Environment Waikato Technical Report 2007/02

A Discussion on Decoupling Economic Growth from the Emissions of Carbon Dioxide

www.ew.govt.nz
ISSN 1172-4005

Environment Waikato
REGIONAL COUNCIL

Prepared by:
Annabelle Giorgetti

For:
Environment Waikato & The Parliamentary Commissioner for the Environment

P O Box 4010	P O Box 10241
HAMILTON EAST	Wellington

14 February 2007

Doc # 1114156-v10

Peer reviewed by:
Annabelle Giorgetti Date Feb 2007

Approved for release by:
Paul Chantrill Date Feb 2007

Disclaimer

This technical report has been prepared for the use of Waikato Regional Council as a reference document and as such does not constitute Council's policy.

Council requests that if excerpts or inferences are drawn from this document for further use by individuals or organisations, due care should be taken to ensure that the appropriate context has been preserved, and is accurately reflected and referenced in any subsequent spoken or written communication.

While Waikato Regional Council has exercised all reasonable skill and care in controlling the contents of this report, Council accepts no liability in contract, tort or otherwise, for any loss, damage, injury or expense (whether direct, indirect or consequential) arising out of the provision of this information or its use by you or any other party.

Table of Contents

Executive Summary

The purpose of this paper is to highlight the key sustainability issues associated with decoupling to encourage further discussion on the topic. It explores the link between economic growth and energy consumption and consequently the production of greenhouse gases (GHGs), specifically carbon dioxide (CO_2) emissions.

Like the rest of the world, New Zealand relies on fossil fuels for energy production, which release CO_2 emissions. These emissions have increased by 33 per cent since 1990. If New Zealand does not change its energy policies, then fossil fuels will prevail in electricity production and energy prices will rise.

Most countries are experiencing a direct link between CO_2 emissions and GDP: whilst economic activity rises, emissions increase. Progress in decoupling CO_2 emissions from economic growth has been slow. Most countries have experienced a slight drop in emissions relative to GDP but absolute emissions are still rising.

International trends show that declines in energy intensities have not been sufficient to offset a growing travel demand; absolute levels have not declined. Observed increases in demand for transportation and energy supply are consistently offsetting any gains.

There is mixed evidence on the causes for decoupling. Globally, it does not seem to be possible to offer a general answer as to whether decoupling is happening or not, therefore a focus on the actual CO_2 emissions may prove more productive.

New Zealand does not seem to have achieved either relative or absolute decoupling between GDP and CO_2 emissions. Emissions are growing at a higher rate than GDP. Recent data show a slight relative decoupling between GDP and energy demand.

The costs of not taking action to curb climate change are estimated to be five times the costs of action. Only the degree of urgency of action is being contested. In the absence of policy interventions, the long-run positive relationship between income growth and emissions per head is likely to persist.

New Zealand, like a number of other countries, will not be able to meet its Kyoto Protocol commitments solely through domestic decoupling and will have to buy emissions allowances on the international market.

Domestic decoupling opportunities include pricing CO_2 emissions, improving resource productivity and efficiency and supporting innovation. Opportunities are limited by a number of barriers New Zealand is experiencing related to its physical location, the type of its energy resources and the nature of its economy.

Looking at the long term costs and benefits of each policy option will identify the most promising mix. A short term policy measure for New Zealand may include buying allowances coupled with preparing domestic decoupling policies in the future. The more medium to long term goal could be to pursue domestic decoupling. With a number of initiatives already announced or under development to tackle climate change, New Zealand is best to use decoupling as an indicator to measure the success of its policies, rather than introducing it as a separate policy measure.

1 Introduction

1.1 Purpose

The purpose of this paper is to highlight the key sustainability issues associated with decoupling to encourage further discussion on the topic. The paper analyses and provides comments on some successful approaches to decoupling. Decoupling relates to the delinking of environmental damage from economic growth. The link between economic growth and energy consumption and consequently the production of greenhouse gases (GHGs), specifically carbon dioxide (CO_2) emissions is explored. This paper provides some preliminary findings on the topic recognising its complexity.

Specifically the paper covers the following key issues:

- Definition of coupling and decoupling
- The link between economic growth and CO_2 emissions
- Experience overseas and in New Zealand
- Can the link be broken?
- What are the challenges?
- What are the opportunities?
- Implications for New Zealand

1.2 Background

Global warming is caused by GHGs. The most dominant GHG for most countries is CO_2 (OECD, 2002). For New Zealand, methane emissions (CH_4) and CO_2 are the two main GHGs (MfE, 2007). CH_4 emissions come largely from livestock and CO_2 emissions are released largely by the burning of fossil fuels.

Global warming is caused by GHGs trapping infrared radiation from the earth within the atmosphere. If current GHG trends continue, the mean global temperature could increase 1.4 to 5.8°C by 2100 relative to 1990 and the global sea level could rise by 9–88 centimetres by 2100 (IPCC, 2001)[1].

Though these may seem like minor changes, they will have multiple adverse consequences. Forests and other ecosystems, unable to adapt to changing temperatures and precipitation patterns, will be damaged (Hawken, 1999). These ecosystems provide natural resources to produce goods and services (Hawken, 1999). Human societies rely on natural resources for economic development. Damaging these resources will compromise the ability of humans to continue the type of lifestyle they are currently living (Hawken, 1999).

For most countries, economic development is linked to CO_2 emissions (Sheram, 2000). Measuring economic growth helps explain the nature of the growth in emissions. Gross Domestic Product (GDP) is one way to measure economic growth[2].

Two thirds of New Zealand's energy comes from fossil fuels (MED, 2004). Like the rest of the world, New Zealand relies on fossil fuels for energy production (MfE, 2007). Fossil fuels such as coal, gas and oil provide energy sources for electricity, transport and households (MED, 2004).

Whereas CH_4 emissions made the largest contribution in 1990, CO_2 emissions were the major GHG in New Zealand's emissions profile in 2002 (MfE, 2007). Since 1990,

---

[1] Globally averaged surface temperatures have already increased by 0.6 ± 0.2°C over the 20th century (IPCC, 2001).

[2] GDP is the annual value of all goods produced and services provided within a nation (Gilpin, 1997). Despite many shortcomings in using GDP (such as it fails to reflect adequately social and environmental progress), it is widely used to measure progress in economic growth.

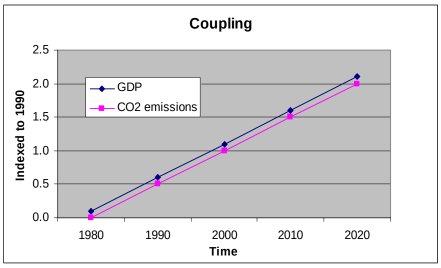
CO_2 emissions have increased by 33 per cent contributing to global warming (MfE, 2007).

This report looks at the relationship between GDP and CO_2 emissions. Looking at this relationship helps to understand how emissions grow in relation to economic growth. This will highlight what type of action, if any, can be taken to reduce emissions, without compromising economic growth. This report also explores whether decoupling is a useful policy measure.

The relationship between economic growth and CO_2 emissions is complex, subject to a number of variables (Galeotti, 2003). Thus the study of this relationship is challenging. The objective lies in reducing CO_2 emissions to acceptable levels as economies continue to grow (OECD, 2002).

1.3 A Definition of Coupling

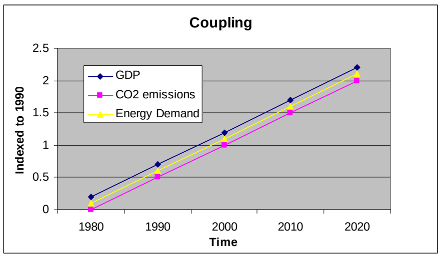
If CO_2 emissions grow at the same rate as GDP they are said to be 'coupled' or linked (Sheram, 2000). Theoretically, as GDP grows and countries get richer, CO_2 emissions grow at the same time (Azar, 2002). Graph 1 gives an example of coupling between GDP and CO_2 emissions.



Source: adapted from Azar, 2002.

Graph 1 An Example of Coupling between GDP and CO_2 Emissions.

CO_2 emissions result from the use of energy in form of fossil fuels (MfE, 2007). There seems to be a relationship between the demand for energy and GDP (Statistics New Zealand, 2006). Graph 2 shows an example of the link between GDP, energy demand and CO_2 emissions.



Source: adapted from Azar, 2002.

Graph 2 An Example of Coupling between GDP, Energy Demand and CO_2 Emissions

Most low and middle income countries are experiencing a direct and positive link between economic growth and increased energy consumption leading to increased CO_2 emissions (Sheram, 2000).

1.4 Evidence of Coupling Overseas

The relationship between CO_2 emissions and income in different countries has been analysed with the help of Environmental Kuznets Curves (EKCs) (Borghesi, 1999). Contrary to coupling, theoretical EKCs follow a typical bell-shaped, "inverted U" curve as shown in Figure 1 (Stern, 2006).

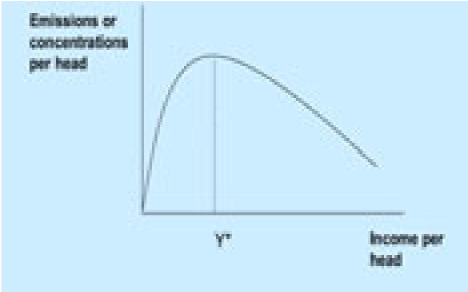


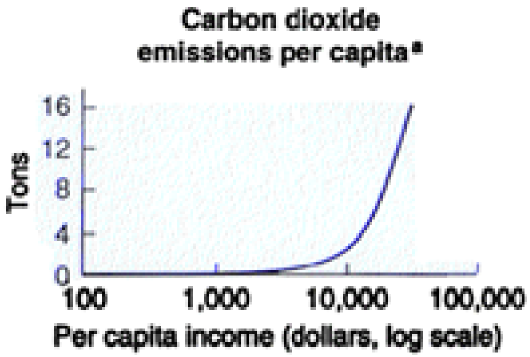
Figure 1 Hypothetical Environmental Kuznets Curve (Stern, 2006)

The EKC theory implies that continued economic growth and ensuing income growth of a particular country will eventually diminish CO_2 emissions per head. During the early stages of economic growth CO_2 emissions get worse; the poorer the country the higher the emissions. As citizens get richer by receiving higher incomes, emissions slow down and eventually decrease (Borghesi, 1999).

Comprehensive literature on EKCs has reviewed the relationship between different pollutants and economic growth (Aldy, 2005; Azar, 2002; Borghesi, 1999; Galeotti, 2006; Hill, 2002; Stern, 2005). Results are wide ranging, particularly given the assumptions used. Variables such as the type of pollutant, the nature of analysis and local variability complicate the findings on whether EKCs exist or not.

This paper focuses on the relationship between GDP and CO_2 emissions only. CO_2 emissions seem to be much harder to decouple from income (Azar, 2002). This could be due to the fact that emissions are distant in time and space weakening political pressure to do something about it (Azar, 2002).

For CO_2 emissions the existence of an EKC is hard to prove. For instance, Aldy has concluded that EKCs do not exist for CO_2 emissions (Aldy, 2005). That means that emissions do not fall when income rises. Quite the opposite, there seems to be a direct relationship between the two (Azar, 2002). This relationship can be seen in Graph 3, which shows an analysis across a number of countries.



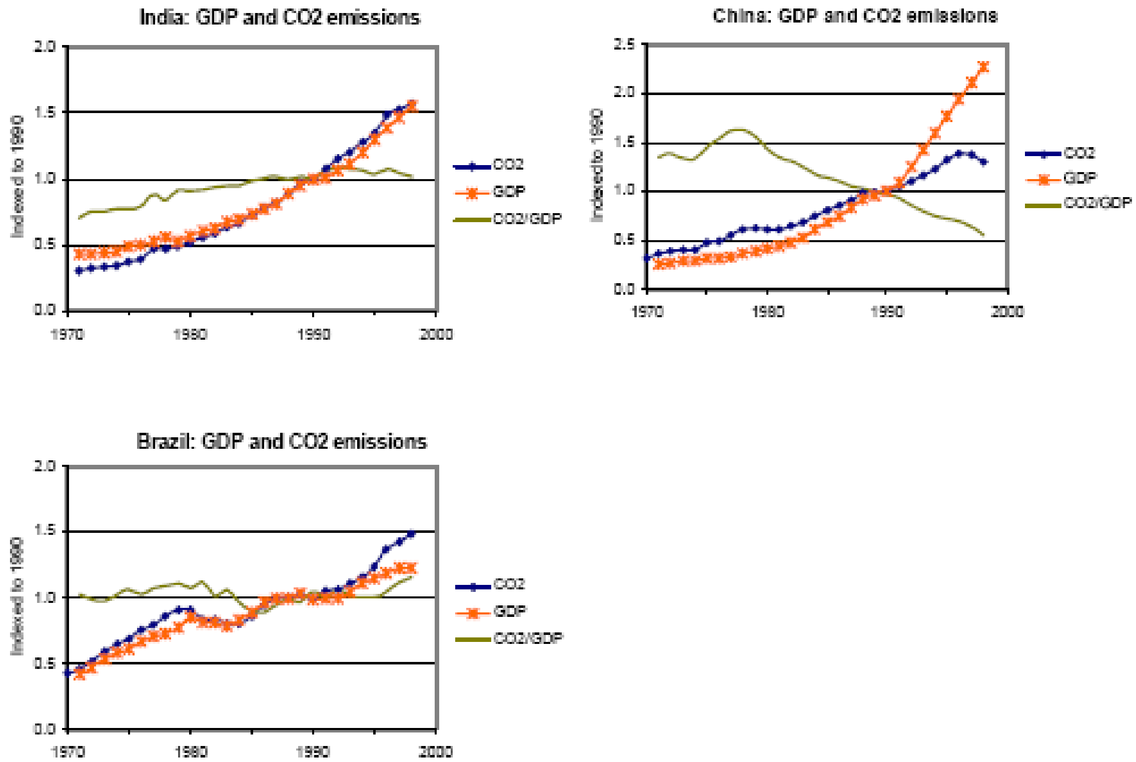
Note: Estimates are based on cross-country regression analysis of data from the 1980s.
[a] Emissions are from fossil fuels
Source: Azar 2002

Graph 3 CO_2 Emissions per Capita Income

As income rises led by economic growth, emissions per capita also rise.

Most developed countries such as the European Union, Japan, Sweden and the United States have experienced a slight drop in CO_2 emissions relative to GDP between 1970 and 2000 (Azar, 2002). This drop was faster over the period 1973 to 1988 than during subsequent years (Azar, 2002). CO_2 emissions started out being considerably higher than GDP in the 1970s but the gap narrowed in the following two decades, indicating a loss of the coupling.

Developing countries experiencing economic growth see a significant rise in CO_2 emissions. This has been the case for India, China and Brazil (Graph 4).



Source: Azar, 2001.

Graph 4 GDP and CO_2 Emissions for India, China and Brazil. Indexed to 1990.

For India and Brazil, emissions have grown in line with, or faster than, GDP over the past thirty years. Although it looks like emissions in China are starting to drop, there is uncertainty about the reliability of the GDP data (Azar, 2002).

1.5 Causes of Coupling

There are some reasons to support the theory of EKCs. The fall in emissions brought about as income rises and economies mature is believed to be caused by:

- consumers preferring less material intensive services;
- a fall in the demand for new infrastructure;
- materials being converted and used more efficiently; and
- an increase in recycling of energy-intensive materials (Azar, 2002).

It is said that these changes occur ‘naturally’ as countries become richer, leading to a fall in CO_2 emissions (Borghesi, 1999). However, both developed and developing countries have experienced and still are experiencing absolute growth in CO_2 emissions (Azar, 2002). Some exceptions include developed countries that have taken an active role in reducing emissions (such as Sweden), or developing countries which have not experienced economic growth (Azar, 2002).

The Organisation for Economic Co-operation and Development (OECD) indicates that increases in global absolute CO_2 emissions are caused primarily by:

- strong population and economic growth;
- energy production;
- consumption patterns and trends; and
- low real energy prices in the 1990s (OECD, 2002).

Stern outlines several reasons why CO_2 emissions do not tend to fall as economies grow, therefore not following the EKC theory:

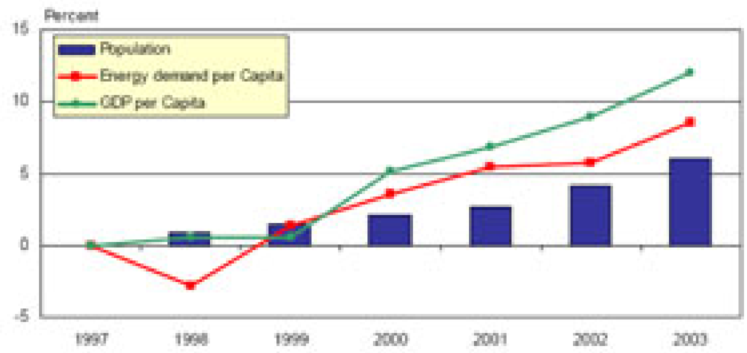
- Globalisation increases trade between countries around the globe raising transport needs for products, and therefore CO_2 emissions.
- Even though there is the desire to reduce emissions as individuals become richer, large reductions have not materialised.
- The global nature of climate change means that the incentive for individually doing something is very low.
- The relocation of manufacturing activity to developing countries just relocates emissions.
- Demand for some carbon-intensive goods and services – such as air transport – is highly sensitive to income and will continue to grow as incomes rise.
- Car transport is likely to rise rapidly in many developing countries (Stern, 2006).

For these reasons, at the global level and in the absence of policy interventions, the long-run positive relationship between income growth and emissions per head is likely to persist (Stern, 2006). Breaking the link requires significant changes in consumer choices, the relative prices of goods and services which produce high emissions and in key technological trends (Stern, 2006).

1.6 Evidence of Coupling in New Zealand

In New Zealand energy consumption has been growing faster than the global average (MED, 2004). This is caused predominantly by transport, industry and electricity generation demands (MED, 2006). This demand is directly linked to economic growth (MED, 2004).

Population growth also increases emissions. Graph 5 shows that there is a relationship between population growth, energy demand and GDP (Statistics New Zealand, 2006).

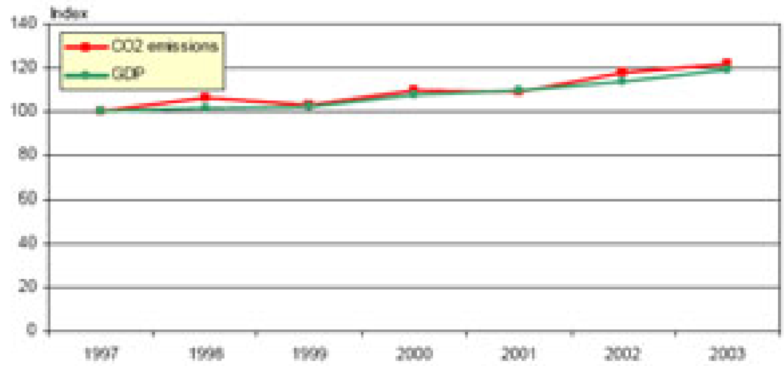


Source: Statistics New Zealand, 2006, p.6.

Graph 5 Change in Population, GDP/Capita and Energy Demand/Capita (1997 =100)*

Graph 5 shows that energy demand and GDP per capita are coupled. Between 1997 and 2003, New Zealand's total population has increased by around 6 per cent, whilst at the same time GDP per capita grew at double this rate. This has increased the demand for energy, especially fossil fuels (Statistics New Zealand, 2006).

There is evidence that CO_2 emissions are linked to economic activity (MED, 2004). Graph 6 shows that total CO_2 energy emissions in New Zealand between 1997 and 2003 closely follow GDP (Statistics New Zealand, 2006).



Source: Statistics New Zealand, 2006, p.8.

Graph 6 Change in New Zealand CO_2 Emissions Versus GDP (1997 = 100)

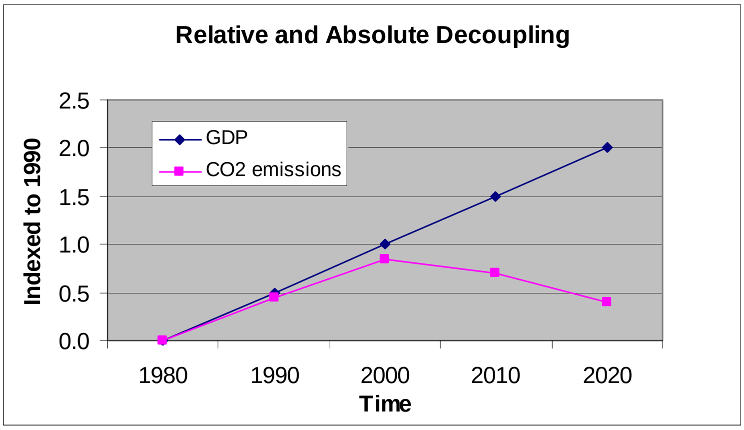
Since 1997, total CO2 emissions have increased by 21 per cent whereas GDP only increased by 19 per cent (Statistics New Zealand, 2006). CO_2 emissions have been growing at a slightly higher rate than GDP.

This analysis is limited by data availability from Statistics New Zealand, who have analysed New Zealand data on decoupling only as far back as 1997. Most overseas studies go back as far as the 1970s. Statistics New Zealand in co-operation with the Ministry of Economic Development, is hoping to extend analysis until the early 1990s by mid 2007. However, this is dependent on the quality of data available (Brown, 2007). Time constraint has not allowed to research for further data.

1.7 Relative or Absolute Decoupling

Decoupling is said to occur when CO_2 emissions grow at a slower rate or negative rate relative to their economic driving force over a given period (OECD, 2002). Essentially there are two types of decoupling between CO_2 emissions and economic growth: relative and absolute (Azar, 2002).

Relative decoupling causes emissions to grow at a slower rate than economic growth. Absolute decoupling causes emissions to decline whilst the economy grows. Graph 7 gives an example of relative and absolute decoupling.



Source: adapted from Azar, 2002.

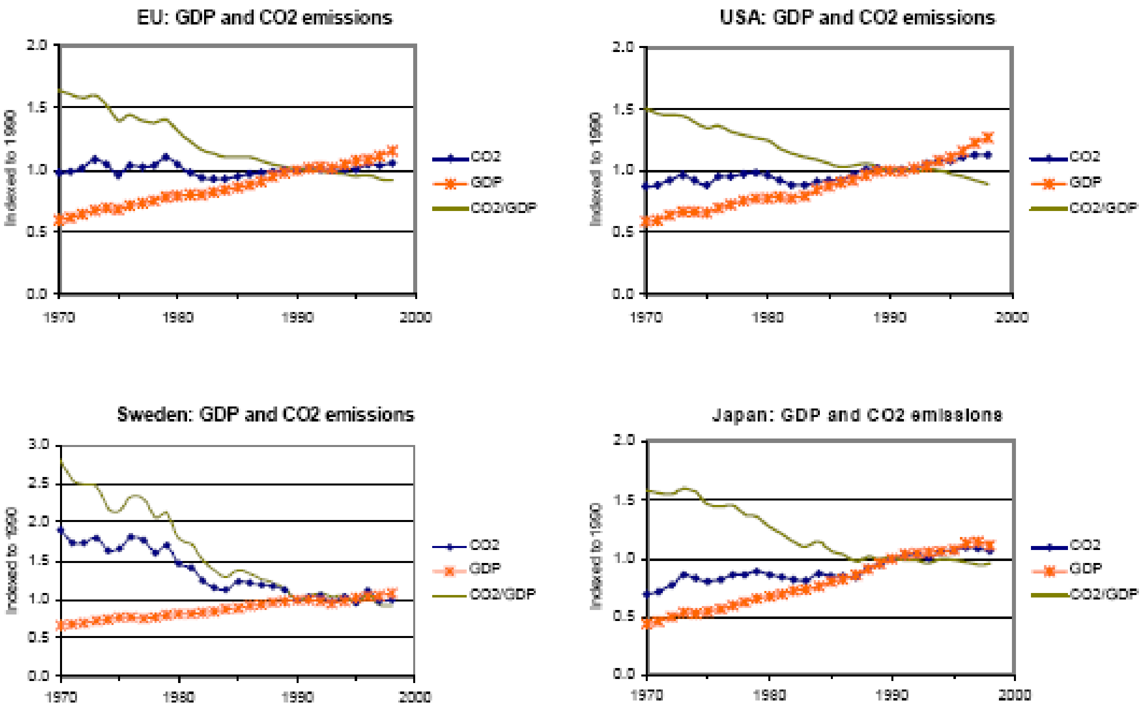
Graph 7 An example of Relative and Absolute Decoupling between GDP and CO_2 Emissions

Until the year 2000, relative decoupling occurred: emissions grew at a slower rate than GDP. After 2000, absolute decoupling started, with emissions having a negative growth rate.

Absolute decoupling cannot be achieved without relative decoupling occurring first. The growth rate needs to slow down before it can become negative. This raises the question of whether to aim for absolute or relative decoupling. Relative decoupling on its own may be insufficient because the residual absolute levels of emissions may still be too high (Azar, 2002).

1.8 Evidence of Decoupling Overseas

Progress in decoupling CO_2 emissions from economic growth has been slow in most countries, which have experienced increases in absolute emissions between 1970 and 2000 (Azar, 2002). Generally, absolute decoupling has not been achieved with few exceptions such as Sweden (Azar, 2002). In the same period, some relative decoupling has occurred in the major and emerging economies. Graph 8 shows the level of decoupling occurring in the European Union (EU), the United States (US), Japan and China (Azar, 2002).



Source: Azar 2002

Graph 8 GDP and CO_2 Emissions in the EU, Sweden, the US and Japan. Indexed to 1990[3].

The EU, Sweden, the US and Japan have experienced a drop in CO_2 emissions compared to GDP over the entire period (Azar, 2002). They all have experienced relative decoupling, whilst absolute emissions are still rising. Sweden seems to be one of the few countries to have achieved absolute decoupling. Most other developed countries have achieved relative decoupling; they have reduced CO_2 emissions per unit of GDP but total emissions have continued to rise (OECD, 2002; Azar, 2002).

In most countries, progress in the last forty years has been too slow to meet the climate targets set by the Swedish government (Azar, 2002). Such targets seem technically and economically possible and are necessary to stabilise the global climate (Azar, 2002).

1.9 Causes of Decoupling

International evidence on the causes of decoupling is mixed (MfE, 2005). There is some evidence that energy efficiency has contributed to decoupling energy use from economic growth (MfE, 2005). Other factors include changes in economic structure, the

[3] Note that in the case of New Zealand it would have been preferable to provide these statistics over a longer time period but the limited availability of consistent and complete data has restricted analysis between 1997 to 2003 (Statistics New Zealand, 2006).

types and quality of fuels used for electricity generation and the value added to products being consumed (MfE, 2005).

Some drops in emissions have resulted from major changes in the way economies are structured. Economic collapse in the former Soviet Union decreased emissions around 40 per cent in the 1990s (Azar, 2002). In the UK, an increase in coal prices relative to gas in the 1990s encouraged a switch away from coal towards gas in power generation (Azar, 2002). Emissions from gas are less than coal. In Luxembourg, fuel substitutions such as switching from domestic coal burning to imported nuclear electricity for steel production have reduced absolute emissions.

Sweden's drop in emissions is largely due to its reliance on nuclear, hydro and biomass power for energy supply[4]. Sweden has managed to stabilise emissions at 1990 levels by introducing a carbon tax, which has promoted biomass use (Azar, 2002).

However, as gas production declines in the North Sea, the continuation of this falling trend is uncertain. The economy in the former Soviet Union is recovering. Increasing reliance on Russian gas, nuclear and coal energy generation will increase emissions.

In the European Union, other measures to reduce emissions were voluntary energy reduction agreements, increased oil taxes and some degree of market restructuring in the power sector. This has roughly stabilised emissions, despite a growth in GDP by 15 per cent since 1990 (Azar, 2002).

Japan experienced decoupling due to the GDP growth rate slowing down in the nineties (Azar, 2002). The US experienced a relative decoupling in the 1990s, but absolute emissions grew by as much as the total emissions in Africa (Azar, 2002).

Overall, there is mixed evidence on the causes for decoupling (MfE, 2005). The first difficulty seems to lie in determining what exactly has caused or failed to cause decoupling. The second difficulty lies in assessing to what extend a specific cause has achieved decoupling (Brown, 2007). It does not seem to be possible to offer a general answer as to whether decoupling is happening or not, therefore a focus on the actual CO_2 emissions may prove more productive (Azar, 2002).

1.10 Carbon intensity

Another way to analyse decoupling is to measure carbon intensity. Carbon intensity is defined as GDP per tonne of CO_2 emissions. Major economies in the world such as the EU, Japan, China and the US have experienced falls in carbon intensity in the last three decades of the 20th century (Azar, 2002).

However, international trends show that declines in energy intensities have not been sufficient to offset a growing travel demand: absolute levels have not declined (IEA, 1997). In many OECD countries, any decreases of CO_2 intensity have been partly due to increased use of natural gas, biomass and nuclear energy (OECD, 2006). This fall has been enhanced by falling energy intensities as economies shift towards more services-based, rather than product-based economies and, in some cases, economic collapse (Azar, 2002).

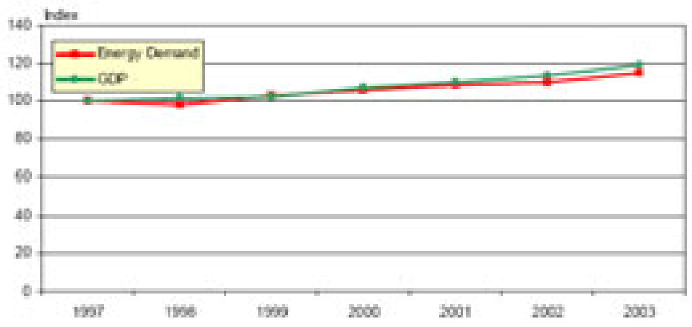
Even though there are trends in some major economies of falling carbon intensity, the observed increases in demand for transportation and energy supply consistently offset any gains in reductions (EU, 2003).

[4] Nuclear, hydro and biomass emit negligible CO_2

1.11 Evidence of Decoupling in New Zealand

New Zealand does not seem to have achieved either relative or absolute decoupling. Since 1997 total CO_2 emissions have been increasing faster than GDP (Statistics New Zealand, 2006).

In terms of energy demand, GDP grew faster between 1997 and 2003: New Zealand's demand for energy products has increased by 15 per cent while GDP has increased by 19 per cent (Statistics New Zealand, 2006). Graph 9 shows a slight relative energy decoupling, indicating a break in the link between economic growth and energy.



Source: Statistics New Zealand, 2006, p.8.

Graph 9 Change in New Zealand's Total Energy Demand Versus GDP (1997 = 100)*

1.12 Autonomous or Policy Driven Decoupling

Reductions in emissions can take place autonomously, implying that decoupling is a natural process that occurs when economies mature. The alternative is to introduce policies intended to improve efficiency and instigate structural changes in order to decrease CO_2 emissions. Structural changes consist of changes in production or consumption patterns.

To some extent, decoupling seems to occur automatically as the structure of economies change and efficiency improvements arise (Pearce, n.d.). These are driven by innovation and technological progress (Pearce, n.d.). Relative decoupling may be caused by manufacturing activity (producing goods) being outsourced to other countries, which does not improve the absolute amount of pollution globally (Stern, 2006).

Natural decoupling tends to be insufficient to stabilise climate. Historically the UK has followed a development path which can be regarded as typical and autonomous decoupling has accounted for less than half of required CO_2 reductions (Pearce, n.d.).

Autonomous decoupling to secure sustainable development involves risks. For instance, the urgency of an environmental problem such as climate change would tend to favour a more immediate decoupling driven by specific policies (Stern, 2006). Autonomous decoupling seems less risky when the effects of emissions are not irreversible[5], which is unlikely to be the case for climate change (Pearce, n.d.).

The Stern Review estimates that no action is risky and expensive: the overall costs and risks of climate change will be equivalent to losing at least five per cent of global GDP each year (Stern, 2006). The costs of action are estimated to be five times less, at around one per cent of global GDP each year (Stern, 2006). This makes a strong case for action.

Critics reviewing Stern's report cast doubts over the immediacy of action required (Nordhaus, 2006; Dasgupta, 2006). The immediacy results from the use of very low

[5] Irreversible refers to effects of actions that can be renewed only after a very long period of time.

discount rates. The near-to-zero discount rates used in the Stern review favour urgent and immediate action but this may not be necessary (Nordhaus, 2006; Dasgupta, 2006).

As economies grow, CO_2 emissions grow too. Based on his economic review of global climate change effects, Stern concludes that 'different assumptions about the definition and growth of income produce different projections for emissions but this does not affect the conclusion that emissions are well above levels consistent with a stable climate and are likely to remain so under business as usual' (Stern, 2006, p.181).

2 Opportunities and Challenges

Essentially, without policy action, absolute emissions will remain unacceptably high (Stern, 2006). This section explores potential opportunities to work towards relative or even absolute decoupling. Each opportunity has advantages and disadvantages. The following opportunities are highlighted in this discussion.

- Pricing CO_2 emissions.
- Resource productivity.
- Supporting innovation.
- Efficiency improvements.
- Other strategies.

2.1 Pricing CO_2 Emissions

One of the causes for the continued increase in emissions is that the effects of climate change are rarely included voluntarily in decision-making (Stern, 2006). Climate change induced by CO_2 emissions is seen as the biggest market failure of human history (Stern, 2006)[6]. The true costs of polluting the atmosphere with CO_2 emissions are not being borne by the people responsible but by everybody facing the threat of climate change.

Very few systems are in place to allow for damage payments. In New Zealand, there is no explicit economic value or market system in place to capture the costs of CO_2 emissions (MED, 2006). Therefore the relative costs of electricity generation options do not currently reflect their impact on climate change. At the same time, low emissions from renewable resources such as hydro, wind and solar tend to be undervalued (MED, 2006).

For instance, the CO_2 emissions costs produced when electricity is generated from coal or gas are a significant element of total electricity generation costs (Denne, 2006). One third of coal generation costs at Huntly power station in the North Island are contributable to CO_2 emissions (Denne, 2006). Currently there is no market in place to capture these costs (MfE, 2005).

Surprisingly, despite the barriers and evident market failures, the private sector still attempts to improve the rate at which it emits CO_2 emissions (Cabinet Office, 2001). Current reductions to stabilise the climate are insufficient (Stern, 2006).

The challenge lies in quantifying and assigning a dollar value to the damage caused by CO_2 emissions, so that they become part of economy (Costanza, 1997). Quantifying damage to ecosystems is an emerging science: a more controversial experiment has been the work done by Costanza on putting a preliminary value on the world's ecosystem services of US$36 trillion (Costanza, 1997).

Economic or market-based instruments (MBI) are policy tools that affect the monetary costs or benefits of private actions and can reflect the costs of CO_2 emissions. MBI

[6] The lack of an appropriate pricing signal is called a market failure.

work by either changing market prices (charges or subsidies) or introducing markets where previously there were none (Denne, 2006). Examples for capturing CO_2 emissions are tradable permits, taxes and levies. The proposed and subsequently scratched carbon tax in New Zealand was an example of such an instrument (MfE, 2007). An example of an international MBI is the European emissions trading system, which allows countries to trade emission allowances between each other (MfE, 2007).

Another advantage is that MBIs can potentially achieve reductions cheaper than other regulatory means: they can introduce incentives beyond traditional regulatory approaches (Denne, 2005). They also can potentially raise revenue, which could be spent on developing means to reduce emissions (Denne, 2006).

The degree of success is subject to a number of conditions (EEA, 2006). Further work could be done on exploring the potential applications of MBIs to reduce CO_2 emissions. The New Zealand Climate Change Office has provided a comprehensive review of climate change policy options (MfE, 2005). It recommends a review on the best mix of MBIs and regulatory policies to use.

2.2 Supporting Innovation

CO_2 emission reductions require new ideas, products and technologies. This process is called innovation. Introducing a carbon trading system is an example of an institutional innovation (Cabinet Office, 2001). A new technology for producing electricity, which does not emit CO_2 emissions, is an example of a technological innovation (Cabinet Office, 2001).

Both types of innovation are required and tend to need government support to get started (Cabinet Office, 2001). Uptake of new technologies can be slow needing targeted innovation policies. For example, the 'valley of death' between research and actual commercialisation can cause an innovation to fail. The valley of death means that the project is too small to attract major funding and therefore needs extra funding from government (Cabinet Office, 2001).

Generally, governments tend to support fundamental Research and Development (R&D) only, leaving the rest to the market (Cabinet Office, 2001). Firms are often not able or willing to develop new approaches. Taking on new technologies with limited experience is high risk. Most businesses are not risk takers in technology.

Uptake of CO_2 emission reduction innovation can be restricted by insufficient know-how, experience and availability of new technology (Cabinet Office, 2001). Again specific funding could alleviate this.

The UK government recommends that policy makers may be best to use a mix of policy instruments to create incentives and innovation (Cabinet Office, 2001). Some innovation examples can be summarised as follows:

- assisting universities and the private sector to fill the gap between research and commercialisation;
- addressing financial troubles such as access to capital for small companies and structural barriers such as where new entrance is excluded; and
- improving the design of products (Cabinet Office, 2001).

An example of successful targeted innovation is the Danish wind turbine industry. It started with a pioneering R&D programme in the 1950s, which developed the prototype for a wind turbine. Policy support in the 1970s combined both 'demand pull' and 'supply push' policies. Demand pull involved financial support through direct subsidies such as installation grants and favourable planning regimes for the turbines. Supply push included R&D programmes, a national test station facility and standardisation of the turbine design.

Denmark today secures 15 per cent of its electricity from wind and has a world market growing at 25 per cent accounting for more than 50 per cent sales world wide (Cabinet Office, 2001).

2.3 Resource Productivity

Another way to reduce CO_2 emissions is to produce more goods and services with fewer natural resources and less emissions by increasing resource productivity. Resource productivity measures the efficiency at which economies produce goods: the more efficient the production of goods, the lower the emission of CO_2 (Cabinet Office, 2001).

In terms of CO_2 emissions there are two concerns: how well are goods being produced and how much gets put into the atmosphere as a result of production? The capacity of the atmosphere to absorb GHGs is the type of natural resource that is most obviously under threat around the world (Cabinet Office, 2001). Expanding the definition of resource productivity to include the assimilative capacity of the Earth reflects this threat (Cabinet Office, 2001)[7].

How materials are being converted tends to be influenced by numerous factors. Design, innovation, culture, industry processes, economic, political and market systems all have a role to play (Cabinet Office, 2001). ‘Factor Four’ (Von Weizsäcker, 1997) argues that in theory resource productivity can be improved fourfold by doubling wealth while halving resource use.

2.4 Efficiency Improvements

Efficiency improvements in producing goods can be attained through substituting different types of material or by reducing the actual unit of material per utility gained. An example of the former would be substituting coal with wind for energy generation. The latter involves recycling and sharing resources such as car pooling.

Efficiency improvements are not a new concept. Engineers and scientist have sought to reduce industry’s use of energy and resources for centuries, even millennia (Hawken, 1999). For decades, the energy used to make a given product has been falling by typically a per cent or two a year. These changes are faster when energy prices rise and slower when they fall (Hawken, 1999).

This is confirmed by the International Energy Agency (IEA): energy used in producing goods in advanced economies has improved by around 2.2 per cent per annum in the lat four decades of the 20th century, even when the mix of materials produced changes (IEA, 1997). Changing the mix of materials produced will additionally increase efficiency changes (IEA, 1997). Policy instruments targeting the mix will increase efficiency changes.

Hawken suggests that at each stage of the industrial process, a host of opportunities for improving efficiency still exist, even in the most efficient countries and industries (Hawken, 1999).

2.5 Other Strategies

Another way of looking at decoupling strategies is the approach taken by Tukker, who identified five main decoupling strategies (Tukker, 2005).

1. <u>‘Reduce emission factors’</u>

[7] The assimilative capacity of the environment represents the capacity of land, water and the atmosphere to absorb waste and pollution (Hawken, 1999).

This is the most commonly and often successfully applied environmental strategy and can be referred to as implementing end-of-pipe measures and cleaner technology. An example of this is substantial reductions in car emissions in Europe, despite a considerable rise in demand.

2. ‘Produce more with less’

This strategy seeks to improve production efficiency and promote innovation in the production system itself. An example would be an energy supply based on the use of ‘solar income’ (solar, wind and water energy) rather than fossil fuels. This needs a radical change in the technology structure in society.

3. ‘Stimulating multiple use’

This strategy looks at enhancing the use of products, for example through designing products with more than one function. Sharing, renting or pooling the same product reduces emissions.

4. ‘Spending with less impact’

This involves spending more on services such as experience, brand names and intellectual property rights as opposed to products. Another element would be to encourage the sale of goods and services which produce lower CO_2 emissions in their production and consumption than more standard products.

5. ‘Enhancing quality of life per $ spent’

The aim here is to create living conditions where less material goods are needed to reach the same quality of life. Quality of life factors need to be promoted.

Strategies addressing the production part of the system are seen as relatively ‘straight-forward’ (Tukker, 2005). The first three strategies above improve production patterns. The last two strategies deal with consumption patterns. Historically policy has mainly focused on the first two strategies (Tukker, 2005).

3 Conclusions

3.1 Lessons Learnt from Overseas

The following key lessons from overseas are highlighted.

- International evidence on the causes of decoupling is mixed.
- It is difficult to offer a general answer to whether decoupling is happening or not, therefore a focus on the actual CO_2 emissions may prove more productive.
- CO_2 emissions as opposed to other pollutants seem to be much harder to decouple from income.
- There is some evidence that energy efficiency has contributed to decoupling energy use from economic growth.
- A ‘natural’ fall in CO_2 emissions which is supposed to be occurring as countries grow richer is likely to be insufficient to stabilise global warming.
- Some major economies have experienced some relative decoupling.
- Most developed and developing countries are still experiencing an absolute growth in CO_2 emissions.
- Some exceptions include countries such as Sweden which have used a carbon tax and have benefited from low emissions energy supply.
- Causes for decoupling include changes in the economy such as economic collapse, fuel switching, energy efficiency and increased oil taxes.
- Observed increases in demand for transportation and energy supply are consistently offsetting any gains in carbon intensity reductions.

It is likely that in the absence of policy interventions, the long-run positive relationship between income growth and emissions per head will persist. Decoupling has shown that it is essential to reduce absolute CO_2 emissions, i.e. to achieve absolute decoupling. Relative decoupling is useful to highlight the trends in CO_2 emissions relative to GDP. Relative decoupling may mean a drop in emissions relative to GDP but that drop may still be insufficient to minimise climate change impacts.

3.2 Implications for New Zealand

The lack of consistent long term data and the uncertainty around the causes of decoupling overseas complicate the analysis for New Zealand. Some tentative conclusions from the decoupling analysis are drawn.

- New Zealand seems to be lagging behind other developed countries in reducing CO_2 emissions: most developed countries have experienced relative decoupling.
- New Zealand does not seem to have achieved either relative or absolute decoupling between CO_2 emissions and GDP in the period 1997-2003.
- On the contrary, there is evidence of strong coupling between CO_2 emissions and GDP in that same period.
- CO_2 emissions have even been growing faster than GDP between 1997 and 2003.
- Between 1997 and 2003 New Zealand has experienced a slight relative decoupling of energy demand and GDP.

These findings are relative to the following background.

- In New Zealand, energy consumption has been growing faster than the global average.
- Two thirds of New Zealand's energy still comes from fossil fuels.
- In 2002 CO_2 emissions were the major GHG for New Zealand.
- Since 1990 CO_2 emissions have increased by 33 per cent.

If New Zealand does not change its energy policies, then:

- CO_2 emissions will rise substantially;
- the demand for electricity will rise substantially;
- fossil fuels will prevail in electricity production; and
- energy prices will rise (MED, 2006).

3.3 A Potential Decoupling Strategy

There is a question as to whether decoupling has to happen domestically or whether (for GHG emissions) it can happen at the global level through New Zealand buying emission allowances on the international market. In the short-term (up to 2012) one of the measures that can assist New Zealand reduce CO_2 equivalent emissions and meet its Kyoto Protocol obligations will be to purchase units internationally (Cabinet Business Committee, 2006).

New Zealand, like a number of other countries, will not be able to meet its Kyoto Protocol commitments solely through domestic emission reductions (MfE, 2005). Therefore New Zealand will have to buy emission allowances, at least in the short term. MfE recommends that New Zealand consider strategies which it might use to acquire emission units in the international market using Kyoto mechanisms[8].

[8] Which include outright purchase of emission units and alternatives such as earning units in developing countries through use of the Clean Development Mechanism.

There are opportunities to pursue domestic decoupling but there are several reasons why it may be more difficult for New Zealand to decouple domestically:

- a long history of providing most its energy needs from renewables, i.e. 70 per cent of electricity generation is from renewables – the third highest amongst developed countries;
- its high dependence on transport, high level of car ownership and low use of public transport coupled with the country's length and distance between cities;
- predicted high growth in oil dependent road transport;
- limited scope to expand the railway network;
- existence of large reserves of low grade fossil fuel in the from of coal;
- high reliance on the energy-intensive primary sector for its exports and economy;
- no more large rivers to dam for hydro; and
- lack of any known large gas reserves (MED, 2006).

Solutions such as switching from coal to gas or importing electricity rather than burning coal (like other countries such as the UK and Luxembourg have done) are unlikely options for New Zealand. There is unlikely to be a major shift in the structure of the economy such as the economic collapse in the former Soviet Union, which is undesirable for many other reasons. Due to the country's geography, large reductions in transport emissions can result from improved vehicle efficiency, increased public transport use and alternative fuels (Cabinet Business Committee, 2006).

Large reductions will depend on the fuel mix for future electricity generation, which implies a shift towards renewables. MED suggests that renewable resources can easily meet projected electricity demand until 2030 and achieve the largest possible emission reductions across the whole energy sector (MED, 2006). The fuel mix can be influenced by policy measures such as costing the damage caused by GHGs. Even without allowing for the cost of GHG emissions, recent estimates have shown that renewables are less costly or close to the cost of fossil fuel generation (MED, 2006).

In terms of land use, there is an opportunity to develop policy measures to discourage conversion of land from forestry to other uses (Cabinet Business Committee, 2006). Trees store carbon as they grow and therefore act as storage for CO_2 emissions.

It is useful to look closely at the long term costs and benefits of aggressively pursuing renewable energy options and efficiency improvements against buying emission allowances on the international market. This will clarify which policy mix is best to use. Essentially, in terms of GHG emissions, the advantage is that it does not matter where reductions happen around the globe, as long as they do happen.

The New Zealand Climate Change Office (NZCCO) recommends that the Government '… consider formulating an alternative climate change goal for New Zealand that better manages the risks, opportunities and impacts associated with our net emissions position while engaging with the international community in an attempt to secure broad and balanced participation and action on climate change policy' (MfE, 2005). This calls for a mixed approach of domestic decoupling and international cooperation.

The main condition remains that reductions happen at least cost. Some countries will achieve reductions more cheaply than others and will therefore have a comparative advantage. Those countries will sell their allowances. For New Zealand, a short term policy measure may include buying allowances coupled with preparing domestic decoupling policies in the future. The more medium to long term goal could be to pursue domestic decoupling.

The question then remains on whether a separate policy measure on decoupling is needed. Government policies on climate change are advancing in New Zealand, with a number of initiatives already announced or under development (Mallard, 2006). The

Government is working towards a strategy for energy (MfE, 2005). Measures of a proposed action plan include:

- accounting for the cost of GHGs (and therefore CO_2 emissions) from electricity generation to reflect the relative costs caused by the fuel that produced the GHGs;
- establishing a price signal so that investors in new generation can see the value of GHGs avoided; and
- facing the owners of existing fossil fuel generation (such as Huntly power station) with the full costs of GHGs.

Further work to reduce emissions in the electricity sector is expected on:

- optimising efficient use of energy;
- incentives for supply of energy from non-fossil sources;
- disincentives for fossil fuel electricity generation;
- a possible narrow carbon tax on electricity generation;
- further energy research; and
- the use of solar water heating (Cabinet Business Committee, 2006).

Decoupling proves to be a more useful concept when it provides a better understanding of the relationship between GDP and CO_2 emissions. It provides a framework to clarify how GDP and CO_2 emissions are related to energy demand. Particularly, decoupling can serve as an indicator to highlight:

- differences between developed and developing countries;
- the degree of decoupling – absolute or relative;
- key trends in emissions and GDP over time;
- at what point in time an eventual decoupling is occurring;
- potential causes of decoupling; and
- the need for and degree of success of policy interventions.

If government policies are successful at achieving decoupling, then forming a specific policy measure on decoupling may not prove beneficial.

Glossary

Assimilative Capacity:	Represents the capacity of land, water and the atmosphere to absorb waste and pollution. In terms of CO_2 emissions, the assimilative capacity of the environment is the Earth's atmosphere.
Biomass:	Organic matter that is used to generate electricity. This includes energy crops and trees, agricultural food and feed crops, wood and wood wastes, animal wastes etc.
Carbon Intensity:	The ratio between CO_2 emissions and GDP. Provides an indication on the change on emissions compared to unit of GDP.
Clean Development Mechanism:	An arrangement under the Kyoto Protocol allowing industrialised countries with a greenhouse gas reduction commitment (so-called Annex 1 countries) to invest in emission reducing projects in developing countries. This is because generally emission reductions are more costly in their own countries.
Climate Change:	Increasing industrialisation and human activity (such as industry, agriculture and transportation) are increasing the amount of GHGs in the Earth atmosphere. This causes the Earth to heat up at fast rate. This effect is known as global warming. This warming affects weather patterns and climatic conditions.
Carbon Dioxide (CO_2):	An unregulated, invisible, odourless gas with no direct human health effects. The main greenhouse gas emitted by the energy sector.
CO_2 per Capita:	Average CO_2 emissions per person.
CO_2-equivalent:	Measures the combined climate changing potential of emissions of multiple GHGs. Emissions of each gas are converted to an amount of CO_2 that would cause the same climate change impact.
Consumption:	Total personal consumption expenditure, i.e., the purchase of currently produced goods and services out of income, out of savings or from borrowed funds. It refers to that part of disposable income that does not go to saving.
Decoupling:	'Refers to breaking the link between 'environmental bads' and 'economic goods'. In particular, it refers to the relative growth rates of a pressure on the environment and of an economically relevant variable to which it is causally linked. Decoupling environmental pressures from economic growth is one of the main objectives of the OECD. Decoupling occurs when the growth rate of an environmental pressure is less than that of its economic driving force (e.g. GDP) over a given period. Decoupling can be either absolute or relative. Absolute decoupling is said to occur when the environmentally relevant variable is stable or decreasing while the economic driving force is growing. Decoupling is said to be relative when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of the economic variable. Decoupling indicators measure changes over time and the concept of decoupling is attractive for its simplicity. However, it is important to note that the concept of decoupling has no automatic link to the environment's capacity to sustain, absorb or resist environmental pressure' (Statistics New Zealand, 2006, p.27).

Discount Rate:	Based on the idea that a $ today is not worth the same than a $ tomorrow. Discounting is therefore used to value projects, which stretch into the future in today's money.
Ecosystem Services:	The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life. Examples include provision of clean water, maintenance of liveable climates (carbon sequestration), pollination of crops and native vegetation, and fulfilment of people's cultural, spiritual, intellectual needs.
End-of-Pipe Measures:	Focusing on reducing emissions rather than prevention. For example, planting trees to absorb emissions is an end-of-pipe solution as opposed to introducing a more efficient technology.
Energy Demand:	Demand of energy products (coal, oil, gas, electricity etc) by New Zealand's households and intermediate consumers (government and businesses).
Environmental Intensity:	Environmental impact per unit of production value.
External Costs:	A cost falling on a third party who normally cannot pay or be compensated for in the market system.
Fossil Fuels:	Coal, natural gas, liquefied petroleum gas (LPG), crude oil and fuels derived from crude oil, including petrol and diesel. They are fossil fuels because they have been formed over long periods of time from ancient organic matter and cannot be renewed in our lifetimes. That is why they are also called non-renewables.
Global Warming:	Gradual increase in the earth's surface temperature.
Greenhouse Effect:	In the general atmosphere surrounding the Earth, the warming effect due to selective absorption by certain gases such as CO_2, CH_4, nitrous oxides, ozone, chlorofluorocarbons and water vapour.
Greenhouse Gases:	A collective expression for those components of the atmosphere that influence the Greenhouse Effect, namely CO_2, CH_4, nitrous oxides, ozone, chlorofluorocarbons and water vapour. Nearly half of New Zealand's total emissions are produced by agriculture, predominantly methane (CH_4) from farm animals and nitrous oxide from soils and fertilisers. However, the principal growth in New Zealand's emissions comes from increased CO_2, primarily from the energy sector. Most of this increase has come from transport and electricity generation.
Gross Domestic Product (GDP):	The total market value of goods and services produced by a nation. Non-market values are excluded.
Income:	The money that is received as a result of the normal business activities of an individual or a business. For example, most individuals' income is the money they receive from their regular pay checks.
Innovation:	Generic term for the successful development of a new idea – anew product or service, or the production and bringing to the market of that new product or service.
Kyoto Protocol:	An international agreement to address global warming and delay climate change. New Zealand committed to reducing its GHG

emissions back to 1990 levels, on average, over the period 2008 to 2012 or to take responsibility for any emissions above this level if it cannot meet this target.

Natural Capital: Stock of natural resources and environmental assets including water, soils, air, flora, fauna, minerals and other natural resources.

Natural Resources: Materials that occur in nature and are essential or useful to humans, such as water, air, land, forests, fish and wildlife, topsoil and minerals.

Peak Oil: The point when worldwide production of conventional crude oil peaks in volume, which is expected to result in an increase in oil prices from a decline in the availability of cheap and easily accessible oil sources.

Policy Measures: Actions developed to address a perceived problem or further a government objective. Can include regulatory, economic or information based tools.

Pollution Intensity: The rate at which pollution is produced.

Primary Energy Supply: Energy use of a country, which includes coal, crude oil, natural gas liquids, gases, electricity and heat and other energy products.

Renewables: Energy fuels which do not emit CO_2 emission and can be renewed, e.g. geothermal, wind, hydro and wave.

Structural Changes: Changes in how materials are being produced and how people consume.

Valley of Death: Where innovative ideas and research go to die before they have the chance to arrive in the marketplace.

Wealth: Usually refers to money and property. It is the abundance of objects of value and also the state of having accumulated these objects.

Welfare: Refers to the economic well being of an individual, group, or economy.

Wellbeing: A contented state of being happy and healthy and prosperous.

References

Aldy, J., 2005: An Environmental Kuznets Curve Analysis of U.S. State-Level Carbon Dioxide Emissions, *Journal of Environment & Development*, 14(1):48-72.

Azar, C.; Holmberg, J. and Karlson, S. 2002: *Decoupling : past trends and prospects for the future*. University of Götenberg, Department of Environmental Economics, Stockholm.

Borghesi, S., 1999: The Environmental Kuznets Curve: a Survey of the Literature. FEEM Working Paper No. 85-99. FEEM. Fondazione Eni Enrico Mattei, Milan

Brown, M., 2007: Statistical Analyst, Statistics New Zealand, telephone conversation 18th January.

Cabinet Business Committee, 2006: *Climate Change Policy : Overview of Progress Towards Reducing Transport CO2 Emissions*. Office of the Associate Minister of Transport, Wellington

Cabinet Office, 2001: *Resource Productivity: Making More with Less.* Great Britain. Cabinet Office. Performance and Innovation Unit., London

Commission of the European Communities, 2003: *Towards a Thematic Strategy on the Sustainable Use of Natural Resources*. Commission of the European Communities, Brussels

Costanza, R. 1997: The Value of the World's Ecosystem Services and Natural Capital. *Nature*, 387 (May 15). 253-260

Daly, H.E., 1996: *Beyond Growth : The Economics of Sustainable Development*. Boston: Beacon Press.

Dasgupta, P., 2006: Comments on the Stern Review's Economics of Climate Change. Prepared for a seminar on the Stern Review's Economics of Climate Change, organised by the Foundation for Science and Technology at the Royal Society, London

Denne, T. 2005: *Economic Instruments for the Environment.* Environment Waikato Technical Report 2006/23. Waikato Regional Council (Environment Waikato) / Covec Ltd., Hamiton.

Denne, T., 2006: *Full Costs of Electricity Generation.* Unpublished report, prepared for Environment Waikato. Waikato Regional Council (Environment Waikato) Hamilton.

Donovan, N. and Halpbern, D. 2002: Life Satisfaction : The State of Knowledge and Implications for Government. Great Britain. Cabinet Office, London

Energy Efficiency and Conservation Authority (EECA), 2006: *Draft New Zealand Energy Efficiency and Conservation Strategy : Action Plan to Maximise Energy Efficiency and Renewable Energy in New Zealand*. Energy Efficiency and Conservation Authority, Wellington

Ehrlich, P. and Holdren, J. 1971: Impact of population growth, *Science* 171:1212-1217.

European Environment Agency (EEA), 2006: *Using the Market for Cost-Effective Environmental Policy : Market-Based Instruments in Europe.* European Environment Agency (EEA), Copenhagen

Galeotti, M. 2003*: Environment and Economic Growth: Is Technical Change the Key to Decoupling?* FEEM Working Paper No. 90.2003. FEEM. Fondazione Eni Enrico Mattei, Milan

Galeotti, M.; Manera, M. and Lanza, A. 2006: *On the Robustness of Robustness Checks of the Environmental Kuznets Cur*ve. FEEM Working Paper No. 2006.22. FEEM. Fondazione Eni Enrico Mattei, Milan

Gilpin, A., 1997: *Dictionary of Environment and Sustainable Development.* Wiley, Chichester.

Hawken, P.; Lovins, A. and Lovins, L.H. 1999: *Creating the Next Industrial Revolution : Natural Capitalism*, Little Brown, Boston.

Hicks, J.R. 1946: *Value and Capital.* 2nd ed. Clarendon Press, Oxford

Hill, R. and Magnani, E. 2002: An Exploration of the Conceptual and Empirical Basis of the Environmental Kuznets Curve. *Australian Economic Papers*, 41(2):239-54

Hirsch, F. 1977: *Social Limits to Growth.* Routledge & Kegan Paul, London

Hirsch, R.; Bezdek, R. and Wendling, R. 2005: Peaking Of World Oil Production: Impacts, Mitigation, & Risk Management.
http://www.pppl.gov/publications/pics/Oil_Peaking_1205.pdf (01 Dec. 2006)

International Energy Agency, 1997: *Energy policies of IEA Countries (Compendium).* International Energency Agency, Paris

Intergovernmental Panel on Climate Change (IPCC), 2001a: *Climate Change 2001: The Scientific Assessment, "Policy Makers Summary", Working Group I contribution to the Third Assessment Report of the IPCC.* Cambridge University Press, Cambridge.

Intergovernmental Panel on Climate Change (IPCC), 2001: *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge.

Mallard, T. 2006: *Economic Transformation: Giving Effect to the Five Themes.* Cabinet Paper to Cabinet Policy Committee. Ministry for Economic Development, Wellington.

Meadows, D. H.; Meadows, D. L.; Randers, J. and Behrens, W.W. 1972: *Limits to Growth.* Universe Books, New York

Meyers, N. and Kent J., 2004: *The New Consumers : the Influence of Affluence on the Environment.* Island Press, Washington

Ministry of Economic Development (MED), 2006: *Powering Our Future: Towards a Sustainable Low Emissions Energy System : Draft New Zealand Energy Strategy to 2050.* Ministry of Economic Development, Wellington

Ministry for the Environment (MfE), 2007: *New Zealand Climate Change.*
http://www.climatechange.govt.nz (16 Jan. 2007).

Ministry for the Environment (MfE). 2005: *Review of Climate Change Policies*. Ministry for the Environment, Wellington

Nordhaus. W., 2006: The Stern Review on the Economics of Climate Change.
http://nordhaus.econ.yale.edu/SternReviewD2.pdf (01 Dec.2006)

Organisation for Economic Co-operation and Development (OECD) 2002: *Working Together Towards Sustainable Development : the OECD Experience*. OECD, Paris

Organisation for Economic Co-operation and Development (OECD) 2002: *Indicators to Measure Decoupling of Environmental Pressure from Economic Growth.* OECD, Paris

Organisation for Economic Co-operation and Development (OECD) 2006: Decoupling : a Conceptual Overview. *OECD Papers Special Issue on Decoupling Agricultural Support* (5)11:
No. 414.

Organisation for Economic Co-operation and Development (OECD) 2006: Decoupling : Policy Implications. *OECD Papers Special Issue on Decoupling Agricultural Support* (5)11:
No. 415.

Opschoor, H. 1998: Economic Growth, The Environment And Welfare: Are They Compatible? In R. Seroa da Motta (Ed.) *Environmental Economics and Policy Making in Developing Countries: Current Issues.* Edward Elgar, Cheltenham. 13-36

Parliamentary Commissioner for the Environment, 2006: *Changing Behaviour : Economic Instruments in the Management of Waste.* Parliamentary Commissioner for the Environment, Wellington

Pearce, D. [n.y.p]: Economic Growth and the Environment. In. *Environment and Economic Development* [forthcoming publication]

Porritt, J. 2005: *Capitalism : as if the World Matters.* Earthscan, Sterling VA.

Shafik, N. and Bandyopadhyay, S. 1992: *Economic Growth and Environmental Quality, Background Paper for the 1992 World Development Report*. World Bank, Washington D.C.

Sheram, K. and Soubbotina, T. P., 2000: *Beyond Economic Growth: Meeting the Challenges of Global Development.* World Bank, Washington D.C.

Sinclair, G., 2006: *Price of Kyoto Compliant Emission Units : Report for the New Zealand Treasury*. The Treasury, Wellington

Statistics New Zealand, 2006: *Energy, Economy and Emissions 1997-2003 : Environmental Accounts.* Statistics New Zealand, Wellington

Stern, N. 2006: *The Economics of Climate Change : the Stern Review.* HM Treasury, Cabinet Office, London.

Stern, D.I., 2005: Beyond the Environmental Kuznets Curve : Diffusion of Sulphur-Emissions-Abating Technology. *Journal of Environment and Development* (14):101-124.

Thornley, A. and Brown-Santirso, M. 2006: *Decoupling Economic Growth And Energy Demand In New Zealand*. (Paper presented to New Zealand Association of Economists Conference 2006) http://www.nzae.org.nz/conferences/2006/20-HAMMOND.pdf (01 Dec. 2006)

Tukker, A., 2005: *The Relevance of Sustainable Consumption Policies for Realising Decoupling,* Paper for 10th European Roundtable of Sustainable Consumption and Production (ERSCP 2005), 5-7 October, Antwerp, Belgium. http://www.vito.be/erscp2005/documents/papers/PAPER076.P_01 Dec. 2006)

United Nations. 1992: *Agenda 21: Earth Summit : The United Nations Programme of Action from Rio.* United Nations, New York

Veenhoven, R., 2006: *World Database on happiness, Item bank,* Erasmus University Rotterdam http://www.worlddatabaseofhappiness.eur.nl/hap_quer/hqi_fp.htm (01 Dec. 2006)

Von Weizsacker, E.; Lovins, A.B. and Lovins, L.H. 1997: *Factor Four: Doubling Wealth, Halving Resource Use : a Report to the Club of Rome.* Earthscan, London