A Brief Introduction To

Climate Change

And

Peak Oil

For

New Zealanders

By
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Adrienne Puckey

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Foreword

This work is born out of an increasing concern for the future of our families, our country, and our world. At a detailed level, the subject-matter is complex and interconnected, and knowledge of the issues is evolving rapidly. However, at a big picture level, the basic facts are simple and stable. If we carry on with our present levels of fossil fuel use, the number of people the planet is able to support, will be significantly reduced.

It is a brutal message, and one that we, ourselves, are struggling to come to terms with. The contrast with the widely-accepted ethos of ever-rising living standards could hardly be more stark. Born in New Zealand in 1946 and 1948, we are from the baby boom generation, and have enjoyed post-war prosperity, cheap education, and plentiful employment.

Individually and together we have led carbon-intensive lives. Both were raised on parental income generated directly by New Zealand's high-emitting dairy industry. As adults, we have worked in industries responsible for considerable emissions. We have driven huge distances and have travelled frequently by air.

Sean has an MA (Hons) from the University of Auckland, specialising in transport geography, and diplomas in Teaching, Business and Industrial Administration and Counselling. He has worked in the transport industry, publishing and university administration, and has written and published on various aspects of transport and travel.

Adrienne is a Chartered Accountant who has spent 26 years in the paper, forestry and timber industries in New Zealand, UK, and Australia, and on projects in Canada and Norway. She has an MBA from the University of Auckland, has recently completed a PhD on the history of Mäori and Päkehä political economic relations, and is currently post-doctoral research fellow in the Mira Szászy Research Centre of the University of Auckland's Business School.

We are married to each other, have five adult children and five grandchildren, between us. For a long time we remained largely oblivious to the impending collision between our way of life and the constraints of the planet we inhabit. What little we knew seemed so remote and abstract that it barely intruded into our consciousness as we jetted around the world.

Our first awakening occurred in 2002, when we heard a radio interview with Canadian environmentalist, David Suzuki. We bought the book he was promoting, *Naked Ape to Superspecies.* It turned out to be a real eye opener. But, our weddedness to a high-carbon lifestyle initially meant that we took little practical action.

Our second awakening came in September 2004 when a small item in the *New Zealand Herald* reported a parliamentary question directed at Treasurer, Dr Michael Cullen, by Green Co-leader, Ms Jeanette Fitzsimons. She asked whether the Budget's assumptions for the future price of oil took into account "peak oil". What was "peak oil"? We turned to the internet, and were ill-prepared for the shock that followed. Global oil production was expected to peak in the next few years, with major implications for pricing and availability. References to peak oil were also frequently linked to climate change.

With a newly-heightened awareness of the issues, we began trying to consume less, and more thoughtfully. We moved closer to the places we visit most. We cut down on flying. Adrienne built up her skills in sustainable gardening, joined the Accountants' Sustainability special interest group and the Auckland Anglican Diocesan Climate Change Action Group. Sean used his knowledge to advocate improvements in rail-based public transport in Auckland.

This booklet comes out of a decision to employ our skills and knowledge in making information about climate change and peak oil more widely available. Our intention is to eventually produce a series of booklets aimed at different groups. The current version is written for people comfortable with fairly complex language, including policymakers, officials, and managers.

Like the overwhelming majority of the world's scientific community, and all major governments, we believe the debate about the causes of climate change is over, and therefore have not given it any space. Information about the science of climate change is readily available from a wide variety of sources.

Any single publication devoted to the complex and interconnected issues of climate change and peak oil is inevitably a summary. We have tried to keep this distillation of our research as compact as possible. For readers wishing to explore more widely, we provide some starting points in the appendices.

Acknowledgments

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Mt Albert, Auckland

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Introduction

In 1800, at the start of the fossil fuel era, the world's population was approximately one billion. By 1900, at the start of the oil era, it had risen to two billion. Today, it is six-and-a-half billion.

The effect of this unprecedented growth in numbers has been compounded by an extraordinary increase in per capita consumption. Both trends have been made possible by the use of fossil fuels, resources that had been little-used until two centuries ago.

Can this go on? Many years ago, economist Kenneth E Boulding (1910 – 1993) provided an eloquent answer -

Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist.

Sadly, despite numerous signs of serious environmental stress, the reality that we live in a finite world is widely ignored. Our present lives are based on using resources at a rate that cannot be sustained. The title of Al Gore's influential movie, *An Inconvenient Truth* is all too true.

Fossil fuel use is critical to the finite limitations that are most likely to impact soonest and hardest. These limitations are encapsulated in the terms *climate change* and *peak oil*. Both have immense implications for the ability of the planet to support present and predicted future population growth.

Climate change is the more well-known of the two phenomena. It is already having a significant effect in countries less prosperous than our own. Peak oil is less well-known. The term refers to an inevitable peak in oil production, followed by a steady ongoing decline.

As the world searches for oil substitutes, and for the means of mitigating climate change, proposed solutions to one are starting to have effects on the other. Looming increasingly large is the issue of food security. Opinions vary on how climate, energy, and other environmental constraints, will impact on food production.

At the optimistic end of the spectrum is the IPCC. Using science that has already been superseded (see next chapter), and ignoring peak oil, it concludes, that although there will be problems in sub-Saharan Africa, elsewhere food production will increase (providing warming doesn't exceed 3^0C).[1]

Representing the other end of the spectrum is Paul Ehrlich, President of the Centre for Conservation Biology at Stanford University, and a leading expert on food security. Acknowledging the future likely impacts of peak oil, climate change and water shortages, he put his view of the global food situation this way:

...the bottom line is that China and the world are accelerating in a fog towards a precipice.[2]

Despite the world's population being well short of the nine billion plus predicted for 2050[3], we are already experiencing a global food crisis.

It is not just humans who are in trouble. Extinctions of other species are already occurring at increasing rates, well in excess of the background rate experienced outside of earlier great mass extinctions. And, ongoing anthropogenic climate change is expected to make things worse.

In the largest collaboration of its kind, scientists studied six biodiversity-rich regions representing 20% of the world's land area. The results, published in *Nature* found that 15 to 37% of species in the regions covered could be driven extinct by the climatic changes expected to occur by 2050 (using the mid-range climate warming scenarios).[4] These scenarios have since been shown to be conservative.

The planet's ecosystems are complex, and poorly understood, particularly at the level of soil microbiology. We know little about which species are the critical ones to save, or how to save them.

...if we don't pay attention to nature's smallest creatures... and the role of the tiniest living things in providing for the rest of us, we may find ourselves in a truly frightening place.[5]

Writing about the overall implications of climate change, James Hansen, Director of the United States National Aeronautics and Space Administration's Goddard Institute for Space Studies recently had this to say:

The stakes for all life on the planet, surpass those of any previous crisis.[6]

1 *Climate Change 2007 Synthesis Report*. Intergovernmental Panel on Climate Change, Page 48.

2 Taken from the report of an interview entitled 'Food Security: Moving Towards the Precipice?' with the Chinese newspaper, *The Economic Observer*, 28 February 2008.

3 United Nations' populations projections, 2006 estimates report issued 13 March 2007. The estimates are based on an expected reduction in fertility rates in developing countries, but if present fertility rates persist, the 2050 figure would exceed 10 billion.

4 *Climate change threatens a million species with extinction,* University of Leeds press release, 7 January 2004.

5 David Suzuki and Holly Dressel *Naked Ape to Superspecies: A Personal Perspective on Humanity and the Global Eco-Crisis,* Allen & Unwin, 2002. ISBN 1-86508-649-5, page 26.

6 James Hansen et al, 'Target Atmospheric CO_2: Where should Humanity Aim?'. Draft paper released, April 2008, available on the Columbia University website.

Background

Climate Change

Global temperatures have a long history of changing. They have been unsuitable for sustaining large human populations in the past, and could well be again in the future.

The present rate of climate change is much faster than in the pre-industrial era, because human activities are releasing unprecedented quantities of greenhouse gases into the atmosphere. Fossil fuel use is responsible for the majority of these.

In 2005, the most recent year for which the United States Energy Information Administration has published figures, total world consumption of primary energy was 463 quadrillion (10^{15}) British thermal units (Btu). Of this, 86.3% was provided by fossil fuels, 6.3% by hydro generation, 5.9% by nuclear energy, and a mere 1.5% by everything else including biofuels, wind, solar, wood, etc. Included in the fossil fuel component is 36.6% provided by oil.[1]

The sheer size of the fossil fuel component of our energy usage is daunting. Unchecked, the emissions caused by their use will change the climate in ways that will be disastrous for ongoing human habitation.

Already, more extreme weather events, costing thousands of lives annually, are being attributed to climate change. Sea level rises are expected to accelerate and threaten many of the world's most densely-populated and agriculturally productive low-lying regions. Possibly the greatest threat is the prospect of ecosystem collapses caused by change happening at a faster rate than the organisms we depend on for food can adapt to.

Feedback Loops and Non-linearity

The likelihood that human-induced emissions will trigger dangerous feedback loops is of increasing concern. Known mechanisms include: oceanic warming, rainforest die-off, the melting of frozen methane, and the albedo effect. Alone, or in combination, they have the potential to accelerate climate change beyond a point where human intervention can halt it.

Oceans presently absorb about half of the human-induced greenhouse gas emissions via various life-forms, particularly phytoplankton. In a recent major study, NASA scientists demonstrated that, as the climate warms, phytoplankton growth rates decrease, reducing the amount of carbon dioxide absorbed. This happens because warming causes stratification of the ocean waters, creating an effective barrier between the surface layer inhabited by the phytoplankton, and the nutrients below. The result is that carbon dioxide is accumulating even more rapidly in the atmosphere.[2]

Rainforests are thought not to be able to withstand more than minor temperature changes. Warming could cause extensive die-off of tropical rainforests, such as the Amazon, releasing massive amounts of stored carbon, and causing even more warming.

Frozen methane has been kept out of circulation, in large quantities, both in the tundra and on the seabed. Should rising temperatures cause gasification, there is no way of controlling its release into the atmosphere. Consequently, temperature rises would accelerate.

The albedo effect results from a reduction in the ice cover. Water and land are darker than ice, and therefore reflect less heat from the sun, warming the planet further.

Other — a recently-discovered feedback loop is the lubricating effect additional melt-water has on the movement of glaciers and ice sheets, a phenomenon which contributes to the albedo effect. There are likely to be additional feedback loops, as yet undiscovered.

Until recently, climate models have assumed that change would happen at a steady rate. However, it is becoming increasingly clear that feedback loops can cause quick step-like events known as non-linearities. Why are non-linearities important? The more lineal (consistent) the rate of change, the better our chances of adapting. Non-linearities significantly reduce the possibility of successful adaptation.

Overview

Temperatures will not stay at their present levels, no matter what we do. The United Nations' Intergovernmental Panel on Climate Change (IPCC) warned that there is so much CO_2 and other greenhouse gases already in the atmosphere that even if concentrations held at current levels, the effects of global warming would continue for centuries.[3] There is wide agreement that the increase needs to be contained to around 2°C above pre-industrial levels if the worst consequences are to be avoided.

The IPCC estimated that a 50-85% reduction in emissions would be required by 2050 to stabilise temperature increases in the 2.0-2.4°C range. This prediction was tempered with the reservation that "the emission reductions required to meet a particular stabilisation level... might be underestimated due to missing carbon cycle feedbacks".[4] The IPCC further commented that "delayed emissions reductions constrain the opportunities to achieve lower stabilisation levels

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1 'International Total Primary Energy Consumption and Energy Intensity - Table 1.8', US Energy Information Administration, Posted 2 July 2007.

2 'Climate change reduces ocean food supply, threatening marine ecosystems', report of a NASA study published in *Nature,* 7 December 2007.

3 IPCC Working Group I, 4th Assessment.

4 *Climate Change 2007 Synthesis Report*. Intergovernmental Panel on Climate Change, Page 67.

and increase the risk of more severe climate change impacts."[5]

Challenging though the IPCC's findings are, new research indicates that they are not challenging enough. In a paper published in 2007, James Hansen of the United States National Aeronautical and Space Administration (NASA), and his co-authors, concluded their article under the subheading *Planet Earth today: imminent peril.* Their focus was on a non-linear climate change process known as an *albedo-flip trigger mechanism*, which seems likely to cause much larger and more rapid sea level rises than has previously been estimated. They demonstrated that the level at which greenhouse gases should be considered 'dangerous' is lower than had been assumed. In other words, action is even more urgent than IPCC reports, published a few months earlier (but based on older research) had suggested. [6]

Discussing Hansen's paper, British journalist George Monbiot said:

> *We are not talking any more about measures which require a little bit of tweaking here and there... We're talking about measures that require global revolutionary change. ... Bold and revolutionary proposals in my book* Heat[7] *don't go nearly far enough. We need to start thinking on a different scale altogether.... small is no longer beautiful. We have to start thinking on the biggest possible terms. We have very little time to act. We have very little time in which to bring about the largest economical and political change the world has ever seen.*[8]

In April 2008, Hansen co-authored a new paper that went even further.

> *Humanity's task of moderating climate change is urgent. Ocean and ice sheet inertias provide a buffer delaying full response by centuries, but there is a danger that human-made forcings could drive the system beyond tipping points such that change proceeds out of our control...*
>
> *Paleoclimate evidence and ongoing global changes imply that today's CO_2, about 385 ppm, is already too high to maintain the climate to which humanity, wildlife, and the rest of the biosphere is adapted...*
>
> *We suggest an initial objective of 350 ppm... Continued growth of greenhouse gas emissions for just another decade, practically eliminates the near-term return of atmospheric composition beneath the tipping level of catastrophic effects.*[9]

Hansen's team are not alone in their findings. Using a quite different methodology, another major paper has demonstrated similar findings, leading to the conclusion that:

> *... avoiding future human induced climate warming may require policies that seek not only to reduce CO_2 emissions, but to eliminate them entirely.*[10]

Our current economic system is based on emitting ever-larger quantities of carbon, well beyond the level natural systems can absorb. Halting this process before unstoppable feedback loops kick in, is a huge challenge. If we fail, the planet's capacity to support human populations will be significantly reduced. Unless we implement drastic changes quickly, major shortages of food, and other climate-related crises, will occur, probably within the life-spans of many people already living.

Peak Oil

Among the world's carbon-based fossil fuels, oil has two outstanding characteristics —very high energy density and ease of transport. Nothing else can completely substitute for it.

Oil is not only used for fuel, but also for an enormous range of plastics and other synthetics, which form part of almost every consumer product we use today. It is critical to the world's food production, being used right through the supply chain from tilling, to packaging and delivery. The so-called "green revolution" which has enabled the rapid growth of human population in recent decades, largely owes its success to the use of oil (and natural gas), in mechanisation, and the production of fertilisers and pesticides.

Oil's attractive attributes have resulted in its rapid exploitation. Remaining resources are becoming increasingly difficult to extract. At some point, probably within a few years, oil production will peak, then begin to decline.

Why will production peak?

When plotted against time, the oil production of a country generally resembles a bell-shaped curve, with the peak at the point where approximately half of the resource has been extracted. This phenomenon was first postulated in the mid-1950s by M K Hubbert, a senior geologist with Shell Oil in the United States.

Although one of the most respected petro-geologists of his era, this particular idea of his was received with considerable scepticism amongst his profession. No country had yet peaked, making it impossible to test his model against real-world data. Hubbert's vindication came in the early 1970s, when the world's then largest producer, the lower 48 states of the United States, peaked just when his model had predicted it would.

Why the bell-shaped curve pattern? It takes time to find fields and put in production infrastructure, hence the initial upslope of the curve. But oil reservoirs consist of

5 *Climate Change 2007 Synthesis Report*, Intergovernmental Panel on Climate Change, Page 73.

6 James Hansen et al 'Climate change and trace gases' *Philosophical Transactions of The Royal Society*, published online 18 May 2007.

7 George Monbiot *Heat: How to Stop the Planet Burning,* Allen Lane, 2006. ISBN 0-7139-9924-1...

8 George Monbiot, reported on www.indymedia.org.uk, 18 August, 2007.

9 James Hansen et al, 'Target Atmospheric CO_2: Where should Humanity Aim?' Draft paper to be submitted, April 2008, available on the Columbia University website

10 H Damon Matthews and Ken Caldeira, 'Stabilizing climate requires near-zero emissions', *Geophysical Research Letters*, Vol 35, 27 February 2008.

porous rock, and it takes energy to force the oil to the production wells. Initially, this energy comes from the natural pressure of gas associated with the oil.

Gas pressures drop as extraction proceeds. While this drop can be compensated for by pumping in fluids or gas, the process is increasingly energy-intensive, and eventually production per well begins to fall.[11]

At a national level, the upslope represents a period when new wells can be added to compensate for the declining output of existing wells. But, the point is eventually reached where it is impossible to add sufficient new wells to off-set these declines. That is the point of peak production. The production curve then enters an irreversible downslope, typically at around the stage where approximately half of the original reserves have been extracted.

Production in the lower 48 states of the United States is now well down the downslope. Other large producers that have already peaked and are progressing down their decline curves include Norway, the United Kingdom, Canada and Mexico.

Following the peak of production, the annual rate of decline in output in the lower 48 states was approximately 4%. This has widely been assumed to be a predictor of the global post-peak rate of decline. However, there are indications that the eventual global decline rate may be higher. The UK's oil output, for instance, has been declining at around 8% per annum.

One of the differences between the UK and the lower 48 states of the US is the use of modern high technology in extraction, which appears to result in faster depletion (see later discussion). The lower 48 states peaked before the introduction of these techniques, whereas they were widely applied from an early stage in the UK's much newer North Sea fields.

If 4% is taken as a global indicator then, compounded over a 10 year period, a decline of 33.5% in world production could be expected in the first decade after peak. A 6% decline rate (the average of the lower 48 states and the UK) would produce a decline of 46% in the first decade following the peak. For a world used to ever-increasing energy availability, these declines would be very difficult to deal with.

When is the peak likely to be?

The timing of the peak is influenced by a range of factors, often divided into the categories below ground (geological) and above ground (e.g. political, economic, infrastructure). The main driver is the geology, but above ground factors could move the peak a few years one way or the other. For instance, a major global economic recession could delay the peak, as could the speedy achievement of peace in Iraq, which has the world's largest untapped production capacity.

Attempts to calculate the timing of the peak are not only hampered by inevitable unknowns, such as the global economy and the future of Iraq, but also by the secrecy surrounding important geological data.

Undaunted, various researchers are working to make the best possible use of data that is available. The outcome is a range of opinions.

Leading the case for the optimistic viewpoint is the influential private US consultancy, Cambridge Energy Research Associates (CERA), which puts the peak decades away.

Originally similarly positioned, but now increasingly more cautious, is the International Energy Agency (IEA). Dr Fatih Birol, the Agency's Chief Economist recently had this to say:

> *We are on the brink of a new energy order. Over the next few decades, our reserves of oil will start to run out and it is imperative that governments in both producing and consuming nations should prepare for that time. We should not cling to crude down to the last drop — we should leave oil before it leaves us. That means new approaches will have to be found soon.*[12]

Less optimistic are a variety of independent experts, including Colin Campbell (petro-geologist and founder of the Association for the Study of Peak Oil and Gas), Matthew Simmons (Chairman of Simmons & Company International, a Houston-based investment bank specialising in financing oil exploration and extraction) and Chris Skrebowski (Editor of the UK Petroleum Review). They, and others like them, are generally of the view that world oil production is already at, or within, a few years of peak output.

Statements from the major oil companies have, in the past, generally tended to be optimistic. Recently, a more sober tone has begun to emerge from some. In October 2007, Christophe de Margerie, CEO of the major French oil company Total said:

> *One hundred million barrels per day*[13] *is now in my view an optimistic case… It is not just my view: it is the industry view, or the view of those who try to speak clearly, honestly, and not just try to please people… We have been, all of us, too optimistic about the geology.*[14]

A retired vice president of the world's largest oil producer, Saudi Aramco, has had this to say:

> *The worst thing that could happen is to continue to confuse ourselves and the public with too much spin about unlimited energy supplies at cheap prices, alternative fuels on a global scale, or energy independence in a matter of years. That kind of thinking simply dilutes the focus, defers the tough solutions that are needed today, and sets us all up for*

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11 For a more detailed description of how oil fields function, see Matthew Simmons; book, *Twilight in the Desert*, John Wiley & Sons, 2004.

12 Dr Fatih Birol, '*We can't cling to crude: we should leave oil before it leaves us', The Independent on Sunday*, 2 March 2008.

13 Present production has been stalled at around 85 million barrels per day for since mid-2005, despite high prices, and despite many optimistic predictions of possible future production in excess of 120 million barrels per day.

14 www.energybulletin.net, 11 November, 2007.

more future shocks and economic disruptions[15]

Political leaders have generally been reluctant to speak out on peak oil, but there have been some exceptions, most notably our own Prime Minister:

…we're probably not too far short of peak production, if we're not already there.[16]

The comment was made in response to a reporter's question at a regular Prime Ministerial press conference. Interestingly, none of the mainstream news media reported the matter, and the Prime Minister does not seem to have pursued it any further herself in public.

The difference between the optimists and the pessimists lies mainly in their assessments of the future potential of as-yet-undiscovered capacity. Discoveries peaked in the 1960s, and have been falling reasonably consistently ever since. In 1980s, discoveries fell below the rate of production. These long-standing trends don't bode well for the prospect of ongoing increases in production.

Of course new fields are being discovered, but they are smaller than the aging giants that dominate the world's production today. Many are also situated in conditions where extraction is costly and difficult. The celebratory publicity given to the Jack-2 test well in 2006 is indicative of the situation we are in. Jack-2 is situated in conditions which will test the outer limits of production technology.

Rather than indicating continued abundance in oil supply, such measures may be viewed more accurately as indicating the great lengths oil producers must go to in order to find more oil to meet the world's insatiable demand. The "low-hanging fruit" is gone and so is the era of the cheap oil. Ultimately, this is the meaning of the Jack-2 test well.[17]

Thus, while new capacity is constantly being brought on-stream, since 2005 it has only just kept pace with the decline in the output of older fields. Significantly, the present period of high oil prices hasn't resulted in increased net production.

The recent and unexpectedly rapid melting of the Arctic ice cap, due to climate change, offers a possible increase in capacity. However, unresolved issues over ownership of the Arctic seabed, and extreme working conditions, are likely to inhibit early exploration. Large-scale exploitation seems, almost certainly, to be some way off.

At present, the independent experts' figures are tracking a lot closer to observed reality than those of CERA and other optimists. Despite the Prime Minister's statement referred to earlier, the official current New Zealand Energy Strategy (published in October 2007) briefly considers the issue of peak oil, but then uncritically accepts the optimistic IEA prognoses of 2006, which the Agency itself is actively reconsidering (see the quote from Dr Fatih Birol on the previous page). The document sums up the government's official position in the following way:

So, while there will, at some point, be peak 'cheap' oil from conventional sources, the world has plentiful sources of fossil-based oil.[18]

Our government is not alone in its uncritical acceptance of outdated IEA prognoses. British columnist George Monbiot recently had this to say about his own government's position:

Nine months ago I asked the British government to send me its assessments of global oil supply. The results astonished me; there weren't any. Instead it relied exclusively on one external source; a book published by the International Energy Agency… Last week I tried again and got the same response… Perhaps it hasn't noticed that the IEA is now backtracking…[19]

It is possible to make too much of the differences between the alternative points of view. Higher prices to producers are stimulating rapid increases in domestic consumption in oil producing countries, leading to the likelihood that oil exports will peak before production.[20] For an import-dependent country such as New Zealand, the timing of peak exports is every bit as important as the timing of peak production. The New Zealand Energy Strategy (see reference above) makes no mention of this issue.

Further, the prospect of an imminent peak is likely to give oil producers an incentive to keep production in check now so as to benefit from much higher prices later on, optimising future income for their country. Saudi Arabia's King Abdullah recently put his position this way:

I keep no secret from you that when there were some new finds, I told them, 'no, leave it in the ground, with grace from god, our children need it'.[21]

Whether peak exports and/or production occurs in three years' time or thirty, a decline in the global availability of oil will happen within the lifetimes of many people alive today.

How does peak oil fit with climate change? Oil production will still remain relatively high immediately after the peak. Thus, oil's ongoing use will continue to contribute adversely to climate change, even after peak production has passed. Some approaches to alleviating the reduced

15 Sadad al Husseini, former head of exploration and production for Saudi Aramco, interview with the *Journal of Petroleum Technology*, January 2007.

16 www.scoop.co.nz, 21 April, 2006..

17 Dave Cohen, "Jack-2 and the Lower Tertiary of the Deepwater Gulf of Mexico", www.theoildrum.com 11 September, 2006.

18 *The New Zealand Energy Strategy to 2050 - Powering Our Future*. *Section 7. Resilient, Low Carbon Transport.* Published 11 October 2007, page 3.

19 George Monbiot, 'Apart from used chip fat, there is no such thing as a sustainable biofuel', *The Guardian*, 12 February 2008.

20 Dallas-based geologist Jeffrey Brown's Export Land Model provides a readily-available tool for understanding the influence of this issue.

21 Saudi Press Agency, as reported by Reuters, 14 April 2008.

availability of oil can also ameliorate climate change, for instance greater use of public transport instead of cars. Unfortunately, other approaches, such as substituting coal for oil, will accelerate climate change.

As the world's economy depends on ever-increasing oil supplies, peak oil is likely to have a significant economic impact, precluding implementation of such costly mitigations as carbon capture and storage technologies, and improved public transport infrastructure.

Oil has been integral to our way of life. Almost every activity we undertake has an oil component to it. The post-peak era will be very difficult to deal with.

Relevance to New Zealand

Overview

Far from being as clean and green as we like to portray ourselves, on a per capita basis New Zealanders are amongst the world's greatest contributors to oil depletion and climate change. We have an economy based substantially on earnings from farming ruminant animals, long-distance transport of exports, and flying long-haul inbound tourists. We are also major end-users of carbon-intensive products and activities.

New Zealand has long been one of the most energy-intensive countries in the OECD, but worse still, our relative performance has been declining. (Energy intensity is a measure of energy used per unit of production). In 1980 our energy intensity was 65% worse than that of the UK, and 10% worse than that of the United States. As a measure of how far off track New Zealand's performance has been, by 2005 these figures had deteriorated to 150% and 52% worse respectively.[22]

New Zealand's advantages

Despite our high and increasing greenhouse gas emissions, present indications are that New Zealand will be one of the least severely affected in the early stages of climate change. Our mid-latitude location, surrounded by ocean, is a significant asset, as is the relatively high overall elevation of our land surface. And, having a low population relative to productive land area, we could cope with a fall-off in global food production better than many.

For electricity, we have a substantial hydro-generation infrastructure. We have developed geothermal and wind power resources, and have the potential to do more, especially with wind, for which we are one of the best-resourced countries in the world. Tidal and wave generation offer potential, albeit that suitable technology has yet to be proven in operation. Our angle to the sun and sunshine hours also provide the opportunity to expand the use of solar energy.

New Zealand's disadvantages

Fossil Fuel Resources. For a country whose standard of living is so heavily dependent on oil, we produce worryingly little ourselves. Peak oil is likely to hit New Zealand hard.

In recent decades, we have been self-sufficient in natural gas, but we have already passed our own peak of gas production, and will have to find alternatives in the coming years.

It appears that we have large reserves of coal. However, Huntly, our one major coal-fired power station, is now partly fuelled by imported Indonesian coal because of unexpected technical and extraction difficulties with local coal from one of our largest fields.

Our biggest fossil fuel resource is lignite, a low grade coal that is highly polluting to burn. This is located in Southland, a long way from our main energy markets.

Farming. New Zealand's economy is dependent on pastoral farming, which is responsible for almost half of the country's greenhouse gas emissions. The gaseous output of the digestive systems of sheep and cattle alone account for over 30% of the country's total greenhouse gas emissions.[23] These animals belong to a class of animal known as ruminants. From a climate change perspective, the problem with ruminants is that their distinctive digestive systems turns carbon dioxide (originally taken in by the grass they eat) into methane, a much more potent greenhouse gas.

No single issue demands more research in New Zealand. Possible approaches to dealing with ruminant emissions include improving the animals' digestive efficiency, changing their diets, manipulating their digestive microbiology, or selectively breeding low methane producing animals.[24] However, given the nature of the animals' digestive systems, and the type of food they require, it is unrealistic to expect more than minor improvements.

The most certain way of reducing New Zealand's methane emissions significantly is to reduce cattle and sheep populations, which could be done by converting to non-ruminant farming, eg forestry, poultry, pigs and horses. However, our infrastructure is geared towards cattle and sheep, as are our export markets. And, these animals currently provide the majority of New Zealand's overseas earnings.

One possibility being suggested is to shift some of the burden of agricultural emissions onto other sectors of the economy by setting proportionately higher target levels of reduction for such sectors. Not only is this opposed by the sectors concerned, but the sheer scale of agricultural emissions makes it effectively impossible

[22] From data listed on the US Energy Information Administration's website, 2 March 2008.

[23] Ministry for the Environment 2006, cit. Harry Clark, 'Methane Emissions from New Zealand Ruminants', in Ralph Chapman, et al., eds, *Confronting Climate Change: Critical Issues for New Zealand*, Wellington, 2006, p.163.

[24] Harry Clark 'Methane emissions from New Zealand ruminants' in *Confronting Climate Change: Critical Issues for New Zealand*, pp. 165-170.

for any combination of other sectors to fulfil this role to any significant extent.

The ruminant issue has yet to fully register in the global market place. However, with information, perceptions and attitudes changing almost monthly, it would be unwise to count on this continuing. For instance, the *Los Angeles Times* ran an article on 15 October 2007 headed 'Killer Cow Emissions', suggesting consumers do their bit by cutting back on red meat.

If global consumers jump onto a 'ruminants are bad' bandwagon, it might well then be too late to implement a managed transition to more sustainable forms of farming. We cannot aspire to being carbon neutral without tackling these issues.

Distance. Compared with most other countries, New Zealand is a long way from its major markets. The vast majority of our exports are carried by sea. Although, per tonne kilometre of cargo carried, shipping is less carbon-intensive than air transport, total CO_2 emissions from global shipping are double those of aviation, and are increasing at an alarming rate. The International Maritime Organisation predicts that ships' emissions could increase by 72% by 2020. [25]

At present, CO_2 emissions from international ships and aircraft do not come under the Kyoto Protocol. Rectification of this anomaly will have serious implications for New Zealand. Individual consumers in Europe are already starting to take an interest in "travel miles" and "food miles". Research in the UK shows that 66% of consumers say they want to know the carbon footprint of the products they buy.[26]

While we claim that some of our products are more carbon-efficient over the complete production cycle, we risk falling into the trap of comparing two sets of unsustainable systems. Ultimately, Europeans are more likely to believe that their orchardists can adopt sustainable practices more readily than that New Zealand can ship apples sustainably to the other side of the world. It would be wise to have a 'Plan B' for agriculture.

And it is not just with agriculture that we face problems. Our second major foreign exchange earner is tourism. Tourists mainly arrive by long-haul flights, which are inherently highly carbon emitting, and depend on the ready availability of cheap oil. An Australian aviation expert has calculated that one person's emissions from a return Sydney-London air trip were equivalent to five-to-seven years of average car travel.[27]

Recent research by Inga Smith and Craig Rodger at the University of Otago showed that, in 2005, the carbon emissions from inbound international visitor's return air flights was nearly 7.9 million tonnes, roughly the same as for all the country's fossil-fuel-powered electricity generation, and about 10% of the country's greenhouse gas emissions. The researchers evaluated potential offset measures, but found them infeasible. Installing wind turbines as offsets, would cost $10 billion. Using regenerating bush to offset the emissions would require an area equivalent to 15 Stewart Islands.[28] (Although not part of the study, similar calculations could be applied to New Zealanders travelling overseas, and if incorporated, would significantly increase these figures).

Increasingly, the environmental consequences of flying are being discussed in the British media, and elsewhere in Europe. Recently, the leading article in one of Britain's most influential newspapers was headed:

It is plain and simple… this aviation boom threatens the world's future.[29]

The issue could hardly have been put more starkly. Aviation could become the new tobacco!

It is possible that peak oil could eclipse the climate change awareness impact on tourism. Aviation is entirely dependent on oil, currently having no fuel alternatives. Although biofuels have been trialled, their widespread use in aviation faces enormous difficulties (see later discussion on biofuels).

Tourism is a discretionary activity that will come under pressure from emissions reduction measures, oil supply reductions and consequent economic disruptions. Without doubt, New Zealand also needs to be working on a 'Plan B' for tourism.

Summary — New Zealand

Due to our heavy dependence on imported oil, and our high levels of personal indebtedness, New Zealand is likely to be one of the more severely affected countries in the early stages of declining oil production.

By contrast, we are likely to be one of the least directly affected countries in the early stages of climate change. Indirect effects are a different matter.

Should the international community decide to tackle emissions decisively, it is unlikely that our continued lack of effective action would be looked upon kindly.

Our reputation as a country with a clean and green environment is priceless. Failure to protect it by inaction on sustainability would pose a considerable economic risk to New Zealand.[30]

There are no easy answers. Business as usual is not an option. The more preparation we make in advance, the better situated we will be. We are entering an era that requires enormous political courage from our leaders.

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25 John Vidal, Environment Editor, *The Guardian*, 3 March 2007.

26 Ian Herbert, 'Carbon footprint of products to be displayed on label package', *The Independent*, 20 March 2007.

27 Murray May, quoted in CSIRO Sustainability Network Update 64e, 15 February 2007, p. 20.

28 'Air travellers to NZ "cost" eight million tonnes of carbon annually', nzherald.co.nz, 1 March 2008.

29 *The Independent,* 2 March 2008.

30 Prime Minister Helen Clark, speech notes for launch of the New Zealand Energy Strategy and the New Zealand Energy Efficiency and Conservation Strategy. 11 October, 2007. Reported on www.beehive.govt.nz

Maintaining Consumption

Faced with an impending decline in oil production, and the need to reduce greenhouse gas emissions, can we maintain our present energy-intensive lifestyles? The short answer is no. However, there is a range of approaches, substitutes and technologies that, in combination, could offer a degree of substitution for oil, and/or amelioration of climate change.

Substituting for oil presents major challenges because there is simply no other fuel with all of its attributes. And, as much as oil use contributes to climate change, some of its possible substitutes are even worse offenders.

We have divided the attempts to maintain consumption into three categories:- adaptation, substitutes, and other technologies. *Adaptations* are ways of working around constraints by doing things differently. *Substitutes* are alternative energy sources that might be used to replace oil and/or mitigate climate change. *Other technologies* are non-energy approaches to energy supply and/or climate change challenges.

Adaptation

Because climate change and peak oil are happening at a faster rate than ameliorative measures can be introduced, adaptation will be an inevitable part of our response. Adaptive strategies involve doing things differently.

It could be argued that the easiest way to deal with climate change would be to get used to it, or even to exploit it. At least initially, climate change might provide some advantages in some regions, including in New Zealand. Potentially, new crops might be able to be grown. The costs of warming houses in winter might reduce.

An example of adaptation comes from the Netherlands. After abnormally severe river flooding necessitated a massive, unwieldy evacuation in 1995, Dutch officials rethought their whole approach to flood protection. Rather than building ever higher barriers against the North Sea storms, hydraulic engineers designed a scheme to purposely breach the dikes during critical flood conditions, releasing waters into areas where flooding would cause least damage. The initiatives were called "Living with Water", and were just the latest manifestation of the country's long tradition of living with the water that surrounds it.[1]

Extreme weather events have always been part of human history, and adaptive measures have been taken, with varying degrees of success. One traditional adaptation was to migrate to less densely populated areas – an option that is now less available because populations worldwide have increased dramatically, and national border controls are more stringent.

There are limits to adaptation. For inhabitants of countries that become flooded or drought stricken, and which cannot afford major public works, the only adaptations available might be death or migration! Even in less affected countries, such as New Zealand, the eventual likely scale and costs could go well beyond those that might reasonably be accommodated by the "learning to live with it" approach.

Thus, although adaptation will undoubtedly play a role, the search is on for more direct means of maintaining consumption.

Energy Alternatives

Fossil Fuels

All fossil fuels are derived from ancient biomass that has been transformed geologically, by heat and pressure. The processes involved are extremely slow, taking many millions of years. We are currently drawing on reserves so much faster than any possible replenishment. For all practical purposes, these reserves are finite.

Because oil is the most attractive of all the fossil fuels, it has been extracted with particular industriousness. Oil production will therefore peak ahead of other fossil fuels, which are increasingly in contention as potential oil substitutes.

Conventional natural gas consists of methane and other gaseous hydrocarbons. It produces the lowest greenhouse gas emissions of all the fossil fuels per unit of energy, and is easily transported by pipeline.

But, ships and terminals are significantly more costly to build and operate than those used for oil. Increasing demand from existing uses of gas (such as for generating electricity and manufacturing fertilisers) limits its availability as an oil substitute. And, it's gaseous characteristics mean it is not directly substitutable for oil in many applications.

New Zealand's gas output peaked in 2001. Worldwide, conventional natural gas production is expected to peak one to two decades after oil. Much of the remaining untapped capacity is located in Russia and Iran, two countries with which the West has problematic relationships. Gas fields decline more quickly than oil fields, so the post-peak era is likely to be particularly challenging.

Unconventional natural gas has similar qualities as a fuel to conventional natural gas. The difference lies in its location, which is in difficult conditions, often requiring yet-to-be commercialised production technologies. Relatively little is known about the size of exploitable reserves, although there is every reason to believe that they are fairly large.

Previously, the ready availability to cheap-to-reach conventional natural gas meant that there was little incentive to explore resources and develop technologies. But, depleting or inadequate conventional gas resources

1 Eve Fairbanks, 'What we can learn from the Netherlands', *The New Republican*, 5 September 2005.

is providing an incentive for accelerating development in a number of countries. In the United States, so-called "tight gas" is increasingly contributing to overall gas production. In New Zealand, Solid Energy is exploring the commercial viability of extracting coal seam gas.[2] Japan is actively researching technologies to exploit methane hydrates, (a frozen form of unconventional gas dealt with in the following section).

Because it emits considerably less carbon dioxide per unit of energy than coal, unconventional gas could help mitigate climate change if employed as a coal substitute. However, its use as an additional source of energy, would have the opposite effect. The potentially huge scale of the reserves gives considerable cause for concern in this regard.

Methane hydrates are a frozen form of unconventional natural gas. Occurring in areas of permafrost, and on the seabed, they are known to be extremely difficult to exploit, and have thus been little studied to date. With only the sketchiest of data to draw on, estimates of global reserves vary hugely. A 2002 report from the Soloviev Institute for Geology and Mineral Resources in Russia estimated them to be similar to the remaining conventional reserves of natural gas.[3] But, the United States Geological Service has estimated that methane hydrates may contain more organic carbon than all the world's coal, oil and conventional natural gas combined.[4]

As the energy market tightens, there is increasing incentive to solve the technical challenges standing in the way of exploiting this resource. Lacking significant quantities of more conventional fossil fuels, Japan recently managed to extract "industrial quantities" over a six day period.[5] If commercially successful, exploitation will inevitably lead to a large increase in greenhouse gas emissions.

Any exploitation of methane hydrates carries risks of large-scale uncontrolled release, something which is generally not a problem with other fossil fuels. As methane is a more potent greenhouse gas than carbon dioxide, such releases would be potentially disastrous.

Tar (oil) sands / heavy oil – large quantities of these resources exist, principally in Canada and Venezuela. Extraction of tar sands is already occurring on a commercial scale in Canada. The source material is mined, and requires significant processing to convert it into the liquid end product. Mining and processing are both highly energy (natural gas) intensive. Processing also requires enormous quantities of water. There are doubts about whether enough natural gas and water is available to sustain long-term substantial increases in output.

The high resource inputs result in high greenhouse gas emissions. A massive scaling up in output would have serious consequences for climate change.

An experimental technology, currently under trial, burns oil sands *in situ* to provide the primary energy source. If successful, this would overcome the constraints of natural gas supplies, but at the cost of even greater greenhouse gas emissions.

Oil shale is a rock containing a form of organic matter known as kerogen. Some shale is burned directly as a fuel in electricity generation, but coal is much better suited to this application. The big appeal of shale is that kerogen can be converted to oil.

Globally, the gross energy contained in shale is thought to exceed that of oil. However, the net energy available after extraction and processing is quite a different matter. Conversion requires considerable amounts of energy. And, despite decades of effort, no way has yet been found to achieve large-scale conversion at commercially viable rates of net energy return.

In recent years, Shell Oil has been the leading investor in the field. But, in 2007, the company announced a significant scaling back of its efforts, signalling that commercialisation was, at best, quite some way off.[6] There is thus little sign that the small-scale and spasmodic nature of the industry is likely to change in the foreseeable future.

Coal is plentiful, and is also relatively cheap to produce. Coal's main use worldwide is in electricity generation. The sheer global scale of coal-fired electricity generation makes the electricity sector one of the worst greenhouse gas emitters. Despite wide acceptance of the need to reduce usage, global hard coal consumption in 2006 increased by an extraordinary 8.8% over the previous year. In the 25 years to 2006, it increased 92%.[7]

Unfortunately, per unit of energy produced, coal emits more than double the amount of carbon dioxide emitted by oil. While capturing and storing carbon dioxide emissions from coal-fired power stations is widely discussed, large-scale implementation is, at best, some way off (see the later section on sequestration).

Converting coal to an oil substitute is an established technology, originally developed by Germany during World War II. It was re-established in South Africa during the apartheid era, and is still used there. Massive scaling up is technically feasible, but the process is costly, and gross emissions are very much higher than for oil-based products.

Underground gasification of coal is a new technology currently under development, with a pilot plant already operating successfully in Australia. If commercialised, this technology would open up the exploitation of huge deposits that have previously been too costly to extract. Such an outcome would have extremely serious consequences for climate change.

Recent analyses indicate that coal reserves could be

2 Waikato Times, 24 April, 2008.
3 'Hydrates Updated' on www.europe.theoildrum.com, 18 April 2008.
4 'Unconventional Natural Gas Resources', www.naturalgas.org
5 'Japan's Arctic methane hydrate haul raises environmental fears', on timesonline.co.uk, 15 April 2008.
6 Tom Little, *Peak Oil Review*, 14 May 2007.
7 "Coal Facts 2007", World Coal Institute.

much less than the oft-stated "hundreds of years".[8] Even so, confirmed reserves are still more than large enough to put stabilisation of greenhouse gas levels beyond reach.

Eighty percent of New Zealand's estimated coal reserves are in a low quality form known as lignite. Located in Southland, they are a long way from our main energy markets. Because of their low energy density, and high levels of contaminants, increased use of lignite would have severe ecological consequences.

So far, lignite has not been greatly used in New Zealand. But, this resource is now being actively promoted for large-scale electricity generation and/or liquids conversion.

Biofuels

Biofuels are derived from recently-grown biomass. Although, they generally don't perform quite as well as oil-based fuels, from a peak oil perspective, they have the attraction of providing the most easily-used substitutes for oil-based products.

From a climate change perspective, their theoretical attraction is that they return recently-captured carbon to the atmosphere, leaving the net amount of carbon in the atmosphere essentially unaltered. (The use of fossil fuels, by contrast, adds previously long-stored carbon to the atmosphere, thus increasing atmospheric carbon.)

In practice, biofuels are never carbon free, requiring fossil fuels for production and storage. But, their main weakness is that they will require large quantities of space to grow if their use is to be scaled up significantly. Securing this space involves displacing something else, either food crops or natural ecosystems.

Globally, there is increasing unease about the possible impact of large-scale biofuel production on food supplies. In October 2007, the UN Special Rapporteur on the Right to Food, Jean Ziegler, demanded an international five-year ban on producing biofuels, calling them *a crime against humanity*.[9] Two months later, the United Nations Food and Agriculture Organisation warned that the soaring cost of food was threatening the survival of millions of people in poor countries. Food prices had risen an unprecedented 40% partly due to climate change, as well as demand for biofuels.[10]

Global food supply difficulties are putting enormous pressure on politicians to review their previous preference for biofuels.[11] In April 2008, the European Commission showed signs of backing away from its 10% biofuel requirement, one of the most important components in its campaign to reduce greenhouse gas emissions.

The New Zealand government is under similar pressure. Previously, New Zealand's Energy and Efficiency Conservation Authority estimated that, by 2012, we could produce up to 3.4% of our petrol from non-food producing land.[12] This percentage then became the required level of sourcing under the government's proposed legislation.

The target is likely to be a stretch. Generally the type of land envisaged doesn't support growth well, and the terrain is often remote or difficult to access, requiring high fossil fuel inputs for transport, machinery and fertilisers. In addition, the target, which would take four years to achieve, represents less than the recent annual rate of increase in New Zealand's petrol consumption (which has been running at around 5% p.a.).

As global concerns about food security increased, it became clear that New Zealand's biofuel requirements could add to the problem. In April 2008, the Parliamentary Commissioner for the Environment called for the government's current bill to be scrapped.[13] She is not alone in her concerns.

> *The problem is the land producing biofuels is competing with that for food production and there simply isn't sufficient land globally to do both. It's not a good look for New Zealanders to be filling their cars with biofuels while the world's poorest starve.*[14]

It isn't just the impact that biofuel production has on food supplies that is drawing criticism. Biofuels' actual effectiveness in reducing greenhouse gas emissions is also being widely queried. A recent study, led by a scientist at the US Nature Conservancy, and published in *Science* found that

> *...when peat lands in Indonesia are converted into palm-oil plantations,,, it would take 423 years to pay off the carbon debt. ... when forested land in the Amazon is cut down to convert into soybean fields... it would take 319 years of making biodiesel to pay off the carbon debt caused by chopping down the trees in the first place.*[15]

A recent heading to Dave Hansford's weekly "Ecologic" column summed the biofuel situation up in a nutshell:

> *The road to hell: Biofuels seemed like a good idea at the time.*[16]

Grain ethanol production is already well-established, but production is only commercially viable with substantial farm subsidies.

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8 Energy Watch Group, 'Coal: Resources and Future Production', April 2007 (reported on by Richard Heinberg, March 2007); B. Kavalov and S. D. Peteves of the Institute for Energy (IFE), 'The future of Coal', prepared for the European commission Joint Research Centre, May 2007, (reported on by Richard Heinberg, 9 May 2007).

9 http://news.bbc.co.uk, 27 October 2007

10 http://news.bbc.co.uk, 17 December 2007

11 'Politicians in reverse on biofuels: fuel for the rich a "crime against humanity"', *Sunday Star Times,* 20 April 2008.

12 Elizabeth Yeaman, Senior Advisor Renewable Energy, Energy Efficiency and Conservation Authority (EECA), presentation to Engineers for Social Responsibility (ESR) 19th National Conference, Auckland, March 2007.

13 'Misgivings in New Zealand', *Sunday Star Times, 20 April 2008.*

14 Nick Smith, National Party MP, reported in the *Sunday Star Times*, 4 May 2008, page C6.

15 'The great green con: study reveals the cost of biofuels', *The New Zealand Herald*, 14 February 2008.

16 *New Zealand Listener,* 29 March 2008. page 49.

Superficially, grain ethanol offers lower carbon emissions than oil. However, production requires significant use of oil and gas (in farm machinery, pesticides, herbicides, fertilisers, transport and processing plants). Energy returned on energy invested (EROEI) is poor, even negative in some circumstances.

Grain is fundamental to sustaining human life. Producing ethanol from grain puts pressure on food supplies.

> *Filling a Range Rover with subsidised ethanol would take as much grain as would feed an African family for a year. Rich countries' fuel substitution programmes often consume more energy than they save [doing] the opposite of what was intended.* [17]

Scaling grain ethanol as a substitute for oil is a recipe for a humanitarian disaster.

Sugar ethanol can be produced either from cane or beet. Cane-sourced ethanol is already in common use as an oil substitute in Brazil. It is commercially viable, and low carbon emitting.

There is a worrying potential for cane ethanol to displace food crops and/or tropical rainforest. Tropical rainforests are major carbon sinks. Deforestation releases huge quantities of captured carbon.

New Zealand does not have a suitable climate for growing sugar cane, and does not produce beet.

Cellulosic ethanol is produced from woody biomass. A lot of work is going into developing suitable processes, but commercialisation is hampered by the difficulty of achieving a positive net energy yield.

The matter of what constitutes waste is also an issue. If left *in situ*, a lot of so-called waste is recycled by natural processes to reinforce soil fertility. Ongoing removal reduces the long-term productivity of the land.

Given the amount of wood waste generated in New Zealand, cellulosic ethanol may have some potential. On a global scale, however, even if the outstanding issues can be successfully resolved, it seems unlikely that cellulosic ethanol will be able to be scaled up to play more than a minor role as an oil substitute.

Whey-based ethanol uses a by-product derived from cows' milk. Dairy farming is a major source of carbon emissions. Thus the environmental merits of using fuel derived from this source are highly questionable.

A 10% whey ethanol petrol blend was launched in New Zealand by Gull in 2007. Although the supplier, Fonterra, is one of the world's largest milk processors, it announced that it had insufficient uncommitted product to supply other petrol outlets. It seems unlikely that whey-based ethanol will be able to be scaled up much further.

Biodiesel technology is already well established. Unusually for an oil substitute, it is cost-effective (ignoring externalities), and there are no significant technical obstacles to its everyday use.

[17] Mike Moore, former NZ Prime Minister and Director-General of the World Trade Organisation, reported in *The New Zealand Herald*, 28 April, 2008,

The downside of biodiesel lies in the consequences of growing its two main feedstocks, palm oil and rapeseed. Palm oil is grown on former tropical rainforest and associated peat lands. Clearing these is one of the world's worst contributors to greenhouse gas and particulates emissions, and to biodiversity reduction.

Rapeseed was traditionally used to produce cooking oil, margarine, and cattle feed. Not only is a food source being diverted to fuel use, but rapeseed farming causes worse water pollution than most other crops.[18]

New Zealand has some small-scale potential biodiesel feedstocks, most notably tallow. However, tallow is in demand for other more profitable purposes. Furthermore, tallow is produced from ruminant animals, an environmentally unfriendly source, which will need to be scaled down if we are serious about reducing greenhouse gas emissions.

Algae seems to have some potential as a more environmentally-friendly source of biodiesel. To date, the technology has not advanced beyond small-scale trials due to processes failing when scaled-up. While a New Zealand firm has recently claimed a major secret technological breakthrough, this has been greeted with a generally sceptical response.[19]

Even if a real breakthrough in algal technology is made, just like plant-based biofuels, production will be dependent on sunlight as the energy source. That means space being allocated to it, space that is presently occupied by something else.

In summary, it seems unwise to count on biodiesel playing more than a minor role in oil substitution.

Biomass gasification covers a range of proposed technologies which aim to turn biomass into gas, which can then be converted to liquids, if desired. The appeal of this approach lies in the possibility of using waste as the feedstock, eg chaff. A small number of demonstration projects are under development, the most advanced being in Germany.[20] At present, capital costs are too high to be commercially viable. The availability of suitable quantities of feedstock is likely to limit scalability. While further research is warranted, it seems unlikely that biomass gasification will play more than a minor role in ameliorating peak oil or climate change.

Thermal depolymerisation and other biofuels - several other biofuel technologies are under investigation. However, there is a pattern of hype followed by a reality check as each new 'answer' to the oil problem runs into significant difficulties. Several years ago, thermal depolymerisation (TDP) was heralded as being able to take any organic material and turn it into oil. TDP was going to deal with the world's waste, supplement dwindling oil supplies, slow down global warming, and make oil for $8-12 a barrel. Costs turned out to be very much higher than forecast, unforeseen complications

[18] *The Guardian*, 19 April 2007.

[19] Joanne Black, 'Fuel's Gold', *New Zealand Listener*, 24 May 2007, page 16ff.

[20] Robert Rapier 'A visit to the new Chloren BTL Plant', posted on theoildrum.com 5 May 2008.

arose, and small technical problems turned out to be big when the process was scaled up.

Non-fossil Electricity Generation

Coal and natural gas are the main sources of energy for electricity generation globally. The only presently massively scalable substitute is nuclear fission.

In October 2007, the New Zealand government announced that state-owned electricity companies would be directed to source all new generating capacity from renewable sources.[21] There is some hope that this ambition might be achievable in New Zealand, but there is little indication that it is possible in many other countries without radical transformation of their economies.

Although it is presently used in this role only to a very limited extent, electricity has potential as an oil substitute via a range of technologies including electric trains, trams, trolleybuses, plug-in hybrid vehicles, and the manufacture of hydrogen fuel (dealt with in more detail later in this chapter).

Hydro-generation is a long-established renewable technology, which provides a relatively small percentage of worldwide generating capacity, but a much larger, although falling, percentage in New Zealand.

Twenty years ago, hydro power accounted for more than 70 percent of the total electricity generated. As the population and the economy have grown, hydro power's share has declined to approximately 60 percent of total electricity generated today.[22]

Although capital costs can be high, running costs are low, and compare well with fossil-fuelled alternatives. Despite the advantages of hydro-generation, future expansion is limited by the availability of suitable new sites, and by other environmental considerations. Mini-hydro schemes are easier to implement than large-scale schemes, but there is little chance that they will become numerous enough to have a significant impact.

Until recently, hydro-generation has been held out as a climate-friendly alternative, but overseas research has raised important queries. Emissions of significant quantities of the potent greenhouse gas methane have been attributed to decaying biomass on the lake floors of dams.[23] More work needs to be done before the scale and relevance of this issue is better understood.

Near-surface geothermal generation is an established low-carbon technology. Although New Zealand is a leader in this field, commercially viable sources are limited here, and even more so globally. Currently, geothermal contributes around 6% of New Zealand's generating capacity, but this share is unlikely increase significantly in future.

Deep-level geothermal is a theoretical concept only. If the heat of the earth's core could be tapped, its potential as a non-carbon energy source would be almost unlimited. However, exploitation presents major technical, energy input and cost issues, and these appear to be a very long way from resolution.

Wind energy is one of the few true bright lights on the horizon. Apart from the carbon emitted in constructing and installing turbines, this is a nil-carbon technology. It is currently in operation, and is steadily being improved. Furthermore, it is commercially viable, under present conditions, and returns positive net energy on energy invested.

Nevertheless, output is intermittent, suitable sites are limited, and there is often local resistance to visual intrusion. Also, density is low, meaning that facilities cover much greater areas than is required for fossil-fuelled generation.

Although global scalability is limited, wind generation is expected to play a steadily-increasing role in New Zealand, which is one of the best-situated countries in the world for wind.

Solar (general) — the sun daily delivers 20,000 times more energy to the earth than we currently use in the form of fossil fuels.[24] However, as an electricity source or oil substitute, energy from the sun has some major inherent problems, such as intermittency, and the technology required to capture it. Also, generating facilities cover much greater areas than is required for their fossil-fuelled equivalents.

Although it is possible to envisage solar technology eventually making a large contribution, there is no immediate sign of a breakthrough of the scale necessary to have a significant impact on the problems of climate change and peak oil in the near future.

Solar photovoltaic technology converts light from the sun directly into electricity, without any intermediate thermal phase. The technology is already widely in use, but only in small-scale applications where connections to a grid, or other source, are inconvenient.

Current photovoltaic technology employs silicon, a common element, but one that is costly to purify to the extent necessary. These costs have proved stubbornly difficult to reduce to a level low enough to make mass generation commercially viable.

Photovoltaic technology continues to be an area of intense research activity. Even so, progress seems likely to be incremental, rather than dramatic. There is no apparent immediate prospect of a leap of the magnitude necessary for photovoltaic generation to play a significant role in displacing fossil fuels in electricity generation in the near term. New Zealand is well positioned to take advantage of photovoltaic generation, if ever such a breakthrough were to be achieved.

Solar thermal energy harnesses energy from the sun as heat (eg directly as in water heating, or indirectly as in electricity generation).

21 'New fossil fuel plants banned for 10 years', *The Dominion Post* | 12 October 2007.

22 'Water, wind and Kilowatts', Statistics New Zealand, April 2008.

23 J. Giles, 'Methane quashes green credentials of hydropower', *Nature* 444, 30 November 2006.

24 David Goodstein, Professor of Physics, California Institute of Technology, *A Crude Awakening: The Oil Crash,* DVD.

Solar hot water has domestic and light industrial applications. Solar thermal energy can also be used in building design. Small-scale technologies have been progressing steadily, and are widely used in many countries, including New Zealand.

Water heating is a major energy use, and therefore a valuable target for further development. Hot water cylinders offer the added advantage of helping smooth solar's inevitable intermittency.

Solar energy potentially offers large carbon emission reductions for New Zealand, but government attempts to advance its use have been little more than half-hearted. In the absence of priced-in externalities for other electricity sources, subsidies are needed to facilitate widespread use of solar water heating.

Subsidies could include funding larger-scale more cost-efficient production, and a larger and better-trained workforce of installers.

Internationally, much research effort is focused on solar thermal-to-electricity generation. Several techniques are being trialled.

Wave & tidal energies seem to offer considerable potential. The sources are huge, widely available, and operation should be practically carbon-free. There is no shortage of ideas but, despite much research, only minor commercial deployment has occurred with tidal, and none with wave generation.

New Zealand has many potential sites, two of which — Cook Strait and the mouth of the Kaipara Harbour— have received recent attention. Both are costly and difficult places to undertake major engineering projects.

It seems unwise to count on wave and tidal generation being available on a scale sufficient to have a significant early impact on greenhouse gas emissions and oil shortages over the next few decades.

Osmotic power utilises the osmotic pressure difference between fresh water and sea water. Power plants would be located at the mouths of rivers. A pilot plant started operating in Norway in 2003. Commercialisation will require significant further development of membrane technology, and a major scaling-up of membrane manufacturing capacity. If successful, energy from this source is expected to be non-intermittent and relatively CO_2-free, with plants occupying less space than most other renewable energy sources.[25] However, suitable sites are likely to be limited, and the environmental consequences are presently uncertain.

Nuclear fission releases energy by forcibly splitting heavy uranium atoms. Depending on enrichment and eventual disposal methods, emissions could be as low as 3.3 grams total CO_2 per KW-Hr, compared with 400g from natural gas and 700g from coal.[26] Energy return on energy invested is also very positive.

Unfortunately, there are significant downsides. Accidents are potentially catastrophic. Waste is dangerous for thousands of years. And, despite many decades of research, effective and financially viable waste storage technologies have not yet been established. Moreover, fission generation faces future uranium availability issues, and carries risks of nuclear arms proliferation.

Commercially, fission generation cannot compete with fossil-fuelled generation. Nevertheless, nuclear fission is the only existing low-carbon technology with an established potential to be massively scaled-up. It appeals to politicians desperately seeking means of reducing carbon emissions while maintaining current lifestyles.

At present levels of usage, replacing fossil fuels with nuclear power would require around 6,400 reactors.[27] This assumes no growth in energy usage, and no loss of efficiency in converting electricity to transport fuels such as hydrogen. A more likely requirement would be in the order of 10,000 reactors.[28] As at late 2007, there were just 439 reactors in service and another 34 under construction.[29] Reactors have a finite life, and a proportion of those presently being constructed are replacements for capacity being retired.

Thus, despite much talk, the number of nuclear power stations currently under construction is well short of that needed to reduce dependence on fossil fuel-powered generation.

The construction of nuclear power stations requires a sophisticated and highly specialised manufacturing infrastructure. Scaling the industry up to the extent necessary to replace significant amounts of fossil energy will take decades. The scientific evidence on climate change appears to indicate that we don't have that much time to avoid catastrophe.

From a climate change perspective, nuclear energy would best be employed as a replacement for coal-fired generation. But, with peak oil looming, governments are likely to be tempted to divert nuclear capacity towards the manufacture of hydrogen fuel as an oil substitute. If this were to happen, any mitigating effects of nuclear generation on climate change would be reduced or eliminated.

Given New Zealanders' long-standing anti-nuclear position, and our other viable energy options (most notably wind), it seems unlikely that nuclear power will be used in this country in the foreseeable future.

25 Stein Erik Skilhagen, Jon E. Dugstad, Rolf Jarle Aaberg, 'Osmotic power - power production based on the osmotic pressure difference between waters with varying salt gradients', in Desalination 220 (2008) 476-482.

26 Vattenfall Environmental Product Declaration, independently audited, cited in Martin Sevior, 'Is Nuclear Power a Viable Option for our Energy Needs', The Oil Drum, August 2006 & March 2007, p.4.

27 Derived from statistics provided on the websites of the Energy Information Agency and the International Atomic Energy Agency.

28 David Goodstein, Professor of Physics, California Institute of Technology, *A Crude Awakening: The Oil Crash,* DVD.

29 International Atomic Energy Agency website.

Fast breeder reactors are a variant of nuclear fission technology that create an ongoing supply of new fuel within themselves as part of the fission process.

Unlike fusion technology (see below), operational fast breeder reactors have been built, albeit primarily for developmental purposes. They are much more costly and complex than conventional fission reactors, and present greater proliferation risks.

While uranium remains relatively plentiful, there is little incentive to productionise fast breeder technology on a large scale.

Nuclear fusion releases energy through fusing light atomic nuclei. The technology has many attractions as a means of electricity generation. For instance, waste would be much less of an issue than with fission, and nuclear proliferation risks are said to be minimal.

However, harnessing the process for power generation is proving to be exceptionally difficult. Although fusion was first used to create hydrogen bombs in the 1950s, fusion has so far proved impossible to control in a form that would be usable for electricity generation. After five decades of considerable effort, not a single successful demonstration project has been built. Nor does one look likely any time soon.

Summary – energy alternatives

Oil, natural gas and coal together supply around 86% of primary energy at the moment. A decline in oil production is imminent, and a peak in conventional natural gas production is expected to follow a decade or so afterwards. The extent of exploitable unconventional gas reserves is presently undetermined.

Coal is more plentiful than other fossil fuels, but perhaps not as plentiful as has been thought. Unfortunately, on a per unit of energy basis, coal emits considerably more greenhouse gases than do oil and natural gas.

Even at presently low levels of output, biofuels are causing food shortages and are unlikely to provide more than a minor substitution for fossil fuels.

Wind and solar offer glimmers of hope. In the near- to medium-term, however, these are not going to meet more than a tiny proportion of demand. The uncomfortable fact is that the only massively scalable, low-carbon energy technology is nuclear fission. Even this faces resource limitations and presents major environmental risks. Furthermore, scaling the nuclear industry up will take decades, time that we don't have.

Other Technologies

As no combination of environmentally-safe energy sources is sufficiently scalable, in a realistic timeframe, to meet the dual challenges of climate change and peak oil, the pressure is on to look at all options, including many that are not energy sources in themselves.

Extractive Efficiencies

Extracting fossil fuels involves high energy inputs, which add to greenhouse gas emissions. Two countervailing trends affect extractive efficiencies. Technological improvements improve efficiencies for a given set of conditions, and against this there is an inevitable decline in efficiency as the easiest-to-reach resources are worked out first.

For coal, which is still relatively plentiful, technology is probably still gaining. But, extractive efficiencies are already in decline for oil, with drilling venturing into more and more extreme conditions, requiring ever-increasing energy inputs.

For natural gas, a recent report on North American natural gas production shows that EROEI is falling rapidly, and drilling has to be increased to maintain production in an already well-developed area.[30] Globally, the remaining large, untapped reserves are located long distances from potential markets. Transport energy inputs are likely to be increasingly influential on the overall energy efficiency of natural gas.

Enhanced Recovery

A significant proportion of the oil in any field is too costly to recover. Even a modest increase in the global percentage rate of recovery would affect the timing of peak oil and increase greenhouse gas emissions.

Counter-intuitively, technological advancement might even be hastening the arrival of peak oil. Matthew Simmons, a major financier of oil field technology, has had this to say:

> *Repeatedly over the past decade, the best technical experts at the finest Western oil companies assumed that the new technical tools were facilitating long-term production gains. Too often, however, the new tools merely acted as super-straws that quickly extracted the target oil and then led to decline rates steeper than the industry had seen. The gains were short-lived and in most cases probably* ***reduced*** *the amount of oil that would ultimately be recovered from the reservoir.*[31]

The North Sea is a prime example of an oil province where high-tech extraction has prevailed, but where oilfield life has been short, and flows are falling at unprecedented rates.

While rising oil prices act as an incentive to increase percentage rates of recovery, the impact is dampened by rising costs. At the margins of commercially viable recovery, the energy inputs required are inevitably high, and will increase further as the percentage rate of recovery increases.

Thus, the incentive to enhance percentage rates of recovery at a time of rising energy prices is diminished by the additional *amount* of energy needed to produce each unit of output, as well as by the additional *cost* per unit of energy input. Higher oil prices, therefore, do not necessarily have the strongly positive effect on percentage rates of recovery that one might expect.

[30] John Friese 'North American Natural Gas Production and EROEI Decline', theoildrum.com, 27 February 2008.

[31] Matthew R Simmons *Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy* John Wiley & Son Inc, Hoboken, New Jersey, (2005), p 116.

Hydrogen

Hydrogen is not an energy source, but rather an energy carrier, fulfilling a similar function to a battery. Its main attraction is as a means by which electricity can be converted to a portable transport fuel. In this role, hydrogen has an advantage over batteries because it is much lighter.

Hydrogen does not occur naturally on its own. Breaking the molecular bonds that bind it to other materials requires more energy than is available from the hydrogen, once separated. Large-scale use of hydrogen will be highly energy intensive, and just as damaging to the climate as the energy sources used to produce and distribute it.

There are several ways to separate hydrogen. Present small-scale separation plants tend to use a natural gas-based process. But, as this substitutes an excellent fuel for an inferior one, it is not going to provide a long-term, large-scale answer. Also under investigation are proposed technologies involving, amongst other things, enzymes and solar energy. None has ventured outside the laboratory at this stage, and none presently look like being scalable in any relevant timeframe.

The only commercially proven hydrogen separation technology likely to be at least moderately scalable in a timeframe relevant to climate change and peak oil, requires electricity. The only forms of electricity generation scalable to the extent necessary are coal, and nuclear fission. Coal-fired generation could be scaled-up fairly quickly, but it is already one of the worst contributors to greenhouse gas emissions. Nuclear fission has major unresolved timing, cost, waste disposal, decomissioning, and proliferation issues.

Although, once separated, hydrogen performs something like a low-density fossil fuel, its highly reactive nature as a gas means that it is hard to contain, requiring extremely costly infrastructure. An alternative to storing hydrogen as a gas, is storage in the form of metal hydrides. These are easier to handle, but widespread use of hydrides would involve overcoming many major technical and safety hurdles.

Whether in gas or hydride form, hydrogen has significantly less energy density than oil, and is unlikely to be able to be used in applications such as aviation, where high density is important. Also, hydrogen does not contain carbon, and cannot substitute for oil in plastics, fertilisers and pharmaceuticals. Therefore, although hydrogen is widely promoted as an oil substitute, its costs would be very much higher, and its uses a lot more limited than those of oil.

Any so-called "hydrogen economy" would be very different from the present oil-based economy.

> *The future may well hold hydrogen fuel cell-powered cars — but not in numbers approaching the current global fleet of 775 million vehicles... it will be possible for only a tiny wealthy minority to ... [use] ... highly efficient Hypercars.*[32]

[32] Richard Heinberg, *The Party's Over*, New Society Publisher, 2003, page 149.

Sequestration

Sequestration technologies offer the attractive prospect of enabling us to make more use of coal while at the same time reducing greenhouse gas emissions. All of the proposed technologies have limitations, and even in combination, they represent a far from straight-forward or complete answer.

Biological sequestration involves employing the natural systems by which CO_2 is absorbed by trees as they grow. The oxygen is expelled and the carbon retained, the latter making up a significant proportion of a tree's weight.

Unfortunately, the effectiveness of biological sequestration is compromised by two major issues, leakage (i.e. the return of carbon to the atmosphere) and deforestation.

Opportunities for leakage are various. For instance, if mature trees are cut down to facilitate new growth, what happens to them is important. Storing unused felled trees is an unlikely long-term solution. More probably the wood would be converted into manufactured products. This takes energy, generates emissions and creates waste that needs to be stored or disposed. Additional disposal issues arise at the end of the manufactured product's life.

Disposal is important because decomposition in the absence of oxygen (anaerobic decomposition) causes carbon to combine with hydrogen, forming methane (CH_4), a much more potent greenhouse gas than CO_2. Therefore, burying wood or paper waste in landfills results in greater climate damage than was prevented by the growth of the original trees, even before manufacturing and transport is taken into account.

Leakage can also occur unintentionally as a result of forest fires and wind throws, phenomena that are expected to increase with climate change.

> *...if leakage is as serious ... as suggested by some studies, then it may occur that governments will expend billions of dollars in subsidies or other forms of incentives, with little or no net gain in carbon, forests or secondary benefits. Preliminary results suggest that market interactions in carbon sequestration program analyses require considerably more attention.*[33]

Deforestation is the other major limitation of biological sequestration. Sadly, in New Zealand and worldwide, the relentless global increase in demand for agricultural products is pushing forests aside. Although the New Zealand government has taken steps to encourage afforestation by offering carbon credits, it is too early to say whether these will be enough to reverse the trend.

On a global scale, given the need to feed ever-growing numbers of people, there seems little possibility of achieving a significant net increase in tree-based biological sequestration. Despite all this, tree planting,

[33] Kenneth Richards and Carrie Stokes 'A Review of Forest Carbon Sequestration Costs Studies: A Dozen Years of Research', *Climate Change*, March 2004.

reforestation and retaining old forests are very worthwhile things to do.

Biochar sequestration involves stabilising biologically-based carbon, and returning it to the soil. Stabilisation is achieved through charring (partly burning in the absence of oxygen). The resultant product offers the advantage of improving soil productivity, and thus the carbon uptake of plants. Biochar also has the potential to reduce nitrous oxide emissions to the air and nitrate leaching into waterways. [34]

However, recent Swedish research has shown that biochar promotes soil microbes and causes a large loss of soil carbon.[35] There is little present indication that this technology can be counted on to make a significant contribution to combating climate change.

Geological sequestration is aimed at capturing carbon dioxide emitted from large stationary sources, such as power stations, steel mills and cement plants, and storing it in geological structures. This technology is not currently in use on a large commercial scale anywhere in the world.

Capturing carbon dioxide at power stations and cement plants is considered feasible at a cost. The major challenge is storing it in a manner that prevents escape. Leading contenders for storage sites are saline aquifers, and depleted gas and oil fields.

Suitable sites are likely to be limited, and not necessarily near the carbon dioxide sources. Energy and infrastructure requirements inevitably make this an expensive technology. Early indications suggest a doubling or more in the cost of electricity generated.

Transporting captured carbon dioxide to suitable storage sites is likely to be energy-intensive, as will be the level of pressurisation necessary.

Initial research has raised many questions concerning the consequences of long-term containment of high-pressure carbon dioxide on geological structures and groundwater, etc. [36] Even very low leak rates would undo the benefits.

So, while this technology might eventually prove safe and affordable at some time in the future, that future is not yet 'just around the corner'.[37] Indeed, in February 2008, geological sequestration received a significant setback when, the US government pulled funding from the first large-scale project due to ballooning costs.[38] It would seem imprudent to count on geological sequestration providing more than relatively minor assistance with climate change amelioration over the next few decades.

[34] *Biochar professorships set up.* Press release from Jim Anderton, New Zealand Minister of Agriculture, 13 December 2007.

[35] Professor David Wardle, Swedish University of Agricultural Sciences, "Limitations of charcoal os an effective carbon sink", published on www.slu.se, 1 May 2008.

[36] Karsten Pruess, Lawrence Berkeley National Laboratory, 'Modeling Carbon Sequestration in Saline Aquifers', www.yale.edu/yibs/sequestration-forum-presentations.

[37] 'Clean solutions for coal', *NZ Herald* website, 11 March 2007.

[38] Reuters, 13 February 2008.

New Zealand has few large-scale static emitters, and our fractured and unstable geology is likely to leak too easily. While we have depleted gas reservoirs, they are mostly distant from major static emitters. Thus, it seems unlikely that geological sequestration will play any significant part in constraining New Zealand's greenhouse gas emissions.

Oceanic sequestration uses the ocean and seabed to take up carbon. Already approximately half of our greenhouse gas emissions are absorbed naturally in the oceans. This process is causing an increase in oceanic acidity.

> *...ocean acidification, could have profound impacts on some of the most fundamental biological and geochemical processes of the sea in coming decades. Some of the smaller calcifying organisms are important food sources for higher marine organisms. Declining coral reefs due to increases in temperature and decreases in carbonate ion would have negative impacts on tourism and fisheries. Abundance of commercially important shellfish species may also decline and negative impacts on finfish may occur. This rapidly emerging scientific issue and possible ecological impacts have raised serious concerns across the scientific and fisheries resource management communities.*[39]

Despite the oceans already being overstretched, proposals are being advanced to use them to sequester even larger amounts of CO_2. Several technologies are under consideration, including fertilisation, and surfacing deep-water nutrients.

Both involve artificially stimulating vast increases in surface algae populations. The intention is that the algae will absorb carbon as part of their growth process, then die and sink to the seabed, where the carbon they have embodied will be sequestered.

The fertilising approach involves adding iron particles to the sea's surface, inducing algal and plankton blooms in areas where natural iron levels are too low for such blooms to occur naturally. The pumping approach would stimulate plankton and algal populations by raising nutrients from the oceanic depths.

The attractions of these approaches is that they are potentially massively scalable. The downside is that our rudimentary knowledge of oceanic and seabed ecology does not allow us to predict what the actual outcomes would be. The ocean plays a vital role in sustaining the biosphere. Any deliberate change to oceanic ecosystems on the massive scale proposed, needs to be approached with extreme caution.

Mineral carbonate sequestration involves converting carbon dioxide into solid carbonates. Most approaches rely on the availability of magnesium and calcium, minerals which must be mined. Mining is a carbon-intensive activity. Use on a meaningful scale would require the mining of these minerals in quantities way

[39] website of the United States National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory, www.pmel.noaa.gov

beyond anything previously envisaged. The size and accessibility of the relevant resources is yet to be fully assessed in this light.

One option being researched, which doesn't require mineral deposits, is sequestrating CO_2 from steel-making by forming carbonates with the alkaline earth component of used slag.

Whatever the process, once carbonated, the resultant material needs to be stored. The quantities are likely to be huge. It would therefore be advantageous if the output could be put to some productive use.

Early indications are that mineral carbonate sequestration might offer some potential.[40] However, there is little sign that it will be massively scalable to the extent of making a significant contribution to stabilising atmospheric carbon dioxide. New Zealand has only very limited amounts of mineral resources suitable for this process.

Reflection Technologies

Greenhouse gases reduce the amount of heat radiated from earth into space. Interest has been expressed in the possibility of re-stabilising the energy balance by reflecting back some of the sun's heat before it has a chance to warm the earth.

Earth-based and space-based reflectors of different types are being considered. Space-based particles have the attraction of being the cheapest to put in place on a large scale. However, they lack reversibility, which is an important issue, given the possibility of serious unintended negative side-effects. Recent modelling at the United States National Centre for Atmospheric Research, for instance, has shown that particles, of the type being proposed, would cause severe damage to the ozone layer.[41]

Ground-based structures might be reversible, but they are likely to be very costly, and to render large areas of land unusable. Given the present absence of firm proposals to implement any of this family of expensive high-risk technologies, it seems unwise to count on reflection-based approaches making a significant contribution in the foreseeable future.

Nitrification inhibitors

Nitrous oxides arising from the break down of nitrogen-based fertilisers make up approximately one-sixth of New Zealand's total greenhouse gas emissions.

A New Zealand-developed compound has been claimed to reduce nitrous oxide emissions by over 50%. Sprayed on pasture, it is reputed to yield other benefits, including reduced river pollution, and enhanced pasture growth.[42]

Opinion within the country's farming industry is divided on the overall effectiveness of the technology, and it does not yet yield credits under the Kyoto Protocol.

Conclusion

Just three proven technologies (coal-to-liquids, and coal-fired generation and nuclear fission generation) are sufficiently scalable to maintain present levels of energy consumption in the face of declining oil production.

Coal-to-liquids and coal-fired electricity generation would worsen greenhouse gas emissions significantly. Nuclear fission generation is costly, slow to scale-up, and has safety, waste-disposal and proliferation issues.

Although the output of coal-to-liquids technology is a readily-useable transport fuel, this is not the case with the other two options. Coal-fired and nuclear generators produce electricity, an output with only limited direct application as a transport fuel. Replacing oil with energy from these sources raises many technical, cost and efficiency issues.

None of the other energy sources and alternative technologies appear to be potentially scalable, in a relevant time-frame, to play more than a bit-part in compensating for falling oil output.

Already, even with oil production at near record levels, world coal use is growing quickly, becoming a major factor behind the record 3% per year rise in global CO_2 emissions over the four years to 2006.[43]

If the peak of oil production is reached sooner than the two to three decades optimists are counting on, governments are likely to come under strong pressure to replace lost oil production with coal and lignite, probably in a mix of coal-to-liquids, and electricity generation. Such a move would almost certainly put climate stabilisation out of reach.

Biological sequestration is the only proven option for removing significant quantities of carbon from the atmosphere. For this approach to have any effect, the current rate of deforestation will need to be reversed, a change which shows no sign of occurring. None of the other sequestration technologies is proven at a relevant commercial scale, and most involve very high technical and/or environmental risks. Others will never be more than bit players, even in the most favourable conditions.

To put it bluntly, no combination of supply-side options whether they be alternative energy sources, or sequestration technologies, will sustain present levels of energy use while at the same time delivering emissions reductions. To achieve emissions reductions, we are going to have to reduce energy demand. That is the subject of the next chapter.

40 Simon Upton, 'What Can a Small Country Do?' in Ralph Chapman, et al., eds, *Confronting Climate Change: Critical Issues for New Zealand*, Wellington, 2006, p.276.

41 *New Scientist*, 3 May, 2008, page 17.

42 Rod Oram, 'Fertile Ground for Change', *Sunday Star Times*, 30 September 2007.

43 IEA, 2006.

Reducing Demand

As the previous chapter has shown, there is no combination of adaptations, alternative energy sources or new technologies available in the next few decades that will allow us to maintain present levels of energy consumption if we are also to successfully address the issues of climate change. There is therefore a need to reduce demand.

Demand reduction faces much resistance. Nevertheless, if we wish to maintain a planet suitable for human habitation, there is little choice.

Demand can be reduced through a combination of two differing approaches – increased efficiency, and direct reductions in consumption. Of these, increased efficiency is the least effective, but the most appealing politically. Reducing consumption directly would be a much more effective approach, but it is seldom, mentioned by politicians due to its lack of political appeal.

Increased efficiencies

Increasing the efficiency with which we use energy can allow us to continue to do much the same things we do now, but with less energy. There are a lot of savings to be made. New Zealanders and Americans use much more energy per capita to achieve a similar quality of life to that found in Europe or Japan. Greater use of more fuel-efficient cars, increasing use of public transport, more compact, better insulated homes would all help.

However, in the absence of administrative structures to capture the gains, increased efficiencies often fail to deliver significant energy and emissions savings. In many cases they result in increased use of energy.[1] For instance, the relentless drive for improved manufacturing efficiencies by the motor industry has caused a steady decline in the real cost of cars, and a rapid escalation in their use. The ongoing development of ever more efficient jet engines has dramatically reduced fares and led to a rapid expansion in air travel.

Even where efficiency gains reduce total energy used for a particular activity, there is a real possibility that savings from that activity will be spent on other energy-intensive activities. For example, if a buyer of a more efficient car spends the money saved on fuel to pay for an overseas trip, the overall result is likely to be a net increase in atmospheric carbon.

Thus, although energy efficiencies intuitively seem like a good idea, they usually need an administrative structure to generate real net emissions reductions. Such structures inevitably require government intervention in the market.

1 This phenomenon is known as the Jevons Paradox, named after William Stanley Jevons who, in 1865, observed that the consumption of coal in Britain rose as steam engines became more efficient.

Reducing consumption

Reducing consumption involves both using less and doing less.

Until approximately 200 years ago, long-term living standards were relatively constant for most of the world. The agricultural and industrial revolutions changed all that. Driven by fossil fuels, the past two centuries have produced an explosion of consumption by those fortunate enough to live in countries such as New Zealand.

By the standards of our ancestors we have more certain and cheaper access to food, we travel much more and own many more possessions. Our health is better, we live longer, and generally the trends in all these factors have been pretty consistently upwards.

As long as energy has been available in ever-increasing quantities, growth has generally not been difficult to sustain. Economic health and increasing energy use have been very closely entwined.

If fossil fuel energy use is to reduce significantly over a period of one or two generations, then economic growth and energy use will have to be decoupled. This will require major changes. A 'business as usual' approach is not going to work.

Government Initiatives

The Stern Review, commissioned by the British Government, described climate change as 'the greatest and widest ranging market failure the world has ever seen'. [2]

Market failures occur when established pricing mechanisms result in significant under- or over-consumption. A striking example of market failure in the New Zealand context is private car usage. Car users are not charged with the costs of carbon emissions, and therefore make much more use of their vehicles than they would do if they had to meet these costs.

Because of their unique powers, and central role in planning and managing the economy, only governments are in the position to redress market failures. Public schooling and public health systems are successful examples of how this process works when a likely market failure would adversely affect the majority of voters. However, if the majority of voters draw short-term benefits from a market failure, then it is much more difficult for governments to act. Climate change is a classic example.

In the New Zealand case, although the word 'sustainable' has arrived on the political landscape with a vengeance, little in the behaviour of country's major political parties, to date, would suggest that they think the public is ready to hear the message that our present levels of consumption are unsustainable.

2 guardian.co.uk 30 October 2006.

An opinion poll, conducted in September 2007 found that while most New Zealanders accept that climate change is caused by human activities, only a fifth were prepared to pay for emissions reductions.[3]

Governments have a range of methods by which they can direct, encourage, and build support for change, including educational programmes aimed at modifying behaviour. New Zealand examples include those to discourage smoking and drink-driving.

Other relatively easy-to-implement measures include the integration of fares between various modes of public transport, which has been well-proven overseas to increasing the use of public transport. Housing New Zealand is retrofitting older houses for energy efficiency. Investing in more research will certainly be beneficial. The government itself is New Zealand's largest energy user, and many of its own practices can be changed administratively, without political difficulty.

Even in total, the easy-to-implement measures are not going to get anywhere near achieving the scale of emissions reductions required. For this to happen, more challenging approaches will have to be taken. These will inevitably include taxes, and/or trading mechanisms. The New Zealand government tried to implement a carbon tax in 2003, but backed-off as a result of opposition. It tried to introduce a trading mechanism in 2008, but postponed implementation because of perceived political dangers.

These failures occurred even despite the government being clearly motivated to try to begin addressing the country's excessive emissions. Given two failed attempts to date, it is clear that no solution will be possible to this impasse without broad support across the political spectrum. How likely is this to happen? The indications are not particularly positive.

The political obstacles are not restricted to New Zealand. What follows is a brief introduction to the available approaches and their relative merits and limitations.

Taxes and incentives allow governments to promote change. This approach is largely the prerogative of central government, although local governments also play a part. Various tools are available, including carbon taxes, subsidies, grants, allowances and loans.

Taxation has a number of advantages over emissions trading (see below). Pricing is more certain, administration is easier, as is its application to many smaller emitters. But it is less flexible than emissions trading for price setting.

What happens to the money raised from carbon taxes is particularly important. Withdrawing the amount collected from circulation would be effective, but extremely unpopular. A fiscally-neutral approach is more politically acceptable, but balancing fiscal neutrality with effectiveness isn't easy.

If the government spends carbon tax revenue on road building, for example, this would undermine the effect of levying the tax in the first place. Likewise, if the government used a carbon tax to fund income tax reductions, the effectiveness of the scheme could be undermined by individuals spending the increase in their net income on carbon-emitting activities, such as overseas travel.

There is a good argument for a fiscally-balanced carrot and stick approach with the funds being applied to carbon reduction projects. For instance, revenue raised from carbon taxes on sheep and cattle could be used to fund incentives for farmers to change to more sustainable types of farming. And, taxes on petrol could be used to fund public transport.

Subsidies, grants, allowances and loans can be used as incentives to foster new technologies. In the Netherlands, companies need to comply with sustainability criteria to control bio-energy production to keep subsidies awarded to them. These criteria include demonstrable reductions in greenhouse gases and maintaining or enhancing air quality; enhancing soil quality; adding to local welfare; not endangering food supply or harming biodiversity, or soil or water quality or quantity.[4]

Emissions trading schemes are directed at climate change, rather than peak oil. Under such schemes, rights to generate emissions are established and traded. Some emitters will be able to reduce their emissions at a lower cost than others. For those whose costs are higher, it may be more economical to buy credits from emitters who can reduce emissions more cheaply. Theoretically, trading would facilitate emissions reductions at a lower overall cost than would taxation. Politicians like emissions trading, because, unlike taxes, the inevitable cost increases are less apparent at the proposal stage. Also, the responsibilities for cost increases are spread more widely.

Many businesses actively resist the imposition of realistic and reducing caps for their sector. For instance, Fonterra, a cooperative owned by farmers of ruminant animals, is strongly opposed. Fonterra is New Zealand's largest company by far, and a major political force to be reckoned with.

Unfortunately, even where the business community supports emissions trading, this support is not necessarily connected with the goal of reducing emissions. The attraction of emissions trading schemes to the more favourably-disposed sectors of the business community lies in the creation of a tradable asset, namely carbon credits. Where there are tradable assets, particularly ones that can be picked up freely or cheaply to start with, then there is an opportunity to make a profit. A recent article in *New Scientist* summed up the situation:

> *The danger for now is that carbon capitalism becomes disconnected from the reality of the planet's carbon cycle... if big reductions continue to appear on the books while increases always stay off them.*[5]

3 Opinion poll conducted by Colmar Brunton for Television New Zealand, September 2007,

4 theoildrum.com, 8 May 2007.

5 Fred Pearce, 'Dirty Sexy Money', *New Scientist*, 19 April 2007, page 38 ff.

This quote comes worryingly close to describing the New Zealand government's recently postponed emissions trading scheme. Various sectors of New Zealand's economy were to be brought in under a staged transition. It was intended to start with forestry, the sector that is most likely to benefit financially from the scheme. Meanwhile the entry of agriculture, a sector responsible for approximately half of the country's emissions, was to be deferred until 2013, i.e. into the remote political future. Now, it has been deferred even further.

Even if the recently-deferred New Zealand scheme had been implemented, there are considerable grounds for scepticism about its likely effectiveness. The government predicted that its impact of the scheme on economic growth would be minimal. This is probably correct. And therefore, in the absence of any national programme to decouple economic growth from emissions, it is not unreasonable to assume that emissions reductions would be small.

Before the scheme was deferred, the Sustainability Council of New Zealand commented on it as follows:

Without a change in direction, New Zealand will be looking down from the top of an emissions cliff when it sets new target reductions after 2012. The current ETS rules will deliver less than a 2% reduction in gross emissions during the next five years, leaving New Zealand's gross emissions 30% above its Kyoto target over the period to 2012.

After 2012 a new target will apply. Even if this turns out to be at the low end of what is being proposed internationally (25% below the current target), then that opens up a 55% gap.[6]

Following the postponement, we are in an even worse position.

Political difficulties are not the only obstacle to effective emissions trading schemes. The opportunities for fraud are massive. There are many more unknowns surrounding carbon credits than is typically the case with other class of tradable asset.

...to my knowledge, carbon trading is the only commodity trading where it is impossible to establish with reasonable accuracy how much is being bought and sold, where the commodity that is traded is invisible and can perform no useful purpose for the purchaser, and where both parties benefit if the quantities traded have been exaggerated. It is, therefore, an open invitation to fraud...[7]

Two senior academics from Stanford University, and a US watchdog group, International Rivers have recently published separate studies on the effectiveness of the United Nations' clean development mechanism (CDM). In summary, the two reports found that:

...the UN's main offset fund is being routinely abused by chemical, wind, gas and hydro companies who are claiming emissions reduction credits for projects that should not qualify. The result is that no genuine pollution cuts are being made, undermining assurances by the UK government and others that carbon markets are dramatically reducing greenhouse gases... [8]

Do emissions trading schemes really produce significant reductions in emissions? To date, there is scant evidence to show that they do. Nevertheless, the concept is probably worth persisting with. We don't have the luxury of being able to drop emissions trading for a proven more effective alternative. The main danger is that we place unrealistic faith in trading schemes working, and shirk other efforts at demand reduction.

The Kyoto Protocol is an agreement between most of the world's nations aimed at reducing emissions of greenhouse gases. Bodies below the nation state level are not signatories and don't participate directly. The protocol incorporates an emissions trading scheme.

Industrialised countries, and countries in transition to a market economy, have adopted individual emissions targets for the commitment period 2008-2012. The means of achieving targets have been left entirely to the governments of the states concerned.

Although the Kyoto Protocol allows countries to purchase credits to compensate for missed targets, the trading mechanisms are complex, and have not yet been fully implemented. The emissions of most industrialised countries are in excess of their targets.

New Zealand's target is to return to our 1990 levels of emissions for the first commitment period, 2008-2012. We are currently more than 20% above this target, and rising. Our government has not traded so far, but when it starts, it faces credit purchases in the order of $1 billion or more.

Kyoto has many imperfections.

- Targets are well below those that the scientific evidence suggests are required to stabilise atmospheric carbon dioxide at levels sufficient to avoid serious consequences.
- It is not clear how trading will be effective when nearly all the major signatories are in deficit.
- The world's largest economy, the United States, is not a signatory.
- Although rapidly-growing developing emitters, such as China and India, are signatories, they have no effective limits.
- International aviation and international shipping, which are large emitters, are not included.
- Credits allowed for offsets are probably too optimistic.
- Coverage does not extend past 2012.

6 'Households and SMEs pay 90% of Emissions-related Charges', Media Statement, Sustainability Council of New Zealand, 30 April, 2008.

7 Bryan Leyland, 'Carbon Trading Open Invitation To Fraud', Press Release: New Zealand Climate Science Coalition Thursday, 22 November 2007.

8 'Billions Wasted on UN Climate Programme' by John Vidal, Environment Editor www.guardian.co.uk, 26 May, 2008.

A UN summit held in Bali in December 2007, was to begin the process of negotiating a Kyoto replacement. The outcome was not encouraging. The US, Canada and Japan successfully resisted EU proposals to include a commitment to cuts of 20-40% by 2020.[9] As a result of this opposition, cuts of 20-40% remained as aspirational guidelines, with no clear prospect of practical implementation. It should be noted that even cuts of this level are a very long way short of what the scientific evidence indicates is necessary.[10]

Local government is responsible for town and country planning, the built environment – housing, roading, industrial and commercial – public transport and local resources, especially water.

Although their flexibility is restricted by the need to give effect to legislation, local and regional bodies can tailor regulations to local conditions more effectively than central government.

Local government bodies have a significant role to play in planning for adaptations to the localised effects of climate change, including flooding. They can also assist with emissions reductions by planning and managing land use, public transport systems and urban design.

Other Initiatives

Small-scale offsets are intended to balance carbon emissions with carbon absorption. There is a carbon-offset scheme available in New Zealand, operated by Landcare Research NZ Ltd. Money paid into the scheme is used to compensate people who retire land from pasture for natural regeneration. The scheme, labelled EBEX21©, provides measurement, management, and mitigation for offsetting greenhouse gas emissions, based on a verified system of native forest regeneration.[11]

Offsetting has its limitations. When you take a flight, the carbon is definitely and promptly emitted. Offsets are less certain and less immediate. Some schemes have received bad press because controls over the use of money invested in them have been inadequate.

Although New Zealand's scheme appears to be well-managed, and has monitoring systems in place, even Landcare recommends that offsets be used as a last resort, after all other steps have been taken to reduce carbon emissions. It would be much better for the environment if the flights were not taken, and the forests were encouraged to regenerate anyway.

Small-scale carbon offsets are effectively voluntary taxes, or philanthropic gestures, over which the payer has some say about where the money is spent. Ultimately, such voluntary actions will be inadequate for reducing emissions to the required level. Globally, offsets will also be limited by the availability of spare land to grow significant amounts of additional biomass to be held in a solid state in perpetuity.

Non-Government Initiatives - a ground swell of concerned individuals has been gathering to address a range of environmental issues. In New Zealand, this movement has been reflected by the publication of books such as Rod Oram's *Reinventing Paradise* and Gareth Renowden's *Hot Topic,* and in many other individual and group actions.

There is a variety of ways in which the public can be actively involved. These include making submissions, disseminating information, lobbying, developing pilot programmes, and walking the talk.

One activist group is the Climate Defence Network, which offers a range of lobbying ideas for individuals. It also advises on how to set up a Carbon Reduction Action Group in your community.

The NZ Business Council for Sustainable Development provides business leadership as a catalyst for change toward sustainable development, and to promote eco-efficiency, innovation and responsible entrepreneurship.

Professional bodies focusing on sustainability issues include Engineers for Social Responsibility, and the Sustainability Working Group of the Society of Accountants.

Conclusion

Substantial demand reduction is essential if we are to avoid the worst effects of climate change. Unfortunately, none of the major approaches under consideration looks at all likely to succeed on the scale necessary.

As Jevons first observed in 1865, increasing efficiency often triggers increased consumption. And, although carbon taxes might work, no government has had been able to implement an effective scheme.

Emissions trading is widely espoused as a solution, but it is wide open to fraud, and there is little evidence that it works in practice.

At an individual level, it is difficult to ensure that energy and emissions savings are not dissipated elsewhere. Great determination is needed to turn personal efficiencies and reduced usages into actual gains for the planet.

Nevertheless, individual efforts are important — for the direct environmental impact they might have, and for building support for more effective government initiatives, as well as for the development of individuals' own adaptability.

9 'Making sense of the Bali finale', www.telegraph.co.uk, 17 December 2007.

10 See the Background chapter of this booklet.

11 David Whitehead 'The role of forests in climate change mitigation', in *Confronting Climate Change: Critical Issues for New Zealand*, page. 292..

The Wider Context

Economic

During 2005-2006, a major review of the global economics of climate change was conducted in the UK, under the leadership of Sir Nicholas Stern (chief economic advisor to the British government, and former chief economist of the World Bank). He concluded that ignoring climate change will damage economic growth.[1]

He found that, even in conditions of uncertainty, it was better to invest in measures that might eventually prove unnecessary, than to not invest and suffer avoidable catastrophes. The review quantified the cost of preparing for climate change as 1% of global GDP each year, for planned costs and investments over a transition period. By comparison, losses for not acting would be at least 5% of global GDP each year, now and forever into the future.[2]

Stern proclaimed that 'The world does not need to choose between averting climate change and promoting growth and development. Changes in energy technologies and in the structure of economies have created opportunities to decouple growth from greenhouse gas emissions.'

Stern's work was based on the then widely-accepted linear projections of climate change. It did not take into account peak oil, or the more recently reported non-linear developments in the Arctic and Greenland ice sheets. Therefore the economic consequences of ignoring environmental limitations are likely to be higher than he calculated.

Indeed, two years after the publication of his report, Stern acknowledged new scientific work was indicating that oceans and forests were absorbing less carbon than previously assumed.

> *Emissions are growing much faster than we thought, the absorptive capacity of the planet is less than we thought, the risks of greenhouse gases are potentially bigger than more cautious estimates and the speed of climate change seems to be faster.*[3]

Even though the economic data is convincing, the 'economy vs environment' argument is far from dead. In New Zealand, the economy is so heavily dependent on high-emitting industries, that there are loud voices in favour of putting the economy first, regardless of the environmental consequences. Indeed, one government-owned energy company recently appealed against climate change being considered in resource consent applications.

Fossil fuel substitutes and efficiency gains are not going to be enough on their own to stabilise carbon dioxide levels in the short term. The only way that presently offers the scalability, timeliness, and certainty to reduce greenhouse gas emissions, is large-scale reduction in consumption of fossil fuels. Can an economic system based on ongoing growth cope with a contraction in energy use?

Globally, there are many other concerns. Can the world economy continue to cope with the United States' high fiscal (government) and current account (external) deficits, and the high levels of debt of US consumers? What is going to be the effect of the huge expansion of the derivatives trade for which contracts now amount to many multiple times global GDP?

A major correction seems a likely outcome of these instabilities. Peak oil, or any one of a number of other possible events, could be the trigger. What does all this mean for climate change, for peak oil and for New Zealand?

A major economic correction would reduce energy use, at least in the short term. One example of a major economic correction is the collapse of the Soviet Union. This resulted in eastern European energy use falling by about 40%.

While economic contraction would reduce the effects of peak oil and climate change in the short term, this could be at considerable cost in the longer term. Preparing for peak oil and climate change by building new infrastructure and carrying out more research will be expensive. In a post-correction world, there is likely to be significantly less money available to carry out such work.

Can New Zealand's economy decouple growth from emissions when our main industries of tourism and agriculture are heavy emitters? What would be the impact on the New Zealand economy of a global economic correction? While Stern does not deal with peak oil, this issue poses questions that are just as testing. For example, to sustain the energy intensity of our economy, will we be tempted to make up for declining oil availability by using highly polluting and carbon-emitting lignites, a resource that we have in abundance?

Food, Health & Population

After centuries of relative stability, the world's population stood at approximately one billion in 1800. It then doubled over the next hundred years. A major driver of this growth was coal, the first fossil fuel to be exploited on a large-scale.

In the twentieth century, population growth accelerated, more than tripling, to over six billion. This spectacular growth was helped by the invention, in 1909, of a process to synthesise fertiliser from fossil fuels. In parallel, the development of the oil-powered internal combustion engine opened up the possibility of farming areas that were previously too difficult.

In the process, food supplies have become heavily dependent on fossil fuels. Around 1500 litres of oil-

1 Stern Review, short summary of conclusions, August 2006.

2 ibid.

3 'I underestimated the threat, says Stern', guardian.co.uk, 18 April 2008.

energy equivalents per capita are required each year to feed the average American. Uses that this energy is put to include manufacturing fertiliser 31%, operating machinery 19%, transportation 16% and irrigation 13%.[4]

Some analysts wonder whether the present population of six-and-a-half billion already exceeds the long-term carrying capacity of the planet.

Without fossil fuels, the stupendous growth in human numbers that has occurred over the past century would have been impossible. Can we continue to support so many people as the availability of cheap oil declines?[5]

UN estimates suggest that the world's human population will grow to at least nine billion by 2050. Feeding this number of people at a time of increasing climate change, and declining oil production, is going to be extremely difficult.

The present food crisis, brought on in part by the use of biofuels as an oil substitute, shows just how perilously poised food supplies are.

Now cars ... are out-competing hungry people... almost a third of the US corn crop - which has traditionally helped feed hungry nations - will go for fuel... Already 25 million people in India are believed to have cut their meals from two to one a day. The calorie intake from an average meal in El Salvador has fallen by half in less than two years.[6]

Water availability is another major food security issue. Alpine glaciers are shrinking, and this is threatening dry season water supplies to some of the world's most populous regions. Climate-change-related shifts in rainfall patterns are threatening food supplies in rain-dependent areas. The Fourth Assessment Report of the IPCC estimates that yields from rain-dependent agriculture in Africa could be cut in half by 2020.[7]

Some of the problems with water are part of a wider pattern of resource constraints. For example, in many areas, supplies depend on extracting water from underground aquifers, often at much faster rates than replenishment. Increased demands for irrigation are putting supplies under stress.

The world will need 55 percent more food by 2030. This translates into an increasing demand for irrigation, which already claims 70 percent of all fresh water consumed for human use.[8]

With water availability already in decline in many areas, it is not clear where the extra needed is going to come from.

Biofuels and water supplies are not the only worries. Another is that a significant proportion of the world's major grain crops are grown in areas already close to the upper temperature threshold of those crops. Research at the Lawrence Livermore Laboratory and the Carnegie Institution, has shown that rising temperatures are reducing crop yields.[9] Further rises in temperatures are likely to result in increasing loss of production to insect pests.[10] Meanwhile, fish stocks are depleting rapidly, and topsoil quality is deteriorating.

Food supplies are also being affected by dietary changes associated with increased middle-class prosperity, particularly in Asia. Newly-affluent groups are eating considerably more meat than previously. Per unit of energy contained, meat requires much larger energy inputs than grain.

Climate change is affecting health in other ways. Injuries and loss of human life are being caused by more frequent and extreme weather events. Tropical diseases are expected to spread to higher latitudes as temperatures increase. Water quality is declining in many regions, partly as a result of declining supply, itself partly related to climate change. According to the United Nations Educational, Scientific and Cultural Organisation (UNESCO), poor water quality is a key cause of diarrhoea and other diseases that killed about 3.1 million people in 2002, 90% of whom were children under the age of five.[11]

Hopes that genetic engineering might help were dealt a serious blow recently by an authoritative new study conducted at the University of Kansas. Confirming the results of earlier research at the University of Nebraska, the genetically-engineered crops studied were shown to be 10% less productive than traditional crops.[12]

There are alternatives to heavily oil-dependent food production. Energy inputs can be reduced by localising production. Organic farming and permaculture offer more sustainable agricultural techniques. Cuba suffered a sudden and substantial drop in fuel supplies after the fall of the Soviet Union. Its use of these methods provides a unique example of a country with an energy-intensive agricultural system transitioning to a much lower level of energy intensity.[13]

Although a steep drop in energy intensity would be

4 Dale Allen Pfieffer 'Eating Fossil Fuels', published on fromthewilderness.com , 2004.

5 Richard Heinberg, 'Threats of Peak Oil to the Global Food Supply', *Museletter # 159*, July 2005.

6 'Rising prices threaten millions with starvation, despite bumper crops', Geoffrey Lean, Environment Editor, *The Independent on Sunday,* 2 March 2008.

7 *Climate Change 2007 Synthesis Report*. Intergovernmental Panel on Climate Change, Page 48.

8 'Water: a crisis of governance says second UN World Water Development Report', Press Release No. 20006-14, UNESCOPRESS, 4 March 2006.

9 David Lobell and Christopher Field, *Environmental Research Letters*, Vol 2 No 1, 16 March 2007;

10 'Insect explosion a "threat to crops"', *The Independent,* 12 February 2008, reporting on recent research carried out at Pennsylvania State University.

11 'Water: a crisis of governance says second UN World Water Development Report', Press Release No. 20006-14, UNESCOPRESS, 4 March 2006.

12 'Exposed: the great myth of GM crops', *The Independent on Sunday,* 20 April, 2008.

13 In 1990, Cuba lost 80% of its pesticide and fertiliser imports, and half of its petroleum. The country embarked on the greatest conversion to organic agriculture yet attempted, a process documented in a DVD entitled *The Greening of Cuba*.

a considerable challenge for New Zealand, we are cushioned from the worst effects by a biocapacity of approximately two-and-a-half times that required to sustain our present population. Most other countries are in ecological deficit, and the few with a surplus generally have smaller surpluses than New Zealand.[14]

Externalities & Ethical Issues

The economic concept of externalities lies at the heart of many of the ethical issues raised by climate change and peak oil. An externality is a cost born by a person who is not a party to the transaction that gave rise to that cost. For example, the fuel burned during a flight affects the climate experienced by people all over the world, and also the climate for people in the future, including many not yet born. Costs born by people who are not parties to the transactions between the airline, its suppliers, and customers, are called externalities.

For people already living, externalities wouldn't be so much of an ethical issue if everyone lived similar lifestyles and bore a similar share of overall costs. But this isn't the case. For instance, New Zealanders are frequent flyers by world standards, but are geographically less exposed than most to the worst effects of the early stages of climate change. By contrast, on a per capita basis, Bangladeshis make only a small fraction of the use of aviation, but are already early and serious casualties of climate change brought on, amongst other things, by New Zealanders' flying.

Intergenerational externalities are just as important. Our greenhouse gas emissions will affect our own and other people's children and grandchildren.

Externalities are difficult to compensate for because those affected are numerous, widespread, and difficult to identify. Ethically and economically there is a strong case for trying to eliminate externalities as far as possible. Looking at the externalities of climate change from an economic perspective, Sir Nicholas Stern described the situation as "the greatest market failure the world has seen".[15] In other words, under-pricing externalities, had led to an excessive and economically damaging level of greenhouse gas emissions.

Only governments have the ability to establish suitable pricing mechanisms, but they are reluctant to use this power. The net beneficiaries of the failure to price in externalities are relatively prosperous adults in relatively prosperous countries, who have much more political influence than those who bear the brunt of this failure (i.e. the young, the yet-to-be born, and poor people overseas). Hence the lack of action.

The net beneficiaries gain massive economic advantage which they defend politically with great vigour. If the unheard were to be offered a choice, they would almost certainly prefer instead good health and life, rather than being compensated for poor health or death. Tragically, just admitting to the inequity of this situation is more than most who gain from it are capable of.

Once the need to reduce carbon emissions and fossil fuel use has been accepted, questions inevitably arise about how much, by whom, and when. Poor countries and poor individuals (even within more wealthy countries) are likely to be disadvantaged first and hardest. Any ethically sound arrangement would result in a significant degree of wealth transfer to compensate.

Various formulae have been suggested to ensure that responsibilities are carried equitably between countries. The Global Commons Institute (GCI), has devised the *Contraction and Convergence* strategy for reducing emissions. Its oil equivalent, *The Oil Depletion Protocol*[16], has been promoted by American academic, Richard Heinberg. Although these strategies provide interesting starting points, they are not compatible with each other[17] and are too idealistic to gain widespread support in their present form.

One specific ethical issue is how to respond to the currently rapid industrial development of previously lesser-developed countries. China is most frequently referred to in this context, and it is of particular relevance because of the enormous size of its population (approximately 25% of the world total), and the unprecedented speed at which it is industrialising.

One reaction in the West has been to blame China's increasing resource use for the problems we are facing. This ignores China's historically low per capita resource use, which is still small, even today. For the year 2000, per capita carbon dioxide equivalent emissions were 4 tonnes for China, 19 tonnes for New Zealand, and 26 tonnes for the US.

What is more, much of China's resource use is to manufacture products destined for consumption in the Western world, or for the infrastructure necessary to facilitate such production. It is hardly likely that China will heed calls from us to reduce its resource use while we keep demanding ever-increasing quantities of products from its factories.

Another ethical issue is immigration. Given our present unusually large excess of biocapacity (see previous section), New Zealand might come under increasing pressure to accept climate refugees. And, given our history of high per capita emissions, there would be a strong ethical case for our accepting them.

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14 Suzuki, David, *A David Suzuki Collection; a lifetime of ideas*, Allen & Unwin, 2003, p 73.

15 'Publication of the Stern Review on the Economics of Climate Change', HM Treasury, press notice, 30 October, 2006.

16 Also referred to as 'The Rimini Protocol' and 'The Uppsala Protocol'.

17 For Contraction and Convergence fuel use/emissions are calculated on a per capita basis, but for the Oil Depletion Protocol the calculation is the total per country, and no account is taken of importers' own production, which is still a component of fuel use and emissions.

Where To From Here?

Until two hundred years ago, humans made little use of fossil fuels. Since then, their increasing exploitation has temporarily allowed many of us to enjoy a way of life which has paid little regard to the limitations of our finite planet. The most pressing of these limitation are the inability of the planet to provide oil at an ever-increasing rate, and its inability to absorb ever-increasing quantities of greenhouse gases without catastrophically altering the climate.

Adjusting to these limitations is going to be difficult – physically, economically, politically, and psychologically. For the world's climate to be stabilised at a level that avoids runaway climate change, net greenhouse gas emissions need to be reduced to near zero.[1] The longer the delay in starting the reductions, the deeper the reductions will have to be. At present, rather than being reduced, emissions are increasing rapidly.

As oil is becoming harder to extract, there is an increasing incentive to replace it with coal, which is still readily available. Unfortunately, per unit of energy, coal gives off over twice the carbon dioxide emissions of oil.

At 86.3%[2] of global primary energy used by humans, the sheer scale of fossil fuel energy use is daunting. All other sources combined contribute just 13.7% to primary energy use. Of the non-fossil sources, hydro (which presently contributes over 6.3%), has little potential for a significantly-expanded market share. This is due to the fact that the easiest and best situated sites have largely already been exploited. The remainder are either remote and/or would come at considerable environmental and social costs.

Nuclear fission (currently 5.9% of primary energy) is the only non-fossil energy source that can be scaled up to any significant extent in the timeframe required. However, nuclear power plants are slow to build, and the nuclear industry is presently a very long way short of being able to construct the number of plants required.[3]

Of the remaining primary energy sources such as solar, tidal, biofuels, and the rest — despite all the talk, there is not even the remotest chance that they can be stepped up from 1.5% to take over a significant proportion of the 86% provided by fossil fuels by 2050. The coal-driven global expansion in energy use is overwhelming any contribution they might make.[4]

Sustainable energy-sources fall well short of being able to meet the level of emissions reductions required. What then are the options if catastrophic climate change is to be avoided? One is the use of technical solutions, and the other is to reduce consumption, either separately or together, on a truly massive scale.

There are four possible technologies potentially scalable to a significant extent — biological, geological, and oceanic sequestration; and reflection. Biological sequestration is the easiest technically, as it just means allowing trees to grow. However, pressure to clear forests for ever more agricultural land for biofuels, and to feed the world's growing population, severely limits this option's contribution.

The other three technologies are presently untested, apart from a limited number of small-scale trials. All carry major risks of unintended consequences. Geological sequestration, received a big setback when the US government recently withdrew funding from the only major proposed commercial trial.

Could a massive scaling-up of nuclear generation, combined with a similarly massive deployment of presently untested technologies achieve the necessary reduction in greenhouse gases? Well, its is just possible perhaps, but the risks would be extremely high (from the untried technologies, as well as those associated with the nuclear industry). Even accepting the risks, it is still unlikely that the sheer scale of deployment required would be achievable.

That leaves demand reduction as the main potential source of emissions reductions. At present, fossil fuel energy use is growing at record rates. Deliberately-implemented demand reduction seems to be a remote possibility. Taking New Zealand as an example — despite consistently supporting the Kyoto Protocol, but well into overshoot of its modest targets, the government recently announced a $2 billion project to add to Auckland's motorway network, and hence increase emissions. Our highly-emitting dairy industry is also expanding rapidly, as is air travel. How all this fits with espoused emission reductions has been left unexplained.

A recent editorial in the *New Zealand Listener* addressed the issue:

> *As the government has discovered, signing up to agreements like the Kyoto Protocol is one thing, but meeting the obligations under them is quite another.*[5]

The New Zealand government is not alone in this discovery. Worldwide, nearly all governments are continuing along similar paths of espousing emissions

[1] See references and quotes under the heading 'Climate Change' in the Background chapter of this booklet.

[2] US Energy Information Administration *International Total Primary Energy Consumption and Energy Intensity - Table 1.8,* Posted 2 July 2007.

[3] For more, see under the heading 'Nuclear fission' in the Maintaining Consumption chapter of this booklet.

[4] US Energy Information Administration *International Total Primary Energy Consumption and Energy Intensity - Table 1.8,* Posted 2 July 2007.

[5] 'Promises, promises: reducing carbon emission presents a challenge that requires careful planning rather than empty gestures', *New Zealand Listener*, 15 March, 2008, page 7.

reductions, while simultaneously taking actions that have the opposite effect. A conference report of Yale University's School of Forestry and Environmental Studies by former director Daniel Abbasi states:

The problem of climate change is almost perfectly designed to test the limits of any modern society's capacity for response — one might even call it the 'perfect problem' for its uniquely daunting confluence of forces.[6]

Looked at dispassionately, there seems little hope. One of the greatest scientists of the last half-century, James Lovelock, has said recently that climate change has passed a tipping point and is unstoppable. According to Lovelock, nothing can prevent large parts of the planet becoming too hot to inhabit, or falling victim to sea level rises. He expects about 80% of the world's population to be wiped out by 2100. Rather than engage in trying to prevent the inevitable, Lovelock's suggestion is to

Enjoy life while you can. Because if you're lucky it's going to be 20 years before it hits the fan.[7]

Of course, it is one thing for the 88-year old Lovelock to say this, but would your young child or grandchild give you the same advice if they knew what Lovelock does? We doubt it.

Sadly, Lovelock is far from alone in his thoughts, although few in the public eye have had the courage to speak them so boldly. Surely, there is another position. Richard Heinberg recently had this to say:

The healthiest response to dire knowledge is to do something practical and constructive in response, preferably in collaboration with others, both because the worst can probably still be avoided and because action makes us feel better… We all know that we are in for difficult times, and that there is no guarantee that, even if we do everything we can, the result won't be human die-off and environmental devastation…

If, when an opportunity to influence policy does arise, there are no articulate advocates of a clearly worked-out alternative pathway... then doom will have become a self-fulfilling prophecy.[8]

While we acknowledge the cold scientific logic of Lovelock's analysis, Heinberg's position appeals more to our hearts. How can we give up on the futures of our children and grandchildren? How can we know for certain that courageous political leadership won't be found in time? How can we be sure that even small contributions at an individual level will not have a beneficial effect later on? How can we be sure that preparations we make now won't help ourselves and our families survive? We can't.

But, we can be sure that if we don't do anything, any possibility of positive gain arising from our actions will be foregone.

What can we do as New Zealanders? Can we rethink our way of life? We believe that we can start trying. This list of policy suggestions is based on the ideas of James Howard Kunstler[9] and modified by us to suit New Zealand's situation.

- Start thinking beyond the car. Keeping cars running in large numbers, regardless of efficiencies and types of fuels, is not likely to prove sustainable.
- Start working on how to move people and things less and differently, including making greater use of rail, particularly electrified rail.
- Drastically reduce long-distance travel, particularly by air, and particularly overseas.
- As much as possible, finding ways to decouple economic health from greenhouse gas emissions, drastically reducing our dependence on high carbon emitting economic activities, most notably tourism and pastoral farming.
- Begin the process of organising towns differently, having people live closer to work, schools and shops, preferably within walking distance where possible, but at least in such a way that public transport can be used routinely.
- Start producing food differently, reversing the trend towards large-scale agribusiness, with its high reliance on energy inputs and intense use of oil- and gas-based fertilisers, herbicides and pesticides.
- Begin questioning the need for hugely energy-intensive activities such as the Bluff aluminium smelter.
- Begin working on reducing the consumption of meat and dairy products, which produce much higher levels of emissions per calorie, than fruit and vegetables.
- Develop and implement ways of reducing consumption overall, moving away from the concept of shopping as a pastime, reducing waste, and routinely re-using, repairing and recycling items that are presently thrown away.
- Step up education on energy issues, and seek to eliminate present high levels of energy-illiteracy.
- Re-localise schools, hospitals, food supply and manufacturing .

Individuals can take action on some of these items, but for a significant level of change to occur, governments are going to have to be involved.

At present there is a considerable disconnect between what scientists say is necessary and the level of change governments say they intend to carry out. There is an equally large disconnect between what governments say they intend to do, and the effects of their actions. Some actions, such as extending motorways and airports, will increase emissions. Others, such as promoting biofuels and carbon trading, look to be largely ineffective in reducing such emissions. The combination of these

6 Daniel R. Abbasi, *Americans and Climate Change: Closing the Gap Between Science and Action*, 2006, page 17.

7 Decca Aitkenhead, 'Enjoy Life While You Can', www.guardian.co.uk, 1 March 2008

8 Richard Heinberg 'Beyond hope and doom: Time for a peak oil pep talk', Post Carbon Institute website, 2 March 2008.

9 wwww.kunstler.com 5 February 2007.

disconnects, represents a huge problem.

Al Gore put the situation this way:

The central challenge is to expand the limits of what's now considered politically possible. The outer boundary of what's considered plausible today still falls far short of the near boundary of what would actually solve the crisis.[10]

[10] *NY Times Magazine,* 20 May 2007.

Our hope in writing this booklet is to help shift the political boundary a little. Our focus has been on demonstrating the urgency and extent of action required. It is our belief that individually and collectively New Zealanders can make a difference. Whether or not that difference will ultimately be sufficient, we cannot know, but the extent of the failure will inevitably be worse if we don't try.

Appendices, etc

Glossary

Anthropogenic emissions - emissions resulting from human activities.

Biogenic emissions – naturally occurring emissions, e.g. from volcanoes and geyser.

Biogas – methane produced by fermentation of organic matter.

Biomass – matter derived from plants and animals.

Cap and trade - a type of emissions trading system under which a regulatory body sets an overall target for reductions that acts as the "cap." Individual emitters are allocated permits to emit, the total number of which add up to the cap. Emitters who can reduce emissions at a low cost, can then sell (or trade) the credits arising from their reductions to those emitters for whom the cost of reducing emissions is higher than the cost of the credits.

Carbon dioxide equivalent – a standardised measure of emissions for which the quantities of other greenhouse gases (see below) are adjusted to take into account the strength of their effect compared with carbon dioxide.

Carbon sequestration – storing carbon in a form that is not released into the atmosphere.

Carbon sink - places where carbon is naturally kept out of atmospheric circulation. For example, rain forests, coal, oil, soil, and oceans.

EECA - The New Zealand government's Energy Efficiency and Conservation Authority

Embedded or embodied energy – the amount of energy used to produce an item and to transport it to its point of use, including all its component parts and an allocation of the energy components of plant and equipment used in its manufacture.

EROEI - energy return on energy invested – the ratio of energy produced to energy required in its production. A valuable tool in measuring the viability of alternative energy sources.

Externalities – costs arising from an economic transaction that fall on people not party to the transaction.

Feedback loop - a process in which outputs are self-reinforcing. For example, warming temperatures are melting permafrost, which contains frozen methane. The methane released in the melting process causes more warming which melts more permafrost, and so on.

Greenhouse gases (GHG) – atmospheric gases that cause the earth to absorb more energy from outgoing infrared radiation than from incoming solar radiation. In terms of those affected by human activities, the most important are: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (NO_2).

IPCC - The United Nation's Intergovernmental Panel on Climate Change.

Kyoto Protocol – an agreement between nations intended to reduce greenhouse gas emissions. Signed by many countries, and later ratified by all developed countries, except the US.

Scalability – the ability to increase output or effectiveness by a significant extent. This is an important test in evaluating energy alternatives. For instance, coal-fired electricity generating capacity can be increased significantly to meet increasing global energy needs, but sugar ethanol cannot because sugar cane will only grow in a relatively narrow range of conditions.

Sustainable – activities which use natural resources at a rate that is less than, or equal to, the rate of their replenishment.

Timeliness – the ability to deliver solutions within a timeframe relevant to the problem being addressed. This is an important test in evaluating options for mitigating effects of climate change. For instance, wind-powered electricity generation is an existing technology and therefore meets the test of timeliness. The problems facing the development of nuclear fusion technology are so great that it is unlikely to meet any relevant test of timeliness.

Further Information

Recommended Books

We have found the following books particularly useful. Most are, or have been, available in New Zealand:-

Ralph Chapman, Jonathan Boston & Margot Schwass (editors) **Confronting Climate Change: Critical Issues for New Zealand** Victoria University Press, Wellington, 2006. ISBN 0-86473-546-4. An invaluable

collection of articles by more than 30 leading scientists and policy experts arising out of a Climate Change and Governance Conference held in Wellington in 2006.

Jared Diamond **Collapse: How Societies Choose to Fail or Survive** Penguin Group (Australia), Camberwell, 2007. ISBN 978-0-14-027951-1. A look at the lessons that can be learned from history when societies face major issues such as resource constraints.

Tim Flannery **The Weather Makers: The History & Future Impact of Climate Change** Text Publishing, Melbourne, 2005. ISBN 1-920885-84-6. An internationally acclaimed Australian scientist, gives an excellent all-round introduction to climate change.

Chris Goodall **How to Live a Low-Carbon Life: the individual's guide to stopping climate change**, Earthscan, UK and USA, 2007, ISBN 978-1-84407-426-6. A comprehensive, one-stop guide to reducing an individual's CO_2 emissions to 3 tonnes a year. (Accompanies the website listed below).

Niki Harre & Quentin D Atkinson (editors) **Carbon Neutral by 2020** Craig Potton Publishing, Nelson, 2007 ISBN 978-1-877333-69-9. A collection of separately-authored articles, each discussing different areas of focus in the search for carbon neutrality in New Zealand.

Richard Heinberg **The Party's Over: Oil, War and the Fate of Industrial Societies** New Society Publishers, British Columbia, 2003. ISBN 0-86571-482-7. A classic work on peak oil by one of the most respected writers and academics in the field.

James Howard Kunstler **The Long Emergency: Surviving the Converging Catastrophes of the Twenty-First Century** Atlantic Monthly Press, New York, 2005. ISBN 0-87113-888-3. An intensely thought-provoking take on life in a resource-constrained world.

Mark Lynas **Six Degrees: Our Future on a Hotter Planet** Harper Perennial, London, 2008. ISBN 978-0-00-720905-7. A readable, but highly sobering review, in one degree steps, of what the scientific literature indicates will be the effect of global temperature increases.

George Monbiot **Heat: How to Stop the Planet Burning** Allen Lane, London, 2006. ISBN 0-7139-9924-1. A respected columnist for Britain's *Guardian* newspaper presents a unique analysis of the actions one country (the UK) needs to take to fulfil its part in stabilising climate change.

Rod Oram **Reinventing Paradise: How New Zealand is Starting to Earn a Bigger, Sustainable Living in the World Economy** Penguin Books, Auckland, 2007. ISBN 978-016-300753-1. A multi-award winning financial journalist addresses New Zealand environmental issues from a business perspective.

Francesca Price **Wa$ted! Save Your Planet, Save Your Cash**, Random House New Zealand, Auckland, 2007. Based on the television series of the same name, this is a colourful and practical guide to reducing individual's carbon footprints.

Gareth Renowden **Hot Topic: Global Warming and the Future of New Zealand** AUT Media, Auckland, 2007. ISBN 978-0-9582829-1. An accessibly-written book on climate change and its likely consequences, from a New Zealand perspective.

Matthew R Simmons **Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy** John Wiley & Son Inc, Hoboken, New Jersey, 2005. ISBN 0-471-73876-X. A top merchant banker to the oil industry analyses oil supply issues, and provides an excellent description of how oil fields function.

David Suzuki & Holly Dressell **Naked Ape to Superspecies: A Personal Perspective on Humanity and the Global Eco-Crisis** Allen & Unwin, Crows Nest, NSW, 2002. ISBN 1-86508-649-5. One of the world's leading academic ecologists, and his co-author, take a wide-ranging look at the world's human-induced ecological problems.

Recommended DVDs

An Inconvenient Truth — former Vice President Al Gore's personal crusade to raise global awareness of climate change.

The End of Suburbia: Oil Depletion and the Collapse of the American Dream

and

Crude Awakening: The Oil Crash — two excellent introductions to peak oil.

The Greening of Cuba shows how food production in Cuba coped with a drastic drop in fossil-fuel availability following the collapse of the Soviet Union.

Recommended Websites (New Zealand)

www.mfe.govt.nz/issues/climate/ - Ministry for the Environment

www.eeca.govt.nz - Energy Efficiency and Conservation Authority

www.carbonzero.co.nz - The carboNZero programme, administered by Landcare Research, encourages and supports individuals and organisations in minimising their carbon dioxide emissions.

www.climatedefence.org.nz - The Climate Defence Network is a coalition of conservation, outdoors and recreational organisations that aims to promote and support the reduction and mitigation of human-induced climate change.

www.sef.org.nz - Sustainable Energy Forum aims to promote the transition toward sustainable energy in New Zealand. Home of the excellent *Energy Watch* newsletter.

www.nzbcsd.org.nz - The NZ Business Council for Sustainable Development promotes business leadership as a catalyst for change toward sustainable development.

Recommended Websites (International)

www.ipcc.ch - United Nations' Intergovernmental Panel on Climate Change

www.lowcarbonlife.net - provides regularly updated

information and commentary on low-carbon products, and accompanies Chris Goodall's book on *How to Live a Low Carbon Life*.

www.theoildrum.com - US-based, but with associated sites in other countries. Focuses mainly on oil, with an emphasis on the timing of peak oil, technical and other issues. Much of the content is written by expert members, and is unique to the site. Updated daily.

www.peakoil.com A US-based news site tapping worldwide sources. Focuses mainly on energy, but also covers geopolitical and environmental issues. Updated constantly.

www.energybulletin.net - a US-based news site covering energy and environmental issues. Includes articles written specifically for the site. Updated daily.

Graphs of NZ Energy & Emissions Data