THE SOCIAL IMPLICATIONS OF DECARBONISING THE NEW ZEALAND ECONOMY

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Abstract

There is strong evidence that the mean surface temperature of the Earth has risen significantly since 1900. Recent evidence suggests that, if warming of more than 2ºC (above pre-industrial levels) is to be avoided, then the emissions of greenhouse gases by developed countries, like New Zealand, may need to fall by up to 70% by 2030 and 90% by 2050. Achieving such a rapid decarbonisation will require major changes in energy generation, transport fuels and behaviour, land use and urban design, underpinned by modifications to national policy frameworks, and changes in social attitudes and behaviour. This paper outlines the case for rapid decarbonisation, assesses the implications for New Zealand's economy and society, discusses the required policy changes and the likely economic and distributional impacts of such changes, and explores institutional factors influencing policy development and implementation. The paper draws on recent international and domestic studies of the likely economic and distributional impacts of policy measures to mitigate climate change. It also refers to some survey evidence concerning public attitudes towards climate change and the willingness of citizens to change their behaviour and support policy measures to reduce emissions.

INTRODUCTION

Climate change poses one of the great challenges for humanity in the 21st century. The magnitude of this challenge has been highlighted by the *Stern Review Report: The Economics of Climate Change* (Stern 2006) and the *Fourth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC 2007). According to the "Summary for Policymakers" prepared by Working Group 1 of the IPCC:

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> Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations (p.10) … Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns (p.10) … For the next two decades a warming of about 0.2°C per decade is projected (p.12)… Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very *likely*[2] be larger than those observed during the 20th century (p.13) … Both past and future anthropogenic carbon dioxide emissions will contribute to warming and sea level rise for more than a millennium, due to the timescales required for removal of this gas from the atmosphere. (p.17)

As the Stern Review argues, human-induced global warming has the potential to generate very serious, large-scale and irreversible impacts. If the worst of these impacts are to be avoided, or at least minimised, urgent action is required to reduce greenhouse gas emissions. In effect, it will be necessary to decarbonise the global economy, and to do so as rapidly as possible. This will require fundamental and lasting changes in, amongst other things, the sources of energy, modes of transport and the nature of transport fuels, the management of land resources, and urban design. Such changes, and the policies required to achieve them, will have significant and wide-ranging economic and social impacts – including impacts on income distribution, attitudes and behaviour. Quite apart from this, if the assessment of the IPCC is correct, then, irrespective of the policies pursued by the international community over the coming decades, further significant global warming is very likely to occur during the 21st century and this will, in turn, have a range of ecological, social and economic impacts – mostly negative.

The primary purpose of this paper is to consider some of the likely social implications of decarbonising the New Zealand economy. In so doing, we deliberately adopt a broad view of the meaning of "social" – in effect, we are concerned with the human consequences of the measures taken to mitigate climate change, including economic, distributional, regional, sectoral, health-related and other impacts. We also adopt a loose definition of "decarbonisation" as including the reduction of greenhouse gas emissions from the agricultural sector. In order to provide a context for such a discussion, the paper begins by outlining in more detail why decarbonisation is required and why such action is urgent. Having considered the case for decarbonisation, we outline the current global and New Zealand policy contexts. Following this, we develop a framework for considering the social implications of rapid decarbonisation, and then begin the task of applying this framework to New Zealand. Given space constraints, we focus on one example, adjustment in New Zealand's transport and urban systems. Finally, we consider some of the issues requiring further research.

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2 In the language of the IPCC "very likely" means at least a 90% chance.

The paper draws on recent international and domestic studies of the likely economic and distributional impacts of policy measures to mitigate climate change. It also explores some available survey evidence concerning public attitudes towards climate change and the willingness of citizens to change their behaviour and support policy measures to reduce emissions.

It is important to note what this paper does *not* address. First, we do not examine the complex issue of how climate change will impact on New Zealand (whether directly or indirectly via its impact on other countries). In any case, we argue, below, that the largest impacts on New Zealand in the next decade or so will flow from domestic *mitigation* initiatives. But it is worth observing that there is a growing literature on the impacts of climate change on New Zealand and other countries (e.g. see Chapman et al. 2006, Stern 2006) and the matter will be fully explored in the forthcoming report of Working Group 2 of the IPCC (to be released in April 2007). We note in passing that there are important impacts from climate change abroad that could impinge on New Zealand, through channels such as global security impacts or immigration flows. The British Foreign Secretary remarked recently that climate change is a "threat we face … to the most basic conditions underpinning our global society" (Beckett 2006).

Second, this paper does not examine the social implications of New Zealand *failing* to take effective measures to reduce emissions over the medium-to-longer term. Any failure to participate in widely supported international efforts (and thus, in effect, to "free ride" at the expense of other countries) could well prompt retaliatory action, for instance via trade and other sanctions (Stiglitz 2006). This could be very damaging to the New Zealand economy. Moreover, if New Zealand continued to invest in carbon-intensive infrastructure for several more decades and was then forced by the international community to decarbonise at a very rapid pace, there would be inevitable and potentially significant economic losses. Finally, we do not address the topic of adaptation to climate change. All countries will need to adapt to varying extents over the coming century; such adaptation will in many cases be costly, difficult and socially disruptive, and may in turn create ripple effects for the world economy and for New Zealand.

THE CASE FOR RAPID DECARBONISATION

Globally, greenhouse gas emissions from the burning of fossil fuels, land-use changes and other human activities have been rising for more than a century (although the annual rate of increase has fluctuated considerably). As a result, the concentration of CO_2 in the atmosphere reached 380 parts per million (ppm) in 2006, or around 35% above pre-industrial levels. If the other five greenhouse gases covered by the Kyoto Protocol are taken into account (i.e. CH_4, N_2O, SF_6, HFCs and PFCs), it is estimated that the concentration of CO_2 equivalent (CO_2e) in the atmosphere is presently around 430 ppm (Stern 2006:201). This is nearly 50% higher than pre-industrial levels. On a plausible business-as-usual scenario, the Stern Review (p.202) estimates that the concentration of CO_2e will reach 550 ppm by 2035, and much higher levels later in the century.[3]

There is some uncertainty over the implications of increasing greenhouse gas concentrations in the atmosphere on the global mean surface temperature. However, most estimates suggest that a sustained doubling of CO_2 concentrations from pre-industrial levels (to around 550 ppm) can be expected (other things being equal) to generate an increase in the global mean surface temperature of approximately 3ºC at equilibrium, with a likely range of between 2ºC and 4.5ºC (IPCC 2007:9). According to the IPCC, warming of less than 1.5ºC "is *very unlikely*", while warming beyond 4.5ºC "cannot be excluded".

Table 1 outlines an indicative range of likelihoods of exceeding a certain increase in temperature, at equilibrium, for a series of stabilisation levels measured in CO_2e. The "maximum" and "minimum" columns provide the maximum and minimum chance of exceeding a particular temperature increase, based on 11 recent studies (see Meinshausen 2006). The results reported for the "Hadley Centre" in Table 1 are based on Murphy et al. (2004), while the results of the "IPCC TAR 2001" (IPCC, *Third Assessment Report 2001*) are based on Wigley and Raper (2001). Note that the individual values are approximate only.

As shown in Table 1, the higher the stabilisation level in terms of CO_2e, the higher the increase in temperature that is likely. Further, even if Herculean efforts were to result in CO_2e concentrations being stabilised at 450 ppm – which is only about 20 ppm above current levels – there is a strong likelihood that the global mean surface temperature will increase by more than 2ºC (i.e. above pre-industrial levels), a reasonably good chance that it will increase by more than 3ºC, and even a small chance that it will increase by more than 4ºC. Indeed, as Meinshausen (2006:264) has observed, "Only at levels around 400 ppm CO_2 equivalent or below, could the probability of staying below 2ºC in equilibrium be termed "likely" for most of the climate sensitivity PDFs [probability density functions]". This is important because the European Union and a number of other governments have concluded, on the basis of the available scientific evidence, that an increase of more than 2ºC would be "dangerous" – i.e. in terms of magnitude, seriousness and irreversibility of the environmental, economic, social and political harms that it would inflict.

3 Carter et al. (2006:197) dispute the proposition that CO_2e concentrations in the atmosphere will increase by as much as 120 ppm by 2035, but given various assumptions (e.g. continued global economic growth, limited action to reduce greenhouse gas emissions, etc.) there can be little doubt that concentrations will continue to increase and may do so at an accelerating rate.

Table 1 Likelihood of Exceeding a Temperature Increase at Equilibrium

Stabilisation Level (CO_2e)	Maximum	Hadley Centre Ensemble	IPCC TAR 2001* Ensemble	Minimum
Probability of exceeding 2˚C (relative to pre-industrial levels)["dangerous" warming]				
450	78%	78%	38%	26%
500	96%	96%	61%	48%
550	99%	99%	77%	63%
650	100%	100%	92%	82%
Probability of exceeding 3˚C (relative to pre-industrial levels)				
450	50%	18%	6%	4%
500	61%	44%	18%	11%
550	69%	69%	32%	21%
650	94%	94%	57%	44%
Probability of exceeding 5˚C (relative to pre-industrial levels)				
450	21%	1%	0%	0%
500	32%	3%	1%	0%
550	41%	7%	2%	1%
650	53%	24%	9%	5%

* IPCC, *Third Assessment Report 2001*.
Source: Based on Stern (2006:220)

As summarised by the Stern Review (2006) and elsewhere (Chapman et al. 2006, Schellnhuber et al. 2006), the kinds of negative impacts that can be expected include an increase in the sea level of several metres, more severe droughts, floods and storms, the loss of most coral reefs and mountain glaciers, and the extinction of a significant proportion of terrestrial species. Changes of this nature are very likely to involve major water shortages in many regions, reduce food production, inundate many coastal settlements and river deltas, and cause huge economic losses. Quite apart from this, sustained high concentrations of greenhouse gases in the atmosphere could well have serious adverse impacts on oceanic chemistry and marine ecosystems (Turley 2006, Turley et al. 2006).

If the global community is to have even a modest chance of avoiding such impacts, the currently available evidence suggests that concentrations of CO_2e will need to be stabilised *well under* 550 ppm. Achieving such a low target, however, presents formidable political and technical challenges. To start with, if CO_2e concentrations are to be stabilised (irrespective of the precise level), global greenhouse gas emissions must fall such that they no longer exceed the natural uptake of carbon from the atmosphere. Recent evidence suggests that the natural uptake of carbon is probably less than 20% of *current* emissions. Accordingly, the Stern Review (2006:218) argues that stabilising CO_2e concentrations will require emission reductions of *at least 80%* from 2005 levels. This, of course, is a global figure. What the implications might be for individual countries, like New Zealand, will depend on the nature of future international agreements that are negotiated to address climate change. However, if some countries are required to reduce their emissions by considerably *less* than 80% (e.g. because they currently have much lower than average emissions per capita), then other countries will need to cut their emissions by a higher percentage (e.g. 90% or more). Given New Zealand's high emissions per capita, comparatively high income per capita, and potential for energy system adaptation, it may well be required by the international community to contribute disproportionately to any future emission reduction programme.

If the preceding analysis is broadly correct, and if a relatively low stabilisation target (e.g. 450–500 ppm CO_2e) is to be achieved without significant or protracted overshooting, then it will be necessary to decarbonise the global economy very rapidly. Table 2, drawn from the Stern Review, illustrates the emission paths required to reach three different stabilisation targets: 450, 500 and 550 ppm CO_2e. As shown in the table, to have any realistic chance of stabilising at 450 ppm CO_2e, global greenhouse gas emissions must peak no later than around 2010 and then fall at a rate of about 7% per annum, with an overall cut in emissions of about 70% (below 2005 levels) by 2050.

Are such rapid and sustained cuts achievable? The Stern Review (2006:218–237) is highly doubtful, certainly given existing and readily foreseeable technologies and assuming continuing global economic growth. Our own view is that the momentum in the world economy now makes a 450 ppm outcome almost inconceivable. Stabilising at 500 ppm CO_2e is somewhat less daunting (see boxed row of Table 2). Nevertheless, emissions would need to peak no later than around 2020 (to avoid overshooting), and then fall at around 4–6% per annum, with a decrease of 60–70% by 2050. The evidence presented in the Stern Review indicates that such rates of reduction are outside the parameters of what has been achieved thus far in individual states (let alone at the global level), except during periods of serious political and economic upheaval. Moreover, in all likelihood any attempt to stabilise at 500 ppm CO_2e (or less) will necessitate the premature retirement of carbon-intensive capital stock, retrofitting cleaner technologies (which tends to be a more expensive option than starting from scratch), and the adoption of relatively costly low-carbon technologies. This, inevitably, will tend to increase the overall costs of mitigation. Even to achieve a stabilisation target of 550 ppm CO_2e will be very challenging. As the Stern Review (2006:234) notes, this is likely to require cutting current global *average* emissions per capita by *50%* by 2050 and an even larger reduction in emissions per unit of GDP.

Table 2 also highlights the importance of *early* policy action. Delaying the introduction of effective measures to curb emissions will necessitate more substantial reductions at some later point in order to meet a particular target. Even a delay of 10 years in the date at which emissions peak could mean that emissions will have to fall 50–100% faster to achieve the particular target in question. To compound matters, any significant delay is likely to increase the risk of severe climate impacts and accentuate the potential for triggering abrupt changes in the climate system (see Steffen 2006).

Table 2: Illustrative emission paths to stabilisation

Stabilisation level CO_2e	Date of global peak emissions	Global emissions reduction rate (% per year)	Percentage reduction in emissions below 2005 values[a]	
			2050	2100
450 ppm	2010	7.0	70	75
	2020	–	–	–
500 ppm (falling to 450 ppm in 2150)	2010	3.0	50	75
	2020	4.0 – 6.0	60 – 70	75
	2030	5.0[b] – 5.5[c]	50 – 60	75 – 80
	2040	–	–	–
550 ppm	2015	1.0	25	50
	2020	1.5 – 2.5	25 – 30	50 – 55
	2030	2.5 – 4.0	25 – 30	50 – 55
	2040	3.0 – 4.5[d]	5 – 15	50 – 60

Notes: a. 2005 emissions taken as 45 $GtCO_2e/yr$
b. overshoot to 520 ppm
c. overshoot to 550 ppm
d. overshoot to 600 ppm.
The symbol "–" indicates that stabilisation is not possible given the relevant assumption.

Source: Stern (2006:200).

Significantly, there remains considerable uncertainly over the likely natural uptake of carbon during the coming century, and in particular over whether changes in the climate will increase or reduce the natural absorption rate. At this juncture, the available evidence suggests that there is a significant risk that the absorption of CO_2 by the Earth's soils, vegetation and oceans will slow as the mean temperature increases. If this is the case, then even greater reductions in cumulative emissions (and / or expansion of carbon sinks) will be required to achieve any particular stabilisation target. Furthermore, after stabilisation has been achieved it is expected that the level of natural absorption will fall, partly because of the gradual exhaustion of the vegetation sink and partly because of a weakening of the rate of ocean uptake (Stern 2006:223). Given this situation, greenhouse gas emissions may well need to keep falling long after stabilisation has been achieved. Indeed, according to the Stern Review, it may be necessary in the long run to reduce annual emissions to less than 1GtCO_2e in order to maintain a particular stabilisation level. This would mean cutting emissions to about 2% of current levels – which are close to 45GtCO_2e per annum.

THE GLOBAL POLICY CONTEXT

At a high level, the global prospects for tackling climate change "in good time" and in an internationally harmonious manner are not encouraging. John Gray, Professor of European Thought at the London School of Economics, for example, remarks that "[c]limate change cannot be prevented, only mitigated, and whatever is done to deal with its effects there is sure to be large-scale disruption and conflict" (Gray 2006). Against this backdrop, what is the medium-term global policy outlook?

For a variety of reasons any global effort to stabilise CO_2e *concentrations* is likely to take decades to achieve. Leaving aside the cumbersome and time-consuming nature of global negotiations over climate change policy, there is substantial inertia in the global economy and social patterns with the result that it will take considerable time and effort to move towards a low-emissions pathway. This is due to lengthy infrastructure investment processes and long replacement cycles for most capital stock, as well as the sheer magnitude of the task of decarbonising complex and expensive energy and transportation systems (e.g. replacing carbon-intensive capital stock with low-carbon technologies). Equally, the Earth's climate system is characterised by considerable lags. Hence, even if greenhouse gas *emissions* are stabilised and then reduced rapidly over the next few decades, CO_2e *concentrations* will take several more decades to stabilise, the global mean surface temperature will continue to rise for a much longer period, and the sea level is likely to continue rising for several thousand years.

Thus far, only a few governments have given serious consideration to achieving domestic emission reductions of the magnitude required to achieve a CO_2e stabilisation target within the sort of range (such as proposed by Stern) that both offers the possibility of avoiding devastating change (by keeping CO_2e concentrations below 500 ppm) and allows for a realistic level of reduction on the part of developing countries (around 10% cuts by 2050). On the latter, the nature of global politics is likely to be critical, but our surmise is that, given responsibilities for past emissions, it may be easier to achieve 90% reductions in developed countries by 2050, as long as Kyoto-type flexibility mechanisms are accepted, than push developing countries beyond 10% cuts (refer Stern 2006:521).

The momentum for major reductions is building, especially in Europe (e.g. the Netherlands has committed to 80% reductions by 2040, and the United Kingdom to 60% by 2050). Interestingly, even where ambitious policy targets have been proposed – such as the objective of the state of California to cut emissions by 80% from 1990 levels by 2050 – it is not clear that these will present a significant burden for the economy in question and may even yield net economic benefits (see California Environmental Protection Agency 2006, Farrell 2005).

Because of the global nature of the problem, any genuinely effective action will require multilateral agreement. In this regard, two important developments are worthy of note. The first is the set of steps building on the Kyoto Protocol, which was only ever a first step. Any serious global effort to stabilise greenhouse gas concentrations in the 450–550 ppm CO_2e range will require much tougher reduction targets, including measures to bind most, if not all, jurisdictions. While international discussions have already commenced on the possible shape of a new post-2012 global agreement on reductions, serious negotiations have yet to commence and are unlikely to do so until the Bush Administration is replaced in the United States. For such reasons, the overall structure, contents and stringency of a new agreement may not become clear until 2010–2011. Be that as it may, it is very likely that the next agreement will require developed countries to make deep cuts in their emissions (e.g. 20–30% reductions on 1990 levels by 2020). This would be a major stretch for New Zealand.

Second, in 2005 the European Union (EU) introduced an Emissions Trading System (ETS). The ETS currently covers about 12,000 industrial facilities and power stations within the EU which, collectively, account for nearly half the Union's carbon emissions. Under the ETS, companies can buy and sell carbon allowances (within a fixed cap), with the price governed by supply and demand as in other markets. There have been a range of problems with the ETS, as might be expected with the trading of a new commodity. But a key benefit of the scheme is that it has established a price (and cap) for carbon. This not only provides an incentive for companies to restrain their carbon emissions, but does so in a manner that achieves emission reductions in a least-cost manner. Furthermore, placing a price on carbon gives companies more certainty about the future as they assess their investment options. This, incidentally, is critical to the logic underpinning the Kyoto Protocol.

THE NEW ZEALAND POLICY CONTEXT

Although New Zealand's greenhouse gas emissions constitute only about 0.2% of the global total, emissions per capita, as noted earlier, are relatively high (around 11th highest). This is partly because of substantial methane and nitrous oxide emissions from the agricultural sector.

To date, New Zealand has had less success than the EU in developing and implementing emission reduction policies. In fact, climate change policy has been characterised by lengthy and inconclusive debates, a lack of consensus amongst key stakeholders, governmental indecision and prevarication, and a series of significant policy reversals (see Boston 2006, Chapman 2006, Ward 2006a). Under Kyoto, New Zealand accepted a binding target to reduce greenhouse gas emissions to the 1990 baseline level during the first commitment period (2008–2012).[4] Unfortunately, the country is a long way from meeting this target. Gross emissions (before accounting for forest sinks) have continued to increase, and in 2006 were about 21% above the 1990 baseline. Indeed, emissions of CO_2e are expected to be around 30% higher than 1990 levels during the first commitment period, largely because of increased CO_2 emissions from transport, rising methane emissions (as a result of a growth in the number of ruminant livestock), and a substantial rise in nitrous oxide emissions (largely from dairy effluent, dung and urine deposits, and fertiliser usage) (see Clark 2006, Whitehead 2006). Declining forest planting rates are exacerbating the situation.

As a result, net emissions are currently projected to be around 12% (or about 41 million emission units) over 1990 levels during 2008–2012, even after offsets from forest sinks are included.[5] This is likely to entail fiscal costs (via the purchase of carbon credits from other countries or firms), unless the then government elects not to meet its international treaty obligations (which could do immense damage to the country's reputation and credibility).

It is possible that reducing emissions will be more difficult in New Zealand than in some other developed countries, but this contention needs to be examined. One reason often cited is that New Zealand already produces around 60% of its electricity from renewable sources, one of the highest percentages in the world, so lifting this percentage would appear difficult. But there is scope to expand renewable generation substantially, given our rich renewable resource endowment. It will not be costless, and it will take time to retire old fossil-fuel-based plants, but it is feasible, and may produce significant co-benefits such as new technology development, with associated export opportunities.

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4 Technically, the target was to stabilise emissions at 1990 levels or take responsibility for any excess over 1990 levels. Thus, at a price, New Zealand can in principle buy emission units on the international market to meet its obligations, if it considers that is less costly than reducing emissions.

5 For the most recent data on New Zealand's Greenhouse Gas Inventory, see:
http://www.climatechange.govt.nz/resources/reports/nir-apr06/html/page2.html
For projections for the first commitment period, see the 2006 "net position" report:
http://www.climatechange.govt.nz/resources/reports/projected-balance-emissions-jun06/html/index.html

However, almost 50% of greenhouse gas emissions are generated in the agricultural sector, and there are limited "quick fixes" currently available in this area. But again, there are some options available, such as reducing the use of fertiliser (for instance with a fertiliser charge), turning marginal agricultural land back to shrubland and/or forest, replacing some livestock farming with "carbon farming" (e.g. the growing of crops for biofuels), use of nitrification inhibitors, and ruminant livestock selection (Ministry of Agriculture and Forestry 2006, Clark 2006). Significantly more research investment is needed in this area (Upton 2006). It is unclear that measures to promote change in these areas would be very disruptive to the agricultural sector, or generate significant social implications for the sector, unless stringently applied with a short lead-in time.

Bringing together the global and New Zealand contexts, let us suppose that the global community reaches agreement on a post-2012 regime that involves relatively deep cuts in emissions by developed countries during the following decade or two, with obligations on developing countries to stabilise their emissions at 2012 levels. Under this agreement, New Zealand is obliged to reduce CO_2e emissions by at least 20% in net terms (compared with 1990 levels) by 2025, and make 50% cuts by 2050. In fact, a more stringent scenario can easily be envisaged, under which 35% cuts would be required by 2025 and *80–90% by 2050*. Either way, it is assumed that there will be an active global carbon market and that New Zealand will be in a position to purchase (and possibly sell) carbon credits on the international market. Having said this, it is also assumed that New Zealand will endeavour to avoid placing too much reliance on buying permits on an unpredictable global market, and will aim to achieve a substantial level of "self-sufficiency" in emission reduction, i.e. substantial domestic emission reduction. The next section sets out a framework for considering the social impact of such emission reductions.

THE SOCIAL IMPLICATIONS OF DECARBONISATION – A FRAMEWORK

In outline form, a framework for considering social implications contains six core propositions:

- Over the next decade or so, the social implications of climate change will flow most strongly not from the *direct* impacts of climate change itself, but from the **policies** adopted to mitigate climate change, i.e. from decarbonisation policies.
- The social implications will depend strongly on the **nature** of the policies adopted, including aspects such as revenue recycling.
- The social implications are likely to be influenced by the degree of **foresight** exercised in government policy, private sector and individual repositioning.
- The implications will depend significantly on the **resilience** of the various sectors of the economy, the **lifetime** of the economic capital in those sectors, and people's adaptability and commitment to developing more sustainable ways of living.

- The social implications of decarbonisation are likely to be less disruptive to the extent that there are opportunities for **communities and individuals to engage directly** in developing appropriate actions to reduce emissions.
- **Uncertainty** around the magnitude of climate change impacts, and technological and social responses, means there is a good argument for *more* demanding mitigation policy action, not less.

TOWARDS SOCIAL IMPLICATIONS: THE CORE PROPOSITIONS

Proposition 1: Over the next decade or so, the social implications of climate change are likely to flow most strongly not from the direct impacts of climate change itself, but from the policies (decarbonisation policies) adopted to mitigate climate change. This is because, as we have seen, policy action must be taken rapidly and radically, ahead of slowly building environmental impacts, if very serious impacts are to be avoided at a global level. Even a few years ago, this was not so certain, i.e. the scale and urgency of the emission reductions needed was less clear, and it was widely assumed that a gradual mitigation strategy over a number of decades would be adequate to optimally manage climate risk. With the greater urgency outlined above, the need for very major mitigation actions on a timeframe of 10 years or so implies substantial impacts from those mitigation policies. This is not to say that adaptive actions are unimportant, or that they do not require policy attention. Some actions, such as measures to mitigate flooding, as a result of an increased frequency of extreme daily rainfalls, and actions to prevent inappropriate development in exposed coastal areas, need to be taken now or soon (New Zealand Climate Change Office 2004a, 2004b). However, the largest impacts on our economy and society are likely to flow from the need to join stringent international efforts to mitigate critical climate damage.

Proposition 2: The nature and magnitude of the social implications will depend strongly on the *nature* of the policies adopted. There is a wide range of policy possibilities.[6] For instance, there are price-based mechanisms (e.g. carbon charges, tradable quotas, subsidies, etc.) and other mechanisms (e.g. education, information provision, regulatory controls), and such mechanisms can be applied comprehensively across the economy, or selectively. However, because of the urgency and scale of climate change, voluntary agreements and modest educative policies are no longer adequate. It is concerning that, in 2007, some of our business leaders are still calling for "voluntary" approaches (O'Reilly 2007), and voluntary reporting of agricultural emissions is still being considered by the Ministry of Agriculture and Forestry (MAF 2006:46).

6 There is an extensive and rapidly growing literature on climate change policy issues. See, for instance, Congressional Budget Office (2003), Helm (2005), Schneider et al. (2002) and Stern (2006). For recent contributions to the New Zealand policy debate see: Chapman (2006), New Zealand Government (2005), Upton (2006) and Ward (2006b).

Also, in our view, decarbonisation policy will almost certainly rely on a **mix of instruments**, including both price-based mechanisms *and* regulation, for example energy efficiency requirements (Ministry for the Environment 2006:14). Given the complexity of the likely policy mix, it is not possible to deduce social impacts by considering just the flow-through effects of a simple relative price change (i.e. a rise in the price of fossil-fuel intensive products and services), even though tracing the main consequences of such price changes may provide a useful rough guide.

To briefly elaborate on why New Zealand governments are likely to rely on a mix of instruments, we see three reasons. First, the scale of the problem of climate change, and the social and economic adjustment it will bring, necessitate using every cost-effective instrument available. Second, such a mix has proved necessary to tackle effectively major entrenched social problems in the past, such as cigarette smoking. Allied to this, the government may also see climate change as a problem that everyone in society needs to make a contribution to fixing, and this may dispose the government to an approach in which everyone is asked to bear part of the burden of adjustment. Regulation of increasingly scarce urban water in Australia, for example by restrictions on water use, rather than water pricing, illustrates an understandable though not necessarily optimal response in such situations (Byrnes et al. 2006, Quiggin 2007). Third, price instruments, while important to drive major adjustment in the economy, may have significantly larger (and sometimes less hidden) distributional impacts than regulation, and governments are unlikely to want to place an undue burden of economic adjustment on those who cannot easily bear it. Relevant principles include fairness, avoiding an increase in inequality, and providing adjustment assistance where needed.

While price instruments are likely to be only part of future policy packages, they are a vital part. As long as the price signal is sufficient, price instruments ensure that the (social) cost of carbon is comprehensively built into the decision making of investors, producers and consumers. This is important for influencing the pattern of demand, helping to encourage the development of new low-carbon technologies, and prompting the adoption and diffusion of such technologies. It is also likely that such price-based mechanisms will be comprehensive, and not limited to the energy and transport sectors, although considerable debate will take place about the application of price instruments to the agricultural sector.

Other policy initiatives likely to be adopted include substantially increased public and, in some cases, private investment in research and development, especially in relation to renewable energy technologies, carbon capture and storage, and agricultural emissions; specific regulatory and fiscal measures to enhance energy efficiency, encourage low-carbon transport modes, and expand carbon sinks; regulatory changes to encourage the adoption of renewable energy sources, improve building and product standards, and enhance the amount and quality of information available to consumers and investors; and so forth.

The nature of the policy instruments selected and the manner of their application may have significant distributional implications, leaving aside for the moment efficiency and effectiveness. The proposed carbon charge dropped in December 2005 was estimated to have very minor distributional impacts (Creedy and Sleeman 2006). It may be that certain policy responses are ruled out by concerns about the risk of increasing social and economic inequalities. In any event, policies will need to be assessed against such criteria not just in a short-term sense (e.g. how can housing assistance help low-income households move away from unsustainable forms of household heating?) but also long-term – e.g. how will raising building code standards to reduce housing-related emissions affect the supply of housing at the lower end of the market, over time?; and will increases in code-driven efficiency be offset by behavioural change? (Miliband 2006, Sanne 2000).

An important aspect of the design of any instrument which puts a price on carbon is *revenue recycling*. Potential social implications are far-reaching. Discussion of this issue in the New Zealand context, and the raising of public awareness of the means and merits of recycling of carbon charge revenues, was poorly handled in the last decade, including in the lead-up to the late-2005 decision to drop the proposed carbon charge. In our view this may have contributed to a concern, on the part of some, that the proposed carbon charge was a "tax grab", and that impacts on the economy and particular groups might not have been substantively eased by financial assistance or adjustment measures. Bertram (2001) and Infometrics (2001), among others, have pointed out that if revenue from a relatively small carbon charge or auctioned permits is recycled back as (general) tax reductions, the result may be an increase in employment and economic output, or at least no reduction. The experience of some other countries, for example the Netherlands and the United Kingdom (Ministry for the Environment 2006), suggests that the public is more likely to accept a price on carbon emissions if it can understand how the revenue accruing to government will be recycled in constructive ways to facilitate adjustment (European Environment Agency 2000, IPCC 2001).

Proposition 3: The nature and magnitude of the social implications are likely to be influenced by the degree of foresight exercised in government policy, private sector and individual repositioning. On the one hand, policies may emphasise leadership (Clark 2007) and proactively anticipate decarbonisation and foster early moves to adapt and adjust, so allowing the decarbonisation process itself to be less rushed, and less economically and socially disruptive. On the other hand, there is a high risk of a policy configuration that assumes that New Zealand can take its time to respond. This is likely in our view to result in New Zealand being obliged in due course to adhere to a forced pace of decarbonisation set by the international community.

The latter scenario is one in which New Zealand has to respond, but in a reactive way, in order to retain our "licence to operate" in the world community, i.e. to stay trading in a global context where emission reduction is seen as both necessary and urgent. It would also be a world in which first mover advantages, our clean green reputation, and economic opportunities to exploit new markets for more climate-friendly products or services are forgone. It is worth underlining how rapidly the international context is moving – and the associated risk that New Zealand may lag behind many other countries in terms of business and policy response. For example, the Carbon Disclosure Project, reporting to investors with US$31 trillion in assets, has been running since 2002; New Zealand companies are now starting to be subject to its scrutiny (Hamilton 2006). This amounts to a form of international pressure to exercise foresight on climate change, and build climate change mitigation and adaptation into their business strategies.

There is an increasing body of evidence (Esty and Winston 2006) that in a globalising world, foresight about environmental constraints, and pro-activity in turning such constraints into business opportunities, is critical to ongoing competitiveness. Examples include BP, which made an initial investment of US$20 million to reduce internal CO_2 emissions and by 2006 had found around US$1.5 billion worth of savings (Esty and Winston 2006). There is associated evidence that taking environmentally positive actions can become a point of advantage in the labour market – a progressive firm can be better able to recruit and retain motivated workers (British Telecom 2006).[7] For New Zealand companies, capitalising on New Zealand's already good environmental reputation through long-sighted strategic positioning is likely to help attract and retain talented people in a competitive international labour market.

Proposition 4: The nature and magnitude of the social implications will depend significantly on the *resilience* of the various sectors of the economy, the lifetime of the economic capital in those sectors, and people's adaptability and commitment to developing more sustainable ways of living. By resilience we mean the ability of various sectors of the economy, and the businesses and people within them, to adapt to rapid and major change. Because the nature of the capital in different sectors varies, a sectoral analysis of implications is necessary. Some further comment on the resilience of particular sectors of the New Zealand economy to robust mitigation policy measures is offered below.

As well as physical capital, there is also culture to contend with. In this context, we mean the engrained patterns of behaviour that generations of New Zealanders have learnt. This is a huge challenge, as "car culture" and patterns of behaviour are now, after many decades of mass car ownership, heavily embedded. The post-WW2 growth

7 "Sixty-six per cent of employees say that knowing about our social responsibility activities makes them proud to work for BT." (British Telecom 2006:10).

of car transport and decline in use of public transport (e.g. trams, rail) in Auckland has been more dramatic than that of almost any developed world city (Tritt 2006). The implication, however, is that it may take several decades to shift people to more sustainable and climate-friendly transport modes.

Proposition 5: The social and economic impacts of decarbonisation are likely to be less disruptive and more benign to the extent that there are opportunities for communities and individuals to engage directly in developing appropriate actions to reduce emissions. In the United Kingdom, David Miliband, the Secretary of State for Environment, Food and Rural Affairs, underlines the advantages of decarbonisation policies that engage and empower individuals, for example through personal carbon allowances. Potentially, he contends, such a system may be more equitable, empowering and effective than the traditional tools of information, tax, and regulation (Miliband 2006), although there is debate over the balance of advantages and disadvantages of such an approach (e.g. Roberts and Thumim 2006).

In New Zealand, the process of developing Long-term Council Community Plans, under the 2002 Local Government Act, has begun to reveal a community appetite for more sustainable community development paths, including finding ways to deliver more sustainable lifestyles (Local Futures Research Project 2006). Despite some resistance, there is also a community groundswell for translating such aspirations into critical instruments such as Regional Land Transport Strategies, which shape investment in land transport over long time periods (Living Streets Aotearoa 2007, Option 3 2007). Our perception is that local and regional councils are only beginning to engage with communities over the issue of climate change mitigation and adaptation, with councils such as Kapiti Coast and Waitakere taking a lead. But where they have moved faster and further, they have detected a willingness on the part of the community to engage in thinking about the behavioural implications of climate change, and a willingness on the part of individuals to engage in finding creative solutions.

One indication of the underlying willingness of New Zealanders to commit to being more environmentally sustainable comes from the Growth and Innovation Advisory Board survey of 2004 (Growth and Innovation Advisory Board 2004). This in-depth survey process (which included focus groups and a sample survey) found "quality of the natural environment" as very important or important to 87% of respondents. Only "quality of life", which clearly has an important environmental component, ranked as more important (93%). Outcomes such as economic growth were less often important (67% in that case) to New Zealanders. Our supposition is that while this will not necessarily translate directly into a willingness to make personal sacrifices for the sake of the global environment, it does mean that New Zealanders do place considerable weight on actions that protect the environment, both locally and globally.

Rose et al. (2005), in the New Zealand Values Survey, conducted December 2004 to March 2005, found similar attitudes. For example, over 80% of respondents agreed or strongly agreed with the statement that "Economic growth should only occur if it does not cause lasting damage to the environment". And over 90% of New Zealanders surveyed agreed that "Individuals should take responsibility to minimise any environmental harm they may cause". In relation to the former finding, the evidence is now clear, and increasingly understood, that climate change is causing damage of a lasting nature. More specifically, a survey conducted for Communities for Climate Protection – New Zealand found that 74% of New Zealanders surveyed believe climate change is a serious problem, and 56% of those surveyed had thought about, or had taken, actions to help reduce the effects of climate change (CCP-NZ 2006:1).

New Zealanders' awareness of climate change, and perceptions of and attitudes to mitigation are important factors affecting willingness to engage in personal action, or to support government policy measures. Awareness and attitudes are likely to have been changing rapidly in recent months, with the steep recent increase in media coverage of climate change issues, both from an international and New Zealand perspective. The Ministry for the Environment and other interested parties are currently considering a polling process to monitor these changes.

Proposition 6: Assessing the nature and magnitude of the social implications is complicated by continuing *uncertainty* over the likely speed and scale of climate change impacts, the development of new technologies, and the willingness of people to change their behaviour. Uncertainty acts as a barrier to action for some, but also strengthens the case for more demanding mitigation policy action.

When scientific uncertainties are highlighted by the media, and there is a significant level of climate denial reported by the media, it is natural to either wait for "clincher" evidence, or, in the language of economists, to maintain "option value" through "rational delay" (Chapman 2006). But it is now increasingly clear that such delay, as argued earlier, is becoming costly, as it engenders larger future environmental and social impacts.

Although the scientific evidence establishing the basic fact and causes of climate change is now overwhelming, significant uncertainties about impacts and responses remain. For instance, there are uncertainties over how individuals and companies will respond to the policy initiatives taken by governments. There are equally large uncertainties over the likely nature and speed of technological change in different markets during the coming decades, together with the costs of adopting existing and new low-carbon technologies. In addition, there are major uncertainties concerning the indirect impacts on New Zealand of policy changes in other jurisdictions.

To give but one example: it is unclear how international tourism and travel, and hence visitor numbers to New Zealand, might be affected by higher costs of flying, arising from efforts to reduce emissions in the aviation industry. Becken (2006) has noted that the "eco-efficiency" of tourist travel from China, Australia and Singapore is considerably "better" than that of tourists from Canada, Germany or the United States. Eco-efficiency is defined for this purpose as amount of money spent per unit of energy consumed in New Zealand. This implies that a rise in fuel costs on the back of a carbon price is likely to affect the latter markets more adversely, unless offsetting strategies can be adopted, such as the development of biofuels for aircraft (to which there are currently major technical barriers). Irrespective of direct price effects, visitor numbers are also likely to be influenced by attitudinal and behavioural changes prompted by growing international concern over climate change. Monbiot (2006:188) has noted that it is evident that "long distance travel, high speed and the curtailment of climate change are not compatible". And there are increasingly visible signs that high-income consumers are now starting to think twice about long-haul overseas tourist travel (Teutsch 2007, Climate Friendly 2007, Roberts 2007).

A more general result from the literature is that the uncertainty about the social and economic impacts of climate change is an argument for more active policy. Stern (2006:328), for example, notes that there is an asymmetry between unexpectedly fortunate outcomes of global climate change and unexpectedly bad outcomes. The higher the temperature for a given concentration of greenhouse gases, the more rapidly adverse impacts are likely to increase. Second, the worse the outcome, the lower will be the incomes of people affected by them, so any monetary impact will have a bigger impact on wellbeing.

DECARBONISATION AND RESILIENCE

Earlier, we remarked that the resilience of the New Zealand economy and society to robust mitigation policy measures is a critical consideration. Here, we outline how an analysis of resilience might be approached. We note first that discussion about economic impacts is usually couched in static terms, focusing on likely economic costs and benefits of decarbonisation, based on the economy as it is currently configured. In those terms, we note that the economic cost of mitigation will be unevenly distributed across industry sectors – carbon-intensive sectors will face higher adjustment costs and a likely loss of competitiveness. However, some proactive firms will adjust relatively easily if they have been anticipating climate policy developments. The need for mitigation cannot be a surprise: there have been stronger and stronger signals about reducing carbon intensity since around 2000, and – if businesses have been alert, and sceptical of advice from climate change "deniers" and vested interests – they may have picked up signals since as early as 1990, when the first IPCC report was published.

Macroeconomic Resilience

Clearly, despite the signals, many businesses will face adjustment costs. Stern (2006:267) estimates that stabilising CO_2e concentrations at 500–550 ppm will cost about 1% of annual global GDP by 2050 (with a range of between –5% and +2% of GDP). In other words, global GDP is likely to be about 1% lower mid-century than it would have been had there been no mitigation strategy in place. Beyond that date the costs of mitigation are much less certain. Overall, Stern's calculations are consistent with much of the recent literature on the costs of decarbonising the global economy (see Hatfield-Dodds 2006, Metz and van Vuuren 2006, Giles 2006). Closer to home, The Allen Consulting Group (2006) has estimated that an "early action" scenario involving a carbon price rising to $600/tonne of CO_2e could reduce Australian GDP by up to 6% by 2050. This sounds considerable until one realises that in their projection the economy still expands 120% by 2050 – it would simply, with "early action", reach the same level of GDP 2.5 years later. These results should apply, very broadly speaking, to New Zealand, at least as a guide to the order of magnitude of adjustment costs, although, as noted above, the size of the costs and the extent of opportunities opened up will depend significantly on how proactive New Zealand is in responding.

The resilience of the economy in a macro sense depends on the flexibility of its capital stock, and capital longevity. Because it takes time to turn over the capital stock – i.e. to make more efficient cars, houses and power stations – the economic costs of rapid decarbonisation will be significantly higher than those associated with a slower pace of emission reductions (e.g. Stern 2006). A fast reduction strategy will necessitate the premature retirement of carbon-intensive capital stock, and the retrofitting of cleaner technologies (which tends to be a more expensive option than starting from scratch). This, inevitably, will tend to increase the overall costs of mitigation.

In a macro sense, the resilience of the economy and society also influences the *benefits* arising from decarbonisation. What is critical here is New Zealand's capacity to identify and foster opportunities in new markets and industries (including financial services, renewable energy, carbon farming etc.), and create new jobs in the process. The international competition to exploit these new markets has begun but, as long as it invests strategically, New Zealand is likely to be able to find niche opportunities in areas where it has a comparative advantage, or can develop one, such as in biofuels and marine energy. New Zealand does not have a good record in terms of strategic investment; for example, Sims (2006) notes New Zealand's dismally low investment in renewable energy research and development to date. However, New Zealanders are adaptable and new enterprises are easy to establish in New Zealand (World Bank 2005). Moreover, New Zealand has an underlying advantage with its image as a clean, green and innovative country, and this gives New Zealand exporters a modest head start. Nevertheless, in green technologies such as photovoltaics (solar power), where

Germany and Japan are leading the field, and wind energy, where Denmark and Germany are well-established, New Zealand may struggle to create industries and new jobs.

Countries such as Denmark, Germany and Japan have not developed leads in climate-friendly business domains simply because they set out to improve their long-term business positioning. Often, these investments have been steered by a vision of business becoming more ecologically sustainable over time in order to meet social responsibility aspirations, and business leaders have seen a synergy between climate friendliness and business opportunities. In many instances, climate change policy initiatives have the potential to reduce business costs by improving energy efficiency and organisational efficiency, reduce costs of waste management, and contribute to business outcomes in related ways (Esty and Winston 2006). Policies that consciously foster climate-friendly business development, as well as supporting efficiency, are likely to have higher overall payoffs.

Microeconomic Resilience

Various economic analysts, and the work of Hatfield-Dodds (2006) and The Allen Consulting Group (2006) in particular, suggest that rather than causing major reductions in GDP or income, the major effect of rapid decarbonisation is likely to be to a change in the *nature of the trajectory* of the economy (both the global economy, and New Zealand's) in a microeconomic sense. In other words, the economy will become different in kind, but not necessarily significantly smaller in size, as long as well-designed policies are implemented, and as long as New Zealand's workforce and businesses remain flexible.

This will be reflected in many aspects of the economy and society. The major microeconomic implications for New Zealand will be felt particularly in the energy and transport sectors, energy-intensive metals (e.g. aluminium), household consumption, tourism, building and housing, and urban design, and with lesser but still important implications for other areas such as manufacturing, agriculture and forestry (which are not particularly energy-intensive). Across all these sectors there will be a greater focus on energy efficiency and reduced use of fossil fuels (New Zealand Business Council for Sustainable Development 2005, Parliamentary Commissioner for the Environment 2005, Chapman and Piddington 2006). We can expect growth in new energy sources such as wind and marine energy, and new forms of geothermal energy, reductions in transport intensity and a move to new fuels, an investment in ways to reduce the major non-carbon greenhouse gas emissions (methane and nitrous oxide), and renewed efforts to capture carbon in forests as well as in algae. Whether these changes are highly disruptive or not depends on the extent to which business anticipates change and invests strategically to minimise disruption and maximise opportunity, or whether it lags behind overseas competitors in terms of taking advantage of developing markets and the direction of evolution of technology and associated jobs.

In some sectors, elasticities of response, in economic terms, will be low and there may be resistance to emissions reductions. It may be economically efficient for sectors to respond to different extents (to a given price signal, for example), but slowness by some sectors to pick up the signals ultimately means that other parts of the economy have to adapt to a greater extent. We are assuming that, overall, New Zealand will face very stringent and legally binding emission reduction targets (such as those in the Kyoto Protocol, but more demanding). Wherever forced economic adjustment is necessary in any sector, especially under a rapid decarbonisation scenario, significant social impacts can be expected. Given space constraints, we focus on one example, adjustment in New Zealand's transport and urban systems

Before turning to the example, however, we emphasise that micro-level resilience is not a given, but is influenced by individual flexibility, social responsiveness, and adaptive institutions (Folke et al. 2002). In a social sense, rapid decarbonisation will be more difficult than slow decarbonisation. Clearly, being forced to retire emission-intensive assets early and replace them is painful when it impacts on household budgets, rates and taxes. This applies to household assets such as heating systems and cars but also infrastructure assets such as motorways that are collectively funded. Forced rapid asset replacement may also be socially divisive, as those with little margin in their daily budgeting face extra costs, such as that of buying a car that meets a new emissions test, or adjusting their heating system to one that is permitted by regulation. For example, unflued bottled-gas heaters are likely to be removed from the market sooner or later by regulation for a number of reasons, including their carbon emissions, but this adjustment is likely to be perceived as unreasonable by many low-income households who use these for their home heating. The difficulty associated with rapid adjustment of equipment such as heating systems can be mitigated if capital outlay costs can be reduced, for example for low-income families through a deliberate social assistance policy. More generally, the social costs of decarbonisation can be mitigated if adjustments are signalled and begun early and progressed gradually rather than abruptly. And costs can be lessened if adjustment is supported by open, learning institutions (Lebel et al. 2006).

ADJUSTMENT OF TRANSPORT AND URBAN SYSTEMS IN NEW ZEALAND

New Zealand's transport and urban systems, by which we mean vehicles and patterns of transport, patterns of urban infrastructure and land use arrangements, and associated building and housing, will have to adapt much more rapidly than is comfortable, under any credible decarbonisation scenario designed to avoid devastating environmental impacts. In following a rapid or even moderately rapid decarbonisation path, the stresses on our cities will be substantial.

Transport

The transport sector is responsible for over 40% of New Zealand's CO_2 emissions (and around 20% of total greenhouse gas emissions), emissions have increased 62% since 1990, and the base-case New Zealand government "Energy Outlook" projection is for 35% growth in emissions from oil by 2030 (Ministry for the Environment 2006:23, Ministry of Economic Development 2006:35). Such a prospect is completely at odds with the major cuts in emissions that are needed. While most vehicles cannot currently be adapted to become more economic fuel users, re-engineering to use some biofuel is feasible. But the most cost-effective approach to deliver a major cut in emissions from the sector is to progressively convert the entire stock of capital in the transport sector to biofuels or plug-in electric hybrids over the next two decades or so. Fortunately, the relatively short lifetimes of road vehicles (for example, private vehicles in New Zealand average around 12 years old) makes this feasible (EECA 2006) even if costly. It will require a large investment in a new biofuels industry, with associated infrastructure, delivery systems and so on. That has begun already, but the scale identified in government announcements to date, 3.4% of fuel sales by 2012 (Clark 2007) will need to be radically increased. Or, to the extent that electric vehicles prove more popular, it will require a major investment in renewable electricity generation. One estimate is that running a plug-in car fleet for around 80% of journeys (up to around 50km) would be manageable, with a modest lift in electricity generation (Hood and James 2007:39). Neither the biofuel nor the renewable electricity industry is employment-intensive, but skills and expertise developed in building these industries in New Zealand are potentially exportable and may provide longer-term income-earning opportunities.

The Interlinking of Transport and Land Use

Transport and land use have co-evolved in New Zealand urban areas; we are now a private vehicle-dependent nation with a high level of per capita energy use for transport (Newman et al. 2005) and a relatively low level of public transport use. Our cities, particularly the more rapidly growing major ones of Auckland, Hamilton and Tauranga, have become much more dispersed in recent decades and now generate comparatively high levels of CO_2 emissions. In the face of a pressing need to reduce emissions, initial adjustment will tend to occur at the margin first: for instance the disadvantages of building further low-density suburbs on the urban periphery are now clear, and the parallel advantages of transit-oriented development are also evident (McIndoe et al. 2005). The Auckland and Christchurch growth strategies, for example, are both based on growth at nodes rather than indiscriminate expansion, but these strategies will have to become firmer if further sprawl is to be avoided (Auckland Regional Growth Forum 1999, Newman et al. 2005, Arbury 2005, Greater Christchurch Urban Development Strategy 2005). Peri-urban areas such as Franklin (south Auckland) will have to regulate against expansion, or very clear price signals will have to raise the price of fossil fuels sufficiently that peripheral expansion simply becomes economically infeasible. Investment in motorway extensions, which have validated and encouraged further sprawl in the past, will be able to be redirected.

At the institutional level, these changes will also have important implications. Low (2003:16) writes, in the Australian context, that "the road construction authorities need to reconstitute themselves as roads management agencies whose primary task is the efficient and sustainable functioning of the urban transport system as a whole." We are already seeing the gradual repositioning of Land Transport New Zealand as an agency with a brief that is wider than roads, and more focused on access, within an evolving brief that focuses much more clearly on sustainability (Wright 2006). However, it has some distance to go to appreciate the magnitude of the implications of climate change for land transport planning. But the institutional adjustment that will be necessary for roading authorities is only one example of the institutional change necessary across the board, in both public and private sectors. Low's comment, that "planning in the 21st century has a core problem: mitigation of, and adaptation of cities to global warming" (Low 2003:22), will apply to most other institutions and professions as well.

Transport, Urban Design and Health

There is increasingly strong evidence that moving to more sustainable transport patterns is likely to have significant and positive social benefits in terms of better health. Greater use of active modes, i.e. walking and cycling, and public transport, which usually involves walking at trip ends, has been shown to be associated with health benefits. Studies have shown, for example, that, after controlling for individual differences, those living in sprawling areas are more likely to walk less in their leisure time, weigh more, and have a greater prevalence of hypertension than those living in more compact places. Similarly, communities characterised by less-dense development (sprawl) are associated with more vehicle travel and less walking and biking than are more densely developed communities (Dearry 2004). Frank (2004), in a US study, found that each additional kilometre walked per day is associated with a 4.8% reduction in the odds of being obese. He also noted that there is a strong case for interventions such as traffic calming techniques that make it safer and more pleasant to walk by reducing the speed of cars, and thus reducing the convenience and utility of this sedentary form of travel. Another effective intervention would be allocating the proceeds of higher fuel taxes to improvements in pedestrian, biking, and public transportation infrastructure and services (Living Streets Aotearoa 2006).

An encouraging recent development in New Zealand is the application of health impact assessment (HIA) tools to urban design and transport planning. For example, Christchurch has carried out an HIA in relation to its proposed Urban Development Strategy (Canterbury District Health Board 2006) and concluded, among other things, that informed urban design can help reduce socio-economic inequalities, even though the regeneration process can also increase them; and that enhancing the position of the most vulnerable is an important challenge.[8] Similarly, an HIA has been carried out to address the health implications of the draft Wellington Regional Land Transport Strategy (Quigley et al 2006). These are two instances of analysis of the linkages between land use planning, transport systems and urban design, focusing on one area of social implications. They are examples of putting a sustainable development approach into practice, as required by the Local Government Act 2002.

A concern during the transitional period of decarbonisation is that poorer communities will not be readily able to make the adjustment to reduced car dependence. Better-off households are more likely to buy more eco-efficient vehicles, or be able to relocate to where transport connections are good, and walking and cycling options are more feasible, and safer. Poor communities on the suburban fringe are more likely to be locked in to transport patterns and housing which will not only become increasingly expensive as the price of carbon rises, but may continue to be damaging to their health. A social investment strategy could ease the process of adjustment for such households, for example, by provision of inexpensive and reliable public transport services to such areas, together with the provision of social housing in more central parts of urban areas, preferably close to higher density transport nodes.

ISSUES FOR FUTURE RESEARCH

We have not explored the likely *regional* impacts of mitigation (or adaptation) in this paper. Such an analysis would be both useful, to gain an idea of important differential impacts – such as urban versus rural adjustment issues – but also difficult, because of the unevenness with which economic activity is distributed across regions. To take one example, a rising price of carbon, impacting in part directly and in part through a higher price of electricity, is likely to lead to the closure at some point of the Tiwai Point aluminium smelter, with significant repercussions for employment in Southland. Whether this operation should be "ring fenced" for a period and if so, how, should be debated. Over time, the electricity resources in question may be able to be redeployed to alternative higher value uses. More generally, social implications will depend on how impacts on various sectors, including energy, tourism and transport, play out, and the adjustment potentials and patterns of such sectors.

8 Interestingly, climate change was not addressed in the Greater Christchurch HIA, presumably due to the "rapid" format chosen for the assessment.

This issue of *revenue recycling*, which arises with emissions trading assuming that at least some emission allowances are auctioned (i.e. not all emission allowances are allocated "gratis") needs to be further explored in the New Zealand context, with particular attention being given to how revenue can be used to create positive incentives for behavioural change ("carrots"), and how groups in society most vulnerable to economic adjustment might be fiscally assisted. Modelling of recycling for the case of a small carbon charge may not apply for a substantially larger carbon price, as is likely to be necessary to achieve the magnitude of emission reductions noted earlier.

Analysis of the *co-benefits* of technological and behavioural change also warrants more research. The example given above of moving to more efficient and sustainable heating systems illustrates that the co-benefits of technological or social change can offset the costs, and make the change more acceptable. Unflued gas heaters, for instance, though perceived to be cheap, may not in fact be so. In health terms, they can impose significant costs, especially for households where a member has a respiratory condition. In sheer financial terms, they are cheap to buy but costly to operate (He Kainga Oranga/ Housing and Health Research Group et al. 2005). Overall, regulation to mandate more efficient heating systems may turn out to be warranted as much for its co-benefits, as for its carbon emission reduction benefits.

CONCLUSION

If the world is to avoid devastating climate change later this century and beyond, cutting the greenhouse gas emissions of developed countries such as New Zealand by 50% to 90% by 2050 may well be necessary. This conclusion rests on various assumptions, but important ones are that it will be more realistic for New Zealand to cut its emissions radically than for poorer developing countries (with lower per capita emissions), such as China, to do so; and that the world community will conclude that it is wise to avoid exceeding CO_2e concentrations above 500 ppm. We note that at a concentration level of 500 ppm, there is still around a 1-in-3 chance of exceeding 3ºC of warming at equilibrium. That is, by any standard, a large risk for the world community to take, given that the consequences of 3ºC of warming would almost certainly be beyond "dangerous" and may be "catastrophic" (Hansen 2005, Pierrehumbert 2006). In this light, cutting emissions has huge cost-avoidance benefits (Sachs 2007).

Almost all domains of activity in our society will be affected by climate change, either via the mitigation of future damage by decarbonisation, or the direct effects of climate change and adaptation to it.[9] We have argued in this paper that stringent mitigation – cutting our greenhouse gas emissions by something between 50% and 90% by 2050

9 Some commentators, extending the logic, have concluded that we should give up efforts to mitigate, and simply focus on adaptation (Lawson 2006).

– could have major social implications, although the social impacts will depend on a number of factors, many within our control, such as the exercise of foresight.

In order to avoid devastating future climate change impacts, radical mitigation actions will have to be taken *well before* many of the worst impacts of climate change will be evident. If actions are deferred, future emission cuts and accompanying economic and social adjustment will have to be more rapid, and may move from manageable to unmanageable. In short, foresight is critical, and we are now running out of time (Pierrehumbert 2006). And even though the New Zealand economy could still continue prospering during the transition stage, the difference between a 50% cut and a 90% cut would certainly be noticed.

Whether 50% to 90% cuts are feasible in a social or political sense depends in part on how good New Zealanders turn out to be at envisaging and anticipating future climate change damage, much of which will take place in other parts of the world, and whether New Zealanders are prepared to take the broad and long view, and initiate early and meaningful changes in lifestyles and technologies. The social implications of such reductions will depend significantly on New Zealand's economic and social resilience, community engagement and empowerment in the process of decarbonisation, and whether our enterprises take advantage of the business opportunities that rapid change offers. Effective anticipation requires imagination and action in good time – a tall order, perhaps, but surely not beyond our powers.

This paper has only begun to sketch what rapid (or very rapid) decarbonisation would mean for how we will live, what kinds of energy we will use, how we will travel, and what kinds of work we will do. We expect a New Zealand to evolve over the next few decades in which there is dramatically more use made of renewable electricity, and much greater use of renewable energy more generally. For example, we envisage a sweeping reconfiguration of the New Zealand vehicle fleet to run on biofuels and on electricity. Our homes and buildings can be expected to make widespread use of photovoltaics and solar hot water, they will be better insulated and heated (pellet burners and heat pumps), will be well equipped with smart meters, and will be well on the way to being "zero-carbon". We suspect that New Zealanders will also spend less time driving in private vehicles, and more time telecommuting. More people will live in city centres or nearby, to facilitate walking and cycling; and more use will be made of smart, reliable and convenient public transport.

In all this, the biggest social challenge may well be ensuring that rapid and potentially wrenching adjustment – for some social groups and some sectors – does not increase social and economic inequalities, or create widespread resistance to change. We may well need to find innovative ways to ensure that the most vulnerable in our society are able to adjust rapidly enough, yet do not bear an undue burden of change.

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