approach. The need for a “whole of government” approach is clear. However this is challenging due to the range of areas effected by potential policy. It appears as if little progress has been made since the 1994 and 1997 policy packages were released.

When taking forest sinks into account, New Zealand’s ability to meet its first commitment period targets is acceptable despite increasing emissions due to the positive contribution of forests. However the government has stated that it will not use sink credits to shield emitting entities and that broadly comparable incentives will be given to reduce emission across different sectors. The biggest concern is that the policy and capital investment decisions that are being made now will affect New Zealand’s ability to meet any future commitments under Kyoto.

One piece of certainty is that if the Kyoto Protocol enters into force and if it is to have a positive environmental effect then a tightening in targets will be required over time. Developing countries will also need to accept targets at some point in the future. For these reasons New Zealand needs to be considering policy that affects all areas especially where capital investments have a long life.

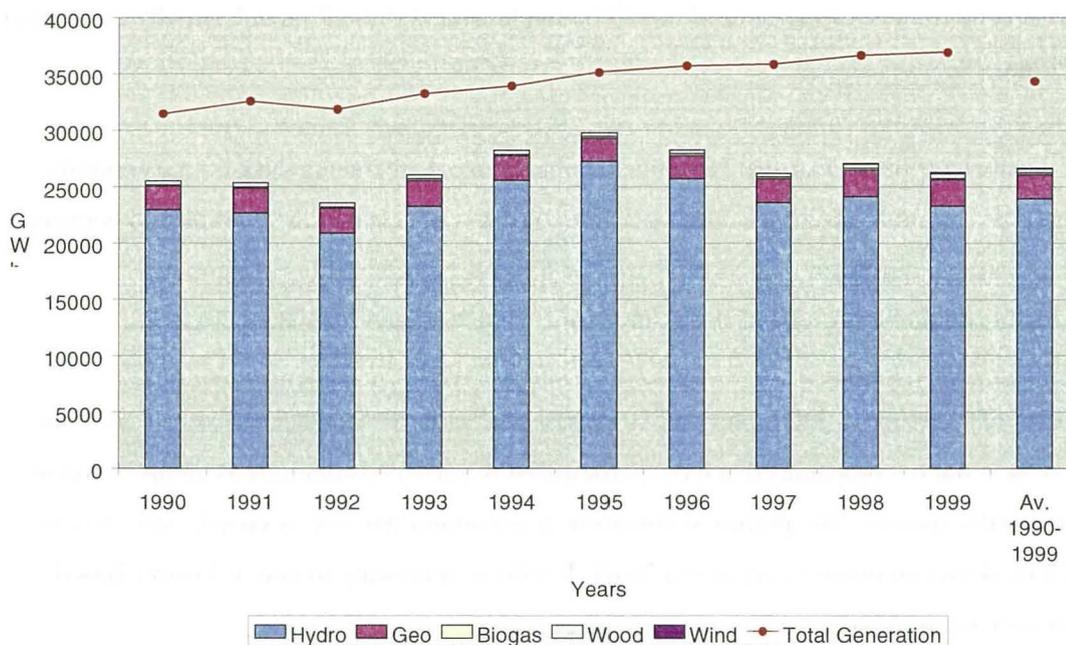
Part of New Zealand’s strategy up until now has been to build its regulatory framework on agreed international mechanisms. However, due to the ongoing failure of the international negotiations to finalise the operational mechanisms of the Kyoto Protocol, this has proved to be difficult. The Bonn Agreement has provided a significant amount of certainty. However the government has not left itself much time to develop what will need to be a very comprehensive policy package.

#### ***9.4.1 Possible impact on the electricity sector of New Zealand’s potential climate change policy***

The impression given by officials at consultation meetings and in press releases suggests that the climate change policy programme to be developed could be based on one of the 1999 Policy Options.

Significantly, it appears that the NEECS will be the first piece of policy certainty with regards to meeting the requirements of the Kyoto Protocol. Though not developed specifically with climate change in mind the NEECS should make a significant contribution towards decreasing CO<sub>2</sub>, which is one of its goals. It will be finalised by October 1<sup>st</sup> 2001. It is likely to include definite targets for energy efficiency improvements and increases in renewable energy supply. This is seen to be important due to renewable energy's decreasing contribution to New Zealand's electricity supply leading to increasing CO<sub>2</sub> emissions from the sector. The historic (1990-1999) sources and levels of renewable energy supply in the NZ electricity sector are shown in Figure 9-2. Figure 7.2 shows the electricity sectors CO<sub>2</sub> emissions.

**Figure 9-2: Sources and proportion of renewable energy electricity supply**



(Source: MED, 2000)

It is generally argued that improving energy efficiency decreases energy costs. However, it is possible that in the electricity sector, this decreased cost could lead to increased use of a resource in the medium to long term. Hence it may also be sound to include some straight energy conservation mechanisms into the Strategy which are presently not included e.g. conservation mechanisms may involve encouraging people to turn lights off versus an efficiency mechanism which encourages the use of efficient light bulbs.

It is possible that the NEECS renewable energy mechanisms may not be fully developed by October. The Minister of Energy has the opportunity to revise the Strategy at any time so details of the mechanisms could be added later. It is important that sufficient analysis and consultation is undertaken prior to implementing a Strategy (or any policy or legislation) that

could have significant economic impacts. It is not yet clear how the targets and/or mechanisms will be given “teeth”. If additional legislation is required this could occur as part of the Climate Protection Bill<sup>22</sup> (CPB), which is likely to detail New Zealand’s legislative requirement for ratification. If this was the case then the scope of the National Impact Analysis, which is required prior to ratification of an international treaty, would include the impact of a renewable energy target and its method of implementation alongside the other climate protection policy options under consideration. If this is not the case it is important that this economic analysis is carried out on a stand alone basis.

The Climate Protection Bill could include two sets of measures or legislation:

- Measures implemented immediately, which are no regrets or very low cost CO<sub>2</sub> cost reduction options and legislation required for New Zealand to ratify the Protocol; and
- A second tranche of measures that will be implemented if the Protocol actually enters into force.

The signals have been clear that Negotiated Greenhouse Agreements (NGAs) are certainly going to be a main focus of pre-2008 measures. What is not clear is the relationship between the legislative requirements of NEECS and the CPB. Renewable energy negotiated agreements could be negotiated at the same time or be included in GHG NGAs.

A Heads of Agreement (HOA) for NGAs is presently with the Minister of Energy. A letter will be sent out to companies that have participated in early consultations as an invitation to enter into discussions. The preferred government negotiator has now been selected. Signing the HOA shows an intent to agree to a NGA. It will be interesting to note if Project Based Credits are incorporated.

The next stage will be for officials to develop a generic NGA upon which negotiations for individual NGAs will be based. Officials hope that organisations will be prepared to enter into these by mid 2002. However this is unlikely unless there is certainty with regard to other climate change policy or some other considerable incentive offered (i.e. avoidance of a carbon tax or allocation of AAUs). Officials seem to view NGAs as a way for industry to generate their own certainty. This is achieved by negotiating a position that will ensure that the impact of policy is limited to a level that will not affect the international competitiveness of the organisation while still achieving real and worthwhile emission reductions.

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<sup>22</sup> This is not an official name, it is a name that has been used in discussions with Mai Chen from the public lawyers, Chen and Palmer. (Chen, 2001)

The design of these, including which organisations/industries will be involved and which gases are included, will be critically important. It is likely that initially only larger emitters will be involved and that the point of obligation may differ for different sectors or fuels i.e. it may be upstream for petrol and downstream for coal. If the NGAs are to remain voluntary, potential signatories will demand certainty around climate change policy with regards to what their particular liabilities will be with or without an NGA. Without certainty and/or an incentive or penalty there are unlikely to be many participants in the NGA scheme.

The domestic policy response will need to offer broadly comparable incentives to reduce GHG emissions across the economy ensuring that the mechanisms selected will allow for least cost opportunities to be recognised. The focus needs to be on no regrets options first. These should be included in the first tranche of mechanisms in the CPB and complemented, as necessary, by other measures such as education, information and selected regulation (eg EECA's existing relevant programmes).

If the Protocol does enter into force, then New Zealand will require an economic instrument that provides emitters with an equal incentive to reduce greenhouse gas emissions.

It is likely that New Zealand entities will be given the right to participate in an international emissions trading system that has environmental integrity. There is great value in designing a system that allows New Zealand companies to discover the international price of carbon as soon as possible. This ensures that the most economically efficient solutions will be used while reducing the potential negative economic impact of policy that requires New Zealand to internalise this cost prior to their competitors. This could be assisted by the government allocating AAUs as soon as possible so that organisations can assess their positions and consider forward trading. This is a more likely possibility now due to post Bonn certainty.

A market mechanism will require a price of carbon to drive any changes in behaviour. It is still under discussion as to whether a pilot domestic emission trading system would be a least cost solution. Some Treasury officials believe that there are few additional benefits to pilot domestic emission trading and that there would be additional costs.

Emission trading is occurring unofficially at present. However the latest the official market will be implemented is likely to be from the beginning of the first Kyoto period (at this stage 2008) and onwards if the Protocol enters into force. The impact of the nascent carbon market has not been considered by officials. The prices that are being achieved are detailed in Chapter 5.

A carbon charge or tax may be introduced as it is seen by the Taxation Review panel to meet the requirements for an eco-tax namely:

- The environmental damage of each unit of emissions is the same across the geographic area to which the tax applies;
- The volume of emissions is measurable; and
- The marginal net damage of emissions is measurable. (MED, 2001).

The final bullet point is perhaps questionable as both scientists and economists have been grappling with this issue for a number of years.

The carbon tax could also be used to cap the total cost to the economy. In order to do this it would also need to reflect a penalty rate for non-compliance with any of the other measures that were introduced. It will represent the maximum cost of carbon at any time. A carbon charge may also ensure that a wider cross section of the economy is covered by the economic measures, for example agricultural methane emissions could be included. Early emission reduction activity is rewarded with reduced cost or exemption from taxation.

A paper on the impact of a carbon charge was due to be forwarded to the Minister of Finance at the end of June 2001 for the Taxation Review. The paper had a narrow scope – it is not looking at the value of having or not of having a carbon charge just the impact of a pre-2008 “low level” carbon charge. Officials are presently suggesting that a carbon charge would not be implemented at the same time as emissions trading.

One unavoidable impact of a carbon charge is that in the medium to long term it will increase the cost of electricity. Driving up the long run marginal costs of thermal operators may allow renewable energy projects to become economically viable. In 1996 WOGOCOP modelled the impact of a \$30, \$60 and \$100/tC charge would increase wholesale electricity prices by 8%, 16% and 28% respectively.

It will be an important part of the policy design that there is no double counting of benefits or that any organisations gets hit more than once by different measures for the same emissions.

Policy should be developed to encourage New Zealand companies to be involved in CDM projects that repatriate CERs and JIs that bring ERUs into New Zealand if this is the most economic response. The government is less likely to encourage overseas investments in JI projects which would lead to New Zealand AAUs leaving the country despite the fact that this could considerably alter the economic feasibility arguments for many renewable energy projects in New Zealand. Little work has been done in this area and decisions have not yet

been reached on how these issues will be dealt with. Unilateral or domestic JI projects could also have a significant benefit, this would involve the allocation of AAUs to domestic investors in the same way they would be allocated to offshore investors. It could allow renewable energy projects to become competitive with CCGT investments.

The increase in renewable energy supply by the electricity industry is one of the major issues relating to the electricity sector's response to climate change.

In Chapter 8, two main methods for reducing or mitigating CO<sub>2</sub> emissions in the electricity generation sector were discussed including energy efficiency in thermal stations to ensure the lowest emissions possible and increasing renewable energy supply which does not generate any GHG emissions. The draft NEECS indicates that the government will be focussing on mechanisms to increase the supply of renewable energy such as a mandatory renewable energy target (MRET) which is explored further in Chapters 11 – 13. Ideally this would also encourage thermal generation energy efficiency measures.



## Section Three

### **A mandatory renewable energy target to reduce GHG emissions in the electricity sector**

*The purpose of this section of the thesis is to identify and analyse a possible response to the climate change policy objectives that impact on the electricity sector.*

*Increasing renewable energy supply is an important requirement of controlling GHG emissions in the electricity sector. In this Section discussions are focussed on the use of a mandatory renewable energy target (MRET) to achieve this.*

- *Chapter 10 explores the issues around the definition of renewable energy, this is one of the first considerations of policy makers developing a MRET.*
- *Chapter 11 identifies six different mechanisms that could be used to implement a renewable energy target.*
- *Chapter 12 describes the development of a tool to assess the impact of a mandatory renewable energy target.*
- *Chapter 13 utilises the tool to assess the impact of five possible mandatory renewable energy scenarios on levels of renewable energy supply, GHG emissions and electricity prices.*



# Chapter Ten

## Renewable energy definition

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When considering a growth mechanism for the renewable energy sector it is first necessary to define the term renewable energy.

The term “renewable energy” has many definitions. They generally revolve around the concept of an energy source used in such a way as to be available indefinitely. However when they are defined in policy documents or legislation the difference between definitions can provide opportunities to some organisations and threats to others. The issues relating to the selection of a renewable energy definition in the context of the electricity sector along with national and international review of definitions are detailed in this chapter.

### 10.1 Significance for electricity generation

In New Zealand, the definition of “renewable energy” is significant as it is utilised:

- in the Power Package and the Electricity Industry Bill;
- in EECA documentation supporting the development of the NEECS;
- and it is likely to arise in other climate change policy documents presently under consideration.

Definitions vary significantly between different states and countries throughout the world. This is because a renewable energy definition needs to be both sensible for the particular environment it applies to and consistent with state or national policies. It is also important that the definition ensures outcomes are complementary to other government objectives.

Government needs to have decided the main objective of any particular policy. For example, a policy with an objective to reduce GHGs should not exclude projects that could make a significant contribution to this goal. A policy to stimulate a new renewable energy industry where the Government could have concerns that opportunities for new technologies would be swamped due to large hydro or geothermal would look considerably different. Therefore two different policies or mechanisms may be appropriate.

A New Zealand Renewable Energy definition will need to consider the impacts with regard to the objectives of climate change policy, energy policy and the Resource Management Act.

The Resource Management Act assesses environmental impacts. A renewable energy definition should not attempt to quantify these impacts by placing arbitrary limits on certain aspects of generic renewable energy solutions such as capacity – this may lead to a reduction in environmental integrity.

A renewable energy definition should be simple, have a recognised and justifiable basis, not attempt to deal with issues that are covered by existing legislation, have environmental integrity and be complementary to the objectives of existing policy and that under development.

## **10.2 Review of national and international definitions**

Appendix 14 shows the findings of a review of renewable energy definitions from national groups, states and countries.

Two definitions of particular note are those of EECA in the draft NEECS and that in the Electricity Industry Reform Act amendments.

EECA's (2001) definition is:

- *Renewable sources* of energy are those where the rate of extraction is either equal to or less than the rate of replacement.
- *Traditional forms* include large-scale hydro electricity and geothermal projects.
- *Non-traditional forms* of renewables include wind, solar (of various types), tidal, biomass and small-scale hydro projects.

The draft Amendment to the Electricity Industry Reform Act's (2000) definition is:

*“renewable energy source” means an energy source that occurs naturally and the use of which will not permanently deplete New Zealand's energy sources of that kind because those sources are generally expected to be replenished by natural processes within 50 years or less of being used.”*

## **10.3 Issues in developing a renewable energy definition**

The review above raised several important issues.

1. Definitions need to be appropriate for the country they apply to. There is no generic definition that is appropriate as available resources, sunk assets and potential impacts need to be considered.

2. If the overall purpose of a renewable energy definition is to limit negative environmental effects then terms such as “traditional” and “new” are insignificant and inappropriate.
3. The term “large hydro” seems to mean different things in different countries and even in different states of the same country. An arbitrary capacity cut off level is not appropriate.
4. The inclusion of native wood in biomass is likely to remain a political issue.

#### 10.4 Selection of Renewable Energy Definition

For the purpose of this work a renewable energy definition is required. The initial definition considered was:

*“Renewable sources of energy are those where the rate of extraction is either equal to or less than the rate of replacement. This includes energy produced from solar, wind, water, geothermal and biomass which does not have an unacceptable environmental effect as laid out in the Resource Management Act.”*

This was a combination of several existing definitions as follows:

- Sentence 1 from the EECA definition,
- 1st phrase of sentence 2 – from US Federal definition,
- 2nd phrase of sentence 2 – brings it into a New Zealand context.

Further consideration after the release of the draft NEECS which uses the EECA definition, led to supporting the EECA definition with the following proviso’s:

1. That this definition means that renewable energy sources include (but are not limited to):
  - solar, wind, water, biomass and geothermal (if operated on sustainable basis);
  - hydrogen and other energy sources produced exclusively from sources included in (a) above.
2. That renewable energy sources do not include:
  - nuclear;<sup>23</sup>
  - fossil fuel; and
  - hydrogen and other energy sources produced from fossil fuel.

This definition is used where possible in the remainder of the thesis, however if the renewable energy data is available on another basis it will be used and the differences stated.

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<sup>23</sup> While some parties may consider nuclear fuel a renewable fuel the use of it is illegal under the New Zealand Nuclear Free, Disarmament, and Arms Control Act 1987.



## Chapter Eleven

# Possible mandatory renewable energy target mechanism

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One of the major outcomes sought from the Government's energy policy is a progressive transition to renewable sources of energy. Many of these options are presently uneconomic, one of the reasons for this is that the cost of environmental externalities are not incorporated in the pricing of fossil fuel energy supply. Therefore if the environmental benefits in terms of reduced GHGs associated with increased renewable energy supply are desired, a policy mechanism will be required to either drive the inclusion of the cost of this environmental externality or encourage the growth of the renewable energy sector in another way. Throughout the world, Mandatory Renewable Energy Targets (MRET) have been used to encourage the progressive transition to renewable sources of energy.

If an MRET is implemented in New Zealand, it will be done within the NEECS which will be released in October 2001. It is likely that further consultation will be required with regard to the appropriate mechanism for implementing the target and the level of the target itself.

The six methods to encourage renewable energy supply that were suggested in the draft Strategy are:

- Negotiated Agreements with generators for set levels of renewable energy supply;
- Negotiated Agreements with retailers for set levels of renewable energy sales;
- Mandatory Renewables Quotas (MRQs) for generators;
- Mandatory Renewables Quotas (MRQs) for retailers;
- a guaranteed price for renewable energy; or
- tradeable fossil fuel electricity generation permits.

This chapter provides an analysis of these six options.

### 11.1 Possible mechanisms for increasing renewable energy supply

The six mechanism options above were analysed on a qualitative basis from the perspective of the electricity industry and do not include the impact on:

- the delivery of other energy services such as heating; or

- other sectors of the economy such as the transport sector if these measures were to be extended to cover other areas.

### ***11.1.1 Negotiated Agreements (NAs) on sales or generation from renewable energy***

Negotiated Agreements (NAs) on sales or NAs on generation from renewable energy are two of the recommended mechanisms. They are agreements between the government and individual companies or groups of companies that state either:

- a particular proportion of their electricity sales will come from renewable energy sources; or
- generators are required to generate a certain proportion of their electricity using renewable sources.

This could effectively be seen as setting a cap on thermal electricity generation.

NAs have previously been used in New Zealand for CO<sub>2</sub> reductions in the electricity sector with ECNZ and other large emitters known as voluntary agreements (VAs) – see Appendix 9. Negotiated Greenhouse Agreements (NGAs), a form of NA are presently being negotiated between government and major emitters.

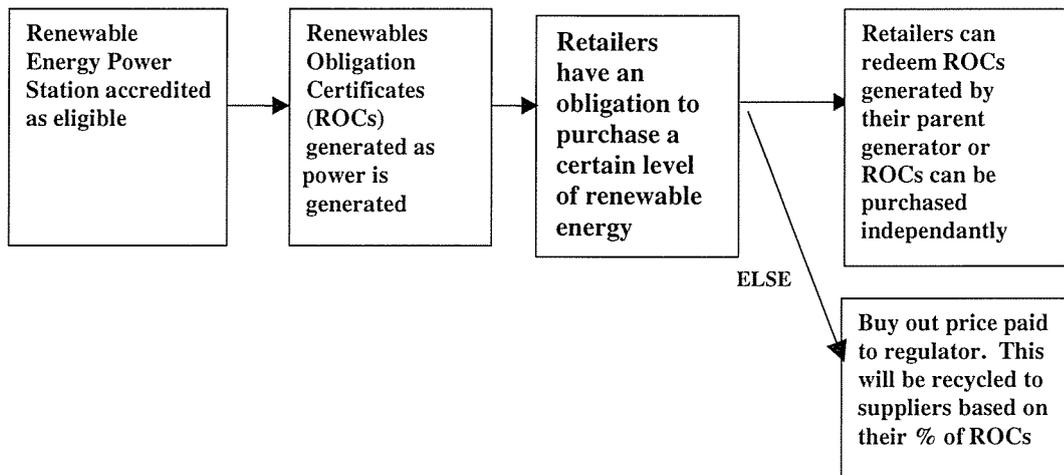
In Australia a similar system called the Greenhouse Challenge also focuses on major emitters. It has also been used in the Netherlands and other countries to encourage energy efficiency and conservation leading to enhanced competitive advantage. The UK uses an 80% exemption from a Climate Change Levy to encourage companies to enter into NAs. The Levy is then recycled to accelerate uptake of low carbon technologies.

### ***11.1.2 Mandatory Renewables Quota (MRQ) for Generators***

The Mandatory Renewables Quota for generators is a statutory requirement on generators to generate a minimum proportion of electricity from renewable sources, which effectively creates a supply push for renewable energy.

The United Kingdom's Renewables Obligation is illustrated in Figure 11-1. It aims to increase the percentage of renewable energy electricity supply from 3% to 5% in 2003 and to 10% in 2010. The buy out price acts as cap on the impact on price, it is under review whether renewable obligation certificates will be bankable or borrowed against.

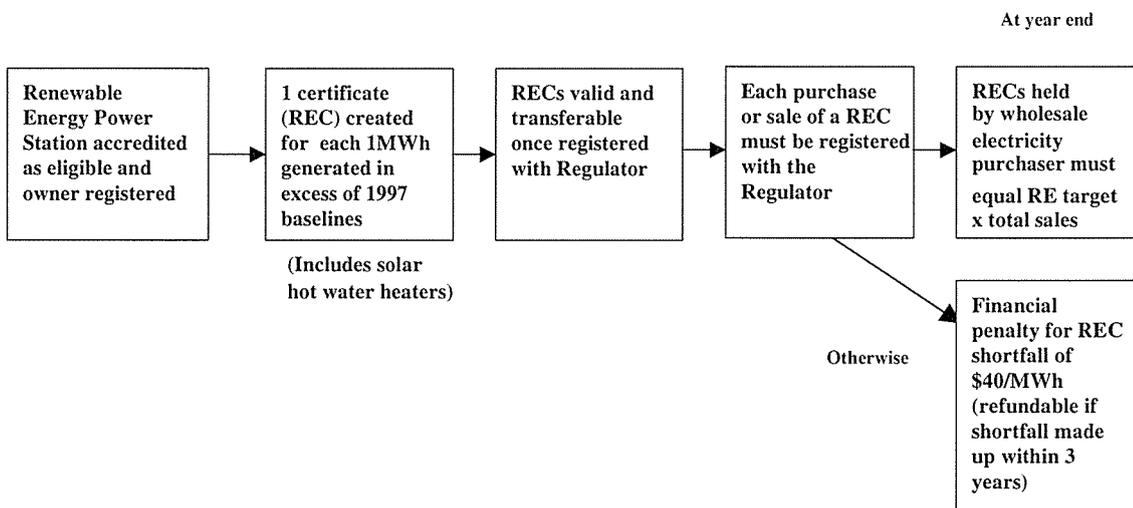
**Figure 11-1: United Kingdom’s Mandatory Renewables Obligation for Generators**



**11.1.3 Mandatory Renewables Quota (MRQ) for Retailers**

A Mandatory Renewables Quota (MRQ) for retailers is a statutory requirement on retailers to purchase a minimum proportion of electricity from renewable sources, which effectively creates a demand pull for renewable energy. The mechanism in place in Australia is illustrated in Figure 11-2. It is a ramping target leading to an additional 9,500 GWh of renewable energy supply by 2010.

**Figure 11-2: Australian Mandatory Renewables Quota for retailers**



The Australian Government has contracted M-Co to manage the Green Electricity Market (GEM). This platform may be a useful tool for whatever system is arrived at in New Zealand however the policy driver by itself would be inappropriate for the following reasons:

- It does not encourage efficiencies within the thermal sector;

- Prioritising new renewables over existing renewables may have a perverse effect in the New Zealand environment. This policy may lead to increased hydro spill however this potential impact needs to be assessed further. This indicates that any system should equally support all renewables if the objectives are to maximise positive environmental outcomes.
- Careful consideration needs to be given to the level in relation to present levels and the cost of available renewable energy electricity generation options.

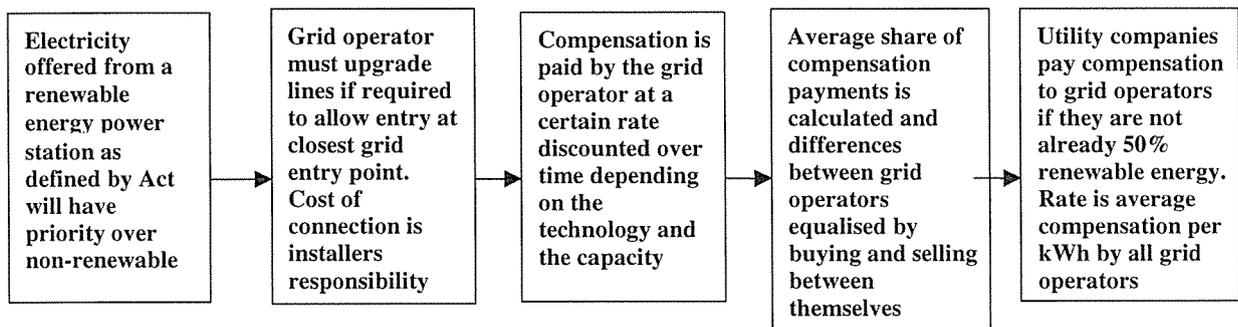
Denmark has a similar system with a target of 20% of total consumer electricity supply coming from renewables by 2003. Presently 12% of its electricity is generated from wind power.

#### ***11.1.4 Guaranteed price for renewable energy***

A guaranteed price for renewable energy is a mechanism that was difficult to find information about in English as Germany is the only country that presently uses this system. The German Renewable Energy Sources Act prioritises grid-supplied electricity from renewable energy sources as illustrated in Figure 11-3. It is funded by a special levy on electricity consumers and the cost of the mechanism amounts to approximately 0.1 pfennig for every kWh consumed (equivalent to 0.1c per kWh).

The Feed-in Tariff Law 1991 provides a guaranteed minimum price for electricity sourced from defined renewable energy technologies e.g. DM 0.99/kWh declining by 5% per year. Low interest loans are also available.

**Figure 11-3: Schematic of German Renewable Sources Act**

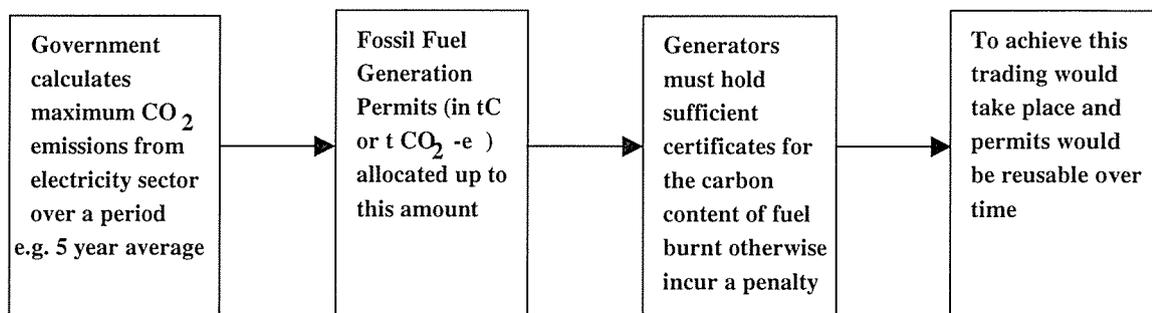


#### ***11.1.5 Tradeable Fossil Fuel Electricity Generation Permits***

A tradeable fossil fuel electricity generation permit system would require trading of fossil fuel rights based on carbon content of fuels, an example of how this system could operate is illustrated in Figure 11-4. It could have several different units such as GWh generated, tonnes

CO<sub>2</sub> emitted or PJ of fuel burnt. This is a novel approach which has not been tried elsewhere but is based on similar concepts to a domestic emission trading systems and would create a demand pull for renewable energy.

**Figure 11-4: Tradeable fossil fuel electricity generation permit scheme**



### *11.1.6 New Zealand issues*

The main questions that must be considered when assessing which is the best system for New Zealand include.

- What is the objective of the system?
- How will it integrate with any other or future systems with the same objectives?
- Who and how will the system be administered/controlled/regulated?
- What are the transaction cost involved?
- How will the target be developed and worded?
- What would the penalties/incentives be?

The advantages and disadvantages of the six mechanisms above are assessed in Appendix 15 which also includes an assessment of a moratorium on thermal build. The option of using financial incentives or a moratorium on building thermal plant are also considered.



## Chapter Twelve

# Development of the Mandatory Renewable Energy Target Impact Tool

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A mandatory renewable energy target (MRET) has been identified by policy makers as a possible response to the objective of:

- reducing GHG emissions in a least cost manner, which is one of the government's main climate change policy objectives; and
- increasing the level of renewable energy supply, which is one of the New Zealand government's main energy policy objectives.

Two major decisions would be required to put a MRET in place - i) the magnitude of the target and ii) the mechanism for implementing the target. This chapter describes the development of a tool to assess the effectiveness of five MRET scenarios for electricity (see Section 12.3.3) with different target magnitudes with regards to meeting the objectives above. A generic MRET mechanism is used in this process however some of the options for implementing the mechanism have been described in Chapter 11.

### 12.1 Introduction to MRET Impact Tool development

A tool has been developed called the MRET Impact Tool (the Tool). Three steps were involved in developing the Tool:

1. Development of five possible MRET scenarios and a list of the electricity generation plants that would be required to meet the additional renewable energy generation target each year.
2. Market simulation of the impact of a MRET utilising an existing New Zealand electricity supply and demand model.
3. Conversion of market simulation information into graphs and data useful for discussion of the renewable energy supply, GHG emission levels and wholesale electricity prices.

The five MRET scenarios developed range from a business as usual (BAU) base case to the implementation of a MRET to return the supply of renewable electricity to 1990 levels.

The MRET Impact Tool:

- assesses the impact of an MRET as it applies to electricity only, not heat or any other form of energy. Therefore in this context MRET effectively implies a mandatory renewable electricity target only;
- considers the 2002 – 2012 period only;
- is based on the New Zealand wholesale electricity market (the electricity market) as at December 2000;
- takes into account the implications of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions but no other GHGs;
- assumes that all other legislation will remain static during the 2000 – 2012 period such as the Resource Management Act;
- indicates the outcomes for a generic MRET mechanism using a ramping target. It does not represent the outcome of any particular mechanism used to implement the MRET; and
- assumes that the MRET does not impact on the offer behaviour of the owners of existing generation assets. However for the purpose of the model the new renewable stations will be offered in to the wholesale electricity market at zero to ensure that the plants operate.

Other assumptions made in the development of the Tool are discussed later in this chapter where context is required to illustrate the assumption. As with all models the assumptions significantly impact on the outcome of the modelling.

## **12.2 MRET Impact Tool components**

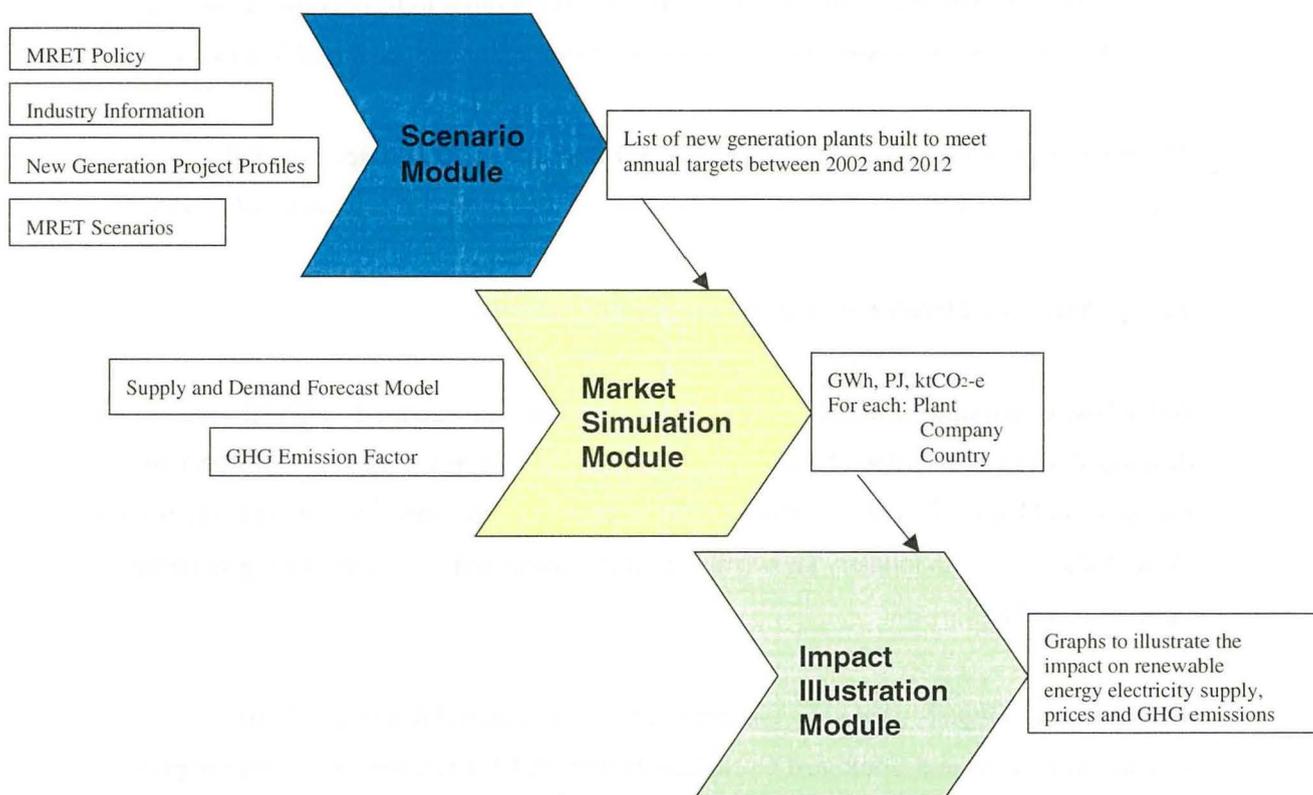
The inputs and outputs of the three parts of the MRET Impact Tool are summarised in Figure 12-1.

The Tool has three major components:

1. The Scenario Module generates the list of electricity generation plants that would need to be built each year under any of the potential renewable energy target scenario. The development of the Scenario Module is further discussed in section 12.3. This information is used as the input to the Market Simulation Module.
2. The Market Simulation Module uses an existing Meridian Energy business tool enhanced for the purpose of this exercise. It is a supply and demand model that simulates the market considering offer strategies, demand side information, physical generation and transmission capabilities and business costs. The enhancement of the model for use in the Tool is discussed in Section 12.4.

3. The Impact Illustration Module manipulates the output from the Market Simulation Module into a graphical format. The development of this module is discussed in Section 12.5.

**Figure 12-1: Summary of the MRET Impact Tool inputs and outputs**



### 12.3 Scenario Module

The purpose of the Scenario Module is to generate MRET scenario information for the Market Simulation Module, which simulates the impacts of a renewable energy target on the electricity sector of New Zealand. The Scenario Module is an Excel spreadsheet. The following sections describe the development of the Scenario Module and its inputs.

#### 12.3.1 Scenario Module development

The Scenario Module was used to create five different MRET scenarios and the data describing how the targets will be met. Three stages are involved in this process.

1. Develop a list of possible new generation projects sorted from the lowest long run marginal cost (LRMC) to the highest. The LRMC includes the cost of capital, and operation and maintenance costs. The unit for the LRMC in this exercise is c/kWh.

2. The second stage was to develop the five mandatory renewable energy target (MRET) scenarios and calculate annual renewable energy generation targets for each year between 2002-2012.
3. The third stage was to generate a list of the new generation plants that will need to be commissioned each year in the 2002 – 2012 period in order to meet consumer demand and the MRET target while taking into account commissioning and building times.

The Scenario Module uses a percentage basis for the target and takes account of the changes in the level of thermal generation due to commissioning and decommissioning of a plant.

### *12.3.2 Stage 1 - Develop new generation plant profiles*

A database of possible new electricity generation stations was required. This information was developed using focussed workshops involving Meridian Energy's Strategic Growth team members and led by the author. Ministry of Commerce (MoC) data<sup>24</sup> was used as the basis of these discussions with industry knowledge used to expand and specify the new generation options available.

Two groups of projects need to be considered, these are renewable energy electricity generation projects and Combined Cycle Gas Turbine (CCGT) electricity generation plant projects, which are the most economic large scale generation options at present.

#### *12.3.2.1 New renewable energy generation project profiles*

Ministry of Commerce (MoC, 2000) publications provide information on the availability and cost of additional electricity generation capacity in New Zealand as shown in Table 12.2. Data from a recent study on wind generation potential in New Zealand is also included (EECA, 2001) which has more optimistic cost estimates for wind opportunities, these are shown in parentheses. The total cost reported is assumed to be the average long run marginal cost (LRMC) of operating this type of plant.

This information was used as a starting point for a discussion by the Meridian Energy Working Group. The group members' experience was called upon to take into account relevant industry information and recommend variations as shown in blue in Table 12.1.

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<sup>24</sup> Ministry of Commerce or MoC became the Ministry of Economic Development (MED) during 2000.

It needs to be noted that bioenergy, biomass and cogeneration were not considered in the MoC or EECA work referenced here. As a result it has not been considered in this work. However biomass opportunities exist at a cost of about 8c/kWh or less if utilising waste streams from food and fibre processing plants so future work should be expanded to include these options. This will become more important as increasing numbers of forests approach maturity and harvest leading to more waste biomass is available. In the future biomass may make a significant impact on New Zealand's energy mix.

**Table 12-1: Options for Additional Electricity Generation Capacity – MoC, EECA and Meridian Energy**

Generation Type	MoC Data			MEL Enhanced Data	
	Total Cost c/kWh	Potential Capacity MW	Potential Supply GWh/year	Total Cost c/kWh	Potential Capacity MW
Hydro efficiencies	4.0-5.0	100	700		
Gas combined cycle	4.3-4.5	700	5300	Removed due to commercial nature of information	
Low cost geothermal	5.5	200	1650		
Low cost hydro					
Coal	6.3	No limit	No limit		
Mid cost geothermal	6.5	200	1650		
Low-cost wind	6.7 (6.0)	200 (235)	850 (970)		
Mid-cost wind	8.2 (6.9)	200 (430)	850 (1,550)		
High cost geothermal	8.5	400	3300		
Mid-cost hydro					
High-cost hydro	8.6	500	4200		
High cost wind	9.5 (8.1) (10.4)	400 (400) (505)	1700 (1,225) (1,190)		
High-cost hydro					
Distillate (fuel oil)	11.3	No limit	No limit		

(Source: Ministry of Commerce, 2000, with Meridian Energy enhancements shown in blue print and EECA (2001) in brackets)

Based on the above list, a second workshop was held with the Working Group to create the generation investment profile. This is a list of power stations and details of the owners and operational attributes of each plant. The resultant list of stations is summarised in Table 12-2 and shown in full in Appendix 16, these have been sorted in order of increasing LRMC

**Table 12-2: Summary of Meridian Energy's view of potential renewable energy electricity generation plants**

Removed due to commercial nature of information
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When assessed on a resource basis which takes into account where actual resources exist to enable projects to be carried out at the specified cost, the results were different to those in Table 12-1, especially for projects with a lower LRMC. The comparison between the macro and resource specific analysis is shown in Appendix 17. This is because there is extensive knowledge within Meridian Energy of the specific projects that exist in these cost brackets whereas at the higher prices less information is available. However at the higher prices it is possible to find many suitable projects. These costs are the on-site costs only and do not take into account any effects of line losses or requirements for line upgrades.

It must be kept in mind that there are many possible outcomes of this assessment. Meridian's project specific data is only one possibility based on industry knowledge and experience. This exercise did demonstrate how it is important to move from the general to the specific and highlighted the problems that officials may have in attempting to generate such data. This is likely to be a difficult situation to remedy due to the highly strategic nature of some of this information.

#### *12.3.2.2 New CCGT plant profiles*

The Working Group was also utilised to assess the most likely CCGT thermal plant options. The expected supply and demand developments in the electricity market until 2012 were discussed at length in order to decide:

- which companies would invest in the next CCGT;
- what size the plant would be; and
- where they would be built.

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### ***12.3.3 Stage 2 - Develop MRET scenarios and annual renewable energy targets***

Five different scenarios were developed to represent a range of possible renewable energy targets.

1. Business as Usual (BAU) Scenario – represents the expected AAU path taking into account present policy settings and includes one 400MW CCGT being built in 2004 and another in 2007.
2. 1990 Renewable Energy Level (1990 RE Level) Scenario - a renewable energy target scenario representing a return to the same proportion of renewable energy supplied for electricity generation as 1990 proportions which is the Kyoto Protocol’s base year i.e. 81.07% of electricity was supplied by renewable energy sources in 1990 (MOC, 2000 and is made up of hydro, geothermal, biogas, wood and wind generation).
3. Present RE Level (1999 RE Level) Scenario - a renewable energy target scenario representing a return to the same proportion of renewable energy that existed in 1999. The most recent actual data available data from the MED New Zealand Energy Datafile, 2000 was used showing the 1999 level of renewable energy was 71.08%.
4. Hybrid 1990 RE levels (Hybrid) scenario – this is a hybrid of the first two scenarios with one 400MW CCGT built in 2004 while the remaining generation requirement met by

building renewable energy plant. It also includes the effect of the draft NEECS target of 20% improvement in energy efficiency by 2012.

5. Energy Efficiency scenario – this was based on BAU expectations with the addition of an effective 20% improvement in energy efficiency. i.e. BAU with 1% reduction in annual demand as it is assumed that BAU incorporates 1% improvements in demand as suggested in the draft NEECS.

For each scenario any supply or demand side variations from the BAU needs to be represented in the Market Simulation Module, as detailed below. Supply side changes include different thermal or renewable energy generation builds<sup>25</sup> and decommissionings due to policy impacts while demand side changes reflect energy efficiency impacts on demand.

The Tool will show the impact of a target with a new renewables focus i.e. assumes policy drives the development of new renewable plant and only the market influences the existing renewable operation. This decision was taken as internationally policy tends to encourage new renewable developments only. No incentives are given to maximise the utilisation of existing renewable energy. However this is not necessarily appropriate taking into account the fact that New Zealand already has such a high proportion of renewable energy and the impact of new capacity on existing renewable energy including the net GHG effect.

Each scenario assumes:

- No other mechanisms are in place that will affect the market price such as carbon trading.
- That BAU practices, with regard to energy efficiency and fuel swapping projects will take place (this is assumed to be represented by the 1% annual improvement in energy efficiency reflected in BAU data).

The method used to develop each of these scenarios is outlined in the following sections.

#### *12.3.3.1 BAU Scenario (Scenario 1)*

The BAU Scenario will be discussed in more detail as its purpose is to act as a benchmark for the other scenarios. The BAU Scenario represents the expected business as usual path with a continuation of present policy settings.

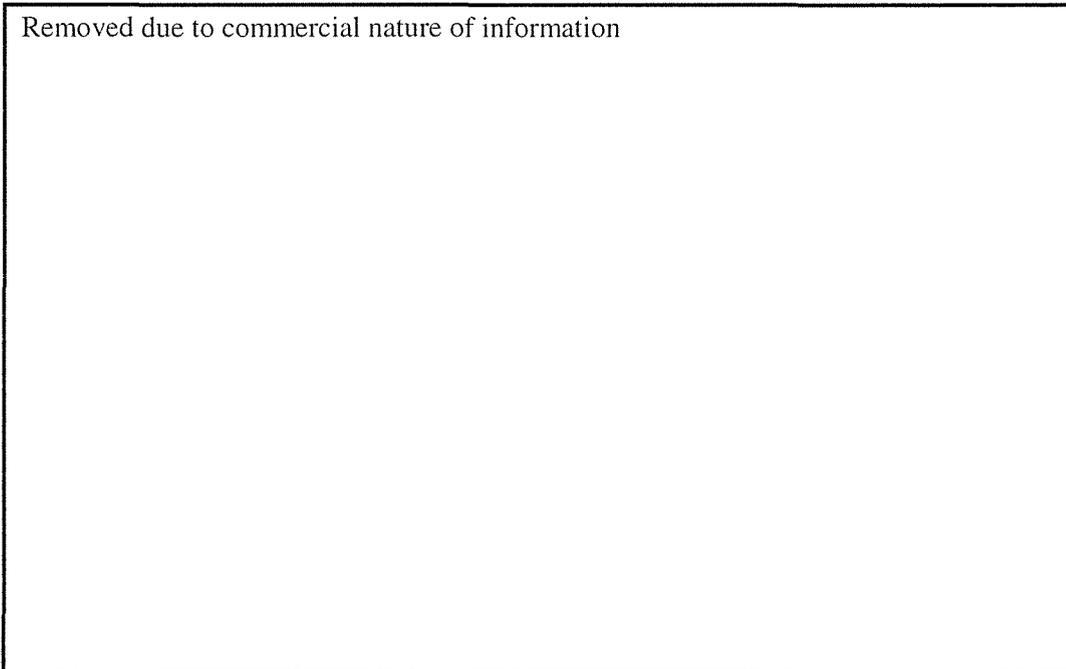
The future capacity forecast represents Meridian Energy's expectation and is based on a combination of independent views, existing indications from the market and engineering life

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<sup>25</sup> "Builds" is a term that will be used to refer to building and commissioning of an electricity generation plant.

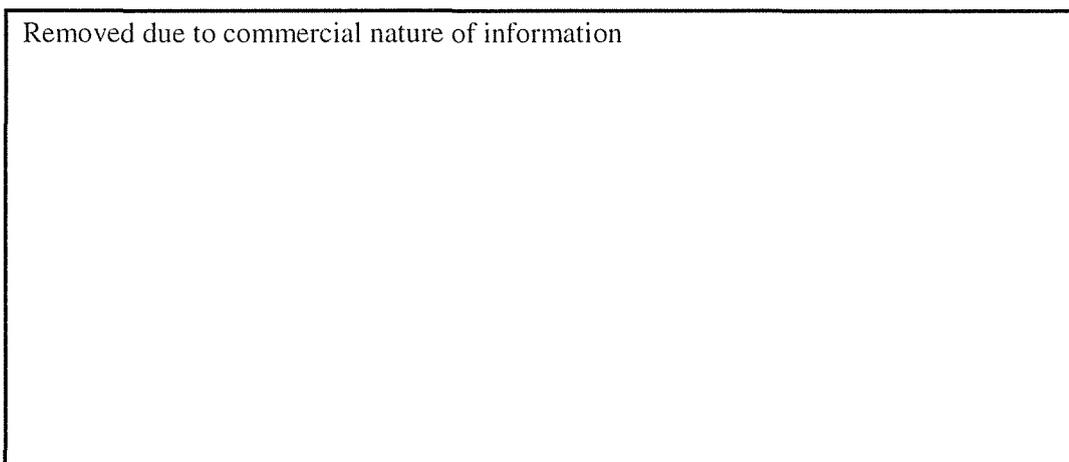
cycles. The historical and future expected generation build (Figure 12-2) only indicate expectations to 2009 though this has been extended to 2012.

**Figure 12-2: New Zealand generation build (actual last 10 years, forecast next 10 years)**

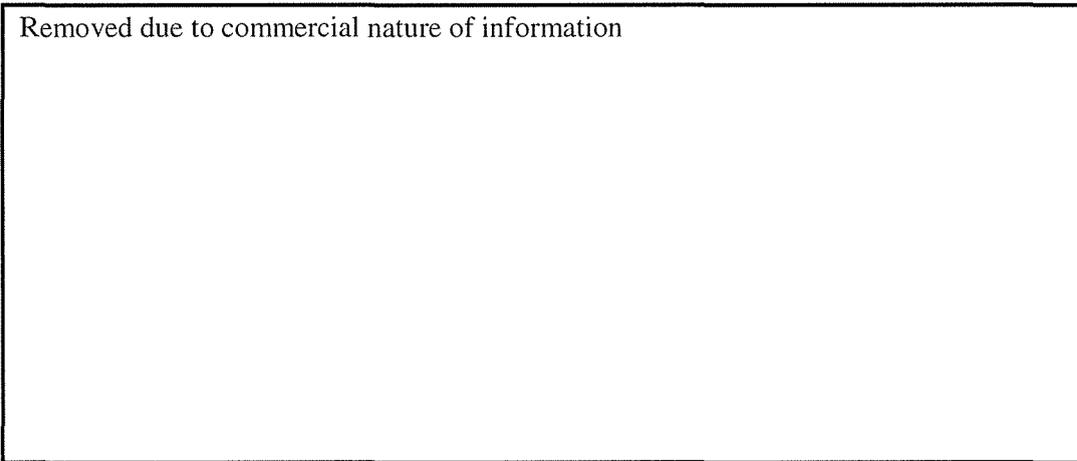


These decommissioning forecasts are mainly due to the engineering life cycle and efficiency drivers and leads to a 200MW decrease in available capacity. It is recommended that these assumptions are reassessed against present market situations if further work is carried out in the future.

The demand side will be represented using the New Zealand energy consumption data (which represents electricity requirements) and the demand side forecast shown in Figure 12.3. This also shows the expected source of the generation broken into geothermal, hydro, thermal, wind and other (this generally represents co-generation plants).



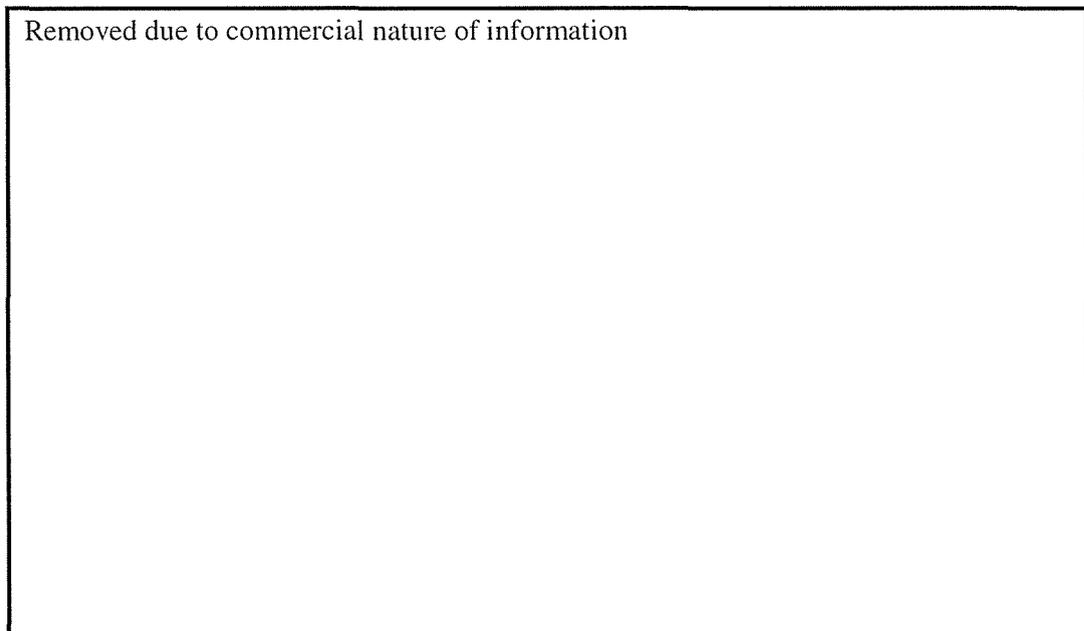
**Figure 12-3: New Zealand generation and demand forecast (actual last 10 years and forecast to 2009)**



It is interesting to note that the contribution of wind is expected to be so small that it barely shows at the bottom of this graph due to its scale in proportion to the other technologies. This graph also shows the amount of excess generation available.

The other important aspect to be considered in building this outlook is the peak load requirements shown in Figure 12-4. It is essential that sufficient capacity is available to meet peak demand requirements otherwise blackouts can occur. It is not enough to simply ensure that the total annual generation requirements are met the location of the load and the generation also need to be taken into account.

**Figure 12-4: New Zealand capacity and peak demand forecast (actual last 10 years and forecast to 2009)**



In summary, under business as usual total generation is expected to increase from 36,940GWh in 1999 to 45,650GWh in 2012. The level of renewable electricity is expected to reduce from 71.08% to 62.6%. However this does represent an increase in renewable energy supply from 26,255GWh to 28,562GWh due to increasing demand levels.

#### *12.3.3.2 1990 RE Level Scenario (Scenario 2)*

The 1990 RE Level Scenario assumes that new government policy will require the electricity industry to return to the same level of renewable energy generation as existed in 1990 by 2012 i.e. 81.07% renewable energy electricity supply by 2012. 1990 has been selected as the baseline year for this scenario, as it is the base year of the Kyoto Protocol.

The draft NEECS has the objective of increasing renewable energy supply by 2012<sup>26</sup> by a yet to be defined quantity. The May 2001 Terms of Reference (ToR) released by the MfE (2001a) for a project to investigate the target and mechanisms for transition to renewable sources of energy referred to two options:

- adopting a target for renewable energy that would result in renewable energy's share increasing significantly from the current level by 2012;
- adopting a target for renewable energy that would result in renewable energy's share returning to the current level by 2012.

The 1990 RE Level scenario represents the first ToR option as this target would result in a significant increase in RE levels from current level i.e. 71.08% to 81.07%. No assumptions are made about the mechanism for achieving the increase other than a ramping target will be used.

The 1990 RE level scenario base data is shown in Appendix 19. In summary, the data shows that 10,754GWh of renewable energy will be required by 2012, this is 37.7% more than would have been built under BAU. This overall target is broken down into annual targets as shown in Appendix 20.

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<sup>26</sup> The 2012 date is likely to have been selected as the final year of the first Kyoto period and as policy is likely to be in place by 2002, this allows 10 years for action.

Removed due to commercial nature of information

Decommissioning can impact on GHG emission figures if the plants would have been generating under business as usual. In this scenario the decommissioning effect reduces the total new renewable energy required from 10,754 to 10,303 GWh. This reduction in the amount of new renewables required is due to the impact of the New Plymouth 1 which would have generated 556GWh of thermal electricity. This means that 81.07% x 556 GWh of new renewables is no longer required (see calculation in Appendix 20). In the BAU scenario modelling none of the other decommissioned plants would have been used for generation and hence their decommissioning does not reduce the amount of new renewables required. The impact on the amount of renewables required is spread over the years following the decommissioning by reducing the target by the % cumulative increase required in that year (i.e. 47.37% in 2007) and reducing the new build by the annual incremental targets proportion of the decommissionings. This methodology is most easily understood by examining the table in Appendix 20.

#### *12.3.3.3 Present RE Level Scenario (Scenario 3)*

The second MfE ToR option was to adopt a target for renewable energy that would result in renewable energy's share returning to its current level by 2012. This is reflected in the Present RE Level Scenario, which assumes that new government policy will require the electricity industry to return to the same level of renewable electricity generation as in 1999 by 2012 i.e. 71.08% (MED, 2000) by 2012.

Removed due to commercial nature of information

In summary, renewable energy generation is expected to increase by 6,190 GWh from current levels, this represents a 21.67% increase over BAU expectations.

Annual target calculations are shown in Appendix 22. These calculations take into account the plant decommissioned in 2007 that would have otherwise operated. Therefore the increased renewable energy generation required by 2012 is reduced by 395GWh to 5,795 GWh.

#### 12.3.3.4 Hybrid Scenario (Scenario 4)

The Hybrid Scenario considers:

- that a realistic view of the future until 2012 will include one additional CCGT;
- a policy to increase renewable energy supply will be developed so the target for this is taken to be a return to the 1990 renewable energy level of 81.07% by 2012;
- the government has indicated a commitment to energy efficiency so the first NEECS target of a 20% improvement in energy efficiency by 2012 will occur.

On the supply side the commissioning profile is:

- a 400MW CCGT is completed by Genesis at Huntly in 2004; and
- the sufficient commissioning of renewable energy generation plant to meet the remaining demand.

Removed due to commercial nature of information

On the demand side, officials have stated that a 20% improvement in energy efficiency by 2012 can be broken down into a reduction in energy demand of 2% per annum. Officials have also stated that energy efficiency improves at 1% per year under BAU due to improved technologies and replacement of capital assets etc. For modelling purposes it was assumed that the Base Case reflects this 1% annual improvement in energy efficiency. For this scenario the demand will be scaled down by a further 1% per year indicating the success of the NEECS energy efficiency mechanisms. This leads to a total of 2% improvement in energy efficiency per year.

The base data for this scenario is shown in Appendix 23. To summarise this data, an additional 7,650 GWh of renewable energy will be required over present levels indicating a 26.8% increase in renewable energy over BAU forecast levels. It is important to note that in this scenario the total increase in demand drops so that demand growth only increases by 4,882 GWh in 2012 rather than the 8,710 GWh required in Scenarios 2 and 3. No additional changes were made to the model to indicate how the market may react to this and further work is required to assess the impacts of different excess capacity levels. It may be possible to generate more comparable data if the excess capacity levels were maintained at similar levels for each scenario (as discussed in Section 15.2).

Removed due to commercial nature of information

In total the electricity produced from new renewable energy build required by 2012 is 9,813 GWh.

#### *12.3.3.5 Energy Efficiency Scenario (Scenario 5)*

This scenario is effectively the Base Case taking into account the successful implementation of the NEECS energy efficiency objective. The supply side will be modelled in the same way as the Base Case and the demand side will be modelled with an additional 1% reduction in demand as explained in the Hybrid Scenario description. The Scenario Module is not required for this scenario as these changes can be carried out directly in the Market Simulation Module.

#### *12.3.4 Stage 3 - New generation plant required to meet annual targets*

The annual MRET GWh figure is calculated using the ramping target system used in the Australian MRET system (Chapter 11). The data required to generate the list of new generation plant required each year is the:

- 2012 business as usual renewable energy generation levels (GWh) and 2012 business as usual total generation (GWh);
- present renewable energy generation levels (GWh) and present total generation (GWh);
- 2012 target as either a percentage, total or increment;

The base data and this information is summarised in Table 12-3.

The new generation plants required to meet the annual target between 2002 and 2012 for the 1990 RE Level, Present RE Level and Hybrid Scenarios are shown in Appendix 25 respectively. This is called the build list and is the input for the Market Simulation Module. Scenarios 1 and 5 do not require lists of new generation as the BAU scenario is a standard scenario for the Market Simulation Module and the Energy Efficiency scenario simply requires the demand in that module to be reduced by 1%.

The build list for each scenario shows the plant which must be built to meet the annual renewable energy target. The difference in annual targets for each scenario leads to differences in the order of the new generation build. Another reason for variation in order is the size of the plant being built. For example, if a plant commissioned in 2004 also meets the target requirements for 2005 then nothing would be built in 2005. The spreadsheet automatically takes such issues into account.

**Table 12-3: Data and summary of MRET Scenario data**

<b>Background Data</b>	<b>Source</b>	<b>Total demand (GWh)</b>	<b>RE (%)</b>	<b>Total RE (GWh)</b>		
Actual 1990	MED Energy Datafile	31,467	81.07	25,510		
Actual 1999	MED Energy Datafile	36,940	71.08	26,257		
<b>Scenario Name</b>	<b>Basis</b>	<b>Total 2012 demand (GWh)</b>	<b>RE req'd or expected in 2012 (%)</b>	<b>Total RE req'd or expected in 2012 (GWh)</b>	<b>RE req'd above 2002 level (GWh)</b>	<b>Total demand above 2002 BAU (GWh)</b>
1. Base Case (and BAU)	<ul style="list-style-type: none"> <li>• 1 x 400MW CCGT in 2004.</li> <li>• 1 x 400MW CCGT in 2007.</li> </ul>	45,650	62.57	28,562	0	0
2. 1990 RE Levels	<ul style="list-style-type: none"> <li>• New RE to meet MRET.</li> <li>• See Appendix 19 and 20</li> </ul>	45,650	81.07	37,009	10,754 (10,302)*	8,710
3. 1999 RE Levels	<ul style="list-style-type: none"> <li>• New RE to meet MRET.</li> <li>• See Appendix 21 and 22</li> </ul>	45,650	71.08	32,446	6,191 (5,795)*	8,710
4. Hybrid	<ul style="list-style-type: none"> <li>• 1 x 400MW CCGT in 2004.</li> <li>• 1 % reduction in demand/energy efficiency improvement.</li> <li>• 1999 RE Level.</li> <li>• See Appendix 23 and 24</li> </ul>	41,823	71.08	33,906	7,650 (9,812)*	4,883
5. Energy Efficiency	<ul style="list-style-type: none"> <li>• 1% decrease in demand</li> </ul>	41,823	63.23	26,444	-2,118	-3,827

Key: Data in black is from MED (2000), data in blue is calculated, data in brackets and marked with an asterisk indicates the actual new renewable energy build required after taking into account the thermal commissioning and decommissioning.

### ***12.3.6 Verification of the Scenario Module***

The generation build lists underwent an internal Meridian Energy peer review process to ensure that they represented the organisations present view. Meridian's Unit Cost Model was used to ensure that the LRMCs used were sensible.

It is important to note that the generation build list is based on current information and can change significantly. For example changes in information on gas reserves and demand growth could lead to a different new generation project profile.

It is recommended that these profiles should be reviewed to assess if the suggested investment by each company is likely to be possible in the period of time suggested from the aspect of access to capital.

A Meridian Energy modelling expert reviewed the Scenario Module to ensure that it provided sensible outputs. Simple arithmetic calculations were added as checks to highlight errors as they occurred.

## **12.4 Market Simulation Module**

Meridian Energy's supply and demand forecasting tool is a well tested highly confidential business tool. Therefore it is not appropriate to enter into extensive discussion about its operation or its base assumptions. It has been in use for sufficient time that its ability to forecast supply and demand has been proven by comparison to actual supply and demand developments.

### ***12.4.1 Market Simulation Module development***

Meridian Energy's supply and demand forecasting tool was enhanced during this exercise.

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#### *12.4.2 Market Simulation Module input data*

The Market Simulation Module simulated the supply and demand effects of the 5 MRET Scenarios and required the following inputs:

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### *12.4.3 Market Simulation Module output data*

The Market Simulation Module outputs for the 5 MRET scenarios for each of the behaviours are shown in Appendix 27. These are the input for the Impact Illustration Module.

The output of the Market Simulation Module that is of relevance for each scenario is shown in three tables detailing GWh, PJ's, and ktCO<sub>2</sub>-e for:

- New Zealand total;

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The Market Simulation Module also calculated the emission intensity based on the ktCO<sub>2</sub>-e and GWh data.

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#### 12.4.4 Verification of results of the Market Simulation Module

New Zealand's total GHG emissions were calculated for the electricity sector in 1999 and 2000 by MED so it was possible to use this data. To verify that the Market Simulation Modules is producing credible results, its outputs were compared to the MED total CO<sub>2</sub> emission figures for 1999 and the 2000 data (which were only released after the modelling was completed) as shown in Table 12-4.

In order to carry out this comparison, it was necessary to assume that emissions are even throughout the year (this is obviously incorrect but useful for the purpose of this comparison). As MED data is based on calendar years 50% of 1999 MED data and 50% of 2000 MED data is assumed to be comparable to the Market Simulation Module data from the 2000 financial year.

**Table 12-4: Comparison of Market Simulation Module and MED GHG emission data**

Data source	ktCO <sub>2</sub>	ktCO <sub>2</sub> -e	Difference (ktCO <sub>2</sub> -e)	% difference
MED 1999 – 2000 data	5,400			
MED 2000 – 2001 data	5,005 <sup>27</sup>			
MED 50/50%	5,203			
Market Simulation Module Base Case (Competitive behaviour – BAU scenario)		5,212	+9	0.2%

NO<sub>2</sub> and CH<sub>4</sub> represents less than 0.2% of the CO<sub>2</sub>-e emission factor (see Appendix 26) utilised for the modelling which is less than the level of error in CO<sub>2</sub> alone (+/- 5%). So comparisons are appropriate as the differences between the two sets of data are negligible. This gives a high level of confidence that the Market Simulation Module, which is the MRET Impact Tools GHG calculation engine, is accurate. For future modelling it is recommended only CO<sub>2</sub> is assessed.

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<sup>27</sup> This reduction between 1999-2000 and 2000-2001 was possibly caused by the temporary shut down of the Otahuhu B CCGT plant due to turbine malfunction which led to more use of inefficient plant in the 1999 – 2000 period.

## 12.5 Impact Illustration Module

The Impact Illustration Module is an Excel spreadsheet and uses data provided by the Market Simulation Module to generate graphs that illustrate the MRET impact under the different scenarios.

Graphs were produced for each of the five scenarios and are shown in Appendices 28 -32 and are used as the basis for discussions about the impact of the five scenarios on the New Zealand's electricity sector's GHG emissions and the cost of reducing these emissions.

Graphs produced for each scenario include:

- Stacked bar graph showing GWh and PJ generated by each company versus time;
- Stacked bar graph showing ktCO<sub>2</sub>-e generated by each company versus time;
- The fair value price path versus the supply cost path (\$/MWh versus time);
- Bar and line graph of "New Zealand Incorporated" GWh and emission intensity (ktCO<sub>2</sub>-e/GWh versus time).

## Chapter Thirteen

# Analysis and potential impacts of five mandatory renewable energy target scenarios

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The outputs of the MRET Impact Tool were used to assess the potential impact of an MRET based on the five scenarios developed in Chapter 12 which were:

- Business as usual (BAU);
- Return to 1990 RE levels in 2012;
- Return to present RE levels in 2012;
- Hybrid of the above; and
- Successful energy efficiency mechanism implementation.

The government's objective of reducing GHG emissions in a least cost manner was assessed for each scenario by quantifying the impact on GHG emissions and sector emission intensities; the effect on the wholesale price of electricity; and the total capital investment that would be required to meet New Zealand's electricity needs with the MRET in place compared with the costs involved without it.

The government's objective of increasing renewable energy supply was assessed by quantifying the levels of renewable energy electricity supply.

Therefore the main impact assessment criteria selected were:

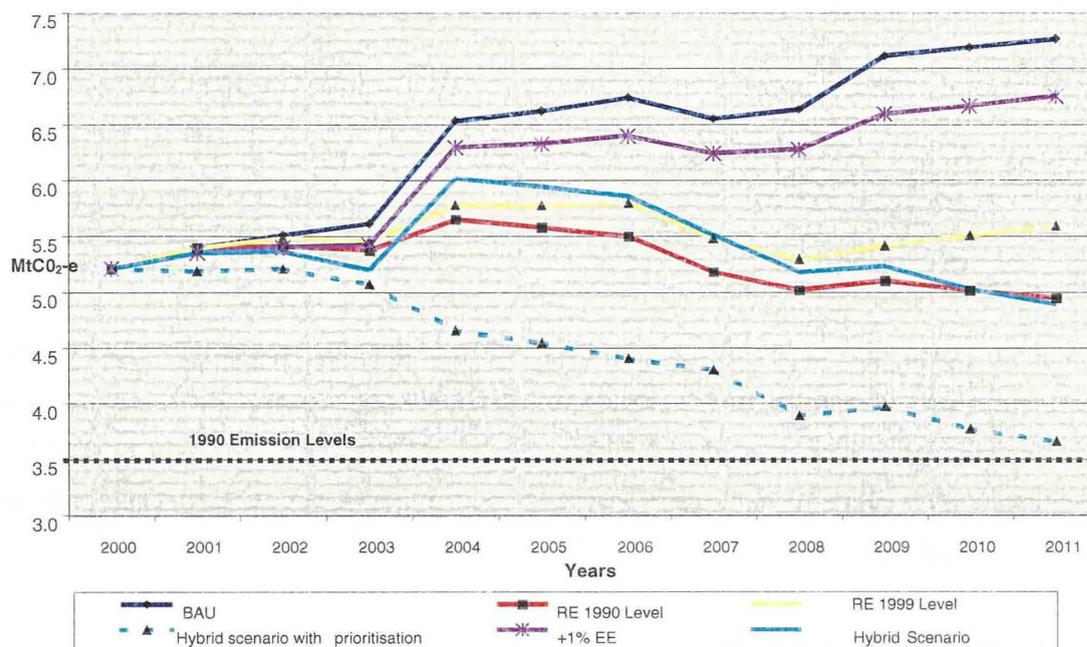
1. New Zealand's GHG emissions and emission intensity;
2. the wholesale price of electricity;
3. the total capital investment to meet the scenario objectives; and
4. the real effect of the target on the renewable energy supply.

For each of these 4 assessment criteria the BAU scenario and the best case scenario were discussed in depth. The other scenarios were only mentioned if any significant issues are noted. An assessment of the overall effectiveness of an MRET target in meeting the government's objectives completes the chapter. Throughout this thesis renewable energy only refers to renewable electricity, however it is possible that the mechanism that is implemented could also apply to other kinds of energy such as heat, steam and transport fuels.

### 13.1 The impact of an MRET on New Zealand's GHG emissions

One of the main objectives of a MRET is to decrease GHG emissions. Increasing the level of renewable energy generation mitigates the GHG emissions that would have resulted if that same amount of electricity was generated using thermal generation. The total GHG emissions from the electricity sector in 1990 was 3.5 million tonnes (MED, 2000). None of the MRET scenarios modelled reduced 2012 emissions to this level as shown in Figure 13-1.

**Figure 13-1: New Zealand electricity sector's emission path under the MRET scenarios**



Under the BAU Scenario, GHG emissions from the electricity sector rose 40% from 2000 to 7.26Mt CO<sub>2</sub>-e per year by 2012.

The 1990 RE Level scenario produced the lowest emissions over the whole 2002 – 2012 period so would be the most beneficial scenario on a cumulative basis. The emissions from this scenario would be further decreased if existing renewable energy generation was prioritised over thermal generation. This would occur in a wet year or if a policy was put in place to prioritise or incentivise existing renewable energy generation over thermal generation. This will be called prioritisation in further discussions. It indicates that some of the new renewable generation could offset existing renewable generation. Hydro would be offset rather than geothermal or wind which operate as base load. Presently hydro is often the peaking or marginal plant.

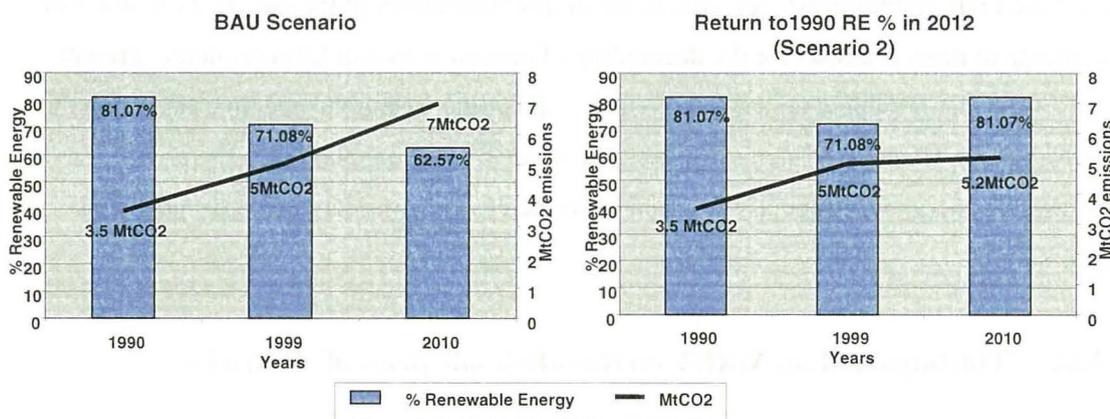
The lowest level of emissions in 2012 was achieved by the Hybrid scenario with a significant further decrease noted with prioritisation. The total additional renewable energy capacity

required in the Hybrid scenario was lower than 1990 RE Level scenario requirement despite having the same % renewable energy target of 81.07%. This was due to the effect of the energy efficiency improvements that are expected through the NEECS. Despite all this, even with prioritisation, GHG emission levels only fall to about 3.6 Mt CO<sub>2e</sub> in 2012 which is still slightly higher than 1990 GHG emission levels of 3.5MtCO<sub>2e</sub>. Considering that CO<sub>2</sub> emissions can only be measured to an accuracy of 5%, this could be considered an acceptable outcome.

It is important to remember that this assessment only considers a MRET mechanism as a method of achieving New Zealand’s Kyoto Protocol target as applied to the electricity sector. However these measures should only be implemented if they are the least cost solution to the economy. It may be more cost effective to reduce emissions in another sector, or use emissions trading or sink credits to take responsibility for emissions, rather than reducing GHG emission using an MRET target for the electricity sector.

So a return to 1990 renewable energy supply levels would not achieve the objective of returning to 1990 emission levels. This is because total electricity demand is expected to increase by about 2% per year so while the percentage of renewable energy may be the same as 1990 the total amount of electricity generated is increasing and therefore total emission levels from thermal generation will increase. Figure 13-2 shows that there is not a direct relationship between the percentage of electricity generated from renewable sources and emission levels.

**Figure 13-2: Indirect relationship between % renewable energy and emission levels**



In New Zealand, precipitation in hydro catchment areas can significantly impact on GHG emissions. For example, the emissions for New Zealand’s electricity sector for 2000<sup>29</sup> (MED, 2001) show that emissions dropped to approximately 5Mt from 5.4Mt in 1999. This is mirrored by inflow levels in the Waitaki and Manapouri systems, taking into account that low inflows will may lead to higher requirements for thermal generation in order to meet demand.

Figure 7.2 illustrates this. 1999 was a below average year, hydro inflows were 92% of the 20 year mean while 2000 was an above average year with inflows being at 101% of the 20 year mean. This effect was exacerbated by Otahuhu B CCGT plant being out of operation for the latter part of the year requiring older less efficient thermal generation plant to be used which is due to the direct relationship between  $\text{mtCO}_{2e}$  and GWh thermal generation.

### ***13.1.1 The impact of an MRET on the emission intensity of the electricity sector***

Emission intensity is a measure of the amount of GHG emitted per GWh of electricity generated. It is a useful comparative measure. The emission intensity of electricity generation from the sector is a function of several things including the:

- efficiency of the thermal generation plant;
- amount of renewable generation available;
- offer strategies of the generators; and
- availability of “fuel” e.g. water, for the renewable generators.

In 1990, New Zealand’s electricity generation emission intensity was 111  $\text{tCO}_2/\text{GWh}$ ; in 1999 it was 146  $\text{tCO}_2/\text{GWh}$  while under BAU it would be 159 $\text{tCO}_2/\text{GWh}$  in 2012. In 2012 under the best case or Hybrid Scenario, the emission intensity would be 117  $\text{tCO}_2\text{-e}/\text{GWh}$  and with prioritisation the emission intensity would be 87.5 $\text{tCO}_2\text{-e}/\text{GWh}$ <sup>30</sup>.

With technology developments that improve efficiencies of thermal power generation and increased renewable energy generation, the emission intensity of the electricity sector will continue to drop. It allows for the decoupling of emission growth from economic growth indicating that growth in demand is possible without increasing the negative effects on the environment. However if increasing demand is met by thermal plant then the proportion of renewable energy will decrease and lead to an increase in emission intensity and actual emissions.

## **13.2 The impact of an MRET on the wholesale price of electricity**

Assessing the impact of a MRET on the wholesale price of electricity is a way of assessing the impact on the economy. Electricity is an essential service and the low cost of electricity is seen as one of the more significant parameters of New Zealand’s competitive advantages.

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<sup>29</sup> This data was released after the completion of the modelling.

<sup>30</sup>  $\text{tCO}_2/\text{GWh}$  is used for data which is based on  $\text{CO}_2$  alone i.e MED data, while  $\text{tCO}_2\text{-e}/\text{GWh}$  is used for data generated by the MRET Impact Tool which also incorporates  $\text{CH}_4$  and  $\text{N}_2\text{O}$ .

Some of New Zealand's major industries, such as the light metal and the concrete and cement industries, have electricity as one of their largest costs of production. Therefore any policy that could increase electricity prices needs to be carefully considered.

In the competitive electricity wholesale market, generation capacity is offered into the market on a half hour by half hour basis. Generators offer in their generation in tranches at appropriate prices taking into account the value of their fuel and the other costs of operating their plant – this generates a supply curve.

Retailers bid in how much electricity they are expecting to require which creates a demand curve. The amount of generation required at any moment is set by the amount of electricity demanded by consumers at that time plus losses. Since electricity can not be stored the systems that are required to ensure sufficient good quality electricity is always available are complex. The nature of the market ensures that the lowest price is made available to the market though this may not necessarily feed down to all consumers, due to different contractual agreements.

The wholesale spot price is set every half hour based on where the supply curve crosses the demand curve. The price of that tranche of generation is the market clearing price or the wholesale price which is paid for all electricity generated in that half hour. This is a simplistic description of the operation of the market and explains the bulk movements in price which are driven by offers for electricity. It does not take into account, for example, that production and consumption are spatially separated and therefore instantaneous losses occur. In fact every half hour of every day a price is established at each of the 244 grid connections points (nodes) around the country (i.e. each has its own supply and demand curve). The price discovered this way is called the spot price. This method is used as it allows the energy costs, transmission costs (including cost of losses), requirement for reserves and grid constraints to be reflected. It also sends investment signals to market participants. There is a secondary market where generators and buyers also hedge spot prices. The wholesale price in 2000 averaged \$32.50/MWh at the Haywards node<sup>31</sup> (M-Co, 2001).

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<sup>31</sup> The Haywards node is at the bottom of the North Island.

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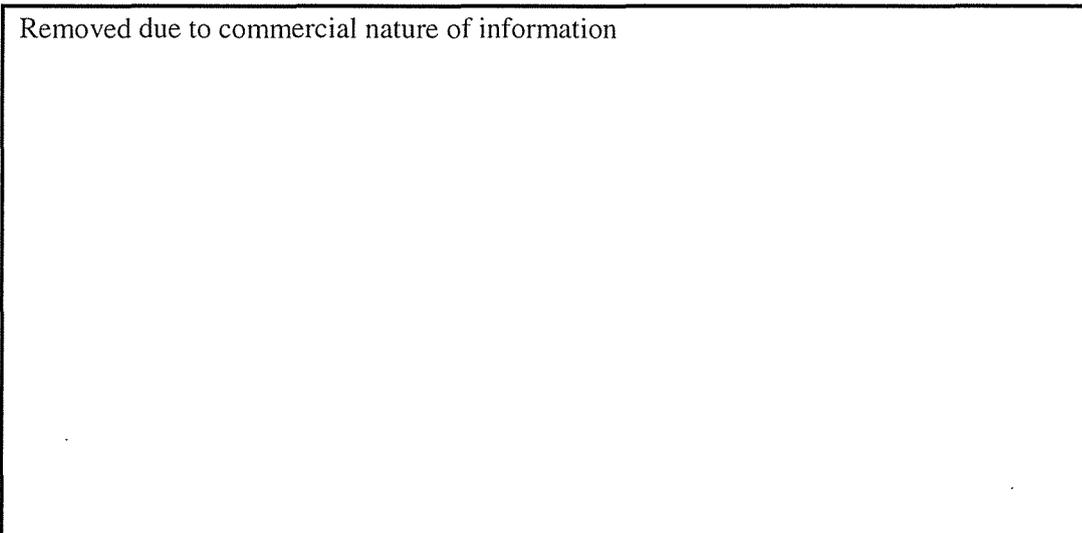
**Figure 13-3: Supply cost for new renewable generation capacity (ranked by cost)**

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There are two measures of interest when assessing the sector's ability to meet demand. The capacity (MW) must be available to meet peak demand while the generation (GWh) must be available to meet total demand. The GWh are calculated taking into account plant availability and capacity factors (Figure 13-4). The MRET Impact Tool uses a GWh basis but the model includes a check to ensure that sufficient MW are available to meet peak demand and prevent blackouts. This was met in all of the five scenarios.

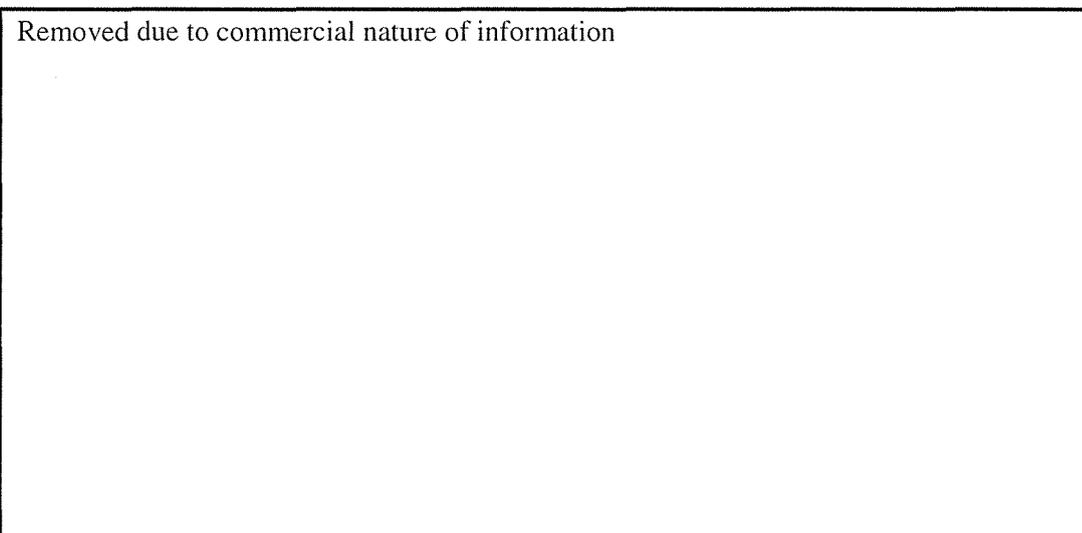
If new renewable energy generation is stimulated by policy then higher cost generation may be built prior to options with lower costs because they require shorter resource consent and building times. Minimising the time involved in the RMA consents process could therefore assist in ensuring New Zealand's energy sector is as economically efficient as possible.

**Figure 13-4: Supply cost for new renewable electricity supply (ranked by cost)**



If policy changes the market outlook suddenly, then time will be required for the market to respond.

Project Aqua, the 540MW Meridian Energy hydro project proposed in the South Island, has a significant impact on this curve due to its considerable size. In the modelling it has actually been broken down into two tranches as it is possible that it could be built in a stepwise manner. The final LRMC of this project is still being assessed. A LRMC of \$43/MWh has been used for the purpose of this study as this is the estimated cost involved in getting the electricity generated to New Zealand's median demand point (in the middle of the North Island) taking into account that it will be built in the lower South Island and that the majority of demand is in the upper North Island.

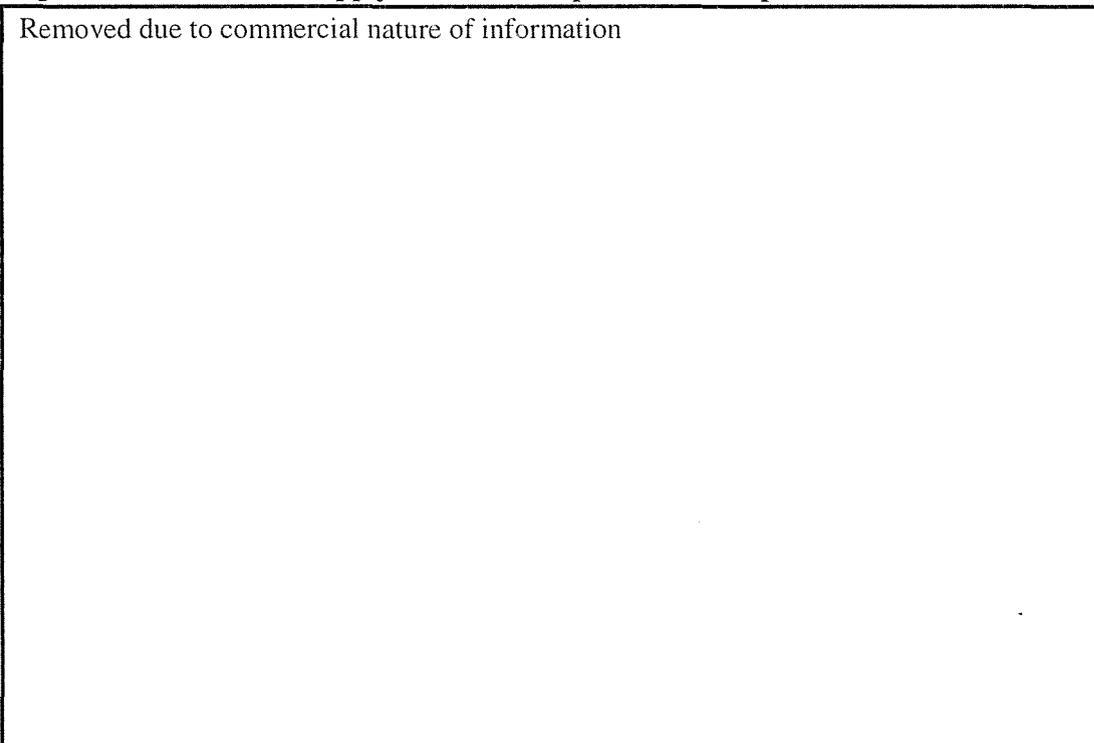


The inclusion of Project Aqua significantly impacts on the cost/supply curve and therefore the total cost of any new capacity above 350MW. As would be expected the graph indicates the scarcity of resources in that the more capacity required the more expensive it gets due to the reduced availability of good quality resources.

Due to variations in the annual target for each MRET scenario, each has a different estimated supply cost curve which can be compared with the expected market price path of the BAU scenario as shown in Figure 13-5. Note that prioritisation would not increase costs (so are not represented on the graph) but would decrease emissions and increase renewables.

The graph shows the modelled price expectation for 2000 was around \$XX/MWh but this price was the average price for the whole market in contrast to the \$32.5/MWh M-Co figure which is the average price at the Haywards node.

**Figure 13-5: Estimated supply cost versus expected market price**



(Note: The 1990 RE Level (red) line tracks the Hybrid scenario (turquoise) line from 2004 onwards.

Several points can be taken from this graph:

- The difference between the supply cost and the market price is the difference between what it costs to supply and what the market is prepared to pay. Generators can therefore not economically justify building these renewable energy plants in the present market and policy environment. The difference needs to be covered in some way. This could be in the form of a direct incentive payment such as a guaranteed price or through a market mechanism that will enable generators to recover this additional value. The graph shows that this difference increases over time as we move up the supply curve for new renewable generation. At its maximum the size of the incentive required is over \$35/MWh (c.f. the Australian penalty of A\$40/MWh) or a total electricity price of around \$75/MWh. It is

recommended that further work is done to calculate the  $\$/\text{tCO}_2$  that this represents so that a cost of  $\text{CO}_2$  abatement curve could be built of all the  $\text{CO}_2$  reduction options.

- Any generator whose MC is lower than the MC of the marginal plant which sets the market price will increase its profit as the market price increases. This effect could be controlled if a secondary market (e.g. a renewable energy certificate market) was used to provide the additional revenue stream required to encourage additional renewable energy generation. This would also reduce the overall cost to the economy as it would mean that the electricity price and market would not be affected to the same extent. It would mean that the market clearing price would not need to be the LRMC required to cover the cost of the newly built renewable generation and would not need to be paid to all generators during that period. The market price of the renewable energy certificates would escalate over time to a maximum of  $\$35/\text{MWh}$ . The impact this new market would have on existing renewable energy generation would need to be assessed. It may be possible to design a market mechanism that encourages the use of both new and existing renewable generation, but this would increase the cost to the economy above a mechanism that only rewarded new renewables.
- Energy efficiency leads to a decrease in the market price due to the reduced demand as shown by the purple line that represents the Energy Efficiency scenario.
- The Hybrid Scenario includes some of the energy efficiency benefits while still maintaining renewable energy at 1990 levels. When assessing the scenarios on a least cost basis this appears to be the best option with the level of incentive needed being only approximately  $\$25/\text{MWh}$  above the forecast market price.

For the purpose of this modelling exercise, all renewable energy generation built to meet the target has been offered into the market at  $\$0/\text{MWh}$  to ensure that the plant will run. Existing renewable energy generation plant is offered into the market following the normal expected offer strategies of the owner of each plant. The Market Simulation Module was developed in order to carry out this function. If the MRET that drives this behaviour is based on a secondary market or direct payment that covers the difference in the market price and the MC, then the owners of the new plant may adopt this bidding behaviour. The MC of the new renewables will also change over time depending on access to fuel (as indicated by the high prices of the winter of 2001 due to the shortage of water for renewable hydro generation). It will be important that generators have the ability to signal this to the market. Therefore the assumption used in this model of offering in new renewables at zero should be enhanced further to reflect the likely true offer behaviour within the market. This means that the two scenarios that do not have new renewables i.e. BAU and Energy Efficiency, do show a true market price in Figure 13-5, but the other scenarios do not as they have new renewables

offered in at zero. Therefore the market price generated by the Meridian Energy supply /demand model is not accurate.

This offer method enhancement also allows for some analysis of the true effect on the profitability of the various market players and it would mean that a market price path could be developed for each of the MRET scenarios. At this point in time the information from the MRET Impact Tool only allowed for an analysis of supply costs and greenhouse gas impacts.

### 13.3 Total capital investment required for each scenario

The third way of assessing the impact of an MRET on the economy is looking at the additional capital investment that would be required to meet the target over the capital cost of the BAU scenario.

The cost of the capital investment required for each scenario was calculated by totalling the capital cost for each plant required to meet the renewable energy target. For scenarios requiring additional renewable energy plants to be built (i.e. scenarios 2, 3 and 4) this data is shown in Appendix 25. The cost of the CCGT plants in scenarios 1,4 and 5 is \$1 million/MW i.e. \$400 million dollars for each 400MW CCGT.

**Table 13-1: Capital investment for the five MRET scenarios**

Scenario	Capital Investment (2002-2012)	Increase over BAU
1. BAU scenario	2 x 400 = \$800 million	-
2. 1990 RE Levels	\$3320 million	315%
3. 1999 RE Levels	\$1823 million	128%
4. Hybrid scenario	3120 + 400 = \$3520 million	340%
5. Energy Efficiency	\$800 million	0%

There is a significant additional capital cost for each of the scenarios which increase the level of renewable energy capacity ranging from 128% to 340%.

This assessment criterion would be more useful if each scenario maintained the same level of excess generation capacity. This work should be carried out in the future. At this stage in the modelling it is not appropriate to use this as a comparative measure.

### 13.4 The impact of an MRET on renewable energy electricity supply

Table 13-2 compares the % target with the % renewable energy generation achieved for each scenario under the competitive, accommodating and aggressive behaviours.

**Table 13-2: Comparison of renewable energy targets and actual modelled outcomes**

Scenario	Target		MRET Tool Output – 2012					
	2012% RE <sup>1</sup>	RE GWh	Low		High			
			%	GWh	%	GWh		
1. BAU	62.57 <sup>2</sup>	28,562	62.57	28,562	64.48	29,436		
2. 1990 RE Levels	81.07	37,008	76.06 (-5.01)	34,720 (-2,288)	79.92 (-1.15)	36,482 (-562)		
3. 1999 RE Levels	71.08	32,448	74.11 (+3.03)	33,830 (+1,382)	75.06 (+3.98)	34,264 (+1,816)		
4. Hybrid scenario	81.07	33,906	73.17 (-7.90)	30,603 (-3,303)	80.30 (-0.77)	33,584 (-722)		
5. Energy Efficiency	61.77 <sup>3</sup>	25,834	63.19	26,427	66.27	27,717		

Notes:

Parenthesis show the differences between the modelled outcome and the target. Blue print shows where the target has been exceeded and the red print shows where the target has not been met.

1. Based on total generation required to meet forecast demand of 45,650 GWh for scenarios 1,2 and 3 and 41,823 GWh for scenarios 4 and 5 due to decreased demand due to the success of NEECS energy efficiency measures.
2. BAU forecast data – not a target.
3. Not a target – BAU forecast data with decreased demand of 41,823GWh (or 1% p.a. decrease in BAU) and BAU generation builds.

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Under BAU the level of renewable electricity supply as a % of total generation is expected to drop to 62.6% by 2012.

Under the Energy Efficiency scenario, renewable electricity supply, on a percentage basis would be similar to the BAU percentage renewable energy but actual generation in GWh drops

to 25,834GWh due to a total decrease in electricity demand. In this scenario, two 400MW CCGTs are built while demand drops by 1% below BAU due to energy efficiency gains. This effectively increases the level of excess capacity in the market leading to less efficient use of generation assets.

The other three scenarios were designed to achieve an increase over BAU in renewable energy generation by 2012, calculated on a percentage basis of total generation. Under normal competitive behaviour, none of the scenarios actually meet their renewable energy generation objective.

#### ***13.4.1 Scenarios (2&4) aim to return to 1990 level of renewable electricity by 2012***

The Scenario Module was built to calculate the additional renewable energy generation, on a GWh basis, required to meet the 2012 renewable energy target. It was assumed that the additional renewable energy generation would not reduce the BAU renewable energy generation supply (28,562 GWh). This assumption proved to be incorrect for both scenarios 2 and 4 as despite an increase in renewable energy capacity, the renewable energy generation supplied did not meet the targets of 37,008 and 33,906 GWh respectively. This is because the amount of additional renewable generation required to achieve the target was higher than the total additional generation required to meet the growth in demand during the 2002 – 2012 period. This led to all renewable energy capacity (both the BAU capacity and the new additional renewable energy capacity) being under utilised—so the target was not met.

According to the MRET Impact Tool's outputs, in scenarios 2 and 4, the actual amount of renewable energy supply in 2012 would be significantly below the target of returning to 81.07% renewable energy generation. Aggressive behaviour on the part of the existing renewable energy generation suppliers would be required to get as close as possible to the target (see section 13.1)

For scenario 2, the 1990 RE Level scenario, the amount of new renewable generation required (10,753GWh), was approximately 23% over the total increase in demand between 2002 and 2012 (8,710 GWh) (see Appendix 19).

In the Hybrid scenario, the amount of new renewable generation required (7,650GWh) was approximately 57% over the total increase in demand between 2002 and 2012 (4,883GWh) that includes efficiency improvements (see Appendix 23). The outputs for this scenario were further from meeting the targets than the other scenarios and aggressive behaviour (as

explained in section 12.4.3) made a greater improvement in this scenario than in any other. This indicates that the new renewables were significantly offsetting the existing hydro assets.

It is possible that allowances could have been made for this behaviour in some way in the modelling, for example further thermal plant could have been decommissioned. In the modelling, decommissioning of thermal plant only occurred at the end of its economic and/or technical life. Increasing the amount of decommissioning would require plant that still had operational life to be shut down early. This would be an uneconomic decision in the current policy climate and drivers would be required to encourage this type of activity. It is possible that this could have a negative impact on dry year security of supply.

Scenarios 2 and 4 effectively show the impact of excess generation capacity (which is the current situation). The inefficient use of the existing hydros may have led to unavoidable hydro spill (if lake levels were high and demand did not require all available generation).

#### ***13.4.2 Scenario 3 aims to return to 1999 levels of renewable energy supply in 2012***

Scenario 3 exceeded its target of 71.08% RE, under all the behaviours. This scenario called for additional renewable energy generation that was about 30% below the total increase in demand between 2002 and 2012. No additional thermal plant was built to cover the shortfall between demand and additional generation requirements but no blackouts occurred<sup>32</sup>. This meant that the existing excess of supply situation was reduced and led to the more efficient use of existing generation assets particularly hydro generation.

There was little difference in the amount of renewable energy supply in each of the market behaviours indicating that all renewable capacity is generally being better utilised.

#### ***13.4.3 Best scenarios for increasing renewable energy generation – 4 & 2***

If the objective was to increase renewable energy supply on a percentage basis then scenario 4, the Hybrid Scenario, with aggressive behaviour (i.e. existing hydro being prioritised or in wet years) would achieve this best with 80.3% (or 33,584 GWh) of the total generation being from renewable sources.

If the objective were to increase the amount of renewable energy supply in actual generation terms, then the optimal scenario would be scenario 2. While it did not achieve its target of

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<sup>32</sup> The Market Simulation Module has a built in check to check if a scenario triggers a blackout situation.

81.07%, it did lead to the highest amount of actual renewable energy generation at 35,242GWh (77.20%) with competitive behaviour. If policy led to the prioritisation of existing renewable energy over thermal, then the total renewable energy generation under this scenario would be 36,482 GWh (79.92%).

#### ***13.4.4 MRET Issues***

These discussions emphasise the problems that can result if percentage measures are used. The Australians came up against this problem and no longer discuss their target as an incremental increase of 2% in renewable energy supply over 1997 figures by 2010. It is now stated as an increase of 9,500GWh by 2010 above 2001 generation figures.

The Australian Energy Agency is an umbrella group representing the renewable energy and co-generation industries in Australia. They say that according to the latest figures produced by the Electricity Supply Association of Australia (ESAA), unexpected growth in the electricity market means 9,500GWh will only represent a boost of 0.5 per cent for renewables by 2010 (Myer, 2001). In order to get back to the original intent of the renewables legislation (i.e. 2% increase in RE), Australia would need to lift renewables output by 13,000GWh by 2010. The ESAA states that:

- the current 9500GWh target would add about \$320 million to a national electricity bill likely to be \$25 billion in 2010, being an increase of 1.28 per cent;
- if the target were boosted to 13,000GWh, the costs would be increased by over \$500 million (2% increase); and
- if the target climbed to 20,000GWh, the extra cost would be \$1 billion (4% increase).

The calculation of these costs needs to be part of the NZ policy assessment for setting the renewable energy target. Other issues impact on the additional cost such as the impact of new thermal builds on the wholesale electricity price due to excess supply, the potential impact of a carbon price, the growth in demand, the potential impact of other policies. If actual generation supplied rather than a percentage increase of renewable energy supply were used then these issues would not arise.

It was hoped that the MRET Impact Tool could be utilised to quantify hydro spill that could occur due to new renewable generation offsetting existing hydro generation. However this issue is complex and more extensive modelling would be required to assess this quantitatively. The issue is that the marginal plant is often hydro so if new renewable generation is offered in at a lower price (or in the case of this modelling at \$0/kWh) then it could lead to marginal hydro plant not being required. This means that the new renewables would offset existing

hydro generation which could lead to additional hydro spill. However this is also dependent on issues such as the level of hydro lake storage and the overall demand levels. It may be that offsetting a marginal hydro plant simply leads to an increase in average storage levels for that system.

### 13.5 Summary of MRET Scenarios

Five possible MRET scenarios were assessed against four main impact assessment criteria. One of these criteria, the total capital investment required to meet the MRET objective was inappropriate due to the fact that building excess capacity means the capital cost of some scenarios is artificially high.

If a policy decision was being made, the “cost” of each MRET scenario would need assessing in a much more comprehensive manner and should incorporate the administrative costs of developing, implementing and operating the mechanism.

Based on the other three assessment criteria, and assuming that each criteria is given an equal weighting, the Hybrid scenario with existing hydro generation prioritised over existing thermal (i.e. aggressive behaviour) was the “best” scenario. The worst scenario is the BAU under competitive behaviour. Some of the criteria are represented by more than one parameter.

The results of this assessment are summarised in Table 13-3, which compares the “best” Hybrid scenario and “worst” BAU scenario.

**Table 13-3: Comparison of the “best” (Hybrid) scenario against the BAU**

<b>Parameters</b>	<b>BAU<sup>33</sup></b>	<b>Rank against other scenarios</b>	<b>Hybrid<sup>34</sup></b>	<b>Rank against other scenarios</b>
2012 RE (%)	62.57	5 <sup>th</sup>	80.3	1 <sup>st</sup>
2012 RE (GWh)	28,562	4 <sup>th</sup>	33,584	3 <sup>rd</sup>
2012 Emissions (MtCO <sub>2</sub> -e)	7.26	5 <sup>th</sup>	3.6	1 <sup>st</sup>
2012 Emission Intensity ( tCO <sub>2</sub> -e/GWh)	159	5 <sup>th</sup>	87.5	1 <sup>st</sup>
Supply Cost (\$/MWh)	40	2 <sup>nd</sup>	77.5	4 <sup>th</sup> Equal
<b>Overall Ranking<sup>35</sup></b>		<b>5th</b>		<b>1st</b>

<sup>33</sup> With competitive behaviour.

<sup>34</sup> With aggressive behaviour.

<sup>35</sup> As noted earlier a calculation of \$/tCO<sub>2</sub> would be a useful addition to the assessment criteria selected.

This means that to return to emission levels close to 1990 levels the following measures are required:

- a 20% energy efficiency target as in the NEECS;
- prioritisation of existing and new renewables to avoid new renewables offsetting generation from existing renewable generation plants;
- one 400MW CCGT to be built reducing the need for the less efficient Huntly power plant to run and no other thermal plant built;
- a MRET implemented to increase the amount of renewable energy supply such that renewable energy's share of electricity generation returns to 1990 levels i.e. 81.07% by 2012.

## Section Four

### Climate Change Case Study Meridian Energy Ltd

*This purpose of this section of the thesis is to apply an understanding of climate change issues to a company case study.*

*Meridian Energy Ltd (Meridian Energy) is the sponsor of this work and makes an interesting case study as it is a 100% renewable energy company, so the physical and policy aspects of climate change are likely to impact on its business.*

*This case study will be carried out as follows:*

- 1. A brief background on Meridian Energy and its assets to provide context.*
- 2. A comparative assessment of Meridian Energy's climate change policy risk on a GHG emission level basis.*
- 3. An assessment of the possible impacts of climate change on Meridian Energy.*
- 4. Meridian Energy's existing climate change related commitments i.e. reporting on ECNZ's Voluntary Agreement.*
- 5. A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis based on expected climate change policy outcomes.*
- 6. An assessment of the key success factors influencing the maximisation of the opportunities that exist for Meridian Energy.*
- 7. Meridian Energy's approach to managing opportunities and threats resulting from climate change policy developments.*



# Chapter Fourteen

## Case Study on Meridian Energy Limited

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Meridian Energy Limited (Meridian Energy) will be used as a case study to investigate the impact of climate change issues on an electricity company in New Zealand.

Climate change policy developments could have a significant impact on Meridian Energy's business in advance of the increasing physical impacts that climate change is likely to have. It is in the interesting position of generating zero emissions as all of its electricity generation is from renewable energy sources.

Meridian Energy perceives that New Zealand's response to the Kyoto Protocol may present opportunities to its business.

### 14.1 Brief background on Meridian Energy Ltd

Meridian Energy is a state owned enterprise (SOE) bound by the requirements of the State Owned Enterprises Act 1986.

Meridian Energy's Statement of Corporate Intent (1999) states that its primary objective is to operate as a successful business which is as profitable and efficient as comparable businesses not owned by the Crown.

Meridian Energy is the largest generator of the three state-owned enterprises formed from the split of ECNZ (the Electricity Corporation of New Zealand) on 1<sup>st</sup> April 1999. Meridian Energy's core business is the generation, marketing, trading and retailing of energy and wider complementary products and solutions which meet customers needs. This includes the management of hydrological reservoirs and related assets. (Meridian Energy Ltd, 2000)

Meridian Energy's nine South Island hydro-electric power stations represent 30% of New Zealand's total installed generating capacity and it is responsible for 70% of New Zealand's total hydro storage. It also owns one 225kW wind turbine in Wellington and a 40MW heat energy facility at Blue Mountain Lumber in Otago. In 2001, five small hydroelectric power stations were purchased in Australia, these qualify to varying degrees for Renewable Energy Certificates under the Australian Renewable Energy (Electricity) Act 2000.

A summary of Meridian Energy's generation portfolio is shown in Table 14-1.

**Table 14-1: Meridian Energy's Generation Portfolio**

Station	Location	Fuel	First commissioned	Station rating (MW)	Nominal annual generation (GWh)
Manapouri	Manapouri SI	Hydro	1969	585	4400
Tekapo A	Waitaki SI	Hydro	1951	25	160
Tekapo B	Waitaki SI	Hydro	1977	160	800
Ohau A	Waitaki SI	Hydro	1979-80	264	1150
Ohau B	Waitaki SI	Hydro	1983-4	212	970
Ohau C	Waitaki SI	Hydro	1984-5	212	970
Benmore	Waitaki SI	Hydro	1965-66	540	2200
Aviemore	Waitaki SI	Hydro	1968	220	900
Waitaki	Waitaki SI	Hydro	1935-36	105	500
Wgtn Turbine	Wellington NI	Wind	1993	0.23	1
BML	Otago SI	Biomass	2000	10	Negligible
<b>New Zealand</b>				<b>2,332.23 MW</b>	<b>12,051 GWh</b>
Pindari	NSW	Hydro	2001	6	14
Burrendong	NSW	Hydro	1996	19.0	64
Copeton	NSW	Hydro	1996	22.5	58
Glenbawn	NSW	Hydro	1995	5.5	13
Yarrowonga	Victoria	Hydro	1994	9.0	47
<b>Australia</b>				<b>62.0 MW</b>	<b>196 GWh</b>
<b>TOTAL</b>				<b>2,394.23MW</b>	<b>13,047 GWh</b>

(Key: SI = South Island, NI = North Island, NSW = New South Wales, BML = Blue Mountain Lumber)

(Based on Meridian Energy, 2000)

Meridian Energy operates in the electricity retail market nationwide, and is the "incumbent" in five local retail areas: Whangarei, Dannevirke, Waipukurau, Oamaru and Christchurch. Meridian Energy provides electricity to the New Zealand Aluminium Smelter and has approximately 220,000<sup>38</sup> domestic customers. It has a staff of approximately 175.

<sup>38</sup> As of July 2001, this number includes the 120,000 South Island customers purchased by Meridian Energy from On Energy.

In 2000, a new business unit was launched called Meridian Solutions whose objective is to provide energy solutions to industrial partners. Generally, this will be done by buying or developing energy centres (i.e. electricity, heat, steam or cooling plant on customers' sites) and selling electricity, heat and steam back to the customer who is also the host of the energy centre.

Meridian Energy as a company is completely dependent on the environment. The environment provides generation stations with fuel and affects consumer demand for its product. Meridian Energy's hydro resources are shared with a wide range of users such as kayakers and fishermen therefore the relationships that the company has with these co-users is considered to be very important. The use of these resources are controlled by consents and other agreements under the Resource Management Act (RMA). Meridian Energy holds approximately 120 RMA consents. The RMA can impose mitigation requirements on electricity generators that emit various gases including GHGs, however due to the nature of Meridian Energy's assets none of their RMA consents include such a requirement. Background information on the RMA is available in Appendix 8.

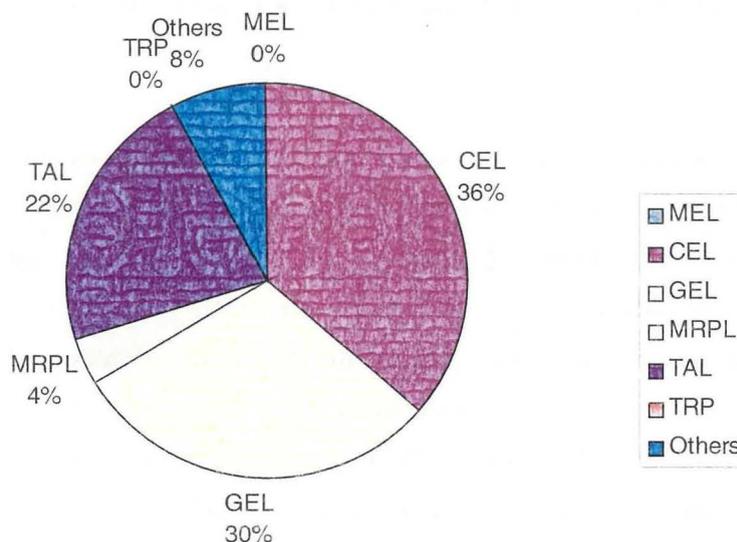
Meridian Energy is presently exploring the option of a new series of power stations on the Lower Waitaki River. This investigation is called Project Aqua. The project is presently at the feasibility analysis stage and is expected to have additional irrigation benefits. The six stations are expected to have a total capacity of 570MW and are likely to generate approximately 3200GWh per year.

## **14.2 Comparative assessment of electricity generators climate change policy risk**

Depending on the method used to generate electricity each New Zealand electricity company has a different level of exposure to risk associated with the outcomes of climate change policy which focusses on incorporating the external environmental costs of fossil fuel use. For those companies, such as Meridian Energy, which only utilise renewable energy resources there may even be benefits. This all depends on the level of a company's GHG emissions and the policy mechanisms that are selected.

The level of risk that electricity generation companies are exposed to, assuming the risk is directly commensurate with 1999 GHG emission levels, is shown graphically in Figure 14-1. The MRET Tool was used to generate this data.

**Figure 14-1: Climate change policy risk for New Zealand electricity companies based on 1999 carbno emissions**



(Key: MEL = Meridian Energy Ltd, CEL = Contact Energy Ltd, GEL = Genesis Energy Ltd, MRPL = Mighty River Power Ltd, TAL = Transalta Ltd (now NGC), TRP = TrustPower Ltd., Others = Others)

This graph shows that Meridian Energy has no risk due to its production being 100% renewable and Contact and Genesis are most exposed to climate change policy risk. These proportions will change each year depending on the levels of inflows into hydro catchments and rivers and other supply issues, such as outages of various plants and demand issues such as magnitude and location of demand.

Depending on a company’s present renewable energy profile, different mechanisms are required to drive changes in behaviour. Meridian Energy, for example, requires incentives to build additional renewable generation if these options are not otherwise cost effective. Thermal generators will require a cap on emissions to drive energy efficiency and emission reduction behaviour.

Any consideration by Meridian Energy of the potential impact of climate change policy needs to consider both the effect on its business and also the potential effect on the businesses of its main customers. The most significant of these is the New Zealand Aluminium Smelter (commonly known as Comalco), Meridian Energy’s largest customer. Electricity is one of its largest production costs and any policy limiting the emission of SF<sub>6</sub>, which is a by-product of its process and has the highest global warming potential of any of the GHGs, would significantly affect its business. Comalco, as part of the Rio Tinto group, has been well aware of these issues for over a decade. It has decreased its emissions by approximately 33% since

1990 (Robertson, 2001) so it may actually be in a position to sell credits depending on the AAU allocation methodology that the government implements. As Comalco has a climate change policy strategy in place it will not be considered further in this work. Opportunities that Meridian Energy and Meridian Solutions may have to assist smaller customers mitigate climate change impacts will be highlighted.

### **14.3 The physical impacts of climate change on Meridian Energy's business**

Meridian Energy's electricity generation business is completely weather dependant so its physical climate change risk is higher than most other electricity companies in New Zealand. This may be countered by the fact that climate change policy could provide it with a greater opportunity than most other electricity companies as discussed later in this chapter.

Meridian Energy's physical climate change risk is due to the impact on demand if the weather is particularly hot in summer or cold in winter and the dependence on the elements to drive Meridian Energy's generation stations. For this reason it is prudent for the organisation to adopt the precautionary principle and develop strategies for managing climate change risk.

At this point the impact of climate change on electricity demand is not incorporated into Meridian Energy's forecasts as the potential 6% decrease in demand over 100 years (MfE, 2001) is insignificant in comparison with the approximate 2% annual increase in demand that is the presently accepted forecast. These models are always under review so any significant changes will be incorporated in the future. If the energy efficiency measures within the NEECS strategy are effective and meet their objective of reducing consumer energy demand by an additional 1% per year then this could impact on the forecasts. Meridian Energy intends to keep a watching brief on these issues. The energy efficiency mechanisms that have been suggested in the draft NEECS are not expected to have a significant impact on Meridian Energy in the short term.

The impact of climate on the generation side of the business is carefully considered. Meridian Energy has a full-time hydrologist who supports the electricity trading team by providing information on expectations for precipitation, hydro storage lake inflows and water management. At present this information is forecast based on historical information combined with short term climate and weather forecasts. The inflow expectations allow a value for water to be calculated which contributes to the optimisation of generation and storage lake levels. Meridian Energy uses the expert knowledge and information management practices that are available in organisations such as NIWA to supplement the in-house expertise.

If adverse weather conditions continue to increase then hydro-electricity systems may need to be managed more conservatively. Systems are in place within Meridian Energy to manage potential flood conditions due to heavy inflows. There are also systems to control the impacts and risks associated with dry year events. Presently it is considered that a dry year will occur approximately every eight years.

2001 has illustrated the dry year risk associated with being dependent on one fuel source which is controlled by the weather. Dry years also have a negative impact on New Zealand's GHG emissions due to the increased use of thermal generating plant to cover for the reduced availability of hydro generation resource.

This dry year risk can be mitigated in several ways:

1. Ensure that contracted electricity sales position is so low that existing hydro generation can meet the demand even during a dry year. However this increases exposure to revenue risk in normal and wet years when wholesale market prices are lower.
2. Ensure all resources are used as efficiently as possible i.e. multiple use of the same water as on the Waitaki system, Project Aqua will further increase the usage factor.
3. Diversify. Having a hydro generation base gives a great deal of flexibility as the storage lakes can operate as a form of pre-generation battery. Meridian Energy has approximately 3 months storage in its lakes when they are full. Most other renewable energy options are complementary to hydro. For example wind generation can be utilised when the wind is blowing, and hydro used when it is not. Wind is therefore one "hydro firming" option, others include biomass generation plant, which often have variable generation patterns due to access to raw materials<sup>39</sup> and geothermal plants, which tend to operate as base load so hydro assets can support it by offering peaking load options.

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The management of dry year risk within the wholesale electricity markets is still being considered in the wake of the winter of 2001.

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<sup>39</sup> Seasonal access to fuel can be dealt with in a number of ways such as multi fuel use.

## **14.4 Recent Meridian Energy initiatives that impact on climate change**

Meridian Energy is involved in various renewable energy and energy efficiency initiatives on both the demand and supply side that reduce the impact of energy use on the environment.

### ***14.4.1 Recent renewable energy initiatives***

Meridian Energy's recent renewable energy initiatives include:

- Purchasing Power Facilities Pty, the largest private producer of renewable energy in New South Wales, Australia. Meridian Energy Australia Pty Ltd now owns and operates hydro power generation facilities on five irrigation dams in NSW and Victoria. These are entitled to RECs which will assist Australia in meeting its MRET. Meridian Energy has a real understanding of the impact that this system has on energy project economics and so has a particular interest in seeing a similar system appropriately implemented in New Zealand. Further information about the policy that impacts on the electricity sector in Australia and specifically renewable energy initiatives is provided in Appendix 33;
- Establishing a business unit, Meridian Solutions whose objective is to develop energy services opportunities with industrial, commercial and institutional customers:
  - This includes consultancy services and investment in energy centres, and other energy related equipment, providing energy on a sustainable and where possible renewable basis with a strong focus on energy efficiency and operational excellence; and
  - Its first major investment is at Blue Mountain Lumber's site in South Otago which consists of a 10MW thermal boiler, fuelled by sawmill waste (principally pine sawdust, shavings and other wood wastes), supplying steam to timber drying kilns and also generating electricity from a 1.6MWe steam turbine. This development is neutral from a greenhouse gas perspective.
- Announced Project Aqua – a proposal to develop the Lower Waitaki River for joint irrigation and hydro generation.

### ***14.4.2 Recent demand and supply side energy efficiency initiatives***

Meridian Energy's supply side energy efficiency initiatives include:

- Second Manapouri tailrace tunnel is an energy efficiency project that will increase the output of the Manapouri station from 585MW to 760 MW, producing enough electricity to supply an additional 64,000 households (640 GWh);
- The replacement of runners at Aviemore power station, is expected to result in an efficiency gain of 45 GWh. This would also be considered a renewable energy project;

- The Automation and Remote Control (ARC) project to assist with optimisation and to coordinate more efficient dispatch. This is expected to increase the efficiency of operations by about 1%, an extra 125 GWh of electricity; and
- The investments in Superlink, inherited from ECNZ. If this super-conductor technology is used for transmission purposes it has the capacity for significant efficiency improvements;

The hydro-efficiency projects are discussed further in Section 14.4.4.

Meridian Energy's demand side energy efficiency initiatives include:

- Providing an energy efficiency advisory service through its call centre for residential customers;
- Energy efficiency related retail acquisition offers (e.g. an offer to customers of Smiths City that involves a \$50 voucher to be spent on electric heaters or hot-water cylinder wraps or blankets in Christchurch);
- Working with end users to develop demand interruption contracts that provide additional reserve for the North Island which in turn facilitate greater access to South Island renewable energy and higher utilisation of high efficiency single shaft gas turbines;
- Small positional investment in:
  - WhisperTech, the Christchurch based developer of a 0.4kw and 1kW residential scale combined heat and power unit; and
  - N<sup>th</sup>Power, a venture capital fund in the United States very active in investing in a wide range of end use and supply technologies; and
  - Investment in Ceramic Fuel Cells Limited, inherited from ECNZ – this technology has a high thermal efficiency conversion factor.

During the winter of 2001 encouraging demand side energy conservation was an important part of Meridian Energy's response to the potential power crisis. It offered incentives to domestic customers and developed existing and new relationships with organisations that were able to control their demand either by:

- changing time of peak use,
- reducing demand, or
- by utilising on-site energy centres (that tended to be fossil fuel based and hence generated GHG emissions) to contribute power to the grid.

Despite the fact that the electricity crisis was avoided these relationships are still being explored to assess the best ways to prepare for such an occurrence arise in the future such as through innovative hedge mechanisms.

### ***14.4.3 Meridian Energy's Sustainability Report***

Meridian Energy publishes a Sustainability Report as a companion document to the Annual Report. The 2000-2001 report will contain a carbon footprint exercise carried out by Landcare Ltd using the EBEX 21 system (Landcare, 2001). This has been used to assess the CO<sub>2</sub> produced from Meridian Energy's corporate activities such as running offices and travel between sites.

### ***14.4.4 Meridian Energy's Voluntary Agreement reporting obligations***

Meridian Energy agreed in 1998 to report on the incremental greenhouse gas reduction impact of the three hydro asset upgrade projects mentioned above, which were included in a 1995 Voluntary Agreement (VA) between the Electricity Corporation of New Zealand and the New Zealand Government. The greenhouse gas reductions from these projects were expected to be 181.1 ktCO<sub>2</sub>/year based on agreed ECNZ calculation methods. 41.2% of this target had been achieved to the beginning of the 2001/2 financial year, however the target had not been met prior to the completion of the agreement in 2000.

The ECNZ VA agreement used a CO<sub>2</sub> offset figure or emission factor of 587tCO<sub>2</sub>/GWh for the three South Island hydro efficiency projects. It should be noted that this emission factor used to calculate the CO<sub>2</sub> emission reductions in the VA reports and reported in Meridian Energy's Sustainability Report is now deemed inaccurate. This is due to the developments in New Zealand's electricity market since the reforms noted in Appendix 6. Meridian Energy is involved in work to develop a more appropriate emission factor, as discussed further in Section 14.6.4.

The three projects in the VA have now been completed and are outlined below.

- *Aviemoire Power Station Re-running.*  
The Aviemoire re-running project involved retro-fitting the turbines with new high efficiency runners. The peak efficiency of the re-runnered turbines is significantly higher than the previous turbine design, and has resulted in an annual generation gain of 127 GWh based on data to July, 2001. This corresponds to an emission reduction of 75ktCO<sub>2</sub>/yr based on ECNZ's historic emission factor.
- *Waitaki Automation and Remote Control (ARC) Project.*  
The new automatic control equipment enables an optimisation system to co-ordinate a more efficient dispatch of generation within Waitaki Valley Stations. The ARC project involved upgrading the generation plant control equipment and the remote operation of all stations in the Waitaki Valley.

The physical work was completed in 2000. The final optimisation software has now passed testing stages (as at June 2001) and is being deployed. The increase in efficiency post deployment is still to be assessed with the results likely to be available in 2002.

- *Manapouri Second Tailrace Tunnel (2MTT) Project.*

The Manapouri Power Station output has been limited to 585 MW despite a higher design capacity because of higher than anticipated friction in the tailrace tunnel reducing the potential hydraulic head by about 30m. The additional 640GWh of additional generation by building a second tailrace tunnel is expected to reduce CO<sub>2</sub> emissions by about 376kt/CO<sub>2</sub>.

As at the end of 2001 the 2MTT project was approximately 70% complete with 89% of the tunnel excavated and the plug removed from between Tunnels 1 & 2. The second tailrace is expected to come into operation in the second quarter of 2002. The specific efficiency gain will be assessed at the end of the project.

Further generic details of the VA programme and methodologies are discussed in Appendix 9.

#### **14.5 Meridian Energy's strengths, weaknesses, opportunities and threats (SWOT) relating to climate change policy**

This analysis is carried out in the present climate change policy context which includes:

1. A pending NEECS (by 1<sup>st</sup> October 2001) which is likely to contain cross-sectoral mechanisms to achieve:
  - A 20% improvement in economy wide energy efficiency by 2012 and
  - An increase in renewable energy supply, by a yet to be specified amount, by 2012.
2. The government's continued commitment to ratify the Kyoto Protocol by September 2002.
3. Negotiated Greenhouse Agreements that may encompass both greenhouse gas reductions and energy efficiency targets between government and industry and which are likely to be in place until at least 2008.
4. The government is yet to decide how to pass down the responsibility for New Zealand's Kyoto commitments or sink credits.

5. Kyoto Protocol target if it enters into force. This requires decisions to be made on the point of obligation of targets and the possible allocation of New Zealand's AAUs. It has stated that it will attempt to achieve broad sectoral involvement and that the sink credits generated by forests planted after 1990 will not be used to shield other sectors from the need to reduce emissions. Those with responsibilities will have two main choices with regards to methods of meeting targets:
  - On-site emission reductions to the level of the obligation; or
  - Purchasing the right to emit above this level using emissions trading, for which there is already an international market emerging. Opportunities exist in this market for project based credits from emission reduction projects including renewable energy, energy efficiency and fuel switching type projects. In the near future the rules for CDM projects are likely to be sufficient to allow CERs to be generated from such projects in developing countries. Forward trading around JI type of projects between industrialised countries are likely to increase over time. These types of projects were explained in Section 4.4.
  
6. Possible carbon tax or carbon charge that could be imposed based on the recommendations of the Taxation Review. This will be part of the manifestos of political parties at the next election (probably late 2002) and so is unlikely to be implemented prior to 2003.

## SWOT ANALYSIS

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#### **14.6 Key success factors for maximising opportunities and minimising threats**

The following are key success factors to ensure that Meridian Energy sees maximum value from its strengths and opportunities and minimises the risk associated with the company's weaknesses and threats. These issues will be dealt with by:

- Contributing to appropriate climate change policy development with an emphasis on encouraging beneficial property right allocation associated with emission reduction activities (such as renewable energy projects).
- Contributing to the development of the renewable energy target and mechanism recommended in the draft NEECS.
- Ensuring systems are in place to quantify emission reduction benefits from projects using a methodology that will be acceptable to possible trading or commitment counter-parties.
- Maximising emission rights e.g. ensuring that the emission factor used to calculate emission reductions from projects is appropriate (and preferably high).
- Explore emission reduction trading opportunities.
- Participate in the development of an Heads of Agreement for a NGA with government which could include concepts such as a pilot JI project.

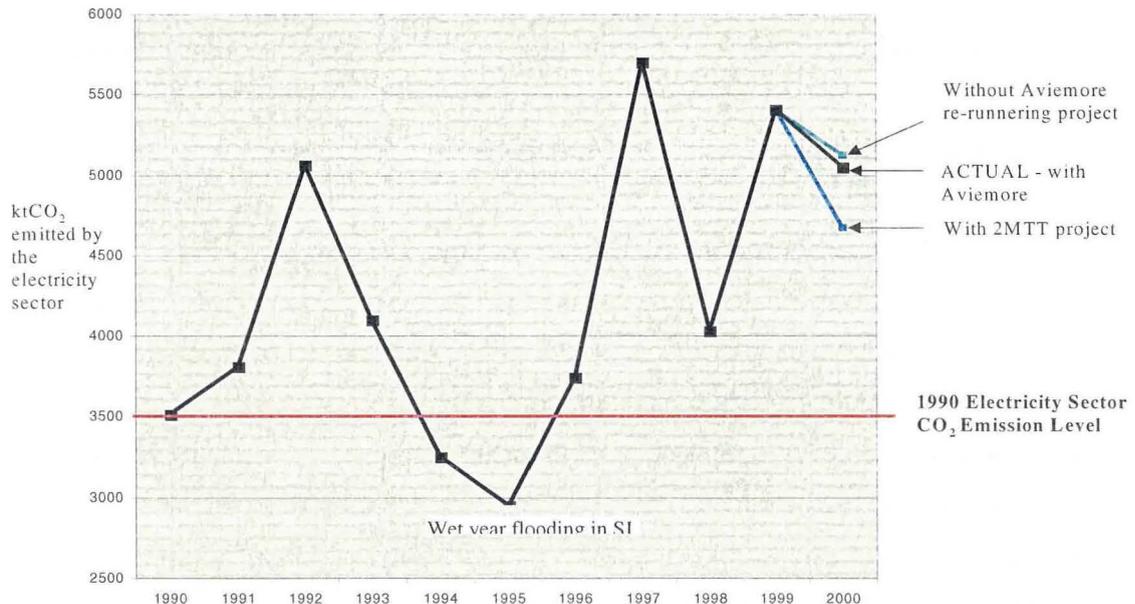
### 14.6.1 *Contribute to policy development with an emphasis on the allocation of emission reduction property rights to renewable energy projects*

Three of the most important issues in the domestic policy environment from Meridian Energy's perspective are:

1. the definition of renewable energy (Section 14.6.2);
2. the allocation of emission reduction property rights to renewable energy projects. These will be tradeable in the emerging carbon market;
3. the requirement that policy ensures that the emission reduction credits are allocated to the investor in the emission reduction activity.

In order for officials to decide to allocate emission reduction property rights to renewable energy projects they need to be aware of the impact that renewable energy projects make on New Zealand's emission profile. Figure 14-2 shows the contribution of the Aviemore and 2MTT projects described above.

**Figure 14-2: Contribution of renewable energy projects to New Zealand's emission profile**



This contribution needs to be recognised with the allocation of a property right. This is important because most renewable energy projects are uneconomic in the current market that does not reflect the social cost of the environmental externality associated with the electricity generation from CCGTs which are the most economic new generation option at present. This allocation will act towards internalising this cost and drive investors towards making decisions that support the Government's Kyoto Protocol commitments.

The requirement that policy ensures that emission reduction credits are allocated to the investor in the emission reduction activity will involve careful policy design. The issue can be illustrated with an example. Meridian Energy invests in a wind farm which reduces New Zealand's GHG emissions. As the investor in the project which leads to the emission reductions, Meridian Energy should receive any associated emission reduction credits. However the reduction in emissions will occur within another organisation such as Genesis as the owner of Huntly Power Station whose emissions are reduced by default due to Meridian Energy's investment in the wind farm. Genesis should not earn credits from the investment of Meridian Energy however this could occur if Huntly was a point of obligation and if allocation of AAUs was on a historical emission basis. This would mean that Genesis would be able to utilise, and perhaps sell, the excess AAUs due to the reduction in emissions caused by Meridian Energy's wind project. It is important that the emission reduction market and the electricity market are separated.

In order to contribute in a focussed way to the policy discussions Meridian Energy requires an overriding philosophy with regards to climate change. This is still under development within the organisation but the following philosophy was utilised in responding to the draft NEECS.

1. There should be a *whole of Government approach*<sup>40</sup> to developing renewable energy policy in this area as illustrated in Figure 14-3.
2. CO<sub>2</sub> emissions should be reduced at the *lowest cost* possible – this principle is inherent in the Flexibility Mechanisms contained in the Kyoto Protocol. Domestic JI i.e. unilateral JI projects should be considered to enable projects to be carried out that have an emission reduction benefit to New Zealand with the AAUs kept within New Zealand.

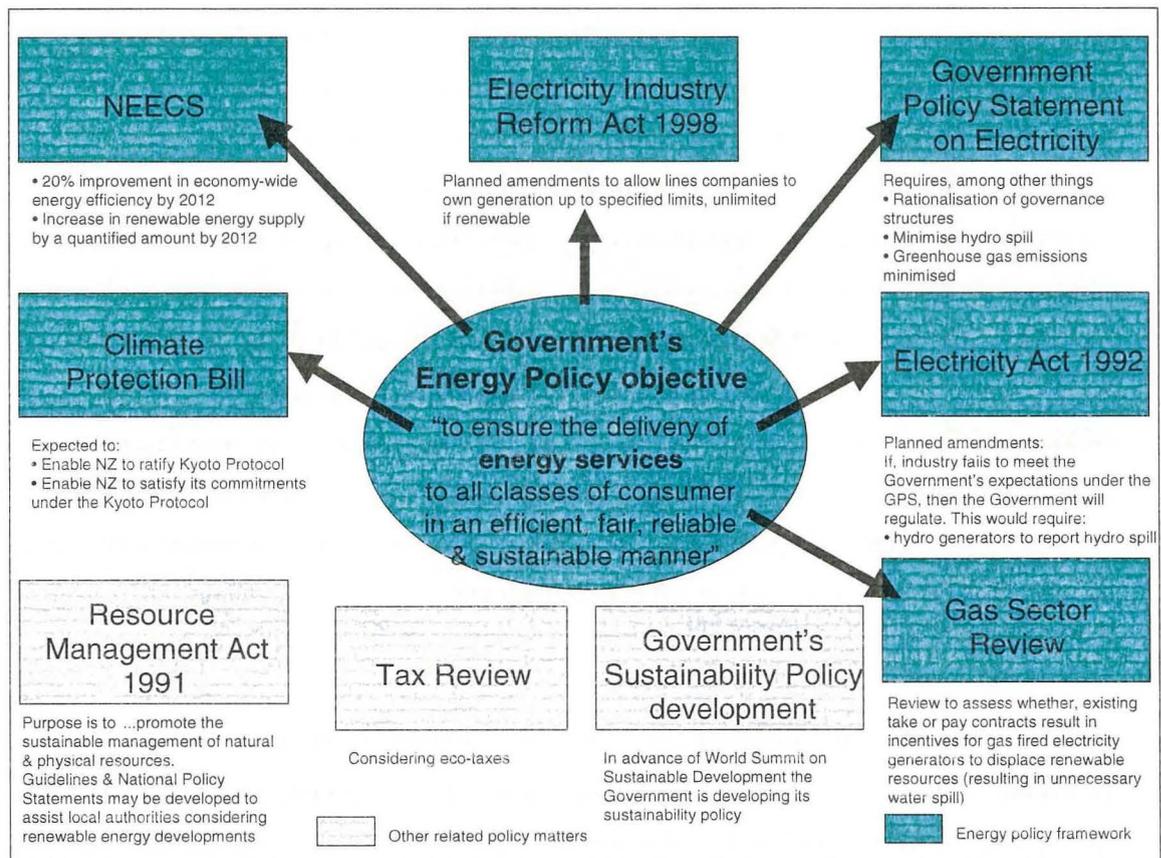
It is important to note that CO<sub>2</sub> emissions from the electricity sector can only be reduced by reducing fossil fuel burn. Incentivising renewable energy investment without reducing fossil fuel burn can only mitigate future increases in CO<sub>2</sub> emissions. This suggests a mechanism that “pushes down” CO<sub>2</sub> emissions and “pulls up” investment in renewable energy may be appropriate.

3. There should be a *gradual transition path* to prevent sudden shocks to industry and the economy. This suggests a transparent phasing of implementation measures.

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<sup>40</sup> This approach has recently been endorsed by the Controller and Auditor General in his report, “Meeting International Environmental Obligations”, April 2001.

**Figure 14-3: Whole of government approach**



(Source: MEL, 2001)

4. Industry, business and communities should understand any exposure to energy efficiency, and climate change policies. This suggests a legislative basis for phased implementation is essential. It is also essential that policy ensures that investors in renewable energy and energy efficiency projects see any financial benefit associated with emission reductions – not a third party.
5. Implementation measures should encourage both demand and supply sides of the economy to take cost effective steps towards energy efficiency improvements and increasing the proportion of electricity generated by renewable energy sources. This suggests an appropriate mix of incentives and punitive measures i.e. "carrots and sticks".
6. There should be efficient price signals with externalities internalised in prices. This suggests the price of carbon should be reflected in the price of electricity.
7. Experience from overseas should be acknowledged, and lessons learnt. However, mechanisms should not be picked up in their entirety without appropriate modifications taking into account New Zealand's unusual energy profile.

#### *14.6.2 Assist officials with the development of the renewable energy target and mechanisms*

This is an essential stream of work for Meridian Energy as much of its business planning includes a “renewable energy future” that assumes that additional income streams will be available for renewable energy projects. Therefore it is essential that Meridian Energy is involved in any government processes that could impact on this while assessing actions that could be taken to develop this income stream in advance of climate change policy certainty.

One of the most important issues is the definition of renewable energy. Meridian Energy supports the definition laid out in Chapter 10. It is particularly important that large hydro is included in the definition so that it encompasses Project Aqua. The Government has stated that they will not be backing particular technologies therefore none should be excluded however there are concerns about diversity of supply in response to the impact of low lake levels on electricity prices during the winter of 2001.

When defining the scope of what would be included in any mechanism for increasing the supply of renewable energy it is important to consider New Zealand’s existing renewable energy asset base. Any system that is implemented needs to ensure that it does not negatively impact on the efficiency of operations of the existing stock. This could be resolved by including both new and existing renewable energy supply in any mechanism that is implemented. For this reason, the most advantageous of the five MRET scenarios tested in Chapters 11-13, are the mechanisms that return to 1990 levels of renewable energy with prioritisation of existing renewables over thermal generation. Scenarios 2 (1990 RE Levels) and 4 (Hybrid) both had this target level. If it was assumed that Meridian retained a similar proportion of the new renewable generation then Scenario 2 would be the most advantageous to the company as the total amount of renewable energy generation is the highest.

It is likely that measures to increase renewable energy supply will continue to sit within the NEECS strategy. Meridian Energy provided EECA with a comprehensive submission on the draft NEECS in June 2001. This was developed by the Regulatory Strategy Manager and the author with involvement from interested parties throughout the company. Meridian Energy assumed in its submission that the Governments’ major objective in implementing a MRET was to increase the renewable energy supply in order to reduce GHG emissions. The submission was prepared to highlight to government officials the issues that would have a significant impact on Meridian Energy and could affect the ability of a MRET scheme to achieve its apparent objectives. The submission also emphasised the need for clarity with regards to how the objectives of NEECS support the objectives of the Government’s energy

policy. This highlighted the need for a whole of government approach to climate change related issues and the need to develop a system that is appropriate for New Zealand's present unique renewable energy profile.

Meridian Energy indicated its preferred mechanism to increase the supply of renewable energy and provided an insight into what an appropriate supply target would be.

In considering which of the six options for increasing the supply of renewable energy (predominantly considering electricity) it wished to recommend, Meridian Energy considered that it was in its interest to have a system:

- to encourage renewable energy generation and capacity implemented as soon as possible, especially if it encourages the use of both new and existing renewable energy assets. This will mean that Meridian Energy will see either a price benefit or an improvement in the economic feasibility of renewable energy projects that are not presently economically feasible;
- with the lowest transaction costs possible for the country, the industries involved and Meridian Energy particularly. This indicates that a fossil fuel based system would be better than a renewable energy credit type system as there would be no transaction costs for Meridian Energy;
- that the system does not attempt to use the existing market structure to achieve objectives other than those that it was designed to address. The generation of a secondary market is preferable for the short and medium term. In the longer term when the cost of carbon is truly reflected in electricity prices then this will not be required;
- that includes depreciation benefits;
- that is as flexible as possible, to ensure least cost solutions for all participants in the scheme and to enable maximum participation of parties with access to projects that will reduce GHG emissions and increase renewable energy supply;
- which ensures that all stakeholders in the system from government, local government (as the implementers of the RMA) to consumers are aware of the system and its implications including its costs and benefits;
- that generates the capacity required to participate in an emissions trading market as soon as possible. This would be eased if the mechanism had tC or t CO<sub>2</sub>-e as the unit of measurement.

The mechanisms to increase the level of renewable energy supply recommended in Meridian Energy's NEECS submission were:

- a CO<sub>2</sub> emission cap and trade scheme or fossil fuel trading system;
- a low level carbon charge;

- tax based incentives and targeted funds to facilitate investment in renewable energy and distributed generation;
- renewable energy development guidelines under the Resource Management Act 1991 (“RMA”); and
- an information campaign aimed at raising awareness within business and communities of climate change issues.

It was seen that capping CO<sub>2</sub> emissions would have the advantage of:

- incentivising the introduction of more efficient thermal technology;
- allowing New Zealand firms the opportunity to discover the price of carbon on the emerging international market; and
- creating the commodity that will allow New Zealand firms to participate in an international market providing access to least cost abatement opportunities.

Meridian Energy only gave an indicative comment on the level of a target. The company is aware that in setting any target there is a direct trade-off between achieving policy objectives and the cost to the economy. Therefore it is essential that comprehensive economic analysis is carried out during the target selection process.

Meridian Energy did recommend that the target was on a GWh rather than on a MW or % basis. A target of 8,000GWh of “new” renewable generation by 2012 was suggested, as a minimum, based on renewable energy supply covering the shortfall in demand (assuming growth of 2%) if

- CO<sub>2</sub> emissions were capped at 90% of current levels, and
- existing fuels were utilised as efficiently as possible.

If the 20% energy efficiency improvements targeted by the Strategy occur then the energy supply shortfall would decrease to 3,000GWh.

### ***14.6.3 Robust measurement of emission reductions from renewable energy projects***

There are many methodologies available for estimating the GHG emissions from projects, activities, sectors or countries. Quantifying emissions from existing operations allows emission reductions opportunities to be identified and emitting processes managed in an environmentally efficient method.

If Meridian Energy wishes to participate in the carbon market, it is essential that a robust measurement method is used to assess the emission reductions from projects which is transparent, verifiable and acceptable to all parties.

#### *14.6.3.1 Recommended measurement methodology*

Meridian Energy is involved in the Energy Federation of New Zealand project entitled Methodologies for Projects to Reduce Greenhouse Gas Emissions. Participants include representatives from other energy companies and service providers, major users, consultants, EECA and MfE. The expected outcomes of this project include guidelines for companies to measure and report their greenhouse gas emissions and methodologies to assess greenhouse gas savings from projects including;

- renewable energy;
- distributed energy;
- waste heat utilisation;
- energy efficiency improvements; and
- sequestration projects.

It is expected that a new emission factor for the electricity sector will be required to achieve these objectives.

Initially the project will consider the Greenhouse Gas Protocol Initiative (2000) of the World Business Council for Sustainable Development (WBCSD) and World Resource Institutes (WRI). This identifies several key information elements that make a GHG inventory report credible:

- absolute emissions - data for all six GHGs on a tonne basis;
- inventory characteristics – the sources of the gases, basis of reporting (i.e. ownership versus control), baselines, reporting period;
- description of any facilities and/or sources excluded from the inventory;
- summary of the methodologies chosen to estimate the emissions.

Meridian Energy sees this EFNZ forum as an appropriate vehicle for developing a methodology that will have national and international credibility. The methodologies are expected to be completed in 2002. As the guidelines are developed they will possibly be implemented within Meridian Energy. They will also be used to build up a portfolio of possible emission reduction projects that may be used to generate emission reduction credits.

Appendix 34 summarises and provides references for some of the resources available for quantifying greenhouse gas emissions, the focus having been on methods that could be utilised when assessing emissions from energy projects. The Appendix also includes methods ranging in magnitude from assessing national GHG inventories to project based emission quantification methods.

#### *14.6.4 Maximising emissions rights - the value of the Electricity Emission Factor*

The electricity emission factor represents the reduction in emission levels due to the additional value of each GWh generated by renewable energy or energy efficiency measures. It is effectively a conversion factor from GWh to tCO<sub>2</sub> i.e. the unit is tCO<sub>2</sub>/GWh.

A nationally acceptable figure that represents the current market structure does not presently exist. This is seen to be a significant issue by most electricity sector participants and particularly those organisations that are involved in the negotiation of HOAs for NGAs. Meridian Energy's concerns about this issue are being addressed through involvement with the Ministry for the Environment officials who are developing this factor. After the price of carbon, this factor has the most significant effect on the potential value that could be seen from emission reduction projects.

Until an appropriate factor is developed, the VA emission factors are still being used within the industry. All changes in electricity use during the period of the VA would be accounted for at an average marginal thermal electricity generation emission factor of 624 tCO<sub>2</sub>/GWh or 587tCO<sub>2</sub>/GWh for Meridian Energy's South Island stations to take into account line losses. These figures were developed based on base load being offered by hydro stations with the marginal plant being a thermal station. They were based on Huntly using coal and New Plymouth using gas each being the marginal plant 50% of the time. (MoC, 1995).

It is recommended that Meridian Energy continues, in communications to New Zealand Government officials, to use this emission factor despite its inaccuracies until officials implement a new factor. It is in Meridian Energy's interest that this factor is as high as possible.

It is likely that the new emission factor will be lower than the VA figures due to the improved efficiencies (and therefore lower emission intensity) of New Zealand's thermal plants and the fact that the marginal plant is no longer always thermal. One possible factor is 380tCO<sub>2</sub>/GWh which would be appropriate if a standard CCGT was the marginal generation plant of the most cost effective new generation. A coal plant would have a considerably higher emission factor.

$$\text{New Coal (High efficiency 40.0\%)} = 91.2 \frac{(\text{g CO}_2)}{(\text{MJ})} * 9,000 \frac{(\text{kJ})}{(\text{kWh})} = 820.8 (\text{g CO}_2 / \text{kWh})$$

$$\text{New Gas (High efficiency CCGT 50\%)} = 52.8 \frac{(\text{g CO}_2)}{(\text{MJ})} * 7,200 \frac{(\text{kJ})}{(\text{kWh})} = 380.2 (\text{g CO}_2 / \text{kWh})$$

#### *14.6.5 Explore emission reduction trading opportunities*

A carbon market based on emission reductions and carbon sequestration is already operating internationally. This is still a thin emerging market. The market and the value of carbon is discussed in Chapter 5.

In order to participate in this market Meridian Energy requires:

- “something to sell” – i.e. carbon property rights (as discussed in Section 14.6.1);
- “as much of the product as possible” - which will be calculated using an electricity emission factor (as discussed in Section 14.6.4); and
- “a buyer”.

The “buyer” may come from a variety of places:

1. Meridian Energy could enter into contractual agreements to carry out emission reduction projects if these provide the least cost solution to meeting the emission reduction targets of companies that have emission reduction obligations. These could be participants in NGAs in New Zealand, the Greenhouse Challenge in Australia or other schemes throughout the world.
2. There may be a Kyoto hedge type product that could be offered to industry with NGA obligations that assigns renewable energy generation to them so that the electricity they need to account for within their NGAs will have an emission factor of zero.
3. If emission reduction credits are assigned Meridian Energy may be able to attract companies (such as energy companies in Japan) interested in participating in JI type projects. Ideally policy would be set up so investors in JI type projects could be both domestic and international.
4. National programmes are in place in the Netherlands and under development in other countries. For example the ERUPT scheme in the Netherlands purchased credits from countries with economies in transition in a deal in 2000 to assist it with meeting its Kyoto Protocol targets.

The “packaging” of these deals will be important. Relationships are presently being developed with possible trading partners and a registry of projects with GHG abatement details is being developed to assist with this process.

Other trading issues include the possibility of a green electricity market or the use of a trading mechanism relating to a renewable energy certificate. The concept of labelling renewable electricity is presently being explored by Meridian.

#### ***14.6.6 Participate in the development of an HOA for a NGA with government***

While NGAs were originally developed with large emitters in mind it may be possible to discuss an innovative NGA approach to the government that includes energy efficiency and renewable energy projects in return for the allocation of AAUs. This option will be explored further internally and with the government negotiators.

### **14.7 Approach to future climate change policy developments**

As a result of the in-house information dissemination that was carried out as part of this work, Meridian Energy now has board members, a management team and staff in most departments that are aware of the potential impact of climate change policy on the company. Developments in this area are seen as an area of opportunity.

Meridian Energy's Regulatory Strategy Manager will be responsible for ongoing interactions with officials involved with policy development and decision-makers. Assistance will be provided by the Sustainable Energy and Climate Change Advisor (the author). This position has been created in response to the recognition of the value of focus on climate change policy developments and related opportunities.

The Sustainable Energy and Climate Change Advisor is also responsible for identifying and developing climate change and sustainable energy business opportunities in New Zealand, Australia and elsewhere. Examples of this are:

- maximising the potential number of Renewable Energy Certificates that can be earned by Meridian Energy's new Australian hydroelectric plants by assisting to assess the most beneficial generation baseline;
- the development of potential trading partnerships relating to new renewable energy income streams;
- the development of an NGA based product package which requires involvement teams throughout Meridian Energy. The package may include an offer of electricity (potentially labelled as "green"); an energy and/or GHG abatement opportunity audit; a partnership approach to the negotiation and fulfilment of NGAs with government; and the potential for customer involvement in Meridian Energy renewable energy or energy

efficiency projects that offer a least cost solution to the customer's GHG reduction commitments.

Each energy efficiency project or renewable energy project in which Meridian Energy or Meridian Solutions invests in the future will contribute to New Zealand's goal of reducing and minimising GHG emissions. It will be an important part of the role of the Advisor to keep this issue in officials' minds and ensure that policy mechanisms are put in place that recognise the investors in these projects.

As policy drives organisations to recognise that they are operating in a more carbon constrained world it will become increasingly evident that when generating renewable electricity, more than one income stream is potentially available. Meridian Energy is now poised to explore and maximise these opportunities.

## Chapter 15

### Summary and conclusions

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#### 15.1 Summary

**Objective One: To understand the environmental, economic and political issues associated with the development of the Kyoto Protocol as an international response to climate change**

##### *15.1.1 The science and global implications of climate change*

Greenhouse gases represent about 0.1% of the atmosphere and play an essential role in maintaining the conditions required for life on earth. The main GHGs, in order of environmental significance, are CO<sub>2</sub>, CH<sub>4</sub>, NO<sub>2</sub>, PFCs, HFCs and SF<sub>6</sub><sup>41</sup>. These gases reduce the amount of solar heat that would otherwise be radiated back out into space leading to the enhanced greenhouse effect (commonly known as the greenhouse effect) which is resulting in climate change.

Records show that the climate is changing. Some of this may be due to natural climatic cycles but human activity is altering the composition of the global atmosphere which also impacts on the climate. The burning of fossil fuels and agricultural and industrial practices lead to GHGs being released into the atmosphere at a faster rate than would otherwise occur. CO<sub>2</sub> concentrations alone are expected to increase by up to 250% over pre-industrial levels by 2100.

The IPCC (2001) has found that there is new and stronger evidence that most of the observed warming of the past 50 years is attributable to human activities (IPCC I, 2001).

Indications of climate change include: the 1990's being the warmest decade of the last one thousand years (MfE, 2001); the global mean sea level estimated to have risen between 10 and 20 cm in the last 100 years; and rainfall patterns have changed with more heavy precipitation events occurring.

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<sup>41</sup> The level of uncertainty associated with the estimation of these global GHG emission range from +/- 5% for CO<sub>2</sub> up to +/-50% for CH<sub>4</sub>.

In the future climate change is expected to cause:

- the arid and semi-arid areas of Southern Africa, the Middle East, Southern Europe and Australia to become more water stressed while more water may be available in South East Asia;
- decreased agricultural production in many tropical and sub-tropical countries while production may increase in mid-latitude regions;
- increased deaths from heat stress and vector borne diseases such as malaria and dengue fever while winter mortality may decrease in other areas;
- displacement of tens of millions of people due to floods and rising sea levels;
- and changes to the function of ecological systems such as coral reefs and forests.

If emissions rise at their current rate, the Earth's mean temperature is expected to increase by between 1.4 and 5.8°C and the average sea level will have risen by between 9 and 88cm by the year 2100. Precipitation patterns are expected to change and more extreme weather events are expected to occur (IPCC I, 2001).

Climate change is a global problem as one tonne of GHG emitted anywhere in the world has the same impact on the atmosphere. However the impact is different from one region to another. To date, developed countries have been responsible for most anthropogenic GHGs due to their increased level of industrialisation and intensive agricultural techniques, however the negative impact on developing countries may be larger and they are less equipped to adapt.

### ***15.1.2 The Kyoto Protocol***

The most significant climate change policy progress to date has been the development of the Kyoto Protocol to the UNFCCC. The Kyoto Protocol's objective is to stabilise GHG concentrations at a level that would prevent dangerous anthropogenic interference with the climate system. It was developed by representatives of 186 countries at a series of meetings called the Conference of Parties (COP), adopted in 1997, and signed by 84 parties (i.e. countries).

Within the Kyoto Protocol, 38 industrialised countries agreed to collectively reduce the emissions of six key GHGs to 5.2% below their 1990 emission levels on average between 2008 and 2012. By July 2000, it had been ratified by 33 developing and 1 industrialised country. However to enter into force 55 countries representing 55% of the emissions from industrialised countries must ratify it. In order for a country to ratify, it must have domestic

policies, regulations and legislation in place that will allow it to meet its commitments under the Protocol.

Industrialised and developing countries have different commitments under the Protocol, all are required to have inventories of their GHG emissions and forest sinks but only industrialised countries have emission reduction targets which vary following negotiations depending on their national situation.

If countries emit more than their targets they must take responsibility for excess emissions by using the Flexibility Mechanisms. The Flexibility Mechanisms include:

- Joint Implementation (JI) where an industrialised country invests in an emission reduction project in another industrialised country and acquires credits from that country called emission reduction units (ERUs);
- Clean Development Mechanism (CDM) where an industrialised country invests in an emission reduction project in a developing country in return for credits created by the CDM Executive Board called certified emission reductions (CERs);
- Carbon sinks, such as forests planted after 1990, absorb carbon from the atmosphere and generate “sink credits”; and
- Emissions Trading (ET) where an industrialised country purchases credits (Allocated Amount Units or AAUs) from another country or organisation which has reduced its emissions.

AAUs, ERUs, CERs and sink credits are commonly all known as “credits”.

Since its development in 1997, the Kyoto Protocol has become more important as a political tool rather than an environmental one. While its present environmental impact is negligible it does put processes and systems in place that allow for more significant progress in the future. It can be expected that emission targets will be tightened over time and will also incorporate developing countries in some way. The cost of carbon or the cost of the environmental externality associated with the impact of GHG emissions on the environment, will become reflected in prices of goods and services and the world will become increasingly GHG emission constrained (some refer to this as carbon constrained).

In March 2001, the USA, whose emissions represent 36% of the total emissions from industrialised countries, pulled out of the international negotiations after announcing the Kyoto Protocol “fatally flawed”. Despite the US withdrawal, the Bonn Agreement was developed in July 2001 at COP6.5 providing sufficient information and certainty to industrialised countries to allow the ratification of the Kyoto Protocol.

Though the entering into force (or ratification) of the Kyoto Protocol is not definite, reaching the stage of 55 countries ratifying is highly achievable as many developing countries see the Kyoto Protocol as an important risk management and sustainable development tool. The challenge will be ensuring that those countries represent 55% of the 1990 CO<sub>2</sub> emissions from the UNFCCC's Annex I i.e. the industrialised countries.

There is a strong likelihood that the EU (25% of total industrialised countries 1990 emissions), Russia (17.4%) and Canada (3.3 %) will ratify, possibly as early as at the Rio + 10 Earth Summit in Johannesburg in September 2002. Japan (8.5%) plans to finalise its ratification position in January 2002, which could lead to the entry into force of the Kyoto Protocol as early as 2002 despite the US withdrawal.

### *15.1.3 Carbon Markets*

The Flexibility Mechanisms will drive the development of an international emissions trading market which allows companies to find least cost solutions to emission reduction objectives. Studies carried out prior to the US withdrawal from the Protocol indicated that the NPV of meeting the global emission reduction commitments was less than NZ\$21/ tCO<sub>2</sub>-e. The market value was expected to be around NZ\$70 – 85 billion if the Flexibility Mechanisms were used and industrialised and developing countries were included. The US withdrawal has decreased the international price of carbon as they were expected to have been one of the largest buyers of GHG emissions.

Whether the Protocol becomes operational or not there is already an emerging market for emission reductions that is likely to grow based on organisations' desire to mitigate future risk associated with the Kyoto Protocol or to take early mover opportunities.

A review and analysis of the emerging international GHG market (Natsource, 2001) found that approximately 60 inter-company transactions, involving 55 million tonnes of CO<sub>2</sub>-e had taken place up until August 2001. The nominal prices range from New Zealand \$1.20 – \$20 per tonne since trading started in about 1996.

**Objective Two: To focus the research on New Zealand, it's GHG emissions and consider the impacts of climate change and policy relating to the electricity sector**

*15.1.4 New Zealand's GHGs, the effect of climate change and its Kyoto Protocol commitments*

Climate change is a particularly important issue to New Zealand as agriculture and tourism are two of its major industries, almost 70% of its electricity is generated from hydro power, all of which will be affected by the weather because of and biosecurity issues that climate change could cause.

New Zealand's dependence on primary industries also contributes to its unusual emission profile leading to the highest proportion of non CO<sub>2</sub> emissions of any country. Most of New Zealand's 1990 GHG emissions were from the agricultural sector namely cattle and sheep CH<sub>4</sub> emissions (46% of total emissions) and the use of nitrogen fertiliser producing NO<sub>2</sub> (19% of total emissions) while CO<sub>2</sub> emissions only represent 32% of total emissions.

Although New Zealand's emissions only represent around 0.2% of the total emissions from industrial countries, this represents the fifth highest per capita emission rate in the world.

New Zealand's total GHG emissions in 1990 were approximately 75.4MtCO<sub>2</sub>-e which will be the amount of Assigned Amount Units (AAUs) that New Zealand will be given, these are effectively rights to emit to that level. During the 2008 to 2012 Kyoto commitment period, New Zealand's emissions are forecast to exceed this by 34MtCO<sub>2</sub>-e. Forest sinks planted after 1990 will make a significant contribution to reducing the excess position by absorbing about 130MtCO<sub>2</sub>-e and actually put New Zealand in a position of being a net seller of approximately 96MtCO<sub>2</sub>-e credits. However the government has stated that the sink credits will not be used to shield any other sector from reducing emissions, and it is committed to an equitable sharing of the burden to reduce emissions.

The major impacts of climate change in New Zealand include

- changes in the weather;
  - changes in the severity and frequency of climate extremes;
  - changes in rainfall – with decreases on the East Coast and increases elsewhere;
  - changing wind patterns and strength;
  - decrease in South Island snow storage;
  - potential temperature rises of between 0.7°C and 3.1°C over the next 100 years.

- changes in bio-security issues that could impact on human and animal health;
  - possible proliferation of pests and vector borne diseases;
  - changes on agriculture and forestry production due to increased temperatures and CO<sub>2</sub> levels;
  - illnesses related to low winter temperatures could decrease and heat stress illnesses could increase;
  - rising sea levels could increase the salinity of some inland water sources.

#### ***15.1.5 New Zealand's Kyoto Protocol commitment and GHG reduction options***

In August 2001, the New Zealand government reiterated that it plans to ratify the Kyoto Protocol in September 2002. In order for New Zealand to ratify it needs to implement domestic policy to allow it to meet its Kyoto Protocol commitments after considering the economic impact of ratification by carrying out a National Impact Analysis. However New Zealand will only be required to meet its commitment if the Protocol enters into force.

When the Kyoto Protocol does enter into force New Zealand will be committed to reducing its GHG emissions back to 1990 levels (approximately 75.4MtCO<sub>2</sub>-e), on average between 2008 – 2012, or to “take responsibility” for any excess emissions. It can “take responsibility” this by purchasing “carbon credits” which could be:

- AAUs from other countries through ET;
- ERUs from JI projects;
- CERs from CDM projects; or
- sink credits which have either been purchased offshore or created in New Zealand e.g. by forests planted after 1990.

It is likely that New Zealand will meet its Kyoto Protocol obligations for the first commitment period largely due to the absorption of CO<sub>2</sub> by forests planted after 1990. However in later periods changes in behaviour or processes need to occur to reduce emissions onshore or the co-operative Flexibility Mechanisms will be required.

Two of the challenges the New Zealand Government faces is New Zealand's high level of ruminant CH<sub>4</sub> emissions and the significant growth in transport CO<sub>2</sub> emissions since 1990. Many policies are under consideration to address these issues. However this thesis concentrates on the policies impacting on the electricity sector.

### *15.1.6 The electricity sector's GHGs and the effect of climate change*

In New Zealand the transport and electricity sector emissions have increased significantly since 1990. The electricity sector's CO<sub>2</sub> emissions have increased by 19%, on a gross basis from 1990 to 1999 due to a 50% increase in thermal generation over the same period. CO<sub>2</sub> emissions represent over 99.7% of the electricity sector emissions. The sector has undergone considerable reform during this period and is still in a state of flux and is exposed to climate change risk due to its high dependence on the weather, which impacts on the demand and supply side.

According to the IPCC (1997) some of the potential impacts of climate change on the electricity sector include:

- slight levelling of seasonal demand variations due to lower heating requirements in the winter and more air conditioning requirements in the summer;
- method of controlling the hydro lakes could alter due to increased variability in storage lake inflows;
- increased river temperatures could decrease their capacity to cool thermal generating plants;
- transmission losses and line sag increase with higher ambient temperatures.

The electricity sector emitted about 3.5MtCO<sub>2</sub> in 1990 and about 5MtCO<sub>2</sub> in 1999 (MED, 2000), which is expected to increase to 7Mt by 2010. This trend is likely to continue as CCGTs are the most economic new electricity generation option. Policy will be required to ensure that the environmental externalities associated with the use of fossil fuels is reflected in energy pricing, improving the economics of renewable energy electricity generation options to a level that may make them competitive with thermal options.

The overriding electricity policy objective is to ensure that electricity is delivered in an efficient, fair, reliable and environmentally sustainable manner to all classes of consumers (Hodgson, 2000). The major objectives of climate change policy relating to the electricity sector has not been finalised yet. If the objective is to reduce GHG emissions it should focus on improving the efficiency of existing electricity generation, particularly fossil fuel generation, encouraging fuel switching to lower emitting sources and encouragement of renewable energy supply. The encouragement of renewable energy generation in the electricity sector is a particular focus of this work.

### *15.1.7 New Zealand's climate change policy development*

New Zealand's climate change policy has been under development since about 1990 when New Zealand signed the UNFCCC, with the first policy package released in 1994. It is likely the latest tranche of policy options for consultation and submissions will be released in October or November 2001.

The present Labour Government's existing climate change policy (Hodgson, 2000) is:

- A commitment to pass legislation to enable New Zealand to ratify the Kyoto Protocol on climate change by mid 2002;
- Development of a comprehensive range of policy measures to ensure that New Zealand is able to meet its commitments under the Kyoto Protocol.

The present Labour government's overall objective with respect to the initial Kyoto commitment period is to limit greenhouse gas emissions to ensure achievement of New Zealand's Kyoto Protocol obligations in a manner that demonstrates environmental integrity and leadership while keeping as low as practicable the social and economic costs of measures to achieve those obligations (CBC Min (01), 2001).

Policies that have already been committed that impact on the electricity sector include:

- National Energy Efficiency and Conservation Strategy (NEECS) will be released on the 27<sup>th</sup> September 2001. This will have a strong demand side efficiency focus with a target of a 20% improvement in energy efficiency by 2012. It will also include a renewable energy target to be met by 2012 however the exact target and the mechanism will not be finalised and is to be developed through a consultative process. This may be in the form of a MRET, which is discussed in more detail in 15.1.9 and 15.1.10.
- Negotiated Greenhouse Agreements (NGAs) are presently being developed with the Government and major emitters. NGAs can be used by major emitters to develop certainty with regards to their fiscal exposure to a possible carbon charge or the possible benefits of the allocation of credits in return for assuring the government that they will reduce GHG emissions by a certain amount. The government sees this as a cost effective, efficient method of reducing GHG emissions while reducing the risk and international competitive impacts associated with possible climate change policy and uncertainty for New Zealand's major industries.

- Emissions trading has been announced as an important part of New Zealand's first commitment period response. It is expected that AAUs, CERs and ERUs will be tradable on an equal basis in the GHG trading market.

Other options that could be included in the raft of climate change policies include:

- a carbon charge, which is being considered by the Taxation Review, which will be released in October 2001. However even if a carbon tax is recommended it will not be implemented until 2003 at the earliest and is likely to be low i.e. \$5/tC - \$10/tCO<sub>2</sub>.
- domestic emissions trading, which is a possibility that would provide the opportunity to build the capacity and systems required to be involved in future and emerging international trading markets. It would also provide the opportunity to begin a cost discovery process for carbon and lead to price signals emerging in products that will be affected by the limiting of GHG emissions.
- emission reduction projects, such as renewable energy, energy efficiency or co-generation projects, could generate project based credits that could be sold in over the counter trades to New Zealand NGA parties or international traders prior to the 2008 emission trading system emerging.

The policies are likely to be brought together in a legislative framework such as the Climate Protection Bill. This will need to cover the requirements of ratification of the Kyoto Protocol including the management of effective inventories and registry systems and the provision of the Government with trading rights enabling it to meet its Kyoto Protocol commitments. The other parts of the Bill are likely to lay out the policy mix including the points of obligation (i.e. which entities within the economy will actually have responsibility for managing emissions).

### **Objective Three: To analyse the effectiveness of a mandatory renewable energy target (MRET) for reducing GHG emissions**

A mandatory renewable energy target (MRET) has been identified by policy makers as a possible response to two Government policy objectives:

- reduction of GHG emissions in a least cost manner, which is one of the government's main climate change policy objectives; and
- increasing the level of renewable energy supply, which is one of the New Zealand government's main energy policy objectives.

### ***15.1.8 Renewable Energy Definition***

In order to assess the impact of policies encouraging renewable energy, it is first necessary to scope the definition of renewable energy. There is considerable debate as to whether large hydro should be included. The Resource Management Act has been developed to take into account the environmental impacts of developments - it is the appropriate test of the environmental integrity of a development.

The following definition is from the draft NEECS with provisos added to reflect the views of Meridian Energy and the author:

*Renewable sources of energy are those where the rate of extraction is either equal to or less than the rate of replacement. (EECA, 2001).*

*The provisos are that renewable energy sources include (but are not limited to):*

- a) solar, wind, water, biomass and geothermal (if operated on sustainable basis);*
- b) hydrogen and other energy sources produced exclusively from sources included in (a) above.*

*Renewable energy sources do not include:*

- c) nuclear;<sup>42</sup>*
- d) fossil fuel; and*
- e) Hydrogen and other energy sources produced from fossil fuel.*

### ***15.1.9 Possible mandatory renewable energy target mechanisms***

There are four main methods that could be used to encourage renewable energy supply:

1. Negotiated Agreements are voluntary agreements between electricity sector participants and the Government to increase the level of renewable energy supply.
2. Mandatory Renewables Quotas are a statutory requirement to provide or purchase a minimum proportion or increased volume of renewable energy. There is a threat of a financial penalty if these levels are not met.
3. A guaranteed price option with different prices for different technologies, however this appears to be a very high cost, complicated system.

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<sup>42</sup> While some parties may consider nuclear fuel a renewable fuel the use of it is illegal under the New Zealand Nuclear Free, Disarmament, and Arms Control Act 1987.

4. A system using tradeable fossil fuel electricity generation permits has the advantage of potentially being a carbon based system. This is effectively a domestic emission trading scheme which could act as a pilot and incorporate international trading options.

#### ***15.1.10 Development of the mandatory renewable energy target impact tool***

The MRET Impact Tool (the Tool) was developed to assess the impact of an MRET on the electricity sector and its ability to reduce GHG emissions and increase the level of renewable energy supply. Three steps were involved in developing the Tool:

1. Development of five possible MRET scenarios and a list of the electricity generation plants (plants) that would be required to meet the additional renewable energy generation target each year.
  - i. Business as Usual (BAU) Scenario which was the base case and includes one 400MW CCGT being built in 2004 and another in 2009;
  - ii. 1990 Renewable Energy Level (1990 RE Level) Scenario - a renewable energy target scenario representing a return to the same proportion of renewable energy for electricity generation as existed in 1990 i.e. 81.07%;
  - iii. Present RE Level Scenario - a renewable energy target scenario representing a return to the same proportion of renewable energy that presently exists. The 1999 level of renewable energy is 71.08%<sup>43</sup>;
  - iv. Hybrid 1990 RE levels scenario – this is a hybrid of the first two scenarios with one 400MW CCGT built in 2004 and renewable energy plant being built to regain 1990 renewable energy levels. It also includes the effect of the draft NEECS target of 20% improvement in energy efficiency by 2012;
  - v. Energy Efficiency scenario – this was based on BAU except for an effective 20% improvement in energy efficiency.
2. Simulation of the impact of an MRET on the electricity market by enhancing an existing New Zealand electricity supply and demand model.
3. Conversion of market simulation information into graphs and data useful for discussion of the renewable energy supply, GHG emission levels (CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O) and electricity prices.

In order to verify the Tool, the GHG results were tested against Ministry of Economic Development electricity sector CO<sub>2</sub> emission data and was found to differ by only 0.2%.

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<sup>43</sup> The most recent actual data available has been used which is 1999 data from the MED New Zealand Energy Datafile, 2000.

### *15.1.11 The impacts of five mandatory renewable energy targets scenarios*

The impact of the five scenarios listed above were considered over the 2002 – 2012 period assuming that no other policy impacting the electricity sector was put in place. MRET scenario impact assessment criteria were selected based on the Governments objective of reducing of GHG emissions at the lowest cost possible to the economy. The MRET impact assessment criteria are:

1. the real effect of the target on renewable energy;
2. New Zealand's GHG emissions and emission intensity;
3. the wholesale price of electricity; and
4. the total capital investment to meet the scenario objectives.

Overall the Hybrid scenario was found to be the "best" scenario. The benefits of this scenario are enhanced if existing renewable energy generation supply is prioritised over thermal generation. The prioritisation aspect would be more difficult to implement than the other requirements of the Hybrid Scenario.

The Hybrid requires one 400MW CCGT station and 1613 MW of new renewable energy generation capacity be built and 463MW of less efficient thermal plant be decommissioned during 2002- 2012. This led to the highest level of renewable energy supply with a total of 33,584 GWh (80.3%) renewable energy supply in 2012 compared to business as usual figures of 28,562 GWh (62.57%) renewable energy supply. Emissions would be reduced to 3.6Mt CO<sub>2</sub>-e from the BAU forecast of 7.26Mt CO<sub>2</sub>-e in 2012. This is very close to the electricity sector's 1990 emissions of 3.5Mt CO<sub>2</sub> (MED, 2001). The Hybrid emission national average CO<sub>2</sub> intensity of 87.5ktCO<sub>2</sub>/GWh is 44% lower than the BAU emission intensity. In summary an additional 5022GWh of new renewable electricity will be generated leading to a reduction of 3.66MtCO<sub>2</sub> for a cost of \$2,520 million over BAU.

The marginal cost of the project required to meet the target is \$77.5/MWh. Most of the projects required to meet the target would have marginal costs of between this and \$40/MWh. The implementation of the Hybrid Scenario would require the wholesale electricity price to increase to \$77.5/MWh from the BAU price of around \$40/MWh or for this price differential to be available from a secondary market e.g. a REC market. This would be a more economic approach as it would mean that the marginal price would only be paid for the new renewables not for the entire generation portfolio each half hour. This \$37.5/MWh difference represents the additional income which needs to be guaranteed to enable generators to build renewable energy plant. It indicates the difference between the maximum supply cost and the expected

average wholesale electricity price. Careful design of the system would be required to ensure that the total cost to the market is minimised. Other scenarios have lower costs. It was hoped that a comparison could be made of the total capital cost requirements. However the scenarios were not standardised with respect to excess generation capacity so a comparison is not possible. Based on existing data, it would cost \$2,720 million (2001) dollars more to achieve the results of the Hybrid Scenario than the cost of BAU. However this would need to be clarified taking into account excess capacity levels which have a significant impact on the cost to the economy.

The 1999 RE Level scenario is a much more cost effective option at only \$900 million over the BAU cost and the wholesale electricity price rising to \$55/MW (or \$15/MWh from a secondary market on top of the wholesale electricity price). However it only achieved emission levels of 5.3MT CO<sub>2</sub>-e (compared to expected emission levels of 7MTCO<sub>2</sub>-e) and renewable energy generation levels of 34,264 GWh or 75.1% due to an additional 958MW of renewable energy generation capacity by 2012.

**Objective Four: To apply an understanding of climate change issues to a company case study - Meridian Energy Ltd**

***15.1.12 Meridian Energy Ltd Case Study***

Meridian Energy is New Zealand's largest renewable energy generator with a capacity of 2,332MW and nominal annual generation of 12,050 GWh. It was selected as a case study to assess the physical and policy impacts of climate change on a major generation company in the electricity sector.

Meridian Energy's renewable energy generation plants contribute significantly to New Zealand electricity sector relatively low emission intensity due to the fact that they have zero operating emissions. This is highlighted by the increase in sector emissions in dry years e.g. 1992. At present it is not economically viable to build most new renewable energy power station options. Despite the fact that the fuel is "free", the capital cost of renewable generation technologies is significantly higher (with a long run marginal cost of about \$55/MWh for wind for example) than thermal generation options such as CCGT (whose LRMC is approximately \$43/MWh). Therefore a value incentive such as a MRET would be required to drive the development of renewable energy ahead of thermal generation.

Meridian's major weakness is a lack of a system to measure and assess GHG emissions in all future Meridian Solutions and Meridian Energy projects. It also lacks a strong argument for the allocation of New Zealand's AAUs.

Meridian's major opportunities include the positive impact on the profitability of existing assets if the cost of carbon becomes reflected in the electricity price (i.e. the average wholesale electricity price increased). If the price increased to the level of the LRMC of renewable generation then new renewable energy projects could be developed. There is a possibility of additional income streams from project based credits. A market for "green" electricity and Kyoto hedges (i.e. zero or low emission electricity) could be developed. Value opportunities exist from the NGA process; and opportunities to influence policy to achieve beneficial outcomes.

Meridian's major threats include the definition of renewable energy or policy instruments that exclude large hydro and therefore Project Aqua; the possible negative impact of new renewables (or any new generation) on the supply of existing renewables (which could lead to hydro spill); possible costs associated with taking responsibility for embedded carbon in hydro lake dams if a life cycle approach is taken; the possible reduction in demand if the NEECS energy efficiency targets are met; and the impact of climate change policy on the viability of large customers such as Comalco.

The key success factors for maximising Meridians' opportunities and minimising the threats include making a full and appropriate contribution to climate change policy development particularly in the area of renewable energy target and mechanism development and project based credit instruments; ensuring robust in-house GHG measurement systems are in place for new projects; ensuring that emission rights are maximised by influencing the value of the electricity emission factor and participating in the development of a Heads of Agreement for a NGA with the Government.

In response to the draft NEECS, it was assessed that a fossil fuel trading system would be the most beneficial policy option to encourage the reduction of CO<sub>2</sub> and encourage the building of renewable energy generation. This analysis was summarised in Meridian Energy's submission on the draft NEECS which recommended:

- a CO<sub>2</sub> emission cap and trade scheme or fossil fuel trading system implemented in three stages;
- a low level carbon charge;

- tax based incentives and targeted funds to facilitate investment in renewable energy and distributed generation;
- renewable energy development guidelines under the Resource Management Act 1991 (“RMA”); and
- an information campaign aimed at raising awareness within business and communities of climate change issues.

The most important issue when assessing any policy option is the trade off between reducing emissions and the cost to the economy. It would be possible for New Zealand’s electricity sector to be 100% renewable if the economy was able to carry the cost without impacting negatively on its economy and international competitiveness.

As policy drives organisations to recognise that they are operating in a more carbon constrained world it will become increasingly evident that when generating renewable electricity, more than one income stream is potentially available.

## **15.2 Recommendations for further work**

This work has been challenging due to significant developments in the political and scientific arenas during the 2000/1 period. While the work completed has generated useful information and analysis, it is clear that further work could increase the value of the information produced by the MRET Impact Tool. This work would include:

- the calculation of \$/tCO<sub>2</sub> reduced in each of the MRET scenarios, so that a cost of CO<sub>2</sub> abatement curve could be generated to compare to other CO<sub>2</sub> reduction options.
- a more detailed assessment of the possible impact of biomass generation and cogeneration options and enhancement of the tool to incorporate emission from geothermal plants;
- an assessment of whether the investment behaviour of the various companies forecast in the Scenario Module was realistic. This is with regard to their access to capital and other issues that would impact on their ability or likelihood to invest in renewable energy plant as suggested;
- the decommissioning assumptions of the Market Simulation Model should be reconsidered in light of the expected new investments;
- in order to compare and utilise all of the results (especially capital cost comparisons) available through the MRET Impact Tool, the issue of excess generation capacity would need to be considered further;
- an assessment of how existing hydro could be prioritised over thermal generation without impacting on the effective operation of the market (this is likely to be difficult to do);
- enhancing the tool to quantify the impact of the MRET on hydro-spill;

- enhancement to ensure the model represents the most probable offer strategies of new generators under whichever mechanism is used to increase RE supply. This could allow a true electricity market price path to be developed;
- the % increase in the electricity cost from each scenario would be a useful indicator. The impact of other issues on cost could also be considered such as the cost of excess supply, the potential impact of a carbon price, the growth in demand and the potential impacts of other policies.
- in future modelling, it is recommended that emission factors only representing CO<sub>2</sub> are used as N<sub>2</sub>O and CH<sub>4</sub> have insignificant impacts on the outcomes using the methodology prescribed in this thesis. The Market Simulation Module has already been altered to represent only CO<sub>2</sub>.

### 15.3 Conclusions

The implementation of a MRET in the electricity sector can reduce GHG emissions. The level and the design of the target and mechanism will control the cost to the economy. Mechanisms that also encourage efficient use of thermal stations and energy efficiency throughout the economy will increase emission reduction benefits. The impact of the MRET on existing renewables must be considered and a system that incentivises all renewables rather than just new renewables has the best environmental outcome.

Of the five scenarios tested, the " best" with regards to reducing GHGs was the Hybrid Scenario that modelled energy efficiency improving a further 1% over BAU and attempted to drive the return of renewable energy to 1990 levels (81%) while one more CCGT was built in 2004. The building of the CCGT may have had a positive impact as it is more GHG efficient than operating existing coal fired plant. The decommissioning of thermal plant that would have been operating under BAU conditions also had an impact.

The cost of a MRET target is reduced if a secondary market is implemented rather than trying to encourage renewable energy developments due to changes in the electricity price. If the main purpose of the MRET system is the reduction of GHG emissions then the cost of abatement curve (\$/tC avoided) for all options available to the economy should be developed and the target set to the level that ensured a total least cost outcome for the country. It is recommended that further work be carried out to develop a cost of abatement curve for the renewable energy options identified in this work.

The main barrier to the development of renewable energy generation is that the LRMC is higher than that of a CCGT and this price differential needs to be recovered within long term contracts in order to allow development to take place. In the future, as the price of electricity increasingly reflects the price of carbon and if there are strong enough drivers to encourage the use of renewables to meet future demand then the average wholesale electricity price will approach the LRMC of renewable energy generation. In the shorter term it is possible that the higher cost could be gained through a secondary market.

In summary a MRET could play an important role in the fight against climate change as it will reduce GHG emissions from the electricity sector, this will contribute to New Zealand meeting its Kyoto Protocol and UNFCCC commitments. Mitigation of anthropogenic GHG activities by New Zealand and the other parties to the Protocol will assist in reducing the risk of climate change. The risks include the possibility of increased temperatures, rising sea levels and a higher number of extreme weather events and the impacts that these changes will have on human and other ecosystems.



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# Appendix 1

## International climate change agencies

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### Intergovernmental Panel on Climate Change

The IPCC was jointly established by the World Meteorological Organisation (WMO) and United Nations Environment Programme (UNEP) in 1988. The purpose of the IPCC is to assess the state of knowledge of climate change issues including science, environmental and socio-economic impacts and response strategies. It is recognised as the most authoritative scientific and technical voice on climate change, and its findings are central to the COP negotiators. The IPCC continues to provide governments with scientific, technical and socio-economic information relevant to evaluating the risks and developing a response to global climate change.

Approximately 400 experts draft, revise and finalise the IPCC reports and another 2,500 experts participate in the review process. The IPCC authors are nominated by governments and by international organisations including NGOs.

The IPCC is organised into three working groups plus a task force on national GHG inventories. Each of these four bodies has two co-chairs (one from a developed and one from a developing country) and a technical support unit. The table below shows the main assessment responsibilities of the IPCC Working Groups.

Working Group	Main assessment responsibilities
I - Science	<ul style="list-style-type: none"><li>• Scientific aspects of the climate system and climate change</li></ul>
II - Impacts	<ul style="list-style-type: none"><li>• Vulnerability of human and natural systems to climate change</li><li>• Negative and positive consequences of climate change</li><li>• Options for adapting to them</li></ul>
III - Mitigation	<ul style="list-style-type: none"><li>• Options for limiting greenhouse gas emissions</li><li>• Other methods of mitigating climate change</li><li>• Economic issues</li></ul>
Task Force	<ul style="list-style-type: none"><li>• Development of guidelines for national GHG inventories</li></ul>

The first comprehensive assessment of climate change was compiled in the IPCC's First Assessment Report (FAR) in 1990 with the Second Assessment Report completed in 1995 (SAR). The Third Assessment Reports (TAR) and the associated Summary for Policy Makers was released this year (2001). Technical guidelines for the preparation of national GHG inventories were published in 1995 and revised in 1996. The IPCC also generates special

reports and technical papers on topics were independent scientific information and advice is required.

### United Nations Framework Convention on Climate Change (UNFCCC)

Article	Topic
Articles 2 - 3	Objectives and principles
Article 4	Commitment
Articles 5 - 6	Research, education, public awareness
Articles 7 - 10	Establishment of the COP, Secretariat and Subsidiary Bodies
Articles 11 & 21	Financial Mechanism and interim arrangement for Global Environment Fund (GEF)
Article 12	Communication of information related to implementation
Articles 13 - 14	Questions regarding implementation and dispute settlement
Articles 15 - 17	Amendments, Annex development and Protocols to the FCCC
Articles 18 - 26	Legal Procedures
Annex I	Parties that take on the Article 4.2 commitments
Annex II	Parties that take on more financial commitments

Annex I and II countries that ratified the Convention must uphold the following commitments and obligations:

- generate “national communications” which report GHG emissions by source and removals by sinks;
- formulate and implement measures to mitigate climate change;
- prepare for adaptation to the impacts of climate change;
- promote technology transfer, sustainable management, conservation, enhancement of sinks and reservoirs;
- participating and co-operating in education, public awareness building, research and monitoring of scientific, technical and educational matters;
- take climate change into account in relevant social, economic and environmental policies.

The Annex I countries have several additional specific commitments including:

- inclusion of climate change strategies in their national communications;
- provision of “new and additional resources” (i.e. not redirected from existing development aid funds) and facilitation of technology transfer.

The economies in transition have a degree of flexibility in meeting these commitments.

### *Reporting commitments under the UNFCCC*

The MfE (1998) stated that under the UNFCCC, NZ has a commitment to report emissions data on the six main greenhouse gases. The Convention also requires countries to provide information on “indirect” greenhouse gases: nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur oxides. NMVOCs include a wide range of organic chemical substances that play a major role in the formation of ozone in the troposphere (lower atmosphere). Ozone in the troposphere is a greenhouse gas, and a major local and regional air pollutant. National data is provided for sources and sinks of these gases using the IPCC categories of energy, industrial processes, solvent and other product uses, agriculture, land use change and forestry, and waste. This is an annual requirement.

It is important that the inventory data for all gases is accurate, comparable, consistent and transparent as possible. For NZ there is a particular need to develop a more accurate and reliable measure of the “agricultural” gases and additional work will be needed to identify “Kyoto forests” i.e. those planted after 1990.

### **Conference of Parties (COP)**

A conference of parties occurs in most years and they are identified by being sequentially numbered. The next COP will be COP 7 in Marrakesh – it will be the seventh session of the COP. COP 6.5 was considered to be a continuation of COP 6.

The COP has established two subsidiary bodies:

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA) which provides the COP with timely information and advice on scientific and technological matters relating to the Convention; and
2. The Subsidiary Body for Implementation (SBI) which helps with the assessment and review of the Convention’s implementation.

The COP guides and is accountable for the financial mechanisms that provide funds on a grant or concessional basis. The Global Environment Facility (GEF) has been entrusted with the responsibility of developing the policies, programme priorities and eligibility criteria, and is reviewed every 4 years. It was established by the World Bank, UNDP and UNEP.

The COP and its subsidiary bodies are serviced by the Intergovernmental Panel Climate Change Secretariat (IPCC Secretariat) which:

- arranges for sessions of the COP and its subsidiary bodies and services meetings;
- collects data, drafts official documents and compiles and transmits reports;
- facilitates Parties for the compilation and communication of information;
- co-ordinates with secretariats of other relevant international bodies;
- reports on the activities of COP.

## Appendix 2

### Kyoto Protocol commitments of Annex I (industrialised) countries

Party	Target as percentage of base year or period	Emissions (Gg in 1990)	Percentage of total emissions by all Parties
Australia	108	288,965	2.1
Austria	92	59,200	0.4
Belgium	92	113,405	0.8
Bulgaria*	92	82,990	0.6
Canada	94	457,441	3.3
Croatia*	95		
Czech Republic*	92	169,514	1.2
Denmark	92	52,100	0.4
Estonia*	92	37,797	0.4
European Community	92		
Finland	92	53,900	0.4
France	92	366,536	2.7
Germany	92	1,012,443	7.4
Greece	92	82,100	0.6
Hungary*	94	71,373	0.5
Iceland	110	2,172	0.0
Ireland	92	30,719	0.2
Italy	92	428,941	3.1
Japan	94	1,173,360	8.5
Latvia*	92	22,976	0.2
Liechtenstein	92	208	0.0
Lithuania*	92		
Luxembourg	92	11,343	0.1
Monaco	92	71	0.0
Netherlands	92	167,600	1.2
New Zealand	100	25,530	0.2
Norway	101	35,533	3.0
Poland*	94	414,930	3.0

<b>Party</b>	<b>Target as percentage of base year or period</b>	<b>Emissions (Gg in 1990)</b>	<b>Percentage of total emissions by all Parties</b>
Portugal	92	42,148	0.3
Romania*	92	171,103	1.2
Russian Federation*	100	2,388,720	17.4
Slovakia*	92	58,278	0.4
Slovenia*			
Spain	92	260,654	1.9
Sweden	92	61,256	0.4
Switzerland	92	43,600	0.3
Ukraine*	100		
United Kingdom of Great Britain and Northern Ireland	92	584,078	4.3
United States of America	93	4,957,022	36.1
<b>TOTAL</b>		<b>13,728,306</b>	<b>100.0</b>

\* Countries that are undergoing the process of transition to a market economy.

(Source: UNFCCC, 1997)

## Appendix 3

### Climate change negotiating groups

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**Alliance of Small Island States (AOSIS)** – this is an ad-hoc coalition of low lying island states that are particularly vulnerable to climate change. There are 42 members who are also members of the G77/China and they often share common positions on climate change. AOSIS members include American Samoa, Antigua and Barbuda, Bahamas, Barbados, Belize, Cape Verde, Comoros, Cook Islands, Cuba, Cyprus, Dominica, Federated States of Micronesia, Fiji, Grenada, Guam, Guinea-Bissau, Guyana, Jamaica, Kiribati, Maldives, Malta, Marshall Islands, Mauritius, Nauru, Netherlands Antilles, Niue, Papua New Guinea, Samoa, Sao Tome and Principe, Seychelles, Singapore, Solomon Islands, St. Kitts & Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Tonga, Trinidad & Tobago, Tuvalu, US Virgin Islands, and Vanuatu.

**European Union (EU)** - The European Union is a party to the convention but does not have a separate vote from its members. It has a common reduction commitment through the creation of the EU bubble. It is a regional economic integration organisation that includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom of Great Britain and Northern Ireland. In the Kyoto Protocol discussions the EU is often referred to as the European Community as that was its name when it signed the Protocol in 1998.

**Group of 77 and China (G77/China)** - This is a group of undeveloped countries that was founded in 1967 under the auspices of the United Nations Conference for Trade and Development (UNCTAD). It now has 132 members. While they share some common ground in the negotiating arena, there are also some significant differences due to country specific issues.

**JUSSCANNZ** - This group is effectively the non-EU industrialised/OPEC countries. Members are Japan, US, Switzerland, Canada, Australia, Norway and New Zealand. Iceland, Mexico and the Republic of Korea may also attend the meetings. This group does not negotiate as a block, the main purpose being information sharing.

**The Umbrella Group** is another non-EU industrialised nation group drawn together due to common negotiating positions especially around the flexibility mechanisms. Members are Australia, Canada, Iceland, Japan, New Zealand, Norway, Russia, Ukraine and the US. Originally the group came together to focus on an effective emissions trading system, now

their mandate has broadened into other major issues. The group has an informal working slogan “working together not tied together”.

**Organisations of Petroleum Exporting Countries (OPEC)** also belong to the G77/China but are reluctant to see the Kyoto Protocol implemented due to the negative impacts on their economies that would follow reduced reliance on fossil fuel products.

Other groups of countries that participate in a significant manner to climate change issues include:

**Organisation for Economic Co-operation and Development (OECD)** was formed in 1961. The original Member countries are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdoms and the United States. The following countries joined subsequently: Japan, Finland, Australia, New Zealand, Mexico, the Czech Republic, Hungary, Poland and the Republic of Korea.

**International Energy Agency (IEA)** is an autonomous body established in 1974 within the OECD framework to implement an international energy programme. The Members are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States, the EC also participates.

## Appendix 4

### Summary of the Kyoto Protocol document

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Article	Topic
Art. 2	Policies and measures
Art. 3	Quantified emission limitation and reduction commitments (i.e. emission reduction targets)
Art. 4	Joint fulfillment of commitments (bubbling)
Art. 5	Methodological issues
Art. 6	Transfer and acquisition of emission reduction units (joint implementation)
Art. 7	Communication of information
Art. 8	Review of information
Art. 9	Review of the Protocol
Art. 10	Implementation of existing commitments
Art. 11	Financial mechanisms
Art. 12	Clean development mechanism
Art. 13	COP/Meeting of parties (MOP) institutional issues
Art. 14	Secretariat issues
Art. 15	Subsidiary Bodies
Art. 16	Multilateral Consultative Process
Art. 17	International emissions trading
Art. 18	Non-compliance
Art. 19	Dispute settlement
Art.s 20-22	Amendment and Annex development procedures
Art.s 22 – 28	Legal procedures
Art 25	Entry into force
Annex A	Greenhouse gases and sector/source categories
Annex B	Quantified emission limitation or reduction commitments by Party

(Source: UNFCCC, 1997)

## Appendix 5

### Important countries and negotiating groups positions on major issues leading up to COP6

Country	Negotiating Group Membership	Annex	Negotiating issues						Likelihood of Ratification?
			Sinks	Emission Trading	CDM	JI	Supplementarity targets	Annex II Targets	
New Zealand	JUSSCANZ, Umbrella Group	I	✓ B1	✓	✓ S	✓	×	×	✓ 2002
Australia	JUSSCANZ, Umbrella Group	I	✓ B	✓	✓ S	✓	×	×	×
USA	JUSSCANZ, Umbrella Group	I	✓ B	✓	✓ S	✓	×	✓	×
UK	EU	I	× 1	✓	✓ PN	✓	✓	×	✓ 2002
Japan	JUSSCANZ, Umbrella Group	I	✓ B	✓	✓ S	✓	×	×	?
Russian Fed'n	G77/China	EIT	✓	✓	✓	✓	✓	×	× (US dependant)
Canada	JUSSCANZ, Umbrella Group	I	✓	✓	✓	✓	×	×	

Key: ✓ - Yes   × - No   ? – uncertain/unclear   **B** – Credits for BAU   **I** – No new activities in 1<sup>st</sup> commitment period   **P** – Supports positive list of projects   **N** - Supports nuclear   **S** – Supports sinks   **I** – Annex I or industrialised countries   **EIT** – Economies in transition

Negotiating Group	Members of the group are;	Annex	Negotiating issues						Likelihood of Ratification?
			Sinks	Emission Trading	CDM	JT	Supplementary targets	Annex II Targets	
EU		I	x	✓	✓	✓	✓	x	✓
G77/China	132 Developing Countries including AOSIS	II/EIT	✓	✓	✓	✓	✓	x	✓
AOSIS	40 small island states.	II	✓	✓	✓	✓	x	x	✓
JUSSCANNZ	Japan, USA, Switzerland, Canada, Australia, Netherlands, New Zealand	I	✓	✓	✓	✓	x	x(Except US)	x(Except NZ)
Umbrella Group	Non-EU Developed Countries.	I	✓	✓	✓	✓	x	x/✓	x(Except EU & NZ)
OPEC	Oil producing nations	II	?	x	x	x	x		x
Environmental NGO's	e.g. Greenpeace, WWF	-	x	✓	x	x/✓	x/✓	x	-

Key: ✓ - Yes x - No ? – uncertain/unclear

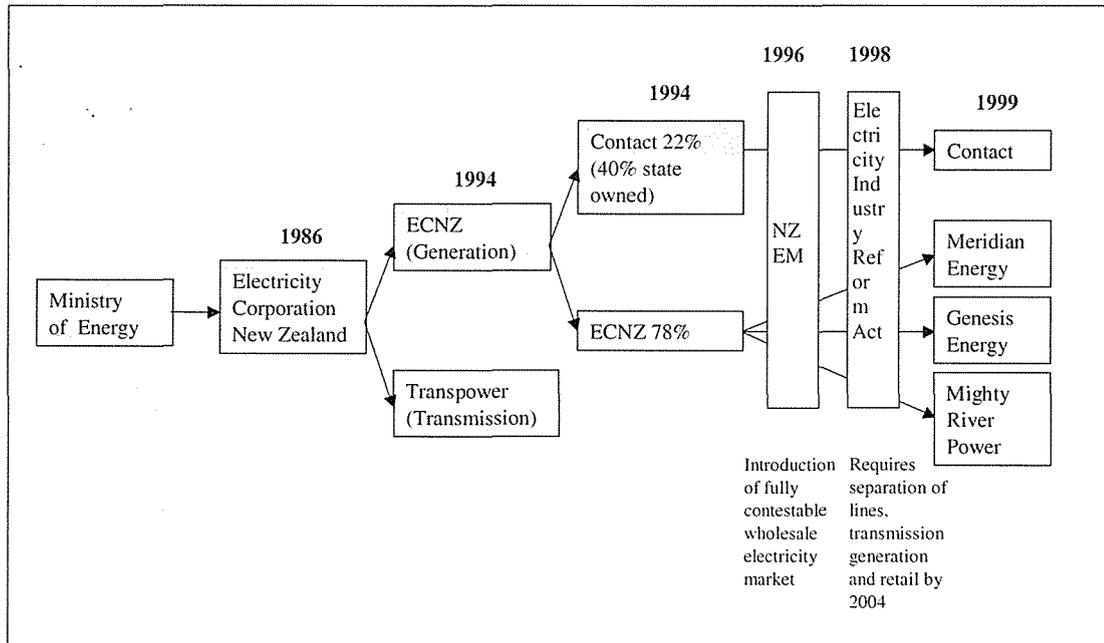
**I** – Annex I or industrialised countries **II** – Annex II or developing countries **EIT** – Economies in transition

## Appendix 6

### New Zealand Electricity Industry

#### Electricity Industry Reforms in New Zealand

The electricity industry has undergone considerable reforms in the past fifteen years. The major changes in industry structure are illustrated below.

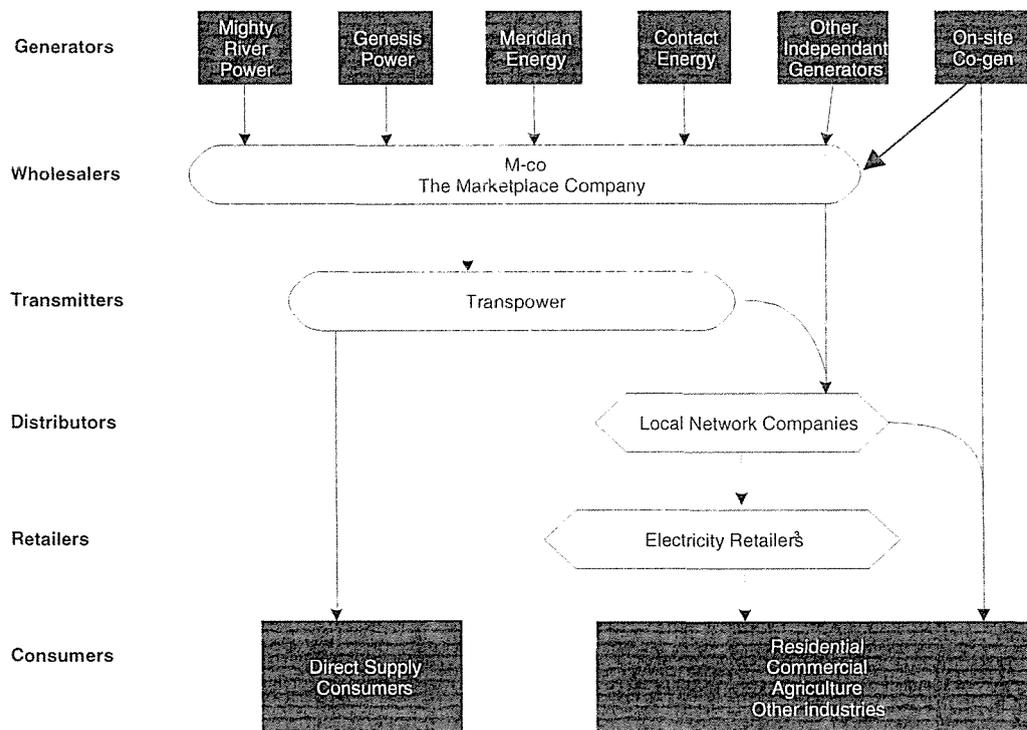


The implications of splitting ECNZ and Contact in 1994 on CO<sub>2</sub> emission levels was investigated by the NZIER (1995) and suggested that, in the short term (i.e. six years), there was likely to be a small increase in CO<sub>2</sub> emission levels. The increase was estimated to be approximately 0.1 million tonnes of CO<sub>2</sub> or 0.4 percent of total emissions. In the longer term, it was expected that emissions would reduce below the BAU pre-reform levels due to the effect on energy efficiency of improved pricing and stronger competitive pressures.

The UNFCCC review team of New Zealand's first national communication in 1996 (UNFCCC, 1996) noted that the implications of these reforms was not clear but that if mitigation was not a condition for resource consent the addition of a 400MW gas-fired power station would increase national emissions by 5%. No further economic analysis of the potential outcomes from a GHG perspective of these reforms has been identified

## New Zealand Electricity Industry Overview

The present structure of the electricity industry is shown below which is based on Ministry of Economic Development, New Zealand Energy Data File, 2000. Each sector is discussed further below. It should be noted that major changes occurred in June and August 2001 with regards to market share especially in the retail area with On Energy selling all its retail customers to Meridian Energy and Genesis Energy Ltd. The figures reported do not take these developments into account. This situation emphasises that the market is dynamic and that weather conditions effect both the supply and demand side of the market.



▶ Contractual agreements between generators and retailers via M-co to purchase and supply power electricity end users through Transpower and local network companies

→ Conveyance of power from generators to end users through distribution

### Notes:

1. Company Names are listed without the suffixes "Limited" and "New Zealand Limited" where applicable.
2. The new SOE's (State-owned enterprises) created from the split of the former Electricity Corporation of New Zealand Ltd (1 April 1999) and Contact Energy Limited (established 1 April 1996) are the major electricity generators.
3. The main electricity retailers are Contact Energy, Genesis Power, Meridian Energy, Mighty River Power, On Energy and Trustpower.

There are several significant attributes of the New Zealand electricity system that will be considered during the course of this work. They include:

- majority of demand in the upper North Island especially around Auckland;
- majority of generation in the South Island;
- significant differences in demand at different times of the day and year;
- constraints to transmission particularly the high voltage direct current (HVDC) link between the North and South Island and the Tokaanu–Whakamaru link;
- present oversupply of generation;
- majority of generation is from renewable and specifically hydro sources.

### Generation

Eleven companies contributed to a total generation for the year ended March 2000 of 37,583 GWh or 135.3 PJ. The generators range in aggregate size of installed capacity from 500MW to the approximate 2,500 MW of Meridian Energy. A breakdown of generation market share in 2000 is shown below. The six largest generators own approximately 40 power stations, which range in size from a few MW to 1000MW.

The energy sources utilised in 2000 were hydro (62%), gas (25%), geothermal (6%), coal (4%), cogeneration (8%) and other fuels such as biomass in the form of biogas, industrial waste and wood, and wind, which contributed 3% of total generation.

Generation Company	Capacity (MW)	% Total Generation	Retail Customers	% Total Customers
Contact Energy	2,131	25	355,000	21
Genesis Power	1,594	19	155,000	9
Meridian Energy	2,323	28	72,000	4 <sup>44</sup>
NGC	530	6	578,000	34
TrustPower	398	5	215,000	13
Mighty River Power	1,075	13	268,000	16
Others (5)	327	4	57,000	3
<b>Total</b>	<b>8,378</b>	<b>100</b>	<b>1,700,000</b>	<b>100</b>

(Source: M-Co, 2000)

Any renewable generation has zero operating GHG emissions while any process that utilises a fossil fuel will generate CO<sub>2</sub> and other emissions. In the case of woody biomass there can be

<sup>44</sup> In 2001, Meridian purchased NGC's Christchurch customer base taking its % of market share to 13%.

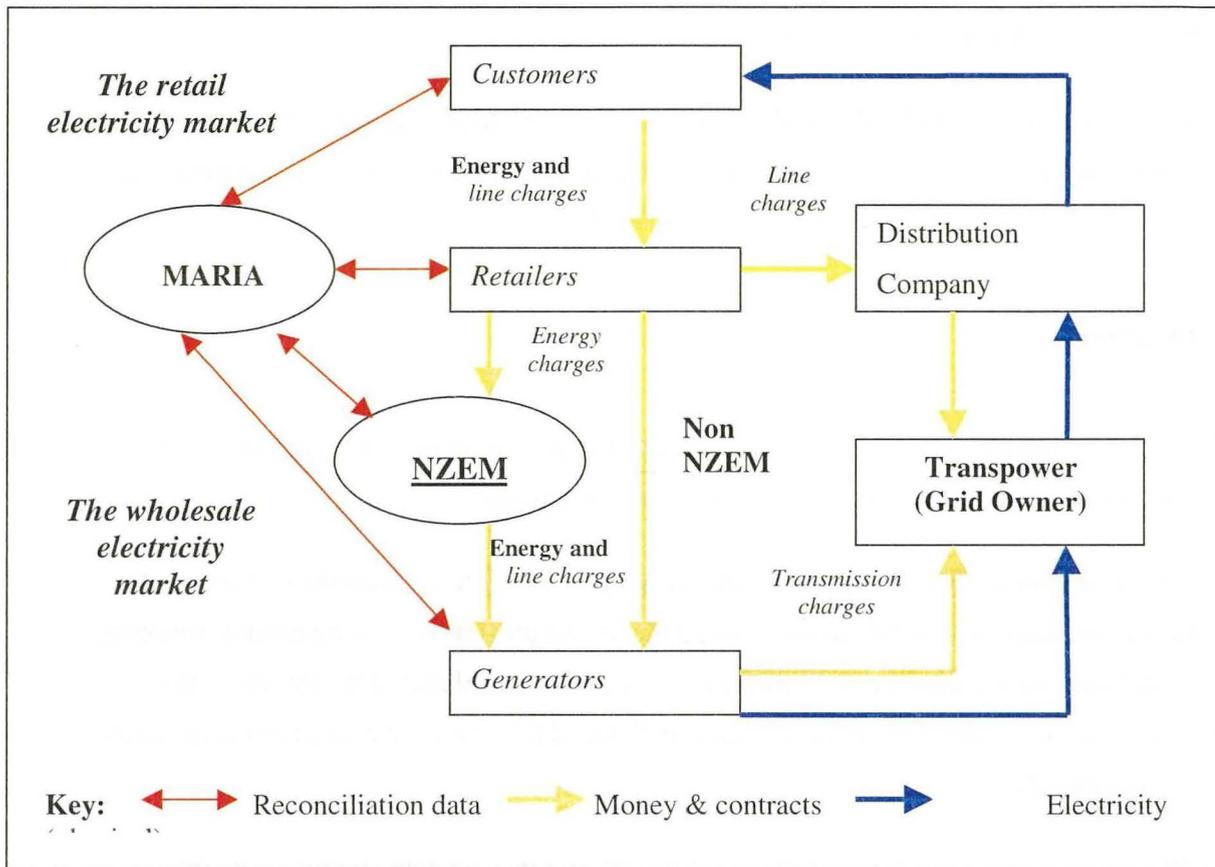
zero net emissions if the forest is replanted. The MED presently define geothermal as renewable though this is under debate as the fields deplete with time and CO<sub>2</sub> is also produced during the steam collection process. The level of carbon in the fuel source influences how much greenhouse gas is emitted, therefore coal has higher GHG emission levels than natural gas. There is an assumption that all carbon in a fuel is converted no matter what energy conversion process is used. It must also be noted that emissions occur during the development stage of any power station and these may be more significant in renewable energy plant than thermal (fossil fuel powered) plant. These issues are assessed during life cycle analysis, however for the purpose of this report only generation emissions are considered.

The amount of generation required at any moment is set by the amount of electricity demanded by consumers at that time plus losses. Since electricity can not be stored the systems that are required to ensure sufficient good quality electricity is always available are complex. The nature of the market ensures that the lowest price is made available to the market though this may not necessarily feed down to all consumers. However the market mechanism does not presently allow for the least cost production of electricity from an environmental perspective. This is because the cost of the externality relating to the impact of the GHG emissions is not internalised in the cost of production. If minimisation of greenhouse gas emission was the main driver, then from a carbon content minimisation perspective, renewable generation capacity would be used prior to gas-fired, followed by coal fired electricity generation. One of the purposes of this investigation is to generate a tool to assess the impacts on market participants of potential policies that could lead to a reduction in the total GHG emission levels for New Zealand.

### **Wholesale Market**

The New Zealand Electricity Market (NZEM) was developed by industry participants as a voluntary and self regulating market. The interrelationships between different parts of the Electricity Market are shown in the figure below.

NZEM's guiding principles are to foster robust, enforceable, efficient and competitive markets for electricity which enable the entry of new buyers and sellers while complying with the Commerce Act (1986). There is also a requirement for maintaining a process to set and change the rules of the market. It is a commodity exchange through which 75% of New Zealand total electricity volume is traded. The rest is purchased on a bilateral contract basis directly by major users under the Metering and Reconciliation Information Agreement (MARIA).



(Source: Based on GSP, 1999)

Every half hour of every day a price is established at each of the 244 grid connections points (nodes) around the country – this is called the spot price. The method used reflects energy costs and transmission costs including losses in the prices. In doing this it also sends investment signals to market participants. There is a secondary market where generators and buyers also hedge spot prices.

The wholesale price averaged 2.58c/kWh in the year to 31 January 2000. During the previous 1998/1999 period, which was a wet year, the price was 3.35c/kWh which supports the argument that vigorous competition has put downward pressure on prices.

### Transmission

Transmission lines connect power stations to local distribution company lines and major users of electricity (e.g New Zealand Aluminium Smelter) directly.

Transpower owns all of the high voltage transmission lines in New Zealand, this is called the national grid. This includes 12,000 kilometres of high voltage alternating current line (HVAC) principally operating at 220kV and 110kV, with some 11, 33 and 66kV lines. The

other major asset is the 600 kilometre long HVDC link from Benmore in the South Island to Haywards in the North Island. The HVDC allows electricity generated in the South Island to be sold in the North and vice versa.

Transpower also schedules the production from all power stations, monitors the network, ensures that reliability, voltage and frequency targets are met and manages grid emergencies i.e. it is responsible for short-term security of supply.

## **Distribution**

The role of distribution companies is to convey electricity from the grid to the end users within their network area on behalf of the retailing companies.

One of the impacts of the Electricity Reform Act (1998) was to separate the ownership of lines from generation and retail businesses to break the previously existing natural monopoly. At that time most companies kept their lines and sold the retail part of the business. The Caygill Review may result in lines companies being able to own some generation particularly if it is renewable.

The outcome of the Act has been the development of approximately 30 lines / network / distribution companies as at July 2000 ranging in size from 5,000 connections to over 500,000 connections. Ownership varies with some being trusts while others are publicly listed companies.

## **Retailing**

The role of the retailer is to sell electricity to consumers by buying electricity from the wholesale market and purchasing transmission and distribution services from distribution companies. The 11 companies compete to meet consumers' electricity needs and have customer bases that range in size from 20,000 customers to over 500,000 customers. Market share of generation and customers is shown below. Not that this is a dynamic market and shares are continually changing.

Despite the lower prices being seen by generators, this has not fed down to small domestic consumers whose inflation corrected prices increased by 3.4% in the 18 months prior to August 1999.

The proportion of the bill received by a typical household broken into sectors of the electricity market are:

- Generation 30%
  - Transmission 13%
  - Distribution 35%
  - Retail 22%
- 100%

The precise breakdown varies depending on location and supply arrangements.

The report to the Minister of Energy from the 2000 Inquiry into the electricity sector stated that electricity prices vary in each sector. For example prices fell in the commercial sector from 21c/kWh in to 11.5c/kWh in 1999, while residential prices moved from 11.5c/kWh to about 13.5c/kWh in 1999. During this period industrial electricity prices remained quite static. (MED,2000).

### **Demand**

The electricity demand for 1999 (March year) by sector is shown below. The total increased by 2% from the previous year.

There are losses associated with both the transmission and distribution systems due to heat. This accounts for the 20PJ difference between the 135.3PJ of electricity generated and the 115.7PJ consumed.

<b>Sector</b>	<b>GWh</b>	<b>PJ</b>	<b>% of total consumption</b>
Residential	11,089	39.92	34.6
Non-residential	20,940	75.39	65.4
<i>of which:</i>			
Industrial	13,745	49.48	42.9
Commercial	7,195	25.90	22.5
<b>Total</b>	<b>32,029</b>	<b>115.3</b>	<b>100</b>

(Source: MED, 2000)

## Appendix 7

### New Zealand's Generic Policy Options

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Policy options include regulation, economic instruments, financial assistance, voluntary agreements, education, information and research. The last four terms are often grouped together under the term complementary measures whose role is defined, by the MfE (1999), as eliciting activities that would be in the merit order of \$/tC but not elicited by the central economic instrument. Such measures are designed to address market imperfections, to encourage change in people's tastes and preferences, to address distributional and equity issues and to address sectors not covered by other measures. Some address decision-makers responsiveness to price while other address non-price barriers.

- Regulations require or prohibit actions. They are rules or standards that must be adhered to. In the context of climate change they may include
  - the requirement to disclose information;
  - keeping emissions below a certain level;
  - minimum energy performance standards (MEPS); and
  - energy efficiency requirements.

Regulations occur within an overarching legislative framework to protect or improve the environment (such as the Resource Management Act). The driving force to comply is some form of sanction such as a fine. Regulations have the advantage of providing certainty and clarity, but the cost of compliance and enforcement may mean that they are not the least cost approach.

- Economic instruments are market mechanisms that use monetary incentives and disincentives to influence behaviour in the desirable direction. They usually operate within a regulatory framework that defines the market. In the case of climate change policy they involve either the financial transfer of funds from the polluter through a tax (e.g. carbon charge) or user charge. The major alternative economic instrument is the creation of a new market, for example, a tradable permit market or a renewable energy certificate. Participants and stakeholders in the market will have better information and an ability to find innovative solutions so this instrument can achieve optimal resource allocation.
- Financial assistance includes subsidies. They can be used in a variety of ways and are intended to induce certain behaviours. For example, assistance may be required where a

market barrier is faced by a new renewable energy or carbon absorption technology during research and development (R&D) or the pre/early commercialisation phase.

- Voluntary agreements mostly involve agreements to meet some sort of target between government agencies and sector groups, individual companies or groups of companies e.g. VAs or Negotiated Greenhouse Agreements (NGAs). These can provide a high level of flexibility and therefore cost efficient outcomes. However, as a method of reaching a collective objective they may have limited benefit as it is difficult to forecast the potential outcomes. VAs can act as avenues for information flows and as an incentive for no-regrets or profitable efficiency projects. There can often be additional benefits to the participants as a positive public relations exercise.
- Education and information. This is where the government acts as a conduit for information to the general public or to specific sector groups. It may be in the form of publicity, the promotion of co-ordination between organisations, an education campaign or the provision of guidelines (non-binding less formal mechanisms than regulations) or best practise information.
- Research. It is recognised that sound science and information should be the basis for climate change policy development so funding through the Public Good Science Fund (PGSF) and other government and private sector sources represents an important component of New Zealand's ongoing climate change response. In 1991, the Government established the National Science Strategy Committee for Climate Change (NSSCCC) to develop a comprehensive strategy for climate change research. The critical drivers for this strategy are reducing uncertainties, protecting New Zealand's interests, identifying opportunities for New Zealand and maintaining international science contact. There are ongoing calls for the need for further funding in this area.

## Appendix 8

### Resource Management Act (1991)

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The Resource Management Act (RMA) remains the only Act to provide guidelines on ways to control GHG emissions. There have been ongoing discussions about the use of the RMA as a vehicle for achieving emission reduction targets.

The RMA was primarily set up to provide for local decision making on local environmental effects. To date, greenhouse gases are included in the RMA's definition of "contaminant" and so the RMA is concerned with avoiding, remedying or mitigating the environmental effects of such emissions.

This regional tool enables consent authorities to require the effects of CO<sub>2</sub> emissions to be avoided, remedied or mitigated through specific consent application by large stationary emitters. The consent for the proposed Taranaki Combined Cycle power station included a condition to fully mitigate the emissions of CO<sub>2</sub> that were additional to those from the electricity generation sector prior to the commissioning of the station by planting trees. (WOGOCOP, 1996). Due to the baseline chosen and the market conditions no trees have yet been planted. This is because the agreement was based the incremental effect of the emissions of the plant. There is a trigger emission level above the total emissions from the sector at that time which would require the trees to be planted. Regional councils have not yet used these conditions as a precedent. Consent authorities are also able to address CO<sub>2</sub> sources and sinks through plans covering transport and land use. Suggested amendments to the RMA have included removing GHG's from the Act. To regulate GHG's using the RMA all emitters would have to apply for a resource consent which would incur unnecessarily high transaction costs. There is scope for regional differences with regards to consent requirements which could lead to different compliance costs relating to carbon dioxide emissions in different regions. This does not equalise the marginal costs of emissions through all sectors and areas of the economy.

WOGOCOP (1996) identified several mechanisms available to Government that could be used to influence local decision making including;

1. Developing a National Policy Statement (NPS);
2. Developing National Environmental Standards (NES);

3. Calling in resource consent applications for determination by the Minister for the Environment (although such decisions are subject to appeal and consideration by the Planning Tribunal);
4. Influencing Regional Policy Statement, Regional Plans and District Plans through consultation on drafts, submissions on proposed documents and non-statutory guidance;
5. Influencing resource consents through submissions.

Options 1-3 would mean local councils must act consistently with these but only options 1 and 2 would be consistent through the whole country. However, before the government can introduce either of these statutory instruments, it must comply with section 32 of the RMA which requires consideration of the alternatives both within and outside of the Act. As stated by WOGOCOP the RMA states that the government must:

- have regard to the extent to which the objective, policy, rule or method is necessary in achieving the Act's purpose, what other means are available and the reasons for and against adopting the proposed objective, policy or method and the principal alternative means; and
- carry out an evaluation (appropriate to the circumstances) of the benefits and costs of the principal alternative means; and
- be satisfied that any objective, policy, rule or method is necessary in achieving the Act's purpose and is the most appropriate means of exercising its function, having regard to its efficiency and effectiveness relative to other means.

It is unlikely that a NPS or NES relating to GHGs could pass the test of section 32 mainly due to the high compliance costs and the problems with cross regional coordination.

There have also been concerns that emitters could face both regional and national requirements for the same emissions.

WOGOCOP concluded that a nationally legislated economic instrument operated at a level sufficient to meet New Zealand's CO<sub>2</sub> commitments under the FCCC, would remove the justification for declining or attaching conditions to a consent or any rationale for promulgating a National Policy Statement under the RMA.

The Local Government and Environment Committee's interim report (2001) highlighted interactions between the RMA and national climate change policy and guidance on the weighting of protection of landscapes and the development of renewable sources of energy have been recommended. This recommendation was also made by the Parliamentary Commissioner for the Environment in the 'Getting More for Less' report released in 2000.

## Appendix 9

### Voluntary Agreements (1995 – 1998)

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The New Zealand Government negotiated Voluntary Agreements (VAs) to reduce GHG emissions with 24 organisations between September 1995 and March 1998. These agreements covered most of New Zealand's largest single point CO<sub>2</sub> emitters and 47% of New Zealand's 1990 CO<sub>2</sub> inventory (MoC, 1995). The participants included most of New Zealand's large energy using industries as well as the main electricity, gas and coal producers.

The signatories anticipated a 32% increase in their outputs by 2000 with only a 14% increase in CO<sub>2</sub> emitted. The commitments made by the signatories added up to a 17% reduction against a base year equivalent (BYE) baseline, or approximately 2,200 kt of CO<sub>2</sub> mitigated per year.

In the order of 40% of the reductions were expected from cogeneration developments, with the rest expected to come from plant upgrades, equipment replacement and energy management projects.

Companies were encouraged to participate due to the threat of a carbon charge if the objective of reaching 1990 net CO<sub>2</sub> emission levels by 2000 was not met. This target was not achieved but the carbon charge was not enacted.

By August 2000, projects with calculated abatement of 619ktCO<sub>2</sub> had been reported which was 28% of the participant's total GHG reduction commitments. Most of the remainder depends on projects now under the control of Meridian Energy Ltd (Jamieson and Pool, 1999).

#### *Methodology*

The methods that formed the basis of these agreements were formulated by a joint industry-government Technical Working Group. The energy accounting method was based on that developed for the Canadian Industry Program for Energy Conservation (CIPEC) and modified for New Zealand circumstances was the basis of the approach. It uses the concept of a BYE emission level as a baseline against which mitigation is measured.

The agreements were based on CO<sub>2</sub> performance in 1990 with targets for the year 2000, with an obligation to report progress each year leading up to the target. They only covered the

emissions under the signatories direct control. A full cycle approach was rejected to keep the agreements clear and the process manageable. The sole exception was the need to account for the impact of electricity and steam purchased off-site to reduce perverse incentives and signals to move generation systems off-site and ensure the credibility of the data reported under the agreements.

The method for accounting for electricity use was a complex issue. Emission factors were developed based on base load being offered by hydro stations while the marginal plant tended to be a thermal station. In recognition of this an emission factor of  $140\text{tCO}_2/\text{GWh}$ , which represented the average national emission factor, was used for the base year only. All changes in electricity use for subsequent years would be accounted for at an average marginal thermal electricity generation emission factor of  $624\text{tCO}_2/\text{GWh}$ . This was based on Huntly using coal and New Plymouth using gas and each being the marginal plant 50% of the time. An emission factor of  $587\text{tCO}_2/\text{GWh}$  was used in the South Island to take into account transmission losses (Government of New Zealand, 1995).

The method used to calculate the electricity emission factor is no longer applicable due to new generation assets and the development of the wholesale electricity market. There was a plan to review the emission factors in 1997 however this never occurred. There is now an urgent need for a new electricity emission factor to be recalculated.

For most companies targets were on a % basis however for ECNZ the agreement was based on specific projects and totalled 874 kt.

The Ministry of Commerce now the Ministry for Economic Development (MED) was assigned the role of implementing and monitoring the voluntary agreements (VAs). ECCA had the role of independently auditing and monitoring the agreements, annual reports and results of the VA programme.

## Appendix 10

### Technical Design Issues For A Domestic Trading Regime

A working paper entitled “Technical Design Issues for a Domestic Emissions Trading Regime for Greenhouse Gases” was released by the MfE in 1998. The key feature of an emissions trading program is a binding limit or cap on emissions due to a reduction target. This total allowed amount is divided into units of trade or certificates. The certificates can be transferred between organisations with low abatement costs to those with higher abatement costs leading to a lowest overall cost outcome.

The success of this mechanism compared with other GHG reduction mechanisms will be dependant on the coverage of a broad range of emission sources and abatement opportunities, the divergence of abatement costs between emission sources and the associated transaction costs. The potential for a pilot scheme has been discussed by officials.

Some of the major technical issues to be determined include:

- The unit of trade:
  - denominated in tonnes of CO<sub>2</sub>-e; and
  - exist electronically with a unique serial number.
- Point of obligation:
  - either at point of emission or production/importation point i.e. upstream/downstream;
  - problems with small diffuse points.
- Certificate allocation:
  - auctioning using price as allocation basis;
  - grandparenting based on historical emissions;
  - hybrid of the two;
  - take into account the marginal cost of abatement or post emission abatement behaviour;
  - new entrants and economic growth need to be considered.
- Administration:
  - market participants could set rules to encourage transparency and information disclosure, provide incentives for compliance while minimising costs;
  - registry required to track ownership;
  - monitoring and reporting would be required;
  - income tax and GST would be payable on certificates.

## Appendix 11

### Low Level Carbon Charge

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In 1999, the Treasury released a paper detailing work that had been carried out on a low level carbon charge. The purpose of a carbon charge would be to achieve least cost reductions of CO<sub>2</sub> emissions in New Zealand, consistent with international obligations. The legislation required to establish such a charge would include:

- Imposition of a charge:
  - on carbon containing products on a \$/emission factor basis and converted to \$/tonne of carbon content;
  - on products that contain anthropogenic carbon produced or imported into New Zealand where carbon is released within New Zealand and is not part of natural cycle.
  
- Rebates or refund:
  - available when emissions occur outside of New Zealand;
  - or if use is non-emitting and verifiable.
  
- Measurement of carbon content:
  - Measurement of actual carbon content where cost effective otherwise estimated.
  
- Point of liability:
  - Closest feasible point to production or import.
  
- Administration.

Earlier work reported by WOGOCOP (1996) shows the expected change in retail prices (and wholesale electricity prices) with various carbon charges as shown in the table below.

Work on the likely impacts of a carbon charge is still being carried out and the present “low level” that is being discussed is \$5/tC.

**Table A9: Increases in retail prices (wholesale for electricity) with various carbon charges (allowing for existing taxes)**

	Coal	Gas	Petrol <sup>1</sup>	Diesel	Fuel Oil	Electricity Generation <sup>2</sup>	Approximate estimated outcome <sup>3</sup>
\$30	22%	5%	2%	5%	7%	8%	20% reduction in gross emissions growth by 2000
\$60	43%	10%	4%	9%	13%	16%	Displace new coal fired plant beyond 2020
\$100	72%	17%	7%	16%	22%	28%	Stabilise gross (and net) emissions at 1990 levels by 2000

1: The reason for the small change in the price of petrol compared with the other fossil fuels is because of the substantial existing excise tax.

2: The estimated increase in electricity generation costs is for a base-load CCGT plant (any increase in wholesale prices would be muted at the retail level by transmission and distribution charges)

3: There is considerable uncertainty regarding the level of carbon charge required to achieve outcomes shown since it would depend on the responsiveness of emissions to price changes, GDP growth and potential autonomous changes in energy efficiency.

(Source: WOGOCOP, 1996)

## Appendix 12

### 1999 Domestic Policy Options

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The MfE's Climate Change: Domestic Policy Options Statement (1999) was the first wide-ranging consultation document prepared by the New Zealand government since the Kyoto Protocol was adopted in 1997. It set out the preferred long term policy package to be developed to meet New Zealand's Kyoto target. A central element of this was a domestic emissions trading (DET) regime interfacing with the planned international trading system. The report suggested three options for a central price signalling measure as well as complementary measures for addressing emissions in the period prior to 2008.

The three options proposed for policy prior to 2008 were summarised by Ward (1999):

**Option 1:** Facilitation of a forward market - an early start to forward trading of 2008-2012 emission units enabled by setting in place the long-term policy option as soon as possible.

This would:

- enhance awareness of domestic international trading systems;
- establish an emission "futures" trading market which interfaces with international markets;
- mean no mandatory domestic emission reduction obligations before 2008;
- require the setting of the long term policy framework as soon as possible to provide forward price signals to the market.

**Option 2:** A "pilot" emissions trading programme (for large energy sector emitters with possible linkages to other sectors) together with a low-level carbon charge for sectors excluded from the pilot scheme before implementing a comprehensive domestic emissions trading programme closer to 2008.

This includes:

- pilot emissions trading for major "point source" emitters exempt from a low level carbon charge that would apply to other CO<sub>2</sub> emissions (see Option 3 for more details);
- negotiation/acceptance of caps on emissions for a single or multiple "budget period" which would set the basis for "permit" trading within the pilot group;
- project-based "credits" can be earned for activities outside the groups (balance of energy sector and agriculture sector);

- a government bid-in fund would add to the investment available for projects and facilitate a competitive market;
- the issues of whether any excess “permits/credits” might roll over to 2008-2012 DET system (or an earlier DET) to provide full credit for “early” action is open for discussion.

**Option 3:** a low level carbon charge (for the energy sector), before implementing a comprehensive domestic emissions trading programme closer to 2008.

This would:

- be applied to all anthropogenic carbon produced or imported then released in New Zealand in the form of CO<sub>2</sub>;
- not apply:
  - where the carbon is exported or re-exported;
  - where no CO<sub>2</sub> is emitted when the carbon is used;
  - if the carbon is absorbed/released as part of a natural cycle;
  - if the transaction costs of including an emitting activity exceeds the benefits of its inclusion in the regime;
- mean the rate of the charge may be about the present value of the expected international emissions price in 2008 (\$5-\$10/tCO<sub>2</sub> or \$18 -\$36/tC);
- be designed so that revenues could offset other taxes or retire Government debt.

Complementary measures including information provision, education and energy efficiency measures would be used with each option.

## Appendix 13

### Sustainable Energy Supply Background Paper For NEECS

The Sustainable Energy Supply (EECA, 2001c) background paper states that:

- The government is investigating the introduction of economic instruments such as taxes, a levy on the use of carbon or a tradable permit scheme.
- The government is investigating the introduction of non-price measures such as
  - the requirement for electricity providers to derive a percentage of their product from renewable sources<sup>45</sup>;
  - the requirement for electricity providers to meet specified levels of energy savings among consumers of energy<sup>46</sup>;
  - demand side bidding introduced into the wholesale electricity market to lower barriers to entry into the market for those promoting new and emerging generation technologies.
- Local authorities could take into account national benefit of a new renewable energy source and CO<sub>2</sub> when deciding resource consents rather than just effects under the RMA.
- Energy supply sector could provide altered incentives to end users such as ensuring that:
  - energy markets produce prices that accurately reflect the true costs of producing energy (including environmental costs);
  - energy markets allow for differentiation of product types so that consumers can choose to use green energy; and
  - transmission and distribution pricing regimes take account of the avoided costs associated with distributed generation projects.
- The government might also like to consider:
  - demonstrations of new generation technologies;
  - improved resource and environmental approvals processes including the removal of legal and administrative barriers for embedded electricity generation; and
  - facilitating the development of regional planning infrastructure to support renewables including the setting of targets for renewables.

The Commercial and Industrial Users background paper (EECA, 2001a) criticises the fragmentation of the electricity efficiency industry and states there is little energy efficiency service offered by energy suppliers. It notes that the deregulation of the energy sector has

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<sup>45</sup> Like the Australian Renewable Energy Certificate Scheme introduced in 2001.

<sup>46</sup> Like the UK's Energy Efficiency Standards of Performance.

lead to lower priced electricity supply contracts which make energy efficiency investments less attractive. The paper also covers several future government initiatives in the industrial sector including:

- the continuation and expansion of existing programmes, particularly an enhanced voluntary agreement programme;
- implementation of a broader range of standards and performance regulations; and
- industrial and regional development initiatives that focus on energy-related technologies.

The Communities and Households background paper (EECA, 2001b) includes issues relating to energy use by householders, health and educational sector infrastructures, national organisations, councils, central government agencies and society as a whole. There were no issues in this paper that provided additional input to this study than that mentioned in earlier background papers.

## Appendix 14

### Review of Renewable Energy Definitions

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*1. Draft National Energy Efficiency and Conservation Strategy documents – EECA, New Zealand (EECA, 2001)*

*Renewable sources* of energy are those where the rate of extraction is either equal to or less than the rate of replacement.

*Traditional forms* include large-scale hydro electricity and geothermal projects.

*Non-traditional forms* of renewables include wind, solar (of various types), tidal, biomass and small-scale hydro projects.

(Authors note – if the overall purpose of any use of renewable energy is to limit the negative effects of fossil fuel combustion on the environment, the terms traditional and non-traditional are insignificant.)

*2. Electricity Industry Reform Act amendments (2001)*

“Renewable energy source” means an energy source that occurs naturally and the use of which will not permanently deplete New Zealand’s energy sources of that kind because those sources are generally expected to be replenished by natural processes within 50 years or less of being used.”

(Authors note - This time span is to allow for the use of biomass and the time allowed for a Pinus Radiata forest to fully regenerate. It will have implications on geothermal suppliers. The MED sought input on the definition from experts.)

*3. Green Party – NZ*

Jeanette Fitzsimons (2000) - “new renewables – wind electricity, passive solar heat for water and space heating, wood waste co-generation in the forestry industry, and eventually biofuels, photovoltaics and hydrogen”

(Authors note – exclusion of hydro may limit potential benefits to NZ on both an economic and environmental level)

*4. Australian Greenhouse Office – Australia*

The following technologies/sources will be eligible under the 2% Renewable Energy measure (where used for electricity generation, or in the case of solar hot water, where displacing electricity);

- solar;
- wind;
- ocean, wave and tidal;
- hydro;
- geothermal;
- biofuels (landfill gas, biogas, biomass);
- specified waste;
  - biomass by-products of agricultural crops but excluding broad-scale land-clearing for agricultural purposes;
  - biomass by-products of sustainably managed forestry operations;
  - biomass by-products of food processing and production industries;
  - sewage treatment;
  - biomass component of mixed municipal wastes;
  - other biomass wastes as approved by the regulator;
- solar water heating;
- pump storage hydro;
- Renewable Stand Alone Power Supply (RAPS) systems;
- co-firing renewables with fossil fuels; and
- fuel cells.

(Note - This definition continues to cause controversy.)

##### 5. UK – *New and Renewable Energy Prospects for the 21st Century, DTI 2000*

Renewable energy, at its most basic level, can be thought of as energy that occurs naturally and repeatedly in the environment. The basic definition of “renewable sources” in the Utilities Act 2000 is “sources of energy other than fossil fuel or nuclear fuel.” A summary of incentives for renewables in the UK is show in Table A10.

The most well known renewable energy sources are probably hydro, wind and solar power. However, as the above definition makes clear, Government targets for renewable energy can include energy generated from: *biofuels* (e.g. all types of biomass, including *energy from waste, landfill gas, sewage gas, agricultural and forestry residues, and energy crops*); *onshore and offshore wind*; *water (hydro power, wave power and tidal energy)*; and *solar energy (including photovoltaics)*.”

Source	10% Target	Renewables Obligation	Climate Change Levy Exemption	Capital Grants
Landfill Gas	✓	✓	✓	
Sewage Gas	✓	✓	✓	
Energy from Waste	✓		✓	
Hydro < 10 MW	✓			
Hydro > 10 MW	✓	✓	✓	
Onshore wind	✓	✓	✓	
Offshore wind	✓	✓	✓	✓
Agricultural and forestry residues	✓	✓	✓	
Energy crops	✓	✓	✓	✓
Wave Power	✓	✓	✓	
Photovoltaics	✓	✓	✓	

(Source: <http://www.dti.gov.uk/renew/ropc.pdf>)

(Note – different definitions are deemed suitable for achieving different policy objectives. However this approach does not add to the simplicity of a comprehensive energy plan with environmental integrity.)

## 6. US State Definitions

Table A11 shows the renewable energy technologies that are accepted as renewable in different states of the USA.

	Wind	Solar	Geothermal	Biomass	Municipal waste	Ocean based	Hydro	Fuel cells <sup>47</sup>
California	X	X	X	X	X	X	X <sub>1</sub>	X
Connecticut	X	X		X	X	X	X	X
Delaware	X	X	X	X			X	
Illinois	X	X		X		X	X <sub>2</sub>	
Maine	X	X	X	X	X	X	X	X
Maryland	X	X	X	X	X	X	X	
Massachusetts	X	X		X	X		X <sub>3</sub>	X
Montana	X	X	X	X			X	
Nevada	X	X	X	X				

<sup>47</sup> Fuel cells can only be considered renewable if the hydrogen is sourced from renewable sources using renewable electricity for its generation.

	Wind	Solar	Geothermal	Biomass	Municipal waste	Ocean based	Hydro	Fuel cells <sup>47</sup>
New Jersey	X	X	X	X	X	X	X <sup>4</sup>	X
New Mexico	X	X	X	X			X	X
New York	X	X	X	X			X	X
Ohio	X	X		X			X	X
Oregon	X	X	X	X	X		X <sub>5</sub>	
Pennsylvania	X	X	X	X	X		X <sub>6</sub>	
Rhode Island	X	X		X			X <sub>7</sub>	X
Texas	X	X	X	X		X	X	
Wisconsin	X	X	X	X		X	X <sub>8</sub>	X

There are additional notations possible throughout this chart but for the purpose of this thesis only the hydro related notes are recorded.

1. Hydro must be no larger than 30MW.
2. Hydro power must not involve new construction or significant expansion of dams.
3. Waste-to-energy and hydro defined as renewable, but not counted as “new” renewables.  
Two interpretations of the term “Naturally Flowing Water and Hydroelectric” is being considered: (1) All hydroelectric eligible except for pumped storage or (2) only run of river hydroelectric.
4. Hydro must be located outside of protected areas as defined by Federal Law.
5. Only “low head” hydro.
6. Only hydro under 100MW that does not require construction of new dams.
7. Only hydro under 60MW.

(Authors note – this shows the definition of “renewable” is highly affected by geography, access to resources and policy drivers.)

### 7. US Federal Definition

Executive Order 13123 defines renewable energy as “energy produced by solar, wind, geothermal and biomass power”. In addition, the Public Utilities Regulatory Policy Act (PURPA) of 1978 included hydro power facilities of less than 30MW capacity and other resources such as municipal solid waste in defining renewable electricity.

## Appendix 15

### Advantages and disadvantages of different mechanisms to increase renewable energy

Mechanism	Advantages	Disadvantages
Negotiated Agreements with electricity sector	<p>Will incentivise more efficient thermal technology</p> <p>CO<sub>2</sub> emissions constrained by agreements (provided the system is mandatory &amp; the non-compliance penalty is high enough)</p>	<p>Will only incentivise thermal generators to reduce emissions, rather than all generators to invest in renewables. Unless renewable energy projects are considered to be emission reduction projects.</p> <p>Unit of measure will not be tradeable internationally/cross sector</p> <p>No experience pre international CO<sub>2</sub> market</p> <p>No early discovery of price of carbon</p> <p>Opportunity to maximise least cost reduction delayed without access to international market</p>
Mandatory renewables quota for electricity retailers – e.g. Australian Green Electricity Market (GEM) scheme	<p>Will increase generation by renewables relative to a “business as usual” scenario provided existing renewables are not offset</p> <p>Will reduce future growth in CO<sub>2</sub> emissions</p> <p>Promote growth in renewable energy technologies with associated export opportunities</p>	<p>Will not reduce current CO<sub>2</sub> emissions (unless renewables offset thermal generation)</p> <p>Will not incentivise more efficient thermal technology</p> <p>Unit of measure will not be tradeable internationally/cross sector</p> <p>No experience pre international CO<sub>2</sub> market</p> <p>No early discovery of price of carbon</p> <p>Opportunity to maximise least cost reduction delayed without access to international market</p> <p>If “new” has priority over “existing” then could result in hydro spill from existing plants</p>

<b>Mechanism</b>	<b>Advantages</b>	<b>Disadvantages</b>
<p>Mandatory renewables quota for electricity generators</p> <p>Mandatory renewables quota for electricity generators (cont)</p>	<p>Will increase generation by renewables relative to a “business as usual” scenario provided existing renewables are not offset</p> <p>Will reduce future growth in CO<sub>2</sub> emissions</p> <p>Promote growth in renewable energy technologies with associated export opportunities</p>	<p>Likely to reduce efficiency of wholesale electricity market if renewable energy dispatch is prioritised, &amp; could cause perverse pricing signals</p> <p>Will not reduce CO<sub>2</sub> emissions (unless renewables offsets thermal generation)</p> <p>Will not incentivise more efficient thermal technology</p> <p>Unit of measure will not be tradeable internationally/cross sector</p> <p>No experience pre international CO<sub>2</sub> market</p> <p>No early discovery of price of carbon</p> <p>Opportunity to maximise least cost reduction delayed without access to international market</p>
<p>Prioritisation of renewables, guaranteed price via end user levy</p>	<p>Will increase generation by renewables relative to a “business as usual” scenario provided existing renewables are not offset</p> <p>Promote growth in renewable energy technologies with associated export opportunities</p> <p>Will reduce future growth in CO<sub>2</sub> emissions</p>	<p>Likely to reduce efficiency of wholesale electricity market if renewable energy dispatch is prioritised, &amp; could cause perverse pricing signals</p> <p>Will not reduce CO<sub>2</sub> emissions (unless renewables offsets thermal generation)</p> <p>Very complex, potential to distort electricity market</p> <p>High administrative complexity</p> <p>Unit of measure will not be tradeable internationally/cross sector</p> <p>No experience pre international CO<sub>2</sub> market</p> <p>No early discovery of price of carbon</p> <p>Opportunity to maximise least cost reduction delayed without access to international market</p>
<p>Tradeable fossil fuel permits (cap &amp; trade scheme)</p>	<p>CO<sub>2</sub> emissions are constrained by number of permits – directly achieves one of Strategy goals</p>	<p>Indirect driver for increase in proportion of electricity generated from renewable energy (increase in wholesale price)</p>

Mechanism	Advantages	Disadvantages
Tradeable fossil fuel permits (cap & trade scheme) (cont)	<p>Will incentivise introduction of more efficient thermal technology (provided CO<sub>2</sub> emissions constraint is low enough)</p> <p>Provides experience of CO<sub>2</sub> emission trading in advance of any international market developing</p> <p>Provides for early discovery of the price of carbon</p> <p>Provides opportunity to maximise least cost reduction delayed without access to international market</p>	
Financial incentives – tax based incentives, or increased funding for targeted industries (e.g. solar)	<p>Will increase generation by renewables relative to a “business as usual” scenario provided existing renewables are not offset</p> <p>Promote growth in renewable energy technologies with associated export opportunities</p> <p>Will reduce future growth in CO<sub>2</sub> emissions</p>	<p>Will not reduce CO<sub>2</sub> emissions (unless renewables offsets thermal generation)</p> <p>Will not incentivise more efficient thermal technology</p> <p>No experience pre international CO<sub>2</sub> market</p> <p>No early discovery of price of carbon</p> <p>Opportunity to maximise least cost reduction delayed without access to international market</p>
Moratorium on thermal build	<p>Caps existing CO<sub>2</sub> emissions</p> <p>Increase in renewable energy investment when demand for new capacity occurs</p>	<p>Existing thermal not displaced by more efficient plant</p> <p>No experience pre international CO<sub>2</sub> market</p> <p>No early discovery of price of carbon</p> <p>Opportunity to maximise least cost reduction delayed without access to international market</p>



## Appendix 16

### **List of possible renewable energy supply generation stations**

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Removed due to commercial nature of information

Note: Biomass has been excluded.



## **Appendix 17**

### **Comparison between macro and resource based assessment of renewable energy opportunities**

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Removed due to commercial nature of information

## Appendix 18

### Justification for thermal plant

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Removed due to commercial nature of information

## Appendix 19

### Scenario 2 - 1990 RE Level Scenario Base Data

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Removed due to commercial nature of information

## Appendix 20

### Scenario 2 - 1990 RE Level Scenario Annual Target Calculations

Years	AUSTRALIA			NEW ZEALAND					
	Cumulative Ramping Target (GWh/year)	Incremental annual increase in RE as % of total target	Cumulative Increase as %	Increase in RE yearly (GWh)	Effect of thermal com'ing (GWh)	Target increase (GWh)	Effect of thermal decom'ing (GWh)	Target reduction (GWh)	Total new RE req'd (GWh)
2002	300	3.16%	3.16%	339.60	0.00	0.00	0.00	0.00	339.60
2003	1100	8.42%	11.58%	905.59	0.00	0.00	0.00	0.00	905.59
2004	1800	7.37%	18.95%	792.39	0.00	0.00	0.00	0.00	792.39
2005	2600	8.42%	27.37%	905.59	0.00	0.00	0.00	0.00	905.59
2006	3400	8.42%	35.79%	905.59	0.00	0.00	0.00	0.00	905.59
2007	4500	11.58%	47.37%	1245.30	0.00	0.00	556.08*	213.56**	1031.74
2008	5600	11.58%	58.95%	1245.30	0.00	0.00	0.00	52.21	1193.09
2009	6800	12.63%	71.58%	1358.21	0.00	0.00	0.00	56.94	1301.27
2010	8100	13.68%	85.26%	1471.13	0.00	0.00	0.00	61.67	1409.46
2011	9500	14.74%	100.00%	1585.12	0.00	0.00	0.00	66.45	1518.67
TOTAL		100.00%		10753.82	0.00	0.00	556.08	450.83	10302.99

\* The GWh impact of decommissioning the 120MW of New Plymouth 1 is calculated using a capacity factor of 52.9 see Appendix 25. I.e.  $120 \times 8760 \times .529 / 1,000$ . The impact of decommissioning the other plants in this scenario is nil as they would not have been operating under BAU circumstances.

\*\*  $556.08 \times \text{renewable energy target } (.8107) = 450.8$ . This total amount multiplied by the incremental annual increase in RE for each year after decommissioning other than the first year where the cumulative increase is used.

## Appendix 21

### Scenario 3 - 1999 RE Level Scenario Base Data

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Removed due to commercial nature of information

## Appendix 22

### Scenario 3 - 1999 RE Level Scenario Annual Target Calculations

Years	AUSTRALIAN			NEW ZEALAND					
	Cumulative Ramping Target (GWh/year)	Incremental annual increase in RE as % of total target	Cumulative Increase as %	Increase in RE yearly (GWh)	Effect of thermal comm'ing GWh	Target increase (GWh)	Effect of thermal decom'ing	Target reduction (GWh)	Total New RE req'd (GWh)
2002	300	3.16%	3.16%	195.49	0.00	0.00	0.00	0.00	195.49
2003	1100	8.42%	11.58%	521.32	0.00	0.00	0.00	0.00	521.32
2004	1800	7.37%	18.95%	456.15	0.00	0.00	0.00	0.00	456.15
2005	2600	8.42%	27.37%	521.32	0.00	0.00	0.00	0.00	521.32
2006	3400	8.42%	35.79%	521.32	0.00	0.00	0.00	0.00	521.32
2007	4500	11.58%	47.37%	716.88	0.00	0.00	556.08	187.22*	529.65
2008	5600	11.58%	58.95%	716.88	0.00	0.00	0.00	45.77	671.11
2009	6800	12.63%	71.58%	781.88	0.00	0.00	0.00	49.92	731.96
2010	8100	13.68%	85.26%	846.88	0.00	0.00	0.00	54.07	792.81
2011	9500	14.74%	100.00%	912.50	0.00	0.00	0.00	58.26	854.24
<b>Total</b>		100.00%		6190.63	0.00	0.00	556.08	395.24	5795.39

\* This number is different from the other scenarios as the renewable target is 71.08%.

## Appendix 23

### Scenario 4 – Hybrid Scenario Base Data

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Removed due to commercial nature of information

## Appendix 24

### Scenario 4 – Hybrid Scenario Target Calculations

Years	AUSTRALIAN			NEW ZEALAND					Total (GWh)
	Cumulative Ramping Target	Incremental annual increase in RE as % of total target	Cumulative Increase as %	Increase in RE yearly (GWh)	Effect of comm'ing (GWh)	Target increase (GWh)	Effect of decom'ing (GWh)	Target reduction (GWh)	
2002	300	3.16%	3.16%	241.59	0.00	0.00	0.00	0.00	241.59
2003	1100	8.42%	11.58%	644.24	0.00	0.00	0.00	0.00	644.24
2004	1800	7.37%	18.95%	563.71	3223.68	495.18	0.00	0.00	1058.88
2005	2600	8.42%	27.37%	644.24	0.00	220.08	0.00	0.00	864.32
2006	3400	8.42%	35.79%	644.24	0.00	220.08	0.00	0.00	864.32
2007	4500	11.58%	47.37%	885.91	0.00	302.64	556.08	213.558	974.99
2008	5600	11.58%	58.95%	885.91	0.00	302.64	0.00	52.20	1136.34
2009	6800	12.63%	71.58%	966.23	0.00	330.08	0.00	56.94	1239.37
2010	8100	13.68%	85.26%	1046.56	0.00	357.52	0.00	61.67	1342.41
2011	9500	14.74%	100.00%	1127.66	0.00	385.22	0.00	66.45	1446.43
<b>Total</b>	<b>9500</b>	<b>100.00%</b>	<b>100.00%</b>	<b>7650.27</b>	<b>3223.68</b>	<b>2613.42</b>	<b>556.08</b>	<b>450.82</b>	<b>9812.87</b>

\* This number is different from the previous scenario as the renewable target is 81.07%.

## Appendix 25

### Annual New Generation Build Lists and Calculations for Scenarios 2-4

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The following three pages show the list of new electricity generation stations that are required to meet the requirements of the three scenarios.

- Page 233 – Scenario 2 – Return to 1990 RE levels (81.07%) by 2012
- Page 235 – Scenario 3 – Return to 1999 RE levels (71.08%) by 2012
- Page 237 – Scenario 4 – Hybrid

Removed due to commercial nature of information



## Appendix 26

### GHG units of measurement/estimation and calculations for gas GHG conversion factor

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This appendix covers:

- GHG units of measurement
- GHG data quality
- GHG emission factors
- GHG data used in this thesis
- Verification of GHG data used

#### GHG units of measurement

The two most common units of measure of GHG emissions are:

- Tonnes of carbon (tC); and
- Tonnes of carbon dioxide equivalent (tCO<sub>2</sub>-e).

The use of different units of measurement in GHG calculations often causes confusion so it is important that the units are always explicitly stated. To convert from a C to a CO<sub>2</sub> equivalent basis, a conversion factor based on the molecular weights is used i.e. 44 for CO<sub>2</sub> and 12 for C.

$$\begin{aligned} & \text{Conversion factor for CO}_2\text{-equivalent to C} \\ = & \frac{\text{Molecular weight of C}}{\text{Molecular weight of CO}_2} = \frac{12}{44} = 0.27 \end{aligned}$$

$$\begin{aligned} & \text{Conversion factor for C to CO}_2\text{-equivalent} \\ = & \frac{\text{Molecular weight of CO}_2}{\text{Molecular weight of C}} = \frac{44}{12} = 3.67 \end{aligned}$$

tCO<sub>2</sub>-e indicates that the GHG emissions have been converted back to the CO<sub>2</sub> equivalent value by multiplying by the Global Warming Potential (GWP) figures as reported in Table 2.1. The GWP of CO<sub>2</sub> is used as the base with a GWP of 1. Different gases have different impacts over time but the IPCC uses the 100 year GWP figures so these will be utilised in this thesis.

In a global sense a tonne of carbon or carbon dioxide is very small so it is more common to report emissions on a kt or Mt basis. In the Kyoto Protocol itself the emission reduction targets are stated in Gg which is the equivalent of kt.

## GHG data quality

It is important to be aware that there are significant uncertainties in the estimates of GHG data available. The estimated uncertainties of the most significant GHGs as reported by the MED (2000) are shown in the table below.

<b>GHG Emissions</b>	<b><u>Level of uncertainty</u></b>
CO <sub>2</sub> emissions	+/- 5%
CH <sub>4</sub> emissions	+/- 50%
N <sub>2</sub> O emissions	+/- 50%
NO <sub>x</sub> emissions	+/- 33%
CO emissions	+/- 50%
NMVOC emissions	+/- 50%
SO <sub>2</sub> emissions	+/- 20%

These uncertainties are based on the emission factors and the energy data used. CO<sub>2</sub> has less associated errors as more data exists concerning variability of CO<sub>2</sub> emission factors in New Zealand while non-CO<sub>2</sub> data is based on global averages from IPCC guidelines.

Emission factors for non-CO<sub>2</sub> GHGs are less accurate than CO<sub>2</sub> emission factors which are based on the actual carbon content of fuel. It is accepted (MED,2000) that complete combustion occurs when fuel is burnt, irrespective of the type of engine used, meaning that all carbon is converted to CO<sub>2</sub>. This means there is double counting of the carbon that is included in CH<sub>4</sub>. However eventually all CH<sub>4</sub> turns to CO<sub>2</sub> in the atmosphere so in the long term, this assumption is correct.

In contrast, non-CO<sub>2</sub> emissions are dependent on several issues including temperature, duration and temperature of combustion and emission control devices.

It is important that the gas that is being referred to is clearly stated with unit basis either C, C-e, CO<sub>2</sub> or CO<sub>2</sub>-e.

## GHG Emission Factors

The most common form of GHG emission data is an emission factor, which is used to estimate the amount of GHG emitted from a given quantity of fuel. It is expressed in terms of the amount of gas released per unit of energy in the fuel. For example, sub-bituminous coal has an emission factor of 91.2 kt CO<sub>2</sub>/PJ. In 1999, electricity generation in New Zealand used 12.2 PJ of coal.

$$\begin{aligned}
& \text{Total emissions (ktCO}_2\text{)} \\
& = \text{Emission factor (ktCO}_2\text{/PJ)} \times \text{Quantity of fuel used (PJ)} \\
& = 91.2 \times 12.2 \\
& = 1112.64 \text{ kt CO}_2
\end{aligned}$$

Therefore the total emissions were 1112.64 kt CO<sub>2</sub> from the use of coal for electricity generation in New Zealand in 1999.

In official NZ GHG documentation, NO<sub>x</sub>, CO and NMVOC are reported more commonly than the HFC family, the PFC family and SF<sub>6</sub>. Often (such as in New Zealand's VA agreements), only CO<sub>2</sub> emissions are considered.

### **GHG data used in this thesis**

Six GHGs are included in the Kyoto Protocol: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, the HFC family, the PFC family and SF<sub>6</sub>. However only the first three will be considered in this assessment, as the levels of the others are insignificant when burning fossil fuels. There is also a lack of data for the HFCs, PFCs and SF<sub>6</sub>.

The data collection process was much more challenging than expected due to the variability of data from different sources. The main problems tended to lie with lack of accuracy with units when reporting CO<sub>2</sub> levels and total greenhouse gas levels. CO<sub>2</sub>-e is a very useful measure because it converts each of the greenhouse gases back to a CO<sub>2</sub> equivalent.

A total CO<sub>2</sub>-e conversion factor for emissions of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O for fuels used in electricity generation was required for the modelling.

Using coal as an example, the CO<sub>2</sub>-e conversion figure was calculated taking into account emissions from CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O and utilising figures from MED's NZ Energy Greenhouse Gas Emissions 1990-1999 (2000).

$$\begin{aligned}
& \text{Conversion Factor to convert PJ of Coal to total CO}_2\text{-e taking into account CO}_2\text{, CH}_4\text{ and N}_2\text{O} \\
& = \text{CO}_2\text{ Emission Factor} + \text{CH}_4\text{ CO}_2\text{-e Conversion Factor} + \text{N}_2\text{O CO}_2\text{-e Conversion Factor} \\
& = \text{CO}_2\text{ Emission Factor} + (\text{CH}_4\text{ Emission Factor} \times \text{CH}_4\text{ GWP}) + \\
& (\text{N}_2\text{O Emission Factor} \times \text{N}_2\text{O GWP}) \\
& = 91.2 \text{ ktCO}_2\text{/PJ} + (0.7\text{tCH}_4\text{/PJ} \times 21 \text{ GWP}) + (1.5\text{tN}_2\text{O/PJ} \times 310 \text{ GWP}) \\
& = 91.67 \text{ ktCO}_2\text{-e/PJ of coal}
\end{aligned}$$

The table below shows a summary of calculations based on MfE's (2000a) data for a range of energy sources.

### Emission Factor Calculations based on MfE (2000a)

Fuel	Carbon Emiss. Factor (ktC/PJ) (reported tC/TJ = ktC/PJ)	Fraction Oxidised	CO2 Conver. (44/12)	Actual Emissions ktCO2/PJ		CH4 Emiss. Factor (tCH4/PJ) (reported kg/TJ = tCH4/PJ)	GWP Conver. Factor 21.000	CH4 CO2 Equivalent (tCO2/PJ) Conver. Factor	N2O Emiss. Factor (tN2O/TJ) (reported kg/TJ = tN2O/PJ)	GWP Conver. Factor 310.000	N2O CO2 Equivalent (tCO2/PJ) Conver. Factor	Total CO2-e Conver. Fact ktCO2-e/PJ
Natural gas	14.400	0.995	3.667	52.536	Gas	2.470	21.000	51.870	0.251	310.000	77.810	52.6
Sub-bit. Coal	25.400	0.980	3.667	91.271	Coal	0.700	21.000	14.700	1.500	310.000	465.000	91.7
Wood	28.400	1.000	3.667	104.133								0.0
Gasoline	18.200	0.990	3.667	66.066								
Diesel	18.700	0.990	3.667	67.881								
Fuel oil	20.100	0.990	3.667	72.963	Oil	2.299	21.000	48.279	0.324	310.000	100.440	73.1

The following table shows the same calculations based on MED's (2000) data.

### Emission Factor calculations based on MED (2000) data

	CO2 Emission Factors	CH4 Emission Factors		N2O Emission Factors		Total CO2-e Conversion Factor
	kt CO2/PJ	tCH4/PJ	CH4 CO2-e Convers. Factor tCO2-e/PJ	tN2O/PJ	N2O CO2-e Convers. Factor tCO2-e/PJ	Total CO2-e Convers. Factor ktCO2-e/PJ
Margins of error	+/- 5%	+/- 50%		+/- 50%		
Global Warming Potential	1.000	21.000		310.000		
<i>Distributed Natural Gas</i>						
Maui	52.450					
Treated	52.540					
Average industrial use	52.490	1.300	27.300	0.090	27.900	52.545
Electricity Generation	52.490	2.700	56.700	0.090	27.900	52.575
<i>Other Gas Streams</i>						
Kapuni LTS	84.100					
Waihapa/Ngaere	56.200					
Kaimiro	65.200					
McKee	54.200					
Ngatoro	52.800					
<i>Coal</i>						
Sub-bituminous B	91.200	0.700	14.700	1.500	465.000	91.680
<i>Biomass</i>						
Wood	104.200	14.000	294.000	4.000	1240.000	105.734
<i>Biogas</i>						
Gaseous biomass	101.000	1.100	23.100	2.100	651.000	101.674
<i>Liquid Fuels</i>						
Petrol	66.600	60.000	1260.000	3.000	930.000	68.790
Diesel	68.700	13.000	273.000	3.000	930.000	69.903
Fuel Oil	73.700	2.900	60.900	0.300	93.000	73.854
Aviation Fuels	68.700	1.500	31.500	1.100	341.000	69.073
LPG	60.400	40.000	840.000	2.800	868.000	62.108
Other Fuels	72.900					
Residual oil for electricity		0.900	18.900	0.290	89.900	
Distillate oil for electricity		0.900	18.900	0.380	117.800	

CO<sub>2</sub> emissions from gas vary from year to year. For these calculations, an average of the 1990 – 1999 emissions is used. The electricity generation and average industrial use figures are based on 50% Maui and 50% treated (ex-Kapuni) gas. These calculations are shown in the following table.

### New Zealand Gas conversion factor (ktCO<sub>2</sub>/PJ) from MED (2000)

	Maui	Treated	Average
1990	53.200	52.400	52.800
1991	52.900	52.800	52.800
1992	52.900	52.700	52.800
1993	52.600	52.500	52.500
1994	52.400	52.200	52.300
1995	52.100	52.900	52.500
1996	52.2	52.9	52.6
1997	52.3	52.4	52.4
1998	52.1	52.2	52.1
1999	51.8	52.4	52.1
Average	52.45	52.54	52.49

The table below shows a comparison of the conversion factors generated using the MfE data versus the data from the MED data for natural gas and coal which are the only two fossil fuel sources used in New Zealand’s major thermal electricity plants. The data highlighted in red was used in the Market Simulation Module. It differs by less than 0.5% from the CO<sub>2</sub> information offered by Baines (1993) which is shown in the last column. This is less than the overall uncertainty relating to the natural gas emission factor which is 5.1% and for the coal emission factor it is 5.2%, based on the uncertainty related to CH<sub>4</sub> and N<sub>2</sub>O being 50% while the uncertainty associated with CO<sub>2</sub> is 5%.

### Comparison of emission factors based on MfE and MED data

	ktCO <sub>2</sub> /PJ			tCO <sub>2</sub> -e/PJ for CH <sub>4</sub>			tCO <sub>2</sub> -e/PJ for N <sub>2</sub> O			Total ktCO <sub>2</sub> -e/PJ			ktCO <sub>2</sub> Baines
	MED	MfE	Diff.	MED	MfE	Diff.	MED	MfE	Diff.	MED	MfE	Diff.	
Natural Gas	52.5	52.5	0.0	56.7	51.9	4.8	27.9	77.8	-49.9	52.6	52.7	-0.1	52.7
Sub-bit. Coal	91.2	91.3	-0.1	14.7	14.7	0.0	465.0	465.0	0.0	91.7	91.8	-0.1	91.2

### Verification of GHG data used

Due to concerns about accuracy of data gathered from various sources, the final data for this exercise was verified by the MfE but still needs to be considered in light of the uncertainties above.

The discrepancies between the MEDs (2000) data and the MfE (2000a) data were discussed an MfE official (Russel, 2001) who suggested the errors had three main causes:

- rounding errors in the reports;
- differences in descriptions of fuel sources, this was particularly a problem with fuel oil,
- MfE New Zealand Inventory data uses different descriptions for different gases; and
- with natural gas there is annual source variability which could lead to discrepancies depending on how which figure is selected.

MfE staff recommended that MED data be used as MfE data is based in annual average figures so MED should be more exact (Russell, 2001).

## Appendix 27

### Market Simulation Module Outputs for Scenarios 1-5

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The following 5 pages show the list of new electricity generation stations by generating company that would be required to meet the requirements of the 5 scenarios.

- Page 247 – Scenario 1 – Base Case
- Page 249 - Scenario 2 – Return to 1990 RE levels (81.07%) by 2012
- Page 251 – Scenario 3 – Return to 1999 RE levels (71.08%) by 2012
- Page 253 – Scenario 4 – Hybrid
- Page 255 – Scenario 5 –Base Case + 1% Energy Efficiency Improvement

Removed due to commercial nature of information.



## Appendix 28

### Scenario 1 – Base Case Scenario Impact Illustration Module Output<sup>48</sup>

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<sup>48</sup> See notes in Appendix 27.



## Appendix 29

### Scenario 2 - 1990 RE Level Scenario Impact Illustration Module Output<sup>49</sup>

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<sup>49</sup> See notes in Appendix 27.



## Appendix 30

### Scenario 3 - 1999 RE Level Scenario Impact Illustration Module Output<sup>50</sup>

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Removed due to commercial nature of information

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<sup>50</sup> See notes in Appendix 27.



## Appendix 31

### Scenario 4 - Hybrid Scenario Market Illustration Module Output<sup>51</sup>

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Removed due to commercial nature of information

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<sup>51</sup> See notes in Appendix 27.



## Appendix 32

### Scenario 5 – Base Case + 1% Energy Efficiency Improvement Market Illustration Module Output<sup>52</sup>

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Removed due to commercial nature of information

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<sup>52</sup> See notes in Appendix 27.



## Appendix 33

### Australian Renewable Energy Policy

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There is a sizable renewable energy programme administered by the Australian Greenhouse Office (AGO) with total funding of up to \$321m available over four years, commencing 1 July 2000 for supporting renewable energy including:

1. Renewable Energy Innovation Investment Fund supports the demonstration and commercialisation of innovative, substantially Australian renewable energy equipment, technologies, systems and processes. This is a 5-year, \$55.6 million competitive grants program;
2. Renewable Energy Commercialisation Program (A\$29.6M);
3. Renewable Energy Showcase (A\$10.5M);
4. Renewables commercialisation, Photovoltaic Rebate Program and Renewable Remote Area Power Grant Program is funded from excise from publicly owned diesel driven electricity generation (A\$321M);
5. Mandatory 2% target for uptake of renewable energy in power supplies. "Electricity retailers and other large electricity buyers will be legally required to source an additional 2% of their electricity from renewable or specified waste product energy sources by 2010." This will represent an additional 9500GWh per annum new renewables by 2010, the maximum penalty that will apply is A\$40/MWh for shortfalls or A\$57/MWh including tax liabilities. Eligible "renewable energy sources" are solar, wind, ocean, wave, tidal, hydro, geothermal, biofuels (landfill gas and biogas) and solar water heating, specified waste, pump storage hydro with fossil fuel contribution netted out, renewable stand alone power supply, renewables component of co-firing and fuel cells using renewable fuel.

The Greenhouse Gas Abatement Program is supported by an investment of A\$400M. Its objectives are to support initiatives that result in significant and sustained reductions in Australia's greenhouse gas emissions and assist in meeting Kyoto Protocol targets.

Its key features include:

- facilitates large abatement opportunities;
- allows participation by a wide range of sectors;
- key criteria for proposal assessment is cost-effectiveness of abatement;
- abatement must be new and additional;
- payments will be tied to performance indicators;
- excludes abatement activities covered by existing measures e.g. 2% renewables.

## Appendix 34

### Resources for the quantification of GHG emissions

Resource	Scope	Comments
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories	Estimation methods for the major sources of GHGs.	Developed for national level inventories, but may be useful for company-level estimates. Available at: <a href="http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm">www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm</a>
Australian Greenhouse Office - National GHG Inventory Committee Workbooks	Workbooks on national emissions inventory	National workbooks available at <a href="http://www.greenhouse.gov.au/inventory/methodology/method_content.html">www.greenhouse.gov.au/inventory/methodology/method_content.html</a> .
World Business Council for Sustainable Development/ World Resources Institute Collaboration	GHG emissions reporting protocol	See Resources section of <a href="http://www.ghgprotocol.org">www.ghgprotocol.org</a>
World Bank Greenhouse Gas Assessment Handbook	GHG emissions assessment methodologies for energy, industrial and land use projects	For evaluation of World Bank sponsored projects. Under "tool kit for Task Managers" at <a href="http://www-esd.worldbank.org/cc/">http://www-esd.worldbank.org/cc/</a>
US DOE, Lawrence Berkley National Laboratory	Guidelines for monitoring, evaluation, reporting, verification, and certification of energy efficiency and mitigation projects	Focus is on energy-related emissions and reductions. Available at <a href="http://eetd.lbl.gov/ea/ccm/ccpubs.html">http://eetd.lbl.gov/ea/ccm/ccpubs.html</a>
US EPA Emissions Inventory Improvement Program, Volume 8, GHGs	Designed to provide guidance to states on estimating emissions of each of the Kyoto GHGs	Available at <a href="http://www.epa.gov/ttn/chief/eiip/techrep.htm#green">www.epa.gov/ttn/chief/eiip/techrep.htm#green</a>

<b>Resource</b>	<b>Scope</b>	<b>Comments</b>
Global Environmental Management Initiative (GEMI)	Overview of the corporate GHG emissions inventory process	See “Measurement and Metrics” sections of <a href="http://www.businessandclimate.org">www.businessandclimate.org</a>
UK Department of Environment, Transport and Regions Reporting on GHG Emissions	Manual on GHG emissions reporting for voluntary reporting by companies	Provides guidance on boundary questions as well as emissions estimation for fossil fuel combustion., Includes lists of guides for sector specific emissions. Available at <a href="http://www.environment.detr.gov.uk/envr/p/gas">www.environment.detr.gov.uk/envr/p/gas</a>
US EPA AP-42	Compilation of conventional and GHG air pollutant emissions factors for stationary sources.	Available at: <a href="http://www.epa.gov/ttn/chief/ap42.html#chapter">www.epa.gov/ttn/chief/ap42.html#chapter</a>

(Source: Loreti C. et al, 2000)