

Garnaut Climate Change Review – Update 2011

Update Paper one:

Weighing the cost and benefits of climate change action

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THE DECISION-MAKING FRAMEWORK FOR ACTION ON CLIMATE CHANGE

Key points

- The 2008 Garnaut Climate Change Review argued that it is neither rational nor helpful for someone to reject a policy recommendation because they do not like it.
 - For discussion of policy to be productive, it is necessary for debate to focus on the validity of the premises, logic and information that led to a recommendation.
 - The transparency of the Review's decision-making framework, premises and sources of information was designed to encourage rational criticism or acceptance of its conclusions.
- There have been few general criticisms of the Review's decision-making framework. It has survived the public discussion as a robust, logical and ethical framework within which to consider the diabolical policy problem of climate change.
 - However, there have been some criticisms of specific choices made within the decision-making framework.
- Five issues that have been the subject of criticism are addressed in this Update Paper: the Review's choice of discount rates; the treatment of uncertainty; the contributions to mitigation from low-income developing countries; determining Australia's proportionate effort as part of global mitigation; and the optimal balance between efforts on climate change mitigation and on climate change adaptation.
- The Update Paper finds that:
 - the Review's choice of discount rate was sound and that the Australian case for climate change action is not affected by reasonable variations in the approach to choosing a discount rate;
 - the presence of uncertainty in the range of possible climate outcomes strengthens the case for climate change action;
 - the Review's approach to the treatment of developing countries as part of a global response remains a robust and ethical basis for a long-term solution;
 - the case for substantial and well-designed Australian action to encourage international agreement on climate responses remains compelling; and
 - while the current and prospective realities of damage from climate change warrant effective efforts on adaptation, this does not weaken the case for strong focus on mitigation.

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Earlier versions of many points in this paper were presented in the Australian Academy of Social Sciences' 2010 Cunningham Lecture. I thank Fellows of the Academy for comments that have helped the preparation of this paper.

Weighing the costs and benefits of climate change action

Climate change is a diabolical policy problem.... It is uncertain in its form and extent, rather than drawn in clear lines. It is insidious rather than (as yet) directly confrontational. It is long term rather than immediate, in both its impact and its remedies. Any effective remedies lie well beyond any act of national will, requiring international cooperation of unprecedented dimension and complexity. While an effective response to the challenge would play out over many decades, it must take shape and be put in place over the next few years... (Garnaut Climate Change Review 2008, pxviii)

One element of this foundational statement in the original Review has been overtaken by the passing of time. Extreme climatic events have become immediately more intense. The later update of the science will explore their connection to climate change.

1. Introduction

1.1. Objectives of the update

In November 2010, I was commissioned by the Australian Government to provide an update of the 2008 Garnaut Climate Change Review (the Review) (see Appendix 1 for the Terms of Reference). Separately, I was appointed as an independent expert adviser to the Multi-Party Climate Change Committee.

This is the first of eight update papers that will focus on new developments and consider whether the case for the conclusions drawn in 2008 has been strengthened or weakened. Individual papers will examine progress on: international mitigation efforts; global emissions trends; the climate science; opportunities for abatement in the land sector and biosequestration; proposals for reducing emissions, including different carbon price instruments; technology developments and innovation policy; and the electricity sector.

This first update paper discusses the decision-making framework of the Review and implicit and explicit criticisms of it since it was presented to the Prime Minister, State Premiers and Territory Chief Ministers on 30 September 2008. This paper focuses especially on five issues: the choice of discount rate (the valuation of the welfare of people living now relative to people living in future); the presence of uncertainty; the interaction between climate change, its mitigation and the growth of incomes and economic welfare in developing countries; what is an appropriate and proportionate Australian contribution to various levels of international mitigation effort; and the optimal balance between efforts on climate change mitigation and on climate change adaptation.

1.2. Findings of the 2008 Garnaut Climate Change Review

At the heart of the Review lay a central question:

What extent of global mitigation, with Australia playing its proportionate part, provides the greatest excess of gains from reduced risks of climate change over costs of mitigation?

This question was asked from the perspective of the Australian national interest. Previous studies had addressed this question for the world as a whole, which turns out to be simpler than analysing the case for mitigation from the point of view of an individual country.

In order to answer this central question, a framework was developed to consider whether the costs of policies designed to mitigate the effects of climate change—to reduce greenhouse-gas emissions—exceeded the benefits of mitigation. Various market and non-market benefits of mitigation were identified for the current century and beyond. Market and non-market benefits of climate change mitigation arise from avoiding the costs associated with climate change itself. Within the framework, detailed economic modelling of market costs and benefits embodying the wisdom of the science was undertaken by the Review team and the Australian Treasury.

The modelling considered only market benefits, focused only on 'most-likely' outcomes of climate change and only on impacts this century. It also presumed that Australia would play no more and no less than its proportionate part in an effective global effort to reduce greenhouse-gas emissions. A set

of principles was defined to allocate the mitigation burden across countries and to calculate Australia's proportionate part in an effective international effort.

The modelling showed that economic welfare was higher at the end of the century with mitigation than without. The net present value of the market benefits of “average” outcomes this century fell just short of the net present value of the costs of mitigation policy. However, when non-market benefits plus the insurance value of avoiding unexpectedly severe outcomes, plus the avoidance of climate change costs beyond the twenty-first century were taken into account, the case for effective global action with Australia playing its proportionate part became compelling.

The Review concluded that Australia has a greater interest in a strong mitigation outcome than any other developed country. It expressed the view that it was in Australia's national interest for effective global mitigation, with Australia playing its proportionate part, to stabilise global greenhouse gas concentrations at 450 parts per million (ppm) carbon-dioxide equivalent (CO₂-e) or less. It was therefore consistent with the Review's judgement of the national interest when the Copenhagen Accord, which emerged from the December 2009 Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), for the first time included an objective of holding the increase in global temperature to below 2°C above pre-industrial levels (roughly corresponding to 450 ppm). This was formally accepted as a goal of the United Nations at Cancun in December 2010.

1.3. The update papers

The Garnaut Climate Change Review Update – 2011 (the Update) builds on the analysis undertaken for the Review, focusing on developments since its release. It considers whether the case for the overall conclusions drawn in 2008 has been strengthened or weakened by knowledge that has become available since that time.

Reflecting the Update's Terms of Reference, a series of papers, of which this is the first, will be released this month and next, addressing:

- the decision-making framework;
- the international mitigation progress;
- global emissions trends;
- biosequestration and the land sector, including reducing emissions through new approaches to management in agriculture and forestry;
- climate change science;
- reducing Australia's emissions, pricing carbon and assisting people affected by new policies;
- the role of innovation in reducing emissions; and
- the transformation of the Australian electricity sector.

Each paper considers how new information and knowledge has affected the key findings of 2008. Some of the Update's early thinking on the seven papers to follow is provided below.

Paper two: Progress towards effective global action on climate change

The Review was undertaken during the implementation of the UNFCCC's Kyoto Protocol agreed in 1997, and the timing of its work straddled the 2007 UN meeting in Bali. It was followed in December 2009 by the UN meeting in Copenhagen and the December 2010 meeting in Cancun.

The Kyoto meeting developed, and the Bali and Copenhagen conferences were meant to extend, an international agreement, under which countries accounting for a high proportion of emissions entered binding commitments to reduce them, with the objective of avoiding dangerous climate change. The Kyoto and Bali meetings were built on premises formed in the 1990s. The countries of the world shared “common but differentiated responsibility” to reduce the risks of dangerous climate change. Because

the developed countries were the source of the urgency of the global warming problem and had much higher per capita emissions, and were in the better position economically and technologically to make larger reductions in emissions, they should take the first large steps to reduce emissions. They alone in the first instance should enter binding commitments to reduce emissions. Moreover, there seemed to be time for developed countries to act first on mitigation and for developing countries to follow once a path to low-carbon growth had been established. Developing countries should take voluntary steps to reduce emissions, but with costs offset by financing from developed countries, through support for transfers of rights to use low-emissions technologies, and financial transfers linked to reductions in emissions.

There would also be financial transfers from developed to developing countries towards managing adaptation to the inevitable effects of climate change. Over time, there would be agreement to some level of mitigation that was calibrated to avoid dangerous climate change, and to a comprehensive set of emissions targets that would meet that objective. The firm allocation of emissions entitlements among countries would form a basis for international trade in entitlements. In the meantime, there would be opportunities for trade amongst developed countries with binding targets, and for purchasing credits for reducing emissions in specified projects in developing countries.

In the event, the Copenhagen meeting did not deliver unambiguous progress towards a binding international agreement. It did, however, deliver elements of a substantial non-binding agreement embodied in the Copenhagen Accord: on a target to limit temperature increase to no more than 2°C above pre-industrial levels; on developed and major developing countries specifying amounts by which they would voluntarily reduce emissions absolutely (developed countries) or below business as usual (developing); and on support from developed to developing countries to reduce emissions from land-use change and forestry, to apply low-emissions technologies, and to adapt to climate change.

The international approach to mitigation changed between Bali in 2007 and Copenhagen in 2009. There has been further development of the Copenhagen approach at the Cancun meeting in December 2010, including on the international monitoring, verification and reporting of emissions.

The Review in 2008 proposed a graduated approach to setting national commitments to mitigation. All developed and high-income countries, and China, would be subject to binding commitments to limit emissions. Middle-income countries would take on one-sided targets below business as usual and the poorest, least developed countries would be involved in the mitigation effort through offset mechanisms and international sectoral agreements where applicable.

The Update will review the implications of the change in the international mitigation regime that occurred in Copenhagen and Cancun, for the world as a whole and for Australian policy.

Paper three: Global emissions trends

The Review developed new projections of likely business as usual emissions growth from the large developing countries, embodying more realistic expectations of economic growth, energy intensity of economic output and emissions intensity of energy than had hitherto been applied by the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA) and other international organisations. It moved international expectations of business as usual emissions growth onto a higher plane.

The Update re-examines likely trends to 2030 in all the variables affecting emissions in the absence of effective mitigation: population, economic output, energy demand, and the economic and technological factors affecting the choice among sources of energy. It explores the implications of the Great Crash of 2008, which lowered the long-term growth trajectory of developed countries, but not the powerful twenty-first century growth momentum of the largest and many other developing countries.

Paper four: Transforming rural land use

The Review identified a range of biosequestration and emissions-reduction options with considerable abatement potential. These had the potential to transform the outlook for Australian reductions in emissions, and also the economic prospects for rural Australia. However, these prospects were surrounded by technical and economic uncertainties, and their realisation would require developments in measurement and monitoring emissions.

A number of studies have assessed these options in further detail since the release of the Review. For example, in 2009 the Commonwealth Scientific and Industrial Research Organisation conducted a detailed assessment of land-sector mitigation potential in Queensland.

The Update draws on new knowledge on biosequestration and emissions-reduction opportunities and on technical developments related to the incorporation of these opportunities into a national and international mitigation regime.

Paper five: The science of climate change

The Review accepted, “on the balance of probabilities”, that the majority opinion of the Australian and international science communities is right, and therefore that: the world has warmed since the mid-twentieth century; a significant part of this warming is attributable to human activity; and global warming will be dangerous to human society if there is no policy intervention to change the growth trajectory of greenhouse-gas emissions. It acknowledged that the majority opinion remains contested by a small number of dissenters with relevant science credentials and by many without those credentials. The Update explores new observations of changes in the climate system, including temperature, sea level and ice sheets. It reviews developments in the science and in the debate about the veracity of the science, and assesses the effects of new knowledge on the certainty with which views on the effects of climate change are held. It takes another look, in light of new knowledge, at some of the impacts on Australia explored in Chapter 6 of the Review, including the anticipated effects of climate change on water resources and sea-level rise.

The latest IEA World Energy Outlook concluded that “the modest nature of the pledges to cut greenhouse-gas emissions under the Copenhagen Accord has undoubtedly made it less likely that the 2°C goal will actually be achieved” (IEA 2010). The modest commitments for action before 2020 may also mean that achieving the 2°C goal will be more expensive and require dramatic cuts after 2020. The IEA suggests that the continued modest reduction in commitments after 2020 would put the world on a lower emissions trajectory, but still one that would lead to stabilisation of concentrations at over 650ppm CO₂-e, or to a mean expectation of warming of more than 3.5°C in the long term. The Update assesses these conclusions and considers their implications.

Paper six: Carbon pricing and reducing Australia’s emissions

The Review examined various approaches to reducing emissions. It concluded that a market-based approach, with economy-wide pricing of greenhouse gas emissions applied through an emissions trading scheme (ETS) or a carbon tax, would be cheaper than regulatory approaches to reductions in emissions. It expressed the view that for Australia, a clean ETS, embodying economy-wide carbon pricing through an emissions trading scheme (ETS) with linkages to overseas carbon markets, would be the most cost-effective market-based approach to carbon pricing. An efficient transition to a low-carbon economy would require the price on carbon would need to be supported by public fiscal support for research, development and commercialisation of low-emissions technologies, funded out of the revenue generated by the sale of emissions permits. The Review suggested that the ETS and support for research, development and commercialisation of new technologies should be complemented by a small number of targeted policies, including assistance to low-income households and transitional support for some emissions-intensive and trade-exposed industries.

The Review’s preference for an ETS depended on the availability of substantial opportunities for legitimate trade in emissions entitlements, which itself depended on an effective international agreement. The Review recommended that, in the absence of such an agreement, an ETS should be legislated and its institutional arrangements established, but that it should operate with a fixed, rather than floating, emissions permit price.

The change in the global mitigation regime at and around Copenhagen and Cancun has reduced the prospects of early movement to a binding international mitigation agreement. The Update considers the best approach to reducing Australia’s emissions in this messy world, while also preparing for the longer-term transition to stronger international action that must occur if we are to manage the risk of dangerous climate change.

The Update reflects on different mitigation policy approaches and carbon-pricing regimes. It considers the implications of Australia’s current fiscal position on the use of carbon-pricing revenue, and

discusses the various potential uses of revenue, including support for technology innovation. It examines the rationale for and approaches to providing assistance to trade-exposed industries, electricity generators and households to manage the effects of mitigation policies, and to reduce the national costs of transition. This paper sets out what a fair and efficient mitigation package might look like for Australia in the current, post-Cancun world.

Paper seven: Low emissions technology and the innovation challenge

New technologies will play a significant role in the global response to climate change.

The Review's analysis of the costs of mitigation embodied detailed judgements about the costs of deploying low-emissions technologies and about how these might change over time. The Update examines the recent developments and trends in cost reductions for low-emissions technologies, particularly in the energy generation and transport sectors. In addition, it carefully considers the factors that are causing changes in costs and technological improvements and, where evidence is available, indicates the contributions of various government policies. It examines both Australian and international developments, recognising that technological developments in one country affect the cost of deploying emissions-reducing technologies in another. Developments in China and the United States receive special attention.

A carbon-pricing mechanism helps to create the economic environment and incentives for households, businesses and governments to reduce their emissions. Technological innovation makes the transition faster, less disruptive and less costly for all involved. Innovation policy is required to remove the market failure associated with the benefits that one person or firm confers on others by investing in innovation.

The Update looks again at the Review's recommendations on support for research, development and commercialisation of new, low-emissions technologies. This paper highlights the implications of the current rate of technological progress for the cost of mitigation in Australia, and suggests how transitional costs could be reduced through innovation policy.

Paper eight: Transforming the electricity sector

The Review noted the likelihood that Australian electricity generation costs would rise rapidly even in the absence of policy to reduce greenhouse-gas emissions. Requirements for new investment in the sector, the increase in capital costs associated with the resources boom, the large increases in coal prices on international markets (which would flow through to prices for coal used in domestic power generation), and the emergence of an East Coast gas export industry (which would raise domestic gas prices towards export parity) were all factors. This expectation has been borne out, and exacerbated by extraordinary increases in costs of electricity transmission. It can be expected that prices will continue to rise independently of a carbon price, and that while a carbon price would push them higher, its effects would be smaller than other sources of upward pressure on electricity prices. Regulatory measures that have been presented as instruments of emissions reduction that are already in place add to the pressures on generation costs. Recent developments show that increases in the costs of transmission and distribution of power have been even more important than increases in generation costs, and raise questions about the policy regimes within which they are occurring.

Much work has taken place since 2008 to prepare the National Electricity Market for the transition that will be required in the coming decades. In particular, the establishment of the Australian Energy Market Operator and analytical work on Scale Efficient Network Extensions and the 2010 National Transmission Network Development Plan address some of the concerns raised in the Review. The Update considers whether current market governance and frameworks are sufficient to encourage the most efficient long-term planning and investment in electricity infrastructure.

In addition, the Update considers the various additional measures that have been adopted to reduce the emissions intensity of Australian generation. It assesses whether there is a case for policies to drive structural adjustment to climate change in the electricity sector beyond an economy wide carbon price and general support for innovation in low-emissions technologies.

Reducing Australia’s emissions—such as through a carbon price—imposes costs. These costs flow through to businesses, industries, households and communities, particularly through higher electricity prices. The Update examines the distributional impacts of a carbon price, particularly on low-income people, and suggests cost-effective means of reducing regressive distributional effects.

2. The decision-making framework revisited

The Review noted that it is neither rational nor helpful for someone to reject a recommendation because he or she does not like it. Sound public discussion and, in the end, sound policy require a critic of a conclusion to identify a premise, a set of information or an element of methodology that is erroneous. The Review sought to be clear in its premises, information and methodology. The transparency of the Review’s decision-making framework, premises and sources of information was meant to illicit rational criticism (see Garnaut [2008, pxxii]), or acceptance of its conclusions.

There have been few general criticisms of the decision-making framework outlined in the Review. The framework has survived the public discussion as a robust, logical and ethical framework within which to consider the diabolical policy problem of climate change.

However, there have been some explicit and implicit criticisms of specific choices made within the decision-making framework, and many criticisms of conclusions that imply a difference in view on how some part of the decision-making framework is applied. The tendency for criticism to focus on conclusions rather than the logic and information that led to them is partly the result of the decision-making framework having been subject to little discussion in the broader climate change debate in Australia.

The Update provides an opportunity for further discussion and extension of understanding of the Review’s decision-making framework, and to analyse explicit or implied criticisms.

Five issues that have been the subject of explicit or implicit criticisms are addressed in this Update Paper: the Review’s choice of discount rates; the treatment of uncertainty about the impact of climate change; whether contributions to mitigation from low-income developing countries can be justified, given the high value to them of growth in incomes; the appropriate extent of Australia’s mitigation in the light of international progress on mitigation; and the balance between efforts on climate change mitigation and climate change adaptation. But let us first focus on the decision-making framework.

2.1 Comparing the costs and benefits of mitigation: the decision-making framework

Would the substantial costs of climate change mitigation exceed the benefits? A contribution towards the answer to this question was made through the Review’s cooperation with the Australian Treasury on modelling the costs of mitigation, in addition to the Review’s own modelling of benefits.

The benefits of mitigation are the avoided impacts of climate change on the community, businesses and the broader economy.

While some of the costs of mitigation come through conventional economic channels, such as reduced economic output as a result of introducing a carbon price, and are amenable to economic modelling, many of the benefits are not so easily measured. The benefits can be difficult to observe and some only accrue far into the future. The Review developed a framework to ensure that all benefits (and costs) were considered and explicitly accounted for in an assessment of costs and benefits.

2.2 The four types of benefits of climate change mitigation

The Review identified four distinct types of benefits of mitigation. Only the first of these benefits and, even for this type of benefit, only effects in the current century are readily amenable to standard quantitative analysis.

Type 1: Currently-measurable market benefits

Type 1 benefits of mitigation are the avoided market impacts of climate change that can be measured and modelled. They are represented as impacts on consumption, incomes and economic output.

The impacts of climate change on infrastructure represent significant Type 1 costs. Impacts on infrastructure, including commercial and residential buildings, water supply, electricity infrastructure and ports, accounted for around 40 per cent of total Type 1 gross national product (GNP)¹ costs.

Around 20 per cent of Type 1 costs arise from direct climate change impacts on agriculture.

Climate change is likely to affect economic activity in other countries. It therefore affects the supply of imports to Australia and the demand for Australian exports and, consequently, Australia's terms of trade (the ratio of Australian export to import prices) (Garnaut 2008, Chapter 6). At the global level, the Review's modelling indicated that unmitigated climate change would probably cause global economic output to fall by around 8 per cent by the end of the twenty-first century, with losses likely to be higher in developing countries than in developed countries. This is important for Australia because developing countries are currently expected to be, even more overwhelmingly, our major trading partners in 2100 than they are in 2011.

This introduces a high risk of slower growth in the mining sector. For example, coal demand is significantly lower because of the fall in global economic growth due to climate change. By 2100, around 40 per cent of the Type 1 costs of climate change to Australia's GNP arise from the negative effect on our terms of trade.

Climate change also dampens demand for labour, causing real wages to be lower, with the fall in wages greater than the fall in output. The modelling in 2008 found that the Type 1 costs of climate change rise over time and cause real gross domestic product (GDP) to be lower by around 6 per cent by the end of the century. Real wages are lower by around 12 per cent.

Type 2: Market benefits not-readily-measurable

Type 2 benefits are similar in nature to Type 1 benefits. They comprise the benefits of mitigation experienced through markets; however, there is currently insufficient information to incorporate these effects precisely into economic models. As a result, the Review relied on judgements to quantify these benefits. Assessments were made about the likely magnitudes of Type 2 benefits relative to Type 1 benefits, and the modelled results of expected Type 1 benefits were adjusted proportionately.

Type 2 benefits were estimated at about 30 percent of the size of Type 1 GNP benefits. They include: impacts such as additional increases in the cost of building construction because of new design requirements; road and bridge maintenance; and impacts on international tourism.

The Review was less than comprehensive in its identification of Type 2 benefits. In agriculture, for example, no attempt was made to take into account the costs of a more variable climate that will accompany climate change. Type 1 benefits were large for agriculture. These were calculated from analysis of the median of the probability distributions of the impacts on agriculture. There was no separate consideration of the effects of greater climate variability on agriculture; these would be Type 2 effects.

Type 3: Insurance value of mitigation

Type 3 benefits are the value of avoiding the risks and uncertainty around the average expectations of climate change. There is some chance that some impacts may be much more severe than the average expectations – possibly extending to the catastrophic. These are balanced by the chance that outcomes will be less damaging than the average expectations.

Climate change is characterised by a complex chain of events, the links between which are impossible to define precisely. Through the use of powerful models, scientists have been able to specify the outcomes that are most likely to occur, and to provide some indication of the probability distribution of

¹ GNP is a measure of the value of goods and services produced in the economy, adjusted for international transfers of income

outcomes around the values that are judged to be 'average'. Sometimes there is considerable confidence in the probability of outcomes—a type of uncertainty that economists call 'risk'. Sometimes the probability distribution is the result of expert judgement but, even in the minds of the best-informed scientists, is highly uncertain. The latter subjective probability distributions are prone to radical change with new information. They embody what economists call 'uncertainty'. Scientists and the general public tend to use the word 'uncertainty' to describe both 'risk' and 'uncertainty'.

Climate change is characterised by a high degree of uncertainty. Moreover, uncertainty tends to expand as we look further into the future.

People facing uncertainty about outcomes that could have a large effect on their welfare tend to value those outcomes less than they would value a certain outcome with the same expected value. They are therefore prepared to pay more than the contribution of bad outcomes in reducing the average of possible outcomes to avoid the possibility of those outcomes. This explains why people and firms commonly buy insurance through private markets. An insurance motive also explains the levels of public expenditure in a number of areas, such as on defence forces: there may be little chance of war so that the 'expected' (average costs weighted by the probability of their occurrence) cost of war in the future may be small, but society is prepared to spend a large amount on the defence forces against the low probability that they will be needed.

While Type 1 and Type 2 benefits capture the impacts on conventional economic activity that we expect to avoid through climate change mitigation, Type 3 benefits capture the value of the possibility that, without mitigation, things could turn out far worse than expected. Climate change mitigation includes the insurance premium that we are prepared to pay in order to protect ourselves from these risks. The Review did not seek to quantify the insurance values associated with Type 3 benefits, and did not include them in the modelling. Rather, it sought to draw attention to their high value.

Type 4: Non-market benefits

Type 4 benefits of mitigation action are the non-market benefits that are generally excluded from conventional economic measures of output because they are difficult, if not impossible, to value.

However, to most people they are of great importance. They include environmental amenity, longevity, health (beyond its purely financial effects), the heritage value of established patterns of social and economic life, and also the welfare of non-Australians.

In March 2010, Secretary to the Australian Treasury Dr Ken Henry (2010) emphasised the value of environmental amenity:

The contribution of environmental resources to wellbeing is broad ranging. And it has both instrumental and constitutive features. In both ways, we are enriched by its existence. The environment sustains life, supports our physical and mental health and provides psychic enjoyment. Constitutively, Australia's unique biodiversity is integral to our cultural identity. Instrumentally, the environment supports the consumption of market products as an input to production. These inputs include the ecosystem services that generate soil fertility, provide protection from erosion and support tourism.

In intergenerational reporting, a discussion of the environment is especially relevant because, provided it is maintained, the environment is likely to offer greater benefits for future generations. It is very likely that improvements in our material wealth and our understanding of the environment will enhance our appreciation and enjoyment of the environment over time.

These non-market services described by Dr Henry are encapsulated by the high value Australians place on the existence of the Great Barrier and Ningaloo Reefs, games on green ovals, urban gardens, or the continuation of town and rural life in the heartland of old Australia in the Murray-Darling Basin.

To consider non-market elements is not to place intrinsic value on environmental conservation, although many would argue that we should do exactly that. It merely accepts that many Australians value such things and would be prepared to sacrifice some consumption of goods and services to retain them in the future.

Many Type 4 benefits are likely to be what economists call 'superior goods'. Superior goods are often relatively scarce and the relative value that people assign to these goods rises as incomes rise. The average incomes of Australians are expected to continue to rise through the twenty-first century – although the current high consumption associated with our spending of income from the temporarily high terms of trade, and a recent decline in productivity make this more problematic than it seemed one and two decades ago. If average incomes do continue to grow, it follows that higher value will come to be placed on the natural estate.

Climate change is expected to greatly diminish the natural estate. So despite improvements in our material wealth, future generations will not have the same access to environmental services. As a result, we cannot be sure that the wellbeing of future generations will be greater than our own. The possibility of highly adverse outcomes from climate change compounds this likelihood.

Box 1: Climate Change and the Great Barrier Reef

The Great Barrier Reef is the largest coral reef ecosystem in the world, and its reefs represent about 10 per cent of all coral reef areas globally. Almost all marine plant and animal groups are abundantly represented in the Great Barrier Reef (Great Barrier Reef Marine Park Authority [GBRMPA] 2009, p2). Climate change will affect almost all Great Barrier Reef species and habitats, and is considered the greatest long-term threat to the ecosystem (GBRMPA 2009, p172).

The average annual sea surface temperature on the Great Barrier Reef could rise by around 3°C above the present average temperature by 2100 with the extent of global mitigation that roughly corresponds to a continued modest implementation of the national pledges in the Copenhagen Accord (International Energy Association 2010). Prolonged elevated sea temperatures have caused two severe mass coral bleaching events since 1998. An atmospheric carbon dioxide concentration of 450 ppm, associated with a temperature increase of around 2°C, would place 34 per cent of coral reefs above the critical limit for bleaching. A temperature increase of around 3°C would lead to 65 per cent of coral reefs being above the critical limit for bleaching, and coral reef habitats would be expected to erode rapidly. In the absence of effective mitigation, over 99 per cent of coral reefs would be expected to be above the critical limit for bleaching (GBRMPA 2009, p96).

In addition to rising sea surface temperatures, increased ocean acidity, sea-level rise and more extreme and severe weather events will all have significant negative impacts on the Great-Barrier-Reef ecosystem (GBRMPA 2009, Chapter 5).

The non-market impacts of biodiversity decline are wide-ranging. The iconic coral reefs have natural and cultural heritage values, and are considered part of the national identity. Many marine species depend on corals for habitat. Inundation due to sea-level rise will cause changes to mangroves, which provide habitat and act as a filter system for water before it enters the reef (GBRMPA, p93).

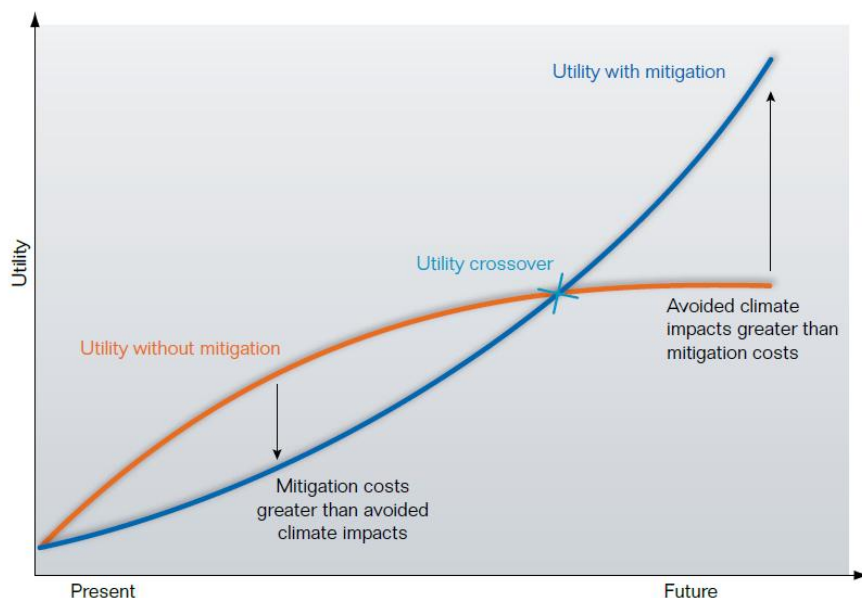
2.3 Weighing the costs and benefits of mitigation

In Figure 1 below, the costs of mitigation and the benefits of reduced climate change are brought together. The comparison of costs and benefits is framed in terms of utility, which can be thought of as wellbeing. This ensures that we consider more than just monetary benefits, acknowledging the importance on non-monetary services including the Type 4 benefits discussed above. We can think of Australian utility, that is the wellbeing of all Australians, as rising with the consumption of goods and services and also with these non-monetary services.

Expectations of the level of national utility over time in the absence of mitigation are plotted stylistically as the orange line. National utility would normally be expected to rise over time, as it probably has through all long periods of Australian history.

The blue line plots expectations of utility over time for a given level of national mitigation, which in turn is associated with a defined degree of global mitigation.

Figure 1: Utility with and without mitigation



(Figure 1.4 from Garnaut [2008, p16])

The costs of mitigation accrue early and the benefits of avoided climate change come later. The utility curve without climate change mitigation is above the utility curve with mitigation in the early years. In the early years, the benefits of no action exceed those of action. After the point in time at which the curves cross over and the orange line is below the blue line, the benefits of action exceed the costs of action.

The two curves in this instance form the shape of a fish. The body of the fish covers years in which the net current benefits of mitigation are negative. The area of the body of the fish represents the excess costs of mitigation in the years to the crossover point. The tail of the fish covers years in which the net benefits of mitigation are positive. The tail of the fish grows in depth and breadth and total area with time.

The big question for policy is whether the area of the body of the fish exceeds that of the tail of the fish.

The size of the fish's body compared with the tail

In order to judge whether the benefits of climate change action exceed the costs—whether the tail of the fish is larger than the body of the fish—the Review undertook some of the most detailed and long-dated modelling ever undertaken in Australian policy analysis.

The modelling could only include measureable benefits (Types 1 and 2) and costs and it could only calculate those until the end of the twenty-first century. Type 3 and 4 benefits, and benefits of all kinds beyond the twenty-first century, have to be assessed qualitatively and taken into account outside of the modelling.

The Review's modelling showed that, just considering Type 1 and Type 2 benefits of mitigation in this century alone, the accrued benefits were almost as large as the costs. In terms of the fish, the crossover point shows that GNP is higher with mitigation than without mitigation at the end of the twenty-first century². This is without incorporating Type 3 and Type 4 benefits. Further, Type 3 and Type 4 benefits of 550 ppm and especially 450 ppm mitigation are likely to be extremely high by the end of the century.

To see whether the tail of the fish is larger than the body of the fish, the Review needed to compare the costs and benefits in the future (when GNP is higher with mitigation) to those of the present (in which we can choose to invest in that future mitigation). Comparing current and future costs and benefits requires economists to choose a discount rate. The Review's choice is discussed further in section 3.

Overall, the Review drew the strong conclusion that there was substantial value in taking early mitigation actions consistent with stabilisation at 550 ppm and even higher value in taking early actions consistent with stabilisation at 450 ppm.

Despite the efforts to explain the limited focus of the quantitative exercise, the costs and benefits of mitigation that were expressed in numbers were treated more seriously in the public discussion than were the benefits ascribed to the insurance value and non-market effects.

2.4 An updated comparison of the costs and benefits of mitigation

One reason for setting out the four types of benefits of mitigation was to avoid the tendency to focus only on effects that can be measured more or less precisely, and to ignore the immeasurable. Early Type 1 and Type 2 benefits may be only a modest part of the potential benefits of climate change mitigation. Type 3 and Type 4 benefits this century and all benefits beyond the twenty first century, may in fact be more valuable than measurable Type 1 and Type 2 effects alone.

Changes to the factors affecting costs and benefits

Since 2008, new information has become available about many of the factors that influence the sizes of the tail and the body of the fish. Updating our view of the quantity, duration and significance of some benefits and costs of climate change mitigation is central to the Update.

The Update does not have time to rerun the modelling. Rather it considers the new evidence and assesses whether the balance of costs and benefits of mitigation is likely to have shifted one way or the other. Early assessments provide an indication of the possible changes in the size and shape of the fish. Here we provide three illustrative cases of change.

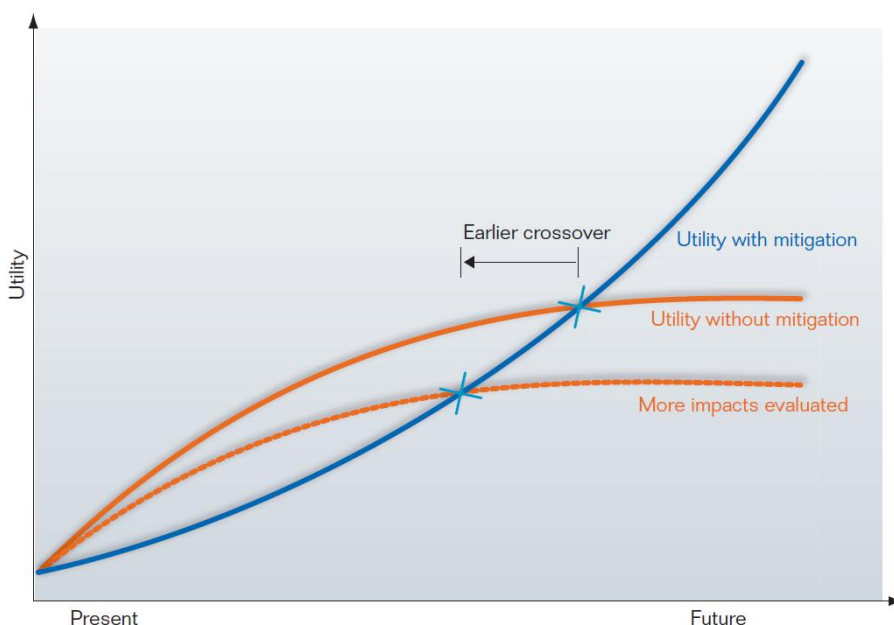
First, the scientific knowledge that has developed over the period since the Review suggests that many climate change impacts are likely to be more serious than the IPCC and other scientific sources used by the Review suggested three years ago. The avoidance of these costs would therefore offer greater benefits than projected in 2008. This has the effect of lowering the utility function under the 'without mitigation' scenario, as seen in Figure 2 below. The body of the fish becomes thinner and shorter and the tail of the fish wider and longer.

² This section has been amended (June 2011) to clarify that the Review found that: (1) GNP would become higher with mitigation in the second half of the twenty-first century; and (2) that GNP with mitigation would be higher than GNP without mitigation by the end of the century.

Second, progress towards a comprehensive global agreement—the time at which there would be opportunities to reduce costs of mitigation in Australia and in the world as a whole through large-scale international trade in emissions entitlements—has been slower than was embodied in the 2008 modelling. This suggests that the costs of any specified degree of mitigation are likely to be greater. This in turn shifts out the point at which the benefits start to outweigh the costs. In Figure 2, the mitigation curve shifts to the right. The fish’s body grows fatter and longer and the fish’s tail shorter and thinner.

Third, it seems that the costs of new low-emissions technologies have declined more quickly than was embodied in the modelling of the costs of mitigation. This is noticeable, for example, in China and the United States – which are likely to be influential in determining costs of low-emissions technologies in other countries as well. In these and other countries, innovation seems to have been accelerated partly as a result of governments’ expansionary expenditures in response to the Great Crash of 2008.

Figure 2: Utility with more climate change impacts taken into account



(Figure 1.6 from Garnaut [2008, p17])

Similarly, the process of learning by doing causes the costs of deploying new technologies to fall in at least the early stages of applications on an increased scale. For instance, there is anecdotal evidence that the switch from batch to continuing production of nuclear power stations in China has reduced the costs of new nuclear power capacity more rapidly than had been assumed in the 2008 models, or expected in China itself. The decline in the costs of important low-emissions technologies in one country lowers the costs of mitigation for the world and Australia. In Figures 1 and 2 this is represented by an upwards shift in the utility curve with mitigation. This thins and shortens the fish’s body and widens and extends the tail.

These and many other factors, including the recent outcomes of the Cancun meeting, global emissions trends (particularly in the developing world), the nature and timing of a carbon price in Australia, and a wide range of other scientific and technological developments will interact to strengthen or weaken the Review’s conclusions in 2008.

The sum of new evidence will indicate whether the conclusion of 2008 remains valid: that mitigation action consistent with stabilisation at 550 ppm has value and that action consistent with stabilisation at 450 ppm has greater value.

3. Valuing future costs and benefits: the choice of discount rate

The costs and benefits of mitigation fall on and accrue to current and future generations differently. In general, the costs of climate change mitigation come early, while the benefits come later. An overall assessment of costs and benefits therefore requires us to look at how we value the future relative to the present. How to value impacts that occur at different times has been the subject of much debate. This is the debate over the choice of discount rate.

The Review focused on this important issue in its introductory chapter. The discount rate may be considered positively, based on actual market interest rates, or normatively, based on judgements about the relative values of the welfare of present and future people (refer to Box 2 for greater detail on the distinction between positive and normative approaches). People living in the future are different to us in at least two respects. First, their preferences are not directly reflected in the decisions we take today; they rely on us to represent their interests. Second, they are likely to be richer than us in terms of the consumption of material goods and services that are available through market exchange.

3.1 A positive discount rate

The financial markets intermediate between future and current savings and expenditure: between people who want to spend (on investment or consumption) more than they earn and people who want to spend less than they earn. The financial markets take the surplus earnings of some people, and make it available to cover others' deficits. The outcome of this intermediation is reflected in various market interest rates. While moving to bring savings and investment, and consumption and savings, into balance, market interest rates embody expectations about the risk that a loan will not be repaid, and the risk that the loan will be repaid in less valuable currency as a result of inflation.

Box 2 Positive and normative approaches in economics

The distinction between positive and normative approaches in economics is an important one. The distinction reflects a broader debate concerning the ethics in economics and economic policy.

Positive economics is concerned with the observation, description and explanation of economic phenomena. It considers economics a science concerned with facts and, as such, avoids value judgments. A positive approach to an economic problem seeks to establish 'what is', rather than 'what ought to be'. With regard to discount rates, a positive discount rate may be derived from observations of actual discount rates determined in real-world markets.

Normative economics is concerned with making value judgements about economic issues including, for instance, the proper objectives of public policy. A normative approach to an economic problem seeks to establish 'what ought to be', rather than 'what is'. With regard to discount rates, a normative discount rate is derived from judgements about how to value the wellbeing of future generations compared with the well being of today's generation.

Can we say that the choice of discount rate should merely reflect the decisions on savings and borrowing that people actually take in the real world? If we could, we would be treating the setting of the discount rate as a positive matter, and the policy task would be to find the appropriate market rate.

The Review concluded that the appropriate market interest rate in Australia would be the long-term interest on government debt, after adjusting for expectations of inflation.

3.2 A normative discount rate

The alternative to a positive approach to determining the discount rate is to consider whether, and how much, the welfare of people living in the future should be devalued relative to those living today when

making decisions that affect the welfare of future generations as well as our own. This is treating the discount rate as a normative matter.

The Review expressed the view that the discount rate should be determined using a normative approach for the purpose of climate change policy. However, it calculated Type 1 and Type 2 benefits and the costs of mitigation to the end of this century (the temporal limit of the reliability of the quantitative models) using both normative and positive discount rates. It happens that, in Australia's case, the appropriate positive interest rate fell within the range of appropriate normative interest rates.

Determining the appropriate normative discount rate involves two decisions (refer to Box 3 for a more detailed explanation of discount rates). The first is a decision about whether we value the welfare of people living in the future as highly as the welfare of people living today. The Review answered "yes". This first decision determines what is known as the rate of pure time preference

Few older Australians would be willing to discount heavily the welfare of their grandchildren's generation relative to that of their own. Our grandchildren can be expected to have a similar view of the welfare of their own grandchildren's generation. This points to the logical implication that society should be regarded as caring about the welfare of humans for generations without limit into the future.³

The Review considered that the only justification for a non-zero rate of pure time preference (that is, valuing the wellbeing of those in the future less than our own) is the risk of future human extinction in any one year from something other than climate change. The probability of extinction is not high in any year and perhaps not in any century, but it is above zero. Therefore, the Review used a very low rate of pure time preference of one twentieth of one per cent.

The second decision is how much to discount the wellbeing of future generations because they are likely to be richer than us in material terms. There is considerable disagreement here.

The Review accommodated strongly diverging views on how much should be spent now to benefit future, presumably richer generations. It did so by choosing two different discount rates. The first, lower discount rate valued one per cent of income today the same as one per cent of (higher) income in the future. This could be considered the lower bound of reasonable outcomes (Garnaut 2008, Chapter 1).

The upper bound, and a more radically egalitarian choice, valued one per cent of income today as much as two per cent of (higher) income in future. This upper bound to the discount rate implies a willingness to redistribute to current from future generations that is well in excess of the extent to which our current income tax system taxes the rich proportionately more than the poor.

This second decision refers to a concept known by economists as the 'elasticity of marginal utility with respect to consumption' (the elasticity of utility). Quiggin (2008) provides a useful example to illustrate what the elasticity of utility means in practice.

If the world's average annual per-capita income is currently around US\$7,000, based on the projections used in the Stern Review, this will reach about \$100,000 in 2100. (Here we are talking about the average for the world as a whole, including many people in developing countries where average incomes are currently very low and likely to grow rapidly through the current century). A value of 1 for

³ Many of the philosopher kings of economics, from Ramsey (1928) to Sen (1961), have argued for a pure rate of time preference that is close to zero, thus placing no discount on the utility of people in the future just because today these people are young or not yet born. As DeLong (2006) points out, a rate of pure time preference of 3 per cent means that somebody born in 1995 "counts for twice as much as someone born in 2020". This flies in the face of the utilitarian principle underlying most economic analyses: that equal weight should be placed on each person. Most people would think it flies in the face of common sense to value different generations unequally. By contrast, some economists, including Nordhaus, a pioneer of economic modelling of climate change, use a pure rate of time preference of 1.5 per cent or higher, calibrated to yield an overall discount rate that matches the real rate of return on capital. Nordhaus does not make an explicit 'ethical' argument to counter Ramsey and Sen's proposition that all generations should be valued equally. Rather, he argues that calculating the net costs and benefits of climate change policies must use observed real interest rates, because abatement is merely one of the many things that society could invest in, and has to compete for funds with those other investment opportunities.

the elasticity of utility implies that a sacrifice of \$70 per person (1 per cent of income) today on mitigation would only be justified if it was to increase the income of our great grand children in 2100 by at least \$1,000 (1 per cent of income).

A value of 2 implies that the same sacrifice would have to result in a benefit of at least \$2,000 in 2100 to be justified. Both the increases to \$1,000 and to \$2,000, but especially the latter, are considerable hurdles by the standards that we normally apply to policy questions involving redistribution.

Quiggin (2008) states that a value of 1 is the most common choice in the literature (see also Jensen & Webster [2007]). By contrast, Dasgupta (2007) argues that an elasticity of 1 implies that the “distribution of well-being among people doesn’t matter much”, and that higher values more adequately reflect distributional concerns and observed savings rates.

Recent work by Smith (2010) finds that an elasticity even of 1 implies savings rates within the range of contemporary experience.⁴

⁴ The analysis for the Review was calibrated with percentage points of GNP or consumption. The use of a discount rate that is higher than the rate of growth of GNP causes the present value of a percentage point of current GNP to be greater than that of a percentage point of future GNP. The use of a discount rate that is lower than the rate of growth of GNP causes the present value of a percentage point of future GNP to exceed that of a percentage point of current GNP.

Using an elasticity of consumption of 1, future income is discounted at the same rate as the increase in per-capita income (plus the rate of pure time preference) while at an elasticity of 2 it is discounted at twice that rate. The two normative discount rates used by the Review were 1.35 per cent and 2.65 per cent.

The Review’s modelling pointed to the expected rate of Australian GNP growth (2.1 per cent over the remainder of the twenty-first century) falling within the middle or higher than the middle of the range of normative discount rates. It follows that near the mid-point of the normative range—near the appropriate market discount rate—the present value of a percentage point of GDP in the early twenty-second century will be similar to that of a percentage point of GDP now (See Garnaut [2008]).

Box 3: The Discount Rate

Almost all public policy problems involve costs and benefits that accrue over time. The use of a discount rate allows us to compare future costs and benefits with today's costs and benefits.

While there is general agreement about the need to use or specify a discount rate there is much less agreement about the choice of discount rate.

The Review took a normative (see Box 2) approach to specifying a discount rate.

This involved making a judgement about whether the welfare of people living in the future is valued as highly as the welfare of people living today. Put simply, do we consider those living in the future to be equal to those living today?

It also involved determining to what extent those living today should forgo consumption to benefit future, presumably richer generations. This embodied a judgement about the appropriate level of redistribution between generations, just as our existing tax and transfer system embodies a judgement about the level of redistribution that is fair between citizens living today.

A higher value for either of these elements yields a higher overall discount rate, which in turn leads us to discount future costs and benefits relatively more. With regard to climate change policy, all other things equal, a higher discount rate weakens the case for mitigation, since many of the costs of mitigation accrue today, while many of the benefits accrue in the future.

More detailed analysis on discounting in economic appraisals of climate change policy is available at www.garnautreview.org.au. The paper, *Discounting, risk and uncertainty in economic appraisals of climate change policy: comparing Nordhaus, Garnaut and Stern*, by Kathryn Smith, places the Review's approach to discounting in the context of the literature and sheds further light on claims about the relative importance of discounting and risk.

One way we can evaluate Dasgupta's argument is to consider the observed level of income redistribution that occurs in practice through income tax systems. That is, the degree to which we tax the rich proportionately more than the poor should help us evaluate how much society values equality. Research indicates that personal income tax systems, on average, in twenty developed OECD countries, imply an elasticity of utility of 1.4 (Evans 2005).

Nordhaus uses a value of 2. A parameter value of 2—the upper bound used by the Review—implies, as noted above, that we should go much further in taking the income and wealth of the rich and giving it to the poor than is the case anywhere in the contemporary world. This conclusion holds even more strongly if we consider the amounts of income that people in rich countries are prepared to transfer to poor countries to raise their standards of living.

While the Review went to considerable trouble to consider the range of reasonable discount rates in calculating benefits and costs, it ultimately found that the conclusion did not depend on whether normative or positive discount rates, or moderate or highly egalitarian normative discount rates, were applied in the circumstances of Australia.

Under all discount rates considered in the Review, GNP is higher at the end of the century with mitigation than without. The net present value of mitigation benefits fall short of the costs by only a modest amount, even when only twenty-first century Type 1 and Type 2 benefits are taken into account. When Type 3 and Type 4 benefits in the twentieth century and all four types of benefits in the twenty-first century are taken into account, the case for mitigation becomes compelling.

3.3 Two notes of caution on the discount rate

The argument for being careful about the sacrifice of current utility through expenditure on mitigation in pursuit of future utility is a powerful one. But there are two important qualifications. First, the rate of substitution between conventional consumption and non-market services is likely to be low when incomes and material consumption are much higher than they are today.

Climate change may greatly diminish the availability of non-market services for future generations. So despite improvements in our material wealth, future generations may not have the same access to environmental services. As a result, one cannot be sure that, despite much higher material consumption, the average utility of people in the future will be greater than the average utility today.

Hence, linking the elasticity of utility to the growth in per-capita income may lead to higher-than-intended discount rates.

Second, if reality turns out to be consistent with the bad end of the probability distribution of outcomes from climate change, there is a possibility that utility derived from material consumption may be not be so much higher for many people in future than at present. This possibility is brought into stronger focus by the exceptionally high incomes of Australians during the current temporary boom in the terms of trade, and by diminished expectations of productivity growth in recent years in Australia as well as other developed countries. When we add in the prospects for environmental degradation, Australians in 2011 can't be quite so sure as earlier Australians might have been that future generations will be better off than themselves.

4. Answering the Review's critics

As noted earlier, there have been few criticisms of the overall decision-making framework but there have been five specific criticisms of choices made within the decision-making framework.

4.1 Was the discount rate used too low?

Michael Porter, from the Committee for Economic Development of Australia (CEDA), argues that the discount rates used by the Garnaut and Stern reviews were unreasonably low (Porter 2009).

The choice of discount rate is important to the judgements made in the Review; a rate materially higher than the higher of the two used in the Review would cause the conclusions on strong mitigation to be less clear-cut. It is therefore worth exploring the critique.

Drawing on Nordhaus, Porter argues that future generations would be better off and that 'low' discount rates failed to discount future incomes appropriately. In particular, Porter refers to rising average global per-capita incomes to suggest that future values would be much higher and hence should be more heavily discounted than in the Review.

The Review's treatment of the discount rate differs substantially from Stern's approach in two ways. The Review did not consider Stern's choice to be flawed. Rather, it anticipated views of the kind that Porter puts forward and demonstrated that using rates that accommodate alternative ways of looking at the issue does not materially affect the conclusions for Australian policy.

First, the Review tested the sensitivity of the result to a much higher discount rate than applied by Stern in his original Review. (The parameters in this higher discount rate are consistent with Stern's more recent views (Stern 2008, p3) on the elasticity of utility for use in climate policy evaluations, as he has suggested that "with the benefit of hindsight" he would use a higher value of the elasticity of utility as his central case.) To go even higher would assert a preference for equality of income distribution far more extreme than has ever been suggested as a basis for practical policy making, for example on taxation or development assistance.

Second, the Garnaut Review methodology required only the selection of a discount rate that is appropriate for Australia. Within the context of the Review, the global distribution issue is dealt with through the development of an allocation of emissions entitlements across countries (modified contraction and convergence) that has reasonable prospects for being accepted by developing

countries. Modified contraction and convergence provides substantial headroom for developing-country growth and hence the ability for poorer-income countries to grow considerably before facing severe constraints on emissions.⁵

4.2 The treatment of uncertainty

The international discussion of mitigation over the past two years has focused more strongly on Type 3 benefits: the value of mitigation as insurance against potentially catastrophic climate change outcomes. Weitzman (2009) has been influential, and the Review's upward adjustment of business as usual global emissions brought the bad end of the probability distribution into clearer focus everywhere.

In this context, there is a stronger case for mitigation when outcomes are uncertain than there would be if the same expected (or 'average') outcome was certain. And yet in some of the Australian public discussion, it has been common to assert that the presence of uncertainty makes it appropriate to adopt weaker approaches to mitigation. This error has been made by economists who honestly and disarmingly say that they are not scientists, but that there is uncertainty, which means that we should not do as much as if we were certain about a bad outcome. This view is based on a misreading of the scientific discussion of uncertainty.

At this point it is worth clarifying exactly what we mean by 'uncertainty'. The notion of uncertainty refers to the fact that, while we can't be sure exactly what form the future will take, we can use the information available to us to assign probabilities to each possible future. We can then take a best guess of what form the future will take, although things could well turn out differently. Our ability to make this inference relies on us having a sound understanding of both the range of possible future outcomes and the likelihood of each of these outcomes. The combination of these forms our probability distribution of future outcomes.

While climate change is characterised by these kinds of 'known unknowns', it is further complicated by a range of 'unknown unknowns'; that is, it is difficult for us to determine all of the potential implications of climate change or, even more so, the probabilities of these implications. As Weitzman (2009, p1) has indicated:

Much more unsettling for an application of (present discounted) expected utility analysis are the unknowns: deep, structural uncertainty in the science coupled with an economic inability to evaluate meaningfully the catastrophic losses from disastrous temperature changes.

In considering the uncertainty of climate change, events that we now deem most unlikely should not be discarded. As time progresses and our understanding of climate science improves, adverse outcomes once deemed highly improbable may come to seem more likely. (There are no reasons to expect that the "Black Swans" that fly across the path of economies will be absent from the relationship between economic activity and the environment (See Taleb [2007]).

Some economists see the value of insurance against bad and possibly catastrophic outcomes as the most persuasive element of the case for mitigation (Weitzman, 2009). Indeed, Weitzman argues that uncertainty may be an even more important consideration in any cost benefit analysis of mitigation than the treatment of the discount rate.

Reading the scientific literature and taking into account the range of opinions on various matters, the informed non-scientist can be left in little doubt about the way in which the scientific community sees uncertainty in climate change.⁶ The existence of uncertainty in climate change does not imply doubt about whether or not there will be any impact at all from unmitigated or weakly-mitigated growth in emissions. The scientific consensus is clear on whether there will be an impact, and on the likely extent

⁵ It is worth noting Ken Arrow's (2007) conclusions in regards to global climate-change action. Arrow prefers to use a value of two for the marginal elasticity of consumption, one of the values used in the Garnaut Review. Using this value, Arrow then calculates from Stern's analysis discount rates for when the present value of the benefits of action on climate change exceed that of the costs. He finds that the benefits exceed the costs for any value of the social (or pure) discount rate of less than 8.5 per cent.

⁶ See, for example, the UK Royal Society's (2010) recent summary of climate-change science.

of the impact. The question of uncertainty relates to the dispersion of the probability distribution around the most likely or average outcome. The principles of prudent risk management dictate that the case for action is strengthened, rather than diminished, by the fact that outcomes could turn out far worse (or better) than we expect. With strong mitigation, we at least rule out, or reduce to low probabilities, the potential for catastrophe.

The Update considers the developments in scientific knowledge since the Review was published in 2008. This includes explicit consideration not only of whether our expectations of outcomes have been revised, but whether there has been an increase or decrease in uncertainty. Any increase in the uncertainty of climate change impacts would strengthen the case for strong mitigation, by increasing its insurance value. A reduction in uncertainty would have the opposite effect. A change in expected outcomes could either weaken or strengthen the case for strong, early mitigation.

4.3 The relationship between Australian and global mitigation and the discount rate

The Review's focus on the comparison of the costs and benefits of Australian mitigation decisions from the perspective of the Australian public interest is different from the focus on global mitigation in earlier studies, including those of Stern, Nordhaus and Cline.

The global mitigation effort is the sum of the separate but inter-related mitigation decisions of individual sovereign countries. It is the sum of the decision processes in all countries. It is Australia's decision-making process and accompanying debate that the Review and its Update seek to inform.

But developing an informative comparison of the costs and benefits of mitigation for Australia depends on Australia's efforts being located realistically within an effective global mitigation effort. That global effort is the sum of national efforts, each of which depends on an assessment of national costs and benefits similar to that which the Review has undertaken for Australia. And in making its own national assessment, each country implicitly or explicitly has to use a discount rate to compare future global costs and benefits.

If you did the same calculations for the world as a whole as the Review did for Australia, you would use a higher discount rate. This is the case whether you use the normative or the positive approach to determine the discount rates.

On the normative approach, people in less wealthy developing countries, with prospects for proportionately larger increases in incomes over any relevant future period, would value current relative to future income more highly than Australians.

Higher discount rates for developing countries also arise using a positive approach, with real interest rates in sovereign debt markets substantially higher in developing countries than in developed countries. Part of the differential may reflect greater scarcity of capital, apart from risk, in a world of imperfect mobility of capital.

Because discount rates—regardless of approach—are higher in developing countries than developed countries, the comparison of costs and benefits of a given percentage reduction in emissions is much less likely to be positive for mitigation in a developing country.

The Review's response to the different circumstances of developing and developed countries was to develop a practical basis for allocating emissions entitlements to low-income countries within a limited emissions budget that had reasonable prospects for passing the test of national interest in at least the countries of substantial economic size.

The use of a contraction and convergence framework to allocate entitlements across countries was part of the practical international regime developed by the Review. The practical regime also incorporated payments from developed to developing countries in support of mitigation and adaptation to climate change.

In my view there are compelling ethical reasons for support of convergence towards equal per capita entitlements to emit greenhouse gases, and for support from developed to developing countries for

mitigation and adaptation. However, the critical point is not ethical. The critical point is the highly practical one that developing countries will not participate in a global mitigation effort unless they can justify participation through calculation of their own national interest. Movement towards equal per capita entitlements, opportunities to trade ‘surplus’ entitlements and transfers from developed countries help them to satisfy the test of national interest (see also Stern, 2009).

The important point for current purposes is that the proposed allocation of mitigation effort across countries and the support for mitigation and adaptation makes the cost of meeting emissions targets manageable for developing countries. It makes it possible for developing countries to be part of and to comply with an international agreement. There is a greater chance that developing countries will enter and honour international agreements if they have opportunities to reduce emissions at low cost and to sell excess entitlements on the international market. The incorporation of these further elements into a global mitigation regime makes it more likely that developing countries’ own calculations of the costs and benefits of mitigation will pass the test of their own national interests.

This line of logic shows why it is not necessary to take into account the high discount rates of developing countries in assessment of Australia’s own interest in mitigation.

Of course, the Review’s proposals on principles for allocation of a limited global emissions budget were just that: proposals for discussion. They have been extensively discussed in developing countries since September 2008. There have been comments that convergence on equal per-capita entitlements from 2050 leaves established large emitters in the developed world—first among them Australia—in privileged positions for too long. There has also been comment, notably in India and also in China, that contraction and convergence does not acknowledge the developed countries’ historical responsibility for the substantial depletion already of the Earth’s capacity to absorb greenhouse gases without dangerous climate change. However, the progress on developed country commitments to provide financial resources for adaptation and mitigation in developing countries, and increased awareness in the developing countries of their own vulnerabilities to climate change, has kept the original Review’s proposals within the broad boundaries of practical feasibility.

The establishment of a global mitigation approach is inevitably a long, iterative process. Through the iterations it will be necessary to recalibrate from time to time Australian expectations of what is a reasonable domestic effort, given international progress.

4.4 Judging Australia’s proportionate emissions-reduction effort

Perhaps the most frequently articulated concern with the recommendations of the Review was that it was wasteful for Australia to do anything because Australia represented such a small proportion of global emissions, or that the recommendations involved Australia “doing more than its share”.

The first of these concerns had its origin in a false premise: that what the rest of the world was prepared to do in reducing emissions was independent of Australia’s own actions. This is simply wrong.

The Review worked from the premise that there would be no effective global action unless all developed countries did more or less their proportionate parts. This had been an explicit premise of the Kyoto and Bali discussions, and coloured all developing-country consideration of participation in an international mitigation effort. While Australian action could not guarantee effective global action, the absence of Australian action would go a long way towards ensuring that there would be no effective global action.

Incidentally, it is not unusual in international affairs for Australia to make a more or less proportionate contribution to international collective action, even when its individual contribution alone cannot be said to be decisive. Participation in the UN security operations in Afghanistan and elsewhere provide examples. Here it is accepted that if Australia receives some benefit from collective international action, it is inappropriate to free ride on the actions of others. In the security sphere it is common for commitments to collective action to be justified on moral grounds, although they could be defended also on the grounds that one country’s commitment makes it more likely that others will also contribute.

The Review accepted that it was not fruitful for Australia to commit all of what would be its proportionate share in a strong global mitigation effort in the absence of commitment by others to commensurate

action. Some limited Australian action (the unconditional commitment to reduce 2020 emissions by 5 per cent from 2000 levels) was warranted as a contribution to keeping alive the prospect of an eventual global agreement, even if there were no international action for the time being. Beyond this, Australia's additional commitments should be proportionate to the commitments of others.

How do we judge what is a proportionate commitment? This requires comparison against the mitigation effort suggested by principles that are agreed internationally or, in advance of agreement, have reasonable prospects of being accepted as a basis for international agreement. The Review suggested modified contraction and convergence as the most suitable set of principles, pending detailed international discussion and negotiation.

While the recommendations were built on careful calculations of a proportionate effort, ignorance of actions in other countries caused perceptions to persist that any Australian effort would put it ahead of the rest of the world. The examination of this perception is a major focus of the Update's paper on international developments.

4.5 The balance between mitigation and adaptation

A few commentators on the Review argued that, whatever the merits of the proposals for mitigation, effective global mitigation was unlikely to be successful to the extent that major disruption of Australian life from climate change would be avoided, and that in these circumstances it was better to focus scarce Australian resources on adaptation rather than mitigation. At least Australian efforts on adaptation would be directly relevant to Australian welfare, whereas the success of an Australian contribution to mitigation depended on the complementary action of other countries. This view was argued eloquently by Professor Richard Blandy of Adelaide in a long correspondence, and there have been implicit suggestions along these lines in a number of contributions.

The Review put the view in Chapter 15 that the first line of Australia's adaptive defence against climate change was investment in the development and dissemination of knowledge about likely impacts. The second line of defence was a range of measures to increase the flexibility of the Australian economy in response to shocks of various kinds: free trade, including in food; improved financial markets, including insurance; and greater mobility of the Australian labour force. The Review recommended the funding of increased scientific and related efforts to expand knowledge of possible future impacts. It saw the measures to increase flexibility and to improve the performance of markets as contributing to a more productive economy in any case—with concerns for adaptation augmenting economic policy reasons for a range of reforms that would increase the productivity of the Australian economy. It argued for a similar focus on scientific information and policies to enhance economic performance in development and adaptation assistance to developing countries in Australia's neighbourhood.

The modelling of the economic costs of climate change and benefits of mitigation assumed a substantial adaptive response to the impacts of climate change: investment in plant breeding would reduce the costs of changes in temperature and availability of water on crop yields; investment in more resilient buildings and infrastructure would increase initial costs but reduce subsequent damage.

Should the Review have gone further, and advocated the commitment of a substantial part of the resources that it recommended be committed to mitigation, to investment in more resilient structures to reduce inevitable impacts of climate change? Here we are not talking about marginal adjustments but a major shift in emphasis, funded by a substantial downgrading of the mitigation effort.

Such a major reallocation of Australian effort away from mitigation would reduce the chances of effective global mitigation, for reasons that will be discussed in the second Update Paper, to be released on 7 February 2011. That would not matter if there were no chance of substantial reduction of global emissions below business as usual through international cooperation in which Australia played a part. Despite the disappointments in international discussions, the world has already moved a significant way away from business as usual emissions trends, as discussed in the third Update Paper to be released on 11 February 2011.

While there are good reasons to wish that the world, and Australia as part of that world, were further down the track towards effective global mitigation to achieve the "2°C" target agreed by the international community at Copenhagen and Cancun, there is a large distance between where we are

after Copenhagen and Cancun, and where we would have been with no international mitigation at all. There is still a chance of achieving strong mitigation objectives, and at worse we are headed towards materially less damage from climate change than would have been the case with no international mitigation effort at all.

The difference in the probable climate impacts and the risks of more between holding global temperature increases to 2°C or to 3°C is immense; and the risks rise even more for the difference between 3°C and 4°C, and further still for 4°C and 5°C, and again for 5°C and 6 °C. There is no point in time at which it is wise to conclude that the damage already caused from climate change is so large that any subsequent damage is of minor importance. Moreover, the challenges and costs of climate change associated with an additional degree of warming, regardless of the warming the planet has already experienced, is likely to overwhelm any attempts at adaptation to reduce the costs.

The climate change that has already occurred has imposed substantial costs on Australia. The incremental climate change that is already in train as a result of increased atmospheric concentrations of greenhouse gases that have resulted from past human activity but which have not yet had their full effects on climate will add substantially to these costs. A large adaptive effort is required already. Indeed, whether or not it is recognised as such, that adaptive effort is already occurring, from the major desalination plants in four Australian cities, through some of the recommendations of the Royal Commission into the Victorian bushfires, to the changed zoning of land in some coastal areas.

It is likely that the financial resources that have been contributed so far to adaptation to climate change substantially exceed the resources that have been invested in mitigation.

The requirements of adaptation take a more immediate and compelling form than the demands of mitigation, and for that reason have advantages in the competition for resources through political processes. These are matters for judgement. Without in any way underplaying the importance of a large, well-designed and well-resourced adaptation effort, my own judgement is that there is no evidence at this time nor any danger of over-investment in mitigation at the expense of investment in adaptation.

One change that is required on adaptation is to think in a more coherent and integrated way about how we expend inevitably large sums on adaptation. The temptation will be to respond to each crisis with a specific response. And yet the increased challenges of extreme events of flood and fire and drought, of disruption of infrastructure in heatwaves, of erosion of coastal properties, of changes in fish stocks and disappointment about sustained river flows for irrigation, are different parts of a single phenomenon. An integrated adaptation response would allow us to make more effective use of the large amounts of resources that Australians inevitably will invest in adaptation.

5. Conclusion

The objective of the Update is to inform the Australian Government and the Australian community of key changes since the 2008 Review and to evaluate their effect on the Review's findings.

It is clear from the Update's preliminary analysis that there have been significant scientific, policy and analytical developments since 2008. The international framework changed fundamentally at Copenhagen and Cancun. The climate science has developed, mostly in ways that heighten rather than ease concerns. There have also been considerable developments in the domestic policy discussion. Interestingly, the costs of some low-emissions technologies appear to have been falling faster than anticipated. However, a late start globally on mitigation has raised anticipated costs of both climate change and its mitigation.

The analysis of the Update is directed towards evaluating the question that was posed at the beginning of the Review about whether gains from mitigation of climate change, within a global framework, exceed the costs. This question hasn't changed.

The decision-making framework within which the Review considered this question has been subject to some debate over the past two and a half years. The main criticisms of the framework have been

examined in this paper. The framework remains, as it was in 2008, a robust, logical and ethical framework within which to consider the most vexed policy question of the age, climate change.

The framework will be applied rigorously in the seven papers that will be released between now and the end of March, and in the Final Update Report that will be presented to the Prime Minister on 31 May 2011.

Those who disagree with the updated recommendations will have the opportunity to accept the premises, logic and information that led to the conclusions, or to contest them. I look forward to a vigorous debate on premises, logic and information, that contributes to climate change policy in the Australian public interest.

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Appendix 1: Terms of Reference

I, GREG COMBET, Minister for Climate Change and Energy Efficiency, hereby commission Professor Ross Garnaut to update significant elements of his 2008 Garnaut Climate Change Review ('the 2008 Review'), and to report by 31 May 2011.

The review update will update elements of the Climate Change Review where:

- significant changes have occurred, or the sum of expert knowledge has increased, since the original analysis for the 2008 Review was undertaken; and
- where such changes or improvements in expert knowledge could have significant implications for the key findings and recommendations of the 2008 Review, such that they should be updated.

The Review Update should consider:

- international developments on climate change mitigation efforts;
- developments in climate change science, and understanding of climate change impacts;
- previous proposals to develop a carbon price in Australia, and the ensuing public debate;
- domestic and international emissions trends;
- changes in low emissions technology costs and availability;
- the potential for abatement within the land sector; and
- developments in the Australian electricity market.

Throughout the Review Update, consultation with key stakeholders will be required to understand views and inform analysis.

A series of publicly released papers is to be prepared between November 2010 and March 2011. A final report is to be presented to the Government by 31 May 2011.

The Report will embody the independent judgments of its author.