Closing windows

Recent climate change science and implications for New Zealand policy

Our window of opportunity to stabilise greenhouse gas concentrations at low levels is closing fast, reports **DR ANDY REISINGER**. If economic recovery over the next few years is fuelled by investments in carbon-intensive infrastructure, it will slam the window firmly shut for the rest of this century and saddle future generations with escalating costs and increasing risk of catastrophic events.

Growing climate legacy

Current emissions of long-lived greenhouse gases, particularly CO_2, are creating a legacy that will last for millennia. About 20% of all CO_2 emitted into the atmosphere today will remain there for more than 1,000 years.[1] This is a key message from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, (AR4), the most authoritative assessment of climate change science up to the end of 2006. The warming effect of current CO_2 emissions on climate is essentially irreversible over many human generations, unless we actively remove CO_2 from the atmosphere. Techniques for doing this exist in theory, but their feasibility and sustainability at sufficiently large scales are currently at best speculative.[2,3,4,5,6]

Some components of the climate system, specifically the world's oceans and polar ice sheets, take a long time to respond to the heating effect of greenhouse gases, so we are already committed to some inevitable further changes. Even if greenhouse gas concentrations could be held constant at today's levels, the atmosphere would continue to warm for more than a century by about another 0.6°C, and sea level would continue to rise for a thousand years or more. [1]

Unfortunately, holding greenhouse gas concentrations constant at today's levels is entirely hypothetical, requiring an immediate, large, sustained drop in global emissions of CO_2 and other long-lived greenhouse gases. More gradual emissions reductions inevitably lead to further increases in greenhouse gas concentra-

STEPHEN HAWKING: CLIMATE CHANGE BIGGER THREAT THAN TERRORISM

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tions and associated climate change. Even the most ambitious scenario for emissions reductions assessed by the IPCC, where global CO_2 emissions peak by about 2015 and decline to almost zero by 2100, would still lead to temperature increases of about 2°C above pre-industrial levels, or about another 1.5°C above average 1980–1999 temperatures. For this amount of warming, sea level would rise inexorably for many centuries by 0.4-1.2m from thermal expansion alone, with additional contributions from melting glaciers and ice caps, possibly several metres due to loss of parts of the polar ice sheets. Greater delays in emissions reductions imply even higher greenhouse gas concentrations, greater temperature increases and long-term sea-level rise. [7]

Recent studies show some climate change impacts are also likely to be irreversible. For example, 20–30% of all species assessed so far are projected to be at increased risk of extinction once global average temperatures rise by 2–3°C above pre-industrial levels. For temperature increases above 4°C, ecosystem models project extinctions around the globe of 40–70% of species assessed. Some key ecosystems are at high risk even within the next few decades, for example coral reefs and the sea ice biome.[2,7,8,9]

Other key impacts would be effectively irreversible at least over many human generations. For example, warming of only another 1°C is expected to increase water stress for hundreds of millions of people, mainly in subtropical regions due to a combination of reduced rainfall, rising temperatures and shrinking glaciers in the Andes, Himalayas and the European alps. For temperatures above 3°C, the number of additional people affected by water stress is projected to be above one billion. Many of those impacts are projected to emerge at very low levels of warming and regional warming observed over the past three decades has already affected many natural systems on all continents and most oceans.[2] In 2009, Solomon and others [10] confirmed that sea-level rise and rainfall reductions in many already dry parts of the world would be essentially irreversible over at least the next 1,000 years even if CO_2 emissions stopped entirely after the year 2100. The magnitude of these persistent changes will crucially depend on efforts to reduce these emissions during the 21st century.

Consequently, it is now a distinct understatement to say climate change requires a "precautionary response," as this implies much greater uncertainty than there is on climate change's negative consequences. Just these climate change projections alone which we already have very high confidence in, e.g. impacts on water security and some key ecosystems, and long-term sea-level rise from thermal expansion, require urgent, sustained, global emissions reductions to keep these impacts within barely manageable limits.

More recent scientific findings only add to the urgency for these measures. This article provides an update on two areas of research with important consequences for global and national policies on climate change, and the United Nations climate change conference in Copenhagen in December 2009. These concerns are the risk of accelerated sea-level rise and increasing evidence that the timeframe we have to stabilise greenhouse gas emissions at low levels is rapidly closing.

Opening floodgates: studies

Rising sea levels are a significant risk to infrastructure worldwide. The thermal inertia of oceans and polar ice sheets implies sea level will rise inexorably for many centuries in a warmer world as the ocean water warms and expands, and land-based ice continues to melt. For this reason, projections of sea-level rise in the long term, many centuries into the future, are usually much higher than increases projected by the year 2100. The last time the Earth was a few degrees warmer than now for an extended period, about 125,000 years ago, sea levels were 4m to 6m higher, mainly from loss of polar ice.[1]

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Given the unavoidability of rising sea levels in a warming world, the critical question is only partly *how much* sea level will rise; it is also *how fast* any given rise might be: how much may occur within the next 100 years, the lifetime of a house, or over the next millennium, the lifetime of large coastal cities. Rate of change is critical as it influences the ability to respond without major social and economic

upheavals in highly developed coastal regions.

Based on current models for the highest emissions scenario, the AR4 report found sea levels would rise by up to about 59cm by the end of the 21st century, but it warned sea-level rise could exceed this rate as the projections do not include uncertainties from feedbacks between the climate system and the global carbon cycle, nor possible further acceleration of glacier flows which drain the polar ice sheets. Such acceleration has been observed in the past decade where glaciers lost their buttressing ice shelves, but it is not incorporated into current models as the understanding of relevant processes is too limited. The AR4 noted that if the enhanced ice flow from Greenland and Antarctic glaciers were to increase linearly with temperature, it would add another 10 to 20cm to sea level-rise by the end of the 21st century, but greater increases could not be ruled out if enhanced loss of polar ice accelerates non-linearly with rising temperatures.[1]

Many studies published after the AR4 have attempted to understand and quantify this potential additional contribution of polar ice sheets to sea-level rise. These studies, using a range of techniques, point to a potentially significant additional contribution from dynamic ice sheet discharge, which could increase total sea-level rise by 2100 to between about 70 and 160cm, although even 2m cannot be ruled out entirely.[11–21]

The most robust information drawn from recent studies is that the quantitative range in the AR4 report should probably be regarded as a lower bound, and no specific figure is a reliable upper bound for sea-level rise by the year 2100.[22]

Policy: uncertain sea-level rise

The relevance of these recent studies for coastal planning depends to some extent on the nature and lifetime of relevant coastal infrastructure. Lack of a robust upper bound of sea-level rise forces us to evaluate infrastructure developments for their ability to adapt to sea-level rise if and when any particular level may eventuate. Adaptation to sea-level rise may need to be adjusted as necessary over time rather than designed to cope with a specific maximum sea-level rise by a specific date. This "adaptive management" approach has been employed in planning for the Thames (UK) estuary and is beginning to be incorporated in government guidance on climate change in the UK.[23,24]

In New Zealand, technical guidance on sea-level rise for local authorities recognises the uncertainties and suggests the need to evaluate a range of scenarios and to consider the potential for adaptation to sea-level rise in excess of any default assumption.[25]. Yet local-scale decision-making processes might struggle to follow this adaptive management approach unless provided with additional central government guidance on fundamental principles and priorities that need to be applied. [26, 27]

Adaptation requirements will also depend on the risk level communities are prepared to accept. For example, building infrastructure that can be adapted to a sea-level rise of 0.5m but not to 1m or more is not necessarily "wrong" (as sea level might rise no more than 0.5m over the next century), but it is clearly risky in view of recent scientific evidence. Whether such risks are worth taking, and who should bear the related costs and benefits, cannot be answered by science. This requires a societal debate and political decisions informed by science.

For urban settlements, specific time horizons for planning and consent processes carry their own problems. They will have to deal with the continuing inexorable rise in sea level beyond 2100 in a warmer world. At some stage retreat rather than protection from the rising sea will almost certainly become the only option. But a regulatory framework with adequate technical and financial support allowing

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for widespread, consistent practical planning for "managed retreat" has yet to be developed. Without a national framework, the combination of "existing use rights" and inevitable local conflicts between public and private benefits, and the costs of protecting infrastructure or the natural character of the coast create significant challenges. [26,28] These challenges can only intensify over time as sea level continues to rise.

Sea-level rise is a challenge not only for adaptation policies but also for global climate agreements on emissions reductions. It may be technically feasible to adapt to sea-level rise of several metres for some countries over the next few centuries, but it is very unlikely to be implemented effectively given the scale of the challenge. It would also come at enormous social and environmental costs. Developing countries particularly would have neither the financial, economic or technical resources nor governance systems to deal with changes of this magnitude. [29] This means risks associated with sea-level rise of several metres can only be reduced significantly by limiting emissions of greenhouse gases and resulting long-term climate change itself.

A reason for increased concern about climate change already noted in the AR4 is the very fact we do not have a good understanding of how much sea-level rise may accelerate over the 21st century. The need to reduce emissions is not only driven by impacts we can foresee with a reasonable degree of certainty. It is made even more urgent by the need to avoid potential impacts where we have lower levels of confidence in projections but which would have catastrophic effects on human well-being and global ecosystems if realised. Recent research on sea-level rise confirms this perspective. [7,30,31]

Closing climate stabilisation windows

Recent greenhouse gas emissions trends suggest the window of opportunity to stabilise greenhouse gas concentrations at low levels and costs is closing fast. The lowest stabilisation level evaluated in the AR4 was for concentrations of 440 to 490ppm CO_2-equivalent. Limiting the increase in concentrations to such a level would require global emissions of CO_2 to peak by about 2015, decline to about 50–85% below 1990 levels by 2050, and fall further to almost zero emissions in 2100. [32] As discussed earlier, this level will still result in long-term warming of about 2°C relative to pre-industrial temperatures and have significant associated impacts, especially in the most vulnerable regions.

The AR4 also provided information on near-term emissions targets that developed and developing countries would have to achieve by 2020 to remain consistent with this stringent mitigation pathway.

Using a variety of metrics and mitigation targets with differing responsibilities for various country groups including historical responsibilities, state of development and technological capacity, the AR4 found developed countries would need to reduce their collective emissions by 25–40% below 1990 levels by 2020. They also found developing countries would need to reduce their collective emissions to substantially below business-as-usual emissions in the absence of any mitigation measures by 2020. [33].

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Recent research has confirmed the robustness of this analysis and clarified the "substantial" reduction from business-as-usual for developing countries would need to be about 10–30% by 2020. [34] Given vastly different development stages amongst developing countries, this implies even stronger emissions limitations for the most advanced developing countries and more relaxed (or no) limitations on least developed countries.

Several studies recently point out the ability to follow this global mitigation path is rapidly disappearing, as many developed countries have failed to halt their growth in emissions and developing countries have accelerated emissions growth in recent years. Reasons for these trends include increased global investment in coal-fired power generation, aspirations of middle classes in many developing countries to reach living standards of the developed world, and failure in many countries to implement a clear price on carbon emissions and/or policies to overcome market failures and social or information barriers. [32,34–39]

Potential future emissions reduction rates are mainly constrained by the lifetime of capital infrastructure, which has a turnover rate of about 1-3% yearly. Global uptake of low-carbon technology is thus expected to take many decades even if investment in such technologies is made financially attractive or the cost of such technologies falls below current carbon-intensive options. [40] This applies particularly to developed economies, unlikely to undergo major growth in new power generation but to gradually transform their existing generation. Decarbonising developed countries' economies in excess of 1–3% yearly over extended periods will be possible only if existing infrastructure is retired prematurely in favour of new low-carbon technologies, or by retro-fitting existing installations (e.g. with carbon capture and storage technology).

These options usually result in significantly higher costs. Yet delays of only a few more years in achieving

real emissions reductions will make sustained decarbonisation rates in excess of 3% yearly necessary if low concentration targets are to be attained. Such delays will only saddle future generations with escalating mitigation costs and/or increasing impacts from climate change and increasing risk of catastrophic events.

Emissions & economic trends

Although the required scale of emission reductions may appear significant, macroeconomic modelling indicates if a price on carbon were implemented globally now, stringent emissions reductions would reduce global GDP growth by less than 0.12 percentage points yearly on average until 2050.[32] But costs for specific countries, sectors and over more limited time periods could deviate significantly from this long-term global average. So concerns about uneven or unfair distribution of costs in different parts of society continue to make it difficult to implement effective policies to achieve a globally optimal outcome at lowest cost.

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The current global economic crisis is likely to put a short-term dent in the relentless rise of global emissions. From 1970 to 2004, overall CO_2-equivalent emissions increased by about 70% and CO_2 by about 80%. Under various business-as-usual scenarios, global CO_2-equivalent emissions are projected to grow by another 25–90% until 2030 relative to the year 2000.[32] If policy packages to stimulate ailing economies focus on traditional carbon-intensive infrastructure projects, the longer-term effect of economic recovery is likely to see rapid growth in global emissions as national economies recover, and increased carbon-intensive infrastructure would be locked into place for many more decades.

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Fortunately, recent analysis[41] gives some hope. Stimulus packages of the G20 nations have devoted significant parts of new and redirected funds to green investments. Of roughly US$2,160 billion in economic stimulus packages unveiled so far, analysis by Edenhofer and Stern suggests about US$400 billion are directed at areas to reduce greenhouse gas emissions. These include, for example, investments in energy efficiency in buildings, renewables and associated upgrades to networks, transport systems, and water and waste management. These investments are expected to capitalise on reduced labour costs and provide training and employment opportunities, while also reducing direct immediate and longer-term costs due to reduced greenhouse gas emissions and energy demand combined with increased energy security.

Edenhofer and Stern say: "providing a stimulus to the economy and protecting the climate do not stand in opposition to each other. Ensuring national recovery programmes are 'green' makes sense not only because climate change poses a far more serious threat to the global economy in the long term than do temporary economic downturns. It makes sense because otherwise, once the world economy recovers, sharply increasing energy prices are likely at some stage to trigger slowdowns. Without transition to a low-carbon global energy system, the next economic crisis is pre-programmed. 'Green;' recovery programmes are not only an option for sound, effective crisis relief; they are a precondition."

The key challenge for public policy is to establish a more sustainable platform for economic recovery, and to ensure the hunt for short-term economic returns does not saddle the next generation with escalating risks arising from climate change and "toxic assets" from carbon-intensive industries. Making the structural adjustments in national economies required for significant, sustained greenhouse gas emissions reductions was never going to be easy. The current economic crisis could prove to be a blessing in dis-

guise if governments use the opportunity to guide the transition to a carbon-constrained world, and avoid creating yet another bubble that will again be pierced when yesterday's "business-as-usual" expectations begin to clash with fundamental external constraints.

New Zealand in the international scene

Briefly, how does New Zealand's domestic approach compare with broad international trends and recent insights? Notably, most of the fiscal stimulus in New Zealand consists of tax cuts. Almost all other OECD countries seem to inject a much higher fraction of their stimulus in response to the economic crisis through direct government investments. This includes significant "green" packages aiming to deliver both employment and transformation of energy demand and supply systems.[41–43] Where additional direct investments are planned in New Zealand, there is little evidence the government is concerned with the potential lock-in effect of investment in traditional infrastructure projects like roading or thermal power generation, which commit New Zealand to further increases in greenhouse gas emissions as the economy recovers. New Zealand is also beginning to mount a case internationally claiming its projected growth in greenhouse gas emissions should be seen as a reason to also give it lighter future targets.[44] If this gamble fails, the hoped-for economic payback from tax-cut driven spending priorities and carbon-intensive infrastructure investments could quickly turn into a liability.

Opportunities for direct government investment abound that could deliver employment benefits and also develop expertise contributing to transformation of our energy and transport supply and demand patterns. Relevant energy policies include training, employment and regulatory and financial support for small-scale renewables such as solar hot-water heating and enhanced housing insulation. They also include feed-in tariffs for renewables like solar photo-voltaics, and regulatory support for net metering. Investments in either public or private transport infrastructure can deliver short-term employment opportunities, but they create vastly different social, environmental and economic legacies through their associated carbon footprints, energy demands, social access to mobility and health co-benefits or trade-offs.

Potential benefits of these "green" stimulus measures suggest a clear need for government agencies to analyse options for aligning economic recovery measures (tax cuts and direct government investments) with New Zealand's strategic energy and transport goals. It's also clear that private sector capital investments stimulated by tax cuts can contribute to long-term climate goals only if there is sufficient certainty about the price of carbon in the New Zealand economy. Urgent clarification and implementation of the New Zealand Emissions Trading System is an essential pre-condition, rather than a barrier, for sustainable future economic growth. PE

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Security a major climate change issue in the Pacific

04/06/09, UN RADIO – With glaciers melting and oceans rising, the UN is urging all its agencies to consider how climate change will affect the world's security. A resolution adopted by the General Assembly on June 3, calls on the UN system to step up efforts to address the challenge. Ambassador Marlene Moses of Nauru-representing the Pacific Small Island Developing States (PSIDS) introduced the resolution. "We stand here at a historic moment. This is both the first resolution for the PSIDS and the first General Assembly resolution on the security implications of climate change."

Pacific Island states are already grappling with the effects of climate change. The Marshall Islands stand only two metres-or just over six feet-above sea level. Marshall Islands, UN Ambassador Philip Muller Phillip said: "We cannot move our people to higher ground, for there is no mountain." Over 60 countries cosponsored the resolution, including members of the Caribbean Community who also have an acute awareness of the reality of climate change. With over 17,000 islands, Indonesia is the world's largest archipelagic nation. The country's ambassador encouraged the furthering of knowledge on how climate change compromises global security. The Pacific Island states range from Papua New Guinea, the second largest island on earth, to smaller reef islands and atolls. Ambassador Moses pointed out her country, Nauru, is the world's smallest island nation.

> "As the rest of the world continues to debate the security implications of climate change, for our peoples the problem is astoundingly real. While some countries may have resources to mitigate and transfer their people to safety during times of natural disaster, we do not have this luxury. Our citizens literally have nowhere to run. Never before has a UN member state disappeared. Now we are faced with the threat of losing many due to the adverse effects of climate change." ■PE