

Australia's Low Pollution Future

The Economics of Climate Change Mitigation

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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.

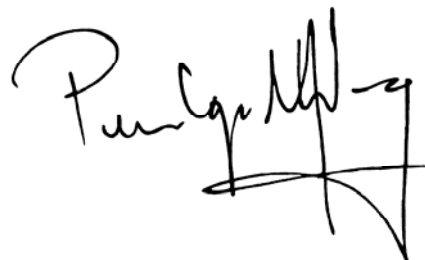
These issues are clearly important to decisions on Australia's scale and rate of emission reductions in coming years.

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

ACKNOWLEDGMENTS

A task of this scale and complexity requires the contributions of many people and many organisations.

This report is the product of a collaborative effort across the Australian Government, the Garnaut Climate Change Review and leading national and international climate change economists.

The Treasury's climate change modelling team is led by Meghan Quinn. Team members are Liangyue Cao, Andrew Ceber, Patrick Costello, Robert Ewing, Owen Gabbitas, Jyothi Gali, Andrew Gurney, Melissa Hinson, Shane Johnson, Damian Mullaly, Hom Pant, Temay Rigzin, Kath Rowley, Robert Scealy, Tom Skladzien, Robyn Stuart and Nicholas Stoney. Helal Ahammad, Sam Hester, David Stephan, Maya Stuart-Fox and Bruce Taplin also contributed.

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ABBREVIATIONS AND ACRONYMS

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CCGT	Combined cycle gas turbine
CCS	Carbon capture and storage
CCSP	Climate Change Science Program (United States)
CDM	Clean Development Mechanism
CGE	Computable general equilibrium (model)
CH ₄	Methane
CIS	Commonwealth of Independent States (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan)
CO ₂	Carbon dioxide
CO ₂ -e	Carbon dioxide equivalent
CPI	Consumer price index
CPRS	Carbon Pollution Reduction Scheme
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCC	Department of Climate Change
EITES	Emission-intensive trade-exposed sector
ESM	Energy sector model
ETS	Emissions trading scheme
GCOMAP	Generalized Comprehensive Mitigation Assessment Process (model)
GDP	Gross domestic product
GNP	Gross national product
GSP	Gross state product
Gt	Gigatonne
GTAP	Global Trade Analysis Project
GTEM	Global trade and environment model
GVA	Gross value added
GWh	Gigawatt hour
GWP	Gross world product
HES	Household Expenditure Survey

HFCs	Hydrofluorocarbons
IEA	International Energy Agency
IGCC	Integrated gasification combined cycle
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
kt	Kilotonne
LNG	Liquefied natural gas
MAC	Marginal abatement cost
MAGICC	Model for the assessment of greenhouse gas induced climate change
MER	Market exchange rate
MMA	McLennan Magasanik Associates
MMRF	Monash Multi-Regional Forecasting (model)
MRET	Mandatory Renewable Energy Target
Mt	Megatonne
MWh	Megawatt hour
N ₂ O	Nitrous oxide
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PFCs	Perfluorocarbons
PJ	Petajoule
PRISMOD	Price revenue incidence simulation model
PRISMOD.DIST	Price revenue incidence simulation model and distribution model
ppm	Parts per million
PPP	Purchasing power parity
RET	Renewable Energy Target
SF ₆	Sulfur hexafluoride
tCO ₂ -e	Tonne of carbon dioxide equivalent
TWh	Terawatt hour
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VRET	Victorian Renewable Energy Target
WEO	World Economic Outlook
WRI	World Resources Institute

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 CO₂-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 CO₂-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.

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

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

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.

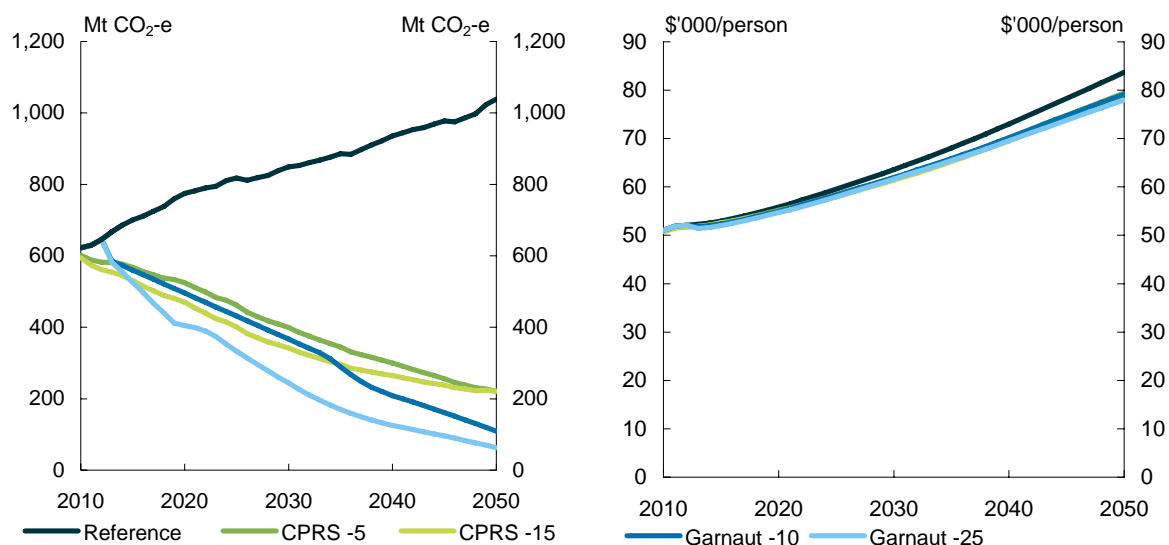
AUSTRALIA IN THE GLOBAL CONTEXT

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).

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).

Chart 1: Five pathways for Australian emissions and GNP
Emissions Real GNP per capita



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/tCO₂-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.

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, \$/tCO 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.

Note: Units are in Australian dollars 2005 prices. Emissions in the reference scenario are actual emissions from GTEM.

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.

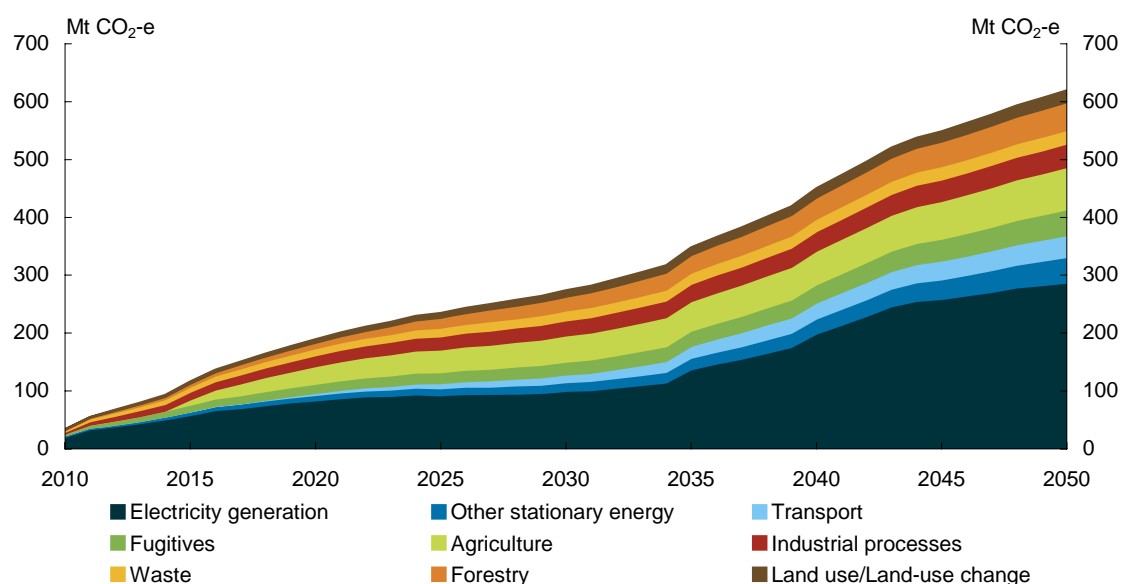
Emission pricing is expected to result in early retirement of some emission-intensive plant and capital, and lead, at least initially, to slightly slower growth in wages and some redistribution of employment. However, these impacts are likely to be restricted to firms in a few specific industries, such 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.

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

Chart 2: Emission reductions by sector
CPRS -5 scenario



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 a substantial 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.