The Climate Institute

LEADER, FOLLOWER OR FREE RIDER?

The economic impacts of different Australian emission targets

Prepared by S Hatfield-Dodds, EK Jackson, PD Adams, W Gerardi

December 2007

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The economic impacts of different Australian emission targets

Summary Report

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*The views expressed in this report are those of the authors, and do not necessarily reflect those of the CSIRO or the Australian Government.

Executive summary

Previous economic analysis by CSIRO, ABARE and the Australian Business Roundtable on Climate Change has found that early action to reduce emissions is consistent with strong continuing economic growth. This previous analysis assumes, in general, that Australia participates in global action; that industrialised countries take the lead in reducing emissions; and that Australia accepts the same emission obligations as other industrialised countries.

The key tension in assessing an appropriate emissions target for Australia is that, all else being equal, deeper and more rapid global emissions reductions would be likely to:

- involve adverse direct economic impacts on Australia through reductions in demand for some of Australia's key exports; but
- provide greater indirect benefits through reducing the pace and extent of climate change and related risks.

This report differs from previous research by examining the relative impacts of Australia taking on a range of emission reduction pathways, higher or lower than the average required for other developed countries.

The economic impacts of these different targets were assessed by the Centre for Policy Studies at Monash University using the MMRF-Green macro economic model of the Australian economy. Consistent with the conclusions of the G8 and others, the analysis assumes global emission reductions of 50% from 2000 levels by 2050. To achieve this goal the scientific literature suggests that developed countries (as a group) would need to reduce their allowable emissions (before international permit trade) by 25 – 40% by 2020 and 80-95% by 2050.The three scenarios assessed against this background were:

Free Rider – Australia stabilises net emissions by 2020 and then reduces them by 40% from 1990 levels by 2050, a reduction that is less than the world average of 50% by 2050. This scenario is called the Free Rider scenario because Australia undertakes only modest action but gains the benefits of global action through reduced climate change impacts.

Follower – Australia follows other industrial nations in global action. Net emissions peak in 2012, are reduced to 1990 levels by 2020 and are 60% below 1990 levels by 2050. This is less than the average required by developed countries to achieve a global reduction of 50% by 2050.

Leader – Australia joins leading nations in global action. Net emissions peak in 2012, are reduced to 20% below 1990 levels by 2020 and, by 2050, Australia effectively becomes carbon neutral as a nation (a 100% reduction in net emissions, including through the purchase of international emissions credits).

The three scenarios all assume the same Australian policy mechanisms – apart from the different emissions targets that define the scenarios – and the same international context. The specification of the scenarios for Australia assumes that developed nations would take the lead in reducing emissions, but that by 2030 all major emitters are actively engaged in global emissions reductions. The analysis assumes developed countries can meet emission obligations through purchase of international emissions offsets, such as those provided by the Clean Development Mechanism (CDM), but at a larger scale.

This analysis does not take into account the benefits of emissions reductions associated with avoided negative impacts of climate change. (Table ES1)

Table ES.1: Climate risks from global warming

Greenhouse gas (CO_2-e) stabilisation	Global warming	What is at risk?	
		Australia	Global
445-490	2.0-2.4°C	• Severe droughts constrain water supplies and farming over wide areas of Australia • More than 90% of the Great Barrier Reef damaged by heat stress every year • 3,000-5,000 more heatwave deaths a year in major population centres • 80% of Kakadu wetlands lost to sea level rise	• Falling crop yields in many developing regions • Significant changes in water availability • Possible onset of collapse of Amazon rainforest • Coral reef ecosystems irreversibly damaged • Many species face extinction (up to 30% of species have increased risk of extinction) • Land-based ecosystems become net sources of greenhouse emissions • Irreversible melting of the Greenland ice sheet (up to 7m rise in sea level)
535-590	2.8-3.2°C	• Severe droughts significantly limit water supplies and farming over a wide area of Australia • Flow in the Murray-Darling Basin falls 16-48% • Most Australian (vertebrate) animals lose 90-100% of core habitat • Functional extinction of coral reefs	• Increasing risk of abrupt, large-scale shifts in the climate system • Collapse West Antarctic Ice Sheet (up to 5m rise in sea level) • Hundreds of millions of people exposed to increased water stress • Hundreds of millions of people exposed to coastal flooding annually

Key results

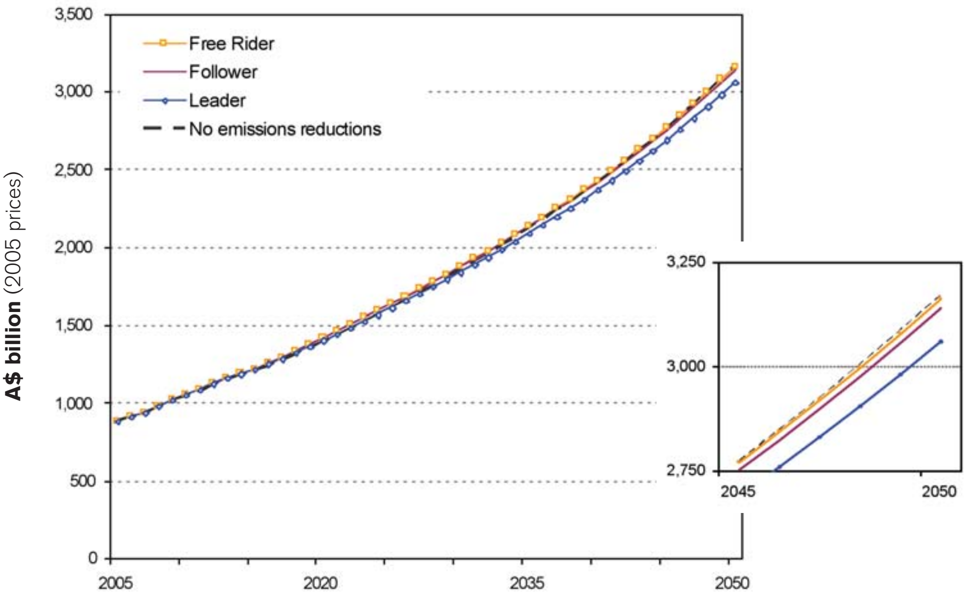
As one of the most vulnerable countries in the developed world to climate change, Australia would benefit significantly from reducing the pace and extent of adverse climate change. However, global emissions reductions will reduce world demand for emissions intensive energy sources, particularly coal, impacting on Australia and other fossil fuel exporting countries.

- This study finds that the negative impacts of a 50% reduction in world emissions, and associated Australian action, are likely to be modest and manageable.

- The modelling suggests that achieving a 40-100% reduction in net emissions by 2050 (including through the purchase of international emissions credits) is consistent with strong economic growth, as shown in Figure ES1. Gross Domestic Product (GDP) and Gross National Product (GNP) increase more than three fold over the 45 years to 2050 across all scenarios. Real GDP grows from less than $1 trillion today to over $3 trillion in 2050 in all scenarios.[†]

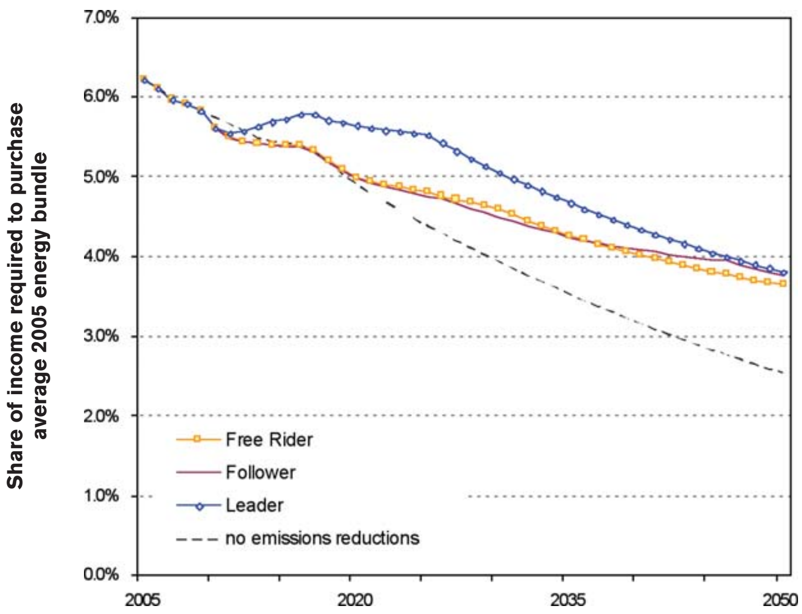
† All results are presented in 2005$

Figure ES.1: Value of economic activity (GNP), all scenarios 2005-2050



- Impacts on employment are very similar across the scenarios and broadly proportional to the impacts on GNP and GDP. Total employment grows by 72% in all three scenarios by 2050, compared with 75% without global or national emissions reductions.
- Real income and economic living standards (adjusted for inflation) grow strongly in all scenarios. Real consumption per person increases 155-158% in the Follower and Free Rider scenarios and 148% in the Leader scenario over the period to 2050, compared to 156% without global or national emissions reductions.
- The modelling suggests that the affordability of energy products would improve, relative to today, across all scenarios, as average real incomes grow more rapidly than real energy prices. Conservatively, the share of average income required to buy the average 2005 consumer energy bundle falls from over 6% in 2005 to below 4% in 2050. (Figure ES2)

Figure ES.2: Energy costs, as a proportion of income, all scenarios 2005-2050



The case for taking a leadership position on emissions reductions

Avoiding dangerous climate change will require decisive global action. It is clear from the climate science that Australia is likely to be more adversely impacted by climate change than most other developed nations, such as through more common and prolonged droughts, more frequent and severe storms, bushfires and floods, and irreversible impacts on the Great Barrier Reef and other fragile ecosystems. This implies that Australia has a stronger interest than most in arguing for deeper and more rapid cuts in global emissions.

There are two major rationales for taking a leadership position in reducing our national emissions.

Prudent Risk Management

First, making more rapid early reductions helps to manage the economic risks to Australia from uncertainty about climate impacts and the pace of global action in response to it. This is because it is much more difficult and costly to accelerate emissions reductions than to decelerate them in response to improved climate science or changing international circumstances. In particular, incremental tightening of long term emission targets risks the premature retirement of long lived emissions intensive capital assets, such as traditional coal fired power stations. Furthermore, climate impacts are driven by cumulative emissions or the overall stock of greenhouse gas in the atmosphere. Therefore, any change in an emission trajectory towards a lower atmospheric stabilisation target needs to offset the stock of past emissions in addition to reducing future emissions. Delayed or overly modest emissions targets thus risk both an 'investment overhang' in plant and equipment with high emissions (at risk of early retirement) and a 'emissions overhang' of past emissions that need to be offset. This implies, as noted by the International Energy Agency, that long term national targets should assume stringent emissions reductions will be required. For example, governments may decide in favour of stabilising concentrations at 550 ppm and adopt a national emissions trajectory consistent with this goal. If, however, changes in scientific information or international circumstances result in lowering of the desired stabilisation target to 400 or 450 ppm in ten years time, emissions would have to drop very sharply. This would involve higher economic impacts than an equivalent, but more gradual, reduction in emissions.

In deciding the most appropriate emission target it is also important to recognise that lags in climate processes mean that precise climate impacts will only be known with certainty after they are too late to avoid, at which point they will be irreversible or likely to take decades or centuries to correct. This contrasts with the economic impacts of emissions reductions, which are reasonably well known, and in most cases involve a delay of a few months or years to reach a given level of economic activity or per capita income.

Leadership and leadership benefits

Second, a clear Australian commitment to decisive emission reductions would help build the confidence and willingness of others to take comparable actions, and provide greater credibility and leverage in mobilising international action to reduce emissions. An associated benefit is that Australia may find it easier to pursue other climate policy objectives, such as in relation to the treatment of emissions intensive traded goods, if it is clear that Australia is not seeking to delay effective global action to reduce emissions.

Beginning the journey to very deep cuts in emissions would also have a number of domestic advantages which are difficult to capture in economic models, such as building a flexible domestic policy regime, the development of new industries and technologies, and expanding the benefits of participating new markets in low emission technologies and emissions offsets.

Taking a leadership position thus buys time and options, akin to buying insurance in an uncertain world.

Assessing the leadership premium

The modelling presented in this report suggests that the 'leadership premium' associated with committing to substantial emission reductions is modest:

- Economic activity increases from less than $1 trillion to around $3 trillion by 2050, with GDP and GNP 1.4% to 3.5% lower in the Leader scenario than in the Follower and Free Rider scenarios.
- Employment increases from 9.7 to around 16.7 million jobs by 2050 across all three emission reduction scenarios.
- Real consumption per person increases from under $24,000 to over $58,000 by 2050 in the leader scenario, around 3.0% to 4.2% lower than in the Follower and Free Rider scenarios.
- Energy price increases occur earlier in the Leader scenario, and will require more active policy management, although energy affordability improves across all scenarios, with expenditure required to purchase the average 2005 energy bundle falling from 6% to 3.8% in the Leader and Follower scenarios and 3.6% in the Free Rider by 2050 (Figure ES.2).

Table ES.2: Impact of Leader scenario relative to other scenarios

	Total change 2005 - 2050			Leader scenario relative to others in 2050	
	Free Rider	Follower	Leader	Free Rider	Follower
Real GNP	256%	253%	244%	-3.3%	-2.6%
Real GDP	249%	247%	242%	-2.0%	-1.4%
Employment	72%	72%	72%	0.0%	0.1%
Real private consumption per person	158%	155%	148%	-4.2%	-3.0%
Difference in net emissions (Mt CO2e)				293	209
Difference in net emissions as a share of emissions in 2010				49%	35%

Note: See Table 4 for performance of the scenarios relative to the base case, without national or global emissions reductions

On the other side of the ledger, the Leader scenario reduces emissions by 209-293 Mt CO_2e more each year than the Follower and Free Rider scenarios respectively. This is equivalent to 35%-49% of Australia projected emissions in 2010, and more than the current annual emissions from the electricity and transport sectors combined.

These findings suggest that making substantial reductions in Australia's net greenhouse emissions is affordable, and consistent with community desires for increasing living standards, economic opportunity, participation and fairness (see Table ES.2 and Figure ES.2).

Committing now to very substantial reductions in emissions would carbon proof the Australian economy, insulating it from future climate policy shocks, and help to achieve decisive global emissions reductions

The key finding of this report is that Australia can afford to take a leadership position in committing to substantial reductions in our net greenhouse emissions, in order to help manage the economic risks to Australia, and to contribute to the global momentum and concrete actions required to avoid dangerous global climate change.

Contents

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The context for choosing an Australian emissions target

The global climate is changing, driven by human activities that release greenhouse gases (GHGs) – primarily burning coal, oil and gas, deforestation, and agriculture.[1] The "best estimates" from climate science indicate further increases in global temperature of 2-4°C over this century, and possibly more than 6°C, depending on future levels of greenhouse gas emissions and the sensitively of the climate system to greenhouse gas concentration increases.[2] This is in addition to observed warming of 0.7°C that has already occurred. These temperature increases would take global temperatures to levels not seen in the past 120,000 years and possibly one million years.[3,4]

Policy makers in Australia are currently focusing on what contribution Australia should make to the global effort to reduce greenhouse gas emissions and reduce the risk of dangerous climate change. The report from the Prime Ministerial Task Group on Emissions Trading found in April 2007 that "there are benefits … in early adoption of an appropriate emission constraint", and that "Australia should not wait until a genuinely global agreement has been negotiated."[5]

The Australian Government is committed to the introduction of emissions trading and constraining Australia's emissions. The Government has set a broad goal of reducing emissions by 60% on 2000 levels by 2050, and with State Governments has commissioned the Garnaut Review to examine the medium to long-term policy options for Australia to contribute to international action on climate change.[6]

This paper presents the key results of macro-economic modelling commissioned by The Climate Institute to explore the direct economic impacts of differentiated emission reduction targets for Australia in 2020 and 2050. This analysis does not take into account the economic benefits of emissions reductions associated with avoided negative impacts of climate change, and therefore tends to underestimate the benefits.

1.1 Reducing climate risks to Australia and the world

There is an emerging scientific consensus that global warming of more than 2°C (above preindustrial levels) would constitute "dangerous"[§] climate change.[7] Scientific assessments by CSIRO and others indicate that global warming of more than 2°C would have significant impacts on extreme weather events, water supplies and resources, and natural systems.[8] Global assessments indicate that warming of greater than 2°C risks global and irreversible impacts (see Table 1), while the most recent science suggests that climate change may be accelerating[9] and that the threshold for "dangerous" climate change may be lower than 2°C.[10] Australia is likely to be more adversely impacted by climate change than most other developed nations, as a result of both its physical circumstances and economic structure,[11,12] and so has a stronger interest than most in arguing for deeper and more rapid cuts in global emissions.

§. The UN's Framework Convention on Climate Change (UNFCCC), signed in 1992, commits governments to avoiding "dangerous" levels of climate change. It is well known that Australia has currently not ratified the Kyoto Protocol, however Australia has ratified the 1992 climate convention and is legally bound to help achieve these objectives.

Table 1: Climate risks from global warming:[13,14,15,16]

Greenhouse gas (CO_2-e) stabilisation	Global warming	What is at risk?	
		Australia	Global
445-490	2.0-2.4ºC	• Severe droughts constrain water supplies and farming over wide areas of Australia • More than 90% of the Great Barrier Reef damaged by heat stress every year • 3,000-5,000 more heatwave deaths a year in major population centres • 80% of Kakadu wetlands lost to sea level rise	• Falling crop yields in many developing regions • Significant changes in water availability • Possible onset of collapse of Amazon rainforest • Coral reef ecosystems irreversibly damaged • Many species face extinction (up to 30% of species have increased risk of extinction) • Land-based ecosystems become net sources of greenhouse emissions • Irreversible melting of the Greenland ice sheet (up to 7m rise in sea level)
535-590	2.8-3.2ºC	• Severe droughts significantly limit water supplies and farming over a wide area of Australia • Flow in the Murray-Darling Basin falls 16-48% • Most Australian (vertebrate) animals lose 90-100% of core habitat • Functional extinction of coral reefs	• Increasing risk of abrupt, large-scale shifts in the climate system • Collapse West Antarctic Ice Sheet (up to 5m rise in sea level) • Hundreds of millions of people exposed to increased water stress • Hundreds of millions of people exposed to coastal flooding annually

1.2 The emerging global policy framework

It is likely that international agreements and action to reduce emissions will build on existing frameworks, and include the following key elements: [17,18]

- Common but differentiated commitments by developed and developing countries, recognising that effective mitigation will require broad-based global participation. Developed nations account for around 75% of historical greenhouse emissions and current concentrations, and have the greatest capacity to resource required actions and investments. Developing nations account for a large and growing share of greenhouse gas emissions, and an even larger share of the available low-cost abatement opportunities.†

- Clear emissions reductions obligations for developed nations, with some differentiation in obligations between these nations (reflecting different national circumstances and capacity to achieve reductions).

- Market based policy approaches and ‘flexibility mechanisms’ that allow nations to meet their obligations through various forms of emissions trading. Arrangements that allow developed nations to meet their obligations through supporting emissions reductions in developing nations will be central to achieving a cost-effective, politically acceptable, and worthwhile global framework.

- Long term goals or milestones that build the momentum and confidence required for national policy action, and provide the necessary security for public and private investment in low emissions technologies and other activities.

† Developing countries are not a homogenous group. Countries such as South Korea with per capita income of about US$18,000 in 2003 and emissions of around 11 tonnes of CO_2/person, could be expected to undertake legally binding emissions limits in the next international commitment period. However, India is unlikely to take on legally binding emission limits in the next commitment period. Whilst India accounts for about 6% of global emissions its per capita income was only about US$2,700 in 2003 and its per capita emissions are around 2 of tonnes of CO_2/person.

This broad approach is supported by both sides of Australian politics. At this stage, however, Australia's specific contribution to reducing global emissions and avoiding dangerous climate change remains unclear.

1.3 Global reductions of 50% by 2050

Increasingly, international discussion around climate change is articulating the need to reduce global emissions by 50% or more by 2050. For example, in June 2007, the leaders of the Group of Eight nations (G8) concluded:[19]

> We are convinced that urgent and concerted action is needed and accept our responsibility to show leadership in tackling climate change. … we will consider seriously the decisions made by the European Union, Canada and Japan which include **at least a halving of global emissions by 2050.** [Emphasis added]

More recently, Parties to the Kyoto Protocol noted:[20]

> … global emissions of greenhouse gases need to peak in the next 10 to 15 years and be reduced to very low levels, **well below half of levels in 2000 by the middle of the twenty-first century** in order to stabilize their concentrations in the atmosphere at the lowest levels assessed by the IPCC to date in its scenarios. Hence, the urgency to address climate change. [Emphasis added]

Halving global emissions by 2050 is broadly consistent with stabilising atmospheric concentrations between 450-550 ppm. The IPCC note that, "Using the 'best estimate' assumption of climate sensitivity, the most stringent scenarios (stabilizing at 445–490 ppmv CO_2-equivalent) could limit global mean temperature increases to 2–2.4°C above the pre-industrial level, at equilibrium, requiring emissions to peak before 2015 and to be around 50% of current levels by 2050."[21] This would involve developed nations reducing emissions below 1990 levels by 25-40%, as a group, by 2020 (see Table 2).[22] Developing countries, particularly the rapidly industrialising countries in Asia and Latin America, would need to substantially reduce the rate of their emission increases by 2020, and emissions from these countries need to peak between 2020-2030, and then begin to decline.

The best available science suggests, however, that stabilising atmospheric concentrations at 450 ppm CO_2e has a less than 50% chance of avoiding a temperature increase of 2^{o}C increase in global temperature (as shown in Table 2) and that stabilising atmospheric greenhouse gas concentrations at or below 400ppm would give the greatest chance of avoiding dangerous climate change.[§, 23,24,25]

This implies that global emissions reductions of more than 50% are likely to be required to avoid dangerous climate change.

§ Given current concentrations and the inertia in the global energy system, it is very likely that greenhouse concentrations will overshoot these levels. Stabilising at 400 or even 450 pm CO_2e may thus require emissions and concentrations to peak and then fall to allow stabilisation at safe levels. However, the more the ultimate stabilisation level is overshot and the longer concentrations stay above these levels, the greater the chance 2^{o}C will be exceeded.

Table 2: Greenhouse concentrations and emission reductions by 2020 and 2050 [26,27,28,29,30]

Concentration (CO_2-e)	Chance of exceeding 2°C (mid range)	Region	2020	2050
450 ppm	54%	Annex I (% change on 1990)	-25% to -40%	-80% to -95%
		Non-Annex I	Substantial deviation from baseline in Latin America, Middle East, East Asia and Centrally-Planned Asia	Substantial deviation from baseline in all regions
		Global (% change on 2000 levels)		-50% to -85%
550 ppm	82%	Annex I (% change on 1990 levels)	-10% to -30%	-40% to -90%
		Non-Annex I	Deviation from baseline in Latin America and Middle East, East Asia	Deviation from baseline in most regions, especially in Latin America and Middle East, East Asia
		Global (% change on 2000 levels)		+5% to -30%

In practice, achieving deep cuts in global emissions by mid-century will also require attention to two additional issues. First, what level of emission reduction obligations should different nations and groups accept as their contribution to avoiding dangerous climate change, given their different emission profiles and economic circumstances? Second, what near term actions should be undertaken to build the momentum and capacity required to ensure longer term goals can be met?

1.4 Australia's contribution to avoiding dangerous climate change

Previous economic analysis by CSIRO, ABARE and the Australian Business Roundtable on Climate Change has found that early action to reduce emissions is consistent with strong continuing economic growth.[31,32] Analysis undertaken for the Australian Business Roundtable suggested that emissions reductions of 60% by 2050 could be achieved with average GDP growth of 2.1% pa, rather than 2.2% per annum without action.[33] ABARE's modelling shows GDP continues to grow by around 2.2-2.3% pa with a 40-45% reduction in emissions.[34] Additionally, economic analyses show that the longer we delay taking action on climate change, the more expensive it becomes for business, consumers and the Australian economy.[35] This previous analysis assumes, in general, that Australia participates in global action, that industrialised countries take the lead in reducing emissions, and that Australia generally accepts the same emission obligations as other industrialised countries.

The modelling commissioned by The Climate Institute for this report seeks to extend these findings by exploring the relative costs of Australia taking on emission reduction obligations that are higher or lower than the average for all developed countries.

The key tension in assessing an appropriate emissions target for Australia is that, all else being equal, deeper and more rapid global emissions reductions would be likely to:

- involve adverse direct economic impacts on Australia through reductions in demand for some of Australia's key exports; but
- provide greater indirect benefits through reducing the pace and extent of climate change and related risks.

Most previous analysis finds that Australia and other fossil fuel exporting countries will suffer disproportionate impacts of global action to reduce emissions. Modelling commissioned by the Australian Government and others indicates that the extent of these impacts are "largely determined by the actions of other countries", rather than the national emissions target adopted.[36, 37] The logic of this finding is that global emissions reductions will reduce world demand for emissions intensive energy sources, particularly coal, and so exports of these products will grow more slowly than they would have otherwise. Modelling by the International Energy Agency, for example, suggests that global emissions reductions could result in world coal demand being 20% lower by 2030 than it would be in the business as usual scenario.[38] A secondary, but still relevant, issue is that of "carbon leakage" or the extent to which national and international policy settings distort the investment and production of emissions intensive traded goods, imposing economic costs on nations like Australia and seeing emissions intensive industries potentially relocated to countries without comparable emission reduction obligations.[‡]

Against this, Australia is very vulnerable to the impacts of climate change, suggesting that it is in our national interest to seek the largest possible reduction in global emissions. Australia is the driest permanently inhabited continent on Earth, and changes in rainfall and the frequency and severity of drought are likely to have significant impacts on water resources and water dependent industries. This is particularly likely in the Murray-Darling Basin and Australia's capital cities. Many of Australia's unique natural systems such as the Great Barrier Reef, the Wet Tropics, Kakadu, south-eastern alpine regions and the biodiversity hot spots of Western Australia face severe threats from even modest levels of climate change. However, these threats cannot be overcome by emissions reductions by Australia alone.

The first consideration may be interpreted as an argument that Australia's national interest would be best served by slower global emissions reductions (to allow more time for economic adjustment of emissions intensive industries) and a "below average" national emissions target. The second consideration suggests the opposite; that our national interest would be best served by more rapid and deeper global emissions reductions (to reduce impacts on climate sensitive sectors and ecosystems, and allow more time for adjusting to climate changes). The ideal outcome, from a narrowly self-interested perspective, would be for other nations to bear the burden of emissions reductions. In practice, however, such free riding is unlikely to be tolerated.

‡ As the IPCC note estimating the carbon leakage is difficult and estimates should be viewed as having a high level of uncertainty. Carbon leakage is a complex issue as companies do not choose to invest in a country solely based on energy prices. Issues such as proximity to resources, sovereign risk, political stability and access a trained labour force are also important considerations. In modelling commissioned for the PM Task Group on Emission Trading, ABARE examined this issue and found that while overall GDP impacts where the same across relevant scenarios a broader international coalition of countries involved in reducing emissions did reduce the rate of carbon leakage. See Appendix H of Prime Ministerial Task Group on Emissions Trading (2007), Report of the Task Group on Emissions Trading, The Department of the Prime Minister and Cabinet, Commonwealth of Australia.

1.5 Issues in managing risk and uncertainty in climate change policy

While assessing the magnitude of these competing effects on Australia's national interest is – in principle – an empirical issue, in practice this assessment will always be subject to considerable uncertainty (particularly in relation to climate impacts), and will also need to be informed by careful consideration of long term risks involved.

In considering these uncertainties it is important to note a number of significant differences and asymmetries in the nature of these direct (policy) and indirect (climate) impacts:

- First, the social and economic impacts of emissions reductions are reasonably well understood and amenable to management through national policy settings (such as through targeted assistance for adversely effected groups, like low income households, or transitional assistance for specific firms and industries).
- Second, a strategy that effectively assumes that Australia is able to free ride on global efforts to avoid dangerous climate change would also present risks. It is questionable whether such an approach would be sustainable or acceptable to either the international community or domestic political constituents. Such an approach would also risk highly disruptive economic impacts if a rapid transition to a low carbon economy is required, and risk reducing Australia's ability to protect our national interests in international negotiations. Also if Australia where to free ride on global efforts this would create an incentive for other countries to do the same and this could undermine effective collective action (the "Prisoners' Dilemma" in game theory).
- Third, the costs of adjusting national emission targets are not symmetric.[39] Shifting to a less ambitious emissions target is easier and is likely to involve lower economic impacts than attempting to rapidly reduce emissions in response to a changed circumstances. For example, governments may decide in favour of stabilising concentrations at 550 ppm and adopt a national emissions trajectory consistent with this goal. If, however, changes in scientific information or international circumstances result in lowering of the desired stabilisation target to 450 ppm in ten years time, emissions would have to drop very sharply. This would involve higher economic impacts than an equivalent but more gradual reduction in emissions. Setting a national emissions trajectory consistent with avoiding a 2°C in global temperature would be a prudent risk management strategy, avoid investment in long-lived carbon intensive capital stock, and give governments the maximum amount flexibility in adjusting and achieving longer-term emission reductions.
- Fourthly, the social and economic effects of the direct climate change are not well understood and are subject to considerable uncertainty. With funded adaptation strategies some types of climate change impacts may be manageable (such as the health risks associated with the reintroduction of malaria). However, management options for other types of impacts are less clear or likely to be very expensive (such as potential increases in drought or extreme events such as bushfires), and continuing climate change may push many systems beyond their ability to adapt. For example, the IPCC have identified that further global warming of more than 1.5°C would exceed the known adaptive capacity of many of Australia's nature ecosystems, warming of more than 2°C would exceed the known adaptive capacity of efforts to maintain Australia's water security, and warming of more than 3-4°C threatens to exceed the know adaptive capacity of agriculture and efforts to ensure Australia's sustainable development.[40] Lags in the climate system also imply that

some changes will be effectively irreversible, or will only be able to be reversed over many decades to centuries.

Nevertheless, we hope that the modelling presented in this report will help to inform consideration of Australia's choice of national emissions targets for 2020 and 2050, and contribute to wider public discussion of these issues.

2. METHOD

Scenarios and modelling approach

This report seeks to contribute to the discussion on appropriate Australian emissions reductions by examining the relative economic impacts of three emission reduction scenarios with different targets for 2020 and 2050, in the context of effective global action to reduce emissions by 50% of 2000 levels by 2050. The scientific literature suggests that avoiding dangerous climate change and achieving a global reduction of this magnitude would involve developed countries, as a group, reducing their allowable emissions by 80-95% by 2050.[41, 42]

The impacts of these different Australian emissions targets were assessed by the Centre for Policy Studies at Monash University using the MMRF-Green macro economic model of the Australian economy.[‡] The three scenarios are:

Free Rider – Australia stabilises net emissions by 2020 and then reduces them by 40% from 1990 levels by 2050, a reduction that is less than the world average of 50% by 2050. This scenario is called the Free Rider scenario because Australia undertakes only modest action but gains the benefits of global action through reduced climate change impacts.

Follower – Australia follows other industrial nations in global action, reducing net emissions to 1990 levels by 2020 and 60% below 1990 levels by 2050. This is less than the average required by developed countries to achieve a global reduction of 50% by 2050.

Leader – Australia joins leading nations in global action, reducing net emissions to 20% below 1990 levels by 2020 and 100% by 2050, effectively becoming carbon neutral as a nation (including through the purchase of international emissions credits).

The three scenarios all assume the same Australian policy mechanisms – apart from the different emissions targets that define the scenarios – and the same international context. All scenarios allow for Australia (and other developed countries) to meet their emission reduction obligations through purchase of international emissions credits, such as those provided by the Clean Development Mechanism (CDM), but at a larger scale.[§]

The analysis assumes global emission reductions of 50% from 2000 levels by 2050 across all scenarios (see Section 2.3). The specification of the scenarios for Australia assumes that developed nations would take the lead in reducing emissions, but that by 2030 all major emitters are actively engaged in global emissions reductions.

Table 3 provides an overview of the key modelling assumptions, with more details provided in the Appendix to this report.

‡ The MMRFGreen model was developed and is operated by the Centre of Policy Studies (COPS) at Monash University. The model is currently being used to evaluate the impacts of climate change and climate change mitigation policies by the National Emissions Trading Taskforce (NETT), by the Garnaut Review, and by the Federal Treasury in its preparation for a Federal Emissions Trading Scheme.

§ See UNFCCC (2007), Background paper on Analysis of existing and planned investment and financial flows relevant to the development of effective and appropriate international response to climate change, UNFCCC, Bonn, Germany for summary of long term prospects for the CDM and other international emission trading markets.

Table 3: Overview of modelling assumptions

Domestic policy settings	**National emissions trading implemented from 2010, with international credits able to be used to acquit domestic emissions obligations.**
Coverage	Emission Trading includes all sources of CO_2-e emissions, including agriculture, land use change (forest converted to croplands and grasslands), and forestry sinks.
Emissions Target (or Emissions Caps)	**Free Rider**: Stabilise around 2010 levels by 2020 (8% above 1990 levels), and reduce to 40% of 1990 levels by 2050 **Follower**: Reduce to 1990 levels by 2020, and to 60% below 1990 levels by 2050 **Leader**: Reduce to 20% below 1990 levels by 2020, and 100% by 2050, effectively becoming carbon neutral as a nation.
Revenue use	Permits are auctioned and all revenue is returned to the Government. Free permits are used to insulate trade-exposed emissions-intensive industries until 2030. All remaining revenue is used to reduce personal and corporate income tax. Reductions in personal income taxes will permanently boost employment due to increased incentive to participate in the work force. Reductions in corporate taxes encourage investment and hence capital formation.
Transitional assistance	Trade-exposed energy intensive sectors are fully insulated to 2020, with insulation phased out in a linear way from 2020 to 2030. Sectors affected are: LNG, iron and steel, non-ferrous metals, export components of the coal and non-ferrous ore industry. Electricity generators receive no special assistance. No special assistance is provided for the terms of trade effects of global emissions reductions.
Global context and linkages	**Global emissions reductions effect world demand for energy commodities, and Australia's terms of trade.** **International permits may be used to acquit domestic emissions obligations. We assume Australia does not provide credits to the international market.**
Carbon price	The Australian carbon price is calculated in each year to achieve the emissions reduction target for that year. International carbon price begins at $A 40 per tonne of CO_2-e in 2010 and increases at a constant percentage rate to $A 200 per tonne of CO_2-e in 2050, consistent with approximately mid range estimates of carbon prices reviewed in by the Intergovernmental Panel on Climate Change.[43,*] The analysis assumes that GST is charged on purchase of international permits. International permits are purchased if the international price is lower than the Australian price would be without these purchases, effectively capping the Australian carbon price to emitters at 10% above the world price.
Terms of trade	Based on previous work for the Australian Business Roundtable, we assume that the global scheme affects Australia's terms of trade by shifting export demand schedules and the foreign supply schedule for oil. At a global price of $A 100 per tonne of CO2-e, world demand schedules for Australian exports will shift down as follows: 50% black coal, 50% oil, 10% iron ore, 20% aluminium and alumina, 20% iron and steel and 20% basic chemicals. Export demand schedules will shift up: 100% for uranium and 50% for gas. The supply price of oil will fall by 50% based on IEA 2006 projections. In addition, we assume that agricultural exporters are able to pass through the value of agricultural emissions at the prevailing world carbon price

* IPCC Category I mitigation scenarios represent stabilisation of CO_2e concentrations at between 445-490ppm. In 2030, carbon prices between around 30 to 200 US$/t$CO_2$-equivalent for Category I mitigation scenarios. In 2050 carbon prices range from around US$100-300/tonne CO_2e.

Energy	Emission reductions impact on energy efficiency and technology options.
Energy efficiency	Global and domestic action to reduce emissions is assumed to result in acceleration in energy efficiency in all uses of energy. On average, the rate of autonomous energy efficiency improvement (AEEI) without emissions reductions is assumed to be 0.5% per annum. In the emissions reduction scenarios AEEI increases to 1.0% per annum in a linear way between 2010 and 2020, and remains at that heightened rate to 2050. This is a lower rate of improvement than has been specified in previous modelling.[44] Previous sensitivity analysis suggests that changes in the AEEI rate have virtually no impact major macroeconomic variables.
Available technologies	Low emission electricity generation options costs are based on previous analysis by MMA.[45] This work includes conservative rates of learning by doing and induced technological change. Carbon Capture and Storage (CCS) becomes available to coal and gas generators in Victoria and Queensland after 2015 in all three scenarios, and after 2040 in WA.‡ Implementation at scale occurs after the carbon price reaches $40 t$CO_2$e, and is proportional to the carbon price. Adoption is capped to reflect retrofitting constraints, with the cap rising in a linear way to 80% over 25 years. Fuel cell technology for motor vehicles is assumed to become economic when the domestic permit price reaches $60 per tonne of CO2-e. The rate of adoption thereafter is a linear function of the domestic carbon price. Nuclear generation is excluded from all scenarios. For other sectors (industrial processing, waste, fugitives), emission abatement is available as low as $15/t CO_2e and increases exponentially as a function of carbon price. Ceilings apply to the total amount of emissions from industrial processing and fugitive emissions reflecting limits on the ability of existing technologies to abate emissions. Only known technology options are considered.
Land Use, Land Use Change and Forestry	It is assumed that emissions from land use change (LUC) declines in a linear fashion from 2005 levels to negligible levels in 2050. For forestry we assume that the carbon price is a specific subsidy and this encourages forestry activity. Forestry sequestration is capped at a maximum of 70 Mt CO_2e.

‡ In the scenarios, carbon capture and storage technology is required to maintain the long-term viability of fossil fuel generation in Australia. However, technologies such as carbon capture and storage and hot rocks geothermal have yet to be demonstrated on a commercial scale, and advanced solar concentrating technologies are significantly more expensive than other technologies. To realise the introduction of carbon capture and storage (and other emerging low emission technologies) by 2015, research, development and demonstration funds would need to be increased, barriers to large investments in high risk demonstration projects removed, incentives provided for projects that will build national clean energy infrastructure, and mechanisms provided to ensure the early deployment of commercial scale facilities.

3. RESULTS

Economic impacts of different emissions targets

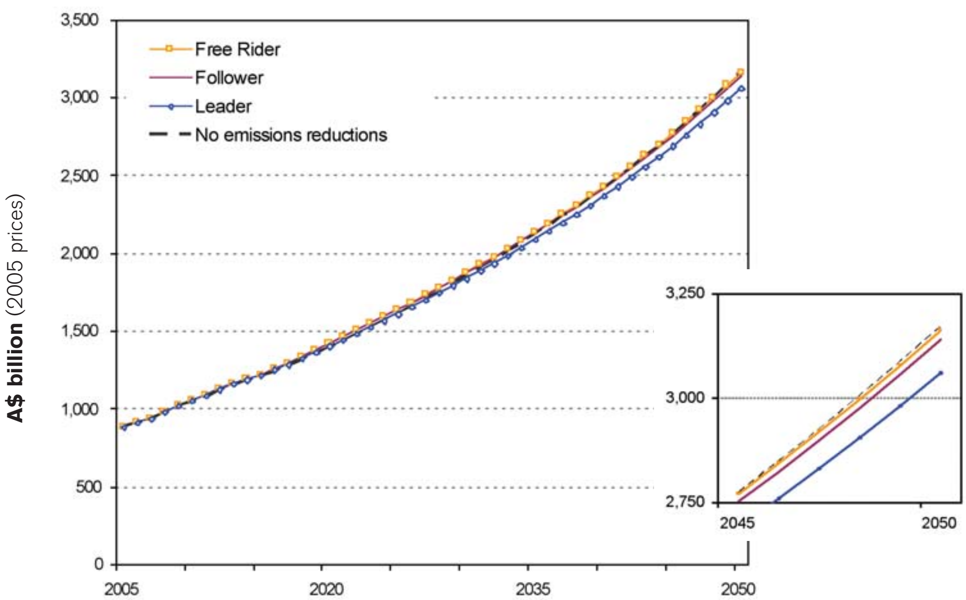
This section presents the economic impacts of the different emissions targets on economic growth and opportunity; income and living standards; insights into the transition to a low carbon economy; and the relative size of different industry sectors.

3.1 Economic growth and opportunities

The modelling suggests that all three emissions scenarios are consistent with strong economic growth, as shown in Figure 1. Gross Domestic Product (GDP) and Gross National Product (GNP) increase more than three fold over the 45 years to 2050 across all scenarios.

Projected average annual economic growth is 2.8% pa in the Leader and Follower scenarios, as measured by both GDP and GNP, rather than 2.9% pa in the base case scenario without emission reductions. This involves a gap of 0.01% to 0.10% pa across the three scenarios for the different measures of economic growth. Impacts of this magnitude are broadly consistent with the results reported by the Australian Business Roundtable on Climate Change[46], as discussed in Section 3.5 below, which found that early action to achieve a 60% reduction in emissions involved a reduction in average annual GDP growth of around 0.1% per annum. This impact was described as "modest" and "affordable".

Figure 1: Value of economic activity (GNP), all scenarios 2005-2050

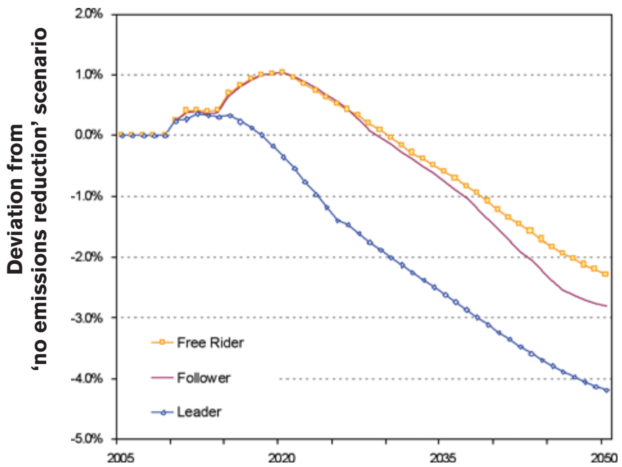


By 2050 these differences in average rates of economic growth result in a GNP or GDP gap relative to the base case of 1-2% in the free rider scenario, 2-4% in the follower scenario, and 4-5% in the leader scenario, with larger impacts on GDP than GNP (see Table 4).

Figure 2 illustrates the impacts of different scenarios relative to the Free Rider scenario (which is interpreted as the minimum undertaking Australia could assume given global emissions reductions of 50%) and relative to the base case without global action to reduce emissions. This shows that the value of economic activity is higher in the Follower and Free Rider scenarios from 2010 to 2030 than if no action is taken to reduce emissions. This is because the Terms of Trade effect associated with global action to reduce emissions outweighs the effect of the domestic emissions constraint. This lowers the value of the Australian dollar relative to other countries, making our exports more attractive and imports less attractive than they otherwise would be, boosting investment, production (as measured by GDP) and returns to labour and capital. Results presented in Table 4 indicate that this boost to economic activity has all but disappeared by 2030, but that real consumption remains higher than in the base case at this point.

Figure 2: Differences in the value of economic activity (GDP), all scenarios 2005-2050

(a) relative to base case without global or national emissions reductions



(b)relative to Free Rider scenario

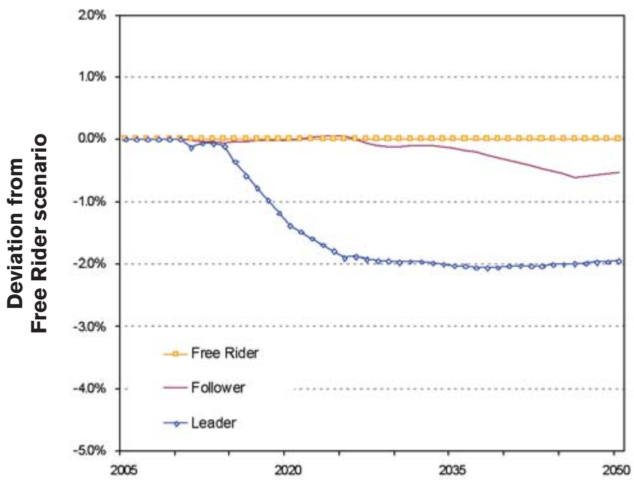


Table 4: Overview of key macroeconomic results

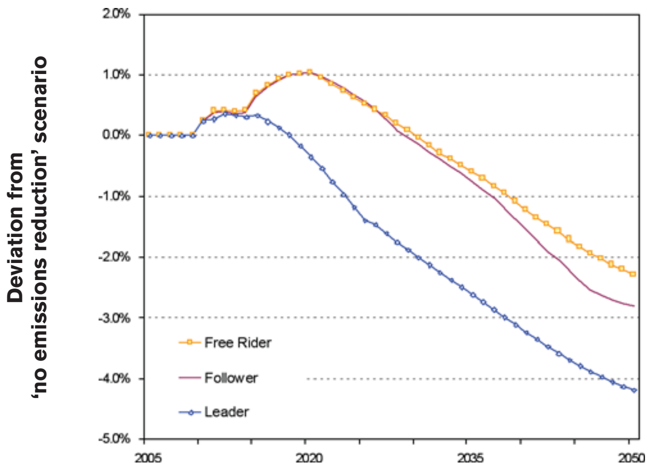
	Average annual growth rates, 2005-2050				Difference in average growth rates		
	Base (a)	Free Rider	Follower	Leader	Free Rider	Follower	Leader
Real GNP	2.9%	2.9%	2.8%	2.8%	-0.01%	-0.02%	-0.08%
Real GDP	2.9%	2.8%	2.8%	2.8%	-0.05%	-0.07%	-0.10%
Employment	1.3%	1.2%	1.2%	1.2%	-0.04%	-0.04%	-0.04%
Real private consumption per person	2.1%	2.1%	2.1%	2.0%	0.02%	0.00%	-0.07%
	Economic performance						
	2005	2030			2050		
	Base (a)	Free Rider	Follower	Leader	Free Rider	Follower	Leader
Real GNP ($A billion) (b)	889	1,877	1,874	1,843	3,163	3,141	3,061
Real GDP ($A billion) (b)	879	1,841	1,839	1,805	3,070	3,053	3,010
Employment ('000 people)	9,695	13,193	13,194	13,210	16,644	16,642	16,651
Real private consumption per person ($A) (b)	23,703	39,425	39,363	38,562	61,251	60,545	58,754
	Difference relative to base case						
		2030			2050		
		Free Rider	Follower	Leader	Free Rider	Follower	Leader
Real GNP		0.0%	-0.2%	-1.8%	-0.3%	-0.9%	-3.4%
Real GDP		0.0%	-0.2%	-2.0%	-2.3%	-2.8%	-4.2%
Employment		0.0%	0.0%	0.1%	-1.9%	-1.9%	-1.9%
Real private consumption per person		1.9%	1.8%	-0.3%	1.0%	-0.1%	-3.1%

Notes: (a) No global or national emissions reductions (b) expressed in real terms, 2005 prices.

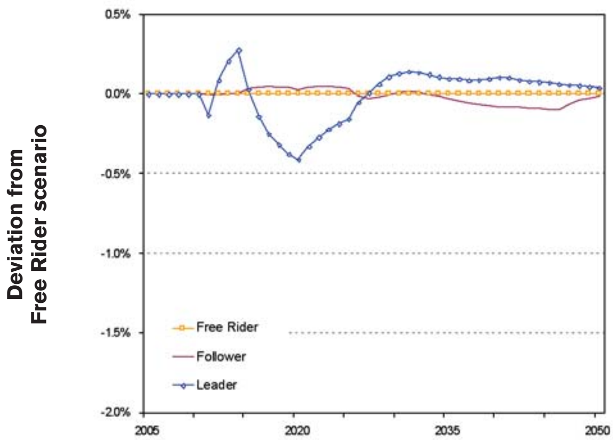
Impacts on employment are smaller but broadly proportional to the impacts on GNP and GDP, with very similar impacts across the three scenarios. Total employment grows by 72% in all three scenarios by 2050, compared with 75% without global or national emissions reductions. Average annual employment growth is 0.04% less than the average in the base case of 1.3% per annum. Figure 3 shows the difference in employment across the three scenarios over the period relative to the base case, and to the free rider scenario. The difference in employment impacts before 2025 is driven by differences in the early revenues generated by the auction of permits across the scenarios, which boost workforce participation by reducing income taxes. This effect occurs earlier in the Leader scenario than in the Follower and Free Rider scenarios.

Figure 3: Differences in employment, all scenarios 2005-2050

(a) relative to base case without global or national emissions reductions



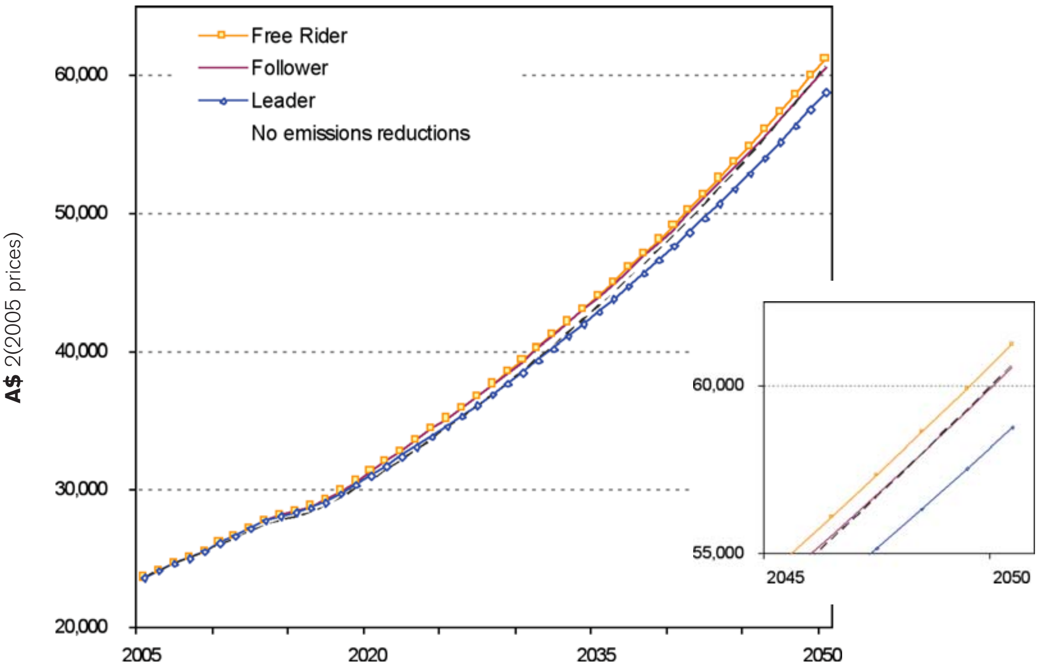
(b)relative to Free Rider scenario



3.2 Income, energy affordability, and living standards

Real income and economic living standards (adjusted for inflation) grow strongly in all scenarios. As shown in Figure 4, real consumption per person increases 158% in the Free Rider, 155% in the Follower and 148% in the Leader scenario over the period to 2050 (see Table 5 in conclusion). The proportional impact of emissions reductions on income (as measured by GNP and consumption) is smaller than the impact on activity (as measured by GDP). The range or ratio of impacts on consumption across the scenarios is slightly larger, however, with consumption in the Leader scenario around 3% lower than the base case in 2050, but very little difference between Follower scenario and the base case (as shown in Table 4 above).

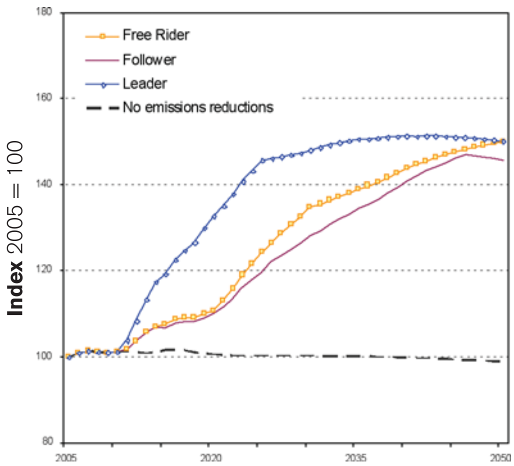
Figure 4: Real private consumption per person, all scenarios 2005-2050



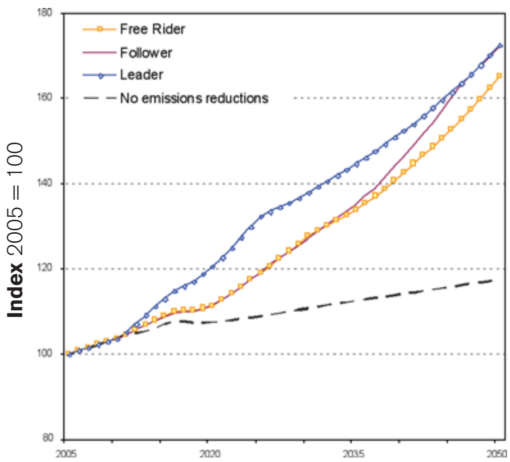
The introduction of emissions trading causes real energy prices to rise faster than inflation, reflecting both the carbon price signal and the additional investment required in low emission technologies. As shown in Figure 5, electricity, gas and petrol prices rise by around 50% by 2050 in the emissions reductions scenarios than they do in the base case, although the timing of these increases varies across scenarios, with prices rising earlier in the Leader scenario. (Note, see below, as income grows faster overall energy affordability improves relative to today.)The plateau in electricity prices after 2020 is consistent with electricity sector modelling where technology cost reductions and the availability of low emission generation options at moderate costs (including renewable generation and carbon capture and storage options). Lower growth in electricity demand also limits price increases.[47, 48]

Figure 5: Consumer prices of energy commodities, all scenarios 2005-2050

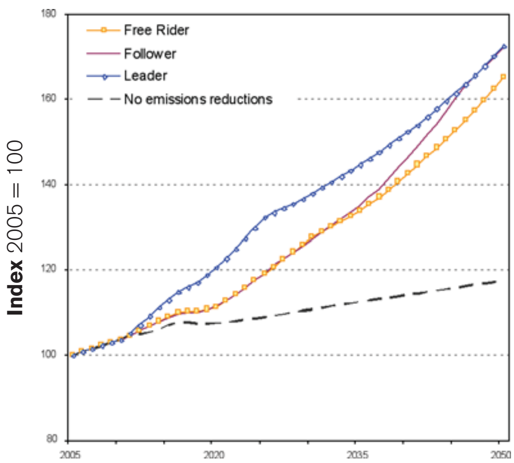
(a) electricity



(b) natural gas

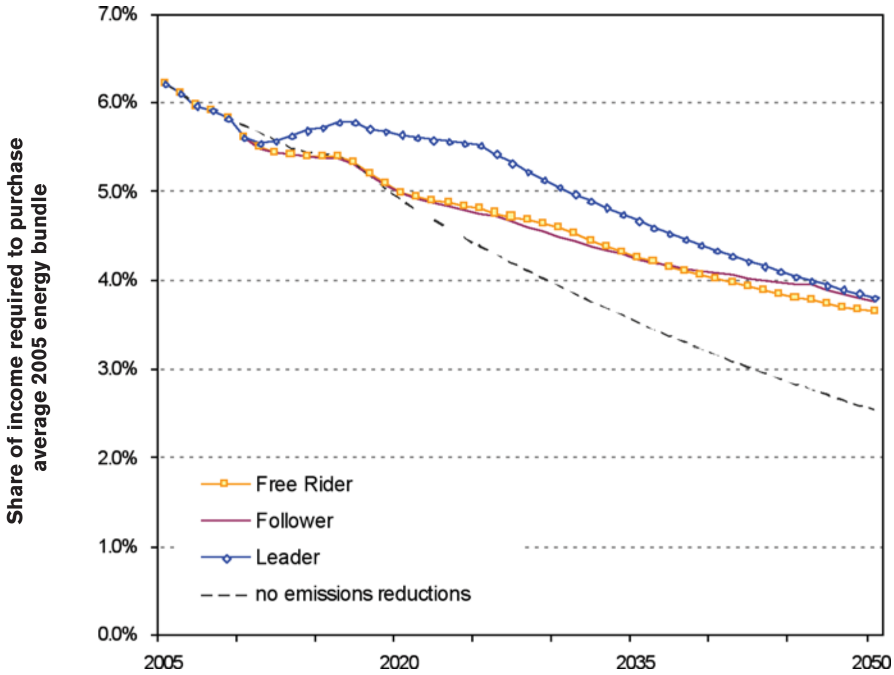


(c) petrol



The modelling suggests that the affordability of energy products would improve relative to today across all scenarios, as average real incomes grow more rapidly than real energy prices. Figure 6 shows that the share of average income required to buy the average 2005 consumer energy bundle falls from over 6% in 2005 to below 4% in 2050. This affordability measure is considered conservative, as it does not take account of expected improvements in energy efficiency or changes in consumption patterns, which will tend to reduce energy expenditure.

Figure 6: Energy costs, as a proportion of income, all scenarios 2005-2050



Taken together, these results suggest that the social impacts of achieving ambitious emissions reduction targets are likely to be manageable.

3.3 The transition to a low carbon economy

The introduction of emissions trading and associated emissions reduction targets drive fundamental changes in the emissions intensity of activities across the economy, particularly in energy generation and use, relative to what would be expected in a future without emissions constraints.

The carbon price implied by the different emissions trajectories is a key indicator of the extent and speed of the transition to a low carbon economy. As shown in Table 5, the carbon price in the Leader scenario rises relatively quickly to the international carbon price (plus GST). Carbon prices in the Follower and Free Rider scenarios rise more gradually, and are very similar until around 2030, after which the Follower price moves up to match the Leader price (although the Follower scenario involves significantly less net abatement than the Leader scenario).

The results suggest, on face value, that significant early abatement is achieved in the Follower and Free Rider scenarios with relatively low current carbon price (with prices not reaching $40 t CO_2e in these scenarios until around 2025). A number of factors contribute to this result. First, coverage in the model is broader than in the proposed emissions trading scheme, particularly in that it includes reductions in emissions from land use change (LUC). The modelling assumes significant reductions are achieved in LUC emissions across all scenarios, much of which occurs by 2030 (see Table 3 and Figure 8). These reductions involve very low costs, and reduce the abatement required from other sources. Second, emissions sensitive investment in long term assets such as electricity generation is influenced by high future carbon prices, bringing forward more abatement than would occur at the current (or spot) carbon price. This also brings forward higher electricity prices, reducing demand growth relative to the base case.

Third, forestry contributes significantly to net emissions reductions in all scenarios in the early period, at relatively low costs, but has only a limited role in reducing emissions after 2030 due to supply constraints.

This implies that carbon prices associated with the currently proposed emissions trading scheme would be expected to be higher in the early period than those suggested by the modelling due to differences in coverage, intertemporal arbitrage arrangements (such as options and futures contracts) which smooth price differential over time, and the need to establish confidence in the emissions trading market.

Table 5: Carbon price, all scenarios 2005-2050

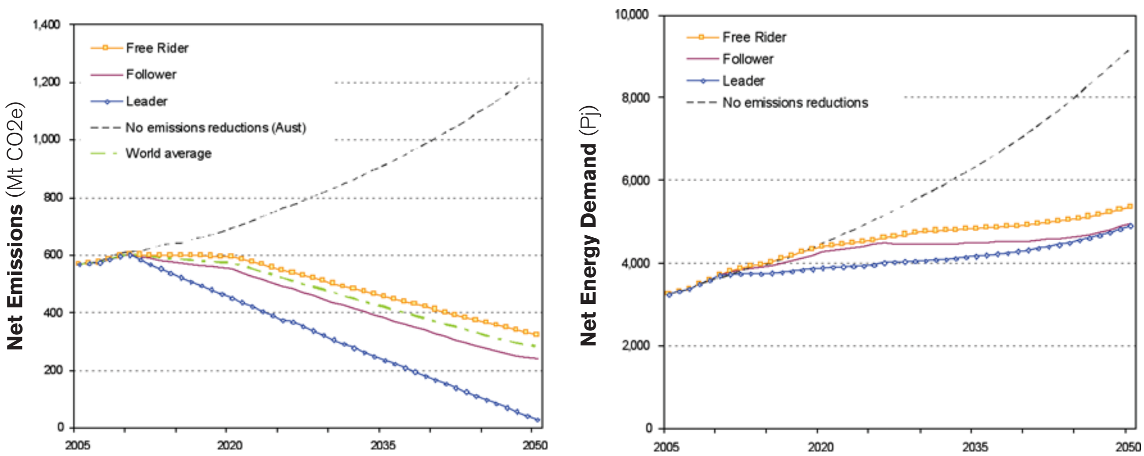
	Abatement relative to base case $MtCO_2e$		Carbon price $A 2005	
	2030	2050	2030	2050
International	na	na	89	200
Free Rider	-330	-912	57	176
Follower	-395	-996	57	203
Leader	-524	-1,205	98	208

The policies modelled in the report result in economic growth being substantially decoupled from energy use, and completely decoupled from greenhouse gas emissions – with economic growth more than tripling the value of the economy (around a 250% increase), while energy use rises by 50% to 65% and net emissions fall 40% to 100% by 2050. This contrasts with a 117% increase in emissions and a 183% increase in final energy demand in the base case. The extent of this decoupling is illustrated in Figure 7 below (in contrast to the economic growth shown in Figure 1 above).

Figure 7: Emissions and energy use, all scenarios 2005-2050

(a) Net emissions

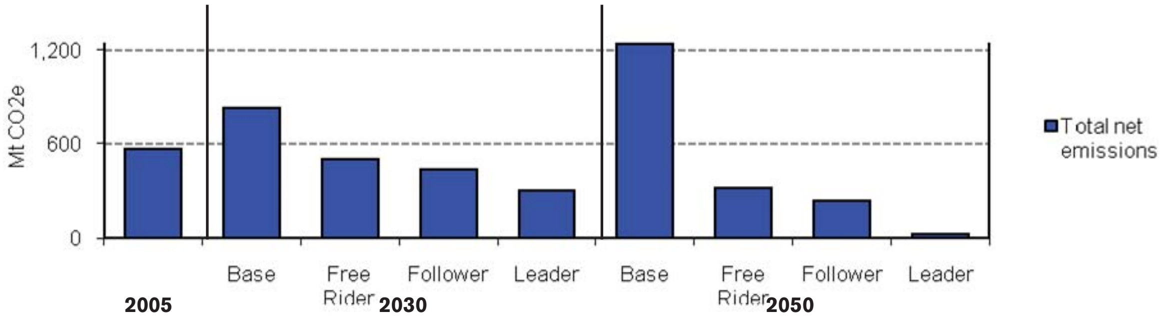
(b) Final energy demand



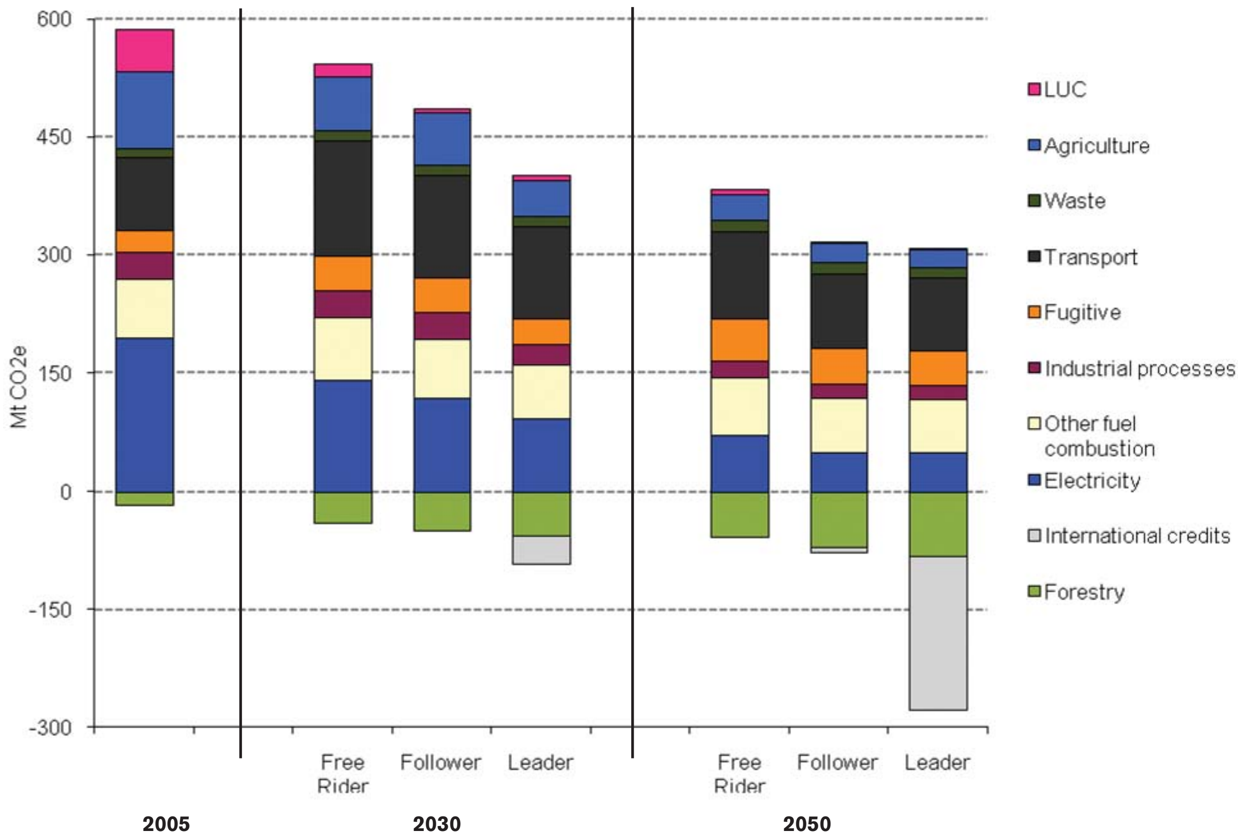
These net emission reductions are achieved through progressive contributions from all sources of emissions, other than waste and fugitive emissions from mining (where reductions are not cost effective), supplemented by increases in forestry sinks, shown in Figure 8. Purchases of international permits play only a modest role overall. Little or no purchases occur in the Free Rider and Follower scenarios, while purchases only become significant in the last decade in the Leader scenario, offsetting almost 200 Mt CO_2e in 2050 (equivalent to the current emissions from electricity) (see Figures 9).

Figure 8: Net emissions by source, all scenarios 2005, 2030 and 2050

(a) Net national emissions



(b) Emissions by source



Energy use per person, including energy used in export productions, rises slightly by 2030 and then falls back to near current levels (around 10% above 2005 levels in the Free Rider, and 1-2% above current levels in the Follower and Leader scenarios).

Total primary energy generation grows slightly faster than population. As shown in Figure 9, total electricity generation increases by 150-160% across the three scenarios. Increased coal fired generation with carbon capture and storage accounts for around half the increase in electricity supply. Renewable energy grows around eight-fold from a low base (an increase of 670-715%), accounting for around one third of the increase in supply, while gas increases by 130-150% to provide the remaining one sixth of the increase in supply.

These changes in technology and generation mix reduce the emissions intensity, or greenhouse emissions per unit of electricity generated, by a factor of ten over the 45 years to 2050, as shown in Figure 10.

Figure 9: Electricity generation by source, all scenarios 2005, 2030 and 2050

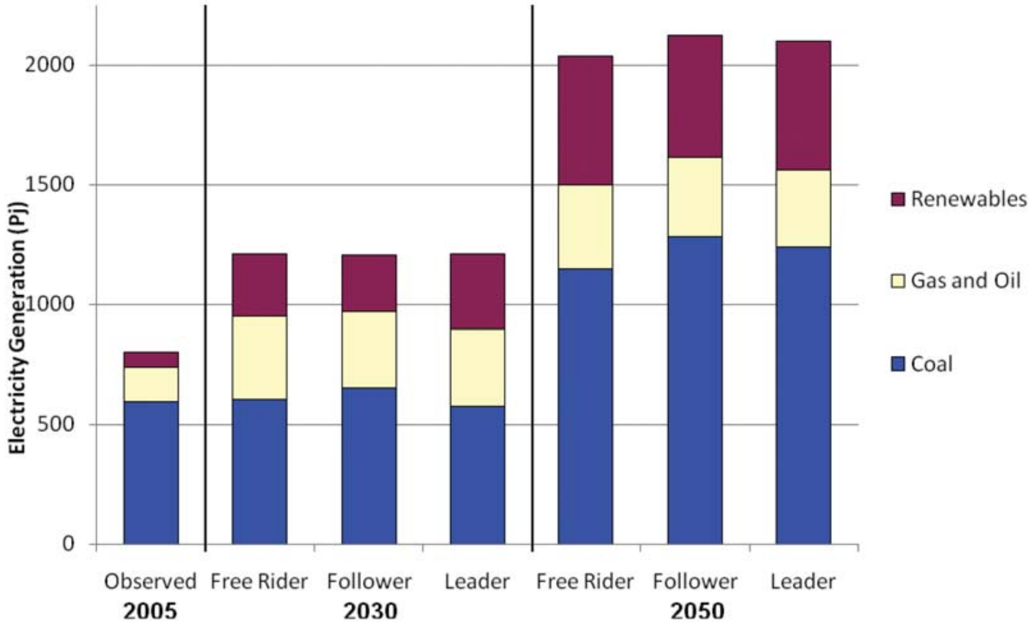
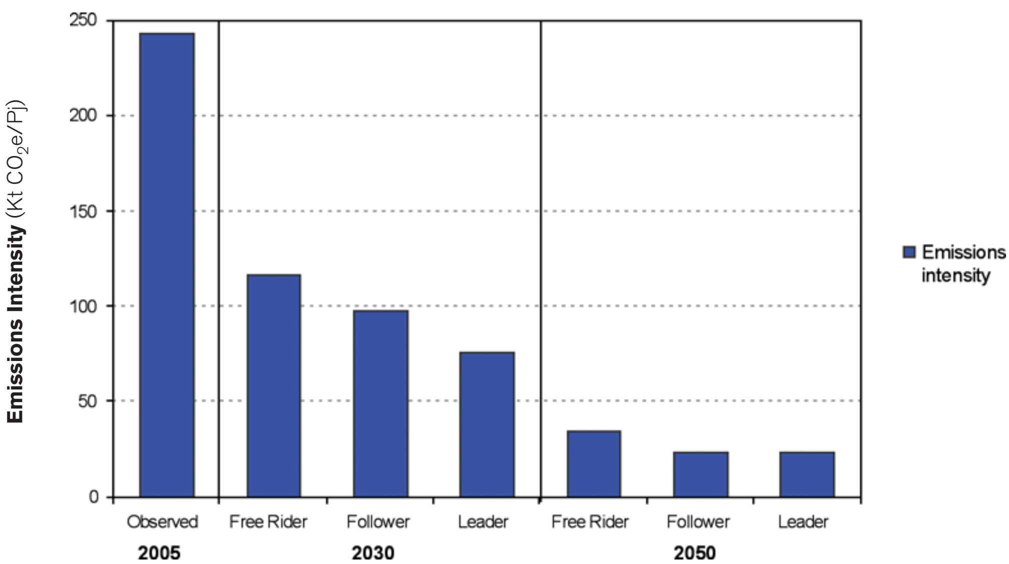


Figure 10: Emissions intensity of electricity generation, all scenarios 2005, 2030 and 2050



3.4 Sectoral economic impacts

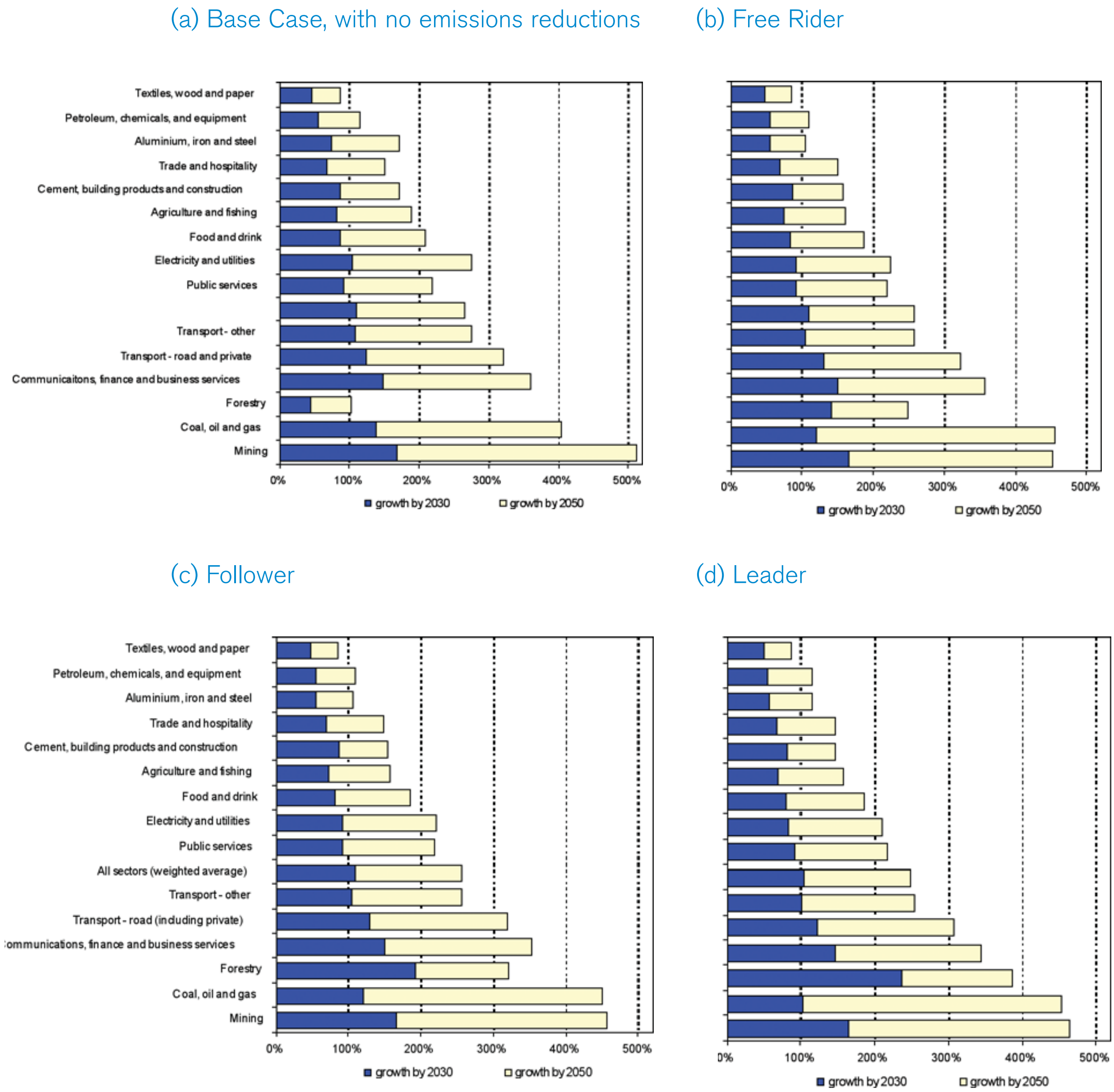
The modelling indicates strong growth in value added across all economic sectors. The pattern of growth in the different scenarios is similar to the base case, as shown in Figure 11. Mining grows strongly across all scenarios, and is the fastest growing sector overall, but increases slightly less in the emissions reduction scenarios than in the base case. The forestry sector is the most sensitive to different national emissions targets, with value added growing less strongly in the Free Rider than in the Leader scenario. Additional forestry activity is also concentrated in the period up to 2030, when the majority of forest establishment activity occurs. Global action to reduce emissions results in smaller increases in value added in the metal production and road transport sectors.

Perhaps the most important sectoral result is that the value of energy commodities – including coal, oil and gas – grows more strongly in the emissions reduction scenarios than in the base case, with growth in natural gas production and LNG exports (driven by world demand) outweighing a contraction in coal production relative to 2005.[‡]

These sectoral results are considered plausible, but are strongly influenced by the assumed changes in the terms of trade associated with global action to reduce emissions and the international carbon price (see Table 3 and the Appendix). Further work is required to explore these impacts, particularly the extent to which economic gains associated with increased production of natural gas (or future renewables based energy intensive manufacturing and processing) might offset reduced growth in demand for existing industry segments, and how appropriate policy settings can enhance the ability of sectors to take advantage of global climate policy action.

‡ The increases in gas production are around double that in the base case without global or national emissions reductions than in the emissions reductions scenarios. Increases of this magnitude would require substantial new discoveries of economically accessible natural gas before 2050. Note that gas mining increases by slightly more in the leader scenarios than in the other scenarios. Changes in the production of other forms of mining – e.g. iron and non-iron ores and coal - are similar across the three scenarios.

Figure 11: Change in value added from 2005 for major sectors, all scenarios, 2030 and 2050



3.5 Comparisons to other studies

The headline economic results suggested by the modelling are at the higher end of the normal range for most international studies,[49] but somewhat lower than previous Australian studies.

The most comprehensive recent international study involved a comparison of eight global economic models and three global energy sector models, examining scenarios for stabilising atmospheric emissions at 450 ppm CO_2 (which is roughly equivalent to 500 ppm CO_2e).[50, 51] The study was focused on representing long-run innovation processes. Nine of these models found that achieving this target would result in Gross World Product[§] being no more than 1% lower in 2050 than it would be without emissions reductions,[‡] with two models suggesting that policy action would increase the rate of

§ Gross World Product (GWP) is the world equivalent to national GDP.

‡ Results for these models are more dispersed in the second half of the century, ranging from +3.5% to -3.0%, with a "best estimate' of global economic impact of 0% to -1.5% of gross product in 2100.

economic growth by 2050 (due to economic returns to increased levels of research and development, and more rapid turnover of energy-related physical capital). The remaining two models suggested much larger economic impacts, peaking above 10% before 2050 and tracking 4-8% below the base case over the second half of the century. The primary reason for these larger adverse impacts was that the models assumed that low emission fossil fuel technologies (such as carbon capture and storage) were either not feasible or were very costly.[†]

The benchmark impact of -2.8% of GDP for the Follower and -4.2% of GDP for the Leader scenario in 2050 is thus three to four times larger than the central estimate for the global economic impact of emissions reductions, consistent with the view that economic impacts on Australia are likely to be larger than average.

The impacts found in this report are somewhat smaller than those reported by the Australian Business Roundtable, however.[52, 53] The main reasons for this arises from the way the current study assumes that Australian emissions trading arrangements will be linked to other schemes and allow the purchase of international permits – consistent with the recommendations of the Prime Ministerial Task Group on Emissions Trading which was released after the Roundtable report. This avoids the relatively high carbon prices that would occur after 2035 without international purchases. It also changes the timing of the terms of trade effect associated with global action to reduce emissions, which has a positive initial economic impact (see section 3.1). While the proportional shifts in the terms of trade are the same as those assumed by the analysis undertaken for the Roundtable, they occur more strongly in the early part of this study because they are linked to the international carbon price, which is initially higher than the Australian carbon price.

Other less important factors that contribute to the estimated impacts being lower than the Roundtable include closer attention to modelling the benefits of income tax reductions, which offset negative economic impacts to some extent through increases in employment;[54] the use of updated cost curves for low emissions electricity generation technologies, based on analysis undertaken for MMA;[55, 56] and greater net emissions reductions from land use change and forestry sinks.

Finally, it is important to note that, like most studies, the results depend crucially on the availability of carbon capture and storage (CSS) and/or a portfolio of other low emission electricity generation options (such as geothermal, solar thermal, or wave power) that are capable of meeting future electricity demand.

† This study, like previous Australian analysis, assumes that post-combustion carbon capture and storage (CCS) is feasible at mid-range cost levels (see Table 3)

4. CONCLUSIONS

Insights into choosing an emissions target

This report provides new information and insights into the likely magnitudes and patterns of economic impacts associated with Australia negotiating differentiated emissions targets for 2020 and 2050, in the context of effective action to reduce global emissions by 50% over that period.

4.1 Deep cuts in emissions are possible with strong growth in economic activity, employment and living standards

Key results from the modelling of 40%, 60% and 100% reductions in net emissions from 1990 levels by 2050 include:

(i) The economic impacts of achieving deep cuts in emissions by 2050 appear modest and manageable, with a reduction in average annual economic growth of 0.01% to 0.10% per annum over the period. The size of the economy is projected to more than treble across all emissions scenarios, with strong growth in all economic sectors, including key export sectors such as mining, energy commodities (coal, oil and gas), agriculture, and metal production. Impacts on income (as measured by GNP and real consumption) are smaller than impacts on gross activity or economic turnover (as measured by GDP).

(ii) The social impacts of these emissions reductions also appear manageable with sensible policy settings. Employment grows 72% in all scenarios, with average annual growth 0.04% lower than is projected without emissions reductions. The affordability of energy products improves, as average income grows faster than real energy prices, so that the share of average income required to buy the current average energy bundle falls from over 6% in 2005 to below 4% in 2050.

(iii) The introduction of emissions trading has the potential to decouple emissions and energy use from economic growth, allowing significant improvements in living standards while dramatically reducing our net national emissions. Emission reductions are achieved across almost every sector, with major contributions from the introduction of low emissions electricity generation and the expansion of forestry sinks. The availability of carbon capture and storage (CCS) technology and the ability to purchase international emissions credits are important components of a cost effective strategy to achieve very deep reductions in net emissions.

4.2 The case for taking a leadership position on emissions reductions

The central tension in assessing the merits of different emissions targets for Australia is that, all else being equal, deeper and more rapid global emissions reductions are expected to involve higher direct economic impacts (from policy implementation) but greater indirect benefits from reducing the pace and extent of adverse climate change.

This study provides a number of insights into the nature and extent of the likely direct effects of national and international climate policies. It finds that the negative impacts of a 50% reduction in world emissions, and associated Australian action, are likely to be modest and manageable (as summarised above). The study also highlights that decisive global reductions in emissions would result in a rebalancing of Australia's export advantages – away from commodities with high embodied or downstream emissions towards commodities with a lower emissions profile, for example – but that this may not result in a net economic disadvantage, as the gains in some sectors may more than outweigh the losses elsewhere. By implication, decisively scaling up our investment in renewable energies may provide a platform for a durable future competitive advantage in energy intensive manufacturing, such as aluminium and steel, based on our extensive renewable energy resources. These issues require further exploration.

The study has not attempted to quantify the indirect benefits of emissions reductions, resulting from reductions in the adverse impacts of climate change. These issues have been addressed by The Stern Review,[57] CSIRO[58], and are being explored in more detail for Australia by the Garnaut Review.[59]

These issues are especially sharp for Australia. It is clear from the climate science that Australia is likely to be more adversely impacted by climate change than most other developed nations, such as through more common and prolonged droughts, more frequent and severe storms, bushfires and floods, and irreversible impacts on the Great Barrier Reef and other fragile ecosystems. This implies that Australia has a stronger interest than most in arguing for deeper and more rapid cuts in global emissions.

There are two major rationales for taking a leadership position in reducing our national emissions.

The first rationale is that making more rapid early reductions helps to manage the economic risks to Australia from uncertainty about climate impacts and the pace of global action. This is because it is much more difficult and costly to accelerate emissions reductions than to decelerate them in response to improved climate science or changing international circumstances. In particular, incremental tightening of long term emissions targets risks the premature retirement of long lived emissions intensive capital assets, such as traditional coal fired power stations. Furthermore, climate impacts are driven by cumulative emissions, and so changes in trajectory effectively need to offset the stock of past additional emissions in addition to reducing future emissions. Delayed or overly modest emissions targets thus risk both an 'investment overhang' in plant and equipment with high emissions (at risk of early retirement) and a 'emissions overhang' of past emissions that need to be offset. This implies, as noted by the International Energy Agency,[60] that long term national targets should assume stringent emissions reductions will be required. For example, governments may decide in favour of stabilising concentrations at 550 ppm and adopt a national emissions trajectory consistent with this goal. If, however, changes in scientific information or international circumstances result in lowering of the desired stabilisation target to 400-450 ppm in ten years time, emissions would have to drop very sharply. This would involve higher economic impacts than an equivalent, but more gradual, reduction in emissions.

In deciding the most appropriate emission target it is important to recognise that lags in climate processes mean that precise climate impacts will only be known with certainty after they are too late to avoid, are irreversible and/or are likely to take decades or centuries to reverse. This contrasts with the economic impacts of emissions reductions, which are reasonably well known, and in most cases involve a delay of a few months or years to reach a given level of economic activity or per capita income.

The second rationale for taking a leadership position is that a commitment by Australia to decisive emissions reductions would provide greater credibility and leverage in mobilising international action to reduce emissions. Avoiding dangerous climate change will require decisive global action. Taking a leadership position will help to build the comfort and confidence of other nations in committing to deeper reductions in emissions. An associated benefit is that Australia may find it easier to pursue other climate policy objectives, such as in relation to the treatment of emissions intensive traded goods, if it is clear that Australia is not seeking to delay effective global action to reduce emissions.

Beginning the journey to substantial reductions in emissions would also have a number of domestic advantages, which are difficult to capture in economic models, such as building a flexible domestic policy regime, the development of new industries and technologies, and expanding the benefits of participating new markets in low emission technologies and emissions offsets.

These considerations suggest that it would be more prudent and economically conservative to pursue deeper and more rapid reductions in global emissions than to wait for more detailed information on future climate impacts before committing to reductions (see Section 1.5). This recognition of the risks of inaction is reflected in the increasing number of global statements calling for emissions reductions of no less than 50% by 2050, and is consistent with the Prime Ministerial Task Group's conclusion that "Australia should not wait until a genuinely global agreement has been negotiated."

Taking a leadership position – like early action – buys time and options, akin to buying insurance in an uncertain world.

4.3 Assessing the leadership premium

The modelling presented in this report suggests that the 'leadership premium' associated with committing to very deep cuts is affordable. Table 5 summarises the premium involved in making Australia carbon neutral, as a country, by 2050. Economic activity is projected to increase from less than $1 trillion to around $3 trillion by 2050 in the Leader scenario, with GDP and GNP 1.4% to 3.5% lower than in the Follower and Free Rider scenarios. Employment increases from 9.7 to 16.7 million jobs by 2050 across all three scenarios. Real consumption per person increases from under $24,000 to over $58,000 by 2050 in the leader scenario, around 3.0% to 4.2% lower than in the Follower and Free Rider scenarios respectively. Long term impacts on energy prices and affordability are very similar across the three scenarios, although energy price increases occur earlier in the Leadership scenario, and would require more active policy management

On the other side of the ledger, net emissions are on track for 100% reductions by 2050 rather than 40-60% below 1990 levels. In 2030 this difference is at least 98 $MtC0_2$-e, more than Australia's current transport emissions. By 2050, the difference in net emissions between the Leader and the Follower scenarios is 209 $MtCO_2$-e per year, greater than the current total emissions from the electricity sector, while the difference between the Leader and the Free Rider Scenario is 293 $MtCO_2$-e per year, greater than the current emissions from electricity and transport combined.

Table 6: Impact of Leader scenario relative to other scenarios

	Total change 2005 - 2050			Leader scenario relative to others in 2050	
	Free Rider	Follower	Leader	Free Rider	Follower
Real GNP	256%	253%	244%	-3.3%	-2.6%
Real GDP	249%	247%	242%	-2.0%	-1.4%
Employment	72%	72%	72%	0.0%	0.1%
Real private consumption per person	158%	155%	148%	-4.2%	-3.0%
Difference in net emissions (Mt CO2e)				293	209
Difference in net emissions as a share of emissions in 2010				49%	35%

Note: See Table 4 for performance of the scenarios relative to the base case, without national or global emissions reductions

These findings suggest that making very substantial reductions in Australia's net greenhouse emissions is affordable, and compatible with continuing growth in incomes, employment and living standards.

The key finding of this report is that the leadership premium associated with Australia committing early to very substantial cuts in our net greenhouse emissions is modest and affordable, and would help manage the economic risks to Australia as well as contributing to the global momentum and concrete actions required to avoid dangerous global climate change.

Appendix: Modelling framework

Modelling was undertaken with the MMRF-Green macro economic model of the Australian economy. MMRF is a detailed, dynamic, multi-sectoral, multi-regional model of Australia. The current version of the model used for this project distinguishes 52 industries, 56 products, 8 states/territories and 56 sub-state regions*. There are five types of agents in the model: industries, capital creators, households, governments, and international agents. For each sector in each region there is an associated capital creator. The sectors each produce a single commodity and the capital creators each produce units of capital that are specific to the associated sector. Each region in MMRF has a single household and a regional government. There is also a federal government. Finally, there are international actors , whose behaviour is summarised by export demand curves for the products of each region and by supply curves for international imports to each region.

A.1 Overview of modelling approach

MMRF determines regional supplies and demands of commodities through optimising behaviour of agents in competitive markets. Optimising behaviour also determines industry demands for labour and capital. Labour supply at the national level is determined by demographic factors, while national capital supply responds to rates of return. Labour and capital can cross regional borders so that each region's endowment of productive resources reflects regional employment opportunities and relative rates of return.

The specifications of supply and demand behaviour co-ordinated through market clearing equations comprise the general equilibrium (GE) core of the model. There are three blocks of equations in addition to the core. The first two describe regional and federal government finances, and the operation of regional labour markets. The third block, which is of direct relevance to this study, contains enhancements for the study of greenhouse gas issues. These enhancements include:

- An energy and gas emission accounting module, which accounts explicitly for each of the 52 industries and eight regions recognised in the model;
- Equations that allow for inter-fuel substitution in electricity generation by region;
- Mechanisms that allow for the endogenous take-up of abatement in response to greenhouse policy measures, including new technologies (for example, Integrated Gasification Combined Cycle coal generation (IGCC), and carbon capture and storage (CCS)); and
- A detailed representation of the National Electricity Market (NEM).

A more complete description of the model is given in Centre of Policy Studies (CoPS) (2007).[61]

A.2 Impact of tax reductions funded through permit auction revenues

Assumptions around revenue recycling are one of the key factors that can explain differences between macro economic modelling on the impact of reducing emissions. Here we assume, free permits are used to insulate trade-exposed emissions-intensive industries until 2030. We assume all remaining permits are auctioned and all revenue is returned to the Government. This revenue is used to reduce inefficient personal and corporate income tax in proportion to existing revenue shares, consistent with the modelling undertaken for the Australian Business Roundtable on Climate Change. This reduces the impact macroeconomic costs of reducing emissions because it improves the efficiency of the economy by reducing inefficient income and corporate taxes at the same time as reducing emissions.

Also we have assumed that generators will receive no compensation for the introduction of an emissions trading scheme. If this compensation is large this could reduce the benefits to the economy from restructuring the tax regime.

Reductions in personal income taxes will permanently boost employment due to increased incentive to participate in the work force. The analysis assumes early tax reductions are targeted to boost workforce participation. This increases labour supply by 0.5-1.0%, phased in as total permit revenues exceed $4-6 billion.[62, 63, 64] Reductions in corporate taxes encourage investment and hence capital formation.

The expansionary effect of the employment boost from targeted tax reductions offsets the inhibiting effect of the emissions constraint to some degree. This reduces the impact of emissions reductions by around 0.7% in 2050. The magnitude of this effect is consistent with previous studies. [65] Table 6 sets out the impact of the emissions reductions on key variables without the targeted tax reform effect, and the difference in these impacts relative to the tax efficiency approach modelled in this report.

Table 7: Sensitivity analysis: Effect of targeted tax reform on the magnitude of economic impacts in 2050, all scenarios

	Difference relative to base case in 2050 Untargeted Tax Reductions			Difference in Estimated Impacts in 2050, Targeted vs Untargeted		
	Free Rider	Follower	Leader	Free Rider	Follower	Leader
Real GNP	-0.9%	-1.6%	-4.1%	0.68%	0.68%	0.70%
Real GDP	-3.0%	-3.5%	-4.9%	0.73%	0.72%	0.75%
Employment	-2.7%	-2.7%	-2.6%	0.74%	0.74%	0.74%
Real private consumption per person	0.5%	-0.7%	-3.7%	0.57%	0.56%	0.58%

* Of the 52 industries, 3 produce primary fuels (coal, oil and gas), 1 produces refined fuel (petroleum products), 6 generate electricity and 1 supplies electricity to final customers. The six generation industries are defined according to the primary source of fuel: Electricity-coal includes all coal-fired generation; Electricity–gas includes all plants using gas turbines, Cogen and combined cycle technologies driven by burning gas; Electricity-oil products covers all liquid-fuel generators; Electricity-hydro covers hydro generation; while the remaining industries cover other forms of renewable generation from biomass, biogas, wind etc. Note that Electricity-wind is the residual category covering all non-hydro renewable generation other than from biomass and biogas.

Other than the petroleum products industry (industry 18), each industry produces a single product. The petroleum products industry produces 5 products – automotive petroleum, aviation fuels, diesel, LPG and other refinery products. Thus, in total 56 products are produced by the 52 industries.

A.3 Limitations of the model for the current project

MMRF is a single country model. Hence model-determined interaction between Australia and the rest of the world arising from the ETS is limited to movements along the export demand and import supply schedules for Australia's traded goods. We do not model feedback from the model-determined changes in the Australian economy on the positions of foreign export demand and import supply schedules.

The model does not endogenously predict the emergence of new industries, such as coal generation with carbon capture and storage, or nuclear.

For the simulations discussed in this report, no attempt is made to include the possible effects of climate change in any of the scenarios. That is, there are no assumptions made about the possible costs as a result of climate change. For example, we do not assume an increase in the price of water resulting from measures designed to adapt to reduced rainfall and reduced runoff in water catchments. Neither do we include other more serious predictions of climate scientists, such as the flooding of low-lying urban areas or increased bush fire activity.

This may also be important for abatement options available in the model as water supplies and extreme events may affect forestry sinks and electricity generation. For example, according to the AGO in the Kyoto target period the forestry sink is projected to be 22.8 $MtCO_2$ / year.[66] However, they note that "The Kyoto reforestation estimates are particularly sensitive to risk of fire and climate effects such as drought." Climate change projections suggest where forestry is water limited climate change will lead to declining production and global warming below 3°C is within the known adaptive capacity of forestry systems.[67] This suggests that climate change may impact on the viability of forestry sink projections in the model and this may marginally increase the cost of achieving projected emission reductions.

Not allowing for the possible effects of climate change means that we do not account for any of the possible direct economic benefits arising from the abatement achieved by an ETS. For example, we do not account for the improvements to the foreign competitiveness of water-dependent agricultural and mining industries that would arise if abatement from the ETS were to ease upward pressure on water prices.

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