AUSTRALIA'S LOW POLLUTION FUTURE

THE ECONOMICS OF CLIMATE CHANGE MITIGATION

SUMMARY

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Foreword

Climate change poses clear risks to Australia's future prosperity.

Only global action can reduce greenhouse gas emissions to a level that significantly reduces the risks of dangerous climate change. In working towards an effective global agreement, the developed world has to lead.

Australia will make its fair contribution, including by implementing efficient market-based policies to substantially cut domestic emissions in a cost-effective way. The Carbon Pollution Reduction Scheme will be the cornerstone of Australia's mitigation policy. This will safeguard our economic wellbeing, and stimulate sustainable low-emission growth that will form the basis of Australia's future prosperity.

This is a complex policy area, with important implications for our economy and society. The Government is taking a careful and deliberate approach, drawing on many sources of advice to ensure it understands the costs and benefits to the economy of reaching our emission reduction targets. This will ensure we meet our responsibility to not only protect the economy of today, but also prepare for the low-pollution economy of the future.

The Treasury has conducted one of the largest and most complex economic modelling projects ever undertaken in Australia. This report investigates the potential economic impacts of reducing emissions over the medium and long term. It spans global, national and sectoral scales, and looks at distributional impacts, such as the implications of emission pricing for the goods and services that households consume.

These issues are clearly important to decisions on Australia's scale and rate of emission reductions in coming years.

We are making the assumptions and results of the Treasury's analysis available to the public. We will consider public responses to this report before the Government makes its decisions on the national target range for the medium term. This will help take Australia to its goal of reducing emissions by 60 per cent below 2000 levels by 2050.

The Government will continue to build Australia's capacity for high quality analysis of the costs and benefits of climate change policy. This will ensure we continue to make a substantial contribution to global efforts, and have confidence that our domestic policies enhance the wellbeing of all Australians.

The Hon. Wayne Swan MP
Treasurer

Senator the Hon. Penny Wong
Minister for Climate Change and Water

Executive summary

Key points

The Treasury's modelling demonstrates that early global action is less expensive than later action; that a market-based approach allows robust economic growth into the future even as emissions fall; and that many of Australia's industries will maintain or improve their competitiveness under an international agreement to combat climate change.

Australia and the world continue to prosper while making the emission cuts required to reduce the risks of dangerous climate change. Even ambitious goals have limited impact on national and global economic growth.

Real household income continues to grow, although households face increased prices for emission-intensive products, such as electricity and gas.

Strong coordinated global action reduces the economic cost of achieving environmental objectives, reduces distortions in trade-exposed sectors, and provides insurance against climate change uncertainty.

There are advantages to Australia acting early if emission pricing expands gradually across the world: economies that defer action face higher long-term costs, as global investment is redirected to early movers.

Australia's comparative advantage will change in a low-emission world. With coordinated global action, many of Australia's emission-intensive sectors are likely to maintain or improve their international competitiveness.

Australia's aggregate economic costs of mitigation are small, although the costs to sectors and regions vary. Growth in emission-intensive sectors slows and growth in low- and negative-emission sectors accelerates.

Allocation of some free permits to emission-intensive trade-exposed sectors, as the Government proposes, eases their transition to a low-emission economy in the initial years.

Accurately predicting which mitigation opportunities will prove most cost effective is impossible. Instead, broadly-based market-oriented policies, such as emissions trading, allow the market to respond as new information becomes available.

Introduction

The global climate is changing. Greenhouse gas emissions from human activities very likely have caused most of the global warming since the 1950s.

Some impacts are now unavoidable. Continued emissions at or above current rates would cause further warming and induce further changes in the global climate system over time (IPCC, 2007a).

Before the Industrial Revolution, the concentration of greenhouse gases in the atmosphere was around 280 parts per million of carbon dioxide equivalent (ppm CO_2-e).[1] Today, concentrations are around 430 ppm. Without policy action these concentrations are projected to rise to 1,560 ppm by 2100, more than five times pre-industrial levels. These concentrations are associated with very high risks of large-scale irreversible climate change.

This scenario, where no mitigation occurs, is the 'reference scenario'. It assumes current trends in economic activity continue into the future. The reference scenario does not include the impact of climate change on the economy.

Stabilising atmospheric greenhouse gas concentrations at levels that significantly reduce the risks of dangerous climate change requires a fundamental shift in current global emission trends. This requires considerable changes in global economic activity. The Treasury, in partnership with many of Australia's leading economic modellers of climate change and the Garnaut Climate Change Review, has explored how such a shift might affect Australia's economy.

This report examines four alternative scenarios in which Australia and the world follow pathways to a low-pollution future.

Two scenarios assume a global stabilisation goal of 550 ppm CO_2-e, which requires that global emissions peak within the next two decades, fall to below current levels by 2050, and fall further after 2050 (IPCC, 2007b). The key difference between the two scenarios is whether global action is united or staged. The other two scenarios assume more ambitious global stabilisation goals of 450 and 510 ppm, which require more rapid global emission reductions: 450 ppm is achieved through united global action and 510 ppm through staged action.

Prosperity increases while ambitious stabilisation goals are achieved. This occurs in all four scenarios.

Efficient mitigation policies that price greenhouse gas emissions from all sources, and in all regions, can break the link between economic growth and emissions, and allow the world economy to adjust efficiently to a low-pollution future. Changes in technologies, processes, production inputs and consumer choices generate most emission reductions. Even with an emission constraint, almost all sectors of the Australian economy grow, and key low-emission sectors grow strongly.

1 References to greenhouse gas concentrations are to the aggregate warming effect of gases covered by the Kyoto Protocol.

Framework for analysis

The analysis and modelling in this report focus on the economic impacts of policies to reduce greenhouse gas emissions ('mitigation policies'), particularly the Carbon Pollution Reduction Scheme (CPRS). This report focuses on the medium to long-term transformation of the Australian economy, not short-run fluctuations arising from events such as the current turmoil in global financial markets.

The report positions Australia within the context of global action to reduce greenhouse gas emissions and stabilise concentrations at 450-550 ppm around 2100. In all scenarios, Australia's action is comparable to that of other developed economies. Developing nations' contributions are differentiated, either through relatively less stringent per capita-based national emission pathways within a united global action framework, or through gradual adoption of emission reduction obligations under a multi-stage framework.

Two scenarios, Garnaut -10 and Garnaut -25, assume an 'optimal' international emissions trading scheme, covering all emission sources and all economies, from 2013. National emission targets are based on the per capita allocation approach developed by the Garnaut Climate Change Review (Garnaut, 2008a). Australia's emission reduction targets in these scenarios are 10 per cent below 2000 levels by 2020 and 80 per cent below by 2050 for stabilisation at 550 ppm (Garnaut -10); and 25 per cent below 2000 levels by 2020 and 90 per cent below by 2050 for stabilisation at 450 ppm (Garnaut -25).

The other two scenarios, CPRS -5 and CPRS -15, examine the potential costs of Australia's Carbon Pollution Reduction Scheme within a more realistic multi-stage global framework. National emission targets gradually diverge from reference scenario emissions, so take greater account of the existing structure of national economies. International emissions trading gradually expands: developed economies participate from 2010; developing economies join over time; there is global participation by 2025. Australia's long-term emission reduction target in both scenarios is 60 per cent below 2000 levels by 2050. CPRS -5 assumes a slower start to global emission reductions and stabilisation at 550 ppm; Australia's medium-term target is 5 per cent below 2000 levels by 2020. CPRS -15 assumes a faster start and stabilisation at 510 ppm; Australia's medium-term target is 15 per cent below 2000 levels by 2020.

This report is not a complete assessment of the economic, social and environmental costs and benefits of climate change policies. The modelling does not include the economic impacts of climate change itself, so does not assess the benefits of reducing climate change risks through mitigation. Other studies explore these benefits in detail (Garnaut, 2008a; Pearman, 2008; Stern, 2007).

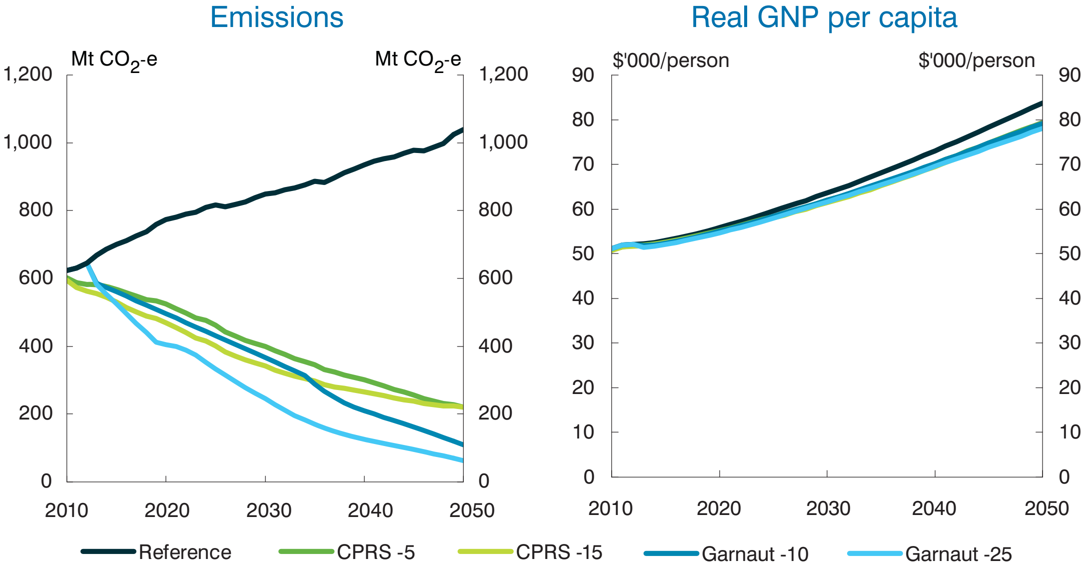
This report is a collaborative effort between leading climate change economists and the Australian Treasury. A suite of global, national, sectoral and distributional models are used to estimate the macroeconomic, sectoral and distributional impacts of the four emission reduction pathways. The stabilisation level, global framework, Australian targets and Australian policy settings are key to impacts on the Australian economy.

Australia in the global context

Australia maintains strong economic growth and achieves its emission reduction targets in all scenarios.

From 2010 to 2050, Australia's real GNP per capita grows at an average annual rate of 1.1 per cent in the policy scenarios, compared to 1.2 per cent in the reference scenario.[2] By 2020, real GNP per capita is around 9 per cent above current levels, compared to around 11 per cent in the reference scenario. By 2050, real GNP per capita is 55-57 per cent above current levels, compared to 66 per cent in the reference scenario (Chart 1).

Chart 1: Five pathways for Australian emissions and GNP



Note: Units are in Australian dollars 2005 prices. The reference scenario shows modelled emissions, while the policy scenarios show allocations (policy targets). Actual emissions differ from allocations due to banking of permits and international permit trade.
Source: Treasury estimates from MMRF.

Emission pricing has a slightly smaller impact on Australia's GDP, as GDP does not include income transfers associated with international emissions trading. From 2010 to 2050, real GDP per capita grows at an average annual rate of 1.2-1.3 per cent in the policy scenarios, compared to 1.4 per cent in the reference scenario.

Australia's emission price is determined by the global price. Higher emission prices are required to achieve lower stabilisation levels, and lower risks of dangerous climate change. Stabilisation at 550 ppm requires an initial emission price of \$23/tCO_2-e in 2010 in nominal terms (\$20 in 2005 dollars). The starting price is 40 per cent higher to achieve 510 ppm, and 110 per cent higher to achieve 450 ppm. Higher emission prices generally lead to higher aggregate impacts on Australia.

2 GNP (gross national product) measures the total output of the Australian economy and international income transfers. It is a more complete measure of the current and future consumption possibilities available to Australians than GDP (gross domestic product) (Box 2.3).

Table 1: Australia's emissions and economy

	Reference	CPRS -5	CPRS -15	Garnaut -10	Garnaut -25
Greenhouse gas stabilisation goal, ppm CO_2-e	n/a	550(a)	510(a)	550	450
Current levels – at 2008					
GNP per capita, $'000/person	50.4	50.4	50.4	50.4	50.4
Start of scheme - at 2010 or 2013(b)					
Emission price, nominal, $/t$CO_2$-e	n/a	23	32	30	52
Medium term – at 2020					
Emission allocation, change from 2000 level, per cent	+40	-5	-15	-10	-25
GNP per capita, $'000/person	55.9	55.2	54.9	55.0	54.7
Long term – at 2050					
Emission allocation, change from 2000 level, per cent	+88	-60	-60	-80	-90
GNP per capita, $'000/person	83.7	79.4	78.7	79.1	78.0
Overall mitigation cost, 2010-2050					
Real GNP per capita, average annual growth, per cent	1.2	1.1	1.1	1.1	1.1
Real GDP per capita, average annual growth, per cent	1.4	1.3	1.3	1.3	1.2

Note: Units are in Australian dollars 2005 prices. Emissions in the reference scenario are actual emissions from MMRF.
(a) Assuming comparable global mitigation effort is sustained after 2050.
(b) Emission pricing commences in 2010 in the CPRS scenarios, and in 2013 in the Garnaut scenarios.

Source: Treasury estimates from MMRF and MAGICC.

At any given stabilisation level, the global framework significantly affects national costs. Under a multi-stage framework (CPRS scenarios), Australia's costs as a share of GNP are slightly higher in the short term, but lower in the long term, than under a per capita based, unified framework (Garnaut scenarios). Two key factors drive this long-term result: under the multi-stage framework, Australia's long-term national target is less stringent (60 per cent rather than 80 per cent); and Australia benefits from acting early.

Where emission pricing is gradually introduced across the world, countries that defer action face higher long-term costs, because global investment is redirected to countries that act early. Australia therefore benefits from being an early mover in a multi-stage world.

Even so, the reasons for pursuing coordinated global action are compelling: early action accelerates cost reductions in low-emission technologies, helps prevent lock-in of more emission-intensive industry and infrastructure, and minimises distortions associated with trade-exposed industries.

In the face of uncertainty, strong coordinated global action has an insurance benefit: it keeps open the option of pursuing lower stabilisation levels in the future. Weaker global action may prove more costly in the longer term.

Compared to other developed economies, Australia faces relatively high mitigation costs as a share of GNP. Emission- and energy-intensive industries contribute substantially to the Australian economy, so Australia faces a relatively greater adjustment task. Differentiation of national emission reduction targets among developed countries, taking account of the structure of existing national economies, could narrow differences in mitigation costs.

Australia also has less mitigation potential at low-emission prices than many other developed and developing economies. Expanding access to international mitigation, through market-based mechanisms, such as international emissions trading and the Clean Development Mechanism, will help reduce the cost of Australia's contribution to the global mitigation effort.

Sectoral effects

While mitigation policies impose relatively small aggregate costs on Australia, impacts vary widely across sectors and regions. Putting a price on emissions drives a structural shift in the economy, from emission-intensive goods, technologies and processes, towards low-emission goods, technologies and processes. As a result, growth in emission-intensive sectors slows, and growth in low and negative-emission sectors accelerates.

The global emission price, changes in global demand, changes in Australia's exchange rate, and the relative energy and emission-intensity of global producers will determine the impacts on Australia's emission-intensive trade-exposed sectors. For other sectors, relative emission-intensity across the domestic economy, general macroeconomic impacts and technology options are key.

Australian producers will face falling global demand for emission-intensive goods and services. Nevertheless, many of Australia's emission-intensive trade-exposed sectors (EITES), such as coal, non-metallic minerals, livestock, and iron and steel, are likely to maintain or improve their competitiveness and share of global trade. These sectors are either less emission intensive or energy intensive than comparable sectors in competitor countries. Overall, these sectors are expected to grow, albeit at a slower rate than they would in a world without emission pricing.

Australia is likely to lose competitiveness where its production is more emission intensive than its competitors, such as for aluminium and petroleum refining. These sectors may contract.

In the absence of unified global action, an emission price may distort the international competitiveness of Australia's EITES. There is little evidence of carbon leakage.[3] Nevertheless, allocation of some free permits to EITES, in accordance with the shielding arrangements proposed in the *Carbon Pollution Reduction Scheme Green Paper*, eases the transition to a low-emission economy for shielded sectors while maintaining incentives for emission reductions. Shielding is projected to impose modest costs on other (unshielded) sectors through its impact on permit trading, electricity demand and energy prices, and redistribute costs amongst shielded sectors.

Coal's long-term future depends on developing new technologies — most importantly, carbon capture and storage. If these technologies do not prove commercially viable, Australia's coal production could fall from current levels. With commercially viable technologies, coal is likely to play a major role in future national and global energy supply, and Australian production is likely to grow.

Low-emission technologies, materials and production processes will become more competitive, and low-emission goods will become more attractive to consumers. Slower growth in world demand for energy commodities will lower Australia's terms of trade. The exchange rate acts as a buffer to changes in world demand, and would be expected to depreciate. This will improve the competitiveness of other sectors, such as manufacturing and iron ore mining.

Emission pricing creates a new source of revenue for sectors that can generate credits through carbon sequestration, such as forestry, stimulating strong growth.

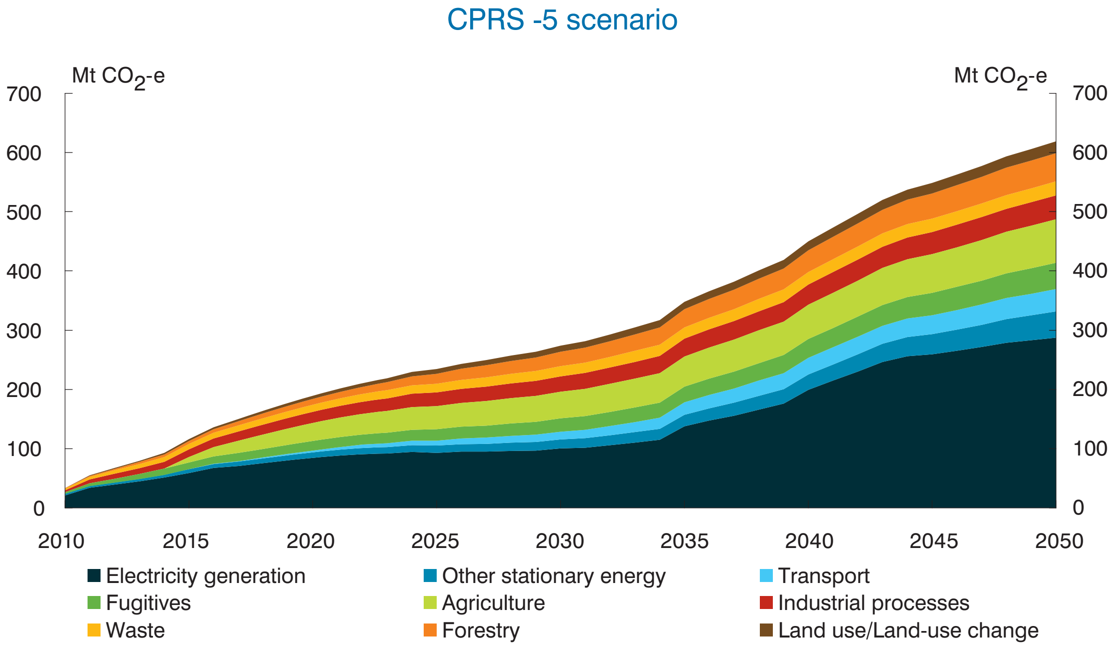
3 Carbon leakage occurs when EITES move to other locations that are more emission intensive than Australia, but do not yet price emissions.

Emission pricing is expected to result in early retirement of some emission-intensive plant and capital, and lead, at least initially, to slightly slower growth in wages and some redistribution of employment. However, these impacts are likely to be restricted to firms in a few specific industries, such as some coal-fired electricity generators, and could be managed through effective structural adjustment assistance.

Australia's wide range of low-emission technology options suggests electricity generation could deliver large emission reductions over time, even if some technologies do not prove cost effective. This report finds no evidence that mitigation policies will compromise the security of energy supply. Under all scenarios modelled, new generation capacity is established in sufficient time to meet projected demand.

Emission pricing could reduce emissions in all sectors (Chart 2). Accurately predicting which mitigation opportunities will prove most cost effective is impossible. Broadly-based market-oriented policies, such as emissions trading, will allow the market to respond as new information about mitigation opportunities becomes available.

Chart 2: Emission reductions by sector



Note: The difference between the total emission reductions in this chart and the gap between reference and policy scenario emissions in Chart 1 is met by Australia importing permits.

Source: Treasury estimates from MMRF.

Impacts on households

Household income continues to grow strongly. Real disposable income per capita grows at an average annual rate of around 1 per cent in the policy scenarios, compared to 1.2 per cent in the reference scenario.

In the CPRS scenarios (in which emission pricing is introduced in 2010), a one-off rise in the price level of around 1-1.5 per cent is expected, with minimal implications for ongoing inflation. For the average household, this corresponds to an extra $4-5 per week spending on electricity and $2 per week on gas and other household fuels. Prices of petrol and emission-intensive meat products will not be affected initially, due to reductions in fuel taxes and agriculture's initial exclusion from the Carbon Pollution Reduction Scheme.

Emission pricing will have a slightly greater impact on low-income households as they spend a higher share of their income on emission-intensive goods. The Government, as it outlined in the *Carbon Pollution Reduction Scheme Green Paper*, is committed to helping households adjust to the scheme, including by increasing benefit payments and other assistance to low-income households through the tax and payment system.

Analysis over long timeframes

This report uses policy scenarios to explore how the Australian economy might change in response to emission pricing. Changes are analysed relative to a reference scenario in which no new policies are introduced.

Like much long-term economic analysis, including that presented in the *Intergenerational Report* (Australian Government, 2007), the modelling approach used here focuses on medium to long-term trends in the economy rather than shorter run fluctuations. The actual path of Australian and global economic growth from now out to 2050 will be affected by a wide range of factors. Business cycles and economic shocks, such as the current global financial crisis, will have an impact on the economy in the short term. Other factors, such as the rate of population growth, could change the trend rate of economic growth in the long term.

These factors should not materially affect the analysis in this report. The economic modelling focuses on changes in the economy resulting from climate change mitigation policies. In principle, even if the reference scenario was different, the direction and scale of these changes should be broadly unchanged.

The results would be sensitive to changes that affect the distribution of economic activity between high and low emission activities. This is why the analysis has been carefully constructed to incorporate the Treasury's best current estimates of longer run trends in the sectoral distribution of output in the Australian and global economies.

CHAPTER 1: INTRODUCTION

Key points

This report is a collaborative effort between leading climate change economists and the Australian Treasury.

This report examines the economic costs of reducing greenhouse gas emissions, not the economic impacts of climate change itself. It should be evaluated in the broader context of all the costs and benefits of climate change mitigation.

The Australian Government has identified climate change as one of its highest policy priorities.

The Government's climate change policy is built on three pillars:

- reducing Australia's greenhouse gas emissions;
- adapting to climate change that we cannot avoid; and
- helping to shape a global solution.

The Government has adopted a long-term greenhouse gas emission reduction target of 60 per cent below 2000 levels by 2050, and is considering the scale and timing of the emission reductions Australia should pursue towards this goal.

As a party to the Kyoto Protocol, Australia is obliged to limit its national greenhouse gas emissions to no more than 108 per cent of 1990 levels during the Kyoto commitment period (2008 to 2012). Post-2012 targets for developed countries are being negotiated internationally, with negotiations scheduled to conclude in Copenhagen in 2009.

The Government will introduce a Carbon Pollution Reduction Scheme as the primary mechanism to achieve its emission reduction goals in a responsible and flexible manner and at the lowest possible cost to the economy (DCC, 2008a). As part of the design features of the scheme, the Government will announce a national emissions target range for 2020 by the end of 2008.

The Treasury established a climate change modelling unit in mid-2007, drawing on resources from across government, to strengthen its capacity to provide high quality analysis and advice to the Government, and support critical decisions regarding the timing and scale of emission reductions. The unit's first task has been to assess macroeconomic, sectoral and distributional impacts on the Australian economy of possible greenhouse gas emission reduction targets and trajectories.

The Treasury has worked with stakeholders, sectoral experts and leading Australian and international economic modellers of climate change in preparing this report.

This report focuses on the economic costs of reducing (mitigating) Australia's greenhouse gas emissions. A suite of global, national, sectoral and distributional models provide a detailed picture of the potential transformation to a low-emission economy. This report does not assess the economic costs of climate change, and the benefits of avoided climate change are not included in the economic models used. Treasury's analysis should be evaluated in the broader context of all the costs and benefits of climate change mitigation.

Global action to reduce greenhouse gas emissions could allow the concentration of greenhouse gases in the atmosphere to stabilise. Stabilisation at low concentrations could significantly reduce the risks of dangerous climate change and the costs of adapting to climate change. In addition, establishing clear long-term mitigation policies will reduce climate policy uncertainty. Reducing uncertainty tends to reduce risks and costs for investors in long-lived assets such as electricity generation infrastructure.

Other reports provide a detailed analysis of the economic benefits of climate change mitigation (Garnaut, 2008a; and Stern, 2007). Most importantly, the report of the Garnaut Climate Change Review includes its independent modelling of some of the economic impacts of climate change on Australia. The Review's modelling uses three of the scenarios in this report (the reference scenario, Garnaut -10 and Garnaut -25), and applies climate change impacts to them. In addition, the Treasury commissioned a scientific report of climate change risks to Australia under alternative emission futures, which provides an overview of the environmental benefits of climate change mitigation (Pearman, 2008).

This is a summary of *Australia's Low Pollution Future: The Economics of Climate Change Mitigation*. It presents the principal findings of the Treasury's analysis.

Chapter 2 describes the analytical framework, including the economic models used and the scenarios examined.

Chapter 3 summarises the likely impacts of reducing greenhouse gas emissions on the Australian economy, including macroeconomic impacts, effects on industries, and implications for households. It compares Australia's costs with impacts on other regions, and discusses the effect of different international policy approaches.

Chapter 4 summarises the key findings and identifies priorities for further analysis.

CHAPTER 2: FRAMEWORK FOR ANALYSIS

Key points

This report explores three stabilisation levels at the lower end of the range explored in the literature: 450, 510 and 550 ppm CO_2-e. The level of global mitigation effort is an important determinant of overall economic impact.

Stabilisation at these levels requires a fundamental shift in emission trends. Once that occurs, the differences — in terms of aggregate economic impacts — are relatively small.

This report uses a suite of models spanning global, national, sectoral and household scales to provide an integrated set of projections across these four dimensions.

In economic terms, climate change results from the externality associated with greenhouse gas emissions: it creates costs not paid for by those who generate the emissions.

The policy challenge is to reduce greenhouse gas emissions. Policy options include imposing a price on emissions, establishing technology and efficiency standards, supporting research and development of low-emission technologies, and instituting direct command and control regulation of emission sources.

An efficient policy reduces the overall economic cost of achieving any given emission reduction objective. Pricing emissions — by introducing a trading scheme — is a cost-effective option. A broad-based price measure ensures all emitters face the same cost for any extra unit of greenhouse gas emitted. This encourages uptake of the lowest-cost opportunities to reduce emissions.

The Government's planned Carbon Pollution Reduction Scheme will price emissions. Large emitters will need a permit for every tonne of greenhouse gas they emit. Permits will be traded in a market, with emitters competing to buy the number of permits they require. At any given time, some emitters will find it cheaper to reduce emissions than to buy permits (DCC, 2008a).

An important determinant of the permit price will be the scheme cap. This sets the upper limit on the number of permits available in the market. The Government will set the cap, taking into account the costs and benefits of different emission trajectories, and the evolving international framework for mitigation action. The international context is crucial, as the level of global action determines the climate change risks Australia will face. This report, and the economic modelling it presents, positions Australia's action within a global framework to reduce emissions and stabilise atmospheric greenhouse gas concentrations.

This chapter outlines the analytical framework of this report. It introduces the reference and policy scenarios modelled, and the assumptions regarding global and Australian mitigation action. It also describes the economic models used. Finally, it provides guidance on interpreting the modelling results.

2.1 The global mitigation task

Without new climate change mitigation policies, global greenhouse gas emissions are projected to rise to double current levels by the late 2030s, then nearly double again by 2100. As a result, greenhouse gas concentrations increase from around 430 ppm CO_2-e today to 1,560 ppm by 2100.

Wide uncertainties surround these projections and their economic impacts. Nevertheless, climate science provides a strong case for achieving global emission pathways that reduce the probability of extreme, irreversible damages from climate change (Box 2.1). Such pathways aim for low and stable long-term greenhouse gas concentration targets, with minimal or no overshooting.[4]

Aggregate global emissions ultimately have to fall to less than one quarter of current levels to allow and maintain stabilisation of greenhouse gas concentrations in the atmosphere (Pearman, 2008). Faster emission reductions would achieve lower concentrations and limit overshooting; delayed or gradual reductions lead to higher concentrations. This report explores three stabilisation levels: 450, 510 and 550 ppm CO_2-e. These levels are at the lower end of the range in the literature (IPCC, 2007b). This is important because the level of global mitigation effort is an important determinant of overall economic impact.

4 Overshooting occurs when atmospheric concentrations initially exceed then return to the target level. Overshooting is inherently more risky than approaching stabilisation levels from below (Pearman, 2008).

Box 2.1: Climate change risks at different stabilisation levels

The global average surface temperature has risen 0.8°C since 1850, and will rise further in the coming decades as a result of emissions that already have occurred.

Climate change risks increase with additional warming. Climate science provides strong evidence of system thresholds, beyond which adverse impacts could increase in a non-linear way (Pearman, 2008).

Without new policies to reduce emissions, the reference scenario sees continued strong growth in global emissions. As a result, the concentration of greenhouse gases in the atmosphere rises strongly to 1,560 ppm CO_2-e by 2100.

This corresponds to an increase in global average temperature of more than 5°C above pre-industrial levels by 2100, and substantially more in subsequent centuries (to 8°C or more above pre-industrial levels).[5] A temperature increase of this magnitude brings very high risks of extreme and irreversible climate change impacts, including the loss of complete ecosystems such as the Great Barrier Reef; severe water availability problems; significant and widespread food shortages; large areas of Australia's coastline permanently or periodically inundated; and greater international instability (Pearman, 2008).

Stabilisation of atmospheric concentrations requires significant cuts in global greenhouse gas emissions. The stabilisation level depends on how soon emissions peak and how quickly they decline. Lower stabilisation levels require global emissions to peak within the coming decade and fall well below current levels by 2050 (IPCC, 2007b).

Global mitigation action to achieve stabilisation at 450 ppm CO_2-e could limit global average warming to around 2°C above pre-industrial levels. This threshold is most frequently mentioned in the scientific literature as the limit beyond which 'dangerous' climate change may occur. For Australia, this level of warming is likely to involve substantial changes to natural and agricultural production systems due to the combined effects of higher temperatures and lower rainfall across much of the nation. Risks from bushfires and other extreme weather also increase, particularly in coastal and rural regions (Pearman, 2008).

Stabilisation at 550 ppm CO_2-e could limit global average warming to around 3°C above pre-industrial levels. Changes projected under a 450 ppm scenario are likely to occur sooner and become more severe in a 550 ppm world. Between 20 and 30 per cent of all species are projected to face a 50 per cent likelihood of extinction under this scenario (IPCC, 2007c). Coastal communities, agriculture and infrastructure would all face significant risks of adverse impacts (Pearman, 2008).

5 All temperature changes are based on the median estimate of climate sensitivity, calculated using the simple climate model MAGICC (Garnaut, 2008b). There is substantial uncertainty in such estimates (Pearman, 2008).

2.2 The scenarios and assumptions

This report uses scenarios to explore the potential economic effects of climate mitigation policy on Australia. Each scenario represents, in a stylised way, a different possible future. The scenarios are illustrative and do not represent the official policy or negotiating position of the Australian Government, are not an official Government or Treasury forecast, and are not an official projection of Australia's future greenhouse gas emissions.

The reference scenario provides the starting point for the analysis. It presents a plausible future path for economic growth, population levels, energy consumption and greenhouse gas emissions in a world without climate change. It does not include new policies to reduce emissions or climate change impacts.[6]

Two scenarios — CPRS -5 and CPRS -15 — examine the potential costs of the Government's proposed Carbon Pollution Reduction Scheme. Australia's action takes place within a simple multi-stage global policy framework. Australia and other countries listed in Annex B of the Kyoto Protocol take comparable action from 2010; and developing countries gradually adopt emission reduction obligations from 2015 to 2025.[7] National emission pathways gradually diverge from reference scenario emission levels towards substantial reductions in the long term.

The CPRS -5 scenario is consistent with stabilisation at around 550 ppm by 2100; the CPRS -15 scenario is consistent with stabilisation at around 510 ppm.

Two further scenarios — Garnaut -10 and Garnaut -25 — were developed jointly with the Garnaut Climate Change Review. These more stylised scenarios assume united global action, with all countries taking on emission reduction obligations from 2013. This represents an optimal post-2012 agreement. National contributions are based on a contraction and convergence approach, whereby the allocation of emission rights among countries converges from current levels to equal per capita rights by 2050 (Garnaut, 2008a).

The Garnaut -10 scenario is consistent with stabilisation at around 550 ppm by 2100; the Garnaut -25 scenario concentrations peak above 500 ppm, then decline to around 470 ppm by 2100 (consistent with stabilisation at 450 ppm soon thereafter).

Table 2.1: Reference and policy scenarios, global features

	Reference	CPRS -5	CPRS -15	Garnaut -10	Garnaut -25
Greenhouse gas stabilisation goal, ppm CO_2-e	n/a	550(a)	510(a)	550	450
Temperature change at stabilisation	8°C or more	3°C	2.6°C	3°C	2°C
Global emissions in 2050, Gt CO_2-e	102	35	27	36	22
Global mitigation action	None	Multi-stage from 2010		Unified from 2013	

Note: Temperature change is from pre-industrial levels, and based on the median estimate of climate sensitivity.
(a) Assumes comparable mitigation effort is sustained in the post-2050 period.

Source: Treasury estimates from MAGICC (concentrations and temperatures) and GTEM (global emissions).

Additional sensitivity scenarios show how mitigation costs might change with different technology availability and performance, and timing and coverage of mitigation policies.

6 This study follows the modelling approach of previous studies in excluding the impacts of climate change, so the results can be compared (Box 3.2). Pre-existing mitigation policies such as the 9,500 GWh/year Mandatory Renewable Energy Target and the NSW Greenhouse Gas Reduction Scheme are included in the reference scenario.

7 Annex B of the Kyoto Protocol lists countries with quantified emission reduction commitments ('Kyoto targets'), and includes the members of the OECD and economies in transition (Russia and other eastern European nations).

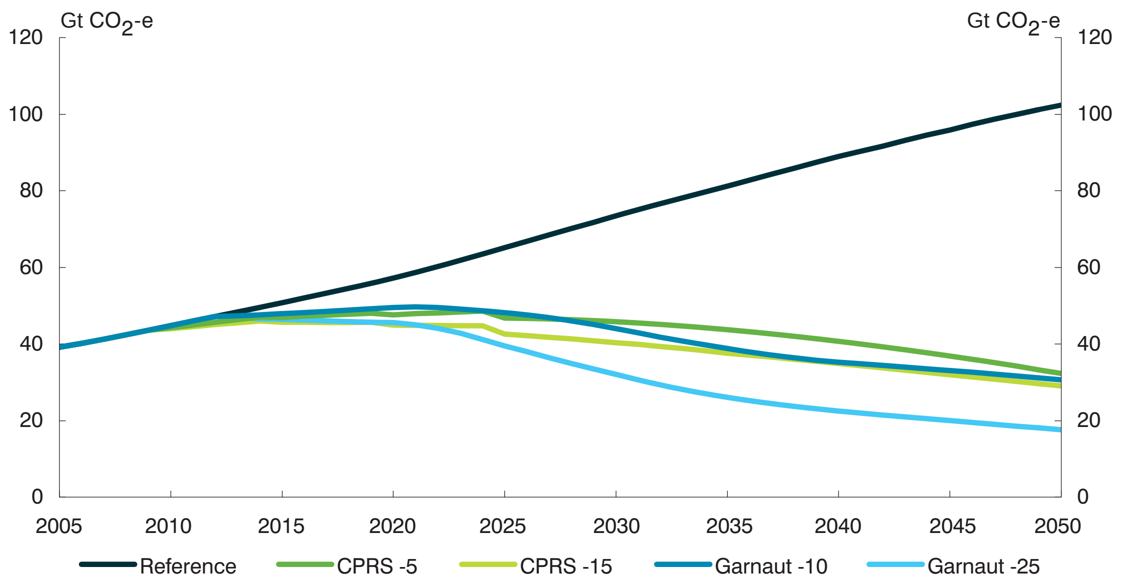
2.2.1 Global emission pathways

Global emissions in the policy scenarios diverge greatly from the reference scenario trend. To allow stabilisation at 550 ppm, global emissions in the CPRS -5 and Garnaut -10 scenarios peak around 2020-2025 and fall to below 2000 levels by 2050. Lower stabilisation levels require global emissions to peak sooner and fall more rapidly: for example, global emissions in the Garnaut -25 scenario peak in 2012 and fall to around 50 per cent below 2000 levels by 2050 (Chart 2.1).

The global emission pathway determines the overall cap on emissions within the international emissions trading scheme, so it determines the global emission price. Because Australia is linked to the international market, it also determines the Australian emission price. Emission prices drive mitigation activity in the economy and are an important determinant of Australia's costs.

The world could achieve any given stabilisation goal via many different global emission pathways. This report uses the so-called 'Hotelling rule', so the global emission pathway is consistent with an efficient distribution of mitigation effort over time, and an efficient market in which permits can be used or banked for future use (Hotelling, 1931; Garnaut, 2008a). The value of a permit (the emission price in real terms) rises at 4 per cent per year, which is assumed to be the real rate of return on a comparable asset.[8]

Chart 2.1: Global emission pathways



Note: Modelled emissions are shown for the reference scenario, while allocations (policy targets) are shown for the policy scenarios. Actual emissions differ from allocations because permits can be banked for future use.

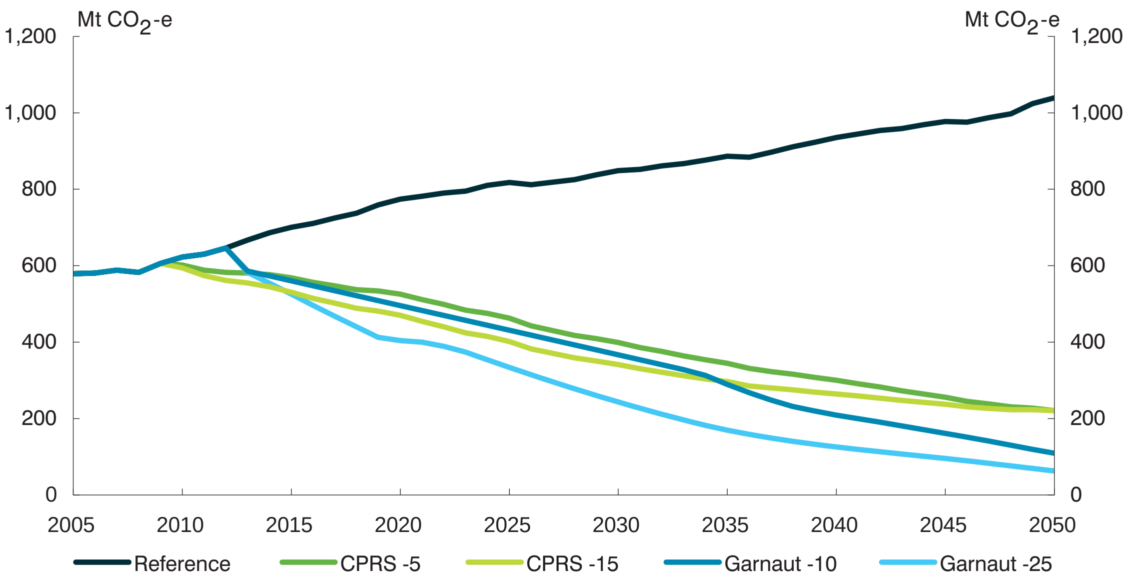
Source: Treasury estimates from GTEM.

8 This rate of return embodies all the commercial risks of holding permits. The 4 per cent embodies a risk-free real rate of 2 per cent and a risk premium in permit markets of 2 per cent.

2.2.2 Australia's emission pathways

The reference scenario and the four policy scenarios correspond to different medium and long-term emission targets for Australia (Chart 2.2). The gap between the reference and policy scenarios is large; the gaps between the policy scenarios are relatively small. This highlights the fundamental shift in emission trends required to achieve the stabilisation levels considered in this report. Once that occurs, the differences — in terms of aggregate economic impacts — are relatively small.

Chart 2.2: Australia's emission pathways



Note: Modelled emissions are shown for the reference scenario, while allocations (policy targets) are shown for the policy scenarios. Actual emissions differ from allocations due to banking of permits and international permit trade.

Source: Treasury estimates from MMRF; Garnaut (2008a).

Each trajectory has corresponding medium- and long-term emission reduction targets (Table 2.2). The targets are reductions relative to Australia's emissions in 2000. Also shown are the per capita reductions. Because Australia's population is projected to grow significantly, an absolute reduction of 5 per cent (in the CPRS -5 scenario) by 2020 corresponds to a 27 per cent reduction in per capita emissions. Each scenario's name indicates the assumed national 2020 target.

Table 2.2: Australia's emission reduction targets
Relative to 2000 levels

	Reference per cent	CPRS -5 per cent	CPRS -15 per cent	Garnaut -10 per cent	Garnaut -25 per cent
Medium-term targets – at 2020					
National	+40	-5	-15	-10	-25
Per capita	+8	-27	-34	-31	-44
Long-term targets – at 2050					
National	+88	-60	-60	-80	-90
Per capita	+10	-77	-77	-88	-93

Source: Treasury estimates from MMRF; Garnaut (2008a).

In a trading environment, actual national emissions are unlikely to match national targets in any given year. If actual emissions are higher than the target, emitters could use previously banked permits or purchase emission rights in the global market; if actual emissions are lower, emitters could bank emission rights for future use or sell them in the global market.[9] As a result, national emission trajectories and targets define Australia's contribution to the global mitigation effort rather than Australia's actual emissions.

2.2.3 Policy settings

International emissions trading and national emission targets drive emission reductions in the policy scenarios (Table 2.3). They act as a simple proxy for the possible policy mix. This stylised approach allows the comparison of alternative national emission trajectories. In reality, a mix of policies and programs is likely to be adopted at local, national, regional and global scales.

9 The Government proposes not to allow the export of Australian permits in the initial years of the Carbon Pollution Reduction Scheme, but favours open linking within the context of an effective global emission constraint (DCC, 2008a).

Table 2.3: Summary of policy assumptions

	CPRS -5 and CPRS -15	Garnaut -10 and Garnaut -25
Australia's emissions trading scheme	Starts in 2010. Is based broadly on the *Carbon Pollution Reduction Scheme Green Paper:* – unlimited banking of permits. – excludes agriculture until 2015. – offsets impact on transport fuels through fuel excise changes until 2013. – shields emission-intensive trade-exposed sectors until 2020, then phases this out. – constrains international permit trade until 2020; then unlimited.	Starts in 2013. Covers all emission sources. Does not constrain international trade in permits. Does not shield emission-intensive trade-exposed sectors (as emission price starts simultaneously in all countries).
Other Australian mitigation policies	Includes Renewable Energy Target of 45,000 GWh per year by 2020.	Does not have other mitigation policies. These cease with emissions trading.
International action	Multi-stage approach: – developed countries set targets and participate in international emissions trading from 2010, developing countries gradually join the scheme with complete coverage from 2025. – national emission targets gradually diverge from reference scenario emission levels. – scheme participants have equivalent emissions trading scheme policy settings to Australia (for coverage, shielding and limits on import of permits).	Unified action from 2013 with national emission trajectories based on a contraction and convergence approach. All countries converge from current levels to equal per capita emission rights by 2050.

2.3 The models

This report uses a range of economic and other models. Models are a useful analytical tool because they account for many of the complex relationships between different activities in the economy, and between Australia and the world. This report uses economic models to assess four dimensions of mitigation policy in Australia:

- global — including the rate and pattern of economic growth, technology development and emissions. This determines the magnitude of climate change risks, scale of the global mitigation task, and trade and capital flows affecting Australia's economy.
- national — including the overall performance of the macroeconomy and patterns of growth across industries, sectors, states and territories. This determines aggregate effects on regions, firms and households.
- sectoral — including likely technological developments and the timing and scale of opportunities to reduce energy use and emissions. This determines the rate and cost of emission reductions, and consequent effects on prices of goods and services.
- household — including detailed impacts on incomes, consumption and prices.

No single model adequately captures all four dimensions. Previous Australian studies of climate change mitigation policy typically focused on one in isolation from the others. This report uses a suite of models that together span global, national, sectoral and household scales to provide an integrated set of projections across all four dimensions (Box 2.2).

The results require careful interpretation.

- None of the models in this analysis incorporates the impacts of climate change itself. The models, therefore, reflect only the costs, not the benefits, of mitigation policy.
- Climate change operates over very long timeframes, so quantitative analysis must take a long-term view. As the timeframe lengthens, assumptions become more speculative.
- The models used in this report are not well suited to examining short-term adjustment paths, so may underestimate costs from changing capital and retraining workers. G-Cubed (one of the global models) incorporates some stylised adjustment costs, so provides some insights to adjustment processes, albeit at an aggregated level. The bottom-up models also provide insights to the adjustment process in the electricity generation and transport sectors.
- The databases used in the whole-of-economy models aggregate firms into broad industry categories, so do not examine firm-level impacts.
- The models do not capture the effects of uncertainty, or non-market factors which can significantly affect economic behaviour.

Box 2.2: The suite of models

The Treasury's climate change analysis centres on three top-down, computable general equilibrium (CGE) models developed in Australia: GTEM, G-Cubed and MMRF. CGE models are whole-of-economy, capturing interactions between different sectors. GTEM and G-Cubed model the global economy, whereas, MMRF is a model of the Australian economy, with rich industry sector detail. Economic modelling is inherently uncertain; using a suite of models provides a broader perspective on possible impacts.

Treasury has worked with economic modellers within and outside government to develop and improve the CGE models, including updating databases, enhancing model flexibility, and incorporating new research and analysis of sectoral growth prospects and mitigation potential.

Bottom-up models of electricity generation, transport and land-use change and forestry complement the CGE models. Detailed analysis of these sectors enriches the understanding of the economy's likely response to climate change mitigation policy, particularly in the short to medium term. Analysis of the impacts on industry costs, consumer prices and household incomes uses the Treasury's own models.

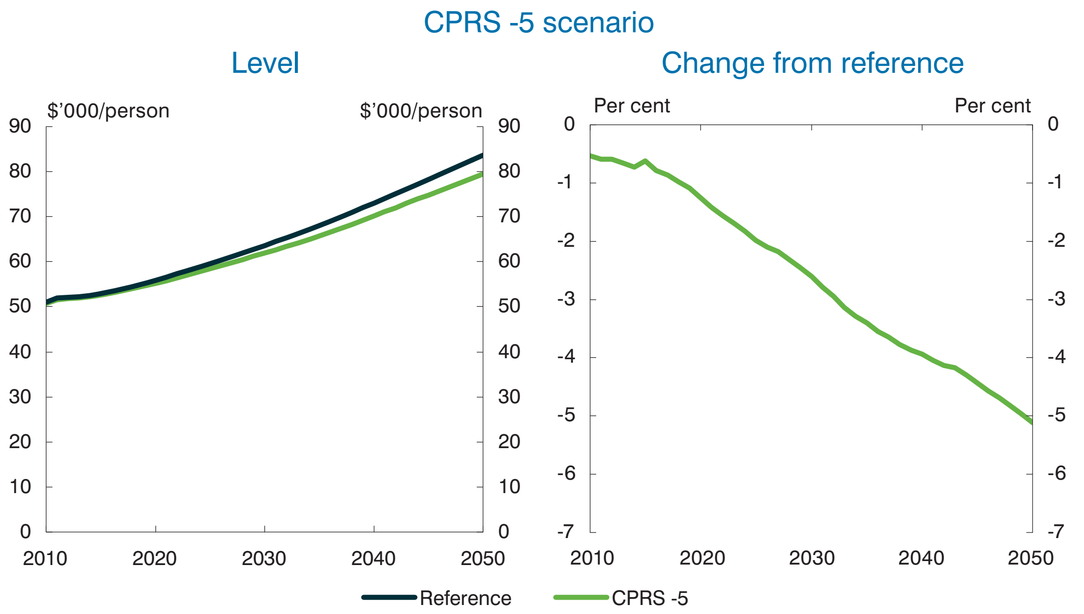
In combination, these models provide an integrated set of projections that are broadly consistent at the macroeconomic level and sufficiently detailed in key sectors.

2.4 Interpreting the results

Modelling results can be presented in different ways, which can influence how people intuitively interpret the results. For example, modelling results are often discussed relative to a reference scenario. This is a sensible approach when examining how a particular economic policy, or shock, will influence the economy in isolation from other events.

Results reported in this way do not mean the policy will have an absolute impact relative to the current world. For example, if GNP per capita in the policy scenario is 1 per cent lower than in the reference scenario in a particular year, this can nevertheless be consistent with continued strong growth in real GNP per capita in the policy scenario. The GNP per capita level is expected to be lower than it would otherwise have been, not lower than its current level. To illustrate this point, Chart 2.3 shows two measures (levels and deviation) of exactly the same result.

Chart 2.3: Impacts on real GNP per capita



Source: Treasury estimates from MMRF.

Changes expressed as a percentage of the reference scenario GNP level indicate the scale of the costs, and allow comparison across years and economies. On the other hand, differences between policy and reference scenario growth rates are appropriate for comparing long-term mitigation costs (Barker et al, 2006). This report uses both measures. In addition, it presents current levels where they provide an important or useful reference point for a particular effect.

Box 2.3: Measuring economic impacts

The modelling encompasses a wide range of variables that could be used to measure mitigation costs. This report focuses on gross national product (GNP) as the appropriate high level measure of economic welfare rather than gross domestic product (GDP). GDP measures output but GNP captures output and international income transfers. Reducing greenhouse emissions, in a cost-effective way, involves international trade in emission rights and influences Australia's terms of trade. Given that context, GNP is a better measure of welfare, and better depicts the current and future consumption possibilities available to Australians.

An issue that has received a great deal of attention in the context of the economic costs and benefits of climate change is how to account for results over long timeframes, in particular how to discount the value of future events. This report focuses on mitigation costs alone, and reports all results in real terms, that is adjusted for inflation, so this presentation issue does not arise.

CHAPTER 3: IMPLICATIONS FOR AUSTRALIA

Key points

Economic prosperity improves in a low-pollution future. Even ambitious emission reduction goals have little impact on growth in Australia's economy and in household incomes.

Large reductions in emissions do not require reductions in economic activity, because the economy restructures in response to emission pricing.

Real household income continues to grow, although households face higher prices for emission-intensive products, such as electricity and gas.

Broadly based market-oriented mitigation policies reduce the cost of achieving emission reduction goals. Exempting emission sources from emission pricing increases costs.

Early global mitigation reduces long-term costs. Strong global action towards low stabilisation levels provides insurance against climate change uncertainty.

There are advantages to Australia acting early if emission pricing expands gradually across the world. Economies that defer action face higher long-term costs, as more emission-intensive infrastructure is locked in place and global investment is redirected to early movers.

Australia's mitigation costs are higher than most developed economies due to its large share of emission-intensive industries. Differentiation of developed countries' national emission reduction targets could help reduce differences in mitigation costs between countries.

Participation in global emissions trading is important to minimising Australia's costs.

Australia's costs will be affected by progress in low-emission technologies, particularly carbon capture and storage, which will affect future demand for Australia's coal resources.

Australia's comparative advantage will change in a low-emission world. Impacts on Australian producers will depend largely on their emission-intensity relative to other producers.

Lower demand for Australia's emission-intensive commodity exports could generate benefits for other export-oriented and import-competing industries through its impact on Australia's exchange rate.

Allocation of some free permits to emission-intensive trade-exposed sectors, as the Government proposes, eases their transition to a low-emission economy. Shielding redistributes costs from shielded to unshielded sectors, and could redistribute costs amongst shielded sectors.

Emission pricing will accelerate the development and deployment of new low-emission technologies.

This chapter covers the macroeconomic, sectoral and distributional impacts of different emission trajectories on the Australian economy. It analyses the global economic and mitigation policy context, then sets out the implications for different sectors and households.

Box 3.1: The reference scenario: starting point for analysis

The reference scenario is a major determinant of mitigation costs, because it determines the scale of the mitigation task.

Important global trends in the reference scenario include strong global economic growth; rising per capita incomes; slowing population growth over the century; continuing reliance on fossil fuels for energy (although the competitiveness of renewable energy sources improves over time); and falling emission intensity of the global economy from 0.7 kg CO_2-e/US$ in 2008, to 0.6 in 2020 and 0.4 by 2050.

As a result, the reference scenario projects strong growth in global greenhouse gas emissions from roughly 42 Gt CO_2-e in 2008 to 57 Gt in 2020 and over 100 Gt by 2050.

Australia sees similar trends: rising per capita incomes and population; declining emission intensity of the economy, from 0.6 kg CO_2-e/A$ of GDP in 2006, to 0.3 kg CO_2-e/A$ in 2050; and rising national emissions, which grow from around 580 Mt CO_2-e in 2008 to 770 Mt in 2020 and more than 1,000 Mt by 2050.

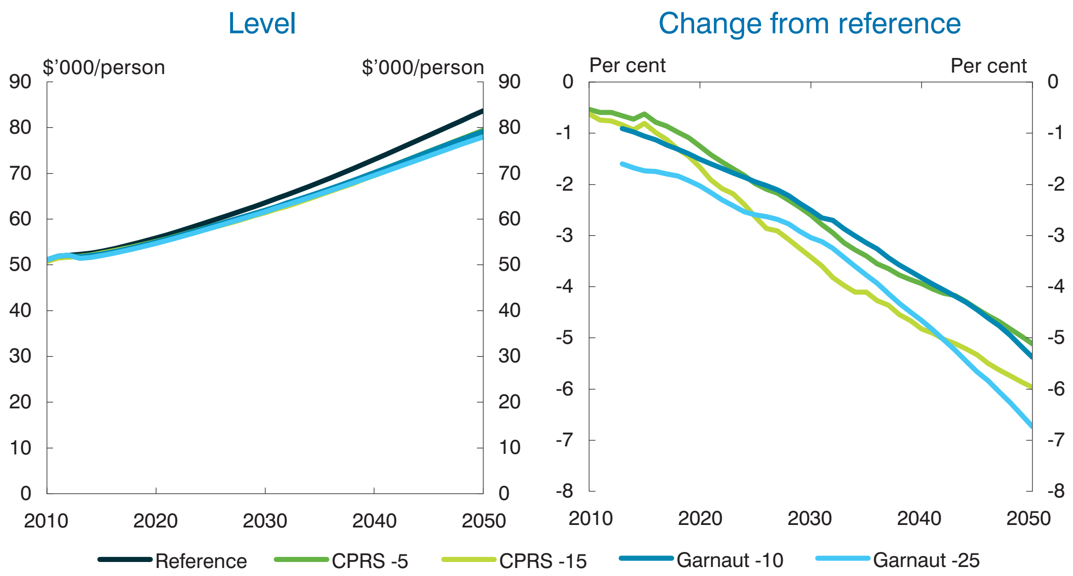
Australia's emissions growth to 2020 in the reference scenario is stronger than Australia's most recent official projections (DCC, 2008b). This is largely due to different sector productivity and stronger economic growth assumptions in the reference scenario, and the absence of new mitigation policies, such as the planned increase of the Renewable Energy Target.

Global emissions in the reference scenario are significantly higher than the reference scenario in many other studies. This increases the overall global mitigation task and associated costs.

3.1 Aggregate national impacts

All four policy scenarios modelled achieve sustained economic growth while substantially reducing emissions. From 2010 to 2050, real GNP per capita grows at an average annual rate of 1.1 per cent in the policy scenarios, compared to 1.2 per cent in the reference scenario. By 2020, real GNP per capita is around 9 per cent above current levels, compared to 11 per cent in the reference scenario. By 2050, real GNP per capita is 55-57 per cent above current levels, compared to 66 per cent in the reference scenario.

Chart 3.1: Australian real GNP per capita



Source: Treasury estimates from MMRF.

Emission pricing has slightly smaller impacts on Australia's GDP. From 2010 to 2050, real GDP per capita grows at an average annual rate of 1.2-1.3 per cent in the policy scenarios, compared to 1.4 per cent in the reference scenario. Change in real GDP is not a complete measure of the economic impacts of emission pricing, as it does not include income transfers associated with international emissions trading.

Stabilising at lower concentration levels requires faster cuts in global emissions and higher emission prices. Stabilisation at 550 ppm requires an initial emission price of A$23/t$CO_2$-e in 2010 in nominal terms (A$20 in 2005 dollars). The starting price is 40 per cent higher to achieve 510 ppm (CPRS -15 scenario) and 110 per cent higher to achieve 450 ppm (Garnaut -25 scenario). Higher emission prices generally result in higher aggregate economic costs.

Emission pricing produces a one-off rise in the consumer price index (CPI) of around 1-1.5 per cent for emission prices in the CPRS scenarios, which start at around A$23-32/t$CO_2$-e (A$20-28 in 2005 dollars). Emission pricing is expected to have minimal implications for ongoing inflation; however, changes in coverage (such as extending the Carbon Pollution Reduction Scheme to agriculture in 2015) could produce additional smaller increases in the CPI at that time.

Large reductions in emissions do not require reductions in economic activity because the economy restructures in response to the emission price. Demand shifts from emission-intensive products such as coal, aluminium, beef and road transport towards lower-emission products such as renewable energy, wood products, chicken and rail transport. The emission intensity of production falls, so that, for example, the metals processing sector produces more iron and steel per unit of emissions. Production methods switch to less emission-intensive technologies and processes, such as electricity generation moving from conventional fossil fuel technologies to renewable sources and carbon capture and storage.

Box 3.2: Comparison of costs with other studies of mitigation policy

A number of recent studies explore the potential economic impacts of mitigation policy on the Australian economy.

Different assumptions, model parameters and analytical scope (how economic interactions between the global, national and sectoral scales are handled) all drive cost estimates. In addition, cost estimates are strongly affected by emission levels in the reference scenario (which varies across studies), as this determines the scale of economic restructuring required to achieve any given emission reduction goal. Other key assumptions include technology availability and cost, and mitigation policy design, including emission reduction targets.

This report's results are within the range of previous estimates. All studies find that even very substantial emission reductions can be achieved while maintaining robust economic growth.

Table 3.1: Mitigation cost estimates: reductions in real GDP and GNP
Change from reference

Scenario/source	GDP reduction in 2020 per cent	GDP reduction in 2050 per cent	GNP reduction in 2020 per cent	GNP reduction in 2050 per cent	Mitigation task(a) in 2050 Mt CO_2-e
CPRS -5	1.1	3.7	1.3	5.1	619
CPRS -15	1.5	4.9	1.7	6.0	742
Garnaut -10	1.1	3.7	1.5	5.4	614
Garnaut -25	1.6	5.8	2.0	6.7	868
Climate Institute(b)	0-2.0	2.3-4.2	0-1.8	0.3-3.4	912-1205
Allen Consulting	1.4	6-13	n/a	n/a	714-888
ABARE	0.7-2.7	1.7-10.7	n/a	n/a	307-573
Concept Economics(b)	0.7-3.9	1.1-6.1	0.6-3.8	1.0-5.4	241-418

Notes: (a) Mitigation task is the difference between emissions in the reference and policy scenarios.
(b) Climate Institute results are for 2030 (not 2020); Concept Economics results are for 2030 (not 2050).

Source: Treasury estimates from MMRF; Climate Institute (Hatfield-Dodds et al, 2007); Allen Consulting Group (2006); ABARE (Ahamaad et al, 2006); and Concept Economics (2008).

The economy's response to emission pricing allows large reductions in the emission intensity of production, so incomes continue to rise while emissions fall. The emission intensity of the Australian economy falls from 0.3 kg CO_2-e/$ of GDP in 2050 in the reference scenario to less than 0.15 kg CO_2-e/$ of GDP in the policy scenarios.

Table 3.2: Headline national indicators

	Reference	CPRS -5	CPRS -15	Garnaut -10	Garnaut -25
Current levels – at 2008					
Actual emissions, Mt CO_2-e	583	583	583	583	583
GNP per capita, $'000/person	50.4	50.4	50.4	50.4	50.4
Commencement – at 2010 or 2013					
Emission price, real, $/t$CO_2$-e	n/a	20	28	24	43
Medium term – at 2020					
Emission allocation, change from 2000 level, per cent	n/a	-5	-15	-10	-25
Actual emissions, Mt CO_2-e	774	585	529	608	505
Emission price, real, $/t$CO_2$-e	n/a	35	50	35	60
GNP, change from reference, per cent	n/a	-1.3	-1.7	-1.5	-2.0
GNP per capita, $'000/person	55.9	55.2	54.9	55.0	54.7
GDP, change from reference, per cent	n/a	-1.1	-1.5	-1.1	-1.6
Emission-intensity of gross output, kg CO_2-e/$	0.5	0.4	0.3	0.4	0.3
Long term – at 2050					
Emission allocation, change from 2000 level, per cent	n/a	-60	-60	-80	-90
Actual emissions, Mt CO_2-e	1039	420	297	425	171
Emission price, real, $/t$CO_2$-e	n/a	115	158	114	197
GNP, change from reference, per cent	n/a	-5.1	-6.0	-5.4	-6.7
GNP per capita, $'000/person	83.7	79.4	78.7	79.1	78.0
GDP, change from reference, per cent	n/a	-3.7	-4.9	-3.7	-5.8
Emission-intensity of gross output, kg CO_2-e/$	0.3	0.1	0.1	0.1	0.1
Overall impact, 2010-2050					
Real GNP per capita, average annual growth, per cent	1.2	1.1	1.1	1.1	1.1
Real GDP per capita, average annual growth, per cent	1.4	1.3	1.3	1.3	1.2

Note: All Australian dollars, 2005 prices. Actual emissions and emission allocations differ due to permit banking and international permit trade.

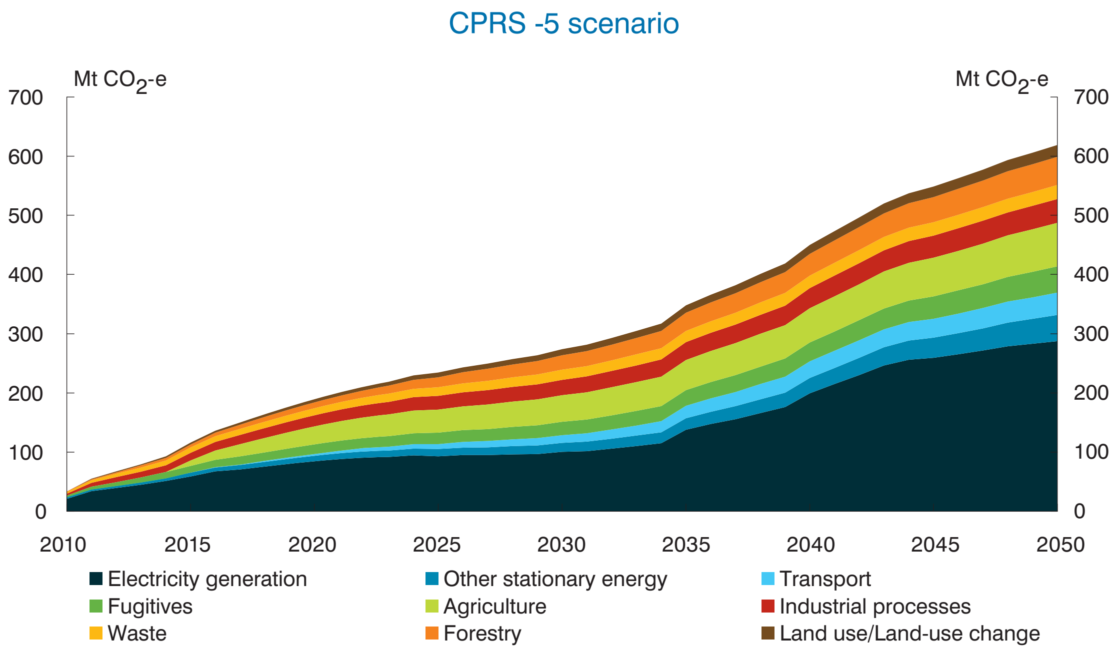
Source: Treasury estimates from MMRF.

While impacts are small at an aggregate level, larger impacts occur at a sectoral level.

All sectors covered by the emission price could reduce emissions (Chart 3.2). Low-emission technologies play an important role in some sectors, such as electricity generation and transport. Changes to management practices, production inputs and processes allow significant emission reductions in agricultural and industrial sectors over time.

The particular mix of mitigation activities projected reflects the assumptions made regarding supply-side opportunities to reduce emissions, and demand-side responses to changes in relative prices. These opportunities and responses are uncertain, particularly over the long term, so are impossible to accurately predict. This is why creating mitigation incentives across the whole economy is more efficient than targeting specific emission sources or sectors. Broadly-based market-oriented policies, such as emissions trading, allow the market to respond as new information about mitigation opportunities becomes available.

Chart 3.2: Emission reductions by sector



Source: Treasury estimates from MMRF.

Developments in the global economy will significantly affect Australia's mitigation costs. Global mitigation efforts will create costs, such as through reduced demand for Australia's coal exports, and benefits, such as through accelerated development of low-emission technologies. The global emission price also will affect Australia's emission price through international emissions trading.

3.2 Australia in the global context

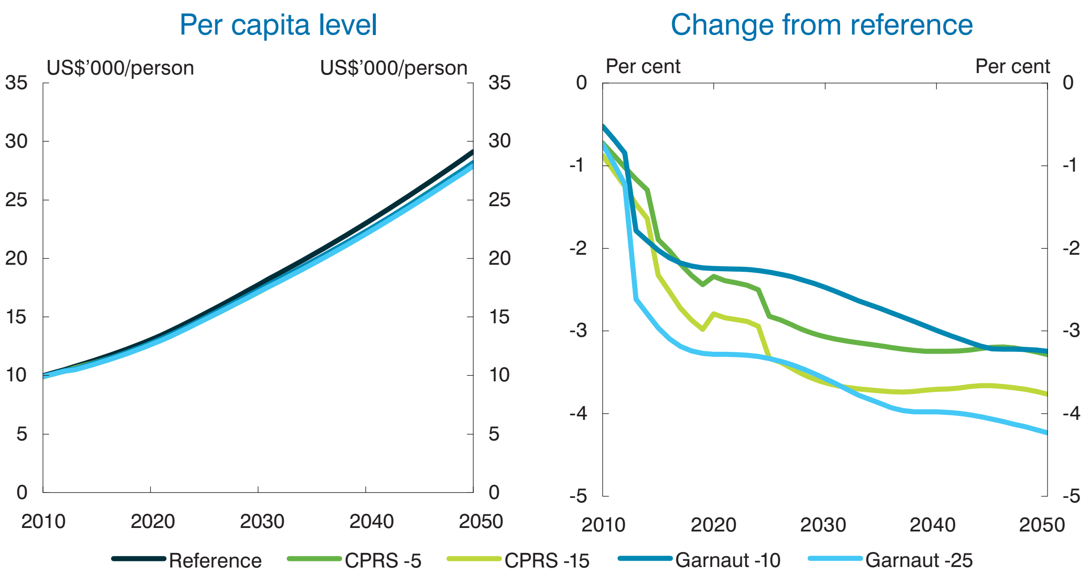
Putting a price on emissions breaks the link between global economic growth and growth in emissions. All scenarios modelled show robust global economic growth, while growth in emissions is dramatically reduced. Australia's aggregate mitigation costs, as a share of GNP, are higher than the world average. Australia has relatively less potential to reduce emissions at low emission prices, so participation in the global emissions trading market is important to minimise Australia's costs. The timing of global action and rate of progress in developing low-emission technologies also affect Australia's overall costs.

3.2.1 The global costs of stabilisation

Mitigation costs vary depending on the nature, horizon and stringency of the global stabilisation target, and the emission pathway travelled to reach it. The global environmental objective is the key determinant of emission prices and aggregate global costs. Lower stabilisation levels, which reduce the risks of dangerous climate change, generally increase mitigation costs. Global costs at 2020, as a share of gross world product (GWP), increase by 50-100 per cent as the stabilisation goal shifts from 550 ppm to 450 ppm; however, this premium narrows over time, so that by 2050 the costs of achieving 450 ppm are around 30-60 per cent higher than those of 550 ppm.

From 2010 to 2050, real GWP grows at an average annual rate of 3.3-3.4 per cent in the policy scenarios, compared to 3.5 per cent in the reference scenario. By 2050, emissions are 65-80 per cent lower than in the reference scenario, while GWP in 2050 is 2.7-4.3 per cent lower (Chart 3.3).

Chart 3.3: Real gross world product



Note: GWP is aggregated using purchasing power parity values. GTEM estimates a 2.7-4.3 per cent reduction from reference scenario GWP in 2050.

Source: Treasury estimates from G-Cubed.

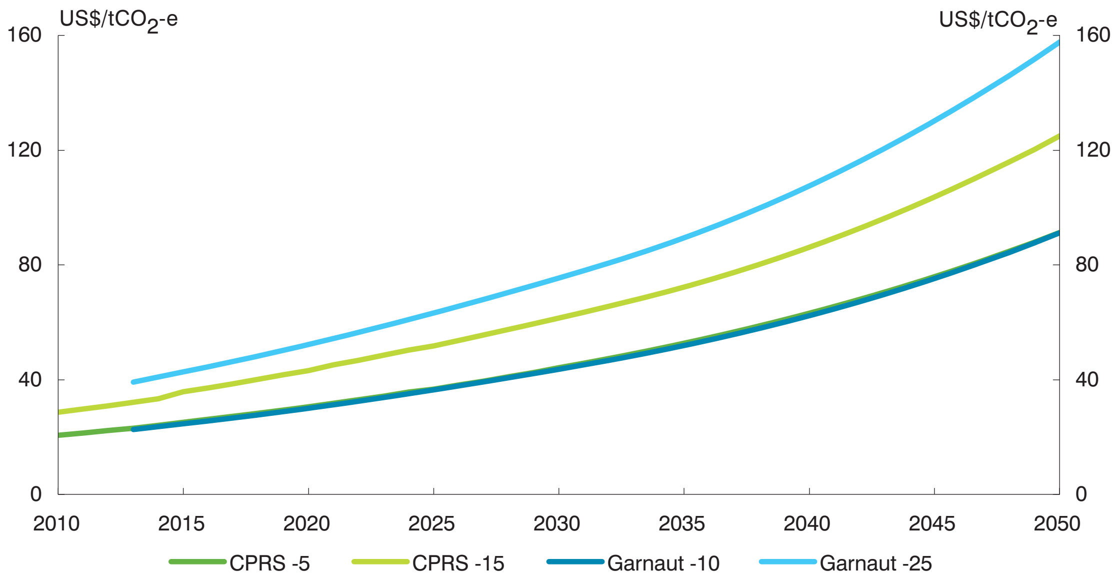
Box 3.3: Setting targets in an uncertain world

The ultimate global environmental objective is uncertain. Even if a stabilisation target is agreed as part of the post-2012 international framework, it may change in the future as understanding of the costs and benefits of mitigation action improves. Stronger mitigation action in the short term helps preserve the option of pursuing lower stabilisation levels, and could be a cost-effective strategy in the face of uncertainty.

Stronger global mitigation action accelerates cost reductions in low-emission technologies, which helps reduce future costs, even if stabilisation goals are relaxed. In contrast, weaker global mitigation action produces higher short-term emissions, which then require faster emission reductions if stabilisation goals are subsequently strengthened. This suggests economic benefits may flow from setting low stabilisation goals at the global level. Weaker global action may prove costly in the long term. This result accords with previous studies of the 'option value' of stronger mitigation action (Yohe et al, 2004).

Stabilising at lower concentration levels requires faster cuts in global emissions, and higher emission prices (Chart 3.4).

Chart 3.4: Global emission price



Note: Price in 2005 US dollars.

Source: Treasury estimates from GTEM.

Table 3.3: Headline world indicators

		Reference	CPRS -5	CPRS -15	Garnaut -10	Garnaut -25
Current levels – at 2008						
Actual emissions, Gt CO_2-e	GTEM	42	42	42	42	42
	G-Cubed	45	45	45	45	45
GWP per capita, US$1,000/person	GTEM	9	9	9	9	9
	G-Cubed	9	9	9	9	9
Medium term – at 2020						
Emission allocation, Gt CO_2-e		57	48	45	50	46
GWP, change from reference, per cent	GTEM		-0.7	-0.9	-0.7	-1.3
	G-Cubed		-2.3	-2.8	-2.2	-3.3
GWP per capita, US$'000/person	GTEM	13	13	13	13	13
	G-Cubed	13	13	13	13	13
Emission-intensity of gross output, kg CO_2-e/US$	GTEM	0.6	0.4	0.4	0.4	0.3
	G-Cubed	0.6	0.4	0.4	0.4	0.4
World emission price, real, US$/t$CO_2$-e			31	43	30	52
Long term – at 2050						
Emission allocation, Gt CO_2-e		102	32	29	31	18
GWP, change from reference, per cent	GTEM		-2.8	-3.5	-2.7	-4.3
	G-Cubed		-3.3	-3.8	-3.2	-4.2
GWP per capita, US$'000/person	GTEM	29	28	28	28	28
	G-Cubed	29	28	28	28	28
Emission-intensity of gross output, kg CO_2-e/$US	GTEM	0.4	0.1	0.1	0.1	0.1
	G-Cubed	0.4	0.1	0.1	0.1	0.1
World emission price, real, US$/t$CO_2$-e			91	125	91	158
Overall mitigation cost, 2010-2050						
GWP per capita, real average annual growth, per cent	GTEM	2.7	2.6	2.6	2.6	2.6
	G-Cubed	2.7	2.6	2.6	2.6	2.6

Note: All dollars are real US (2005); GWP is aggregated in purchasing power parity. Emissions in the reference scenario are actual emissions from GTEM.

Source: Treasury estimates from GTEM and G-Cubed.

Lower stabilisation levels involve tighter constraints on total global emissions, and generally imply lower national emission trajectories and higher national mitigation costs. In the unified global action (Garnaut) scenarios (which allocate emission rights on a per capita basis), stabilisation at 550 ppm implies targets for Australia of 10 per cent below 2000 levels in 2020, and 80 per cent in 2050; whereas, stabilisation at 450 ppm implies targets of 25 per cent and 90 per cent below 2000 levels in 2020 and 2050. To achieve 450 ppm, the associated costs to Australia (as a share of GNP, compared to achieving 550 ppm) increase by around 30 per cent at 2020, and around 25 per cent in 2050.

3.2.2 Australia's economic costs compared to other regions

Mitigation costs will vary widely across economies, both in terms of aggregate economic costs (as a share of GNP) and the marginal cost of reducing each tonne of emissions.

Aggregate costs and marginal costs have different determinants. Aggregate costs largely depend on the share of energy- and emission-intensive industries in the economy (as this determines the extent of economic restructuring required), while marginal costs depend on the nature of emission reduction opportunities in the economy. Some economies, such as Japan, have relatively low aggregate costs but high marginal costs, while others, such as China, have relatively high aggregate costs but low marginal costs. Australia's costs, both aggregate and marginal, are relatively high.

Differences in aggregate economic costs are relevant to assessing the comparability of each country's effort, an important factor in international negotiations on the post-2012 mitigation framework.

Among Annex B countries, Australia is likely to face relatively high mitigation costs as a share of GNP. Australia's costs reflect its large share of emission- and energy-intensive industries and dominance of low-cost coal in electricity generation, compared to the United States, Japan and the European Union. Canada and Russia are also fossil fuel producers, and face comparable or higher aggregate mitigation costs than Australia.

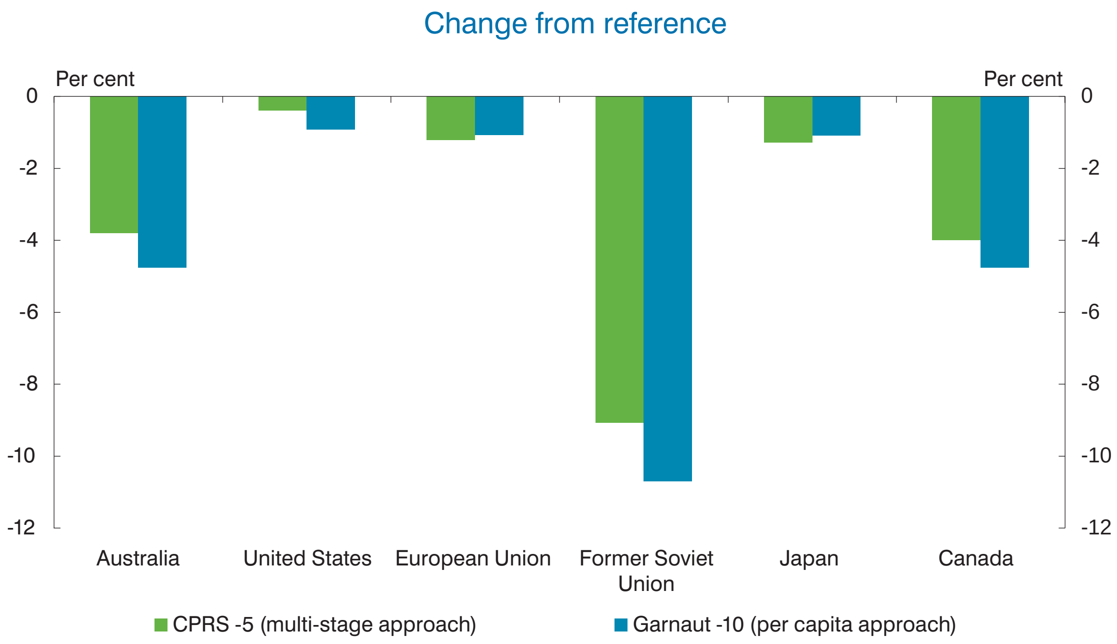
Differentiating national emission reduction targets, by taking account of the existing structure of national economies, could help narrow the differences in aggregate mitigation costs.

This report explores two approaches to determining national contributions to global mitigation: a per capita contraction and convergence approach (Garnaut scenarios); and a simple multi-stage approach (CPRS scenarios). The multi-stage approach reduces costs for Australia, Canada and Russia, relative to the per capita allocation, and increases costs for the European Union and Japan to a limited extent.[10] This outcome is a result of Australia's relatively high per capita emissions, which means that a per capita approach results in a more stringent emission reduction target in Australia, compared to the multi-stage approach.

While the level of impact changes, the overall pattern of relative costs is the same for the two approaches (Chart 3.5).

10 All Annex B countries benefit from the multi-stage approach in the long term, due to the benefits of early action.

Chart 3.5: Real GNP costs in Annex B countries in 2050



Source: Treasury estimates from GTEM.

All Annex B countries achieve strong growth in real GNP per capita in all policy scenarios. While Russia and the transition economies incur the greatest aggregate costs relative to the reference scenario, their real GNP per capita growth is strongest (albeit from a lower base), and it grows to more than three times current levels by 2050. Real GNP per capita in all other regions increases by 52-80 per cent from current levels in the policy scenarios, compared to 54-85 per cent in the reference scenario.

Both the per capita and multi-stage approaches seek to take account of the different responsibility and capacity of developing countries. Even so, many developing countries face similar or higher mitigation costs as a share of GNP than developed countries, because of the larger contribution of emission- and energy-intensive industries to their overall economies.

3.2.3 Australia's marginal costs and international permit trade

Whether, and how much, international trade in emission permits is allowed will affect Australia's costs in achieving any given emission trajectory.[11] The pattern of international permit trade depends on the allocation of emission rights and the relative marginal cost of mitigation (the cost of reducing an additional tonne of emissions) in each region.

International trade can reduce the cost of achieving emission reduction targets because it allows mitigation to occur wherever it is cheapest. Trade does not compromise the environmental objective, because Australia's 'excess' emissions are offset by lower emissions in economies that export permits.

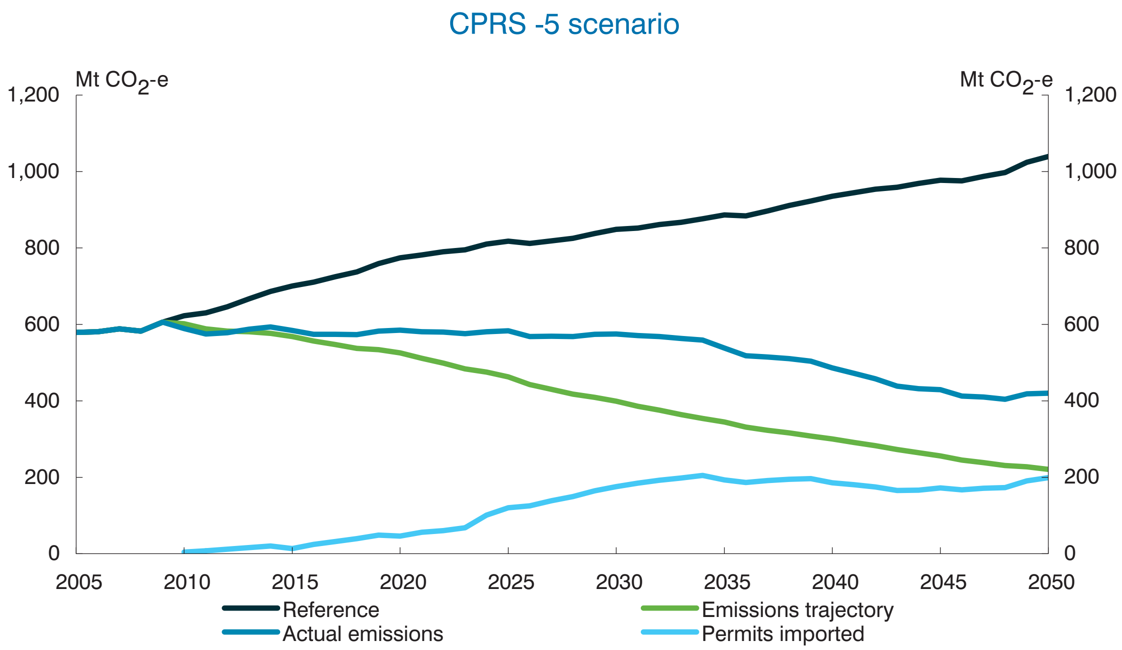
11 References to emission permits include approved project-based offset mechanisms such as credits created under the Kyoto Protocol's Clean Development Mechanism.

The global analysis suggests Australia's marginal costs are higher than many other economies for three key reasons.

- Australia's abundant low-cost fossil fuels make low-emission electricity generation technologies less competitive. As a result, Australia needs higher emission prices to reduce emissions in its electricity sector.
- Agriculture comprises a larger share of Australia's economy, and has fewer mitigation options than many other sectors. Australia is projected to retain a comparative advantage in agriculture in a low-emission world, and so maintains agricultural output, with the associated emissions.
- Like most other developed economies, Australia's pre-existing energy-efficiency standards are higher than in developing economies. Any reduction at the 'margin' is thus more costly.

This means it is cost-effective for Australia to import permits to meet its emission target. Australia's *gross* emissions are generally higher than the national trajectory, and Australia's emission trajectory therefore represents its *net* emissions after trade. Australia is projected to import more permits over time (Chart 3.6). Imports plateau when carbon capture and storage technologies are widely deployed, driving significant emission reductions in Australia's electricity generation sector.

Chart 3.6: Australia's trajectory, actual emissions and permit trade



Source: Treasury estimates from MMRF.

This highlights the importance of establishing a robust and efficient global market that allows all economies to access low-cost mitigation. Linking the Carbon Pollution Reduction Scheme to market-based schemes elsewhere in the world would equalise marginal costs across economies, and help reduce the cost of Australia's contribution to the global mitigation effort (DCC, 2008a; and Prime Ministerial Task Group, 2007).

The multi-stage (CPRS) scenarios explore the potential costs of trade restrictions. Permit trade is capped until 2020 at 50 per cent of mitigation effort.[12] This has no or negligible impact on Australia's costs, depending on the model, because Australia meets its obligations through a mix of domestic mitigation (at the global emission price), permit banking, and trade to the allowed level. If the trade constraints were binding (if fewer permits were banked in the early years, or less domestic mitigation was available), the domestic emission price would rise to stimulate the additional mitigation required to meet the national emission cap. This would tend to increase aggregate mitigation costs.

While international emissions trading reduces the cost of achieving any given stabilisation goal, exempting emission sources (whether sectors, gases or regions) from the trading scheme increases costs. If mitigation from forestry activities is not included in the global framework, the emission price required to achieve 550 ppm could rise by 30 per cent, and global costs (as a share of GWP in 2050) could rise by around 25 per cent. Reducing deforestation and increasing reforestation could provide lower-cost mitigation.

3.2.4 The benefits of early action and the costs of delay

Delaying mitigation action in the global economy will increase climate change risks, lock in more emission-intensive industry and infrastructure, and defer cost reductions in low-emission technologies. This will increase the cost of achieving any given environmental goal.

In a sensitivity analysis where global mitigation action is delayed by seven years, the short-term benefits of delay are quickly outweighed by the additional costs, as greater emission reductions are required in a shorter time to achieve the same environmental outcome. As a result, global costs as a share of GWP are about 10 per cent higher in 2050, and remain higher for the rest of the century. While forward-looking behaviour by firms, individuals, and investors may reduce the size of this effect, this will depend heavily on expectations regarding future mitigation policy.

Extended delay by some major emitters could make stabilisation at low levels impossible. For example, if Annex B countries reduce their emissions to zero by 2050, but other countries follow reference scenario emission levels, greenhouse gas concentrations would be over 650 ppm by 2050 and rising.

If emission pricing is introduced gradually, rather than in all economies at the same time, long-term costs are lower for early movers, and higher for economies that delay. The economies that defer emission pricing become more relatively emission-intensive, so when an emission price is eventually introduced, they face greater costs, particularly because global investment is redirected to early movers.

This is one reason why Australia faces lower costs under the multi-stage approach: while GDP impacts are marginally higher than in the unified approach at 2020, impacts are roughly 10 per cent lower by 2050, reflecting the benefits of greater inward foreign investment.

If global agreement is considered inevitable (at least in the long term), Australia could gain a relative advantage by starting to reduce emissions early.

3.2.5 The role of technology

Progress in developing low-emission technologies is important for reducing global and Australian mitigation costs. Faster technological progress will reduce costs; slower progress will increase costs relative to the central policy scenarios.

12 Effort is defined here as the difference between reference scenario emissions and the national emission trajectory.

More optimistic technology assumptions reduce global costs (measured as a share of GWP) by about 20 per cent in 2050, compared to central technology settings. On the other hand, if carbon capture and storage does not prove commercially viable, global mitigation costs at 2050 could be 10 per cent higher than under central technology assumptions.

Australian costs are sensitive to technology assumptions, as technological progress will affect the value of, and demand for, Australia's coal resources. Australia's costs as a share of GNP in 2050 are 25 per cent lower under more optimistic assumptions, and 25 per cent higher if carbon capture and storage is not viable, compared to central technology assumptions.

3.3 Impacts at the sectoral level

While mitigation policies impose relatively small aggregate costs on Australia, impacts vary widely across sectors (Table 3.4, Chart 3.7).

Pricing emissions drives a structural shift in the economy from emission-intensive goods, technologies and processes towards low-emission goods, technologies and processes. As a result, growth slows for emission-intensive sectors, such as coal, gas, iron and steel, and livestock. Growth accelerates for low and negative-emission sectors, such as forestry and renewable energy.

Pricing emissions also changes Australia's comparative advantage. Australia maintains or improves competitiveness where local production is less energy- or emission-intensive than production of the same good in other countries, such as for coal, and loses competitiveness where local production is more emission-intensive, such as for aluminium.

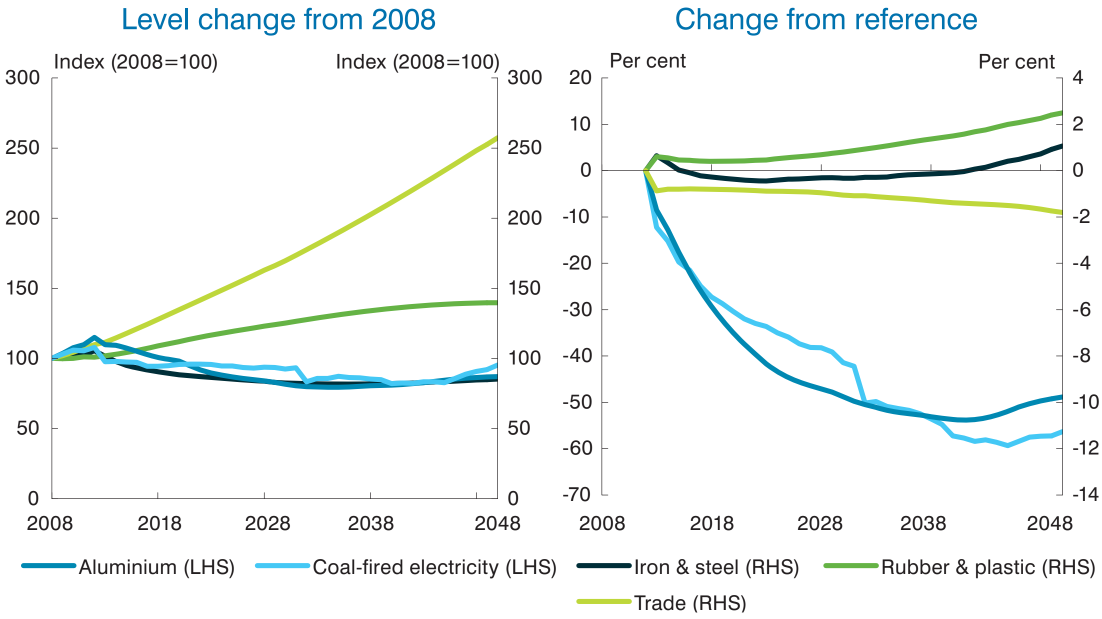
Lower demand for Australia's emission-intensive commodity exports could generate benefits for other export-oriented and import-competing industries through its impact on Australia's exchange rate. Impacts on non-traded low-emission sectors, such as services, broadly reflect the aggregate impact on the domestic economy.

Table 3.4: Impacts across sectors – scale and primary cause
Garnaut -10 scenario, change in gross output relative to reference

Industry sector	2020 per cent	2050 per cent	Key economic drivers
Iron and steel	-0.4	+1.1	Exchange rate depreciation
Coal-fired electricity	-30	-56	Shift to low-emission technologies
Coal mining	-3.7	-26	Falling world demand
Rubber and plastic products	+0.4	+2.5	Exchange rate depreciation
Forestry(a)	+29	+166	Emission credits and rising demand
Aluminium	-35	-49	Loss of competitiveness
Trade	-0.8	-1.8	Reflects domestic economy

Note: (a) Forestry output estimates are based on land area.
Source: Treasury estimates from MMRF.

Chart 3.7: Impacts across sectors
Gross output, Garnaut -10 scenario



Source: Treasury estimates from MMRF.

Effects are broadly consistent across all the scenarios, although sectoral gains and losses are generally larger for lower stabilisation levels. This section presents results based on the unified global action scenario (Garnaut -10), because the assumption of unified global action simplifies the analysis and several sensitivity studies were based on this scenario. The discussion contrasts the results for the other scenarios where differences are important.

3.3.1 Impacts on emission-intensive sectors

Global demand for emission-intensive commodities falls in response to emission pricing. Where Australia has relatively low emission intensity of production, emission pricing improves its competitiveness and is likely to increase its share of global trade in that commodity. This could partially or wholly offset the effect of slowing global demand growth. Where Australia has relatively high emission intensity, competitiveness declines and Australia's share of global trade is likely to fall (Box 3.4).

Box 3.4: Sectoral impacts and structural adjustment

The difference between changes relative to the reference scenario, and changes relative to the level of current activity, are important in assessing structural adjustment needs.

The economy will adjust from its current structure. Mitigation policies will change the pattern of future economic activity, so the reference scenario economy of 2050 will not eventuate. Today's economy, therefore, provides a useful reference point.

The policy scenarios project large reductions in the output of some sectors relative to the reference scenario. However, most of these sectors are projected to grow from current levels; the reductions relative to the reference scenario mean they grow more slowly than they would in a world without climate change.

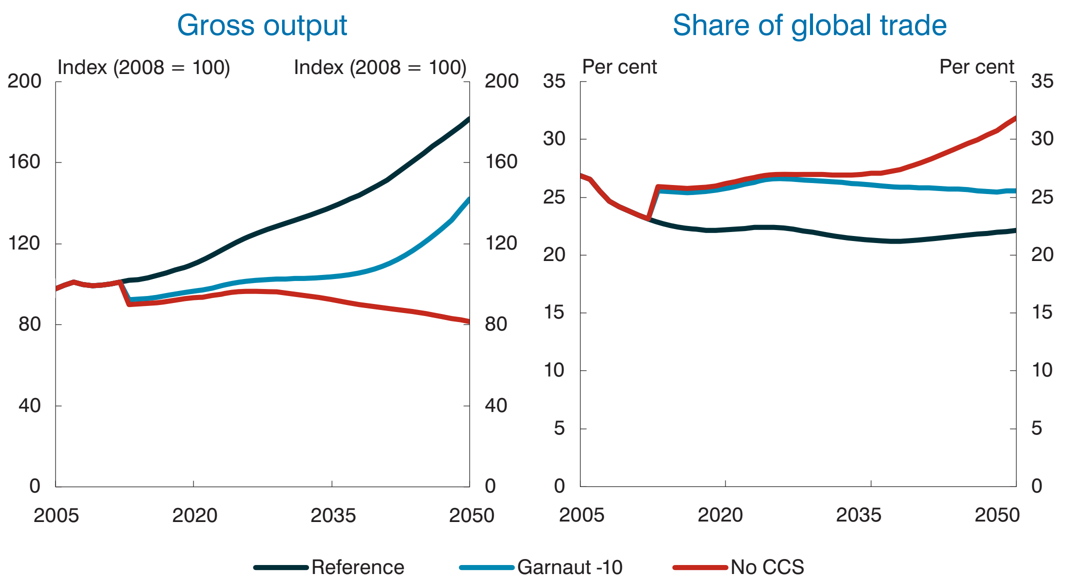
Within sectors, some firms and regions could face a serious adjustment task, including early plant closures. The transition will need careful management. The Government is committed to supporting affected workers and regions where required, and has proposed special measures to manage impacts on emission-intensive trade-exposed sectors and coal-fired generators (DCC, 2008a).

In the medium to long term, employment and investment will move to other lower-emission sectors.

Australian output of key emission-intensive exports, such as coal, aluminium and meat products, grow more slowly than in the reference scenario in all four policy scenarios, as consumers across the world substitute towards lower-emission commodities. However, Australia's share of global trade increases for coal, and is broadly maintained for iron and steel. Australia's share of global trade falls for aluminium, given its relatively higher emission intensity of production in Australia.

Effective carbon capture and storage technologies are key to future demand for coal. Overall, across the four policy scenarios (which assume this technology is viable), Australia's coal output grows relative to current levels. If carbon capture and storage is not viable, coal output falls from current levels (Chart 3.8).

Chart 3.8: Australia's coal sector



Source: Treasury estimates from GTEM.

Impact on competitiveness in a multi-stage world: the role of shielding

Coordinated global efforts help ensure any changes in Australia's comparative advantage arise from real differences in the emission intensity of production, rather than from uncoordinated policy action. Competitiveness distortions may arise where Australia prices emissions before other economies: emission-intensive trade-exposed sectors (EITES) could move to other locations that are more emission intensive than Australia, but not yet pricing emissions. As a result, global emissions could rise, a process called 'carbon leakage'.

The Government proposes transitional assistance for EITES when it introduces the Carbon Pollution Reduction Scheme to reduce carbon leakage and support the transition to a low-emission economy (DCC, 2008a). This transitional assistance 'shields' EITES from the full effect of emission pricing. Crucial features of the proposed shielding are that shielded firms face a strong incentive to reduce emissions, even if they obtain free emission permits, and that the level of shielding gradually declines.

The risk of carbon leakage and cost of shielding is explored in the CPRS scenarios, which assume Australia prices emissions ahead of many other regions.[13]

The results show little evidence of carbon leakage. Where shielding is removed, the emissions and output from EITES in non-participating regions do not increase. This suggests the emission prices in these scenarios are not high enough to induce significant industry relocation. Noticeable impacts only occur at much higher emission prices (roughly double the price of the CPRS -5 scenario).

Nevertheless, shielding does reduce the impact of emission pricing on shielded sectors in the initial years of the scheme. When shielding is applied, output of EITES falls relative to the reference scenario (reflecting the contraction in world demand), but at a more gradual rate. This effect is particularly significant for the aluminium sector. This suggests the shielding arrangements proposed in the *Carbon Pollution Reduction Scheme Green Paper* could ease the transition to a low-pollution future for the shielded sectors.

13 The Garnaut scenarios assume emission pricing is introduced in all economies at the same time, so no carbon leakage occurs.

Shielding redistributes costs from shielded to unshielded sectors, through its impact on electricity prices (higher output in EITES brings greater demand for electricity, and so higher prices), and on permit trading (higher output in EITES means that Australia imports more permits to meet its emission target). Shielding also redistributes costs amongst shielded sectors, by diverting labour and capital from more to less competitive EITES.

Redistribution effects would be greater if shielding mutes mitigation incentives, if a greater proportion of permit revenue is devoted to shielding, or if more permits could not be imported (because international permit trade was more limited).

Both GTEM and MMRF are likely to overestimate carbon leakage and the relocation of production activities: the models are not forward-looking (so firms are assumed to take no account of the possibility of future emission prices in the new location), and do not account for adjustment costs associated with relocation. In reality, industry location reflects multiple factors, including access to skilled labour, legal and political stability, access to resources and quality of infrastructure. These factors suggest that fears of carbon leakage could be overplayed.

3.3.2 Impacts on low-emission sectors

Demand for low-emission goods and services increases, particularly where they provide an alternative to higher-emission commodities, or the emissions trading market creates a new source of revenue.

These effects are evident in the forestry sector. Consumers substitute towards wood products (a low-emission good) and forests sequester carbon and generate credits for sale in an emissions trading scheme.[14]

Forestry's expansion has flow-on effects for some agricultural sectors, particularly cattle and sheep grazing. These activities compete for land, so as forestry expands, livestock production contracts (relative to the reference scenario). This effect strengthens in the scenarios with lower stabilisation levels, as the higher emission prices make forestry even more profitable than competing land uses.

The modelling may overstate impacts on agriculture, as the MMRF model does not differentiate between different land types (high quality agricultural land versus marginal land). If forest expansion occurs predominantly on marginal land, agricultural output may be relatively less affected.

3.3.3 Flow-on effects

Global demand for Australia's coal and aluminium falls in a low-emission world. As a result, Australia's terms of trade — which measure the price of Australia's exports relative to the price of Australia's imports — fall relative to the reference scenario.

This in turn causes Australia's exchange rate to depreciate, which improves the competitiveness of many other export-oriented and import-competing industries, including manufacturing. Wood products; textiles, clothing and footwear; non-meat food; motor vehicles and chemical manufacturing benefit from the lower exchange rate, and increase output relative to the reference scenario. Iron ore mining, dairy and grains also benefit from the lower exchange rate.

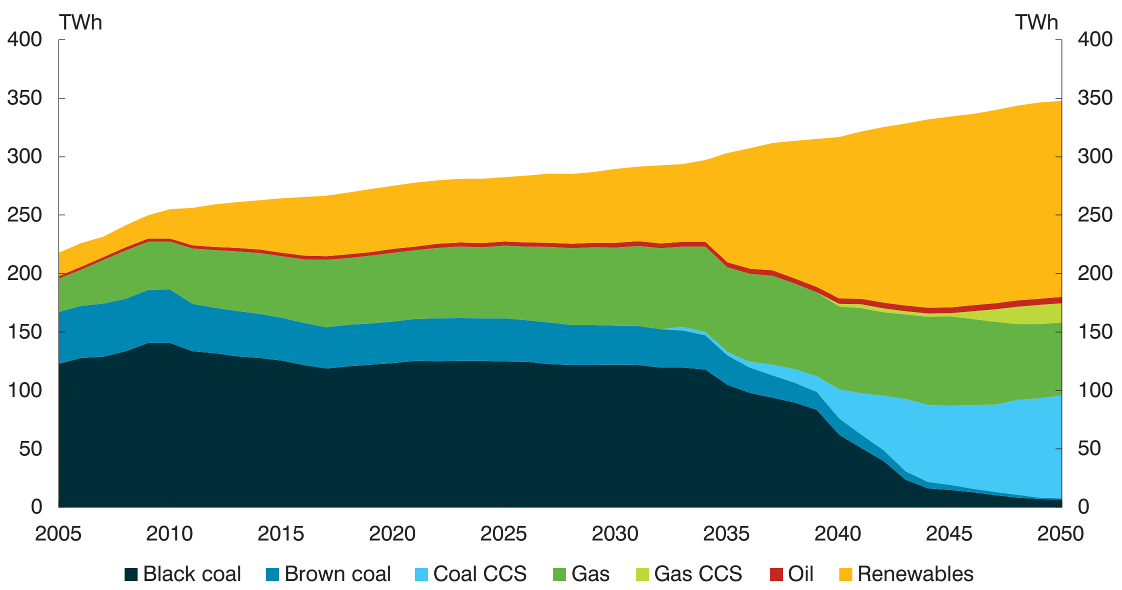
14 The *Carbon Pollution Reduction Scheme Green Paper* proposes to allow reforestation activities to opt in to the scheme from its start in 2010 (DCC, 2008a).

3.3.4 Technological transformation of electricity and transport

Electricity generation accounts for the largest share of Australia's current emissions, reflecting the dominance of coal-fired technologies in Australia. Transport accounts for a smaller but significant share of national emissions. Pricing emissions will drive significant changes in the technology mix of both sectors, improving the competitiveness of renewable energy sources and more efficient technologies, and accelerating the development and deployment of new low-emission technologies.

The mix of future electricity generation technologies is highly uncertain. Demand levels and technology and input costs will play a crucial role and are difficult to predict. Fuel types are likely to shift, with emission prices driving the timing and magnitude of the shift. Conventional fossil fuel technologies will become less competitive; gas (significantly less emission intensive than coal) is likely to increase its market share in the short term; and renewable technologies will become increasingly competitive over time. From the mid-2020s, carbon capture and storage begins to replace conventional coal-fired technologies, including through retrofitting existing power plants (Chart 3.9).

Chart 3.9: Australian electricity generation by fuel



Note: This scenario includes the 45,000 GWh Renewable Energy Target.

Source: MMA.

Emission pricing could bring forward the retirement of some conventional fossil fuel plants, and stimulate construction of substantial new generating capacity. By 2050, renewables account for at least 40 per cent of generation across the policy scenarios, compared to just over 5 per cent in the reference scenario.

Australia's electricity supply remains secure. Emission pricing and adoption of low-emission technologies increases the cost of electricity generation. As these costs are passed on to electricity consumers, demand falls. The combined effect of reduced demand and new plant construction ensures generation capacity meets projected demand in all scenarios.

The planned Renewable Energy Target of 45,000 GWh per year in 2020 stimulates extra renewable deployment in the short term, and brings forward additional domestic mitigation. This does not change Australia's emission price, due to links between Australian and global emission permit markets. However, electricity prices increase slightly, resulting in slightly lower GDP in 2020. GNP is less affected, as the additional domestic mitigation means fewer permits are imported.

As low-emission generation technologies capture a larger share of generation, electricity becomes relatively less emission intensive than other energy sources. This leads industry, households and transport to replace direct use of fossil fuels with electricity. As a result, electricity demand increases strongly relative to the reference scenario after 2050.

The transport sector has relatively higher marginal mitigation costs than electricity, so delivers less mitigation in the short term. Nevertheless, emission pricing drives significant reductions in the emission intensity of transport, including through changes in the fuel mix, vehicle types and transport modes.

Emission pricing improves the competitiveness of lower-emission technologies, such as diesel, and reduces the competitiveness of synthetic fuels (liquid fuels derived from coal and natural gas). As a result, diesel's share of road transport fuel demand increases from around 20 per cent in the reference scenario to 30 per cent in all policy scenarios at 2050; synthetic fuels' share falls from around 10 per cent in the reference scenario to zero in all policy scenarios.

The increased price of transport fuels accelerates the uptake of more efficient vehicle technologies, such as hybrids, as well as a shift towards smaller vehicles. By 2050, electric and plug-in hybrid vehicles supply about 25 per cent of the community's transport needs, compared to around 2 per cent in the reference scenario. Higher road transport costs also stimulate a shift towards rail, particularly for freight.

3.4 Impacts on households

Real household income grows strongly in all policy scenarios. Households face higher prices for emission-intensive products, such as electricity and gas. The share of household income spent on these goods is likely to fall over time.

3.4.1 Introduction of emission pricing

The initial household impacts of the two CPRS scenarios were modelled using Treasury's price and distributional models. This modelling assumes the emission price is fully passed through to consumers, and consumers do not change their consumption of goods and services in response to changing relative prices. Both assumptions will tend to overestimate impacts, so these estimates are likely to represent an upper bound on initial consumer price impacts at a given emission price.

Based on the CPRS scenarios, the emission pricing is projected to lead to a one-off rise in the consumer price level of around 1-1.5 per cent, with minimal implications for ongoing inflation.[15]

Emission pricing will have the greatest impact on emission-intensive goods, such as electricity, gas and other household fuels. The average household is expected to spend an extra $4-5 per week on electricity and $2 per week on gas and other household fuels. This corresponds to an increase in electricity prices of 17-24 per cent and in gas prices of 11-15 per cent.

15 These estimates differ slightly from those presented in the *Carbon Pollution Reduction Scheme Green Paper* as the Green Paper analysis was based on a hypothetical emission price of $20, whereas this range is based on the modelled CPRS scenarios. In addition, the models used have been updated for new input-output data.

The Government plans to offset the impact of emission prices on emission-intensive petroleum fuel products through cuts in fuel taxes (DCC, 2008a), so the price of petrol does not increase when the scheme starts. Similarly, while sheep and cattle production is emission intensive, the price of meat products does not rise when the scheme starts, as the Government plans to exclude agriculture from the scheme in the initial years.

Lower income households are likely to be more affected by the introduction of an emission price than other households, as they generally spend a higher proportion of their disposable income on emission-intensive goods, and may be less able to substitute away from these goods. A single pensioner household in the lowest quintile of disposable income faces an average price rise in 2010 of 1.3 per cent, while households in the highest quintile of disposable income face an average price rise of 0.9 per cent (Table 3.5).

The Government is committed to helping households adjust to the Carbon Pollution Reduction Scheme, including by increasing benefit payments and other assistance to low- and middle-income households through the tax and payment system. These measures, together with the automatic indexation of benefits to reflect changes in the CPI, will help minimise household impacts.

Table 3.5: Estimated price impacts in 2010
CPRS -5 scenario

	Household income quintile(a)					
Household type – primary source of income	All per cent	First per cent	Second per cent	Third per cent	Fourth per cent	Fifth per cent
All	1.0	1.2	1.1	1.0	1.0	0.9
Two income household, no children(b)	0.9	**	1.2	1.0	0.9	0.9
Two income household, with children(b)	1.0	**	1.0	1.0	0.9	1.0
One income household, no children(b)	0.9	0.9	1.0	1.0	1.0	0.8
One income household, with children(b)	1.0	**	1.1	1.0	1.0	0.9
One income single person household(b)	1.0	**	1.1	1.0	1.0	1.0
Self-employed household	1.0	1.2	1.0	1.1	1.0	1.0
Household with primary income source from Commonwealth allowances (e.g. Newstart Allowance, Youth Allowance)	1.2	1.2	1.2	**	**	**
Married pensioner household	1.1	1.2	1.0	**	**	**
Single pensioner household	1.3	1.3	1.2	**	**	**
Sole parent pensioner household	1.2	1.3	1.2	**	**	**
Part-pension and self-funded retiree household	1.0	1.0	1.0	1.0	1.0	0.9

Note: (a) Income quintiles rank households from the lowest 20 per cent of disposable income to the highest 20 per cent.
(b) Principal source of income from wages and salaries.

** Represents those results for which the sample size is too small to produce statistically reliable results.

Source: Treasury.

3.4.2 Household impacts over time

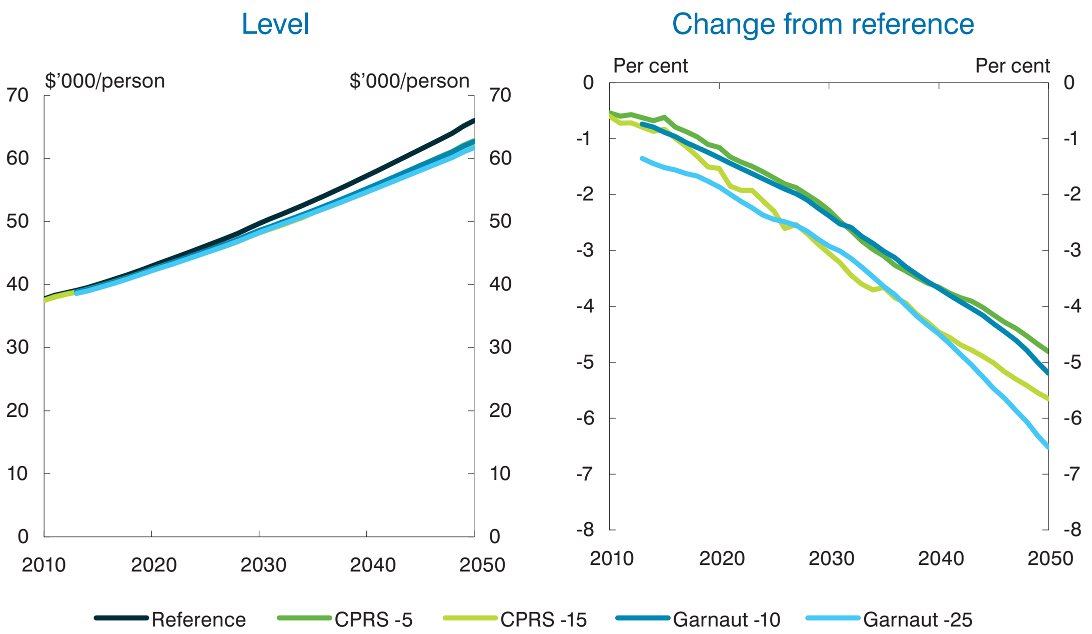
Real household income grows strongly over coming decades in all scenarios. Real disposable income per capita grows at an average annual rate of around 1 per cent in the policy scenarios, compared with 1.2 per cent in the reference scenario. As a result, it is about 7-9 per cent higher than current levels by 2020, and about 50 per cent higher by 2050 (compared with 10 and 60 per cent in the reference scenario).

The largest relative price increases occur for emission-intensive goods such as road and air transport, electricity, and gas used for heating. The relative prices of most products that comprise a large share of household spending (including services, communication, accommodation and housing) fall. Households substitute away from emission-intensive products as their relative prices change.

The share of household income spent on energy and other emission-intensive goods is likely to fall over time. Emission-intensive goods and services comprise a small share of household spending over time in the reference and all four policy scenarios.

Overall, impacts on household consumption broadly mirror the impacts on the overall economy: consumption continues to grow at a slightly slower rate (Chart 3.10).

Chart 3.10: Real consumption per capita



CHAPTER 4: KEY FINDINGS AND FUTURE ANALYSIS

Key points

Australia's economy is well placed to respond to market-based mitigation policies.

With efficient policy settings, Australia can achieve its emission reduction objectives and maintain robust economic growth.

Real household incomes continue to grow with emission pricing. Households will face higher prices for emission-intensive products, however, the Government is committed to helping households adjust to Australia's low-pollution future.

Strong coordinated global action reduces the economic cost of achieving environmental objectives, reduces distortions in trade-exposed sectors, and provides insurance against climate change uncertainty. Where emission pricing gradually expands across the world, there are advantages to being an early mover.

If Australia prices emissions before its competitors do, some emission-intensive trade-exposed sectors could lose some competitiveness. Allocation of some free permits, as proposed by the Government, eases their transition. Fears of carbon leakage may be overplayed.

Accurately predicting which mitigation opportunities will prove most cost effective is impossible. Instead, broadly-based market-oriented policies, such as emissions trading, allow the market to respond as new information becomes available.

Australia's economy will respond to the emission price by restructuring. Most sectors will grow. Firms in a few industries face lower levels of output, and the consequent structural adjustment will require careful management.

This report has not found evidence that pricing emissions will compromise Australia's future energy security.

A key challenge for future economic analysis of climate change policies is to develop methods, models and capacity to allow more integrated analysis of the costs and benefits.

4.1 Principal findings

The world and Australia can significantly reduce the risks of dangerous climate change and maintain robust economic growth.

They can do this by introducing efficient mitigation policies which price emissions. Mitigation costs fall as the policy coverage expands. If all sources of emissions across the globe are included, mitigation costs are minimised. This involves participation by all regions and all sectors to reduce emissions of all greenhouse gases.

Stabilising greenhouse gases at low concentrations requires global action: stabilisation at any level is not possible without mitigation action across all major emitters. If the world acts now, using efficient policy frameworks, it could achieve even low stabilisation levels at relatively low cost. Early strong global action keeps open the option of pursuing more ambitious stabilisation levels in the future, if that proves desirable, and provides insurance against the risks of serious and irreversible climate change.

Delaying action increases the risks and costs of achieving any given environmental goal.

The insurance value of pursuing very low global stabilisation targets (450 ppm and below) and strong united global mitigation action warrants further analysis (Garnaut, 2008a). This issue is critical to current global climate change discussions, including negotiations on the post-2012 mitigation framework.

4.1.1 Implications for Australia in the global context

Australia's aggregate mitigation costs (as a share of GNP) are likely to be higher than the major developed economies, due to its large share of emission- and energy-intensive industries. The global mitigation policy framework therefore will be an important factor in the costs Australia faces.

A broader and deeper international emission market will help minimise the cost of achieving Australia's emission reduction goals, by creating access to lower cost mitigation opportunities in other regions, and minimising distortions associated with trade-exposed industries.

Full participation in international emissions trading would minimise the additional costs associated with more stringent national emission trajectories; strong links between Australia's Carbon Pollution Reduction Scheme and other robust, credible emission markets are crucial.

Comparisons of national emission reduction commitments for the post-2012 period must account for differences in the cost impacts across Annex B regions.[16] Australia, Canada and Russia will likely face higher aggregate economic costs than the United States, the European Union and Japan. Differentiation of national commitments could help offset these cost differences to some extent.

Assuming that global action is eventually forthcoming, economies introducing emission pricing early gain an advantage over the long term, and those that delay face higher costs later. Early action, including by developing economies, is clearly consistent with continued economic development: even for low stabilisation levels, all regions maintain economic growth.

Early mitigation action could ensure economic development supports prospects for long-term growth. For developing economies, delaying obligations could be a costly way to differentiate responsibilities, as delays could encourage further build-up of emission-intensive capital stock that later becomes a significant liability. Early action allows individuals and firms to plan their adjustment pathways and better manage changes in skills acquisition and capital stocks.

16 Annex B of the Kyoto Protocol lists countries with quantified emission reduction commitments ('Kyoto targets'), and includes the members of the OECD and economies in transition (Russia and other eastern European nations).

The relative costs of different international policy frameworks are crucial to current international negotiations and warrant further analysis.

4.1.2 National and trade implications

Economic reforms in Australia over the past three decades have created a flexible and adaptable economy, making it well placed to respond to price-based policies, such as the Carbon Pollution Reduction Scheme, and make the transition to a low-pollution future.

With efficient policy settings, Australia can achieve its emission reduction objectives and maintain robust economic growth. Efficient policies have broad coverage of emission sources and sinks, link to international permit markets, do not limit banking of permits for future use, and provide clear signals regarding future emission reduction targets.

Trade in permits is more efficient than achieving all required emission reductions domestically, as it allows mitigation to occur wherever it is cheapest. Trade does not compromise the environmental objective because Australia's 'excess' emissions are offset by lower emissions in economies that export permits.

Australia's comparative advantage will change in a low-emission world. Australia is likely to retain or improve competitiveness in some energy- and emission-intensive sectors, such as iron and steel, coal and livestock. Australia's competitiveness is likely to decline in other sectors where Australian production is relatively more emission-intensive than its competitors. Modelling suggests this is true for sectors such as aluminium and petroleum refining.

If Australia prices emissions before its competitors do, some emission-intensive trade-exposed sectors could lose some of their competitiveness. However, the results suggest fears of carbon leakage may be overplayed. The report finds little evidence of leakage at emission prices corresponding to all but the most stringent stabilisation goal examined.

The shielding arrangements proposed for emission-intensive trade-exposed sectors in the *Carbon Pollution Reduction Scheme Green Paper* could help ease the transition to a low-emission economy, and assist affected industries with the required structural adjustment.

Overall, shielding redistributes costs from shielded to unshielded sectors of the economy and amongst shielded sectors. The scale of costs will depend on the specific policy design. Maintaining clear mitigation incentives for shielded sectors is crucial. If the level of shielding is increased, or eligible sectors expanded, this would increase costs.

The costs associated with shielding highlight the importance of establishing an effective global mitigation framework. Broad participation in international emissions trading, sectoral agreements or equivalent measures could reduce competitiveness distortions stemming from national mitigation policies.

Slower growth in world demand for energy commodities, especially coal, will lower Australia's terms of trade. In response, the exchange rate (which acts as a buffer to changes in world demand) would be expected to depreciate, thereby helping to maintain the international competitiveness of many other export-oriented and import-competing industries, particularly manufacturing.

This report details possible structures of a low-emission Australian economy. The models approximate the short-term constraints in the real world economy, and cannot provide specific details of the transitional process in all sectors. Further analysis, focused on the short-term implications of mitigation policy, would complement this report.

The scenarios focus on market-based policies that price emissions. This approach helps isolate the effects of different emission reduction trajectories on the Australian economy. This report does not examine the role of policies such as support for research and development into low-emission technologies, and energy-efficiency standards. Where these policies tackle other market failures, such as the public good value of innovation, asymmetric information and split incentives, they could reduce the cost of achieving Australia's emission reduction objectives.

4.1.3 Other implications for sectoral activity

Opportunities to reduce greenhouse gas emissions exist in all sectors of the Australian economy.

The mix of mitigation activity (exactly how much occurs where, and when) is uncertain. An accurate prediction of what sectoral mix of changes in supply and demand will be the most cost-effective route to a low-pollution future is impossible. This underscores the importance of policies that create incentives for mitigation across all sectors without mandating where that mitigation occurs.

Pricing emissions will generate different costs and benefits across different sectors.

Firms in a few industries face lower levels of output compared with current levels. The consequent structural adjustment will require careful management of asset closures, worker retraining and regional planning. The Government is committed to providing additional support to assist affected workers and regions where required (DCC, 2008a).

Electricity and transport together account for almost half of Australia's current emissions; by switching to more energy-efficient and low-emission technologies, they could reduce emissions substantially in coming decades. Further analysis of the short-term implications for the electricity supply industry is warranted. The Council of Australian Governments has asked the Ministerial Council on Energy to consider key energy sector issues raised by the Carbon Pollution Reduction Scheme.

Australia's low-emission electricity generation technology options and prospects include renewables (geothermal, wind, solar and wave) and carbon capture and storage. Consequently, the electricity generation sector should achieve large emission reductions over time, even if some technologies being explored do not prove commercially viable. This report has not found evidence that pricing emissions will compromise Australia's future energy security.

The future cost, performance and timing of carbon capture and storage will affect Australia's coal industry and coal-producing regions. Australia's aggregate mitigation costs will be lower if carbon capture and storage proves commercially viable, as this will help sustain global demand for coal, and therefore, the value of Australia's extensive coal deposits.

Strong, credible and long-term mitigation policy frameworks are likely to stimulate research, development and deployment of low-emission technologies, and help reduce future mitigation costs. Future emission price expectations, and therefore policy credibility, are crucial.

4.1.4 Implications for households

The initial impact on households will be through increases in electricity and gas prices. The CPRS scenarios show a one-off rise in the consumer price index (CPI) of 1-1.5 per cent. Price impacts on petrol and meat products will be deferred until later years through the effect of the fuel tax offset and initial exclusion of agriculture from the scheme. While the price impact of the scheme is estimated to be relatively larger for low-income households, these impacts will be offset by the Government's commitment to help households adjust.

Electricity and gas together account for a small proportion of household spending, and so, despite the price rise, will have only a small effect on overall household consumption. Over time, real household incomes continue to rise strongly.

4.2 Conclusion

This report brought together many of Australia's leading climate change economists to comprehensively analyse the potential effects of mitigation policies on the Australian economy. It rigorously examines and assesses the implications of policies to reduce greenhouse gas emissions for the Australian economy. The report is a key input to Government decisions regarding Australia's future emission pathway, and Australia's role in an effective global response to climate change.

This is a complex policy area, and the Government is drawing on many sources of advice and will consider the full range of costs and benefits of mitigation policy. The Government will consider public responses to this report before it makes its decision on Australia's emission targets for the medium term.

This report forms part of a much wider body of work on the economic impacts of climate change. This report looks only at the costs of mitigation, not the benefits. A critical challenge for future analysis is to develop methods, models and capacity that will allow a more integrated analysis of these costs and benefits.

Climate change analysis will remain a policy priority, informed by ongoing scientific and economic developments and the evolving international policy landscape.

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