Australian Government
Climate Change Authority

# REDUCING AUSTRALIA'S GREENHOUSE GAS EMISSIONS—TARGETS AND PROGRESS REVIEW
# FINAL REPORT

FEBRUARY
2014

Published by the Climate Change Authority

www.climatechangeauthority.gov.au

ISBN: 978-0-9873828-6-3



**IMPORTANT NOTICE—PLEASE READ**



Cover image courtesy of NASA

**Australian Government**
**Climate Change Authority**

27 February 2014

The Hon. Greg Hunt, MP
Minister for the Environment
Parliament House
Canberra ACT 2600

Dear Minister

I present the Climate Change Authority's report on its Targets and Progress Review.

The report is submitted pursuant to sections 289 and 291 of the *Clean Energy Act 2011* (Cth). These require the Authority to make recommendations on an indicative national emissions trajectory, national carbon budget and carbon pollution caps, and to report on Australia's progress in achieving its medium- and long-term emissions reduction targets and budgets. The Authority has consulted widely with the public in conducting this Review. As also required by the Act, the report, together with supporting documents, will be published on the Authority's website (www.climatechangeauthority.gov.au).

Climate change poses major challenges for communities everywhere, and how these challenges are handled will affect the wellbeing of future as well as current generations. Almost by default, governments have to assume the dominant role in policy-making in this area. The Authority hopes its report, which documents these ongoing challenges and canvasses some policy options to tackle them, will assist your government in this endeavour.

As you know, the Authority's members have considerable experience in diverse fields, including science, economics, business and public policy. This experience underpins the recommendations in the report which, in the Authority's view, represent an appropriate balancing of economic, environmental and — not least — community interests.

On behalf of all Authority members, I would like to again acknowledge the sterling efforts of the secretariat in the preparation of this report. The sustained commitment and professionalism of Ms Anthea Harris and her team has contributed enormously to the quality of this document.

Yours sincerely

BRJ Fraser

**Bernie Fraser**
**Chair**

GPO Box 1944, Melbourne VIC 3001 | T: +61 (0)3 8656 3000 | F: +61 (0)3 8656 3030

www.climatechangeauthority.gov.au

# ACKNOWLEDGEMENTS

The Authority would like to thank the many people and organisations that contributed time and expertise to the Targets and Progress Review. These contributions have included climate science advice, assistance with economic modelling and analysis, and international and domestic policy expertise. These contributions have enhanced the quality of the Review and provided evidence to inform the Authority's recommendations.

A number of government departments and public agencies have supported the work of the Authority during the course of the Review. They include: the Department of the Environment, the Treasury, the Australian Energy Markets Commission, the Australian Energy Market Operator, the Australian Embassy in China, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Resources and Energy Economics.

The Authority consulted extensively across a range of industry, academic and non-government stakeholders. The Authority is particularly grateful to the support and assistance provided by: Dr Josep Canadell (CSIRO), Associate Professor Peter Christoff (University of Melbourne), Dr Ian Enting (University of Melbourne), Dr Roger Gifford (CSIRO), Dr Helen Hughes (CSIRO), Professor Lesley Hughes (Macquarie University), Dr Malte Meinshausen (University of Melbourne), Professor Michael Raupach (CSIRO), Dr Luke Reedman (CSIRO), Professor Will Steffen (Australian National University), Dr Penny Whetton (CSIRO), Alex Wonhas (CSIRO), the staff at ClimateWorks Australia, the Global Carbon Capture and Storage Institute, the US Department of State and World Resources Institute.

Finally, the Authority would like to thank the many stakeholders who provided submissions throughout the Review.

# CONTENTS

# SUMMARY

*This is the final report of the Climate Change Authority on its Targets and Progress Review.*

The Climate Change Authority is required by legislation to review Australia's greenhouse gas emissions reduction goals and report on progress towards them. The Targets and Progress Review fulfils these requirements and recommends emissions reduction goals that would provide a clear course for action to 2020, and guidance beyond.

The Authority was established as an independent statutory agency to provide advice to government and parliament. In developing this report, the Authority has assessed an extensive evidence base, along with significant input from stakeholders.

## WHY IS THIS REVIEW IMPORTANT?

*Climate change science indicates the world is warming and human activities are the dominant cause.*

Climate change science is clear—the world is warming and human activities are the dominant cause.

Climate change poses major risks for Australia's people, economy and environment. A warmer climate is predicted to increase the frequency and intensity of weather extremes, such as heatwaves, droughts, floods and bushfires, and to cause rises in sea levels. Australia is likely to better adapt to projected impacts if global warming is limited to less than 2 degrees above pre-industrial levels. With larger increases, adaptation can be expected to become increasingly costly and challenging.

*Global action to limit warming to below 2 degrees will benefit Australia.*

The international community has made a commitment to keeping global warming below 2 degrees. To meet this shared goal, Australia and other countries need to strengthen their emissions reduction efforts.

Australia stands to benefit from stronger global action, but it must also be prepared to do its part to meet the global goal. In this Review, the Authority outlines its views on what a reasonable contribution from Australia would be.

*This Review is timely as Australia considers its emissions reduction goals …*

A review of Australia's emissions reduction goals is especially relevant at this time.

Australia has a formal international undertaking to reduce emissions by at least 5 per cent by 2020, compared with 2000 levels, and has indicated it might do more under certain circumstances. As part of international negotiations, Australia has committed to reviewing its minimum 5 per cent offer and to advising, by 30 April 2014, whether it proposes to increase its 2020 target. (This is not the last opportunity—governments can strengthen their targets at any time.)

A new international agreement, covering emissions reduction goals beyond 2020, is scheduled to be negotiated by the end of 2015. This agreement is intended to cover all major emitting economies; Australia will be expected to indicate its post-2020 targets by the first quarter of 2015.

*… and develops its climate policies.*

The government is currently revising Australia's climate policies. The Authority's Review examines the latest evidence on climate science and the impacts of climate change, international action to reduce emissions, and economic and social implications for Australia. It also reports on where Australia has successfully reduced emissions, where there are gaps and opportunities for greater reductions, and how a suite of policies might help to realise those opportunities in a cost-effective way.

## WHERE ARE WE NOW?

*Australia's emissions intensity has halved since 1990 …*

Australian governments—Commonwealth, state and local—have implemented a range of policies to reduce greenhouse gas emissions over the past two decades.

Australia's emissions were broadly the same in 2012 as in 1990, notwithstanding a doubling in the size of the economy. This means that the emissions intensity of the economy has halved over that period. While broader economic forces have accounted for some of this reduction in emissions intensity, policy has also contributed.

Further, Australia's emissions over the period 2008–2012 averaged 104 per cent of 1990 levels, less than its 108 per cent target under the Kyoto Protocol. As a result, Australia has 116 Mt $CO_2$-e of emissions rights to carryover to its 2013–2020 Kyoto commitment.

*… but more needs to be done.*

Further efforts are, however, necessary to achieve absolute reductions in emissions. In 2012, Australia's greenhouse gas emissions totalled 600 Mt $CO_2$-e, 2.5 per cent above 2000 levels. In the absence of a carbon price or other effective policies, emissions are projected to grow to 685 Mt $CO_2$-e in 2020, 17 per cent above 2000 levels.

## WHAT DOES THE AUTHORITY RECOMMEND?

*The Authority recommends a coordinated set of goals that would manageably spread future efforts over time ...*

In this report, the Authority adopts a budget approach to develop emissions reduction goals for the short, medium and long term (Chapter 7). Setting a budget for emissions through to 2050 highlights the trade-offs involved between actions taken now and those made necessary later. In short, weaker action now imposes a greater emissions reduction task on future generations.

Setting longer term emissions reduction goals, in addition to shorter term goals, is especially significant for investors (and their financiers) in long-lived assets.

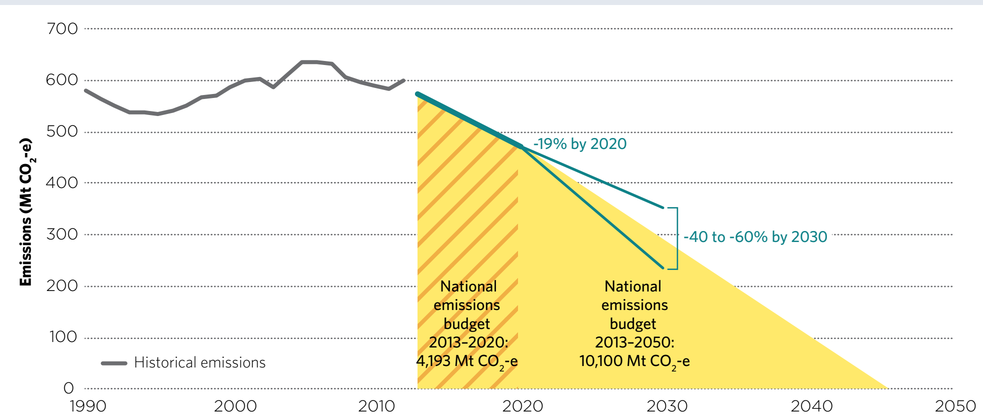
*... comprising 2020 goals, a trajectory range to 2030 and a budget to 2050.*

The Authority recommends a coordinated set of goals for Australia:

- 2020 goals, providing a clear course for short-term action:
  - a minimum 2020 target of 15 per cent below 2000 levels
  - using Australia's carryover under the Kyoto Protocol to raise the 2020 target by 4 percentage points, giving an effective target of 19 per cent
  - an indicative national trajectory consistent with 19 per cent and an emissions budget of 4,193 Mt $CO_2$-e for the period 2013–2020.
- Beyond 2020, guidance for longer term planning and investment, subject to frequent review in light of new information:
  - a trajectory range for emissions reductions of between 40 and 60 per cent below 2000 levels by 2030
  - a national emissions budget for 2013–2050 of 10,100 Mt $CO_2$-e, based on what might be considered Australia's fair share of a global emissions budget.

While different goals were canvassed and assessed, the Authority believes its recommendations provide a credible set of goals for Australia at this time.

**FIGURE 1:** RECOMMENDED EMISSIONS REDUCTION GOALS




**Source:** Climate Change Authority

*Australia needs strong and lasting policies to reduce domestic emissions.*

Targeted and sustained emissions reduction policies, including market-based and complementary measures, are needed now to drive a steady transformation of the Australian economy. These can help Australia stay competitive as the world moves to a low-emissions future. Climate change policies should have regard to their distributional consequences and, as appropriate, be coordinated with industry, trade and other objectives.

*International emissions reductions should complement domestic efforts.*

International emissions reductions can provide an environmentally sound and cost-effective complement to domestic actions. The Authority recommends that Australia draw upon international emissions reductions to help meet the proposed 2020 target, and that the government establish a fund to purchase those reductions.

## THE REASONING UNDERLYING THE AUTHORITY'S RECOMMENDED GOALS

*The Authority recommends a minimum 2020 target of 15 per cent, rising to 19 per cent with carryover.*

Based on all the evidence available to it, the Authority concludes that Australia's 5 per cent target is inadequate (Chapter 9) and recommends a minimum target of 15 per cent, rising to 19 per cent with the carryover from the Kyoto Protocol.

There are three key reasons why the Authority makes these recommendations.

*A 5 per cent target is inconsistent with the below 2 degree goal.*

First, a 5 per cent target for 2020 would not be a credible start by Australia towards achieving the below 2 degree goal. It would leave an improbably large task for future Australians to make a fair contribution to global efforts.

A target of 15 per cent (plus carryover) represents a more appropriate response to the latest science and a more manageable spread of efforts over the decades ahead. While emissions reduction efforts would still have to accelerate in the future, significantly more of the projected budget to 2050 would be available for future years compared with a 5 per cent target.

*The pace of international action justifies Australia going further …*

Second, the scale and pace of global action suggests Australia should be moving beyond 5 per cent (Chapter 4).

*… with China and the United States stepping up their efforts.*

The world's two largest emitters, China and the United States, are stepping up their efforts on climate change. Both countries have emissions reduction targets and are investing heavily in renewable energy—estimated at more than US$100 billion in 2012. China is tightening its vehicle emissions standards, replacing inefficient coal-fired power plants with more efficient plants, and has established five sub-national pilot emissions trading schemes. In the United States, a 2013 presidential action plan on climate change includes new restrictions on emissions from coal-fired power plants, stronger vehicle emission standards and additional energy efficiency measures. These are intended to complement existing state-based market initiatives to reduce emissions and increase the use of renewable energy.

*A 2020 target of 15 per cent plus carryover is more in line with other countries.*

Australia's 5 per cent target is weaker than that of many comparable countries. For example, the United States has a 2020 target of 17 per cent below 2005 levels; the UK has a target of 34 per cent below 1990 levels; Norway has a target of 30–40 per cent below 1990 levels. A target of 15 per cent plus carryover for Australia would be more in line with the targets being pursued by such countries.

*Stronger targets can be achieved at a manageable cost.*

Third, the Authority believes the costs of meeting the recommended target would be manageable.

The costs of delivering the recommended target depend very much on the policies used to pursue it. At this time, the government is still in the process of developing its policies and the Authority could not therefore assess the costs of pursuing the recommended target with such policies.

In these circumstances, the Authority has drawn on economic modelling based on the current legislation to estimate the incremental costs of moving from 5 per cent to a stronger target (Chapter 10). This modelling suggests that adopting a 2020 target of 15 per cent plus carryover would slow annual growth in average per person income by 0.02 per cent, compared with meeting the 5 per cent target.

One reason why the incremental costs are so low is that the current legislation allows a mix of domestic and international reductions to achieve the target. Australia could meet the whole of the incremental emissions reduction task associated with moving from 5 per cent to the recommended target through the carryover and the use of additional international emissions reductions.

The government intends to implement different policies to achieve the 5 per cent target; these will have different costs from the approach envisaged in the current legislation. The issue of costs (and their distribution) will need to be revisited when the government finalises its policies. The *incremental* costs of moving to a stronger target would, however, be comparable to those estimated under the current legislation so long as the stronger target was achieved through the use of international emissions reductions.

*The government's conditions for moving beyond 5 per cent have been met.*

In 2009, the government set conditions for when Australia might move beyond the unconditional 5 per cent target to a 15 or 25 per cent target. In the Authority's view, the conditions for moving beyond 5 per cent have been met. Whether the conditions for 15 per cent have been met is unclear—some elements have been met; others are marginal. The conditions for a 25 per cent target have not been met.

The Authority's charter requires it to examine considerations beyond those accounted for in the conditions, including climate science, international actions, economic impacts and equity. Taken together, these broader considerations are believed to justify the Authority's recommended goals, including a minimum 2020 target of 15 per cent.

*The Authority recommends a medium-term trajectory range of 40–60 per cent reductions by 2030 …*

The Authority recommends a trajectory range for emissions reductions from the 2020 target to a level between 40 and 60 per cent below 2000 levels in 2030. This range should be reviewed periodically as new information emerges.

The middle of the trajectory range is consistent (on a straight-line basis) with the recommended national emissions budget to 2050. Over time, developments in climate science, international action and economic factors can be expected to affect Australia's appropriate medium- and long-term goals. A trajectory range would give Australia the flexibility to adjust its emissions reduction trajectory in response to changing circumstances.

Climate change science suggests that to have a reasonable chance of achieving the below 2 degree goal, global greenhouse gas emissions need to be reduced substantially (Chapter 3). Keeping within a global emissions budget of 1,700 Gt $CO_2$-e between 2000 and 2050 is calculated to give at least a likely (two-thirds) chance of staying below 2 degrees—emitting less would improve the odds; emitting more would reduce them. A significant proportion of this global budget has been used already.

*… and a long-term emissions budget of 10.1 Gt $CO_2$-e to 2050.*

The Authority believes an emissions budget of 10.1 Gt $CO_2$-e for the period 2013 to 2050 (or about one per cent of the remaining estimated global budget) would represent an equitable share for Australia (Chapter 8). Again, this budget should be kept under review and adjusted for relevant developments.

## WHAT ARE THE NEXT PRACTICAL STEPS FOR AUSTRALIA?

*Action can help Australia stay competitive as the world acts to reduce the risks of climate change.*

A strong and coordinated suite of policies is essential for Australia to achieve the recommended goals.

A continuing global trend towards stronger climate action and a lower emissions global economy could make it difficult for Australia to remain competitive as a high-emissions economy. To head off this risk, Australia needs policies now to drive reductions in domestic emissions, promote a steady transformation of the domestic economy, capture low-emissions growth opportunities, encourage innovation and stimulate new low-emissions investment.

Many of these initiatives have long lead times. In the meantime, international emissions reductions can be used to complement domestic efforts and assist Australia to make its contribution to global action in a cost-effective way.

*Australia can achieve substantial domestic emissions reductions …*

Substantial emissions reductions are available domestically (Chapter 11). The Authority has identified low- to medium-cost emissions reduction opportunities across all sectors of the economy, such as:

- using less emissions-intensive energy sources such as renewables, particularly for electricity generation
- reducing fugitive emissions from energy resource extraction, particularly the development of relatively lower emissions mines and uptake of existing and new technologies to capture methane
- modifying industrial processes; for example, using nitrous oxide abatement technology
- improving the efficiency of buildings, equipment and vehicles
- increasing reforestation and afforestation, lowering rates of deforestation and improving land management.

The electricity sector could offer the single largest opportunity for emissions reductions in response to price incentives, through both a reduction in the emissions intensity of generation and energy efficiency.

*… if policies are put in place now.*

There can be lags between designing and implementing a policy to reduce emissions and seeing tangible results—many of the potential actions and investments have extended lead times, and long-lived capital stock turns over slowly. If sustained and cost-effective policies are put in place in the next few years, emissions can be reduced substantially over the period to 2030.

Energy efficiency will be particularly important in the near term. Policies that drive the transition to low-emissions technologies, buildings and vehicles will contribute more to emissions reductions beyond 2020 as equipment and infrastructure is replaced. To be in line with other developed countries and China, Australia should consider light vehicle $CO_2$ emissions standards. They are likely to be an effective complement to a carbon price or baseline and credit scheme, and could deliver significant, cost-effective emissions reductions and other benefits.

*International emissions reductions are a cost-effective and environmentally sound way to help meet Australia's goals …*

Although it is important to drive domestic reductions, climate change is a global phenomenon. As long as international reductions are real, they have the same effect on climate outcomes as domestic reductions.

Over-reliance on international emissions reductions could delay Australia's domestic transition, increasing the risk of disruptive and costly adjustment in future decades. Particularly in the period to 2020, however, using international reductions to complement domestic efforts could help Australia meet its emissions reduction goals at lower cost and support broader trade and foreign policy objectives. In turn, these benefits could encourage more ambitious action, both in Australia and overseas.

*… complementing domestic action.*

The Authority recommends Australia use international emissions reductions to bridge gaps between domestic reductions and the recommended goals. The government has indicated it will achieve the minimum 5 per cent target through domestic emissions reductions, but the Authority believes international reductions could also have a role to play in meeting that target.

There is currently a large supply of genuine emissions reductions available in the global market at historically low prices. Moving from 5 per cent to the Authority's recommended target of 15 per cent plus carryover would require an additional 427 Mt $CO_2$-e of emissions reductions over the period to 2020. The cost of purchasing all these reductions internationally is between $200 million and $900 million, assuming average unit prices of between $0.50 and $2 per tonne (current prices are less than $1).

*The government should establish a fund to purchase genuine international emissions reductions to move from 5 per cent to the recommended 2020 goals.*

The Authority recommends a government fund be established to purchase sufficient genuine international emissions reductions to close any gap between domestic reductions and the recommended 2020 target. This would provide time to implement policies for efficient domestic emissions reductions, while enabling Australia to make a reasonable contribution to global efforts in a cost-effective way.

# RECOMMENDATIONS

| RECOMMENDATION | NUMBER | PAGE |
|---|---|---|
| **Emissions reduction goals—short-term targets and longer term guidance** | | |
| A minimum 2020 emissions reduction target of 15 per cent below 2000 levels. | R.5 | 124 |
| Australia's carryover from the first commitment period of the Kyoto Protocol be used to raise the 2020 emissions reduction target by 4 percentage points, giving a 2020 target of 19 per cent. | R.6 | 124 |
| An indicative national trajectory for the period 2013–2020 that follows a straight line to the 2020 target. This line starts at Australia's first commitment period target under the Kyoto Protocol (108 per cent of 1990 levels) in 2010, and ends at 19 per cent below 2000 levels in 2020. | R.7 | 124 |
| A national carbon budget for the period 2013–2020 of 4,193 Mt $CO_2$-e. | R.8 | 124 |
| Beyond 2020, Australia continue to reduce emissions within a trajectory range bounded by the paths to 40 and 60 per cent below 2000 levels in 2030. | R.9 | 126 |
| A national carbon budget for the period 2013–2050 of 10.1 Gt $CO_2$-e. | R.4 | 117 |
| **Periodic review of goals** | | |
| The trajectory range and the national budget to 2050 be reviewed at least every five years. There could be additional reviews to take account of major developments; for example, in 2016 to take account of international developments on the post-2020 framework. As part of these reviews, the trajectory range would be extended to maintain a similar period of guidance over time, and short-term targets and trajectories would be set within the existing range. | R.1 | 106 |
| The periodic reviews of the trajectory range and the national budget to 2050 have particular regard to the following general criteria—changes in or new information about climate science, the level and pace of international action, and economic factors. | R.2 | 106 |

| RECOMMENDATION | NUMBER | PAGE |
|---|---|---|
| **Actions to achieve goals** | | |
| The government use international emissions reductions to bridge any gap between domestic reductions achieved under the Direct Action Plan and the recommended 2020 goals. | R.11 | 186 |
| The government establish a fund to purchase Clean Development Mechanism units to complement the Direct Action Plan and help meet the recommended 2020 goals. | R.12 | 186 |
| The government investigate the near-term introduction of fleet-average $CO_2$ emissions standards for light vehicles in Australia as a way to secure significant, cost-effective emissions reductions and related co-benefits. | R.10 | 166 |
| **Implementation matters** | | |
| The government recognise voluntary action by cancelling one Kyoto Protocol unit for each tonne of emissions reductions achieved in the period 2013–2020 through:<br>• the voluntary cancellation of domestic units,<br>• the voluntary cancellation of renewable energy certificates, and<br>• GreenPower purchases. | R.3 | 109 |
| Carbon pollution caps for each of the first five years of the flexible-price period under the carbon pricing mechanism of:<br>Year — Cap (Mt $CO_2$-e)<br>2015–16 — 234<br>2016–17 — 228<br>2017–18 — 222<br>2018–19 — 215<br>2019–20 — 209 | R.13 | 199 |

# A

# INTRODUCTION AND CONTEXT

Part A introduces the Targets and Progress Review. In this Review, the Authority makes recommendations to the parliament, through the Minister for the Environment, about emissions reduction goals for Australia. The Authority also reviews Australia's progress towards meeting these goals, and identifies future emissions reduction opportunities—both within Australia and internationally. In developing its recommendations, and in drawing the conclusions set out in this report, the Authority considered evidence and expert and stakeholder views about a wide range of matters.

Part A examines the context for making decisions about Australia's emissions reductions goals. It presents evidence about climate science, the impacts of climate change and what is required to meet the global goal to limit temperature rises to below 2 degrees. It then considers global action to reduce greenhouse gas emissions, how global action measures against the global goal and what this means for Australian action.

Part A sets out:

- the scope of the Targets and Progress Review and the Authority's approach (Chapter 1)
- climate science and the likely impacts of climate change on Australia and other countries (Chapter 2)
- the amount of greenhouse gas emissions the world can emit while preserving a likely chance of limiting global warming to below 2 degrees (Chapter 3)
- global action to reduce greenhouse gas emissions and its implications for Australia's emissions reduction goals (Chapter 4).

# 1 ABOUT THIS REVIEW

Climate change poses serious risks to the Australian community, economy and environment. Effective policies that reduce Australia's emissions and support a global solution are in Australia's interest.

The Climate Change Authority is an independent body established to provide expert advice to the Commonwealth Government on Australian climate change policy. This report fulfils the Authority's legislative requirements to make recommendations about Australia's emissions reduction goals and report on progress in reducing its emissions.

The report recommends short-, medium- and long-term emissions reduction goals, as well as the corresponding trajectory ranges and emissions budgets. This will help inform government decision-making on future international commitments and the design of new policy.

In the Targets and Progress Review, the Authority has considered the latest climate science, international action, Australia's progress in reducing emissions, international and inter-generational equity, the economic costs of different targets and opportunities for future emissions reductions. Australia's existing international obligations and undertakings were a starting point for the Review.

This chapter introduces the Targets and Progress Review. It provides information about the Authority, discusses the Review, and explains the Authority's approach to its analysis and recommendations.

## 1.1 THE CLIMATE CHANGE AUTHORITY

The Climate Change Authority is an independent statutory agency, established to provide expert advice on Australian climate change policy, including through a scheduled series of reviews of climate programs and legislation.

The Authority is chaired by Mr Bernie Fraser and comprises nine members with expertise in climate science, economics, business and public policy. Its work is guided by a set of principles under the *Climate Change Authority Act 2011* (Cth). The Act states that, in conducting a review, the Authority must have regard to the following matters:

- economic efficiency
- environmental effectiveness
- equity

- the public interest
- the impact on households, business, workers and communities
- the development of an effective global response to climate change
- Australia's foreign policy and trade objectives
- any additional principles the Authority considers relevant.

The Authority has taken these matters into account in the Targets and Progress Review.

The Authority is required to consult in conducting its reviews. Public consultation has been a key part of the Targets and Progress Review. The Authority has engaged with a wide range of interested parties, who have provided essential input to the review process.

## 1.2 CONTEXT

Climate change is an ongoing global problem that poses serious risks to the Australian community, economy and environment. Effective policies that reduce Australia's emissions and support a global solution are in Australia's interest.

This report can help inform the Commonwealth Government as it makes decisions in the near future about Australia's 2020 target and post-2020 emissions reduction goals (outlined in Figure 1.1). Under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, countries are considering ways to increase global action to reduce emissions. Australia has committed to reviewing its 2020 Kyoto target and advising whether it intends to strengthen it from the minimum 5 per cent reduction (on 2000 levels) by April 2014. At the same time, UNFCCC Parties are considering a post-2020 international climate framework and Australia will be expected to indicate its post-2020 goals by the first quarter of 2015. The government is also free to strengthen its emissions reduction efforts at any time.

**FIGURE 1.1:** THE AUTHORITY'S REVIEW AND INTERNATIONAL CLIMATE CHANGE MILESTONES 2014–15


This report can also inform government decision-making as it determines new policy settings to address climate change. The government has announced it intends to repeal the carbon pricing mechanism and replace it with a Direct Action Plan. In December 2013, the government released a Green Paper setting out its preferred options for the design of an Emissions Reduction Fund, which is the centrepiece of the Direct Action Plan. A White Paper outlining the fund's final design is due in early 2014.

## 1.3 THE TARGETS AND PROGRESS REVIEW

The Targets and Progress Review covers two legislated reviews under the *Clean Energy Act 2011* (Cth), which require the Authority to:

- make recommendations about Australia's emissions reduction goals, including specifically an indicative national emissions trajectory and a national carbon budget (referred to in this report as an emissions budget) and carbon pollution caps (s. 289)

- report on Australia's progress in achieving its medium- and long-term emissions reduction targets, and progress in meeting a national emissions budget (s. 291).

The matters to which the Authority must have regard in conducting these reviews are set out in the Clean Energy Act and listed at Box 1.1.

**BOX 1.1: LEGISLATED REVIEW REQUIREMENTS**

The Clean Energy Act sets out specific matters to which the Authority must have regard in the Targets and Progress Review:

**Review of caps, trajectories and budgets** (s. 289)

(a) Australia's international obligations under international climate change agreements;

(b) undertakings relating to the reduction of greenhouse gas emissions that Australia has given under international climate change agreements;

(c) Australia's medium-term and long-term targets for reducing net greenhouse gas emissions;

(d) progress towards the reduction of greenhouse gas emissions;

(e) global action to reduce greenhouse gas emissions;

(f) estimates of the global greenhouse gas emissions budget;

(g) the economic and social implications associated with various levels of carbon pollution caps;

(h) voluntary action to reduce Australia's greenhouse gas emissions;

(i) estimates of greenhouse gas emissions that are not covered by this Act;

(j) estimates of the number of Australian carbon credit units that are likely to be issued;

(k) the extent (if any) of non-compliance with this Act and the associated provisions;

(l) the extent (if any) to which liable entities have failed to surrender sufficient units to avoid liability for unit shortfall charge;

(m) any acquisitions, or proposed acquisitions, by the Commonwealth of eligible international emissions units;

(n) such other matters (if any) as the Climate Change Authority considers relevant.

**Review of progress** (s. 291)

(a) the level of greenhouse gas emissions in Australia;

(b) the level of purchases of eligible international emissions units (whether by the Commonwealth or other persons);

(c) the level of greenhouse gas emissions that:

(i) are attributable to activities in the Australian economy; and

(ii) are not reflected in the provisional emissions numbers of liable entities;

(d) voluntary action to reduce greenhouse gas emissions;

(e) such other matters (if any) as the Climate Change Authority considers relevant.

In line with the legislative requirements, this report:

- presents evidence about climate science and international action to reduce greenhouse gas emissions
- assesses Australia's progress in reducing greenhouse gas emissions across the whole economy and within specific sectors
- recommends a coordinated set of emissions reduction goals for Australia:
  - a short-term target for 2020, and an emissions budget and trajectory to 2020 providing a clear course for short-term action
  - a trajectory range to 2030 and a national emissions budget to 2050, providing guidance for longer term planning, subject to periodic review to respond to new information and changing circumstances
- identifies and assesses opportunities for emissions reductions in different sectors of the economy, and policies to capture these opportunities
- recommends international emissions reductions be used to help Australia meet its emissions reduction goals (in particular, its 2020 target).

Box 1.2 defines the key terms, including ‘target’, ‘budget’, ‘trajectory’ and ‘net target’.

### BOX 1.2: KEY DEFINITIONS—AUSTRALIA’S EMISSIONS REDUCTION GOALS

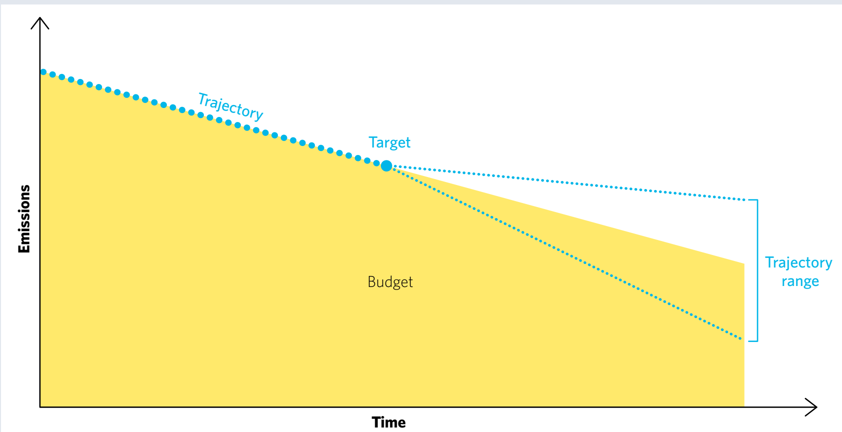
**Target:** A national emissions goal for a specific year. The Authority will recommend a 2020 target expressed as a percentage reduction in emissions from 2000 (see Figure 1.2).

**Budget:** Australia’s cumulative emissions allowance over a period of time. The Authority will recommend a short-term budget for total emissions between 2013 and 2020, and a long-term budget between 2013 and 2050.

**Trajectory:** Australia’s indicative year-by-year national emissions pathway to its target. The Authority will recommend a 2013 to 2020 trajectory. It will also recommend a trajectory range from 2020 to 2030 (see ‘trajectory range’ below). The year-by-year points on the trajectory are indicative (non-binding) targets in each year. The area under the trajectory constitutes an emissions budget.

**Trajectory range:** The range within which future trajectories may be set. A trajectory range provides an indication of future trajectories and flexibility to take into account new information. The Authority is recommending a trajectory range from 2020 to 2030.

#### FIGURE 1.2: TARGET, TRAJECTORY, TRAJECTORY RANGE AND BUDGET




**Source:** Climate Change Authority

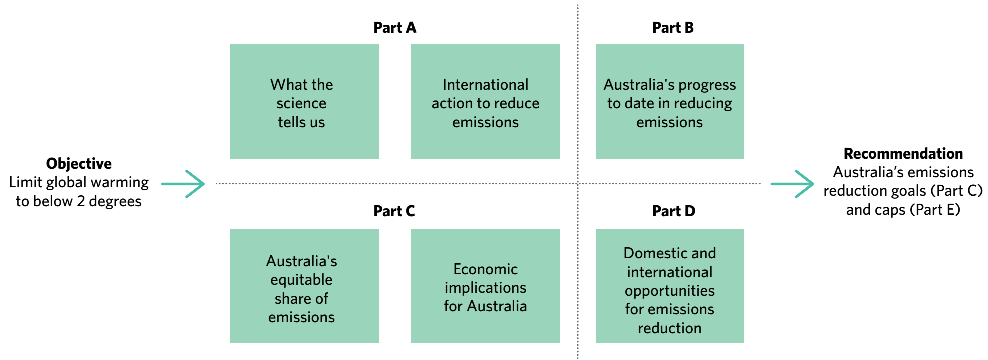
**‘Net’ targets:** The recommended emissions reduction goals are net of trade. This means that any international emissions reductions Australia buys will count as reductions towards its target—but any emissions reductions sold overseas cannot be counted. Emissions in Australia could be higher than the target if offset by purchases of international emissions reductions.

## 1.3.1 THE AUTHORITY'S APPROACH TO RECOMMENDING EMISSIONS REDUCTION GOALS AND ASSESSING AUSTRALIA'S PROGRESS

The Authority has weighed a broad range of considerations in reaching its recommendations, including climate science, global action, the costs of reducing emissions and Australia's appropriate contribution to global emissions reductions.

Figure 1.3 illustrates the key considerations of the Targets and Progress Review, as set out in this report.

**FIGURE 1.3** TARGETS AND PROGRESS REVIEW—KEY CONSIDERATIONS AND STRUCTURE OF THE REPORT




**Source:** Climate Change Authority

The Authority has taken Australia's existing international obligations and undertakings as a starting point for its deliberations, including Australia's commitment to the global goal to limit warming to below 2 degrees. It has also taken into account Australia's other emissions reduction commitments, including its international undertakings under the:

- UNFCCC—to reduce emissions by 5 per cent (unconditional) to 25 per cent below 2000 levels by 2020
- Kyoto Protocol—to limit average annual emissions in the period 2013 to 2020 to 99.5 per cent of 1990 levels, a calculation based on the unconditional 5 per cent target.

None of the Authority's recommendations would lead to Australia breaching its existing international obligations and undertakings. In other words, Australia's existing UNFCCC and Kyoto Protocol commitments have been taken as minimums.

## 1.3.2 PUBLIC CONSULTATION

The Authority conducted extensive consultation as part of the Review. Feedback from stakeholders was invaluable in informing this report and its recommendations. The public consultation included targeted roundtable discussions as well as workshops with experts on a global emissions budget, modelling assumptions and the electricity sector. Details of stakeholder consultation are at Appendix A.

The Authority released an Issues Paper in April 2013 and a Draft Report in October 2013. It received 69 Issues Paper submissions and 138 Draft Report submissions, plus over 12,000 submissions through a GetUp campaign. Submissions are available on the Authority's website at www.climatechangeauthority.gov.au.

## 1.4 STRUCTURE OF THIS REPORT

This report is divided into five parts.

### PART A: INTRODUCTION AND CONTEXT

The Authority has considered Australia's emissions reduction goals in a global context. Part A outlines:

- what climate science tells us about the risks climate change poses for Australians (Chapter 2)
- how climate science can inform the calculation of global emissions budgets and limits on global emissions consistent with a given limit on global warming (Chapter 3)
- global action underway to reduce emissions and Australia's role in that global action (Chapter 4).

### PART B: AUSTRALIA'S POLICIES AND PROGRESS TO DATE

Australia's progress to date in reducing emissions is relevant to considering future action. Part B outlines:

- Australia's policies to address climate change (Chapter 5)
- Australia's progress in reducing greenhouse gas emissions between 1990 and 2012 (Chapter 6).

### PART C: AUSTRALIA'S EMISSIONS REDUCTION GOALS

This sets out recommendations on:

- the timeframe, form and scope of Australia's emissions reduction goals (Chapter 7)
- a long-term budget for Australia, including consideration of equity between countries and generations (Chapter 8)
- Australia's emissions reduction goals (Chapter 9).

Part C also considers the economic implications of the recommended emissions reduction goals (Chapter 10).

### PART D: REDUCING AUSTRALIA'S EMISSIONS—OPPORTUNITIES AND CHALLENGES

This part examines:

- emissions reduction opportunities across different sectors of the Australian economy and challenges to realising those opportunities (Chapter 11)
- the benefits and risks of using international emissions reductions to help meet Australia's goals (Chapter 12).

### PART E: IMPLEMENTATION ISSUES UNDER THE CARBON PRICING MECHANISM

The Authority's recommendations to achieve Australia's emissions reduction goals under the carbon pricing mechanism, including:

- recommendations for annual carbon pollution caps (Chapter 13).

# SCIENCE AND IMPACTS OF CLIMATE CHANGE

# 2

Human activities produce greenhouse gases that are causing the climate to warm. If emissions continue to grow at current rates, warming is projected to increase rapidly over the 21st century, exceeding 2 degrees within the next few decades and foreseeably reaching 4 degrees or more by the end of the century.

Higher temperatures are projected to bring increasingly severe impacts on a global scale, which could include inundation of low-lying coastal areas, climate-induced migration of millions of people, growing risks to human health from many sources and the collapse of vulnerable ecosystems. In Australia, impacts are projected to include changes in rainfall; more frequent extreme events such as drought, flood and heatwaves; damage to sensitive ecosystems and infrastructure; and health effects. The extent of impacts will be determined by a number of factors, including future emissions of greenhouse gases and the climate system's response.

The international community has committed to limiting global warming to below 2 degrees, which requires strong action to reduce the world's emissions. No level of warming is considered 'safe', but 2 degrees would avoid the worst of the projected impacts and could allow Australia to adapt to many of the expected changes. As temperatures increase, adaptation will become increasingly costly and challenging. Global action to limit warming to below 2 degrees provides clear benefits to Australia.

The Targets and Progress Review is founded on science. There is extensive evidence that human activity is causing the world to warm at unusually rapid rates. Despite this evidence, coverage of climate science can be misleading and confusing. This chapter provides a clear summary of the science and the potential impacts of climate change for Australia. It discusses:

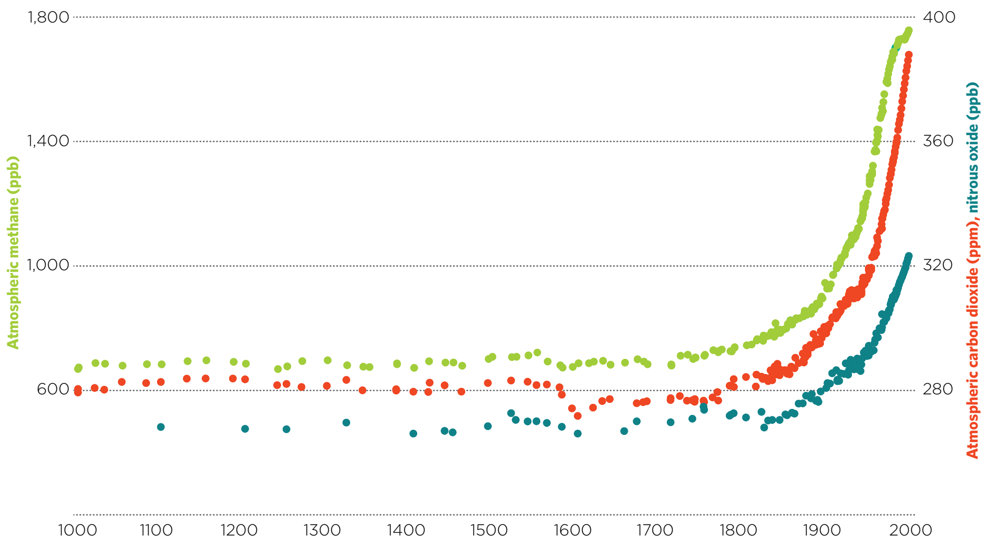
- climate science and the relationship between greenhouse gases and global warming
- the impacts caused by climate change to date
- the projected impacts of climate change, both globally and in Australia
- the social and economic costs of climate change.

## 2.1 CLIMATE SCIENCE

Human activity is causing the climate to warm. Activities such as burning fossil fuels, undertaking industrial processes and clearing land produce greenhouse gases. These gases trap heat radiated from Earth within the atmosphere, like a greenhouse. As concentrations of greenhouse gases increase, more heat is retained and the climate gets warmer.

Since the beginning of the Industrial Revolution in 1750, the concentration of carbon dioxide in the atmosphere has grown by 40 per cent, methane by 150 per cent and nitrous oxide by 20 per cent (IPCC 2013a, p. 7). According to ice core records, which show the atmosphere's historical composition, the current concentrations of these three gases substantially exceed the concentrations at any other time over the past 800,000 years (IPCC 2013a, p. 7). Figure 2.1 charts their concentrations over the past 1,000 years, showing rapid increases in all three major greenhouse gases, particularly since the 1950s.

**FIGURE 2.1:** CARBON DIOXIDE, METHANE AND NITROUS OXIDE CONCENTRATIONS OVER THE PAST 1,000 YEARS




**Source:** Adapted from CSIRO and BoM 2012, p. 8

Climate change is a long-term issue, as greenhouse gases can remain in the atmosphere over very long time scales. Carbon dioxide is the most important long-lived greenhouse gas and it is produced in large quantities by human activities. About one-third of the carbon dioxide increase due to emissions this year will remain in the atmosphere in 100 years and about 20 per cent will still be present in 1,000 years. So, long-lived greenhouse gases released now 'lock in' future warming, even if no more are emitted. For example, maintaining greenhouse gas concentrations (and other atmospheric constituents) at 2000 levels would have increased warming by an additional 0.6 degrees by the end of the 21st century. This is in addition to the 0.8 degrees of warming observed to 2000 (IPCC 2007a, SPM, 10.7.1). The long-term effects of greenhouse gases mean that the worst climate change impacts will be imposed on future generations, regardless of whether they contribute additional emissions themselves.

While it is unequivocal that the climate is warming, the climate system is complex and there are scientific uncertainties about how much the climate will change in the future. There is uncertainty about future emissions and levels of greenhouse gas concentrations, which will be determined by policies, population and technology changes. There is also uncertainty in the precise temperature response to future greenhouse gas concentrations. Climate models project future temperature changes that could be experienced under different greenhouse gas concentration scenarios, but can only estimate temperature increases within a probability range. The probability of limiting warming to 2 degrees under different levels of greenhouse gas emissions is discussed in detail in Chapter 3.

There is also some uncertainty about how land and ocean carbon sinks will operate in a warmer climate. To date, about 55 per cent of carbon dioxide emissions from fossil fuel combustion has been absorbed by the land and ocean combined, with the rest remaining in the atmosphere. However, the ocean has become less effective at absorbing carbon dioxide over the past 50 years, and the ability of trees to increase their uptake of carbon dioxide is projected to peak and decline by the middle of this century (Canadell et al. 2007; IPCC 2007b, p. 213). These changes would result in more carbon dioxide remaining in the atmosphere where the greenhouse effect takes place, so warming could be amplified in future.

While these uncertainties are real, the scientific understanding of climate change impacts has increased substantially since 1990, when the first comprehensive assessment of the state of climate change science was published by the Intergovernmental Panel on Climate Change (IPCC) (see Box 2.1 for an explanation of the IPCC's reports). Since then, there have been large increases in the number of climate observations and studies, substantial development in the scientific understanding of the climate system and increased sophistication of climate models. These advances have resulted in greater confidence in the connection between human activities and climate change, as well as in predicting future climate impacts (Figure 2.2).

## FIGURE 2.2: ADVANCES IN SCIENTIFIC UNDERSTANDING OF CLIMATE CHANGE

| IPCC report | FIRST ASSESSMENT REPORT (1990) | FOURTH ASSESSMENT REPORT (2007) | FIFTH ASSESSMENT REPORT (2013) |
|---|---|---|---|
| **Temperature levels** | Warming over the last 100 years is estimated at 0.3–0.6 degrees | Between 1906 and 2005, global average temperatures warmed 0.74 degrees<br>11 of the past 12 years (between 1995 and 2006) were the warmest since instrumental records began in 1850 | Between 1880 and 2012, average global surface temperatures increased 0.85 degrees<br>The last three decades in the Northern Hemisphere were likely the warmest in 1,400 years |
| **Human involvement in the climate system** | It is certain that greenhouse gases have a natural warming effect and emissions from human activities are substantially increasing the atmospheric concentrations of some greenhouse gases | 'Very likely' (over 90 per cent certainty) that humans have caused most of the warming observed since the mid-20th century | 'Extremely likely' (95–100 per cent certainty) that humans are the dominant cause of warming since the mid-20th century |
| **Extreme events** | No firm evidence of increased weather variability to date<br>'Most likely' that with an increase in mean temperature, episodes of high temperatures will become more frequent, and cold episodes less frequent | 'Very likely' that cold days became less frequent and warm days became more frequent in the late 20th century (~1960)<br>'Very likely' that warm spells, heatwaves and heavy rainfall events will continue to become more frequent over the 21st century<br>'Likely' that the area affected by drought will increase over the 21st century<br>'Likely' increased incidence of extreme high sea level events over the 21st century | 'Very likely' that cold days became less frequent and warm days became more frequent since 1950<br>'Very likely' that frequency and duration of heatwaves and high rainfall events will increase by the late 21st century<br>'Likely' that drought intensity or duration will increase by the late 21st century<br>'Very likely' that incidence and magnitude of extreme high sea level events will increase by the late 21st century |

The improvement in scientific understanding over time also points to earlier underestimates of climate change impacts. Lower levels of warming are now considered to have worse impacts than earlier assessments and are expected to affect more people. There is a greater risk that lower levels of warming could trigger 'tipping points' that result in permanent, highly disruptive changes in the climate system, compared with earlier projections (Smith et al. 2009).

### BOX 2.1: BACKGROUND TO THE IPCC AND ITS FIFTH ASSESSMENT REPORT

The IPCC is the leading international scientific body for the assessment of climate change and operates under the auspices of the United Nations. Its role is to review, assess and synthesise the latest information on climate change, based on the most recent peer-reviewed scientific, technical and socioeconomic literature worldwide. The IPCC produces periodic Assessment Reports that provide comprehensive assessments of the latest science on climate change, vulnerability, impacts and adaptation. The summaries for these reports (called Summaries for Policy Makers) are approved, line-by-line, by the governments of the IPCC's member countries.

The IPCC's reports demonstrate the continually mounting evidence for climate change and its causes. The Working Group I report (on the physical science basis of climate change) for the Fifth Assessment Report was published in September 2013, citing more than 9,200 scientific publications, with contributions from more than 600 authors (IPCC 2013c). The report confirms that the human influence on the climate is clear—it is between 95 and 100 per cent certain that humans have been the dominant cause of warming since the 1950s, when most of the increase in greenhouse gas emissions and temperature has been observed.

## 2.2 EVIDENCE OF THE CLIMATE WARMING

The Earth has warmed in response to the rapid increase in greenhouse gas concentrations since the Industrial Revolution. Between 1880 and 2012, average global surface temperatures over land and the ocean warmed by 0.85 degrees, with each of the last three decades successively warmer than any preceding decade since 1850 (IPCC 2013a, p. 3). The average conceals substantial regional variation, with warming greatest at northern latitudes—the Arctic has warmed at twice the global average rate over the past century and the three decades to 2012 were likely the warmest 30-year period in the Northern Hemisphere for the last 1,400 years (IPCC 2007b, p. 30; IPCC 2013a, p. 3).

Following the release of the IPCC Working Group I report (IPCC 2013a) on the physical science of climate change, some reporting suggested global warming had paused. The evidence does not support this claim (see Box 2.2).

**BOX 2.2: HAS GLOBAL WARMING 'PAUSED'?**

Contrary to some statements about warming over the last 15 years, global warming has not paused. The recent IPCC report (IPCC 2013a) confirms that the world is still getting warmer because of human activities. This long-term trend is unchanged.

The climate can experience a high degree of natural variability over short periods of time. Selection of data over particular short periods can give different results for trends to those obtained when longer periods are considered. The IPCC report identified, for example, that the warming of surface temperatures for the last 15 years (1998 to 2012) was relatively slow. This was due to a combination of factors, including volcanic eruptions that increased the amount of cooling aerosols in the atmosphere, redistribution of heat within the ocean and lower solar radiation levels due to the natural solar cycles. Warming was, however, relatively fast from 1990 to 2006 so, over the longer timeframe of 1990 to 2012, warming has been in line with projections.

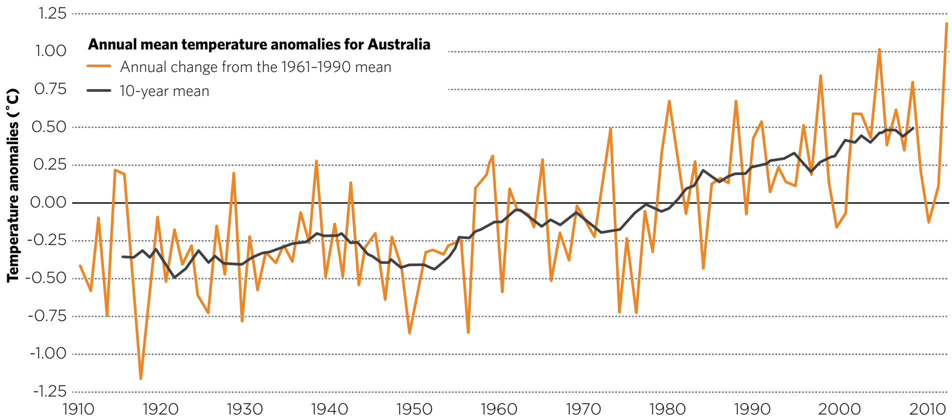
Short-term reductions in the rate of climate warming do not mean climate change has 'paused'. Many other observations of changes in the climate system confirm that warming continues. Globally, average surface temperatures over land and oceans have been successively warmer in each of the last three decades compared with any preceding decade since 1850. The first decade of the 2000s was the warmest on record. Sea levels have continued to rise, warming is occurring at greater depths of the ocean and ice sheets have been melting at greater rates compared to earlier periods.

Numerous Australian temperature records were broken during 2013, which was the warmest year on record, had the warmest summer (2012–13) and spring, and had the hottest winter and summer day ever recorded (BoM 2014). Maximum temperatures in 2013 were 1.45 degrees above the average, while minimum temperatures were 0.94 degrees above the average (BoM 2014). Sophisticated climate models show that Australia's average temperature in 2013 could not have been reached in the absence of human emissions of greenhouse gases (Lewis and Karoly 2014).[1]

Figure 2.3 charts the variation in annual mean temperatures in Australia between 1910 and 2013, compared with the 1961 to 1990 average (red line). The 10-year rolling average is shown in black. While there is considerable natural variability in climate over the short term, every decade in Australia has been warmer than the previous one since the 1980s.

1 The 2014 analysis is based on the same methods and models used in the peer-reviewed journal paper by Lewis and Karoly (2013).

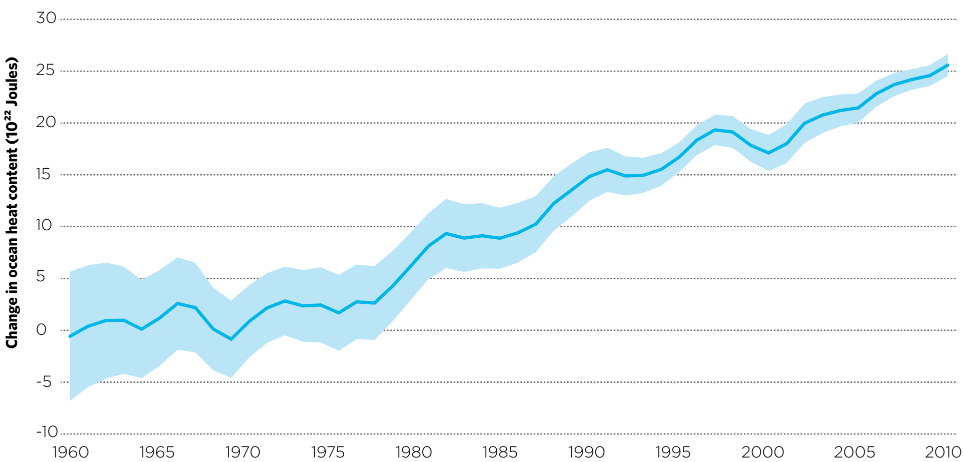
**FIGURE 2.3:** ANNUAL AVERAGE TEMPERATURE ANOMALIES IN AUSTRALIA OVER THE PAST CENTURY




**Note:** Anomalies are compared with the 1961–1990 average temperature.
**Source:** Adapted from BoM 2014

The world's oceans are also warming. Since the 1970s, oceans have absorbed about 90 per cent of the additional heat within the Earth's system (IPCC 2013a, p. 4). The take-up of heat by the ocean (shown in Figure 2.4) is important for moderating air temperature increases and reduces the climate impacts for humans and land-based ecosystems. Most of the ocean temperature increases have occurred at the sea's surface and upper ocean (to 700 metres depth) (IPCC 2013a, p. 5). In Australia, sea surface temperatures have warmed by about 1 degree since 1910—more than the global average (BoM 2014; CSIRO and BoM 2012). In 2010, sea surface temperatures in Australia were the highest on record (CSIRO and BoM 2012, p. 7).

**FIGURE 2.4:** CHANGES IN OCEAN HEAT CONTENT SINCE 1960




**Note:** Ocean heat content is relative to 1970 levels. Shading provides an indication of the accuracy of the estimate.
**Source:** CSIRO and BoM 2012, p. 7

Warmer temperatures are also triggering other changes in the climate system:

- Global average sea levels rose 0.19 metres between 1901 and 2010. This was driven by a combination of thermal expansion (water expanding as it warms), glacier melting and Greenland and Antarctic ice sheet melting. These ice sheets are melting at an accelerating pace and are estimated to have lost a total of about 4,000 billion tonnes of ice combined between 1992 and 2011 (Shepherd et al. 2012; IPCC 2013b, Table 13.1).
- Arctic summer sea ice extent has declined sharply since the 1950s, reaching a record low in the Northern Hemisphere summer of 2012 (IPCC 2007b, p. 83; NSIDC 2012). The melting of ice exposes darker water and landscapes, which absorb more solar radiation and amplify warming (Lenton 2008, p. 3).
- In recent years, glaciers have retreated worldwide, Northern Hemisphere snow cover in spring has declined and substantial thawing of permafrost has occurred, particularly in Russia (IPCC 2013b, ch. 4, pp. 4–5).

  **In Australia, there is evidence that snow has declined** in depth and length of season at some sites, but trends are hard to identify because of considerable annual variability (Hennessy et al. 2008).
- Weather extremes have changed since around 1950. On a global scale, the number of cold days and nights has decreased, while the number of warm days and nights has increased (IPCC 2013a, p. 4).

  **In Australia, the frequency of record high temperatures has been increasing since the 1950s, while record lows have been decreasing in frequency.** In the decade to 1966, record low temperatures occurred twice as frequently as record high temperatures. For the decade to 2009, record high temperatures occurred twice as often as record lows (Trewin and Vermont 2010).
- The frequency of heatwaves across parts of the world including Europe and Asia appears to have increased.

  **In Australia, heatwaves have increased in duration and frequency since the 1970s.** The heatwave that commenced in late December 2012 was easily the longest continent-wide heatwave on record, and temperatures more than 10 degrees above average were recorded across extensive areas of Australia until mid-January 2013 (BoM 2014). Bushfires are also virtually certain to have increased in intensity (IPCC 2007b, TS p. 50).

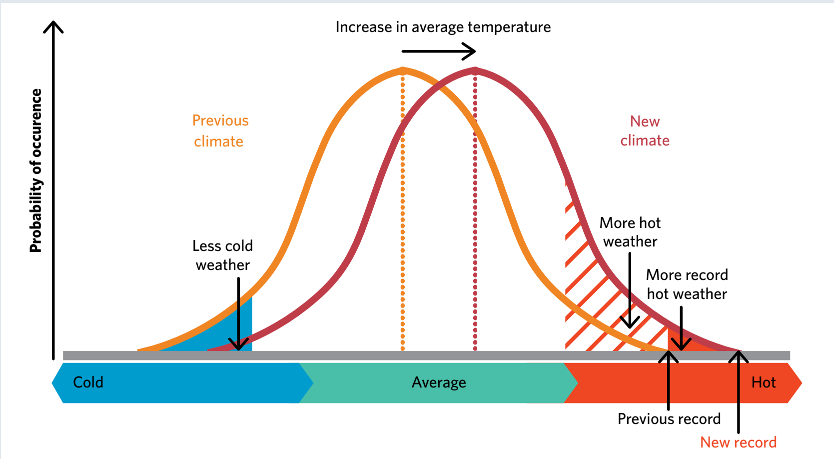
  Heat extremes are discussed in more detail in Box 2.3.
- The ocean has become more acidic because it has absorbed about 30 per cent of the additional carbon dioxide released into the atmosphere (IPCC 2013a, SPM p. 7). Increasing ocean acidity decreases the ability of shelled organisms, including coral, small molluscs and zooplankton, to form shells.

  **In the Great Barrier Reef, the coral population has declined by 50 per cent since the 1980s** (De'Ath et al. 2012).

## BOX 2.3: EXTREME HEAT EVENTS

As shown in Figure 2.5, an increase in average temperatures can have a large effect on the frequency and extent of extreme hot weather (Climate Commission 2013b). In Australia, this pattern is becoming more apparent. Average temperature in Australia has increased by 0.9 degrees since 1910 and, as predicted, there has been a significant increase in the number of hot days (over 35 degrees) and hot nights, and a general decrease in the number of cold days and nights. The 2012–13 Australian summer was the hottest since records began, with more than 80 heat-related records set in January 2013 alone, including the hottest day on record (BoM 2013).

### FIGURE 2.5: THE RELATIONSHIP BETWEEN CLIMATE AVERAGES AND EXTREMES




**Source:** Modified from Climate Commission 2013b

Over the past decade, many other countries and regions have experienced periods of extreme heat, including severe heatwaves in India (2002 and 2003), Europe (2003) and various parts of China (2010) (WMO 2011, p. 5). The 2010 Russian heatwave was of particular note, not only for its intensity and resulting death toll of over 55,000 people (CRED 2011, p. 1), but also for demonstrating another linkage between climate change and extreme weather. The loss of Arctic sea ice resulting from increased air and ocean temperatures has been linked to changes in the polar jet stream—the river of high-altitude air that works to separate Arctic weather from that of northern Europe, Russia and Canada. There is now growing evidence that aberrations in jet streams contributed to various recent extreme weather events, including the record-breaking Russian heatwave (2010), the wet summer and autumn in the United Kingdom and Ireland (2012), the blocking of Hurricane Sandy's trajectory (which subsequently hit New York in 2012) and the recent historic floods in Central Europe (2013) (Grumm 2011; Met Office et al. 2012; Centre for Climate and Energy Solutions 2012; NASA 2013).

## 2.3 PROJECTED CLIMATE CHANGE IMPACTS

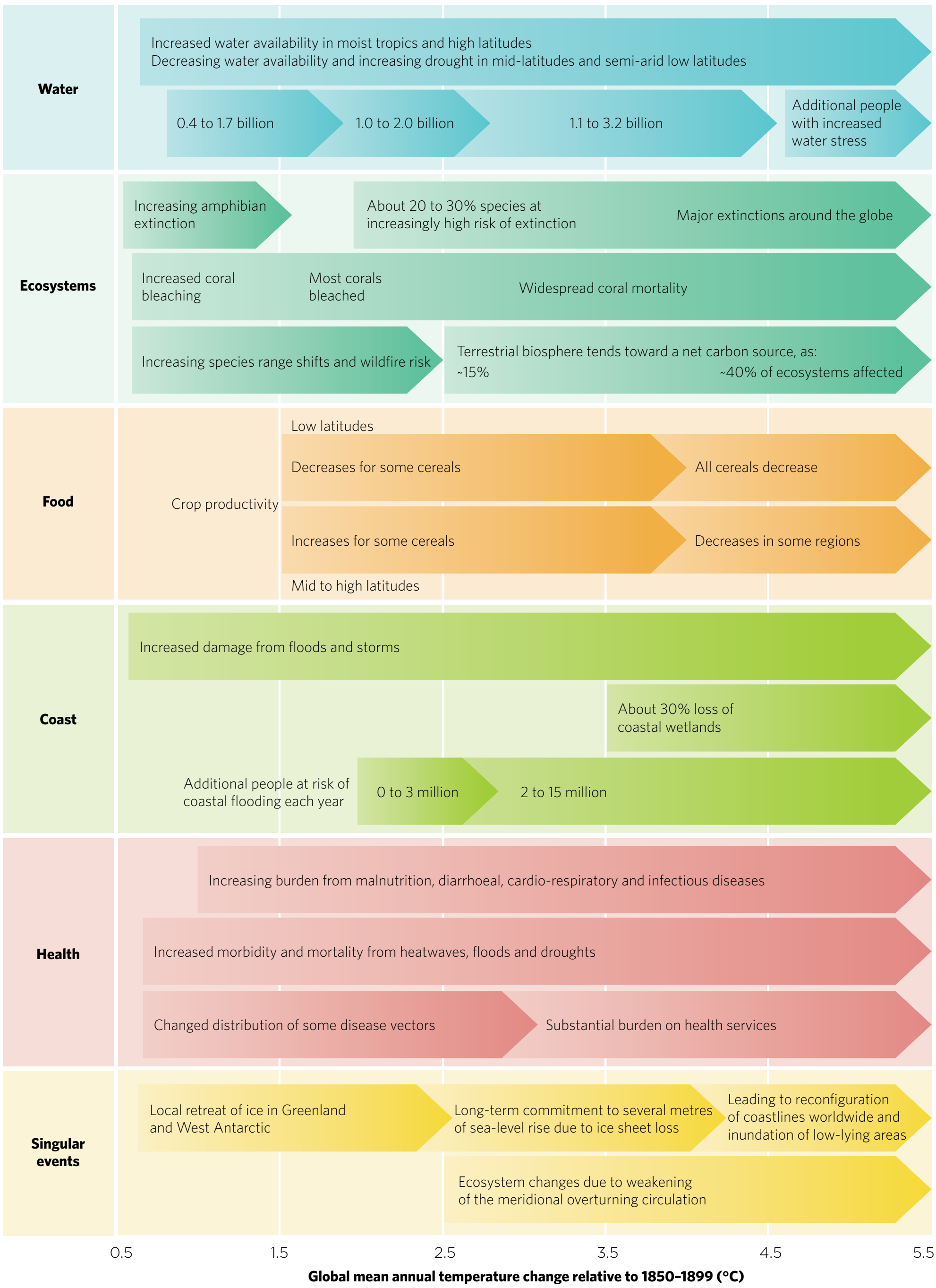
Global warming will affect all components of the climate system, which will have wide-ranging impacts on natural systems and human life. Depending on the level of warming, climate change impacts could affect the quality of our environment, where we live, how healthy we are, what we do and what we eat. Impacts will not necessarily be localised due to the strong interconnections between many sectors. For example, higher temperatures or declines in rainfall could reduce the productivity of land in some locations, which could increase food prices and lead to higher costs of living.

The precise extent, timing and location of impacts from climate change cannot be known with certainty. The climate is a highly complex system, influenced by atmospheric composition, ocean circulation, frozen surfaces and water bodies, land surfaces and the biosphere. Climate science and modelling continue to improve in projecting future states of the world and the likelihood of certain types of impacts occurring in particular regions. Impacts will depend on how much and how rapidly the climate warms, which is influenced by the future concentration of greenhouse gases and the sensitivity of the climate. Scientific research and climate models provide a strong basis for anticipating possible outcomes.

Warming above 2 degrees increases the likelihood that the world will cross irreversible 'tipping points' in the climate system that result in abrupt and permanent changes. Examples of tipping points include a shift in the location and strength of the Indian summer monsoon, which could endanger food production for over one billion people, and the triggering of permanent melting of Greenland and West Antarctic ice sheets, which could increase sea levels by many metres over several hundred years. Two of the most fragile tipping points are believed to be the permanent melting of Arctic summer sea-ice and the Greenland Ice Sheet, which may occur between 1 and 2.5 degrees of global warming (compared with pre-industrial levels). These changes could amplify warming, cause ecosystem changes and raise global sea levels by several metres (Lenton et al. 2008). Crossing any of these tipping points would cause substantial regional and global consequences.

As temperatures increase, impacts can generally be expected to become more severe, as shown in Figure 2.6 and explained in the subsequent examples.

**FIGURE 2.6:** GLOBAL IMPACTS PROJECTED TO RESULT FROM RISING TEMPERATURES




**Source:** Adapted from IPC 2007b, Table TS.3

- Across the world, dry regions are generally projected to become drier (through increased evaporation) and wet regions to become wetter (through increased rain) (IPCC 2007a). Extreme weather events such as heatwaves, droughts, storms, floods and wildfires are projected to become more frequent and more intense for some locations. With 4 degrees of warming, the most extraordinary heatwaves experienced today will become the norm and a new class of heatwaves, of magnitudes never experienced before, will occur regularly (Schaeffer et al. 2013, p. 15).
- **In Australia, the frequency and intensity of fires in many regions are expected to increase substantially in coming decades**, particularly for current high-risk areas, some of which are close to populated centres.

  A low global warming scenario (with temperatures 0.7 degrees above 1990 levels in 2050) would increase the frequency of 'very high' fire danger days by 5–23 per cent and 'extreme' fire danger days by 10–50 per cent.

  A high global warming scenario (with temperatures 2.9 degrees above 1990 levels in 2050) would increase the frequency of 'very high' fire danger days by 20–100 per cent and 'extreme' fire danger days by 100–300 per cent (Lucas et al. 2007, Table E.1).
- **Floods, landslides, droughts and storm surges in Australia are very likely to become more frequent and intense,** and there is high confidence that snow and frost will become less frequent (IPCC 2007b, TS p. 50).

  Snow cover is projected to reduce to zero in most Australian locations that currently experience a significant snow season under a high-emissions scenario (warming of 2.9 degrees above 1990 levels by 2050). This compares with a 38 per cent reduction in snow cover under a low-emissions scenario (warming of 0.6 degrees above 1990 levels in 2050) (Hennessy et al. 2008).
- Sea levels are projected to continue to rise as a result of thermal expansion from warmer waters and melting of ice sheets and glaciers. Under a scenario of strong global emissions reductions (warming of 0.9–2.3 degrees by 2100), sea levels are projected to rise by an average of 0.4 metres. In contrast, sea levels are projected to rise by 0.63 metres under a high-emissions scenario (with a likely temperature range of 3.2–5.4 degrees) (IPCC 2013a, Table SPM.2).

  The long-term effect of temperatures this century on sea levels in 2300 is striking. Sea levels under strong global emissions reductions scenarios are projected to be 0.41–0.85 metres higher in 2300, compared to 0.92–3.59 metres projected for high-emissions scenarios (IPCC 2013b, Table 13.8).
- Sea level rise will increase risks of flooding, coastal erosion and salt contamination of fresh water, with more significant damage to human settlements, infrastructure and coastal ecosystems.

  Under the projected minimum sea level rise in Asia of 40 centimetres over the course of this century, the number of people in coastal populations flooded each year is projected to rise from 13 million to 94 million (IPCC 2007b, ch. 10.4.3).

  **In Australia, coastal flooding events are projected to increase in frequency in many locations.** If sea levels rise by 0.5 metres, the frequency of coastal flooding events in Sydney is projected to increase by a factor of 1,000, so that a flooding event that currently occurs once in 100 years would occur 10 times per year, on average (Climate Commission 2013a, Figure 39). Under a 1.1 metre sea level rise (a high-end 2100 estimate), coastal assets with an estimated worth of $226 billion are potentially exposed to inundation and erosion hazards (Department of Climate Change and Energy Efficiency 2011).

- Ecosystems are projected to experience major changes in structure and function under climate change, with 20–30 per cent of assessed plant and animal species at increased risk of extinction for an average temperature increase of 2–3 degrees, and 40–70 per cent of assessed species committed to extinction above 4 degrees (IPCC 2007b, pp. 38, 242). Particularly vulnerable ecosystems include coral reefs, Arctic and alpine ecosystems, and tropical forests (including the Amazon rainforest). Projected losses of individual species are also likely to have serious ramifications across interlinked ecosystems as well as affecting human food sources and livelihoods (IPCC 2007b, p. 11).
- Coral reefs are projected to experience substantial degradation, even under scenarios where warming is limited to 2 degrees, due to the dual threats of coral bleaching and ocean acidification. Coral reefs are one of the most biologically diverse and economically important ecosystems worldwide. They provide habitat for over a million species and are a major source of fish, supplying more than one-quarter of the total annual fish catch in Asia alone. Coral reefs are also important for coastal protection against storms and are a major tourist attraction (Hoegh-Guldberg et al. 2007; Frierler 2012). By 3 degrees of warming, coral reefs as they currently exist are expected to be destroyed (Hoegh-Guldberg et al. 2007).
- With rising sea levels and more frequent extreme weather events, populations in affected regions may be forced to relocate. Climate-induced migration could create humanitarian crises and cause or exacerbate ethnic, political and international conflict and even terrorism (Department of Defence 2013, p. 18). Under a high-emissions scenario with one metre of sea level rise in the 21st century, one study has estimated that up to 187 million people could experience forced displacement (Schaeffer et al. 2013, pp. 16–17). This is roughly the equivalent of the current populations of Germany, Thailand, Canada and New Zealand combined.
- Human health will be affected by climate change, with increased injuries and deaths from extreme weather events, heat-related illness, food and water scarcity, and disease (including bacterial and vector-borne disease). The risks from higher temperatures, particularly among vulnerable populations, are well documented. For example, the Russian heatwave of 2010 is estimated to have resulted in the deaths of about 55,000 people (CRED 2011).

  In the developing world, climate change is projected to cause increased malnutrition due to declines in local agricultural production. Malnutrition is projected to increase the incidence of stunted growth in children and result in higher numbers of famine-related deaths (Lloyd et al. 2011; Black et al. 2008).

  **In Australia, under a hot and dry scenario with average global warming of 4.5 degrees by 2100, about 17,000 temperature-related deaths would be expected each year** by the end of the century, compared with about 8,500 with no additional climate change, but accounting for population growth (Bambrick et al. 2008, p. 13).

  A warming climate is also projected to increase the area suitable for transmission of vector-borne disease. **Under 4.5 degrees of global warming, the area suitable for mosquitos that transmit dengue fever in Australia is projected to extend southwards from Far North Queensland**, exposing an estimated 4.96–7.93 million people in 2100. This compares with 0.72 million projected to be exposed if the world acts to mitigate the worst of climate change (Bambrick et al. 2008, p. 38).

Australia will be able to adapt to many of the impacts projected from warming of 2 degrees or less. Above 2 degrees, adaptation will become increasingly challenging and, with warming of 4 degrees or more, Australia would not be able to manage its exposure to many severe impacts. Life would become far more difficult (CSIRO 2010, p. 60).

## 2.4 COSTS OF CLIMATE CHANGE TO AUSTRALIA'S ECONOMY AND SOCIETY

The impacts of climate change will be accompanied by far-ranging economic, environmental and social costs that will increase over time with higher levels of warming. The Authority must have regard to these issues in any of its reviews.

### 2.4.1 SOCIAL COSTS

The effects of climate change are likely to differ across social groups, depending on gender, age, socioeconomic status, existing health conditions or disabilities, ethnicity, migration and housing tenure. Research by the Australian Council of Social Service (2013) found that people with the fewest resources have the least ability to cope, adapt and recover from climate change impacts. Within Australia, the following groups have been identified as the most vulnerable to climate change:

- **Households**—Australians on low incomes and those who are unemployed, homeless, living in poor-quality accommodation or frail through age or chronic health conditions are more vulnerable to climate change impacts. This includes impacts on food availability and prices, health effects, water availability, energy and transport costs, and the costs of adaptation—such as investing in water tanks and energy-efficient appliances or retrofitting homes to provide protection from extreme weather.
- **Indigenous Australians**—higher rates of socioeconomic disadvantage and strong income and cultural connections to the natural environment make Indigenous Australians particularly vulnerable to climate change.
- **Australian industries and their workers**—industry and labour mobility will be affected to a greater or lesser extent by climate change impacts on natural resources, such as increased severity and frequency of extreme weather events, water shortages and increased exposure to tropical diseases. Agricultural and tourism sectors may be most vulnerable, with the local community affected by financial, emotional and physical stress (ACOSS 2013; NCCARF 2013).

### 2.4.2 ECONOMIC COSTS OF CLIMATE CHANGE

Stern (2006) and Garnaut (2008) both examined the economic consequences of climate change and came to the same broad conclusions—the economic cost of strong climate action is less than the cost of inaction. Focusing only on market impacts of climate change, Stern found that the total cost of 'business-as-usual' climate change (with no action to reduce emissions) over the next two centuries would reduce average global consumption per person by at least 5 per cent per year, now and every year (Stern 2006, p. 153). This compares with the much lower cost of action to reduce emissions consistent with achieving stabilisation at 550 parts per million (ppm) $CO_2$-e, which was estimated at 1 per cent of annual global GDP by 2050 (Stern 2006, p. xii). Garnaut's study considered both market and non-market impacts of climate change and also concluded that the costs of inaction are greater than the costs of strong action to reduce emissions (Garnaut, ch. 11).

Estimating the true size of climate change impacts is a challenging task—there is inherent uncertainty in climate sensitivity and the timing, size and extent of the climate change impacts themselves. Despite these challenges, Stern made the following conclusions:

- The costs of climate change are invariably underestimated, due to the difficulties in valuing non-market impacts such as environmental damages and health:
  - Stern's attempt to measure environmental and health impacts more than doubled his estimates of the global costs of climate change, from 5 per cent of global GDP per year to 11 per cent.

  - Other non-market impacts are even more difficult to value, such as social and political instability triggered by climate change impacts. Such impacts could have substantial economic and social consequences.
- Models that estimate the costs of climate change also tend to omit the impact of high-risk climate change impacts where there is scientific uncertainty on when or where they will occur:
  - Most cost models do not fully capture extreme weather events, which are projected to increase in frequency and severity under greater levels of warming, and can give large shocks (up to several per cent of a country's GDP) with a single event.
  - Such models also generally omit the economic impacts of the climate crossing thresholds for tipping points, such as the failure of the Indian summer monsoon. While there is scientific uncertainty on the precise temperature threshold at which the monsoon could permanently alter, such significant disruptions to the normal climate cycle would have very large economic, social and environmental consequences (Stern 2006, ch. 6).

Climate change impacts that occur in Australia will also have economic, social and environmental costs. The 2010–11 Queensland floods highlight the types of costs that Australia may need to endure with increasing frequency, as extreme weather events are projected to increase in number and intensity. The floods had the following consequences:

- 35 people died in the 2011 floods and 200,000 people were affected (King et al. 2014, ch. 10).
- Community organisations observed higher rates of homelessness, relationship breakdown and alcohol-related violence in the months after the floods (Climate Institute 2012, p. 21).
- A survey of flood-affected residents in Mackay found that 23 per cent would consider relocating within their town and 15 per cent would consider moving elsewhere if floods increased in frequency. Emigration would have consequences for local economies, growth rates and viability of affected towns (King et al. 2014, ch. 10, p. 95).
- Damage to Queensland's agricultural production pushed up fruit and vegetable prices by 15 per cent and increased national inflation (Climate Institute 2012, p. 22).
- Businesses that were directly affected were still operating below business-as-usual six months after the floods (Climate Institute 2012, p. 22).
- Insurance premiums tripled in many areas of Queensland and Suncorp Insurance embargoed new policies for Roma and Emerald, which had experienced three floods in as many years (Climate Institute 2012, p. 22). To raise $1.8 billion for reconstruction, the Commonwealth Government imposed a flood and cyclone levy on taxpayers earning more than $50,000 in the 2011–12 financial year (ATO 2012; Gillard 2011).

## 2.5 AUSTRALIA'S NATIONAL INTEREST IN LIMITING WARMING TO 2 DEGREES

The risks of continuing to emit greenhouse gases under business-as-usual are severe. Without strong action, the world is likely to experience 4 degrees of warming by the end of the century, which would mean sea level rises of metres over several centuries; displaced populations in some locations; damage, injury and death from more extreme weather; and major disruptions to food production and ecosystem function. In Australia, average global warming of 4 degrees by the end of this century would see temperatures 3–5 degrees higher in coastal areas and 4–6 degrees higher inland. Snow in many alpine areas is projected to disappear completely and winter rainfall in southern Australia could decline by 50 per cent. Life would be substantially harder and many people and sectors would suffer, including future generations that have had no role in producing additional greenhouse gas emissions.

The global community has agreed to limit warming to below 2 degrees. Even under this scenario, Australia would still have to adapt to additional sea level rise, increased frequency and intensity of bushfires, more frequent heatwaves and drought, increased water scarcity, and year-round higher temperatures (CSIRO 2010). Such an outcome would be substantially better than a 4 degree world. It is in Australia's national interest to contribute to the global effort to limit warming to below 2 degrees.

## CONCLUSION

**C.1** Australia is vulnerable to climate change and will face increasingly severe impacts under higher levels of warming. It is in Australia's national interest to contribute to the global goal of limiting warming to below 2 degrees.

# A GLOBAL EMISSIONS BUDGET FOR 2 DEGREES OR LESS

# 3

As established in Chapter 2, limiting the global temperature rise to below 2 degrees provides clear benefits to Australia.

Achieving this goal is challenging, but it remains technologically and economically feasible. All countries—in particular, major emitters—will have to take strong action to reduce their emissions to a level consistent with the 2 degree goal. A global emissions budget can be used to define the limit on emissions that is consistent with this goal. Australia's emissions reduction goals should therefore be considered in the context of a global budget.

Global emissions budgets specify the total amount of emissions that the world could release over a period of time that is consistent with a given rise in global temperature. The budgets are expressed in terms of probabilities to reflect uncertainties about the exact temperature effect of a given amount of greenhouse gases. A tighter global budget reduces the amount of emissions that can be released and provides a higher probability of keeping global warming to 2 degrees or less.

The Authority uses a global emissions budget that provides a likely chance (67 per cent probability) of limiting warming to 2 degrees or less as a reference point for this Review. This limits the amount of greenhouse gas emissions that can be released (as covered by the Kyoto Protocol) to a budget of approximately 1,700 gigatonnes of carbon dioxide equivalent (Gt $CO_2$-e) between 2000 and 2050. About 36 per cent of this budget had been used up between 2000 and 2012.

The Authority is required, under section 289 of the Clean Energy Act, to consider estimates of the global greenhouse gas emissions budget. A global emissions budget sets out the total amount of global emissions consistent with the aim of limiting warming to a specific temperature target. It does not dictate a particular emissions pathway, so long as the budget is not exceeded. This chapter examines global emissions budgets, including:

- whether limiting global warming to less than 2 degrees above pre-industrial levels remains feasible, and the scope and timing of action required to maintain a global emissions pathway consistent with that limit
- what budgets are consistent with a given probability of limiting temperature increases to below 2 degrees, including their characteristics and the greenhouse gases they cover
- the global emissions budget used in the Targets and Progress Review to inform the national budget, targets and trajectories (chapters 8 and 9).

## 3.1 FEASIBILITY OF LIMITING GLOBAL WARMING TO 2 DEGREES OR LESS

Avoiding the worst impacts of climate change will require strong international action to reduce emissions. For the Targets and Progress Review, the Authority has accepted Australia's interest in limiting global warming to below 2 degrees. This is consistent with the global goal agreed by the international community. It has also been adopted by other organisations, including the United Kingdom Committee on Climate Change and the German Advisory Council on Global Change, as a starting point in their consideration of national emissions reduction goals.

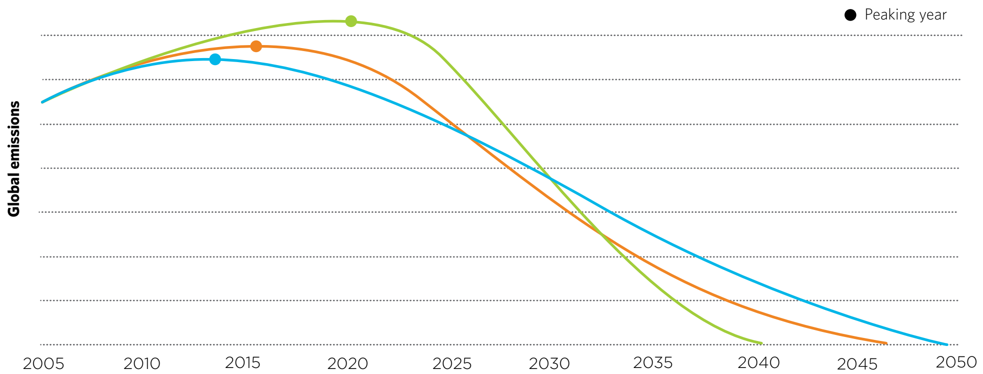
Two critical questions for policy-makers are whether a 2 degree temperature limit remains feasible, and the scope and timing of action required to maintain an emissions pathway consistent with that limit. Global emissions are currently tracking towards the upper bound of projections, on a pathway consistent with a 4 degree increase in global average temperature by 2100 (World Bank 2012, p. xiii). Analysis by the United Nations Environment Programme (UNEP) finds that it is still technically feasible to limit temperature rises to below 2 degrees (UNEP 2012, pp. 1–7). UNEP's analysis, as well as the level of global action, is discussed in more detail in Chapter 4.

The longer emissions reductions are delayed, the faster the available global emissions budget will be used up, requiring greater efforts to reduce emissions in future and eventually ruling out the possibility of limiting warming to 2 degrees or less. The literature on feasible 2 degree pathways finds that they have several important characteristics in common (Rogelj et al. 2011; UNEP 2012):

- **Early emissions reductions**—a near-universal finding is that early action is critical to limit future costs and maintain the feasibility of limiting temperature increases. Many studies point to the importance of global emissions peaking by 2020 (for example, see Rogelj et al. 2012). Delaying emissions reductions:
  - increases the rate of emissions reductions ('decarbonisation rates') that will be necessary in the future
  - increases costs of meeting emissions targets
  - reduces flexibility in choosing how to reduce emissions
  - increases reliance on the development and commercialisation of currently speculative technologies to achieve net negative emissions (see, for example, Rogelj et al. 2013).

Figure 3.1 shows illustrative emissions trajectories that result in the same amount of cumulative emissions, but with different peaking years and maximum rates of emissions reductions.

**FIGURE 3.1: ILLUSTRATIVE ALTERNATIVE GLOBAL EMISSIONS TRAJECTORIES FOR A GIVEN GLOBAL EMISSIONS BUDGET**




**Source:** Climate Change Authority

- **Steep decarbonisation rates**—even with early peaking of global emissions, scenarios to remain within 2 degrees generally require high, sustained rates of emission reductions for much of the rest of this century. The maximum rate of global emission reductions that can be maintained is a key constraint for feasible pathways. One recent study (den Elzen et al. 2010) estimated a maximum global rate of 3–4 per cent per year without using bioenergy with carbon capture and storage, or 4–5 per cent if this technology becomes viable.
- **Demand-side reductions in energy use**—under the IEA's low-emissions scenario ('450 Scenario'), over half of the required emissions savings from energy are achieved by energy efficiency improvements (IEA 2012b, p. 241). Another study found that strong action on energy efficiency can allow some flexibility in the choice and timing of other emissions reduction measures (Rogelj et al. 2013).
- **Negative emissions**—many 2 degree scenarios assume the use of negative emissions technology in the second half of this century (for example, bioenergy with carbon capture and storage). In its survey of 2 degree scenarios, UNEP found that 40 per cent of those considered to provide a likely chance of limiting warming to 2 degree or less require net negative emissions before 2100 (UNEP 2012, p. 26). If net negative emissions prove to be infeasible, a radical shift in mitigation options may come too late to stay below 2 degrees.
- **Technology investment and diversification**—a number of studies highlight the importance of investing in technology. The more ambitious the scenario, the earlier large investments in technology development are required. Pursuing multiple technology options simultaneously reduces the risk of particular technologies proving unviable, and is a more robust approach in the event that some technologies fail.

In submissions to the Review, the Business Council of Australia suggests that the Authority explores less ambitious temperature goals (higher levels of warming) because the world is not currently on track for 2 degrees (*Draft Report submission*, p. 2). Other stakeholders request that the Authority uses a lower, 1.5 degree temperature limit as the basis for its recommendations.

On balance, the Authority considers that a global budget based on 2 degrees is appropriate. As discussed in Chapter 2, it is clearly in Australia's national interest to support a global response to climate change that limits warming to below 2 degrees. While greater international action is necessary to achieve this goal, it remains technically and economically feasible. If the level of global action required to limit warming to below 2 degrees (discussed in Chapter 4) does not eventuate, Australia could reconsider its longer term goals in line with a less ambitious global budget.

While limiting global warming to 1.5 degrees is clearly desirable from a climate change impacts perspective, scenarios consistent with 1.5 degrees rely even more strongly on large-scale implementation of negative emissions technology in the second half of this century. This reliance creates larger risks that the 1.5 degree target would not be met if such technologies prove infeasible. Again, this could be reviewed in light of changing circumstances when Australia considers its longer term goals.

As emissions budgets express temperature outcomes in terms of probabilities, they inevitably include the chance that other temperature levels (besides 2 degrees) will be reached. Selecting an emissions budget with a lower probability of limiting warming to 2 degrees or less will increase the likelihood that higher global temperatures will be attained. By comparison, pathways that provide a 50 per cent or greater chance of limiting warming to 1.5 degrees share many of the same characteristics of 2 degree pathways in the first half of this century (Rogelj 2013). This raises the possibility that a 2 degree pathway could provide scope, with increased effort in future, to shift to a more ambitious 1.5 degree pathway.

**CONCLUSION**

**C.2** Limiting global emissions to keep warming to below 2 degrees is still feasible, but only with immediate and strong international action—especially by the major emitting economies.

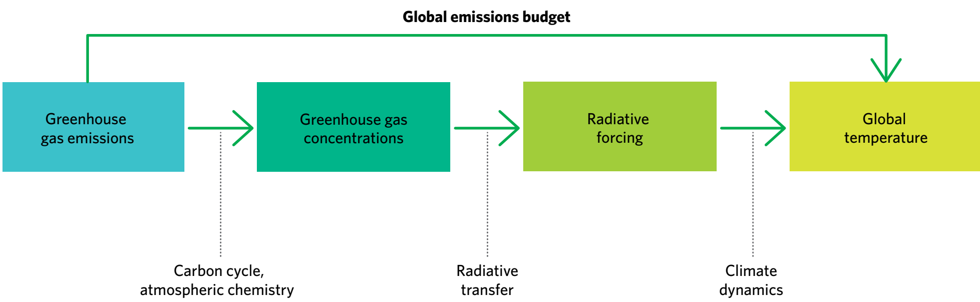
## 3.2 GLOBAL EMISSIONS BUDGETS

The magnitude of global temperature increases is not determined by emissions in any one year, but by the concentration of greenhouse gases in the atmosphere. This is the net outcome of total emissions and removals of greenhouse gases from the atmosphere over an extended period.

Global emissions budgets estimate the total amount of greenhouse gas emissions that will result in a given temperature increase, within a probability range. The emissions budget approach links cumulative emissions of greenhouse gases directly to temperature, without focusing on the intermediate steps shown in Figure 3.2 and discussed in Box 3.1. The relationship between cumulative emissions and temperature is expressed as a probability, to reflect uncertainty of the climate response to a given amount of greenhouse gas emissions.

While global emissions budgets identify the overall limit on global emissions, they do not prescribe the timing of peak emissions or the rate at which emissions must be reduced, so long as the overall budget is not breached. There will be a number of trajectories that could lead to the budgeted level of cumulative emissions and the related expected temperature increase over time, as illustrated by Figure 3.1. Because the emissions budget is ultimately fixed, however, delays in reducing emissions must be compensated with more rapid emissions reductions in future years.

**FIGURE 3.2:** RELATIONSHIP BETWEEN GREENHOUSE GAS EMISSIONS AND GLOBAL TEMPERATURE




**Source:** Adapted from Raupach, Harman & Canadell 2011

The concept of a global emissions budget provides important guidance for setting Australia's national targets. It links to Australia's ultimate aim of limiting warming to less than 2 degrees and provides clear guidance on the scale of the global challenge. Australia's national emissions budget, discussed in Chapter 8, can be thought of as our fair share of the global budget.

Two issues relevant to selecting a global emissions budget as a reference point for this Review are:

- the probability of limiting warming to 2 degrees or less
- whether to specify the budget in terms of $CO_2$ only or of multiple greenhouse gases.

**BOX 3.1: GLOBAL EMISSIONS BUDGETS, ATMOSPHERIC CONCENTRATION AND RADIATIVE FORCING**

Global emissions budgets, also referred to as carbon budgets, have gained prominence as a way to analyse and communicate the scale of emissions reductions required to remain within a global temperature limit. Emissions budgets help to link emissions targets and trajectories to the underlying science of climate change.

Emissions limits that keep global temperature increases to 2 degrees or less can be expressed in a number of ways. Two other measures are the concentration of greenhouse gases in the atmosphere, and the radiative forcing of greenhouse gases and other substances. As set out in Figure 3.2, these measures reflect different intermediate steps in the chain between emissions and global temperature. Atmospheric concentration has been a common way to communicate the limit consistent with a certain level of temperature rise. For example, an atmospheric concentration of 450 parts per million (ppm) is consistent with about a 50 per cent chance of limiting warming to 2 degrees or less.

An approximate 67 per cent probability of limiting warming to 2 degrees or lower could be expressed using the following measures:

- an equilibrium concentration of 415 ppm of $CO_2$-e
- an equilibrium radiative forcing of about 2.1 watts per square metre
- a global emissions budget of 1,700 Gt $CO_2$-e from 2000 to 2050.

## 3.3 PROBABILITY LEVEL FOR BUDGETS

Budgets are expressed in terms of their probability of remaining within a given temperature limit. A higher probability of limiting warming to 2 degrees or less corresponds to a smaller budget. For example, a 50 per cent probability of limiting warming to 2 degrees or less gives an allowable budget of Kyoto gases of approximately 2,020 Gt $CO_2$-e over the period 2000–2050. A 67 per cent probability reduces the allowable budget to approximately 1,700 Gt $CO_2$-e (adapted from Meinshausen et al. 2009, p. 1,161).

Choosing a budget with a higher probability better manages risks from:

- the long-term warming influence of long-lived greenhouse gases
- uncertainties over the precise temperature increase and the possibility of greater warming
- the severity of impacts of a temperature increase above 2 degrees, including the risk of triggering tipping points in the climate system that result in an abrupt change.

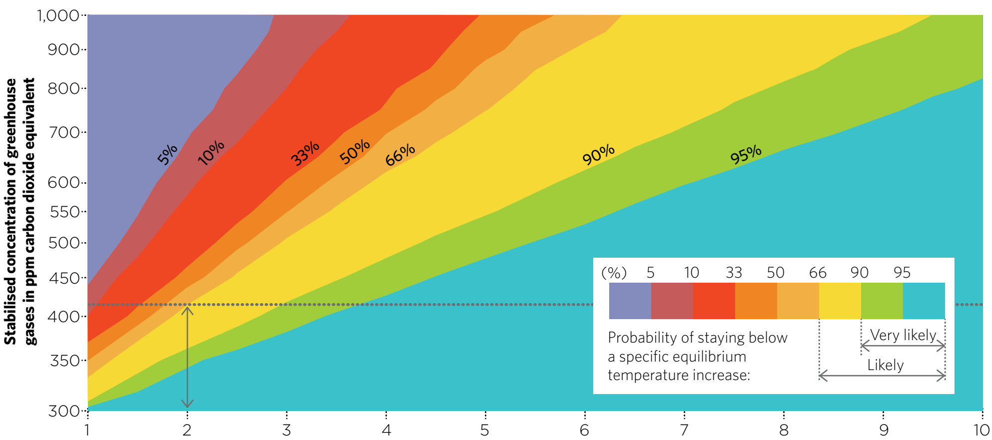
Tighter budgets will, however, require more action to reduce emissions.

In light of the severe global and national risks projected at temperatures of 2 degrees and above, the Authority considers that the global emissions budget used as a reference point for setting Australia's national budget should have at least a 67 cent probability of limiting warming to 2 degrees or less (defined as 'likely'). This is consistent with the probability used by the IPCC in its Fifth Assessment Report, discussed in Box 3.2.

Several submissions to the Issues Paper and Draft Report recommended the Authority use emissions budgets with higher, rather than lower, levels of probability of limiting warming to 2 degrees or less. Other expressed preference for budgets with a relatively high probability such as 80 per cent, but agreed a lower probability budget (such as 67 per cent) was more appropriate on the basis that higher probability budgets are no longer practicably attainable.

Figure 3.3 sets out probabilities (the coloured bands) of remaining below a specified temperature increase for different concentrations of greenhouse gases in the atmosphere. An atmospheric greenhouse gas concentration that provides an approximate 67 per cent probability of limiting warming below 2 degrees, shown by the horizontal dotted line, is also projected to give about a 90 per cent probability of staying below 3 degrees, and more than 95 per cent probability of staying below 4 degrees; however, it gives only a 10 per cent probability of staying below a 1 degree temperature increase.

**FIGURE 3.3: PROBABILITY OF STAYING BELOW SPECIFIC TEMPERATURE INCREASES AT DIFFERENT $CO_2$-e STABILISATION LEVELS**




**Note:** The left scale indicates a $CO_2$-e concentration level at equilibrium from all greenhouse-forcing agents. The arrow illustrates that to limit global temperature increase to below 2 degrees with a likely (greater than 66 per cent) probability, $CO_2$-e concentrations should be should be lower than 415 ppm.
**Source:** Adapted from Rogelj, Meinshausen & Knutti 2012

### 3.3.1 REVIEWING THE GLOBAL EMISSIONS BUDGET OVER TIME

The appropriateness of the chosen global reference budget can be reviewed and adjusted, if necessary, over the longer term. This can occur as part of periodic reviews of Australia's national emissions budget, which the Authority recommends be conducted at least every five years (see Chapter 7). This flexibility would better position Australia to respond should the international community choose a more stringent temperature goal, or if increased scientific understanding of climate uncertainties changes estimates of the allowable global emissions budget. Conversely, if the scale and pace of international action in future is such that a 67 per cent probability of limiting warming to 2 degrees becomes infeasible, the Authority could review whether to move to a reference budget with a lower probability.

## 3.4 CARBON DIOXIDE-ONLY OR MULTI-GAS BUDGETS

The Authority considered whether to adopt a $CO_2$-only or multi-gas budget that includes all the Kyoto gases. $CO_2$ is long-lived in the atmosphere and is the dominant contributor to human-induced climate change. $CO_2$-only budgets are simple, can give a good indication of the likely long-term temperature rise and target the most significant greenhouse gas. A multi-gas budget is most closely aligned with Australia's international obligations under the Kyoto Protocol, but has some scientific limitations. In part, this is because different gases behave differently in the atmosphere and remain there for varying lengths of time.

The Authority received a small number of submissions on the use of multi-gas budgets, with one submitter highlighting their potential limitations. Another supported a focus on $CO_2$ as the longest lived greenhouse gas, suggesting that additional separate budgets should be provided for the other gases.

While acknowledging the limitations, the Authority considers that a multi-gas approach is preferable for the purposes of setting Australia's national emissions budget. Multi-gas approaches recognise the range of activities and gases contributing to global warming. They are also consistent with Australia's international commitments and the approach adopted by other nations. Non-$CO_2$ greenhouse gases are also a significant component of Australia's emissions—about 28 per cent in 2011 (adapted from DIICCSRTE 2013, vol. 1, p. 29). A multi-gas approach acknowledges the importance of reducing these emissions.

## 3.5 GLOBAL BUDGET ESTIMATES

The Authority has used the global emissions budget estimates developed in a 2009 study by Meinshausen et al., *Greenhouse-gas emission targets for limiting global warming to 2°C* (Table 3.1). These estimates have been widely cited by other scientific studies and used by national and international bodies as a reference for global emissions budgets.

### TABLE 3.1: ESTIMATES OF GLOBAL EMISSIONS BUDGETS 2000–2050

| CARBON DIOXIDE (Gt $CO_2$) | KYOTO GASES (Gt $CO_2$-e) | PROBABILITY OF REMAINING WITHIN 2 DEGREE LIMIT |
|---|---|---|
| 900 | 1,370 | 80 per cent |
| 1,010 | 1,520 | 75 per cent (74 for Kyoto gases) |
| 1,170 | 1,700 | 67 per cent |
| 1,450 | 2,020 | 50 per cent |

**Notes:** The budget figures in Meinshausen et al. are specified for 2000–2049; an extra year of estimated emissions has been added to give a budget to 2050. Figures rounded to the nearest 10 Gt. The Meinshausen et al. emissions budget estimates account for the temperature effects of aerosol pollution such as sulphates created by the burning of coal and oil. In 2009, the greenhouse gases covered by the Kyoto Protocol were $CO_2$, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluouride. A seventh gas, nitrogen trifluoride, has been added for the second commitment period of the protocol; overall emissions of this gas are expected to be relatively small.
**Source:** Adapted from Meinshausen et al. 2009, p. 1,161

The global emissions budget used by the Authority as a reference is 1,700 Gt $CO_2$-e for the period 2000–2050, which gives a 67 per cent probability of limiting temperature increases to 2 degrees or less. Approximately 36 per cent of this budget has already been used between 2000 and 2012, with about 1,090 Gt $CO_2$-e remaining for the period 2013–2050 (based on IEA 2012a; see Appendix F.6).

### BOX 3.2: THE IPCC GLOBAL EMISSIONS BUDGET

For the first time, the IPCC quantified a cumulative emissions budget in its Fifth Assessment Report on the physical science basis of climate change, released in September 2013 (IPCC 2013). The IPCC refers to a global emissions budget of 1,000 Gt of carbon to provide a likely (greater than 66 per cent) chance of limiting global warming to less than 2 degrees, and notes that about half that budget has already been emitted.

The IPCC's estimated emissions budget is consistent with the budgets described in the Meinshausen et al. study discussed above and used in this Review. The two studies, however, use some different assumptions and report in different units, resulting in different budget figures. These differences include:

- The IPCC budget is specified in carbon (C) and the Meinshausen budget in carbon dioxide equivalent ($CO_2$-e). A tonne of carbon is equivalent to approximately 3.7 tonnes of carbon dioxide, with a 1,000 Gt C budget equating to a 3,700 Gt $CO_2$ budget.
- The IPCC budget considers the period of 1861–1880 to 2100; the Meinshausen budget only covers the period from 2000 to 2050. Both budgets, however, provide a robust indication of the cumulative emissions to give a likely probability of global warming remaining below 2 degrees.
- The IPCC budget covers the effect of $CO_2$ only and does not include the warming or cooling effects of other substances such as non-$CO_2$ greenhouse gases and aerosol pollution. The IPCC notes that the budget would be lower if these other effects were included.

As discussed above, the Authority has chosen to use a multi-gas budget for a specified time period to 2050 as the most appropriate reference budget for this Review.

The global budget proposed in this chapter as a reference point for the Review is consistent with Australia's national interest and the global goal to limit warming to below 2 degrees. It provides clear guidance on emissions that can be produced by the world to 2050 to give a likely chance of limiting warming to below 2 degrees. It is important to note, however, that continued global efforts to reduce emissions will be required after 2050 to avoid further warming.

**CONCLUSION**

**C.3** A global emissions budget that provides at least a likely (67 per cent probability) chance of limiting warming to less than 2 degrees above pre-industrial levels is used as a reference for the Review. This equates to a global budget of no more than 1,700 Gt $CO_2$-e emissions of Kyoto gases from 2000 to 2050.

# GLOBAL ACTION AND AUSTRALIA'S ROLE

4

As the evidence of the risks posed by climate change has become clearer, there has been a strong trend to increasing global action to reduce greenhouse gas emissions—99 countries, covering over 80 per cent of global emissions, have 2020 emissions reduction goals.

Countries are implementing a range of policies to meet these goals, including renewable energy targets, emissions trading schemes, tax incentives for improved energy efficiency, and fuel economy and electricity generation emissions standards.

More needs to be done to keep warming below 2 degrees and avoid the worst impacts of climate change, but there are promising signs. The level of action has steadily increased over the last 20 years and accelerated recently. The two largest emitters of greenhouse gases—China and the United States—are both stepping up their actions to reduce emissions and these measures could have a significant impact on global emissions.

The next few years will be a critical time as countries decide whether to strengthen their 2020 emissions reduction goals under the UNFCCC (due 2014) and negotiate a new post-2020 climate agreement (due 2015). Australia will be expected to indicate whether it will strengthen its 2020 target in 2014 and put forward a post-2020 target in 2015 as part of these processes.

Australia has made an international commitment to reduce emissions by 5–25 per cent, compared to 2000 levels, by 2020. At the time the commitment was made, the government announced conditions for moving up the range. The Authority's analysis shows that the conditions for moving beyond 5 per cent have been met. Whether the conditions for 15 per cent have been met is unclear—some elements have been met; others are marginal. The conditions for a 25 per cent target have not been met.

While the Authority has taken the government's conditions into account, it is also required to examine a broader range of considerations. In the international context, the Authority has also considered how Australian action compares to that of other key countries and its ability to positively or negatively influence action.

**Australia is a high-emitting, highly developed country with strong capacity to address climate change. An Australian 2020 target of 15 per cent plus carryover would be broadly comparable with the current actions of other key countries considered in this Review, including the United States.**

**A stronger Australian target could have a positive influence on the actions of other countries by demonstrating that emissions-intensive economies can pursue and achieve ambitious targets. Conversely, other countries could use weak Australian action as a reason to delay stronger climate measures.**

Action by all countries is needed to meet the global emissions budget (Chapter 3) and avoid the worst impacts of climate change. In particular, major emitting economies like Australia need to do more. Chapter 4 assesses the level of global action to reduce greenhouse gas emissions. It then considers how the international context should be factored into Australia's emissions reduction goals.

In the Authority's consultations, many stakeholders highlighted the importance of compiling information in as much detail as possible on international actions to reduce emissions. Analysing international action, both in aggregate and with relevant specifics, will be an important part of any future reviews.

## 4.1 GLOBAL ACTION TO REDUCE GREENHOUSE GAS EMISSIONS

Global action is complex—some countries are taking ambitious action now; some are doing less—and the pattern is likely to vary over time. In such circumstances, broad trends are a better indicator than the isolated actions of any individual country at a particular point in time (Box 4.1). This section assesses global trends in climate action, including 2020 targets, climate policies and measures, action in the United States and China, and action beyond 2020.

### BOX 4.1: ASSESSING GLOBAL ACTION

The Authority considers that trends in emissions reduction targets and policies provide the best picture of global action.

The Authority has used a set of 'key countries' to illustrate global trends in climate action. These countries, listed in Table 4.1, include Australia's neighbours, trading partners and countries with similar development levels. They are used for the Authority's analysis of targets and actions, domestic policies and as a comparison point for assessing Australia's emissions reduction goals. Given their significant effect on climate change, the Authority has focused particular attention on the actions of China and the United States, which together constitute over one-third of global emissions.

In assessing global trends in climate action, the Authority has considered targets and commitments to future action, and domestic policies and measures to reduce emissions. Both are important. Targets provide a useful indication of countries' intentions; however, by their nature, they are aspirational. They can only be met if they are backed by policies and measures that make emissions reductions happen. Targets and policies are mutually supportive—targets can help drive the implementation of climate change policies, while successful policies can make stronger targets more achievable.

The Authority has focused its analysis on emissions reduction outcomes—it has not discriminated on the basis of the form of a commitment (legally binding or not) or where it is inscribed (internationally or domestically). The Authority has therefore taken into account progress under the UNFCCC, and has also looked beyond—to domestic action and other international forums. More information about the UNFCCC is in Appendix B, along with information on other international initiatives.

Recently, there has been much attention on the fact the UNFCCC has not yet agreed on a new treaty with legally binding emissions reduction commitments by all countries. 'Legally binding' agreements may provide greater assurance that countries will meet their commitments but they are not the only indicator of action. As well as working towards a new climate agreement to apply from 2020, the UNFCCC has made significant progress to record countries' 2020 emissions reduction goals and create systems to increase transparency. All of this, while not legally binding, helps create confidence that other countries are taking their goals seriously and acting on climate change. Ultimately, emissions reductions matter more than legal form.

Primary sources of information about global action include the United Nations, the World Resources Institute and the Australian Government. In some cases, the Authority has used different data sets for the international analysis than in other chapters of this report, to allow for consistent data sets over a wider range of countries. Appendix B provides further details.

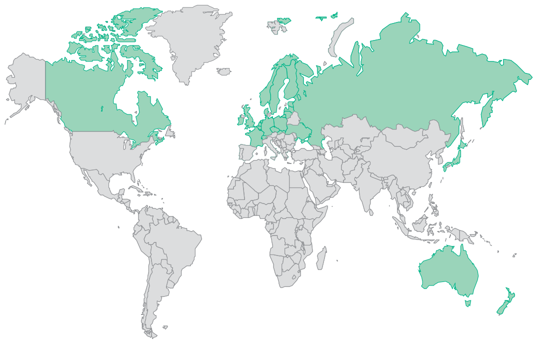
### 4.1.1 2020 EMISSIONS REDUCTION TARGETS

The number of countries with climate change targets has grown rapidly over time—99 countries, including Australia, have committed to 2020 emissions reduction targets and actions under the UNFCCC. These countries account for over 80 per cent of global emissions and 90 per cent of the global economy (Figure 4.1).

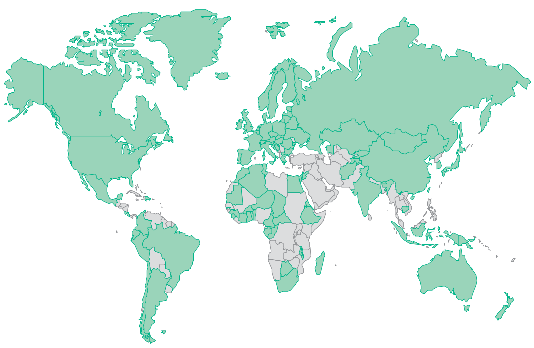
**FIGURE 4.1: COUNTRIES WITH INTERNATIONAL EMISSIONS GOALS UNDER THE UNFCCC**

**1990** – NO COUNTRIES

**1997** – 37 COUNTRIES



**2013** – 99 COUNTRIES



**Source:** Climate Change Authority analysis of UNFCCC 2011, UNFCCC 2013a, Kyoto Protocol commitments

Many countries have included these pledges in domestic legislation and national planning documents, as part of the process of backing international pledges with domestic policies. Some countries; for example, Germany and the United Kingdom, have taken on a higher domestic target than is reflected in their international pledge, so looking at pledges alone may underestimate the extent of global climate action. Table 4.1 shows the international and domestic 2020 targets of key countries.

## TABLE 4.1: 2020 EMISSIONS REDUCTION TARGETS OF KEY COUNTRIES

| | |
|---|---|
| **Australia** | International: 5 per cent, up to 15 per cent or 25 per cent relative to 2000 (5 per cent unconditional). |
| **China** | International: Lower carbon dioxide emissions per unit of GDP by 40–45 per cent relative to 2005.<br>Domestic: China's 2020 target has been incorporated in its medium- and long-term economic and social development plans as a binding target. China has an interim carbon intensity target under its 12th Five-Year Plan (2011–2015). |
| **United States** | International: In the range of 17 per cent relative to 2005.<br>Domestic: This goal is included in President Obama's 2013 Climate Action Plan. |
| **European Union** (28 member states) | International: 20 per cent relative to 1990. Conditional target of 30 per cent relative to 1990.<br>Domestic: Many EU countries have climate targets included in legislation or national plans. The EU also has agreed to a formal 'burden-sharing arrangement' for some of its collective climate targets. |
| **India** | International: reduction in emissions intensity (emissions per unit of GDP) by 20–25 per cent relative to 2005 (excluding agriculture). |
| **Japan** | International: 3.8 per cent relative to 2005. |
| **Germany** | International: 20 per cent relative to 1990, as part of EU target.<br>Domestic: The German Government has legislated a national target of 40 per cent reduction by 2020 relative to 1990. |
| **Indonesia** | International: 26 per cent relative to business-as-usual.<br>Domestic: Indonesia's National Action Plan for Greenhouse Gas Emission Reduction states it could reduce emissions by up to 41 per cent by 2020 relative to business-as-usual with international support. |
| **Canada** | International: 17 per cent relative to 2005. Note Canada has withdrawn from the Kyoto Protocol, but maintains this target under the UNFCCC. |
| **Republic of Korea** | International: 30 per cent relative to business-as-usual.<br>Domestic: The 2020 goal is included in Korea's 2010 Framework Act on Low Carbon, Green Growth. |
| **United Kingdom** | International: 20 per cent relative to 1990, as part of EU targets.<br>Domestic: The UK has a domestic 2020 target of 34 per cent below 1990 levels. It also has a series of binding carbon budgets under its Climate Change Act for the period 2008–2027. The 2027 carbon budget represents emissions reduction of 50 per cent relative to 1990. |
| **South Africa** | International: 34 per cent relative to business-as-usual and 42 per cent relative to business-as-usual by 2025.<br>Domestic: The 2020 goal is referred to in South Africa's 2011 National Climate Change Response. |
| **New Zealand** | International: Unconditional target of 5 per cent relative to 1990. Conditional target of 10–20 per cent relative to 1990. |
| **Norway** | International: 30 per cent relative to 1990. Conditional target of 40 per cent relative to 1990. |

**Note:** Many countries' targets are conditional on the extent of climate action in other countries. Domestic action outlined in this table covers targets included in domestic legislation, national planning documents and other official government plans.
**Sources:** International emissions reduction targets from UNFCCC 2011 and UNFCCC 2013a; domestic targets from country websites.

It is too early to definitively say whether countries will meet their 2020 targets. Many are in the process of implementing policies for which the actual mitigation effect is not yet known (for example, the Republic of Korea's legislated carbon price and South Africa's carbon tax). Other countries, including Norway, have also announced an intention to use fast-acting policies closer to 2020, such as the planned purchase of international emissions reductions. A country's energy mix can also change rapidly for non-climate-centred reasons and make it either harder or easier to achieve a given target. For example, Japan's 2011 nuclear disaster and the United States gas boom—as well as policy choices that limited US gas exports, ensuring lower domestic gas prices and lower emissions because of switching to gas from coal—affected their emissions. Finally, ambition of targets is linked to achievability. Countries with strong targets may be less likely to achieve them, although they may still reduce their emissions significantly.

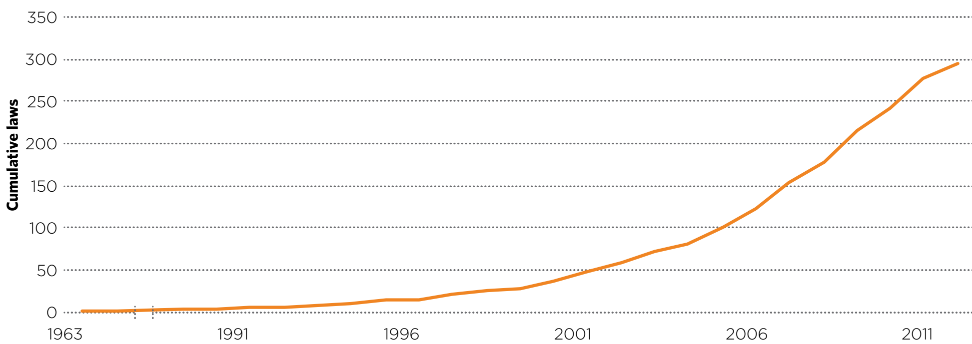
With those important caveats, it is clear that countries are generally taking their targets seriously and implementing policies to meet them. There is also heartening precedent—most countries that have first commitment period targets listed in Annex B of the Kyoto Protocol appear to be on track to comply (two exceptions are the United States, which did not ratify the Kyoto Protocol, and Canada, which withdrew from the Protocol in 2012).

Importantly, the United States and China, the world's top two emitters, are both capable of meeting or exceeding their 2020 targets. The World Resources Institute assessed US policy in 2013, and concluded it could meet its target without new legislation by using existing powers of the sort being employed by President Obama (WRI 2013a). The US Government, in its 2014 Climate Action Report, concluded that the target is achievable (Department of State 2014). Similarly, recent analysis concludes that China is on track to reduce its carbon intensity by more than its 2020 target (PBL 2013). Chinese officials reported in November 2013 that China would make every effort to meet the more ambitious end of its target range and it was considering new targets, including potentially an absolute cap on emissions for its next Five-Year Plan (2016–20) (Li Gao, 2013).

## 4.2 COUNTRIES' DOMESTIC POLICIES AND MEASURES

Countries are putting in place policies and measures to reduce their emissions and meet their targets. Domestic action has increased over time. GLOBE notes that in 2012 there was a total of 286 climate change-related laws in the 33 countries studied (GLOBE International 2013)—see Figure 4.2.

**FIGURE 4.2:** TOTAL CLIMATE CHANGE LAWS IN GLOBE COUNTRY STUDIES, 1963–2012




**Source:** GLOBE 2013

All the major emitting economies now have policies and measures to support their 2020 emissions reduction targets. Policies include incentives for renewable energy, energy efficiency standards, emissions trading schemes and emissions performance standards in electricity generation and transport. Approaches vary from country to country depending on development levels, economic structure and the targeted sector or desired response.

Countries usually adopt multiple overlapping climate policies, including some mix of energy supply policies, energy demand policies, sector-specific measures such as transport standards, and carbon pricing. The International Energy Agency (IEA) collates a database of climate policies and measures covering all the countries in the Authority's key countries set except Indonesia. This database records that there were 858 climate policies and measures in place in 2013 across the Authority's key countries (IEA 2013a).

Table 4.2 describes the climate actions of key countries in different areas. Most countries, including China and the United States, have policies in all these areas. An expanded version of this table is in Appendix B.

**TABLE 4.2: POLICIES AND MEASURES OF KEY COUNTRIES EXAMINED BY THE AUTHORITY**

| POLICY AREA | EXAMPLE OF POLICIES | COVERAGE |
|---|---|---|
| Energy supply | Renewable energy targets, feed-in tariffs | All key countries have energy supply policies in place |
| Energy demand | Appliance and building energy efficiency standards | All key countries have energy demand policies in place |
| Transport | Mandatory vehicle emissions, pollution or fuel efficiency standards; incentives for renewable fuel production | Nearly all key countries other than Australia and New Zealand have some form of mandatory vehicle standards; more than half have greenhouse gas emissions standards |
| Carbon pricing | Taxes or emissions trading schemes | Most key countries have policies in place at national or sub-national level; others including the Republic of Korea and South Africa are planning to introduce policies in 2015 |

## 4.2.1 CLIMATE CHANGE ACTION IN CHINA AND THE UNITED STATES

The two countries with the largest impact on global climate change action are China and the United States. Together, they were responsible for over 37 per cent of the world's emissions in 2009.

Both countries are acting on climate change and stepping up their efforts, including working together. In June 2013, President Obama and President Xi reached a bilateral deal to phase down the consumption and production of hydrofluorocarbons—potent greenhouse gases used in refrigeration and air conditioning—under the Montreal Protocol. In July 2013, China and the United States announced renewed cooperation in areas ranging from carbon capture and storage demonstration to energy efficiency and data collection.

## ACTION IN CHINA

China has a 2020 target of 40–45 per cent reduction in carbon intensity relative to 2005—that is, it aims to reduce $CO_2$ emissions by 40–45 per cent per unit of GDP. Based on Treasury modelling, the Authority estimates that China's target range is between 14 and 22 per cent below business-as-usual emissions intensity, which would imply a reduction from business-as-usual of about 2.6–3.9 Gt $CO_2$ in 2020.

China's economy is developing and a large percentage of its population still lives in poverty, without access to sanitation or clean water. As living standards improve, its emissions will grow. In 2013, China indicated it was considering an absolute cap on emissions in its 13$^{th}$ Five-Year Plan (2016–20). If this cap is put in place, it will be a global climate milestone.

China is investing in renewable energy, imposing stringent energy performance standards and establishing emissions trading schemes. Box 4.2 provides a snapshot of China's climate change action.

### BOX 4.2: CHINA'S CLIMATE CHANGE ACTIONS

- World's largest investor in renewable energy (US$67 billion in China in 2012).
- Proposed scaling down of coal use, including non-binding caps on consumption and production.
- Closed nearly 500 smaller and less-efficient coal power plants by 2010.
- Emissions trading schemes operating in Shenzhen, Beijing, Shanghai, Guangdong and Tianjin, and planned for two other provinces and municipalities. To be followed by a national scheme.

Wind turbines in China (Getty Images)

China has integrated climate change as a core part of its economic planning. Its climate targets are included in its central economic policy document for 2011–15, the 12$^{th}$ Five-Year Plan. This contains targets for energy intensity (energy consumption per unit of GDP—16 per cent reduction by 2015 relative to 2010 levels) and $CO_2$ emissions per unit of GDP (17 per cent reduction by 2015 relative to 2010 levels). Achieving these targets would put China on track to meet its international commitments.

China has shown its ability to set and achieve environmental targets. Between 2006 and 2010, it reduced its energy intensity by 19.1 per cent from 2005 levels (Network for Climate and Energy Information 2012), and replaced nearly 500 small and inefficient power plants with modern and less emissions-intensive facilities.

China is a world leader in renewable and low-carbon energy. In 2012, US$67 billion in renewable energy was invested in China, more than a quarter of the world total (REN21 2013). It also has the world's largest installed renewable generation capacity at 90 GW (excluding hydropower). This compares with the 54 GW capacity of Australia's entire electricity grid (BREE 2013b, p. 33). In 2013, China added more capacity from renewables, including hydropower, than from fossil fuels (National Energy Administration 2013).

Partly in response to severe air pollution, China has announced a target of capping coal consumption at four billion tonnes of coal equivalent per year, with a parallel cap on domestic coal production of 3.9 billion tonnes in 2015. Although these caps are non-binding, they clearly signal China's intention to address its energy use and environmental problems. In 2013, the IEA revised its global coal demand outlook downwards in response to China's policy choices—reflecting both China's importance to global coal and the seriousness of its policy efforts (IEA 2013b). China is also tightening its fuel economy standards for passenger vehicles, exceeding the US standards for some types of vehicles. The standards are set nationally but are being implemented at different times around the country—Beijing tightened its standards in 2013 in line with Shanghai and Guangzhou. Australia has no binding fuel economy standards.

China is implementing market mechanisms to reduce its emissions in seven regions, to be followed by a national emissions trading scheme after 2015.

### ACTION IN THE UNITED STATES

The United States has a UNFCCC 2020 target of 17 per cent reductions on 2005 levels. US emissions have fallen in recent years. According to WRI analysis (2013a), the main factors behind this trend include:

- falling energy demand, including because of lower economic activity
- lower transportation emissions, in part because of tighter vehicle emissions standards
- partial replacement of coal power with gas power and renewable energy.

Both Australia and the United States have discovered large amounts of natural gas that can be extracted using contemporary technology such as fracking. Unlike Australia, US policy choices limited the export of natural gas (Garnaut 2013). This helped keep US domestic gas prices lower, and encouraged fuel switching to gas away from more emissions-intensive coal. This has meant the gas boom has had a noticeable impact on US emissions.

The United States, however, will need to do more to meet its 2020 emissions reduction target. Although US energy emissions are predicted to remain static, other sources of emissions are rising, including industrial gases and methane from natural gas extraction.

Momentum for stronger action is building and the United States is taking its 2020 target seriously. President Obama announced a new Climate Action Plan in June 2013, which aims to reduce US emissions, prepare for the domestic impacts of climate change and increase international climate cooperation. It uses the President's executive powers to increase regulations on new and existing power plants, accelerate renewable energy development on public land, and direct federal agencies to use more renewable energy and improve their energy efficiency. The combined effect of these measures could be significant—for example, the power plant regulations could prevent the construction of new coal-fired power plants without carbon capture and storage technology. A recent US Government report confirmed that concerted efforts to implement the Climate Action Plan would cause energy sector and methane emissions to fall by 2020 (Department of State 2014).

Transportation makes up nearly one-third of total US emissions, and strict vehicle fuel economy and emissions standards introduced in 2011 will deliver large emissions reductions. The US Government estimated the standards would save 6,000 Mt $CO_2$-e between 2011 and 2025, more than 10 times Australia's 2012 total emissions. The US Energy Information Administration (2013) estimates there are already two million hybrid vehicles in the United States, and an additional nine million 'alternative fuel' vehicles capable of using electricity, ethanol, liquid petroleum gas or natural gas.

The United States has been at the forefront of investment in renewable energy for the past decade. Renewable energy investment in the United States totalled US$36 billion in 2012. It is a close second to China in renewable capacity, with 86 GW installed (REN21 2013).

### BOX 4.3: US CLIMATE CHANGE ACTIONS

- World's second largest investor in renewable energy after China—nearly half the electric capacity added in 2012 was renewable.
- Proposed stringent regulations of new and existing coal power plants.
- Emissions trading schemes operating in 10 states.
- Stringent vehicle emissions standards, estimated to save 6,000 Mt $CO_2$-e between 2011 and 2025.

President Barack Obama delivers remarks on climate change, at Georgetown University in Washington, D.C., 25 June, 2013. (Official White House Photo by Lawrence Jackson)

## SUB-NATIONAL ACTION IN THE UNITED STATES AND CHINA

Many US states and Chinese provinces are significant economic entities in their own right and some are taking strong action to reduce their emissions.

China commenced pilot emissions trading schemes in Shenzhen, Beijing, Shanghai, Guangdong and Tianjin in 2013. More than 1,500 liable entities are expected to participate in these five regions, and the total annual emissions of the regions are more than 970 Mt, about one-and-a-half times Australia's. Another two schemes are proposed to start in Hubei and Chongqing. These seven areas make up one-third of China's economy and use about one-fifth of its energy (DIICCSRTE 2013).

Much action on climate change in the United States is happening at state and local level—29 states have adopted greenhouse gas reduction targets or limits, with varying stringency, while nine north-eastern states have had an emissions trading scheme for their power sectors since 2009 (the Regional Greenhouse Gas Initiative). California has a separate emissions trading scheme that began in 2013 and linked to the Canadian province of Quebec in January 2014. The scheme will eventually cover most of California's emissions, which comprise about 7 per cent of total US emissions—equivalent to about 80 per cent of Australia's annual emissions. The states of Oregon and Washington are also considering introducing carbon pricing.

The United States and China are also cooperating on climate change at sub-national levels. The US state of California and the Chinese municipality of Shenzhen are working together on air quality. Both regions have emissions trading schemes in place and have agreed to share policy design and early experiences from these schemes.

**TABLE 4.3:** COMPARING SUB-NATIONAL AREAS TO COUNTRIES

| IF THIS AREA WITH CARBON PRICING WAS A COUNTRY … | … ITS EMISSIONS WOULD BE ABOUT THE SAME AS |
|---|---|
| **California** (440 Mt) | **Spain** (410 Mt) |
| **The nine Regional Greenhouse Gas Initiative states** (470 Mt) | **Poland and Greece combined** (490 Mt) |
| **Guangdong** (510 Mt) | **Italy** (510 Mt) |
| **Shanghai** (240 Mt) | **Singapore** (230 Mt) |
| **Beijing** (100 Mt) | **Chile** (100 Mt) |

**Notes:** Total emissions from the region—carbon pricing covers a subset of these emissions. Data from year 2010 except Beijing (2011), excluding land use. Regional Greenhouse Gas Initiative states are Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont.
**Sources:** WRI 2013b CAIT for US state and country emissions; World Bank 2013 for China sub-national emissions

## 4.2.2 2020 AND BEYOND

While there is a clear trend to increased climate action, more needs to be done, up to and beyond 2020, to limit warming to below 2 degrees.

The UNEP Emissions Gap report (published annually) is one of the most comprehensive studies aggregating countries' 2020 pledges. The report estimates the gap between the level of projected global greenhouse gas emissions with current 2020 pledges, and the level climate science recommends gives a likely chance of limiting warming to below 2 degrees (defined by UNEP as a 67 per cent chance).

The 2013 Emissions Gap report finds that the emissions gap for 2 degrees is 8–12 Gt $CO_2$-e. This is equivalent to about 14–24 times Australia's annual emissions.

Importantly, the report finds that it is technically feasible to limit temperature increases to below 2 degrees with either greater pre-2020 action or post-2020 action. However, it notes that increasing action post-2020 will be more difficult, costly and risky than acting earlier, including because of the lock-in of emissions-intensive infrastructure (UNEP 2013).

Countries are beginning to plan emissions reductions after 2020 in the context of the emissions gap, including an international framework for post-2020 climate action. This framework is due to be negotiated by 2015 and to come into effect in 2020. Countries including Australia are expected to begin putting forward post-2020 goals in the UNFCCC by the first quarter of 2015.

In light of this timeline, many countries have begun internal policy processes to consider medium-term targets such as 2025 or 2030. Several countries have also set domestic 2050 goals to guide their progress, including the EU, the UK, New Zealand, Mexico, Japan and Norway. Table 4.4 sets out current post-2020 goals in key countries. More countries are expected to announce post-2020 goals as international and domestic processes advance.

### TABLE 4.4: POST-2020 EMISSIONS REDUCTION TARGETS OF SELECTED KEY COUNTRIES

| COUNTRY | POST-2020 DOMESTIC TARGET IN PLACE | ADDITIONAL TARGETS UNDER CONSIDERATION |
|---|---|---|
| **Australia** | **2050**<br>Target of 80 per cent below 2000 levels (in current legislation) | |
| **United States** | **2050**<br>In 2009, President Obama committed to a goal of 83 per cent below 2005 levels | |
| **European Union** (28 member states) | **2050**<br>80–95 per cent below 1990 levels | Considering 2030 targets, with a decision expected in March 2014<br>Roadmap to 2050 planning document contains reduction targets of 40 per cent by 2030 and 60 per cent by 2040, both relative to 1990 levels |
| **Japan** | **2050**<br>80 per cent below 1990 levels included in its Fourth Basic Environment Plan | |
| **Germany** | **2050**<br>Germany contributes to the EU 2050 targets and has adopted the EU goal of 80–95 per cent in its energy blueprint | Considering 2030 targets with EU, decision expected March 2014<br>Legislation passed in 2010 sets out a road map to 2050, with indicative targets below 1990 levels—40 per cent by 2020, 55 per cent by 2030, 70 per cent by 2040 and 80–95 per cent in 2050 |
| **United Kingdom** | **2050**<br>The UK contributes to the EU 2050 targets of 80 per cent below 1990 levels<br>The UK's goal is supported by legislated carbon budgets from 2008 to 2027. The 2027 carbon budget represents emissions 50 per cent below 1990 levels | Considering 2030 targets with EU, decision expected in March 2014 |
| **South Africa** | **2025**<br>42 per cent below business-as-usual levels set in South Africa's National Climate Change Response | South Africa has a 'peak, plateau and decline' strategy, where its emissions peak between 2020 and 2025, plateau for about 10 years and then fall |
| **New Zealand** | **2050**<br>50 per cent below 1990 levels | |
| **Norway** | **2050**<br>Carbon neutrality (reduce global greenhouse gas emissions by the equivalent of 100 per cent of its own emissions) | If an ambitious global climate agreement is achieved, in which other developed countries also take on extensive obligations, Norway has stated it will undertake to achieve carbon neutrality by 2030 |

**Note:** Many countries' targets are conditional on the extent of climate action in other countries. Key countries not in this table have not yet announced post-2020 goals.
**Sources:** UNFCCC 2011 and 2013, and country websites

## 4.3 LINKING GLOBAL ACTION TO AUSTRALIA

Australian action both before and after 2020 is part of a broader international response.

In considering recommendations for Australia's 2020 emissions reduction goals, the Authority has considered:

- Australia's existing international undertaking to reduce emissions and the government's conditions for moving beyond 5 per cent
- Australia's relative development level and where different Australian 2020 targets sit on the international spectrum, placing Australia's action in context
- how Australian action can influence other countries.

### 4.3.1 AUSTRALIA'S INTERNATIONAL UNDERTAKINGS AND 2020 TARGET CONDITIONS

Australia has made an international undertaking to reduce its emissions by 5–25 per cent by 2020 relative to 2000 levels. The 5 per cent target is unconditional, and a policy has been set for when Australia might move beyond 5 per cent—to 15 or 25 per cent. The policy conditions are set out in Box 4.4.

The Authority considers that the conditions for moving beyond 5 per cent have been met. Whether the conditions for 15 per cent have been met is unclear—some elements have been met; others are marginal. The conditions for a 25 per cent target have not been met. A clause-by-clause breakdown of the conditions is at Appendix B. Importantly, the target conditions are only one aspect of the Authority's considerations.

A common misconception that the Authority encountered in its consultations is that the target conditions require a legally binding international agreement. The conditions for moving beyond 5 per cent do not refer to the form of international action, binding or otherwise. The Authority's interpretation of the conditions for the 15 or 25 per cent target is that they require coordinated international action but that the element of an 'international agreement' could take a range of forms, not all of which would be legally binding. While a new treaty could meet the conditions, a set of UNFCCC decisions or some other agreement that delivers the results referred to in the conditions could also satisfy them.

### BOX 4.4: AUSTRALIA'S 2020 TARGET POLICY

**Reduce emissions by 5 per cent relative to 2000 levels**
Conditions: None

**Reduce emissions beyond 5 per cent**
Conditions: The government will not increase Australia's emissions reduction target above 5 per cent until:

- the level of global ambition becomes sufficiently clear, including both the specific targets of advanced economies and the verifiable emissions reduction actions of China and India;
- the credibility of those commitments and actions is established for example, by way of a robust global agreement or commitments to verifiable domestic action on the part of the major emitters including the United States, India and China; and
- there is clarity on the assumptions for emissions accounting and access to markets.

**Reduce emissions by 15 per cent compared to 2000 levels**
Conditions: International agreement where major developing economies commit to restrain emissions substantially and advanced economies take on commitments comparable to Australia's. In practice, this implies:

- global action on track to stabilisation between 510–540 ppm $CO_2$-e;
- advanced economy reductions in aggregate in the range of 15–25 per cent below 1990 levels;
- substantive measurable, reportable and verifiable commitments and actions by major developing economies in the context of a strong international financing and technology cooperation framework, but which may not deliver significant emissions reduction until after 2020;
- progress towards inclusion of forests (reduced emissions from deforestation and forest degradation in developing countries) and the land sector, deeper and broader carbon markets and low-carbon development pathways.

**Reduce emissions by 25 per cent relative to 2000 levels (up to 5 percentage points through government purchase)**
Conditions: Comprehensive global action capable of stabilising $CO_2$-e concentrations at 450 ppm $CO_2$-e or lower. This requires a clear pathway to achieving an early global peak in total emissions, with major developing economies slowing the growth and then reducing their emissions, advanced economies taking on reductions and commitments comparable to Australia's, and access to the full range of international abatement opportunities through a broad and functioning international market in carbon credits. This would involve:

- comprehensive coverage of gases, sources and sectors with inclusion of forests (reduced emissions from deforestation and forest degradation in developing countries) and the land sector (including soil carbon initiatives (for example, biochar) if scientifically demonstrated) in the agreement;

- clear global trajectory, where the sum of all economies' commitments is consistent with 450 ppm $CO_2$-e or lower, and with a nominated early deadline year for peak global emissions not later than 2020;
- advanced economy reductions, in aggregate, of at least 25 per cent below 1990 levels by 2020;
- major developing economy commitments that slow emissions growth and then reduce their absolute level of emissions over time, with a collective reduction of at least 20 per cent below business-as-usual by 2020 and a nomination of a peaking year for individual major developing economies;
- global action which mobilises greater financial resources, including from major developing economies, and results in fully functional global carbon markets.

**Note:** 'Advanced economies' refers to Annex I Parties to the UNFCCC and at least some other high-middle income economies; 'major developing economies' refers to non-Annex I members of the Major Economies Forum.
**Source:** Commonwealth of Australia 2013

## CONDITIONS FOR BEYOND 5 PER CENT

In the Authority's view, the conditions for moving beyond 5 per cent have been met:

- Since the target conditions were set, there has been significant process 'clarifying the level of global ambition', with all major emitting economies putting forward 2020 emissions reduction goals under the UNFCCC.
- A robust international framework for measuring, reporting and verifying targets and actions was established in 2011 at the Durban Climate Conference.
- A clear framework for markets and accounting has been established for second commitment period targets under the Kyoto Protocol. For targets outside the Protocol, countries will set out their rules for accounting and markets in biennial reports, due to begin 1 January 2014.

A number of submissions to the Targets and Progress Review stated the conditions for moving beyond 5 per cent had not been met. Organisations with this view were the Australian Industry Greenhouse Network, the Australian Petroleum Production & Exploration Association, the Business Council of Australia and the Cement Industry Foundation. The main reason given was that major developing economies had not yet committed to restrain emissions substantially and advanced economies had not yet taken on commitments comparable to Australia's. The Authority's view is that major developing countries and advanced economics are acting to restrain their emissions, and it has provided evidence to support this position in this chapter. Regardless, this is not one of the conditions for moving beyond 5 per cent. Unlike the conditions for moving to 15 or 25 per cent, there is no requirement in the 'beyond 5 per cent' conditions for major developing economies to commit to restrain emissions substantially or advanced economies to take on commitments comparable to Australia's.

### CONDITIONS FOR 15 PER CENT

Whether the conditions for moving to a 15 per cent target are fulfilled is less clear. Different readers legitimately might come to different conclusions about whether these conditions are met. Some elements are met; for example, there has been strong progress developing a global framework, including targets by all major emitting economies; measuring, reporting and verifying emissions; and taking action on finance and technology for developing countries.

Some elements are marginal, including global action on track to stabilisation between 510 and 540 ppm. Studies generally estimate that the level of global effort is on track to stabilisation at about 550 ppm (Project Catalyst 2010); however, there is significant uncertainty surrounding these estimates. First, there is uncertainty about the exact level of emissions reductions implied by the UNFCCC 2020 pledges (UNEP 2013). Second, the stabilisation outcome depends on the shape of the world's long-term emissions trajectory; this means it is difficult to relate 2020 emissions levels to particular stabilisation outcomes without making significant assumptions about action after 2020 (Rogelj and Meinshausen 2010). Given the degree of uncertainty, stabilisation between 510 and 540 ppm cannot be ruled out.

The condition regarding aggregate advanced economy action is also marginal. Recent analytical work estimates aggregate Annex I Party action to be 12–18 per cent below 1990 levels by 2020 (compared with the 15–25 per cent reductions listed in the conditions) (den Elzen et al. 2012, p. 9). There is uncertainty regarding these estimates, which could pull the aggregate up or down.

### CONDITIONS FOR 25 PER CENT

In the Authority's view, the conditions for 25 per cent have not been met at this time. In particular, while stabilisation of greenhouse gas concentrations at about 450 ppm remains technically feasible, most studies do not consider that the current 2020 pledges are on track. The aggregation of Annex I targets, even under the most favourable assumptions, is unlikely to be 'at least 25 per cent' reductions on 1990 levels.

These conditions have been long-standing Australian policy and have provided guidance to stakeholders about the likely Australian target. The Authority, however, is legislatively required to take into account a broader range of factors beyond these conditions, including estimates of the global greenhouse gas emissions budget, economic efficiency, equity and the level of global action to reduce greenhouse gas emissions. Therefore, while the assessment of the target conditions is an important factor in the Authority's deliberations, it is only one input to its recommendations about Australia's appropriate 2020 target.

In the international context, the Authority has also taken into account how different Australian targets compare with the 2020 targets put forward by other countries, and Australia's ability to influence other countries' climate actions. These matters are discussed in the next section.

## 4.3.2 AUSTRALIA'S PLACE IN THE WORLD

Australia is prosperous compared with most countries. It has the 12th highest GDP per person in the world and a high standard of living, ranking second of 186 countries on the UNDP's human development index.

Australia is also a high-emitting country in absolute and per person terms. Australia has the highest emissions per person of all developed countries and is responsible for about 1.3 per cent of the world's emissions of greenhouse gases. While this may sound like a small proportion of the global total, Australia is the 15th highest emitter of greenhouse gases in the world (of 186 countries: WRI 2013b). Some of this reflects Australia's relatively high share of fossil fuels in its energy supply. In 2011–12, coal represented nearly 60 per cent of Australia's total primary energy supply (BREE 2013a) compared with an OECD average of 20 per cent (IEA 2012). Australia is one of only 19 countries that emits more than 1 per cent of the world's emissions. Combined, emissions from these 19 countries account for more than two-thirds of the world's total emissions.

In the Authority's consultations, many stakeholders suggested that these factors mean Australia should show 'climate leadership', or be at the front end of international action. Against this, some submissions considered Australia had certain characteristics that argued against stronger action and cited potential impacts on Australia's competitiveness and the high cost of reducing emissions in Australia.

As discussed in other parts of the Review (chapters 10 and 12), most studies—both Australian and international—find that Australia has relatively high costs of emissions reductions. These findings are important, but need to be balanced against three factors:

- the magnitude of the costs may be ameliorated by access to international emissions reduction units
- emissions reduction costs—and their distribution across households and industry—depend heavily on policy design. Policies can be designed to help households and moderate the costs on businesses
- while Australia's costs may be relatively high, it also has relatively high development levels and therefore greater capacity to meet them.

An analysis of Australia's place in the world shows that it has high emissions—and the capacity and prosperity to reduce them. Comparing its targets and actions to much poorer countries, including China and India, can be useful for a policy design process or when considering issues of carbon leakage. However, in terms of overall ambition, it would not be fair to expect these countries to take the same action as Australia because they are significantly poorer and have dramatically different capacities to implement policy and respond to climate change. Table 4.5 describes emissions and development data for each country.

## TABLE 4.5: COMPARING AUSTRALIA'S EMISSIONS AND CAPACITY TO ACT

### AUSTRALIA'S EMISSIONS

Per cent of global emissions: 1.3 (15th in the world in 2009)

Emissions per person: 25 tonnes of $CO_2$-e (11th in the world in 2009, highest of any developed country)

### AUSTRALIA'S DEVELOPMENT AND ECONOMY

Human development index ranking: 2

GDP ($Int, PPP): $961 billion (18th in the world)

GDP ($Int, PPP) per person: $41,954 (9th in the world)

### AUSTRALIA'S EMISSIONS AND DEVELOPMENT COMPARED TO KEY COUNTRIES

| | Per cent of global emissions | Emissions per person (t $CO_2$-e) | Human development index* (rank: 1=highest) |
|---|---|---|---|
| **Australia** | 1.3 | 25.1 | 2 |
| **China** | 22.1 | 7.1 | 101 |
| **United States** | 15.3 | 21.2 | 3 |
| **European Union** (28 member states) | 10.9 | 9.2 | From 4 (the Netherlands) to 57 (Bulgaria) |
| **India** | 5.5 | 1.9 | 136 |
| **Japan** | 2.8 | 9.5 | 10 |
| **Germany** | 2.1 | 10.9 | 5 |
| **Indonesia** | 1.9 | 3.3 | 121 |
| **Canada** | 1.6 | 19.9 | 11 |
| **Republic of Korea** | 1.4 | 12.5 | 12 |
| **United Kingdom** | 1.4 | 9.3 | 26 |
| **South Africa** | 1.3 | 11.2 | 121 |
| **New Zealand** | 0.2 | 16.6 | 6 |
| **Norway** | 0.1 | 11.2 | 1 |

**Note:** The United Nations human development index is a composite measurement of development that combines indicators of life expectancy, education and income; PPP is purchasing power parity, used when comparing GDP across countries.

**Sources:** Emissions data from WRI 2013b, year 2009, excluding land use; GDP data from IMF 2013; population data from ABS

### 4.3.3 COMPARING AUSTRALIA'S TARGET RANGE TO OTHER COUNTRIES' TARGETS

In considering an appropriate 2020 target for Australia, it is relevant to consider how different Australian targets compare with the 2020 targets put forward by other countries.

To assist with this analysis, the Authority has considered Australian targets of 5, 15 and 25 per cent relative to targets of key countries. The countries include those with similar levels of development to Australia, major emitting economies and Australia's major trading partners and neighbours.

These countries have put forward targets in different forms with different reference years, which makes them difficult to compare. To facilitate comparison, the Authority has translated the 2020 targets of key countries to the same four key measures on a 2005 base year:

- absolute emissions reductions or limitations
- emissions intensity implied by 2020 targets
- deviations from business-as-usual
- per person emissions implied by 2020 targets.

Each measure provides a different way of looking at the target range. Absolute emissions give a direct assessment of the overall emissions reduction levels. Reductions in emissions intensity demonstrate a country's intended rate of economic decarbonisation. Deviations from business-as-usual give a comparative measure of the effect of targets on emissions and the effectiveness of climate change policies. Per person emissions removes the effect of population growth and links to the contraction and convergence and equity discussions in Chapter 8.

All of these measures have different limitations, and the metric of deviations from business-as-usual is particularly difficult, as it relies on contestable assumptions. The methodology and limitations are explained in Appendix B.

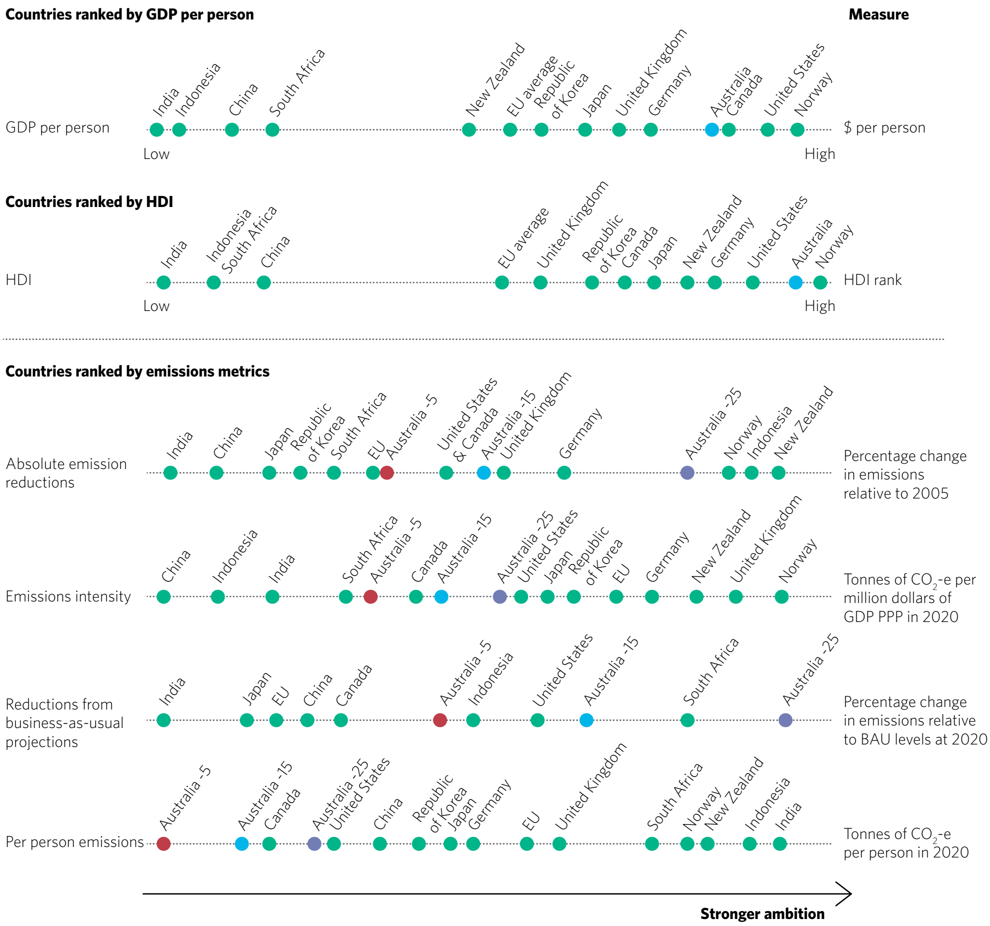
Since each of the four measures provides different information about countries' targets, it is important to look at the whole picture rather than any one measure in isolation. However, even this does not capture all relevant factors. For example, none of the above measures takes into account a country's development level, its previous action or its historical emissions levels. This analysis cannot capture the full international context over time and should therefore be used as a starting point for considering comparability rather than as a definitive formula.

Comparing different countries' targets is complicated by different base years. For example, the US target is a 17 per cent reduction by 2020 compared with 2005 levels. Australia's target range is expressed relative to 2000. To think about an Australian target that matches the US target, a matching base year is needed. In 2020, the US target requires its emissions to be 20 per cent lower than its emissions in 2000. Therefore, a matching target for Australia on this basis would be 20 per cent. Conversely, if Australia was to reduce its emissions by 17 per cent compared with its own 2005 level emissions, this equates to a 10 per cent reduction compared with 2000 level emissions.

With the above caveats, Figure 4.3 summarises the Authority's analysis of how targets of 5, 15 and 25 per cent rank relative to other countries' targets on the four measures. It also includes where Australia sits on the development metrics of GDP per person and human development index.

Several stakeholders suggested the relative cost of abatement as an important comparative measure. This is analysed separately in Chapter 8.

**FIGURE 4.3:** SUMMARY OF AUSTRALIA'S CAPACITY AND POSITION ON DIFFERENT METRICS




**Source:** As for figures B.1–B.4 in Appendix B.

Australia's 2020 target range, particularly the 5 per cent target, does not look comparable to these key countries when measured by emissions per person and emissions intensity. The same target range looks more ambitious when assessed against deviations from business-as-usual. The variability of the conclusions indicates the difficulty of 'calibrating' Australian effort directly to a country or group of countries.

At a very general level, this analysis shows that Australia's 5 per cent target is at the weaker end of the group against most metrics. The Authority's recommended target is broadly comparable to the action of other countries, including the United States. It is not singularly ambitious on any metric. On most metrics, it is weaker than the targets of climate leaders, including Norway. Therefore, the Authority considers its recommended target of 15 per cent plus carryover to be a defensible contribution to the global climate change effort, broadly similar to the actions of other countries with similar capacity and wealth.

## 4.4 AUSTRALIA'S INFLUENCE

Countries do not make decisions about climate targets and policies in a vacuum; they are influenced by the level of global action and the policies and targets of their neighbours, trading partners and countries with similar economies.

Influence can be positive—encouraging greater action—or negative; countries could use the absence of action in another country as a reason to delay further action or defer existing commitments.

Australia is a small but important part of the global picture on climate change. While Australian influence on global efforts should not be overstated, there are certain ways Australia can influence other countries. First, it has strategic roles in international groups. In the UNFCCC, Australia chairs the Umbrella Group—one of the major negotiating blocs that includes the United States, Russia, Canada, Japan and Norway. Australia is also a founding member of the Cartagena Dialogue for Progressive Action; an influential group of developed and developing countries committed to working together to resolve negotiating deadlocks and drive progress in the UNFCCC. Australia's role in these groups means its actions are more likely to be noticed by other countries. Outside the UNFCCC, Australia is active in complementary initiatives that ensure its views are heard in a range of forums (see Appendix B for a list of these initiatives).

Second, Australia also has some influence because of its particular circumstances—it is an emissions-intensive economy with a relatively high cost of emissions reduction. If a country in these circumstances chooses a stronger target—and achieves it—it is likely to have a disproportionate effect spurring action from others. Conversely, Australia is a highly developed country with a high capacity to act. If Australia fails to take strong action, other, poorer countries are more likely to characterise climate change action as unaffordable and unachievable. Demonstrating that a high-emitting and fossil fuel-dependent economy can successfully cut emissions and achieve a strong target may be one of the most effective ways Australia can influence other countries.

Third, Australia can have influence by demonstrating that climate policies can be effective. Countries observe and copy the successful policies of other countries. Successful Australian demonstration can be seen across a range of policies including plain packaging for cigarettes (now being considered or introduced in Ireland, Canada, India, New Zealand, Turkey and the EU) and the Renewable Energy Target (RET), with similar models adopted in the UK and some US states. The demonstration effect of robust climate policies is likely to increase other countries' confidence that they can adopt effective policies, and take on stronger targets in the future.

Timing should also not be overlooked. Australia is uniquely placed to influence global climate action over the next few years. The international climate change framework is in a developmental phase, and many countries are putting in place new policies and looking for examples to model. These factors are likely to mean that action now will be especially influential. Australia's current international roles—chairing the G20 in 2014 and its position on the United Nations Security Council—mean Australian action in the next few years is likely to be noticed by more countries.

Australian influence on collective action can be positive or negative at this critical time. On the positive side, a stronger Australian target underpinned by robust policy is likely to support a sense that countries are serious and committed to achieving their targets. This may help encourage countries to stand by their commitments or do more. Drawing back from our international commitments is likely to have a negative influence; an effect heightened by Australia's high level of development. And, in some ways, negative action can be more influential in collective forums than positive action—the US failure to ratify the Kyoto Protocol and Canada's subsequent withdrawal has received far more attention than the approximately 36 countries that look likely to comply with or exceed their first commitment period targets.

## CONCLUSIONS

**C.4** There is a significant trend to increased global action to reduce greenhouse gas emissions. All the major emitting economies, including China and the United States, have 2020 emissions reduction goals backed by domestic policies and measures. This trend will need to continue and accelerate if the world is to keep warming below 2 degrees.

**C.5** The Authority's analysis of the government's target conditions show that the conditions for moving beyond 5 per cent have been met. Whether the conditions for 15 per cent have been met is unclear—some elements have been met; others are marginal. The conditions for a 25 per cent target have not been met at this time. While the Authority has taken these conditions into account, it is also required to examine a broader range of considerations.

**C.6** Considering a range of measures, an Australian 5 per cent target lags behind the targets of key countries considered in this Review. A stronger 2020 target of 15 per cent plus carryover is broadly comparable with other countries' targets, including that of the United States. This is especially the case given Australia's high level of development, relative wealth and governance capacity.

# AUSTRALIA'S POLICIES AND PROGRESS TO DATE

# B

Part B charts Australia's domestic policies to reduce its emissions and assesses progress Australia has made in reducing its emissions between 1990 and 2012.

Australian governments—Commonwealth, state and local—have implemented a suite of policies to reduce greenhouse gas emissions over the past two decades and there has been considerable change in this suite over time. As in many other countries, Australia's policy suite includes market-based mechanisms, such as the carbon pricing mechanism; regulatory measures, such as minimum energy performance standards; and informational tools, such as energy rating labels.

Australia has made progress towards decarbonising its economy. Australia's emissions were broadly the same in 2012 as in 1990, despite a doubling in the size of the economy. This means that the emissions intensity of the economy has halved over that period. Policy has played an important role, particularly in the land and electricity sectors. Broader economic forces also account for some of the reduction in emissions intensity.

Further efforts are necessary to achieve absolute reductions in Australia's emissions to 2020 and in subsequent decades.

Chapter 5 describes the major policies Australia has used to reduce its emissions.

Chapter 6 describes the trends in Australia's emissions since 1990, at the national and sectoral levels, and the drivers that underpin these trends, including the role of policy.

# 5 AUSTRALIA'S POLICIES ON CLIMATE CHANGE

Australia's existing and proposed policy mix provides important context for considering its future emissions reduction goals.

As in other countries, Australian governments have been implementing policies to reduce emissions for more than two decades. Regulatory measures include labelling and minimum performance standards for appliances, changes to building codes to drive energy efficiency and restrictions on land clearing. A range of market-based schemes has been implemented to promote emissions reductions, including national schemes such as the Renewable Energy Target and state-based schemes.

In 2011, legislation was passed to create the carbon pricing mechanism (a cap-and-trade emissions trading scheme). This commenced in July 2012. The government intends to repeal this legislation and implement the Direct Action Plan. The centrepiece of the Direct Action Plan is the Emissions Reduction Fund, which is to purchase emissions reductions through a reverse auction.

Australia requires a suite of complementary policies to drive cost-effective emissions reductions in its economy.

Chapter 5 introduces Australia's policy initiatives to reduce emissions. It:

- describes Australia's existing policies to reduce emissions
- discusses the need for a suite of policies to realise the full range of cost-effective emissions reduction opportunities
- outlines the government's new policy.

Many policies are used by governments around the world to address climate change, and in most cases a number of policies are used in concert. Box 5.1 outlines the main types of policies used, as context for the description of the policies implemented in Australia.

## BOX 5.1: CLIMATE CHANGE POLICY TOOLS

The main policy tools used to address climate change include:

- Market-based mechanisms, such as:
  - cap-and-trade emissions trading schemes—which put a price on greenhouse gas emissions, by capping the allowed quantity of emissions and requiring liable emitters to surrender a permit for each unit of emissions
  - baseline and credit schemes—which allow participants to obtain credits for emissions reductions beyond a baseline of emissions or emissions intensity. When participants emit more than the baseline, they may be required to purchase credits from other parties or pay penalties
  - carbon taxes—which add a set cost to every tonne of greenhouse gas emitted.
- Regulation, such as minimum energy performance standards, which can be used to help unlock emissions reductions less responsive to price signals.
- Government subsidy or grant programs, which pay for emissions reduction activities by businesses or households.
- Informational tools, such as energy rating labels, which increase consumer awareness of the financial and environmental benefits of more energy-efficient appliances.
- Reporting requirements, such as energy efficiency opportunities, to raise the profile of an organisation's opportunities and performance to decision-makers.
- Support for research, development and commercialisation of low-emissions technologies and practices.

Particular policy tools are likely to be effective at addressing different barriers to emissions reductions. It is likely a range of complementary policies will continue to be necessary in Australia, and elsewhere, to deliver effective global action on climate change in the most cost-effective manner.

The cost of emissions reductions delivered using different policy tools can vary widely. To date, market-based mechanisms, such as emissions trading schemes, have been an important part of policy mixes that have delivered the most cost-effective emissions reductions (Productivity Commission 2011, p. xiv; OECD 2013, p. 4).

An effective and efficient policy mix should:

- Reduce emissions cost-effectively. Where a range of policy tools are used, the relative cost of emissions reductions across policies should be considered. New policies should be subject to appropriate cost-benefit and regulatory impact assessments that take into account the private and public costs and benefits of emissions reductions as well as other relevant factors.
- Be applied consistently and predictably over the longer term. This is particularly important where emissions reductions depend on long-term investment decisions, such as installing new electricity generation capacity.

- Take into account the interaction between policies aimed at reducing emissions and other energy, industry or trade objectives to avoid perverse outcomes or duplication. The IMF (2013, p. 1), for example, notes global energy subsidies may increase global energy emissions by about 13 per cent.
- Assign responsibility to the right level of government. In Australia, Wilkins (2008, p. 32) recommends that the Commonwealth take primary responsibility for emissions reduction policy.
- Identify each policy's distributional effects and, if appropriate, ensure transitional or assistance measures are put in place. Some climate change mitigation policies, like other policies, can have a regressive effect and distributional issues should be considered in the policy design process (Büchs, Bardsley and Duwe 2011, pp. 285–307).

## 5.1 AUSTRALIA'S CLIMATE CHANGE POLICY

Like other countries, Australia has drawn on a wide range of measures to reduce its greenhouse gas emissions.

Climate change policies have been introduced at all levels of government since the late 1980s. Climate change policies began with voluntary schemes such as energy labelling (initially in New South Wales and Victoria from 1986) and the national Greenhouse Challenge Program for industry from 1995. Energy labelling became mandatory from 1992 and progressed to minimum standards on a range of devices from 1999 (including refrigerators, freezers and air conditioners). In 2003, New South Wales introduced its Greenhouse Gas Reduction Scheme (GGAS), one of the first mandatory emissions trading schemes in the world. The Commonwealth Parliament introduced a mandatory RET in the electricity sector in 2001 (see Section 5.1.1).

In 2011, the Clean Energy Future package was legislated. The Clean Energy Act established long-term goals to reduce emissions to 80 per cent below 2000 levels by 2050 and to contribute to a global response to limit warming to below 2 degrees. Other major elements include a carbon price that covers over half of Australia's emissions and the Carbon Farming Initiative (CFI), which provides incentives to reduce emissions in the land sector.

At the Commonwealth level, the main legislated policy tools are currently the RET, the carbon pricing mechanism and the CFI, complemented by funding bodies such as the Clean Energy Finance Corporation (CEFC) and the Australian Renewable Energy Agency (ARENA).

A broader suite of sector-specific initiatives are also in place, and state and local governments play an important role through, for example, land use controls, energy efficiency and renewable energy programs.

### 5.1.1 RENEWABLE ENERGY TARGET

The RET drives investment in renewable energy. It creates a guaranteed market for renewables using a tradable certificate scheme that encourages projects at large scale (for example, wind farms) and small scale (for example, solar PV on household rooftops). Electricity retailers and other entities that purchase wholesale electricity are required to surrender a certain number of renewable energy certificates each year or pay a shortfall charge.

The RET has been in place and driving renewable energy generation since 2001. The target, initially legislated by the Howard Government to deliver 9,500 GWh of renewable energy in 2010, was expanded in 2009 to 45,000 GWh in 2020 by the Rudd Government. At the time, this was estimated to deliver 20 per cent of electricity generation in that year, including renewable generation already operating prior to its introduction. Recent softening of electricity demand means the RET could now deliver a higher share of renewable electricity in 2020 (CCA 2012, p. 43).

The RET target was split into two schemes in 2011:

- the Large-scale Renewable Energy Target (LRET) supports large-scale projects. The LRET has annual fixed targets and a 2020 target of 41,000 GWh
- the Small-scale Renewable Energy Scheme (SRES) supports the installation of small-scale systems. The SRES has an implicit target of 4,000 GWh, but is uncapped. The Authority estimates it may result in about 11,000 GWh of generation in 2020 (CCA 2012, p. 43).

Since the introduction of the RET in 2001, Australia's renewable electricity capacity has doubled (CCA 2012). About one million households have installed rooftop solar PV (DIICCSRTE 2013, p. 89), which the Australian Energy Market Operator (AEMO) estimates will generate about 2,700 GWh in 2013 (AEMO 2013).

Between 2001 and 2012, the RET reduced emissions by an estimated 20 Mt $CO_2$-e (CCA 2012, p. 12).

### 5.1.2 CARBON PRICING MECHANISM

The carbon pricing mechanism requires Australia's largest greenhouse gas emitters—liable entities—to acquire and surrender eligible units for each tonne of $CO_2$-e they emit, creating an incentive to reduce those emissions. The Commonwealth Government intends to repeal the legislation supporting the carbon pricing mechanism; this section describes the scheme as currently legislated.

The carbon pricing mechanism covers more than half of Australia's emissions, including those from electricity generation, direct combustion, landfills, wastewater, industrial processes and fugitives. Some other sectors are covered by an equivalent carbon price (see Part E for further details).

The carbon pricing mechanism has a three-year fixed-price period from 1 July 2012 to 30 June 2015. During this period, the price of Australian carbon units started at \$23/t $CO_2$-e and rises 2.5 per cent a year in real terms.

From 1 July 2015, the number of available Australian carbon units issued by the government under the carbon pricing mechanism will be limited by a cap. Liable entities can acquire units from the government or through trading with other parties. Under the legislation, the minister responsible for climate change must set annual caps, taking into consideration the Authority's advice as part of this Review. The legislation requires caps to be announced five years in advance. In the event that parliament does not set caps through regulation, default caps apply (see Part E).

Australian Carbon Credit Units (ACCUs), generated under the CFI, can be used to meet carbon pricing mechanism liabilities. Approved international units can also be surrendered to meet up to 50 per cent of an entity's carbon liability. At present, approved international units include European Union Allowances (EUAs) and units generated under the Kyoto Protocol (limited to 12.5 per cent of an entity's liability). More detail on international carbon markets is provided in Chapter 12.

### 5.1.3 CARBON FARMING INITIATIVE

The CFI allows approved carbon reduction projects to generate ACCUs. It commenced in 2011. ACCUs can be sold to liable parties under the carbon pricing mechanism, or to individuals and organisations wishing to voluntarily offset their emissions (for example, through the Commonwealth Government's National Carbon Offset Standard).

Sectors eligible for the CFI are not covered by the carbon pricing mechanism. These include agriculture, forestry and waste (for waste deposited before July 2012).

The Clean Energy Regulator (2014) reports that, as of January 2014, 4.2 million ACCUs have been issued, representing 4.2 Mt $CO_2$-e of avoided emissions. Activities that have earned ACCUs under the CFI include:

- Reduction of emissions from waste. The waste sector accounted for the largest number of registered CFI projects and 96 per cent of ACCUs issued; the CFI has 74 registered waste projects involving gas capture, combustion and diversion.
- Management of savanna burning in the Northern Territory. The Indigenous Land Corporation has generated credits through projects that undertake controlled burning early in the dry season.
- Capture of methane from pig manure for use in generating electricity.

### 5.1.4 CLEAN ENERGY FINANCE CORPORATION

The CEFC is a clean energy investment fund. As with the carbon pricing mechanism, the Commonwealth Government intends to repeal the CEFC's legislation.

The CEFC co-finances emissions reduction projects with the private sector. As of June 2013, it has facilitated over $2.2 billion in emissions reduction projects, comprising $536 million of its own funds and private sector co-financing of $1.55 billion. The CEFC (2013, p. 10) estimates its portfolio achieves about 4 Mt $CO_2$-e of emissions reductions annually at a negative cost (or a net return or benefit) of $2.40/t $CO_2$-e.

### 5.1.5 AUSTRALIAN RENEWABLE ENERGY AGENCY

ARENA is a renewable energy investment fund. It provides financial assistance to improve the competitiveness of renewable energy technologies and increase the supply of renewable energy in Australia (ARENA 2013, p. 8).

ARENA provides financial assistance in two areas:

1. Research, development, demonstration, deployment and commercialisation of renewable energy and related technologies.
2. Sharing of knowledge and information about renewable energy technologies.

In 2012–13, ARENA (2013, p. 6) commissioned four major projects totalling $560 million and managed more than 150 projects with commitments of $1.1 billion.

### 5.1.6 OTHER SECTOR-SPECIFIC INITIATIVES

A range of initiatives exists to reduce emissions in the land, industry and buildings sectors:

- Land clearing regulations—annual rates of land clearing have decreased substantially since 1990, largely due to state-based regulations in New South Wales and Queensland on new land clearing, and weaker economic conditions for farming (leading to reduced incentives for farmers to clear land and expand production). Recent relaxation of land clearing regulations in Queensland, New South Wales and Western Australia may affect future emissions reductions (see chapters 6 and 11).
- Minimum energy performance standards—from 1999, some products and appliances such as refrigerators and air conditioners have been subject to minimum energy performance standards through state government legislation. Building on this, the *Greenhouse and Energy Minimum Standards (GEMS) Act 2012* (Cth) implements nationally consistent standards for appliances in the residential and commercial sectors.
- The Energy Efficiency Opportunities (EEO) program—introduced in 2006, this program promotes energy efficiency in Australia's largest energy-using firms (firms that consume more than 0.5 PJ of energy per year). The program requires firms to assess their energy use and identify cost-effective energy efficiency opportunities (with a payback period of up to four years). The government has announced funding for this program will cease from 1 July 2014 (Commonwealth of Australia 2013, p. 145).
- New building standards—under the *Building Energy Efficiency Disclosure Act 2010* (Cth), commercial offices must disclose energy performance and receive a building efficiency rating through the National Australian Built Environment Rating System. Residential energy efficiency standards for new buildings have been in the National Construction Code since 2003; these were strengthened in 2010. Most states and territories now require new residential construction to meet minimum thermal efficiency standards.
- Efficient lighting—the Commonwealth is phasing out inefficient lighting in favour of more efficient alternatives such as compact fluorescent and LED lamps. Sales restrictions on inefficient lighting begun in 2009 will be expanded to a broader range of lighting over time.
- Energy savings 'white certificate' schemes—while the design of these schemes can differ across states, in general they place an obligation on a party—such as energy retailers—to meet an energy efficiency improvement target. White certificates can be generated when businesses or consumers implement energy efficiency measures, and may be surrendered to a regulatory body by a liable party to meet its obligations. These schemes operate in the Australian Capital Territory, New South Wales, South Australia and Victoria.

## 5.2 THE DIRECT ACTION PLAN

The Commonwealth Government plans to introduce the Direct Action Plan to replace the carbon pricing mechanism and other elements of the Clean Energy Future package. In this Review, the Authority has not made any assumptions about policy design or implementation beyond what has been announced.

A central feature of the Direct Action Plan is the Emissions Reduction Fund (ERF) but it also includes:

- rebates for solar panels, solar hot water systems and heat pumps
- grants for renewable energy in schools and towns
- planting an additional 20 million trees.

A Green Paper on the ERF was released by the Department of the Environment in December 2013. It states the ERF will be designed to:

- identify and purchase emissions reductions at the lowest cost
- purchase emissions reductions that are genuine and would not have occurred in the absence of the ERF
- allow efficient business participation.

A key aspect of the ERF will be safeguarding emissions reductions, primarily by setting baselines that discourage emissions growth above historical levels.

The Green Paper states that baselines could be set on a historical business-as-usual basis based on absolute emissions or emissions intensity. Additionally, baselines could take account of external events, such as an economic downturn, by setting them at a facility's historical high point of emissions.

The Green Paper states the government has an objective to not raise revenue from ensuring compliance with the scheme, and the safeguard mechanism could have flexible compliance arrangements that could allow:

- a baseline to be exceeded for a period of time without penalty
- multi-year compliance periods, so a baseline could be exceeded in one or more years if the average baseline of the compliance period is not exceeded
- businesses to offset an exceeded baseline by purchasing emissions reduction credits.

The Green Paper notes the electricity sector is the largest single source of Australia's emissions, and is a key source of potential emissions reductions. The government intends to work closely with the sector on how the ERF can complement existing policy such as the RET.

The Green Paper also seeks feedback on other design issues, such as developing methods to credit emissions reduction activities, managing the auction process and the ERF's coverage.

**CONCLUSION**

**C.7** **Australian governments at all levels have implemented a wide range of policies to reduce emissions over the last two decades, and there has been considerable change in the suite of policies over time.**

# AUSTRALIA'S PROGRESS TO DATE IN REDUCING EMISSIONS

# 6

Australia's emissions were broadly the same in 2012 as in 1990, despite a doubling in the size of the economy over this period. This means that the emissions intensity of the economy (emissions per dollar of GDP) has halved.

Falling emissions intensity is in part due to economic conditions and the changing composition of the economy. For example, emissions-intensive manufacturing's share of the economy has decreased.

Policy has also played an important role over the past two decades. Regulation in the land sector has reduced emissions from land clearing. In the electricity sector, policies such as the Renewable Energy Target, appliance and building standards, and state-based schemes (such as the New South Wales Greenhouse Gas Reduction Scheme, the Queensland Gas Scheme and other state-based energy efficiency schemes) have helped shift the fuel mix towards lower emission alternatives and reduce demand for electricity, particularly since 2008.

In 2012–13, electricity emissions decreased more rapidly than in previous years, with a fall in emissions intensity and slower growth in electricity demand. These emissions reduction trends need to be sustained and accelerated if Australia is to meet its long-term emissions reduction objectives.

Chapter 5 discussed policy tools used to reduce emissions. Chapter 6:

- describes Australia's emission trends between 1990 and 2012
- assesses the drivers of these trends, including the role of policy.

The level of emissions reductions required to meet future goals is discussed in Part C of this report.

**BOX 6.1:** **DATA CONVENTIONS IN THIS REPORT**

Emissions data varies slightly across sources. In this report, historical and projected emissions for the period 1990 to 2030 are taken from the Treasury and DIICCSRTE modelling (2013), which provides continuous data sets for four scenarios of future action for emissions reduction.

Emissions for 2012 are based on preliminary inventory data and modelled estimates available at the time the Treasury and DIICCSRTE modelling was undertaken. They do not reflect 2012 or 2013 emissions reported in the *June 2013 Quarterly Update of Australia's National Greenhouse Gas Inventory*, released in December 2013. The June 2013 Quarterly Update is the source of Australia's estimated carryover from the first commitment period of the Kyoto Protocol. Revisions incorporated in the June 2013 Quarterly Update revise estimated 2012 emissions, but have almost no effect on the rate of growth in emissions between 2011–12 and 2012–13.

Emissions reported for 2013 and beyond are modelled estimates.

All annual data in this report is for the financial year ending 30 June unless otherwise indicated. For example, data reported for 2013 is for the financial year 2012–13.

Australian dollars ($A) are reported in 2012 real terms (that is, adjusted for inflation) unless otherwise specified.

All emissions data has been converted to $CO_2$-e using global warming potentials from the IPCC Fourth Assessment Report. Historical emissions for land use, land use change and forestry (LULUCF) for the period 1990 to 2012 have been adjusted to be consistent with the new accounting rules agreed for the second commitment period of the Kyoto Protocol. This means historical and projected emissions data throughout the report is directly comparable.

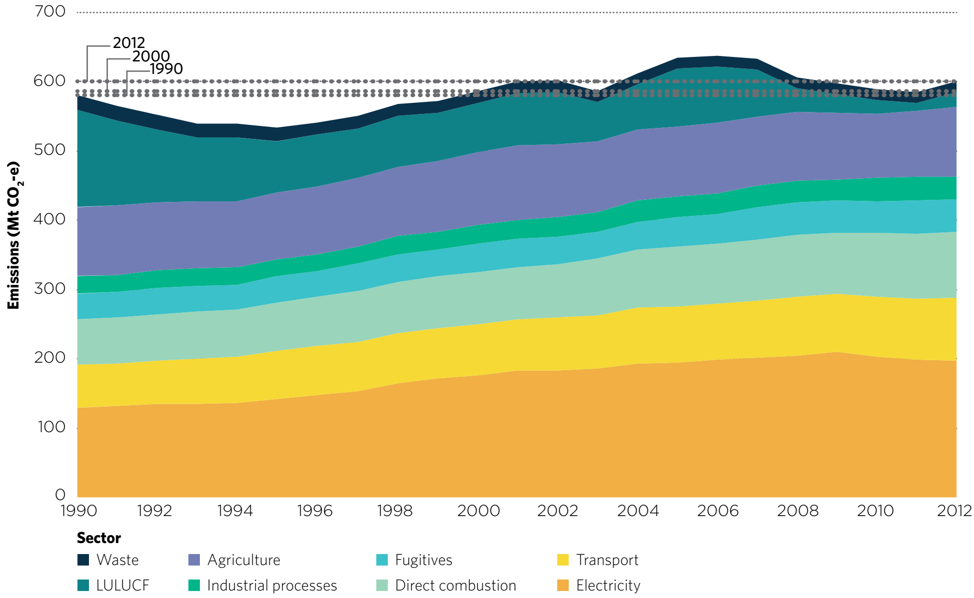
These conventions apply to all data in the report unless otherwise noted.

## 6.1 EMISSIONS TRENDS BETWEEN 1990 AND 2012

In 2012, Australia's emissions were about 600 Mt $CO_2$-e. The majority (72 per cent) of Australia's $CO_2$ emissions are energy-related (Treasury and DIICCSRTE 2013). That is, they are produced in the combustion and production of fossil fuels for transport and stationary energy. The remainder of Australia's emissions result from agriculture, fossil fuel extraction and distribution, waste, LULUCF and industrial processes.

Australia's total greenhouse gas emissions in 2012 were 3.5 per cent higher than in 1990 and 2.5 per cent higher than in 2000 (Figure 6.1).

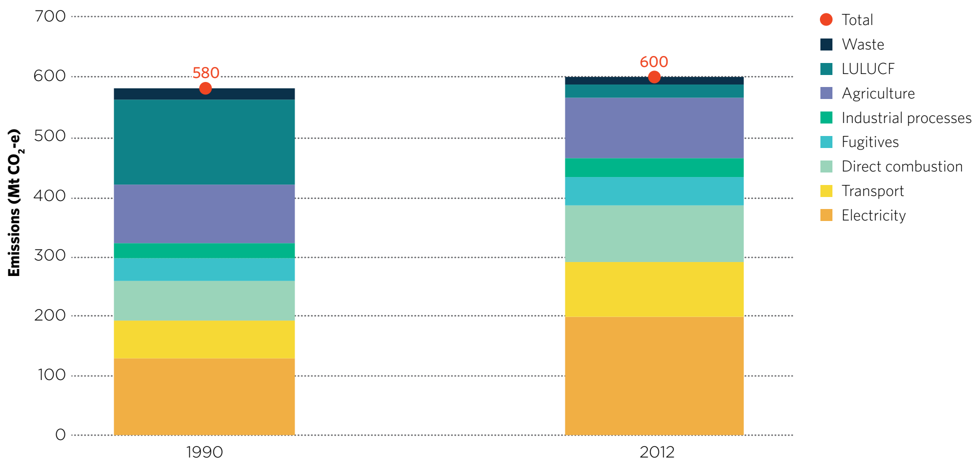
**FIGURE 6.1: AUSTRALIA'S EMISSIONS BY SECTOR, 1990–2012**




**Source:** Treasury and DIICCSRTE 2013; for more detail see Box 6.1

Emissions in most sectors have grown steadily, resulting in a 32 per cent increase in emissions excluding LULUCF in the period 1990 to 2012. In contrast, LULUCF emissions fell by 85 per cent in the same period. These steep reductions offset the increase in emissions from the rest of the economy (Figure 6.2).

**FIGURE 6.2: AUSTRALIA'S EMISSIONS BY SECTOR, 1990 AND 2012**

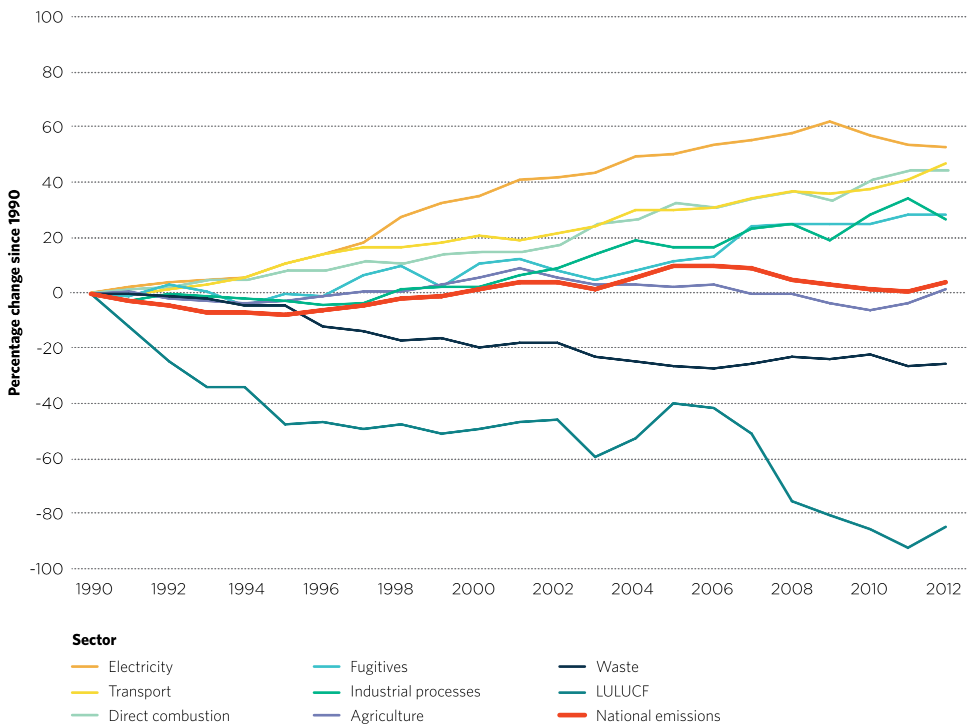



**Source:** Treasury and DIICCSRTE 2013

According to Treasury and DIICCSRTE (2013), the main trends by sector between 1990 and 2012 are:

- electricity and direct combustion of fuels (for example, in buildings and industry) grew by 50 per cent (a 97 Mt $CO_2$-e increase)
- transport emissions increased by 46 per cent (29 Mt $CO_2$-e)
- fugitive emissions (greenhouse gases emitted during the extraction, production, processing, storage, transmission and distribution of fossil fuels) increased by 28 per cent (10 Mt $CO_2$-e)
- industrial process emissions increased by 27 per cent (7 Mt $CO_2$-e)
- agricultural emissions rose by 1 per cent (1 Mt $CO_2$-e)
- LULUCF emissions decreased by 85 per cent (119 Mt $CO_2$-e)
- waste emissions decreased by 26 per cent (5 Mt $CO_2$-e).

**FIGURE 6.3:** GROWTH IN AUSTRALIA'S EMISSIONS BY SECTOR, 1990–2012




**Source:** Treasury and DIICCSRTE 2013

There has been a departure from longer term trends in emissions since 2008. Between 1990 and 2008, total national emissions rose by about 4 per cent, but fell by about 1 per cent between 2008 and 2012. This is due to changes in economic conditions (for example, the global economic downturn slowed growth, while rising energy prices reduced growth in demand for energy) and emissions reduction activities in particular sectors. The departure from long-term growth trends after 2008 is most pronounced in the electricity sector.

Although Australia's total emissions in 2012 are at broadly the same levels as in 1990, this has been achieved in a period of strong growth in GDP. The economy has doubled in size since 1990, from $0.7 to $1.5 trillion in real $2011 terms. This means the emissions intensity of the economy has approximately halved.

Australia's first commitment under the Kyoto Protocol required it to limit emissions in the period 2008–2012 to an average of 108 per cent of 1990 level emissions. Australia's emissions were below this level, averaging 104 per cent over the period. This creates a 'carryover', which can be used towards Australia's second commitment under the Kyoto Protocol. The treatment of this carryover is discussed in Chapter 7.

## 6.2 MAJOR DRIVERS OF EMISSIONS TRENDS

Australia's falling emissions intensity indicates that progress is already being made towards a lower emissions economy.

The Authority commissioned Vivid Economics[1] (2013) to assess the main drivers behind Australia's historical emissions trends between 2000 and 2011 (the last year for which data was available when the work was done). Vivid's analysis suggests that changes in patterns of economic activity have been the strongest driver (Figure 6.4). Emissions growth due to economic growth has been largely offset by:

- a shift in the structure of the economy towards lower emissions sectors; for example, from manufacturing to services
- emissions reductions activities; in particular, in the electricity and land sectors.

These changes are detailed below.

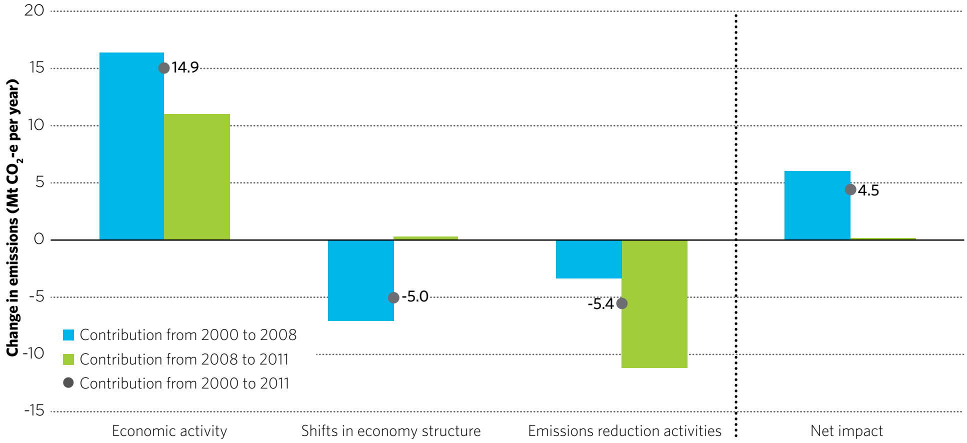
### 6.2.1 ECONOMY-WIDE DRIVERS—ECONOMIC ACTIVITY AND STRUCTURAL SHIFTS

Australia has experienced strong and sustained economic growth at an average annual rate of 3 per cent in real terms between 1990 and 2012 (ABS 2013a), which has led to higher emissions. While Figure 6.4 suggests structural change after 2008 had little impact on emissions, this masks two offsetting effects—change within manufacturing led to falling emissions, whereas change within agriculture following the end of the drought increased emissions.

Figure 6.4 also highlights the role of emissions reduction activities and shows they accelerated after 2008. This is discussed in detail in the next section.

1 Vivid Economics's analysis does not include LULUCF emissions. However, the broader assessment of emissions reduction activities includes this sector.

## FIGURE 6.4: DRIVERS OF EMISSIONS TRENDS, 2000–2011




**Note:** Emissions reduction activities include implementing new energy-efficient technologies, fuel switching and changing operating practices to make sectors more efficient.
**Source:** Vivid Economics 2013; Climate Change Authority

Emissions growth due to economic growth weakened in some sectors after 2008, in part reflecting the global economic downturn. These changes were significant—manufacturing activity fell at an average annual rate of 1.4 per cent between 2008 and 2012, compared with 1.7 per cent growth from 2000 to 2008 (ABS 2013a). This is reflected in moderated emissions growth from economic activity after 2008 (Figure 6.4).

The sectoral pattern of growth is changing over time. Emissions-intensive manufacturing as a share of the Australian economy fell by about 4 per cent between 1990 and 2011. High commodity prices and exchange rates in recent years have accelerated the decline in this share (Treasury and DIICCSRTE 2013). The share of less emissions-intensive sectors rose; for example, the services sector increased its share of the economy by 6 per cent (Table 6.1).

## TABLE 6.1: CHANGE IN SHARE OF ECONOMIC VALUE BY SECTOR, 1990–2011

| SECTOR | CHANGE IN CONTRIBUTION TO OVERALL ECONOMIC VALUE (GVA) FROM 1990 TO 2011 | EMISSIONS INTENSITY OF SECTOR IN 2011 (kg $CO_2$-e/$AUD) |
|---|---|---|
| Manufacturing (C) | -4.3% | 0.66 |
| Commercial and services (F-H, J-Q) | 6.0% | 0.04 |
| Electricity, gas and water supply (D) | -0.9% | 6.06 |
| Construction (E) | 1.1% | 0.08 |
| Mining (B) | 0.4% | 0.52 |
| Transport, postal and warehousing (I) | 0.4% | 0.39 |
| Agriculture, forestry and fishing (A) | -0.2% | 3.22 |

**Note:** GVA (Gross value added) in real $2011 terms using a chain-value measure to approximate volumes net of changes in commodity prices. Bracketed letters are relevant ANZSIC codes. Emissions by ANZSIC code for 2012 were not available at the time of drafting.
**Source:** Treasury and DIICCSRTE 2013; ABS 2013a.

### 6.2.2 EMISSIONS REDUCTION ACTIVITIES AND THE ROLE OF POLICY

Emissions reduction activities are broadly defined to include the implementation of new energy-efficient technologies, fuel switching to lower emissions fuels and changing operating practices in a way that makes sectors more efficient. These activities may be driven by policy, such as increases in renewable energy due to the RET or market factors such as rising fuel prices and falling technology costs.

Detailed sector-by-sector analysis, including by ClimateWorks (2013, p. 5), shows that the emissions reduction activities are concentrated where there have been significant policy initiatives, particularly in the land and electricity sectors.

#### LAND USE, LAND USE CHANGE AND FORESTRY

Between 1990 and 2012, emissions from LULUCF fell by 119 Mt $CO_2$-e, or 85 per cent.

Drought and weakening economic conditions for farmers were important drivers of reductions in land clearing emissions, together with the declining availability of uncleared productive land in the early to mid-1990s (ANU Centre for Climate Law and Policy, *Issues Paper submission*, pp. 7–8). Since 1990, deforestation emissions have decreased by 67 per cent (Treasury and DIICCSRTE 2013), largely due to the ongoing reform of land clearing regulations.

The vast majority of land clearing took place in New South Wales and Queensland. Regulations to restrict land clearing have been implemented at a state level, partly in response to community concerns about biodiversity and climate change. The annual area deforested has halved since 2003, primarily due to these regulations (see Appendix D for more detail).

In 2013, Queensland, Western Australia and New South Wales revised their land clearing restrictions. Queensland's revisions make it easier for farmers to clear trees and natural vegetation and expand cropping operations. Western Australia's revisions allow farmers to increase their annual land clearing rate for specified purposes without a permit. New South Wales's revisions allow clearing of isolated paddock trees and thinning of native vegetation, subject to a self-assessable code.

Rates of new timber forest plantations peaked in 2000. This was largely in response to Managed Investment Schemes, which provided tax incentives for new plantations. New plantations fell sharply after 2000 as investment regulations were tightened, and again in 2007 in response to economic factors and the collapse of investment companies during the global financial crisis.

#### THE ELECTRICITY SECTOR

Between 2000 and 2012, there was a shift in the fuel mix towards lower emissions fuels and renewables, largely driven by policies such as the state-based schemes in New South Wales and Queensland, and the RET. This shift accelerated in 2013 (Section 6.3).

The New South Wales Greenhouse Gas Reduction Scheme was introduced in 2003, and the Queensland Gas Scheme in 2005. This helped the share of gas in electricity generation across Australia grow from 8 to 19 per cent between 2000 and 2012.

The RET was introduced in 2001 and expanded in 2009, contributing to the share of non-hydro renewable generation increasing from 0.6 per cent in 2000 to 3.9 per cent in 2012 (BREE 2013a).

Recent emissions reductions in the electricity sector are due to a combination of falling emissions intensity of generation and flattening demand for electricity.

- The emissions intensity of Australia's electricity supply fell at an average annual rate of about 1.9 per cent over the period 2008 to 2012 due to increases in renewables and gas generation (BREE 2013a; Treasury and DIICCSRTE 2013):
  - renewable generation grew 1.3 per cent on average per year from 2000 to 2008, accelerating to 4.9 per cent between 2008 and 2012 (BREE 2013a)
  - installation of solar photovoltaics has increased rapidly since 2008, from about 30 MW installed in that year to about 2,300 MW in 2012, linked to the RET and state-based incentive schemes (CEC 2012, p. 49)
  - the emissions intensity of electricity sourced from the National Electricity Market (NEM[2]) decreased at a yearly average of 1.5 per cent from 2008 to 2012, and fell a further 4.6 per cent in 2013 (AEMO 2013).
- In the period 1990 to 2008, Australia-wide demand for electricity grew 2.5 per cent on average per year. Between 2008 and 2012, growth softened to 1.1 per cent.[3] Rising electricity prices, lower economic activity and an improvement in energy efficiency have contributed to this:
  - retail electricity prices rose by about 60 per cent between 2008 and 2012. The analysis by Vivid Economics (2013) suggests that the manufacturing sector was the most responsive to these price increases, followed by the commercial and residential sectors
  - economic activity slowed for some key sectors (as described in Section 6.2.1)
  - uptake of efficient lights and appliances (described below) has contributed to moderating consumption.

There were regional differences in the trends for electricity demand; in particular, for Western Australia and the NEM jurisdictions:

- Consumption in Western Australia grew at an average of 6 per cent per year between 2008 and 2012, faster than the average increase across Australia of 1.1 per cent, linked to economic growth.
- Demand for remote and off-grid power sources is thought to be growing, particularly in Western Australia, although relatively little data is available (BREE 2013b, p. 2). As noted above, deployment of solar PV is also growing Australia-wide.
- Demand for electricity supplied by the NEM (not including off-grid or solar PV generation) fell between 2010 and 2013 at an average annual rate of 1.3 per cent (AEMO 2013).

2 The NEM electricity grid covers New South Wales, Queensland, Victoria, South Australia, Tasmania and the Australian Capital Territory, and in 2012 accounted for 86 per cent of total electricity consumed in Australia.

3 Vivid Economics (2013) suggests that BREE data for the commercial and services sector appears inconsistent with data from the NEM. If a correction is applied to the BREE data, the annualised rate of growth falls from 1.1 to 0.2 per cent.

### ENERGY EFFICIENCY AND FUEL-SWITCHING

There is some evidence of energy efficiency and fuel-switching contributing to emissions reductions in the building and industry sectors.

The most significant contributor to emissions reductions in the residential sector between 1990 and 2012 was gas heating. Gas replaced emissions-intensive electric heating as the gas network expanded (BREE 2012, p. 45). The energy intensity of Australia's buildings has decreased by 3 per cent between 2003 and 2011, led by improvements in the operation of buildings, better energy efficiency standards, more efficient appliances and distributed energy (ClimateWorks 2013, p. 20). However, these improvements have been offset by additional buildings and increased use of electronics in homes:

- Building standards have improved energy efficiency in new buildings in particular. For example, new offices now use about 32 per cent less energy than offices built 10 years ago (ClimateWorks 2013, p. 20). Due to the slow turnover of stock, this will take some time to have a significant impact on overall building energy use.
- While minimum standards on appliances have made an impact, gains have been offset by the increase in appliance ownership. For example, ownership of computer and IT equipment has increased from close to zero per household in 1990 to more than one per household by 2008 (BREE 2012, p. 51). More recently, this effect may have been moderated by a shift towards less energy-intensive appliances; for example, from desktop computers to laptops and tablets, and from plasma to LCD televisions.

In industry, higher energy prices combined with policy instruments like the EEO program and minimum standards on some equipment are driving energy efficiency improvements. The government has announced funding for the EEO program will cease from 1 July 2014.

ClimateWorks (2013, p. 3) reports that the falls in energy consumption for large industrial users over the last four years are equivalent to the energy use of about 800,000 households. Since 2008, industrial companies have been implementing about three times more energy efficiency improvements each year than they had previously. Emissions from these companies have been substantially reduced; for example, by self-generating electricity using gas, which has led to an estimated 10 per cent improvement in industrial emissions intensity. This has been offset by large increases in production. The factors that influence the uptake of energy efficiency were the subject of a recent report by ClimateWorks, detailed in Box 6.2.

### BOX 6.2: CLIMATEWORKS AUSTRALIA SPECIAL REPORT ON FACTORS INFLUENCING LARGE INDUSTRIAL ENERGY EFFICIENCY

In July 2013, ClimateWorks published a report on the factors that influence large industrial energy efficiency. This research involved in-depth interviews with 47 large industrial companies that account for 70 per cent of Australia's industrial energy use.

The report identified the key drivers of energy efficiency as higher energy prices, the carbon price, the EEO program and organisational changes:

**Higher energy prices**—87 per cent of respondents identified energy prices as a driver of energy efficiency; companies with higher energy intensities identified prices as strong drivers.

**Carbon price**—81 per cent of respondents reported the carbon pricing mechanism had an impact. While its financial impact has been relatively small, respondents reported it focused their attention on energy and carbon management, and influenced their strategic approach to energy management; for example, prompting consideration of fuel-switching opportunities.

**EEO**—80 per cent of respondents stated the EEO program was a key influence; in particular, that it provided a structure for energy management. Respondents mentioned that the program had changed cultural attitudes to, and catalysed, energy efficiency. The EEO had a greater influence on respondents from companies within sectors with higher profitability and growth profiles. This could mean that companies that are not under financial stress may respond more readily to compliance and reputational drivers.

**Organisational factors**—respondents with better internal practices in certain key areas implement more energy efficiency. For example, companies who analyse energy data, embed energy efficiency in their practices and have senior management oversight of energy efficiency realised more potential for energy savings (by up to 275 per cent) than those without.

The report also investigated barriers to further uptake of energy efficiency, and found that access to internal capital, the long payback periods of energy efficiency projects and opportunity cost of alternative investments were the most prominent barriers. These would need to be overcome for a higher rate of energy efficiency to be achieved.

### FACTORS CONTRIBUTING TO REDUCED GROWTH IN ELECTRICITY CONSUMPTION

Saddler (2013) projects that if NEM electricity consumption had continued to grow from 2005 at the same rate as it had for the previous 20 years, consumption would have been 23 per cent higher in 2013 than it was. Table 6.2 shows the range of factors Saddler identified contributing to the turnaround in electricity consumption growth in the NEM. The biggest contributor was estimated to be the suite of efficiency programs for appliances, equipment and, to a lesser extent, buildings. Structural changes in the economy—notably reduced relative share of emissions-intensive industries and major industrial closures in New South Wales—followed. The other main contributors were reduced energy consumption in response to higher energy prices, primarily by households, and rooftop solar photovoltaics.

**TABLE 6.2: CONTRIBUTION OF FACTORS TO OBSERVED REDUCTIONS OF ELECTRICITY DEMAND GROWTH IN THE NEM: 2005–06 TO 2012–13**

| FACTOR | REDUCTION (TWh) | SHARE OF REDUCTION (PER CENT) |
|---|---|---|
| Energy efficiency programs | 13.5 | 37 |
| Price effect | 5.2 | 14 |
| Reduced growth in demand from large electricity users | 5.0 | 14 |
| Major industrial closures | 3.6 | 10 |
| Rooftop PV | 2.7 | 7 |
| Increase in other embedded generation | 2.0 | 5 |
| Income effect | 1.4 | 4 |
| *Residual* | *3.6* | *10* |
| **Total** | **36.9** | **100** |

**Note:** Income effect assumes real GDP per capita after 2008 grows at 1.5 per cent per annum; totals may not add due to rounding.
**Source:** Saddler 2013, p. 59

Renewable electricity generation also increased over the period, further reducing fossil fuel generation levels.

## 6.3 EFFECT OF THE CARBON PRICING MECHANISM ON AUSTRALIA'S EMISSIONS

It is difficult to assess the impact of the carbon pricing mechanism given it has only been in place for one year. The Department of the Environment (2013, p. 12) reports that Australia's total emissions increased 1.5 per cent between 2012 and 2013, with the economy growing 2.7 per cent over the same period (ABS 2013a). Excluding LULUCF, emissions decreased 0.1 per cent over the period.[4]

In aggregate, electricity, direct combustion, fugitive and industrial process emissions (sectors covered by the carbon pricing mechanism) fell by 1.5 per cent in 2013, mostly due to a 6 per cent fall in electricity emissions. Emissions from transport, agriculture, waste and LULUCF rose by 6.5 per cent in aggregate.

4 Section 6.3 uses the June 2013 updates to the National Greenhouse Gas Inventory, released in December 2013 (Department of the Environment 2013).

At a sectoral level:

- electricity emissions declined by over 6 per cent, due to both a 2.6 per cent fall in demand in the NEM and an increased share of generation from lower emissions sources. Both black and brown coal had their lowest generation levels in more than a decade
- fugitive emissions grew by over 11 per cent due to increased production of black coal and natural gas
- direct combustion and industrial process emissions rose by about 2 and 1 per cent respectively (Department of the Environment 2013, p. 3).

Of the sectors of the economy not directly covered by the carbon pricing mechanism, transport and agriculture emissions both increased about 3 per cent, deforestation emissions increased about 12 per cent, sequestration from afforestation and reforestation decreased by about 14 per cent and waste emissions remained relatively steady (Department of the Environment 2013). Some of these sources are covered by an equivalent carbon price (for example, transport fuels used for domestic aviation and marine and rail transport); others are eligible to create offsets under the CFI (for example, agriculture, land use, and waste deposited before 2012).

A range of studies has tried to assess the impact of the carbon pricing mechanism on Australia's economy and emissions (AEMO 2012; Frontier Economics 2013; Reputex 2013). This assessment is complex because:

- The effect of the carbon pricing mechanism must be calculated relative to a counterfactual scenario, rather than year-on-year change. It is impossible to observe this alternative scenario, though modelling provides some insight. The Treasury and DIICCSRTE modelling (2013), for example, projected that Australia's emissions in 2012–13 would have been 17 Mt $CO_2$-e (2.8 per cent) higher in the absence of the carbon pricing mechanism.
- Comparing emissions over time can identify trends and, in doing so, allow the effect of measures such as the carbon pricing mechanism to be assessed. A single year's emissions data cannot establish a trend.
- Disruptions to electricity generators, such as the flooding of the Yallourn coal-fired power station in 2012, also contributed to a reduction in brown coal generation during 2013 (AEMO 2012, p. 4).
- Preparation by parties affected by the carbon pricing mechanism may have influenced emissions prior to its start. Hydroelectric generators, for example, may have withheld capacity in 2011–12 in anticipation of higher wholesale prices (Frontier Economics 2013, p. 2); this could have contributed to the 34 per cent increase in hydroelectric generation over 2012 (Department of the Environment 2013, p. 7).
- Uncertainty over the longevity of the carbon pricing mechanism may have influenced investment decisions.

## 6.4 THE FUTURE ROLE OF POLICY

Policies affecting LULUCF, discussed in Section 6.2.2, have helped offset growth in emissions across the rest of the economy. In 2012, net emissions from LULUCF were 85 per cent below 1990 levels. In future, LULUCF emission reductions may not continue to offset absolute emissions growth in the rest of the economy.

Australia's emissions reduction goals must be achieved in the context of projected ongoing growth in economic activity and population. There is growing demand for energy resource and livestock exports, as well as for domestic aviation and road transport, among other sectors. Australia's population is projected to increase by about 15 per cent between now and 2020, from approximately 23 million to 26 million people (ABS 2013b).

For the past two decades, Australia's rate of emissions intensity improvement has approximately matched the rate of growth in the economy. To achieve absolute emissions reductions, Australia requires a rate of improvement in emissions intensity that exceeds its rate of economic growth.

Australia's goals are expressed in net terms, meaning they can be met through a mix of domestic and international emissions reductions (Chapter 7). As the world takes action to reduce emissions and limit warming to 2 degrees, Australia will need to transition to a low-emissions economy to continue to be competitive.

To do this, Australia must maintain and build upon the progress made in key sectors, such as LULUCF and electricity, and realise further cost-effective emissions reductions in the remainder of the economy. The associated challenges and opportunities are outlined in Chapter 11.

## CONCLUSIONS

**C.8** Australia has made progress towards decarbonising its economy—the emissions intensity of the economy (emissions per unit of GDP) has fallen by about 50 per cent since 1990.

**C.9** The falling emissions intensity is in part due to the changing composition of the economy, away from emissions-intensive manufacturing. Policy has also played an important role, particularly in the land and electricity sectors.

# C

# AUSTRALIA'S EMISSIONS REDUCTION GOALS

Strong global action to reduce emissions and keep global warming below 2 degrees is clearly in Australia's national interest. Australia is highly exposed to climate change impacts, with significant risks to our people, environment and economy. Australia cannot solve this problem alone, but it is hard to argue for other countries to take the necessary action if Australia is not working to meet the global goal.

In Part C, the Authority recommends a set of emissions reduction goals to guide Australia's transition to a low-emissions economy and contribute to global efforts to limit global warming to less than 2 degrees. Australia needs goals that provide short-, medium- and long-term milestones; linked by a credible pathway from each to the next. Adopting a 2013–2050 emissions budget is especially important in this regard—it reveals the trade-offs between Australia's actions to 2020 and beyond. The Authority recommends:

- A minimum target for 2020 of 15 per cent below 2000 levels, plus 4 percentage points from Australia's carryover under the Kyoto Protocol, giving an effective target of 19 per cent. This target, combined with a national emissions budget of 4,193 Mt $CO_2$-e for 2013–2020, provides a clear course for short-term action.
- A trajectory range tracking to between 40 and 60 per cent below 2000 levels by 2030, and a national emissions budget for 2013–2050 of 10,100 Mt $CO_2$-e. These goals provide guidance for longer term planning, and should be periodically reviewed in light of new information.

It is important that the post-2020 goals are reviewed periodically to ensure that they remain appropriate, taking account of developments in climate science, international action to address climate change and economic factors.

Part C examines:

- the form and scope of Australia's emissions reduction goals (Chapter 7)
- Australia's fair share of the global emissions budget (Chapter 8)
- the recommendations for Australia's emissions goals to 2020 and beyond (Chapter 9)
- the costs of achieving Australia's 2020 emissions reduction target (Chapter 10).

# 7 FORM AND SCOPE OF GOALS

The Authority recommends a set of emissions reduction goals to guide Australia's transition to a low-emissions economy and contribute to global efforts to avoid dangerous climate change. The Authority takes a budget approach, which highlights the trade-offs between actions taken now and those made necessary later. These goals are designed to provide a clear course for action in the short term and guidance for planning in the medium and long term, and include points of review to respond to changing circumstances.

The recommended set of goals includes a 2020 emissions reduction target, a trajectory range from 2020 to 2030, and a national emissions budget for the period 2013 to 2050. These goals are coordinated and consistent. The short-term emissions reduction target represents Australia's next step in the strong action it needs to take to meet the long-term budget. A trajectory range in the medium term balances Australia's effort over time and allows effort to be adjusted in light of new information.

The recommended goals are consistent with international emissions accounting rules. Australia's emissions in the first Kyoto Protocol commitment period were less than its target. This means that Australia has surplus emissions units that can be used towards the 2020 target. The Authority considers that the best use of this carryover is to strengthen the 2020 target by 4 percentage points.

Australia's emissions reduction targets are net of trade. This means they can be met flexibly through a combination of domestic and international emissions reductions—any international emissions reductions Australia buys will count as reductions towards our target, but any emissions reductions sold overseas cannot be counted. Using international reductions would help Australia meet its goals cost-effectively.

Voluntary action, such as individuals and companies offsetting their emissions to become 'carbon-neutral', can achieve emissions reductions above and beyond national targets. The Authority recommends that the government continue a 'targets plus' approach, recognising voluntary action by cancelling an equivalent quantity of Kyoto units.

In developing its recommended set of goals, the Authority has considered important preliminary matters, which are outlined in this chapter:

- the case for the Authority recommending goals to 2020 and beyond
- how longer term goals should be reviewed and updated over time
- how to treat and account for different emissions reductions, including voluntary action to reduce emissions and Australia's surplus emissions rights from the 2008–2012 Kyoto Protocol period.

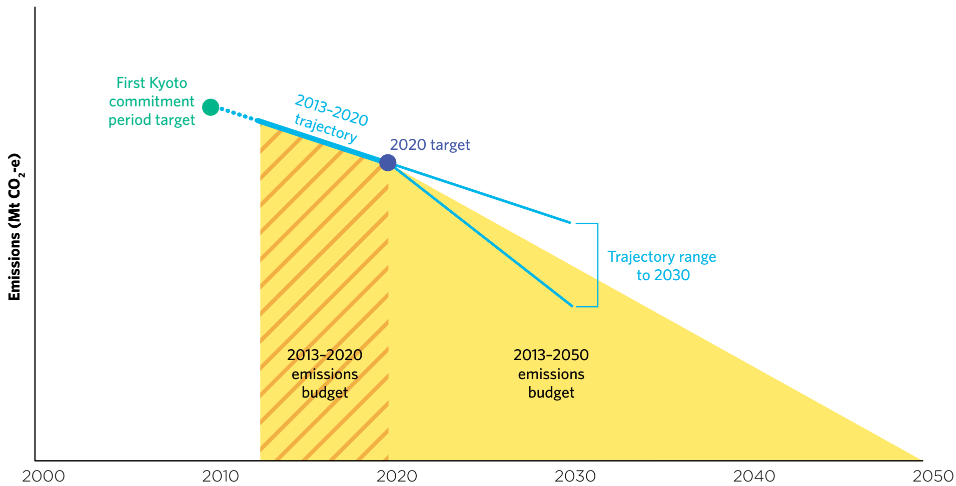
## 7.1 A COORDINATED SET OF GOALS FOR AUSTRALIA

The Clean Energy Act requires the Authority to recommend an indicative national emissions trajectory and a national emissions budget. The legislation gives the Authority discretion over the nature of and timeframe for its recommended emissions reduction goals.

Given that climate change is a long-term issue, there is value in a coordinated set of near-term and longer term goals. Near-term goals should represent a credible step towards the longer term objectives, and not leave too much of the emissions reduction effort until later; equally, too much effort in the near term could prove costly and disruptive.

The Authority is recommending a coordinated set of emissions reduction goals that give a degree of certainty in the short term to 2020, and predictability and flexibility over the medium term to 2030 and long term to 2050 (Figure 7.1).

**FIGURE 7.1:** THE AUTHORITY'S RECOMMENDED SET OF EMISSIONS REDUCTION GOALS




**Note:** Figure is illustrative only.
**Source:** Climate Change Authority

### 7.1.1 2020 GOALS

Australia has committed internationally to a target range of between 5 and 25 per cent below 2000 levels by 2020. As 2020 approaches, it is appropriate to refine the target range to a single 2020 emissions reduction target to provide a clear course for short-term action by Australian governments, businesses, communities and households.

The Authority recommends:

- a single 2020 emissions reduction target
- a trajectory to the 2020 target to indicate the pace of emissions reduction
- an emissions budget for the period 2013–2020 to provide a cumulative constraint on Australia's net emissions.

## 7.1.2 EXTENDING THE TIMEFRAME—POST-2020 GOALS

There is a compelling case for increasing the amount of guidance in Australia's post-2020 emissions reduction goals, including to:

- improve policy predictability by providing an early indication of future emissions reduction goals, which can reduce risk and costs for business
- improve environmental effectiveness by linking Australia's action more directly to a scientifically derived global emissions budget
- clarify the distribution of Australia's effort over time, and the implications of short-term goals for intergenerational equity
- inform international negotiations on the post-2020 framework, as Australia and other countries are likely to begin indicating post-2020 goals in 2014 or 2015
- increase government transparency and accountability for achieving its long-term goal.

A wide range of stakeholders expressed strong support for post-2020 goals, including businesses, non-government organisations and individuals. For example, the Energy Supply Association of Australia said:

> *… [a]s a capital-intensive industry with long-lived assets, long-term investment signals are required to enable an orderly and efficient shift to lower emissions technologies … [S]uch targets will continue to be valuable irrespective of the proposed repeal of the carbon price.* (Draft Report submission, p. 1)

The main concern raised was that these goals need to remain appropriate and relevant as circumstances change; for example, as the international response to climate change evolves. This can be achieved through periodic reviews of medium- and long-term goals to ensure new information is considered.

The Authority concludes that clear but flexible long-term guidance on Australia's emissions reductions can help create a stable, predictable environment for Australia's transition to a low-emissions future.

### RECOMMENDED POST-2020 GOALS

The Authority considers a national emissions budget to 2050 and a trajectory range from 2020 to 2030 would provide long-term guidance while maintaining flexibility to respond to new information. Combining a budget with a trajectory range capitalises on the advantages of each:

- A long-term budget to 2050 provides a direct, transparent link between Australia's emissions reduction goals and its overarching objective to limit warming to below 2 degrees. It can also increase government accountability by providing a simple measure of progress. The budget to 2050 should be subject to periodic review. The Authority's recommended budget is described in Chapter 8.
- A trajectory range to 2030 balances flexibility and predictability for medium-term policy by allowing space to adjust and respond to new information. A trajectory range to 2030 provides some guidance on the distribution of effort to 2050, can inform Australia's international commitments and signals a willingness to take stronger action under the right conditions. The Authority's recommended range is discussed in Chapter 9.

The Authority's approach incorporates many elements proposed by stakeholders in their submissions to the Issues Paper. AGL Energy proposed a long-term national emissions budget to 2050 complemented by a medium-term trajectory range for potential future caps from 2020 to 2030. Energy Australia suggested a trajectory range (also known as a gateway) could be useful to improve investor certainty and that 10 years of gateways from 2020 should be considered. Oxfam, Australian Conservation Foundation and Climate Action Network Australia were broadly aligned in support of post-2020 guidance, such as a long-term budget, interim targets and a longer term trajectory. Some stakeholders proposed medium-term targets; for example, to 2030.

Stakeholders had different views about the merits of trajectories, which may equally apply to the use of a trajectory range. Non-government organisations were broadly supportive, whereas the Business Council of Australia recommended the Authority refrain from nominating trajectories because they would inhibit Australia making the most efficient distribution of emissions reductions over time (*Draft Report submission*, p. 2). The Authority agrees that goals should provide some flexibility in the timing of emissions reduction effort. The purpose of a trajectory or trajectory range, however, is to provide broad guidance on the pace of emissions reductions over time, not to set binding limits in each year. As a result, trajectories allow efficient distribution of effort over time. That said, having recommended a long-term budget, the Authority considers a trajectory or trajectory range that stretched beyond 2030 would be unnecessarily prescriptive at this time.

As discussed further in Section 7.2, post-2020 goals must be reviewed regularly, and the reviews themselves should respond to changing circumstances in a reasonably predictable way.

**CONCLUSION**

**C.10** A coordinated set of emissions reduction goals for the short, medium and long term would provide a more predictable environment for businesses and others to act. An appropriate set of goals for Australia comprises:

- A short-term target for 2020, and an emissions budget and trajectory to 2020 providing a clear course for short-term action.
- A trajectory range to 2030 and a national emissions budget to 2050, providing guidance for longer term planning, subject to periodic review to respond to new information and changing circumstances.

### 7.1.3 DEFINING THE INDICATIVE NATIONAL EMISSIONS TRAJECTORY TO 2020 AND RANGE TO 2030

The Authority recommends straight-line indicative trajectories to the 2020 target and from the 2020 target to either end of the 2030 range (Figure 7.1).

Given that trajectories are indicative rather than binding in every year, and that the appropriate long-term path to reduce emissions is uncertain, straight lines are a sensible approach. They provide a simple pathway to defined goals, and can be subject to regular reviews to incorporate new information. Curved trajectories to 2030 would not provide significant additional guidance.

The trajectory requires a starting point. The Authority defined its recommended trajectory to 2020 in the same way Australia defined its target for the second commitment period of the Kyoto Protocol—based on a straight line from 108 per cent of 1990 emissions in 2010 to its recommended target in 2020. Appendix B discusses how the Authority's recommended 2020 goals relate to Kyoto Protocol targets.

The principal advantage of a trajectory range is that it balances flexibility and predictability. As with Australia's 2020 target, which was originally proposed as a target range rather than a single point, Australia can usefully start with a 2030 trajectory range. This could be particularly helpful for the government as it considers Australia's post-2020 international commitments. Under the UNFCCC negotiations, many countries will put forward post-2020 goals in 2014 and 2015 (Section 4.2). Australia may choose to put forward a range for 2030 now, and narrow this over time as the form and scale of international action becomes clearer. If strong global action to reduce emissions transpires, Australia could track towards the lower (more ambitious) bound of the range; if not, Australia could track towards the upper bound.

The Authority's overall approach to the trajectory range is similar to that recommended by the National Emissions Trading Taskforce (2007) and the Prime Ministerial Task Group on Emissions Trading (2007) but is applied to national emissions rather than caps in an emissions trading scheme.

The width of the trajectory range is also important—an extremely wide range provides little guidance; while an extremely narrow range provides little flexibility to respond to new information over time. The range should maintain flexibility while providing reasonable guidance on the pace of post-2020 reductions.

## 7.2 PERIODIC REVIEW OF LONGER TERM GOALS—WHAT, WHEN AND HOW

The trajectory range to 2030 and the emissions budget to 2050 should be reviewed periodically in light of new information to ensure they remain appropriate and relevant.

The Authority considers reviews of medium- and long-term goals should take place every five years, as currently provided for under the Clean Energy Act. More frequent reviews could tend to reduce, rather than improve, certainty for investors. However, major developments such as new international agreements may warrant special reviews; for example, it may be appropriate to review Australia's medium- and long-term goals in 2016 to take account of any new agreements on the post-2020 framework.

These periodic reviews should be conducted according to clear, defined criteria to help increase policy predictability. The Authority considers three factors of particular importance here:

- **Climate science**—new science that indicates the desirable global budget is smaller than previously estimated could imply stronger action by Australia. Evidence that the global budget is larger than previously estimated could imply less action.
- **The level and pace of international action on climate change**—stronger international action could imply stronger Australian action, and weaker international action could imply weaker Australian action. This criterion would take into account Australia's international obligations and undertakings. These act as a 'floor' to any future trajectories—allowing strengthening but not weakening. In the same way, Australia would not adopt a 2020 target below the bottom of its current 5–25 per cent range.

- **Economic factors**—higher than expected costs (for example, because of macroeconomic shocks or because low-emissions technologies have not developed as expected) could imply weaker action by Australia. Lower than expected costs (for example, because low-emissions technology is cheaper than expected) could imply stronger action is warranted.

Technical considerations may also be relevant. For example, developments in international accounting rules for greenhouse gas emissions could affect the scope of national goals, as discussed in Section 7.3; and changes in national and global population projections could affect the size of the national budget, as discussed in Chapter 8.

The Authority is not inclined to prescribe more specific criteria. These might appear to add clarity, but in practice may not allow decisions to be based on the best available information. For example, the very specific 2020 target conditions are a source of sometimes unproductive debate on the detail of other countries' actions rather than the overall scale and trend in global action. In combination with broad consultation and transparent decision-making, the Authority considers general criteria provide a more robust base for setting appropriate goals over time.

Periodic reviews should:

- Extend the trajectory range to maintain a similar amount of guidance over time. The recommended 2020 goals and trajectory range to 2030 provide 16 years of initial guidance. Similar guidance can be maintained by extending trajectories by five years at each five-yearly review.
- Narrow the existing trajectory range as more and better information becomes available. In truly exceptional circumstances, a review could recommend the trajectory range moves outside the previously defined range.
- Review the 2050 emissions budget and, in the longer term, extend the budget beyond 2050.

## RECOMMENDATIONS

**R.1** The trajectory range and the national budget to 2050 be reviewed at least every five years. There could be additional reviews to take account of major developments; for example, in 2016 to take account of international developments on the post-2020 framework. As part of these reviews, the trajectory range would be extended to maintain a similar period of guidance over time, and short-term targets and trajectories would be set within the existing range.

**R.2** The periodic reviews of the trajectory range and the national budget to 2050 have particular regard to the following general criteria—changes in or new information about climate science, the level and pace of international action, and economic factors.

## 7.3 DEFINING THE GOALS—WHAT IS COUNTED AND HOW?

In recommending targets, trajectories and budgets, the Authority must define which emissions are counted and how. This includes which greenhouse gases, emissions sources and sinks are counted and how international emissions reductions are used. This section sets out:

- the Authority's intended approach, taking into account Australia's international obligations and undertakings under the Kyoto Protocol and UNFCCC
- the practical implications of this approach, particularly for land sector emissions and removals, and the use of units 'carried over' from the first commitment period of the Kyoto Protocol.

### 7.3.1 GOALS SHOULD BE CONSISTENT WITH INTERNATIONAL RULES

The Authority has applied the Kyoto Protocol rules for gases, sectors, sources and markets in its recommended goals because they are the most definitive and binding set of accounting rules.

The Kyoto Protocol sets clear rules on which emissions count towards Australia's Kyoto commitments (Box 7.1). Australia must follow these rules for its current, unconditional commitment to limit average annual emissions to 99.5 per cent of 1990 levels from 2013 to 2020.

The accounting framework for post-2020 emissions reduction commitments is currently under negotiation. These discussions are still in their early stages, but are likely to build on current rules and accommodate the use of a wider range of international emissions reductions from domestic and regional schemes.

The Authority has also followed the UNFCCC and Commonwealth Government practice of accounting for emissions on a production rather than a consumption basis. Some stakeholders support a consumption approach; for example, the Australian Industry Greenhouse Network argues that production-based emissions accounting is less rigorous and distorts the measurement of Australia's efforts to reduce emissions (*Draft Report submission*, p. 6). The Authority considers that production-based emissions accounting provides an appropriate basis for Australia's goals. It focuses on emissions within Australia, over which Australia exercises direct control, and is the basis on which Australia's international commitments are calculated.

Both Australia's domestic emissions reductions and the purchase of international reductions contribute to keeping warming below 2 degrees. Australia's goals are net of trade to reflect this. If Australia's domestic emissions were above the recommended goals, these goals could still be met with purchased international reductions. Chapter 12 discusses the role of international reductions in more detail.

**BOX 7.1: KYOTO PROTOCOL ACCOUNTING FRAMEWORK**

The Kyoto Protocol provides guidance about the emissions countries must count towards their emissions reduction commitments and the units that can be used to meet a commitment. For the second commitment period, Kyoto Protocol rules count emissions:

- of seven greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexfluoride and nitrogen trifluoride)
- from the sectors and sources of energy, industrial processes, solvent and other product use, agriculture and waste
- from the land sector, including afforestation, reforestation and deforestation, and forest management; and countries have the option to elect cropland management, grazing land management and revegetation activities.

The Kyoto Protocol counts national emissions on a net basis—countries' domestic emissions are adjusted for any imports and exports of emission units. It only allows units created under the UNFCCC and the Protocol to be used to meet Protocol emissions reduction commitments. For example, this includes units generated from emissions reduction projects in developing countries under the Clean Development Mechanism but it does not include units generated from reducing deforestation in developing countries.

The government could choose to set additional goals that reach beyond its Kyoto Protocol commitment and count a broader range of international emissions reductions towards those goals. The Authority's accounting assumptions do not preclude this—its recommended targets and budgets could be adjusted to take account of the additional emissions reductions from these other sources.

## 7.3.2 EMISSIONS FROM INTERNATIONAL AVIATION AND SHIPPING

International aviation and shipping are an important and growing source of global emissions. These emissions are not included in national commitments under the UNFCCC. Instead, they are addressed through the International Civil Aviation Organization and the International Maritime Organization, respectively (see Appendix B for further information). The Authority has therefore excluded these from Australia's national targets, trajectories and budgets. To ensure they are accounted for at a global level, the Authority has deducted an allowance for emissions from international aviation and shipping from the global emissions budget before considering Australia's share of that budget (Section 8.3).

This issue should continue to be monitored over time to take account of further information and international developments. If these emissions are included in future national commitments, the national emissions budget should be adjusted accordingly.

### 7.3.3 VOLUNTARY ACTION

Most emissions reduction activities within Australia help meet national targets and Australia's international obligations and undertakings. For example, the government has a range of policies and measures including the RET and Direct Action Plan to meet its goals.

Voluntary action refers to individuals and companies offsetting their emissions to become 'carbon-neutral' and households buying GreenPower (a government-accredited program for energy retailers to purchase renewable energy on behalf of customers). Voluntary Action achieves emissions reductions additional to—that is, above and beyond—national targets.

The government has previously indicated support for voluntary action being additional to national targets (Commonwealth of Australia 2009). In 2013, Australia calculated the emissions reductions flowing from recognised voluntary action in the period 2008–10, and cancelled 2.3 million Kyoto units (CER 2013). This ensured voluntary action delivered emissions reductions beyond the minimum required by Australia's first Kyoto target.

The Authority recommends that the government continue a 'targets plus' approach to voluntary action. This can be done by tracking the emissions reductions from recognised voluntary actions and, at the end of the second commitment period, cancelling an equivalent number of Kyoto units. The Authority has, in consultation with stakeholders, identified three forms of voluntary action that should be recognised—GreenPower purchases, voluntary cancellation of domestic units (for example, Australian carbon credit units generated under the CFI) and voluntary cancellation of renewable energy certificates generated under the RET.

The Authority has also considered voluntary action in its recommended caps (see Chapter 13).

**RECOMMENDATION**

**R.3** The government recognise voluntary action by cancelling one Kyoto Protocol unit for each tonne of emissions reductions achieved in the period 2013–2020 through:

- the voluntary cancellation of domestic units,
- the voluntary cancellation of renewable energy certificates, and
- GreenPower purchases.

### 7.3.4 LAND SECTOR ACCOUNTING

In 2012, Kyoto Protocol Parties agreed to new rules for accounting for land sector emissions. These rules apply for the second commitment period. They make it mandatory for Parties to account for emissions and removals from forest management, and optional to account for emissions and removals from cropland management, grazing land management and revegetation. Australia has elected to count emissions from the optional land use activities, so the Authority has applied the same coverage for its recommended goals.

These accounting changes are expected to lead to net emissions reductions of approximately 12 Mt $CO_2$-e in 2020 (DIICCSRTE 2013). Overall, these activities are expected to provide 90 Mt of emissions reductions over the period 2013–2020 (see Appendix F5); this is equivalent to strengthening the 2020 target by 3 percentage points and makes any particular 2020 target easier to achieve.

## 7.3.5 CARRYOVER FROM THE FIRST COMMITMENT PERIOD OF THE KYOTO PROTOCOL

The Kyoto Protocol takes a budget approach to emissions reduction commitments, giving countries flexibility in meeting their targets. If emissions during a commitment period are less than the country's target, these surplus emission units can be carried forward into the next period. The Authority has therefore analysed 2020 goals and carryover on a budget basis. For example, carryover is assumed to be used towards the 2013–2020 budget, which is then converted to the corresponding 2020 target.

Australia's emissions over the first commitment period (2008–2012) averaged 104 per cent of 1990 levels, less than its 108 per cent target. As a result, Australia has an estimated 122 Mt $CO_2$-e of surplus emission units. Voluntary action during the first commitment period delivered an estimated 5 Mt of emissions reductions. This means Australia has an estimated 116 Mt $CO_2$-e to carryover.[1]

Australia has a choice of how to use this carryover:

- use to help meet its 2020 emissions reduction target
- hold in reserve as insurance and decide later which option to choose
- voluntarily cancel the extra units
- use to strengthen the 2020 target.

The Authority considered these options and their implications for environmental effectiveness, economic impacts and Australia's international influence.

If the carryover was used to help meet the existing, minimum 5 per cent 2020 target, it would reduce costs (relative to meeting the 5 per cent target without carryover) but deliver no environmental benefit, nor any positive influence on international action. Under this option, Australia's effective 2020 target would be 1 per cent below 2000 levels, as carryover is sufficient to cover the remaining 4 percentage points. Given the strengthening trend of international action, Australia's capacity to reduce emissions and revised projections that show the emissions reduction task is already smaller than previously expected (discussed in Section 10.2), the Authority does not consider this an appropriate approach.

In the context of setting caps for the carbon pricing mechanism, some stakeholders suggested the government hold the carryover as insurance for unexpected events. The Authority considered these risks and determined there is no need for this insurance (see Section 13.4).

A range of stakeholders supported voluntarily cancelling the carryover, including the Australian Conservation Foundation (*Issues Paper submission*, p. 11). This option has the environmental benefit of permanently reducing Australia's emissions by the amount of the carryover but, given very few other countries have carryover, is unlikely to have any influence internationally.

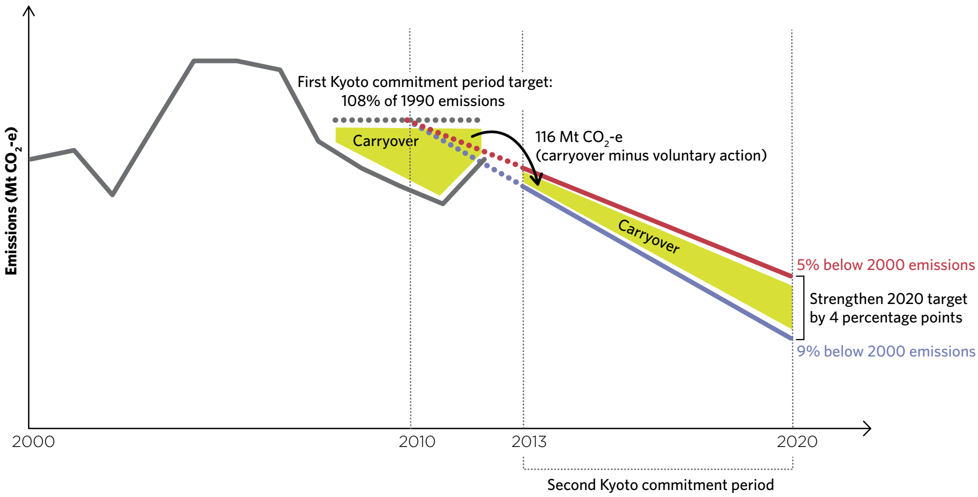
1 Figures do not add due to rounding. For more detail regarding carryover see Appendix E3.8.

Using the carryover to strengthen the 2020 target allows Australia to adopt a more ambitious target for no additional cost, compared to meeting a weaker target without carryover, as the reductions have already been made and can now be used. This has the same environmental benefit as cancelling the carryover, but is more visible internationally. As a result, it is more likely to influence other countries to strengthen their goals, maximising the potential environmental benefits. Strengthening the target by 4 percentage points is equal to an additional 122 Mt $CO_2$-e of emissions reductions; roughly equivalent to Australia's carryover (Figure 7.2).

On balance, the Authority recommends the carryover be used to strengthen Australia's target.

## FIGURE 7.2: CARRYOVER RELATIVE TO THE 2013–2020 BUDGET AND 2020 TARGET

**Note**—Trajectory and target are illustrative only




**Note:** As discussed in Section 7.1, the indicative national trajectory begins at 108 per cent of 1990 emissions in 2010 to be consistent with Australia's commitments under the Kyoto Protocol. Strengthening the 2020 target by 4 percentage points requires an additional 122 Mt $CO_2$-e of abatement over 2013–2020. This is provided by carryover plus 5 Mt $CO_2$-e of additional effort (see Chapter 10). Figures do not add due to rounding.
**Source:** Climate Change Authority

### CONCLUSION

**C.11** The best use of Australia's carryover from the first Kyoto Protocol commitment period is to strengthen the 2020 emissions reduction target.

# AUSTRALIA'S EMISSIONS BUDGET TO 2050

8

A long-term national emissions budget sets a critical constraint on Australia's emissions. It provides a simple measure of the extent to which Australia is acting consistently with the global below 2 degree goal and highlights the trade-offs between short- and long-term action. A long-term budget should be reviewed periodically to ensure it remains appropriate in light of improved information about climate science, international action and economics.

The Authority proposes a 'modified contraction and convergence' approach to calculating Australia's fair share of the global emissions budget. The approach is equitable and feasible. It involves a gradual convergence to equal-per-person emissions rights in the future. As a share of the global emissions budget, this implies a national budget of 10.1 Gt $CO_2$-e for the period 2013 to 2050. This is about 17 years of emissions at current levels and can be met through a mix of domestic and international emissions reductions.

Chapter 8 takes the global emissions budget adopted in Chapter 3 as its starting point, and considers how to share this and derive a long-term national emissions budget for Australia.

## 8.1 APPROACH TO DETERMINING AUSTRALIA'S SHARE

### 8.1.1 DEFINING GLOBAL AND AUSTRALIAN LIMITS ON EMISSIONS

Limiting global warming to below 2 degrees implies a firm constraint on global emissions. As discussed in Chapter 3, the Authority has adopted a global emissions budget that is estimated to provide at least a likely chance of limiting warming to below 2 degrees. This global budget of 1,700 Gt $CO_2$-e for the period 2000–2050 provides a starting point for considering Australia's national emissions budget to 2050.

As discussed in Chapter 7, a long-term national budget provides an important reference point for choosing short- and medium-term emissions reduction goals. If these goals were adopted without considering the long-term constraint, Australia might emit so much in the near term that it would have no budget left for later.

Deciding how much of the global emissions budget Australia should allocate itself involves thinking about what constitutes an equitable and fair share, and is necessarily a matter of judgment. The Authority has considered a range of approaches in coming to its recommendation. These approaches are informed by projections of emissions, economics and other parameters such as population growth. Given the uncertainty in these projections, the Authority recommends the budget to 2050 be reviewed every five years along with the medium-term trajectory range. As discussed in Section 3.3, the global emissions budget can also be reviewed on this timetable.

The Authority has also assessed whether adopting the national budget implied by a particular approach would help Australia play a constructive role internationally. There is no international process that assigns national targets. Rather, countries assess their own national interest, and take domestic actions and make international commitments accordingly. That said, it is clearly in Australia's interest to persuade and encourage other nations to strengthen their contributions to international action. Australia is likely to be more persuasive and encouraging if its own goals are viewed as a fair contribution by others. Similarly, Australia is likely to be more persuasive if it adopts an approach that would strengthen global efforts if it were adopted by other nations.

### 8.1.2 NET GOALS

The Authority's recommended emissions reduction goals for Australia, including the budget to 2050, are net of trade. They represent Australia's responsible contribution to global emissions reduction efforts but do not prescribe where those reductions need to occur. This is consistent with the Authority's recommendation on the use of international emissions reductions (see Chapter 12), accounting rules under the Kyoto Protocol (see Chapter 7) and likely accounting under future international agreements for the period after 2020.

## 8.2 ASSESSMENT OF AUSTRALIA'S FAIR SHARE

There are many different ways to assess the fair contribution of one country to global efforts. The Authority has considered a range of approaches:

- contraction and convergence
- modified contraction and convergence
- common but differentiated convergence
- immediate convergence
- equal proportional emissions reduction costs
- greenhouse development rights.

Of the methodologies assessed, the Authority considers that modified contraction and convergence provides a budget for Australia that is both equitable and feasible, with countries converging to equal-per-person emissions rights in 2050. The different approaches are discussed in more detail in Appendix C.

### 8.2.1 SOME APPROACHES ARE NOT FEASIBLE FOR AUSTRALIA

Some approaches imply very small national budgets and therefore unrealistically rapid emissions reductions for Australia. This includes immediate convergence (which implies a 2020 target of more than 70 per cent below 2000 levels) and greenhouse development rights (which implies a 2020 target of more than 55 per cent below 2000 levels). Both received some support in submissions. The desirability and feasibility of very deep near-term cuts depends in part on how much of Australia's emissions reductions can be sourced internationally. If there is a strong desire to undertake a large share of emissions reductions within Australia, then near-term reductions of this magnitude are probably infeasible.

Approaches such as greenhouse development rights rely on developing a long-term 'business-as-usual' trajectory to calculate national targets. These approaches create important practical problems—as more countries take more action, business-as-usual becomes increasingly abstract and difficult to estimate.

### 8.2.2 FOCUSING SOLELY ON EQUALISING COSTS HAS CONCEPTUAL AND PRACTICAL PROBLEMS

Several stakeholders said that Australia's goals should be based on costs of emissions reductions. For example, the Australian Industry Greenhouse Network stated that the Authority should focus on the 'economic burden of making emissions reductions, since such a metric more closely reflects the working reality that Australia must operate within in international negotiations' (*Draft Report submission*, p. 6).

Cost is an important consideration in setting goals and the Authority has carefully examined the cost implications of its recommended goals in Chapter 10. However, as an approach to deriving Australia's fair share of global climate action, cost-based approaches have three important conceptual and practical limitations.

First, costs are only one aspect of Australia's fair contribution to global action. Australia's capacity, responsibility and exposure to climate change are also relevant considerations. By international standards, Australia is a wealthy nation with high per person emissions relative to other countries. It is therefore fair that Australia takes on some additional costs—particularly relative to developing countries.

Second, the costs of emissions reductions—and their distribution across households and industry—depend heavily on policy design. As Chapter 10 shows, Australia can achieve strong targets at modest cost. Policies can be designed to assist households with increased costs and to moderate the impact on businesses. If countries choose to pursue more costly policies, it should not follow that their fair share of the global emissions budget increases.

Third, cost-based approaches rely on economic modelling, which is not well suited to determining the long-term equitable contribution of countries to the global emissions reduction task. While economic modelling is the best tool available for estimating costs over the short term, projections necessarily become more speculative further into the future. This is because of the wide range of assumptions embedded within models, including industrial composition, technology development and policy design across the world. This suggests that it would be difficult to identify national emissions budgets that equalised proportional costs across countries. Further, the results could be contested rather than useful, as countries would have a perverse incentive to inflate their estimated costs. These points were made by Macintosh (2013, p. 17), who concluded that economic modelling is 'too unreliable, too subjective and too vulnerable to manipulation to provide a reliable and objective basis' to set goals.

The Authority therefore considers that the costs of emissions reductions—by themselves—are not an appropriate way to determine Australia's fair share of the global emissions budget.

### 8.2.3 A BUDGET BASED ON EVENTUAL CONVERGENCE TO EQUAL-PER-PERSON EMISSIONS RIGHTS IS DESIRABLE

On balance, the Authority's view is that eventual equality in per person emissions rights is fair. This approach has received quite widespread support in Australia and among the international community, and was recommended by the 2008 Garnaut Review. Many of the submissions that discussed budget-sharing also expressed support for equal-per-person emissions.

Still, there are some notable criticisms of equal-per-person emissions approaches:

- **Perverse incentives for population growth**—some suggest that allocating national rights based on population size may make countries increase their populations to gain a larger allocation.
- **Inaccurate population projections**—errors in country level population projections 40 or 50 years ahead can be quite large.

The Authority does not find these criticisms convincing.

Regarding population growth, while national allocations increase one-for-one with population, staying within a larger budget with more people is unlikely to be much easier than staying within a smaller budget with fewer people. Moreover, emissions rights are very unlikely to be a major influence on a country's population and immigration policy.

On the accuracy of future population projections, periodic review of longer term goals can include revisions to take account of new population projections. The Authority recommends this be incorporated in the periodic review of Australia's post-2020 goals (see Chapter 7).

Two further criticisms warrant closer inspection—that equality in per person emissions:

- **Does not explicitly consider historical responsibility**—approaches that achieve equality in emissions per person start from the status quo and, as such, do not take responsibility for previous emissions into account when determining emissions reduction goals.
- **Is unfair**—allocating one good (emissions rights) without taking account of peoples' other goods or characteristics (such as income) may be unfair (Stern 2012). A more conventional public economics approach would generally result in a larger allocation to lower income nations and smaller allocations for wealthy nations like Australia.

The Authority's view is that distant past emissions should not determine a country's fair share of the future global budget—those emissions occurred when their harmful effects could not be foreseen. While the modified contraction and convergence approach does not directly account for historical emissions, it does place extra responsibilities on developed countries with high per person emissions. These countries reduce their emissions more rapidly to provide the headroom for rapidly industrialising countries.

The modified contraction and convergence approach also goes some way to dealing with the second criticism, by taking countries' level of development as well as current emissions per person into account. More broadly, the Authority is inclined to agree with Stern's suggested way forward on this issue. His approach sees rich countries fostering a transition to a low-carbon economy, both at home to drive growth and in the developing world to reduce poverty (2012, pp. 101–2).

It is in that spirit that the Authority reiterates that equity on climate change has implications beyond Australia's emissions reduction goals. Australia provides support for mitigation and adaptation to developing countries through its overseas development program; it could enhance this contribution if desired.

### 8.2.4 MODIFIED CONTRACTION AND CONVERGENCE PROVIDES AN EQUITABLE AND FEASIBLE BUDGET

Of the equal-per-person approaches, the Authority finds that modified contraction and convergence is the most equitable and feasible.

Under simple contraction and convergence, emissions rights per person contract over time in countries above the global average, and rise over time in countries below the global average, reaching a convergence level of equal-per-person rights in a specified future year. This implies too great a burden on developing countries. It implies, for example, that China's per person emissions rights would need to fall immediately. A common but differentiated convergence approach also implies very demanding emissions reduction goals for high-emitting developing countries (see Appendix C) .

In contrast, modified contraction and convergence improves equity outcomes through two modifications—fast-growing developing countries are allowed extra room to increase their emissions, and developed countries reduce emissions more quickly to provide this 'headroom' (Garnaut 2008). This is fairer than both simple contraction and convergence, and common but differentiated convergence. By allowing all countries to transition from their current position, rather than move immediately to equal rights, this approach implies strong but manageable emissions reductions for developed countries like Australia. By providing headroom rather than requiring immediate reductions, it also allows rapidly growing developing countries somewhat more time to decarbonise their economic growth. This approach provides the best basis for determining Australia's appropriate share of the global emissions budget, and gives guidance on Australia's other emissions reduction goals.

## 8.3 AUSTRALIA'S NATIONAL EMISSIONS BUDGET

The Authority's recommended national emissions budget for the period 2013–2050, based on Australia's fair share of the global budget, is 10.1 Gt $CO_2$-e. To put this in perspective, if current rates of Australian emissions were maintained, and there were no imports or exports of emissions rights, the budget would be exhausted in 17 years.

The budget is derived through a three-step calculation:

1. The 2000–2050 global emissions budget of 1,700 Gt $CO_2$-e (Chapter 3) is adjusted to remove historical global emissions from 2000–2012 (610 Gt $CO_2$-e).
2. Projected emissions from international aviation and shipping for 2013–2050 (50 Gt $CO_2$-e), are removed, as these are not allocated to any individual country (Section 7.3).
3. Australia's share of the resulting 2013–2050 global emissions budget is calculated as its share of emissions under a modified contraction and convergence approach.

Appendix C provides further details.

As discussed above, this budget is a 'net' goal—to the extent that Australia's domestic emissions exceed the budget, they must be offset by genuine emissions reductions purchased from overseas.

The Authority recommends the budget be reviewed on a regular basis, taking into account developments in climate science, international action and economic factors.

**RECOMMENDATION**

**R.4** A national carbon budget for the period 2013–2050 of 10.1 Gt $CO_2$-e.

# 9

# AUSTRALIA'S 2020 AND 2030 GOALS

The Authority considers that a 5 per cent target for 2020 is not a credible contribution to the global goal of keeping warming below 2 degrees. A 5 per cent target would leave an improbably large emissions reduction task to later; rapid reductions would be needed after 2020 to stay within the recommended long-term budget.

The Authority recommends a minimum 2020 target of 15 per cent below 2000 levels. It considers this to be the minimum consistent with the science. The Authority also recommends that Australia's carryover from the first commitment period of the Kyoto Protocol be used to strengthen Australia's target by 4 percentage points, to 19 per cent below 2000 levels. This target is challenging but achievable. It is a fair contribution to the global task, is consistent with the targets of many comparable countries, and can be achieved at manageable cost.

To 2030, the Authority recommends a trajectory range of 40 to 60 per cent below 2000 levels. This range allows Australia to step up efforts if stronger global action emerges or to moderate them if weaker global action makes more than 2 degrees of warming likely. It also maintains flexibility to respond to new information about climate science and economic developments.

In Chapter 9, the Authority recommends emissions reduction goals to 2020 and 2030 consistent with its recommended budget to 2050 (Chapter 8). It covers:

- the risks and opportunities for Australia within an increasingly emissions-constrained global economy
- the key lines of evidence from this Review to conclude that a 2020 emissions reduction target of 5 per cent is inadequate
- an emissions reduction pathway for the short and medium term (including a 2020 target and 2030 trajectory range).

The Authority makes these recommendations following analysis of the best available evidence and consultation with experts and submissions from over 12,000 members of the public. While different goals were canvassed and assessed, the Authority believes these recommendations provide a credible set of goals for Australia.

## 9.1 THE LONG-TERM BUDGET HAS IMPLICATIONS FOR SHORT-TERM ACTIONS

In this report, the Authority adopts a budget approach to emissions reduction goals for the short, medium and long term (Chapter 7). Setting a budget for emissions through to 2050 highlights the trade-offs between actions taken now and those made necessary later. The balance of effort over time has implications for the costs of reducing emissions and the risks and opportunities Australians face. Stronger action now can help:

- reduce costs and smooth Australia's transition to a low-emissions future
- preserve options and leave a manageable task for the next generation.

### 9.1.1 ACTING EARLY CAN REDUCE COSTS AND MINIMISE DISRUPTION

Early action to reduce global emissions improves the chance of staying below 2 degrees and limits the future costs of climate change (Chapter 3). Early action can also reduce the cost of mitigation efforts, both at the global and national level. While innovation is expected to drive down the costs of low-emissions technologies and open up new opportunities over time, studies of the costs and benefits of mitigation action conclude emissions reduction efforts should not be delayed.

For example, Treasury modelling (2008) suggests strong coordinated global action accelerates cost-reduction in low-emissions technologies, and helps prevent lock-in of more emissions-intensive industry and infrastructure. Delaying global action could increase the cost of achieving climate goals. In the current global context, where action is less coordinated but is gradually broadening and strengthening, the analysis suggests countries that act early could gain an advantage. Those that defer action could face higher long-term costs, as more emissions-intensive infrastructure is locked in place and investment is redirected to early movers. Creating new market opportunities for low-emissions technologies and infrastructure is already an explicit objective of policies in Europe, China and the Republic of Korea (Fankhauser et al. 2012).

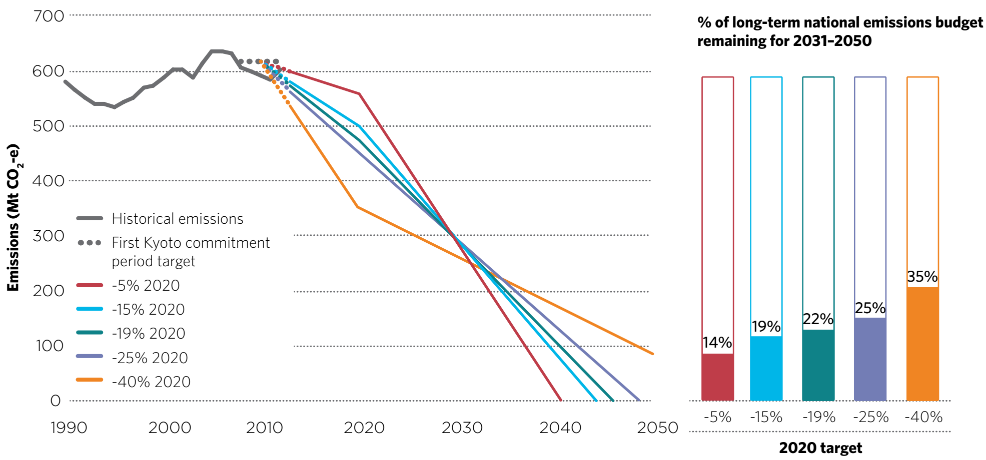
In addition to driving the domestic transition to a low-emissions economy, stronger early action can take advantage of the opportunities in international carbon markets. As discussed in Chapter 10, international emissions reductions are currently available at very low prices. If Australia used more of these low-cost international reductions to meet a stronger target now, it could save more of its emissions budget for later, when prices are likely to be much higher.

Leaving too much of the required effort until later would involve rapid cuts to stay within the recommended national emissions budget to 2050. Rapid cuts could be costly, requiring premature retirement of high-emissions assets, and involve disruptive shifts in regional economies and employment. Responsible use of the emissions budget would help Australia balance its efforts over time and minimise economic and social disruption. Long-term goals, paired with consistent short-term action, can help Australian workers, regions and industries in this transition.

Figure 9.1 shows the trade-offs between early and late action within the recommended budget to 2050. The different trajectories show that stronger action to 2020 leaves more flexibility and options in later years, while weaker short-term targets would require steep trajectories after 2020 and exhaust the budget well before 2050.

- With a 2020 reduction target of 5 per cent, Australia would need to almost halve its emissions in the decade to 2030, and have only 14 per cent of the budget left for the next two decades. A 10 per cent target implies a similarly rapid acceleration of effort beyond 2020.
- A 15 per cent target would still require an acceleration of effort beyond 2020, but with carryover used to strengthen the target to 19 per cent, this option retains 22 per cent of the national budget for the two decades after 2030.
- A 25 per cent target would retain more of the budget for later, but represents a steeper jump from Australia's current position.

**FIGURE 9.1: RELATIONSHIPS BETWEEN 2020 TARGETS, 2030 TRAJECTORIES AND NATIONAL EMISSIONS BUDGETS**




**Source:** Climate Change Authority; historical emissions from Treasury and DIICCSRTE 2013

Stronger early action also preserves Australia's options and flexibility to respond to new information. For example, if new climate science indicates the impacts of climate change are worse than currently understood, it may be appropriate to tighten Australia's emissions budget. Using too much of the budget early closes off this possibility. In contrast, if new science indicates the budget can be relaxed, using less of the budget now does not foreclose options to moderate efforts later. This is also true at the global level—delaying action too far into the future could make it impossible to avoid the worst impacts of climate change, as some impacts become irreversible beyond certain warming thresholds (Rogelj et al. 2013, p. 81).

## 9.2 WHY 5 PER CENT BY 2020 IS NOT ENOUGH

Australia should adopt a stronger 2020 target than 5 per cent. This conclusion is based on all of the evidence considered in this Review.

First, **a 5 per cent target is inconsistent with Australia's fair contribution to the long-term global goal to limit warming to below 2 degrees**. A 5 per cent target would result in Australia using almost all of the recommended national emissions budget in fewer than half of the years it is intended to cover. It would leave an improbably large task for future Australians to make a fair contribution to keeping warming below 2 degrees.

Second, **a 5 per cent target does not keep pace with actions taken by many other countries**. A 5 per cent target compares poorly with the targets of the United States and many other neighbours and trading partners. Of the countries examined (Chapter 4), some have targets less ambitious than Australia's 5 per cent, but they are much poorer than Australia, with lower levels of development and less governance capacity. The Authority considers that Australia's high level of development and high per person emissions justify stronger action.

Third, while Australia's emissions reduction task remains challenging, **adopting stronger targets is easier than previously thought**. Official projections in 2012 suggested Australia would need to cut its emissions by 155 Mt in 2020 and 754 Mt over the period 2013 to 2020 to achieve the unconditional 5 per cent target (DCCEE 2012). The latest projections suggest 131 Mt of emissions reductions in 2020 and 593 Mt over the period 2013 to 2020 are required (Chapter 10). If Australia was to reduce emissions by 754 Mt over the period to 2020, it would now reach an 11 per cent target.

In addition, Australia has an estimated 116 Mt of emissions rights to carry forward from the first commitment period of the Kyoto Protocol. This carryover is sufficient to strengthen Australia's 2020 target by 4 percentage points (Chapter 7). If this carryover was instead used to meet the minimum 5 per cent target, Australia would effectively only have to reduce emissions to 1 per cent below 2000 levels by 2020.

The Authority has also examined the government's target conditions for moving beyond 5 per cent and concludes they have been met (Chapter 4). There has been significant international action since the conditions were set, with commitments by all major emitting economies to emissions reduction goals. The government conditions focus on action and do not require a binding international agreement.

Overall, a 2020 emissions reduction target stronger than 5 per cent is responsible and feasible. A stronger 2020 target would preserve Australia's options and make a fair contribution to global action to limit warming to 2 degrees or less.

## 9.3 RECOMMENDED 2020 GOALS

### 9.3.1 NATIONAL EMISSIONS REDUCTION TARGET

The Authority **recommends a minimum emissions reduction target for 2020 of 15 per cent** below 2000 levels.

It also recommends that Australia's **carryover from the first Kyoto Protocol commitment period be used to raise the target by 4 percentage points,** to 19 per cent below 2000 levels.

This target is a responsible contribution to global efforts and is achievable for Australia.

**Australia stands to benefit from global efforts to keep warming below 2 degrees**. The conclusions of science are clear—the likely impacts of climate change on Australia, including its natural environment, people and economy, are very serious. Even at 2 degrees of global warming, adverse impacts will be felt in Australia and around the world.

Keeping warming below 2 degrees is a substantial challenge, requiring an acceleration of global effort to 2020 and beyond. For Australia, it requires a constraint on emissions over the long term—the budget to 2050—and a significant acceleration of effort compared to the past. The Authority considers a **15 per cent reduction by 2020 is the minimum required to be consistent with the recommended long-term budget**. Adding carryover capitalises on Australia's progress to date and saves more of the national budget for the future.

**The recommended target is in line with the actions of other countries.** The Authority's analysis shows 2020 targets in the range of 15–25 per cent are consistent with the targets of many comparable countries. Australia's high level of development and high per person emissions relative to most other countries suggest a stronger target than 5 per cent is appropriate. Adopting a stronger national target at this crucial time, when the international community is reviewing the level of global action to 2020 and beyond, may have some positive influence on other countries' level of action.

**The recommended target can be achieved at manageable cost, depending on the policies used** (Chapter 10). Under current legislative arrangements, which provide a useful benchmark, meeting a target of 15 per cent is projected to have marginal impacts on the economy. Annual growth in average income per person is projected to slow by 0.02 per cent compared to meeting the unconditional 5 per cent target, growing from $62,350 in 2012 to $66,350 in 2020—about $100 less than it would be if Australia pursued a 5 per cent target. The shortfall in growth could be made up in three months. Australia's carryover can strengthen the 2020 target by 4 percentage points for effectively no additional cost. The government intends to use new policies to pursue the 5 per cent target, which will have different impacts to those modelled and the issue of costs will need to be revisited when the policies are finalised. The incremental costs of moving to a stronger target, however, will be comparable so long as international reductions are used to pursue it. Further, these cost estimates assume a carbon price rising to just over $30 per tonne in 2020. Australia has access to credible international emissions reductions at much lower prices; if Australia purchased these instead, the costs could be even lower.

**Any Australian action to reduce emissions is starting from a solid base, with the prospect of greater reductions to come.** The emissions intensity of the Australian economy has halved since 1990—while the economy and Australian population have grown steadily, emissions have remained relatively flat. Australia's emissions were below its 2008–2012 Kyoto Protocol commitment, and it is making progress towards the 5 per cent unconditional target. The recommended target would help maintain the momentum in Australia's move towards a low-emissions economy and prepare for further acceleration of effort in future decades. The Authority's analysis identifies substantial, low- to medium-cost emissions reduction opportunities across all industry sectors, which could be mobilised by targeted, sustained policies.

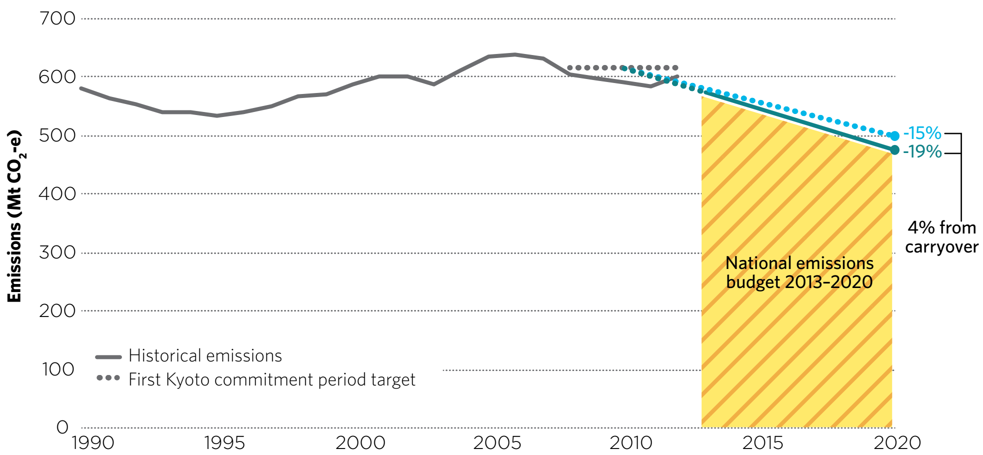
**International emissions reductions can complement domestic efforts,** providing a cost-effective and environmentally sound way to help meet the recommended goals. The Authority believes that Australia should not delay its domestic transition, but particularly in the period to 2020, Australia should use a mix of domestic and international reductions. In particular, the Authority recommends that international emissions reductions be used to bridge any gap between domestic reductions and the recommended 2020 target (Chapter 12).

If the global trend towards stronger action on climate change is sustained, Australia will need to do more to transition away from its high-emissions economy. The Authority's recommendations would help Australia to remain competitive in an increasingly emissions-constrained global economy.

## 9.3.2 NATIONAL EMISSIONS TRAJECTORY AND BUDGET

As discussed in Chapter 7, the Authority recommends a simple straight-line trajectory to 2020. This trajectory tracks from Australia's target under the first commitment period of the Kyoto Protocol to the recommended target in 2020. This trajectory corresponds to a national emissions budget of 4,193 Mt $CO_2$-e for the period 2013 to 2020. Figure 9.2 illustrates the recommended emissions reductions goals to 2020.

**FIGURE 9.2:** RECOMMENDED 2020 GOALS FOR AUSTRALIA




**Source:** Climate Change Authority

Even with a target of 15 per cent plus carryover in 2020, emissions reductions would need to accelerate after 2020 if Australia was to stay on track to meet the Authority's recommended budget to 2050. The next section describes the Authority's recommendations for the medium term.

### RECOMMENDATIONS

**R.5** A minimum 2020 emissions reduction target of 15 per cent below 2000 levels.

**R.6** Australia's carryover from the first commitment period of the Kyoto Protocol be used to raise the 2020 emissions reduction target by 4 percentage points, giving a 2020 target of 19 per cent.

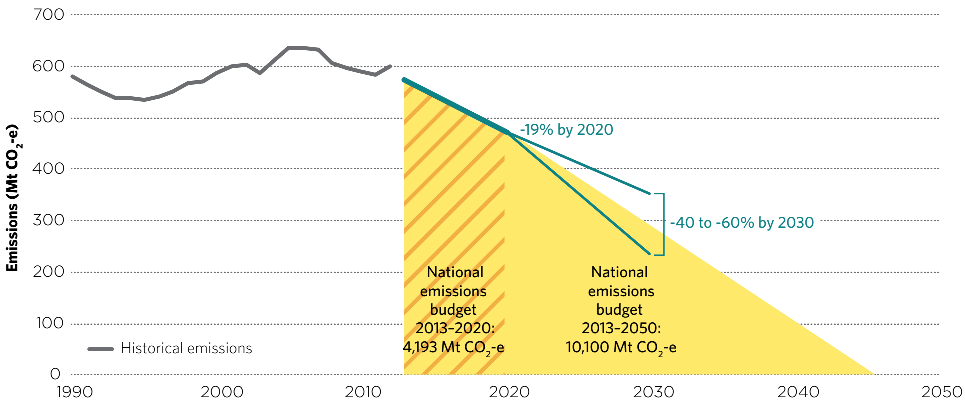
**R.7** An indicative national trajectory for the period 2013–2020 that follows a straight line to the 2020 target. This line starts at Australia's first commitment period target under the Kyoto Protocol (108 per cent of 1990 levels) in 2010, and ends at 19 per cent below 2000 levels in 2020.

**R.8** A national carbon budget for the period 2013–2020 of 4,193 Mt $CO_2$-e.

## 9.4 GUIDANCE BEYOND 2020—RECOMMENDED 2030 GOALS

The Authority recommends a trajectory range to 2030 of 40 to 60 per cent below 2000 levels as guidance for future targets. Figure 9.3 illustrates the recommended trajectory range in the context of the full set of goals.

**FIGURE 9.3:** RECOMMENDED GOALS FOR AUSTRALIA




**Note:** Assumes both the Authority's 2020 target recommendations are accepted—a 15 per cent target plus an additional 4 percentage points from carryover—giving an effective target of 19 per cent.
**Source:** Climate Change Authority

The Authority's twin objectives in recommending a medium-term trajectory range (Chapter 7) are to:

- provide guidance, based on the best available evidence, on the action likely to be required in the medium term to make a fair contribution to global efforts to meet the below 2 degree goal
- retain flexibility to adjust national goals over time in light of developments in climate science, international action and economic factors.

The recommended long-term budget is a key consideration in setting the 2030 trajectory range. As set out in Chapter 8, to determine Australia's national budget the Authority started with a global budget that is projected to give a likely chance of achieving the below 2 degree goal. Staying within this global budget will be challenging, but remains achievable. A straight-line trajectory from the Authority's 2020 target recommendations (15 per cent plus carryover) suggests a 50 per cent reduction in 2030 and zero net emissions by 2046, when the recommended national budget would be exhausted.

The recommended trajectory range provides the flexibility to strengthen or moderate Australia's efforts as new information emerges. Developments in climate science, international action and economic factors will have implications for Australia's appropriate long-term budget and interim goals. For example, international efforts may not accelerate at the rate required to retain a likely chance of staying below 2 degrees. New low-emission technologies may be slow to develop or prove more costly to deploy. On the other hand, climate science may further strengthen, and the additional risks precipitate much stronger international action and more ambitious global goals. It is not possible to know, today, which of these possible futures will eventuate, so flexibility in medium-term guidance is important.

The Authority's recommended 2030 trajectory range provides this flexibility:

- The upper (weaker) bound of the trajectory range tracks to 40 per cent below 2000 levels in 2030. This could be appropriate if, for example, Australia was contributing to global action to limit warming to no more than 3 degrees, or a lower (50 per cent) chance of less than 2 degrees.
- The lower (stronger) bound of the trajectory range tracks to 60 per cent below 2000 levels in 2030. This could be appropriate if, for example, Australia was contributing to global action to limit warming to no more than 1.5 degrees, or a higher (75 per cent) chance of less than 2 degrees.

In this way, the recommended range takes account of different stakeholder views on which global emissions budget provides the best guidance for Australia. Some advocate smaller budgets, arguing that keeping warming below 1.5 degrees is necessary to avoid dangerous climate change. Others contend that a 2 degree temperature limit is no longer realistic given the scale and pace of international action, and budgets consistent with higher temperatures should be considered. Appendix C3 discusses this matter further.

The Authority's recommended trajectory range of 40 to 60 per cent is consistent with global analysis. Höhne et al. (2014) looked at over 40 studies that reviewed fair shares of global emissions reduction efforts and considered their implications for national 2030 targets. They found that to stabilise at 450 ppm $CO_2$-e (which gives a roughly even chance of staying below 2 degrees), OECD nations, including Australia, would need to reduce emissions by approximately 50 per cent from 2010 levels, within a range of 37 to 75 per cent.

As discussed in Chapter 7, the Authority recommends that the trajectory range be reviewed periodically along with the long-term emissions budget to ensure that they remain appropriate.

**RECOMMENDATION**

**R.9** Beyond 2020, Australia continue to reduce emissions within a trajectory range bounded by the paths to 40 and 60 per cent below 2000 levels in 2030.

# 10 ECONOMIC IMPLICATIONS OF AUSTRALIA'S EMISSIONS REDUCTION GOALS

Australia can achieve the Authority's recommended 2020 target of 15 per cent plus carryover at a manageable cost.

Australia faces a substantial but achievable emissions reduction task to 2020. Emissions are projected to grow to 17 per cent above 2000 levels in the absence of a carbon price or new policies. This is less than the previous projection of 22 per cent above 2000 levels, making any emissions reduction target somewhat easier to achieve than previously expected.

The costs of achieving the recommended target, and the distribution of those costs across industries and households, depend heavily on the policies used to pursue it. At this time, the government is still developing the details of the Direct Action Plan to reduce Australia's emissions. The Authority has not speculated on the design; instead it has assessed the potential economic costs under the current carbon pricing legislation. This provides a useful benchmark.

The Authority's analysis shows Australia can achieve the recommended 2020 target while national income and the economy continue to grow.

Under the current legislation, gross national income (GNI) per person is projected to grow by an average of 0.80 per cent annually over the period to 2020 if Australia pursues a 5 per cent target, and by 0.78 per cent with a target of 15 per cent plus carryover.

In dollar terms, GNI per person is projected to grow from about $62,350 in 2012 to $66,450 in 2020 with a 5 per cent target, or to $66,350 with a target of 15 per cent plus carryover (all in real terms).

This means if Australia adopted the recommended target, GNI per person could reach the same level it would have attained with a 5 per cent target, less than three months later. These costs would be broadly distributed across the economy; under the current legislation, moving to a stronger target is not projected to have a material impact on the compliance costs faced by business and the costs passed through to consumers.

One reason why the incremental cost of moving to a stronger target is so low is that the current legislation allows a mix of domestic and international reductions to be used to meet the target. Australia could meet the whole of the incremental emissions reduction task associated with moving from 5 per cent to the recommended target through the carryover and the use of additional international emissions reductions. The cost of achieving a 19 per cent target with carryover is essentially the same as the cost of achieving a 15 per cent target without it.

The level and distribution of costs will need to be revisited when the government finalises its policies. The incremental costs of moving to a stronger target than 5 per cent would, however, be comparable to the costs presented here so long as the stronger target was achieved through the use of international emissions reductions. Further, substantial genuine international emissions reductions are available at much lower prices than the carbon prices assumed in the Authority's analysis. If Australia purchases these lower cost reductions, it could achieve the recommended 2020 target at lower cost.

Chapter 10 examines the economic implications of achieving the Authority's recommended 2020 goals. It covers:

- the scale of Australia's emissions reduction task to 2020
- how the economy might change if Australia moved beyond 5 per cent to a stronger target
- how costs are affected by the mix of domestic and international emissions reductions used to meet the target
- the longer term economic implications of 2020 targets.

## 10.1 EXAMINING THE ECONOMIC IMPLICATIONS OF DIFFERENT 2020 TARGETS

Australia's emissions reduction goals set the overall scale of its contribution to global action on climate change and the pace of its transformation to a low-emissions economy.

Extensive analysis (such as Treasury 2011; Garnaut 2008), and Australia's own experience over the past two decades, shows it is possible to reduce emissions, grow the economy and improve wellbeing at the same time. Since 1990, the size of the Australian economy has approximately doubled, while emissions have remained relatively stable. This means the emissions intensity of the economy (emissions per dollar of GDP) has halved (Chapter 6).

Chapter 10 focuses on the cost of achieving different 2020 targets. It examines Australia's emissions trends in the absence of a carbon price or new policies to understand the scale of the emissions reduction task and the broad economic implications of achieving different targets. The 5 per cent target is a minimum unconditional commitment, so Australia's real choice is whether to stay with this or adopt a stronger 2020 target. The 5 per cent target therefore provides an appropriate baseline for assessing the potential incremental cost of pursuing stronger targets.

### 10.1.1 USING MODELS TO ESTIMATE AUSTRALIA'S EMISSIONS AND ECONOMIC OUTLOOK

The Authority has used economic modelling to help assess the economic implications of its recommended target. The modelling explores Australia's emissions trends, emissions reduction opportunities and economic outlook in the context of the global action required to reduce the risks of climate change. The modelling was conducted by Treasury and DIICCSRTE, in consultation with the Authority (referred to as Treasury and DIICCSRTE modelling).

Economic models are useful tools for exploring the impacts of climate change mitigation policies, as they ensure internally consistent long-term projections of economic activity and the resulting greenhouse gas emissions. While these models have their limitations, they integrate, in a comprehensive manner, economic and other data with economic theory about how the world responds to changing circumstances.

Treasury and DIICCSRTE modelling uses a suite of global, national and sectoral models. The detailed models for the electricity, transport and agriculture sectors provide granular analysis of the industrial sectors responsible for the majority of Australia's emissions, while the economy-wide models capture the longer term reallocation of resources. This approach is the most useful and appropriate framework currently available to assess the market costs of climate change mitigation in Australia. It builds on previous work to define Australia's goals and inform the design of Australia's policies (Garnaut 2008; Treasury 2011).

Further information on the modelling approach and assumptions is provided in the Treasury and DIICCSRTE modelling report (2013).

The analysis presented in Chapter 10 is limited to the costs of reducing emissions. As discussed in Chapter 2, the Authority understands the importance of considering the benefits of action in parallel with these costs. Its recommendations are guided by its analysis of both.

### 10.1.2 WHAT SCENARIOS HAVE BEEN MODELLED?

The Treasury and DIICCSRTE modelling examines a range of future scenarios to gauge Australia's potential economic and emissions outlook (see Box 10.1). The modelling makes assumptions about the future, including about the global economy, technology development, commodity prices and policy settings. These assumptions affect the identified emissions reduction opportunities and the estimated costs. The assumptions draw on international and Australian analysis, expert advice and public consultation as set out in detail in the modelling report.

Assumptions about policy settings are especially challenging, as Australia's climate policy is currently being revised. The government intends to repeal the carbon pricing mechanism and implement the Direct Action Plan. The details of this Plan, including the design of the Emissions Reduction Fund, are still being developed (Chapter 5). Key issues that are yet to be resolved include the form and level of baselines—both for crediting emissions reductions and for any penalties—and the policy settings for the electricity sector (DoE 2013). Rather than speculate on the design, the modelling is based on the current legislative settings. It uses high, medium and low carbon price scenarios; a scenario without the carbon price; and a number of sensitivity scenarios to explore the potential economic impacts of achieving different targets.

Even if the policy settings change, the modelling is informative because it estimates:

- The scale of the emissions reduction task to 2020 for the minimum 5 per cent target and the stronger targets being considered. The 'no price' scenario provides the basis for this estimate—it projects Australia's emissions with existing policies such as the RET and energy efficiency standards but excludes the carbon price and any new policies.

- The incremental cost of moving to stronger emissions reduction targets. The modelling shows that stronger targets are achievable while maintaining economic growth. Though the modelling reflects a different policy framework to that planned by the government, the costs provide a useful benchmark. Further, the incremental costs of moving to a stronger target would be broadly the same under new policy settings if the additional reductions were achieved through the purchase of international emissions reduction units.
- The emissions reduction opportunities that might be available in the Australian economy at different incentive (price) levels, and the associated economy-wide costs. The modelling shows Australia has substantial emissions reduction opportunities across all sectors. While the results show the opportunities likely to be mobilised by the carbon price, many of these could also be mobilised by other policies and incentives.

A key caveat on translating the modelling results to different policy settings is that the distributional effects for industry and households are highly sensitive to policy design. The level and distribution of costs will need to be revisited once the government settles the details of the Direct Action Plan.

### BOX 10.1: CARBON PRICE SCENARIOS IN THE MODELLING

Treasury and DIICCSRTE modelling examines four core scenarios—one without a carbon price and three with different carbon prices.

The three price scenarios are largely based on the current legislation. Companies covered by the carbon pricing mechanism ('liable entities') have to pay for their emissions by surrendering emission units for each tonne of their emissions. The annual emissions cap determines the supply of Australian carbon units (ACUs). Liable entities can also use eligible international units, such as European Union allowances (EUAs), to meet up to a total of 50 per cent of their liability; this includes a 12.5 per cent sublimit on Kyoto Protocol units such as Certified Emission Reductions (CERs). Emissions-intensive, trade-exposed industries receive some free emissions units, and sectors such as agriculture and forestry can generate carbon offsets through the CFI.

The most important variable affecting emission levels is the price of ACUs (the carbon price). Given the links to international markets, the ACU price is assumed to follow the EUA price. The EUA price outlook is uncertain and market forecasts vary. The scenarios therefore span a plausible range, taking account of current market conditions, forecasts and long-term environmental goals.

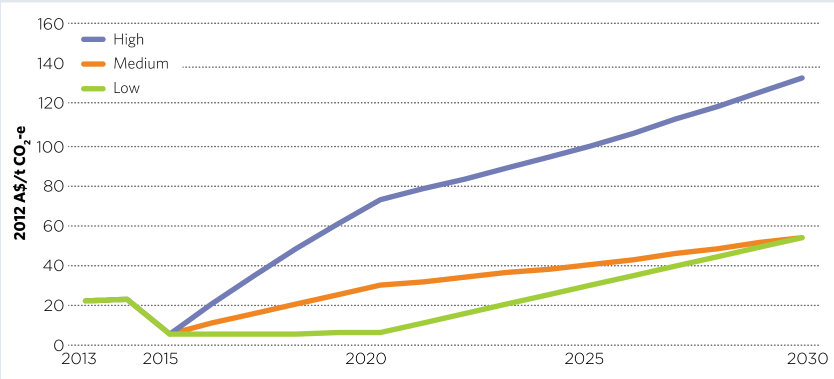
The four scenarios used in this chapter are:

- **No price scenario**—assumes there is no carbon price and no CFI. This scenario includes emissions reductions from pre-existing measures such as energy efficiency measures and the RET.
- **Low scenario**—additionally assumes the carbon price and CFI are in place. The carbon price is fixed for two years, then moves to a flexible price. The flexible price begins at $5.49 /t $CO_2$-e in 2015, and grows at 4 per cent per year in real terms to reach $6.31 in 2020. The price then follows a linear transition to $54.48 in 2030.[1]

1 All dollar amounts (prices and costs) reported in this chapter are 2012 Australian dollars, unless otherwise stated.

- **Medium scenario**—assumes the fixed price for two years, then a flexible price beginning at $5.49/t $CO_2$-e in 2015, and following a linear transition to $30.14 in 2020. From 2021 onward, the price follows the international price from the medium global action scenario, which grows at 4 per cent per year in real terms in US dollars.
- **High scenario**—assumes the fixed price for two years, then a flexible price beginning at $5.49/t $CO_2$-e in 2015, and following a linear transition to $73.44 in 2020. From 2021 onward, the price follows the international price from the ambitious global action scenario, which grows at 4 per cent per year in real terms in US dollars.

**FIGURE 10.1:** ACU PRICES FOR DIFFERENT SCENARIOS, 2013–2030




**Source:** Treasury and DIICCSRTE 2013

Kyoto units such as CERs currently trade at prices well below the prices used in these scenarios, and the modelling assumes there is a price difference between CERs and ACUs for the period to 2020. As a result, liable entities face an effective carbon price below the ACU price; this effective price is a weighted average of the ACU and CER price each year, with weights reflecting the CER sub-limit.

The Authority notes that some assumptions in the modelled scenarios differ from the current legislation; for example, the legislation provides for a three-year fixed price. Sensitivity analysis indicated the differences have only a small impact on emissions and costs. The Authority therefore uses the modelled scenarios for its analysis of the potential economic impacts in this chapter.

## 10.2 AUSTRALIA'S EMISSIONS REDUCTION TASK TO 2020

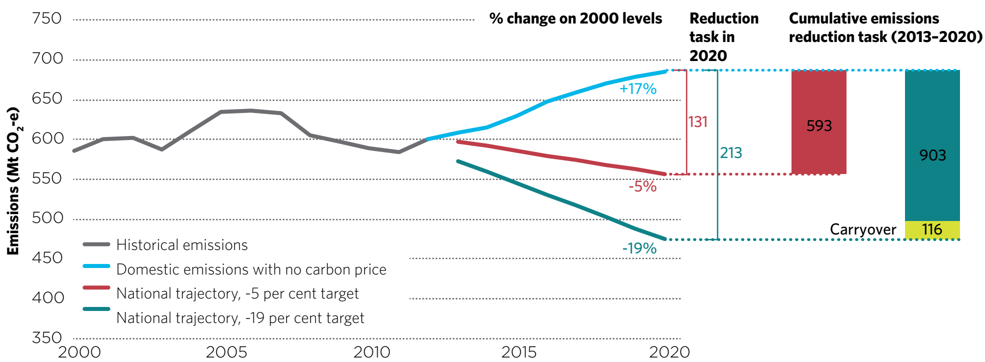
To assess the costs of achieving emissions reduction goals, we need to understand the scale of the task. The Authority has assessed the emissions outlook for Australia, taking into account existing policies such as the RET and energy efficiency programs, but excluding the carbon price and CFI. Figure 10.2 shows the national emissions reduction task—that is, the level of additional emissions reductions that Australia's climate change policies will need to achieve to meet different 2020 targets.

In the no price scenario, Australia's emissions are projected to grow to 17 per cent above 2000 levels by 2020. Australia's international commitments relate to the period 2013 to 2020, so it needs to reduce net emissions over the period to 2020. The cumulative emissions reduction task is estimated to be 593 Mt to achieve an emissions budget consistent with a 5 per cent target (131 Mt in 2020 alone) and 898 Mt for a 15 per cent target.

Adding carryover to give a 2020 target of 19 per cent gives a cumulative abatement task of 1,020 Mt. The increment beyond 15 per cent (122 Mt) is almost matched by carryover itself (116 Mt), so minimal extra effort is required (Figure 10.2).

These estimates assume the RET remains at the currently legislated level of 41,000 GWh in 2020; if reduced, the emissions reduction task would be greater.

**FIGURE 10.2:** AUSTRALIA'S EMISSIONS REDUCTION TASK TO 2020




**Notes:** Emissions reduction task is in Mt $CO_2$-e. Figures may not add due to rounding. Emissions reduction task has been adjusted (increased) to account for voluntary action (see Appendix E for estimates). Assumes both the Authority's 2020 target recommendations are accepted (minimum 15 per cent plus carryover giving 19 per cent).

**Source:** Climate Change Authority based on Treasury and DIICCSRTE 2013

The national emissions reduction task to 2020 is substantial, but smaller than previous estimates. This reflects updates to historical emissions data, a lower outlook for electricity demand and lower rates of underlying growth in some emissions-intensive industries. It also reflects changes to the emissions accounting rules under the second commitment period of the Kyoto Protocol; these allow Australia to count more land sector activities towards its target (discussed in Chapter 7).

The smaller emissions reduction task makes it easier for Australia to pursue any particular target. For example, national emissions projections in 2012 suggested that Australia would need to cut emissions by 754 Mt over the period 2013 to 2020, including by 155 Mt in 2020, to achieve the minimum 5 per cent target (DCCEE 2012). The current estimate suggests less effort is now required to reach this target. Instead, if Australia achieved 754 Mt of reductions over the period to 2020, the latest projections suggest it would now reach an 11 per cent reduction target. Adding Australia's carryover from the first commitment period of the Kyoto Protocol would increase this to a 15 per cent target.

The Authority's abatement task estimate for a 5 per cent target is higher than the estimate in the most recent national emissions projections (DoE 2013) due to different treatment of the carbon price, carryover and voluntary action (see Box 10.2).

### BOX 10.2: DIFFERENT ESTIMATES OF THE EMISSIONS REDUCTION TASK TO 2020

In December 2013, the government published the most recent national emissions projections (DoE 2013). These projections are based on the modelling conducted for this Review.

The projections report discusses Australia's emissions reduction task to 2020 for the minimum 5 per cent target. It estimates the task to be 431 Mt, lower than the Authority's estimate of 593 Mt. Three factors account for the difference:

- **Impact of the carbon price**—the government's estimate takes account of the impact of the first two years of the carbon price (2013 and 2014); the Authority's estimate does not. This reduces the government's estimate by 39 Mt.
- **Treatment of carryover**—the government's estimate assumes all surplus emission rights from the first commitment period of the Kyoto Protocol (an estimated 122 Mt) are used to meet the 5 per cent target; the Authority's estimate does not. This reduces the government's estimate by 122 Mt.
- **Treatment of voluntary action**—the government and the Authority both make an adjustment to recognise voluntary action over the period 2013–2020. The government's adjustment is based on projected GreenPower purchases only; the Authority's adjustment includes GreenPower and the voluntary cancellation of renewable energy certificates. This increases the Authority's estimate by 2 Mt.

### CONCLUSION

**C.12** Australia's emissions reduction task for 2013 to 2020 is projected to be 593 Mt for the minimum 5 per cent target. This is substantial but achievable, and smaller than the 754 Mt task previously projected. If Australia reduced emissions by 754 Mt over the period to 2020, it would now reach an 11 per cent target.

## 10.3 COSTS OF MOVING BEYOND 5 PER CENT TO A STRONGER TARGET

This section examines the incremental cost of moving from the minimum 5 per cent target to the Authority's recommended target.

The Authority recognises that the costs, and distribution of those costs, will depend on the policy implemented to achieve the targets. The Authority has assessed costs based on the current legislative settings; this provides a useful benchmark. The current legislation allows a mix of domestic and international emissions reductions to achieve the target. Emissions are reduced within Australia where the marginal cost of achieving the reduction is less than or equal to the international carbon price. Section 10.4 examines the costs of achieving a greater share of the emissions reductions domestically.

### 10.3.1 HOW COSTS ARISE

Under the current legislation, liable entities pay a price—the carbon price—for their emissions. This increases the cost of emitting activities and drives a shift in the economy from higher emitting to lower emitting activities.

Australia's carbon market is linked to the much larger international market. As a result, the level of the carbon price is largely determined by international markets rather than the level of Australia's own target. Moving to a stronger target would drive additional emissions reductions—contributing to stronger global climate action—but those reductions would largely occur overseas rather than within Australia.

As a result, moving to a stronger target is not expected to materially change the carbon price, and is not expected to have a material impact on the compliance costs faced by liable entities and the carbon costs passed through to consumers (see Section 10.3.4).

Nevertheless, a stronger target would have an impact on the Australian economy. It would reduce the number of Australian carbon units available for the government to sell and increase the number of international units imported. This is expected to have three broad economic effects on GNI:

- A direct income transfer from Australia to buy additional emissions units from overseas.
- A smaller indirect cost from the changes in the terms of trade due to this income transfer (the 'terms of trade effect'). This arises because direct income transfer affects the balance of payments—exports would have to be slightly higher to generate the additional foreign currency, entailing slightly lower export prices, which would tend to reduce the terms of trade.
- A smaller indirect cost associated with replacing the government revenue forgone from sales of Australian carbon units (the 'revenue effect'). To maintain the same level of government services, the forgone revenue would need to be replaced; this would typically involve an additional welfare cost reflecting the marginal excess burden of raising government revenue.

GNI is a broader measure of economic welfare than the more commonly used GDP. While GDP measures the total output of the Australian economy, GNI measures output, international income transfers and the impacts on the terms of trade. GNI provides a more complete measure of Australians' current and future consumption possibilities—what they can afford to buy.

The size of the direct income transfer would be equal to the number of additional international emissions reductions purchased from overseas to meet the stronger target, multiplied by the international carbon price. This income transfer would be small compared to the routine income flows associated with commodity trade, foreign investment and other factors.

The combined impact of these three effects on GNI is estimated to be 1.55 times the direct cost of the additional international units (Treasury and DIICCSRTE 2013). For example, if changing the target requires an additional $100 of international emissions reductions, GNI is reduced by $155, comprising:

- $100 more emissions units bought from overseas—a direct income transfer
- $30 through the terms of trade effect
- $25 due to the revenue effect.

The same costs would arise whether the government purchased international units directly or liable entities purchased international units under the carbon pricing mechanism. The only difference would be that, instead of replacing auction revenue, the revenue effect would arise from raising funds to purchase the additional international units.

The distributional impacts of the income transfer and terms of trade effect are relatively small and would be broadly spread across the economy. The modelling results suggest the lower terms of trade would support growth in export-oriented and import-competing industries, such as agriculture, mining and manufacturing. On the other hand, more domestically focused industries, such as construction and services, would grow more slowly. The projected impact is relatively small; changes in sector output levels in 2020 are less than 0.4 of a percentage point (Treasury and DIICCSRTE 2013, p. 86).

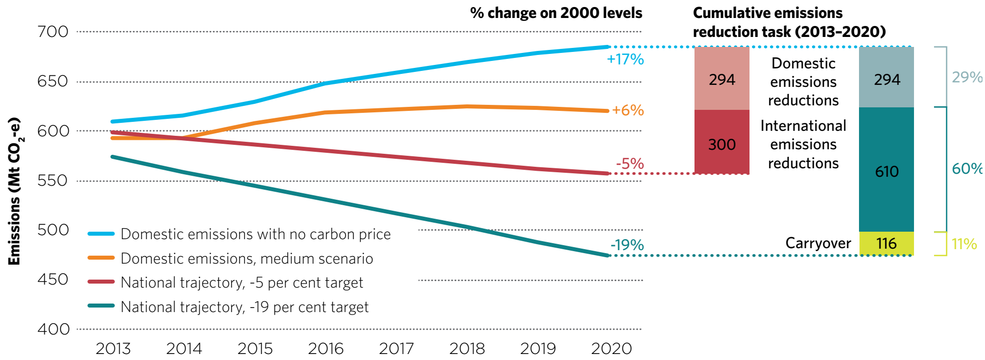
The distributional impact of the revenue effect would depend on how the additional revenue is raised.

### 10.3.2 THE COST OF ACHIEVING THE RECOMMENDED TARGET

Australia needs to reduce emissions by an estimated 593 Mt over the period 2013 to 2020 to achieve the minimum 5 per cent target, as discussed in Section 10.2. Moving from 5 to 15 per cent requires an additional 305 Mt of emissions reductions (for a total of 898 Mt over the period). Moving from 15 to 19 per cent is largely achieved through the use of carryover; Australia's 116 million surplus units from the first Kyoto commitment period almost entirely offset the 122 Mt of additional emissions reductions required.

Figure 10.3 shows Australia's domestic emissions under the medium scenario, where the carbon price starts at a fixed price of $23 in 2013 and reaches $30 in real terms by 2020. Australia's emissions grow to 6 per cent above 2000 levels by 2020; significantly less than the 17 per cent growth in the no price scenario. The remaining emissions reductions—reflected by the gap between domestic emissions and the indicative national trajectory—would be achieved by using carryover and purchasing emissions reductions from overseas.

**FIGURE 10.3:** DOMESTIC EMISSIONS AND IMPORTS FOR DIFFERENT TARGETS, MEDIUM SCENARIO, 2013–2020




**Source:** Climate Change Authority based on Treasury and DIICCSRTE 2013

This suggests that, under the current legislation, Australia would meet the whole of the additional 427 Mt emissions reduction task associated with moving from 5 per cent to the recommended target through 116 Mt of carryover and 310 Mt of imports.[2] The costs presented in this section are estimated on that basis.

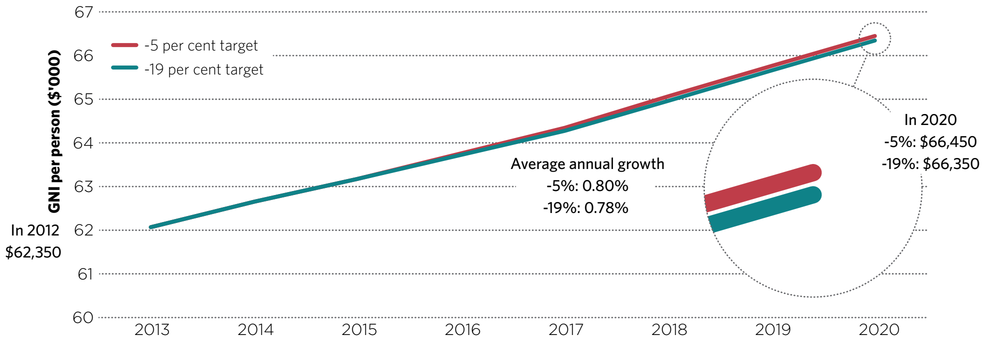
Purchasing the emissions reductions required to achieve this stronger target would lead to a slight slowing of GNI growth (Figure 10.4), due to the transfer of funds overseas, the associated terms of trade effect and the impact on government revenue.

The economic impact can be described using different metrics:

- **Growth in GNI per person**—with a 5 per cent target, GNI per person is projected to grow by an average of 0.80 per cent annually over the period to 2020. Moving to a 19 per cent target slows GNI per person growth to an average of 0.78 per cent.
- **Level of GNI per person**—in dollar terms, GNI per person is projected to grow from about $62,350 in 2012 to about $66,450 in 2020 with a 5 per cent target, and $66,350 in 2020 with a 19 per cent target.
- **Time to attain the same level of GNI per person**—average Australian income continues to rise, but at a slightly slower rate. The level of GNI per person in 2020 with a 5 per cent target ($66,450) would be attained less than three months later with a 19 per cent target.
- **Reduction in GNI level (economy-wide)**—GNI is projected to continue to grow with a 19 per cent target, but at a slightly slower rate. With slower growth, GNI in 2020 would be $3.2 billion (0.18 per cent) lower with a 19 per cent target than it would have been with a 5 per cent target.

2 Figures do not add due to rounding.

**FIGURE 10.4:** GNI PER PERSON, MEDIUM SCENARIO, 2013–2020




**Source:** Climate Change Authority based on Treasury and DIICCSRTE 2013

These impacts on GNI are small relative to other forces driving GNI. For example, the boom in Australia's mining sector and terms of trade is estimated to have added 1.2 percentage points to average annual growth in GNI per person since 2000 (Dolman and Gruen 2012). In contrast, moving to a 19 per cent target is estimated to reduce average annual growth in GNI per person to 2020 by 0.02 percentage points.

**CONCLUSION**

**C.13** Stronger targets can be achieved with relatively small impacts on national income and economic growth, depending on policy design. Under the current legislation, moving from a 5 per cent to a 19 per cent target (15 per cent plus carryover) is projected to slow annual growth in GNI per person to 2020 from 0.80 per cent to 0.78 per cent.

## 10.3.3 THE PRICE OF INTERNATIONAL EMISSIONS REDUCTIONS MATTERS IN DETERMINING THE COST OF STRONGER TARGETS

As noted in Section 10.3.1, the costs of achieving targets depend on the policies used to pursue them. If Australia was to achieve stronger targets by purchasing international emissions reductions, this analysis provides a robust estimate of the economic impact. The costs would be essentially the same if the government purchased the emissions reductions directly rather than liable entities purchasing them under the carbon pricing mechanism. Costs could, however, be more or less, depending on the level of the carbon price.

The outlook for international carbon prices is uncertain and market forecasts vary widely. The modelling therefore examined a range of prices. The costs presented in Section 10.3.2 are based on the medium scenario; costs are lower in the low-price scenario, and higher in the high-price scenario. In all cases, moving from the minimum 5 per cent target to the stronger 19 per cent target requires an additional 427 Mt of emissions reductions; this is met through the use of carryover and international reductions.

- **Low-price scenario**—the lower price applies to both domestic emissions reductions and the price of international emissions reductions. The lower price has a smaller impact on GNI than in the medium scenario. Average annual growth in GNI per person is projected to be 0.823 per cent over the period to 2020 with the minimum 5 per cent target, and 0.819 per cent with a stronger 19 per cent target (see Appendix F7 for details). Slower growth means projected GNI is $0.7 billion lower in 2020, relative to the 5 per cent target.
- **High-price scenario**—again, the higher price applies to both domestic and international emissions reductions. Impacts on GNI are slightly higher—average annual growth in GNI per person is projected to be 0.73 per cent over the period to 2020 with the minimum 5 per cent target, and 0.67 per cent with a stronger 19 per cent target. GNI is projected to be $7.8 billion lower in 2020, relative to the 5 per cent target.

These impacts remain relatively small compared to other economic forces. The projected change to annual growth in GNI per person is less than 0.01 percentage points in the low scenario, and roughly 0.06 in the high scenario; a small fraction of the change due to the mining boom.

The type of international units purchased also affects the costs. The Authority's analysis and cost estimates are based on the modelled price for European units. Emissions reductions generated under the Kyoto Protocol are available at significantly lower prices (currently, Kyoto units are selling for less than $1 per tonne). The impact on the economy would be lower again if, in the context of the government's new policy, Kyoto units were purchased to achieve the stronger target. This is discussed further in Section 10.4.4.

## 10.3.4 THE IMPACT OF THE TARGET IS DISTINCT FROM THE IMPACT OF THE CARBON PRICE

There is a common misconception that stronger targets would impose much higher costs on the economy and on liable entities. This is not the case. Under the current legislation, the economic impact of the 2020 target must be distinguished from the impact of the carbon price. This is explained below and further detail is provided in Appendix F7.

### THE LEVEL OF THE CARBON PRICE SETS THE INCENTIVE TO REDUCE EMISSIONS AND DETERMINES MOST OF THE ECONOMIC COSTS

Under the current legislation, liable entities pay a price for their emissions. This increases the cost of emitting activities, so it encourages firms to reduce their emissions. As a result, the level of the carbon price is what matters most to business and households. The higher the carbon price, the more emissions reductions occur in the economy and the higher the overall costs.

The distribution of those costs between industries, regions and households depends on the emissions intensity of their activities and the goods and services they consume, as well as their ability to shift to less emissions-intensive options (Section 10.5).

### MOVING TO A STRONGER TARGET DOES NOT CHANGE THE CARBON PRICE

Under the current legislation, the carbon price is not expected to be materially affected by the target. This seems counterintuitive at first, but is a result of the links between the Australian carbon market and international markets.

The carbon price is a function of supply (the number of emissions units available to liable entities) and demand (emissions from liable entities). Changing the target would have a substantial effect on supply in a domestic-only market, but has a much smaller effect in one linked to international markets.

- If Australia's carbon market was not linked to international markets, its target would determine the supply of emission units—and, as a result, determine the level of emissions reductions required within Australia. Moving to a stronger target would reduce the supply of emission units and increase the carbon price. The higher carbon price would drive greater emissions reduction efforts by liable entities, so that Australia's domestic emissions would fall to the target level. This extra effort would impose a relatively larger impact on the domestic economy.
- With international linking, Australia's target determines the supply of Australian carbon units. Moving to a stronger target would reduce the supply of Australian units, but have relatively little effect on global supply, as Australia is only a small share of the total market (Appendix F7 provides further detail). Moving to a stronger target is therefore not expected to have a material impact on the carbon price. If the carbon price does not change, incentives to reduce domestic emissions do not change; nor do the compliance costs faced by liable entities and the carbon costs passed on to consumers. Instead, liable entities would buy fewer Australian units and more international units (as long as they stayed within the overall 50 per cent limit). Moving to a stronger target would contribute to global climate action, but the additional reductions would largely occur overseas rather than within Australia. Economic activity within Australia would be largely unchanged.

This was acknowledged by the Australian Industry Group:

> *[U]nder a fully internationally linked emissions trading scheme a deeper target would not increase burdens on industry and hence would not be a serious concern, subject to the very important caveat of the maintenance of the international link.* (Draft Report submission, p. 5)

Australia can achieve stronger targets at relatively small cost. One of the key reasons the costs are small is because the Authority assumes Australia achieves its targets using a mix of domestic and international emissions reductions. The next section considers Australia's emissions reduction opportunities, and how economic impacts could change if Australia pursued more reductions domestically.

## 10.4 USING A MIX OF DOMESTIC AND INTERNATIONAL EMISSIONS REDUCTIONS

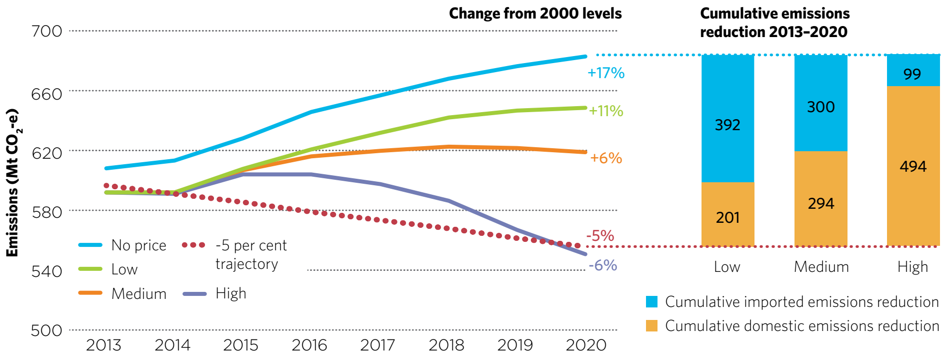
The government has committed to achieving Australia's minimum 5 per cent target through domestic emissions reductions alone. The modelling sheds light on the opportunities that may be available in Australia, and the associated economic impacts. It shows Australia has substantial potential to reduce its emissions, but suggests using some international reductions to complement its domestic efforts is a cost-effective way to meet stronger targets. As long as the imported reductions represent genuine reductions, the environmental outcome would be the same (Chapter 12).

### 10.4.1 DOMESTIC EMISSIONS REDUCTIONS UNDER DIFFERENT SCENARIOS

The Authority has assessed the outlook for Australia's emissions and economy under three carbon price scenarios—high, medium and low—in addition to the no price scenario. The higher the carbon price, the more domestic emissions fall. While emissions in the no price scenario grow to 17 per cent above 2000 levels in 2020, in the low scenario growth moderates to 11 per cent; in the medium scenario emissions grow to only 6 per cent; and in the high scenario they fall to 6 per cent below 2000 levels in 2020 (Figure 10.5). Reductions are projected to occur across all sectors, as discussed in Chapter 11.

These scenarios provide a broad indication of the emissions reductions opportunities that may be available over time at different prices, and useful insights for the development of the government's Direct Action Plan.

**FIGURE 10.5: DOMESTIC EMISSIONS AND CUMULATIVE EMISSIONS REDUCTIONS FOR DIFFERENT SCENARIOS, 5 PER CENT TARGET, 2013–2020**




**Source:** Climate Change Authority based on Treasury and DIICCSRTE 2013

The high-price scenario nearly meets the minimum 5 per cent target using domestic emissions reductions alone—a total of 494 million of the required 593 million tonnes of emissions reductions is achieved domestically.[3] In the medium scenario, only half of the required emissions reductions over the period to 2020 are achieved domestically. This suggests very strong incentives and other policy drivers would be required to meet the government's 5 per cent domestic commitment.

## 10.4.2 ECONOMIC IMPACTS OF REDUCING DOMESTIC EMISSIONS

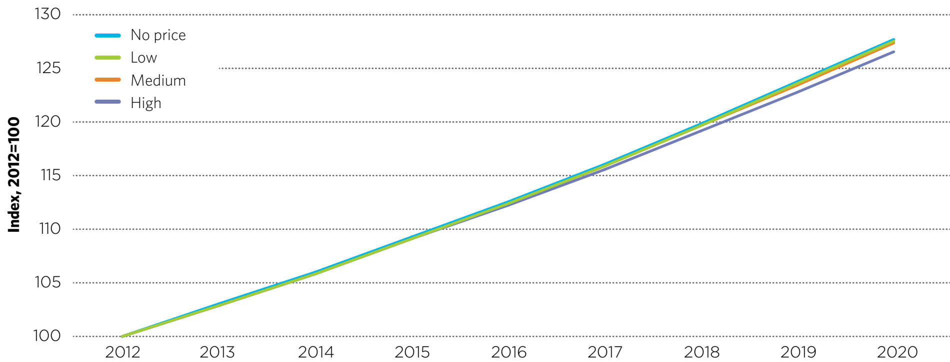
As with emissions, each scenario generates a different economic outcome. This section focuses on GDP results, which primarily reflect changes in domestic economic activity (in contrast, the GNI results in Section 10.3.2 primarily reflect the effects of international trade in emissions reductions).

All of the scenarios project economic growth, even with strong action to reduce emissions in Australia and globally. The effects on GDP growth are relatively small (Figure 10.6) and scale with the carbon price. The high scenario involves the largest shift from high- to low-emissions activities in the economy, and involves the greatest cost. Average annual growth in GDP to 2020 is 2.99 per cent in the high scenario compared with 3.06 per cent in the medium scenario and 3.08 per cent in the low scenario (Treasury and DIICCSRTE 2013).

3 Carryover from the first commitment period of the Kyoto Protocol could close this gap. The Authority considers, however, that the carryover should be used to strengthen Australia's 2020 target.

If Australia chooses to reduce more emissions domestically, these results indicate it would increase costs to government (taxpayers) and the economy as a whole. The results broadly indicate the relative scale of potential macroeconomic impacts. It the government purchased the domestic emissions reductions using general revenue, these costs would be borne by taxpayers. The impacts on industries that generate emissions, and the consumers of those goods and services, would depend on the detailed policy design.

**FIGURE 10.6:** GDP FOR EACH SCENARIO, 2012–2020




**Source:** Climate Change Authority based on Treasury and DIICCSRTE 2013

## 10.4.3 USING INTERNATIONAL EMISSIONS REDUCTIONS CAN REDUCE COSTS

While Australia could achieve the minimum 5 per cent target through domestic reductions alone, the modelling suggests this would require a relatively high price for emissions reductions. This would impose higher costs on the Australian economy—and industry and households—than if some international reductions were used. Using international reductions to complement domestic reductions would reduce the cost of achieving Australia's emissions reduction goals and make stronger targets more affordable.

This can be illustrated by an example in which the international price of emissions reductions follows the medium scenario path:

- If Australia chose to pursue most of its emissions reductions domestically, modelling suggests it would need a domestic incentive similar to the price in the high scenario. This would reduce reliance on imports but increase the cost to the economy. The effective carbon price would grow to $65/t in 2020; Australia would achieve a total of 494 Mt of emissions reductions domestically and use 99 Mt of imports to achieve the minimum 5 per cent target. GDP would be 0.86 per cent lower than the no price scenario in 2020.[4]

4 This cost is based on the high scenario in Treasury and DIICCSRTE modelling (2013), which assumes Australia achieves a 25 per cent target. The GDP result therefore reflects both the impact of the higher carbon price and a very small additional impact from the purchase of international emissions reductions.

- On the other hand, if Australia allowed a greater mix of domestic and international emissions reductions, there would be a greater reliance on imports and a smaller cost to the economy. The effective carbon price would, as in the medium scenario, grow to about $27/t in 2020; Australia would achieve a total of 294 Mt of emissions reductions domestically and use 300 Mt of imports. GDP would be 0.31 per cent lower than the no price scenario in 2020; less than half the cost of achieving most of the emissions reductions domestically.

**CONCLUSION**

**C.14** Using some international emissions reductions to meet Australia's emissions reduction goals reduces costs to the economy, businesses and households. Using a mix of domestic and international emissions reductions to meet the minimum 5 per cent target could halve the impact on GDP compared to only using domestic emissions reductions.

Of course, it is difficult to project exactly how Australia's emissions and economy will develop over time, and which emissions reduction opportunities will emerge. Projections often overestimate future emissions and economic analysis often overestimates the costs of reducing emissions. The Authority examined previous national emissions projections and found they overestimated emissions by roughly 10 per cent on average.[5] Analysis by the Grattan Institute found that environmental markets routinely reduce emissions at lower cost than expected (Daley and Edis 2010). One reason is that, with credible incentives in place, business and households find new and unanticipated ways to reduce emissions. Technology innovation can also change projections (see Box 10.3).

If Australia has more low-cost emissions reduction opportunities than projected in the modelling, then even under the current legislative settings the share of domestic emissions reductions would increase, use of international units would fall and the cost of achieving any given target would be lower. Nevertheless, it could remain cost-effective for Australia to use some international emissions reductions to help meet its target.

5 The Authority compared projections for the period 2008–12 from annual projections published between 2004 and 2007, to Australia's actual emissions in 2008–12.

**BOX 10.3: IMPACT OF INNOVATION ON THE OUTLOOK FOR EMISSIONS AND COSTS**

The international analysis presented in the modelling shows that the cost and availability of low-emissions technologies affects the cost of achieving global and national emissions reductions. The modelling assumptions take account of innovation; technology costs fall over time and new low-emissions technologies gradually become available and competitive. As a result, Australia and the world can accelerate emissions reduction efforts over time.

The technology outlook is hard to predict, so the modelling uses sensitivity analysis to explore how emissions and costs change under different assumptions. For example, higher technology learning rates in the electricity and transport sectors would allow environmental objectives to be achieved with lower carbon prices and smaller reductions in Gross World Product. On the other hand, if carbon capture and storage proved commercially unviable, or no new nuclear power plants were built, carbon prices would need to be higher to achieve a given environmental goal, resulting in larger reductions in Gross World Product (Treasury and DIICCSRTE 2013).

Similiarly, domestic technology costs influence Australia's emissions outlook. As the electricity sector sensitivity analysis shows, if technology costs for solar are lower than currently projected, annual emissions could be about 50 Mt lower from the mid 2030s onwards compared to the medium scenario. This would reduce reliance on imported emissions reductions (ACIL 2013, p. 65).

### 10.4.4 USING INTERNATIONAL EMISSIONS REDUCTIONS UNDER THE DIRECT ACTION PLAN

In light of the government's new climate policy, the Authority recommends a government fund be established to purchase international emissions reductions to help meet the recommended 2020 target (Chapter 12). This would allow Australia to enhance the environmental effectiveness of its climate efforts in an economically efficient way.

The government has indicated it will achieve the minimum 5 per cent target through domestic reductions alone and use Australia's carryover to help meet the target. The Authority estimates this will require 477 Mt of emissions reductions over the period 2013 to 2020 (the 593 Mt gap to 5 per cent, minus 116 Mt from carryover). Strong incentives and policies will be required to achieve this goal.

Moving to the Authority's recommended 2020 target requires an additional 427 Mt of reductions over the period to 2020. International reductions are a robust and cost-effective way to meet this task, and would complement the significant domestic effort planned.

Australia can access a wide range of environmentally robust, low-cost international reductions. As discussed in Chapter 12, for a unit cost of between $0.50 and $2 per tonne, the total direct cost of purchasing the required additional reductions is estimated to be between $210 and $850 million.

## 10.5 DISTRIBUTIONAL CONSEQUENCES OF AUSTRALIA'S TARGETS

The Authority's analysis shows Australia can achieve stronger targets at modest overall cost—Australia's economy and per person income continue to grow as Australia pursues strong emissions reductions. The distribution of costs across households, regions and industry sectors is important, and depends heavily on policy design. Under the current legislative settings, the cost of stronger targets is spread broadly across the economy; this could be different under alternative policy settings. Distributional effects warrant careful consideration when designing policies to achieve emissions reduction goals.

In 2050, the composition of the Australian economy will be very different to its current structure, just as Australia's current economy is very different to that of the 1970s. Shifts in the global economy, technologies, national industry and trade policies, and the broad structural shift from manufacturing to the commercial and services sector, will all shape Australia's future economy, regardless of the action it takes to reduce emissions.

Set against these broader trends, climate policies are likely to have relatively small impacts, but they may be concentrated on particular groups. For example, emissions-intensive, trade-exposed sectors may face competitiveness challenges if they bear higher carbon costs in Australia than in competitor economies. Communities that depend on emissions-intensive industries for employment also face challenges in the move to a low-emissions economy, particularly where there are limited cost-effective opportunities to reduce emissions. Low-income households are more vulnerable to policies that increase the price of emissions-intensive goods and services, because these represent a bigger share of their consumption.

Careful policy design is required to ensure that mitigation policies help businesses and households to respond to these challenges. In combination with broader polices to reduce emissions from electricity generation, governments may provide assistance to low-income households to buy energy-efficient technologies or retrofit public housing to be more thermally efficient, and regional assistance may play a role. For example, under the current legislation, some industries were allocated free permits under the Jobs and Competitiveness Program; and the Regional Structural Assistance Package would have provided $200 million support for workers, regions and communities strongly affected by carbon pricing.

In the context of the Direct Action Plan, the Authority's recommendations could still have limited distributional impacts—the stronger 2020 target can be achieved through government purchase of low-cost international emissions reductions. While the impacts depend on how the government raises the funds, the required amount is relatively small.

### CONCLUSION

**C.15** The costs of reducing emissions and how those costs are distributed through the economy are determined more by policy choice than the particular emissions reduction target. Careful policy design can help businesses and households respond to the challenges of moving to a low-emissions future.

## 10.6 STRONGER 2020 TARGETS MAY REDUCE COSTS OVER THE LONGER TERM

Australia's choice of 2020 target has implications for the cost of meeting targets beyond 2020. This is because the 2020 target affects the size of the remaining national emissions budget—stronger 2020 targets retain more of the national budget for later.

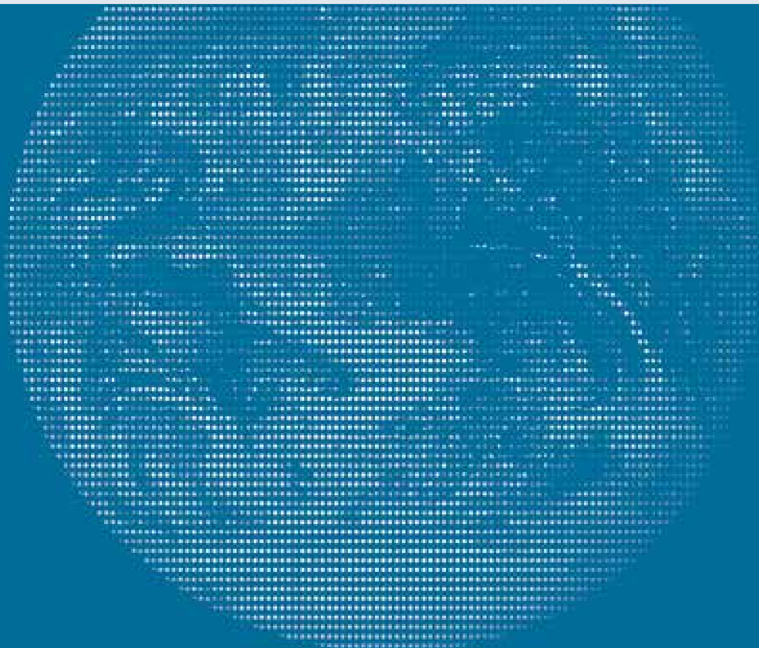
The international carbon price is currently much lower than the projected long-run price consistent with keeping global warming below 2 degrees. This suggests the carbon price could increase rapidly in the future, as the level of action becomes clearer and stronger. Many major global companies are already factoring in much higher carbon prices to their internal operations (CDP 2013). If the price does rise rapidly, it would be more efficient for Australia to have a stronger 2020 target and buy more international units in the period to 2020, while prices are low. This would leave more of the national emissions budget available for the period beyond 2020, when prices could be much higher.

Of course, there is a risk that the carbon price will not rise fast enough to deliver significant economic savings. However, given the low current prices, and the trend of strengthening international action (Chapter 4), the Authority considers this risk small; it is more likely that prices will rise and stronger 2020 targets will prove cost-effective.

There is also a broader rationale for taking stronger action now. Delaying action reduces the chances of keeping global warming below 2 degrees and increases the cost of future efforts. Sustaining and accelerating emissions reduction efforts now can smooth Australia's transition and help safeguard its competitiveness as the world moves to a lower emissions future.

# D

# REDUCING AUSTRALIA'S EMISSIONS— OPPORTUNITIES AND CHALLENGES



Part D describes a range of outlooks for domestic emissions and how different sectors of the economy—and international emissions reductions—might contribute to meeting Australia's emissions reduction goals.

Australia's emissions are projected to rise in the period to 2020 and beyond unless strong policy drivers are put in place. Australia faces a substantial challenge to meet the recommended 2020 target and the longer term emissions budget—but this is achievable if Australia takes near-term action to reduce its emissions. A steady transition will make it easier and less costly to reduce emissions and could help improve Australia's long-term economic competitiveness in a more emissions-constrained world.

Using some international emissions units to complement domestic reductions could further reduce the cost of meeting these goals.

Chapter 11 focuses on Australia's domestic emissions outlook at an economy-wide and sectoral level. It describes cost-effective opportunities to reduce domestic emissions in an environment of continued economic growth and rising international demand for Australian resource and agricultural exports. It builds on the understanding of historical changes in emissions and draws on the Treasury and DIICCSRTE modelling scenarios. It also outlines the emissions reduction opportunities that underpin the Authority's economic analysis of different targets.

Major reductions in Australia's emissions by 2020 and beyond are unlikely without strong policy measures. If effective policies are put in place in the next few years, and are sustained, emissions can be reduced substantially over the period to 2030. Energy efficiency will be particularly important in the near term. Policies that drive the transition to lower emissions technologies, buildings and vehicles will contribute more to emissions reductions beyond 2020 as equipment is replaced.

Chapter 12 discusses the benefits and risks of using international emissions reductions to complement domestic efforts and help meet Australia's targets. It considers the potential sources and volumes of international units available, and the use of international emissions reductions in the context of the government's Direct Action Plan.

# 11

# AUSTRALIA'S EMISSIONS OUTLOOK

Without strong policies to drive emissions reductions, and with strong projected population and economic growth, emissions from most sectors of the Australian economy are projected to rise. Total domestic emissions are projected to grow to 17 per cent above 2000 levels by 2020, and 37 per cent by 2030.

Even with incentives to reduce emissions, growth in export-oriented activity, such as liquefied natural gas (LNG) production and agriculture, is projected to increase emissions in those areas.

To meet its emissions reduction goals, Australia must capture the significant low-cost opportunities it has to reduce emissions, particularly in the electricity generation, industrial processes and fugitive emissions sectors. A set of stable, effective and complementary policies will be important to achieve goals at lowest cost, including targeted policies and regulations to address non-price barriers to reducing emissions.

If Australia is to reduce its emissions in the medium to longer term, effective policies need to be implemented now. Australia's current stock of emissions-intensive and energy-intensive buildings, electricity generators, industrial plants, infrastructure and vehicles will take decades to turn over. New infrastructure will affect Australia's efficiency and emissions levels, for better or worse, for many years. Australia needs clear and sustained policy signals in place as soon as possible to deliver substantial emissions reductions post-2020.

The electricity sector has the largest share of Australia's emissions and the largest emissions reduction potential. Investments in this sector are long-lived—failing to act in the near term to improve energy efficiency in industrial, commercial and residential sectors would make it harder to meet Australia's future emissions reduction goals. Longer term, reducing the emissions intensity of supply is vital. If electricity generation becomes considerably less emissions-intensive, electricity could be used to power other sectors, including transport and direct combustion, reducing domestic emissions.

Improving transport energy efficiency is a major opportunity for substantial low-cost emissions reductions. The Authority recommends the government investigates light vehicle $CO_2$ emission standards for introduction in Australia in the near term.

Chapter 11 describes Australia's emissions outlook in detail and highlights substantial opportunities to reduce emissions from energy supply, buildings, equipment and vehicles.

In this chapter, emissions reduction opportunities are identified relative to a counterfactual 'no price' scenario. This analysis is complemented by Appendix D, which presents a more detailed assessment of Australia's progress against emissions reduction goals and the outlook for emissions, relative to 2000 levels.

## 11.1 WHY ANALYSE AUSTRALIA'S EMISSIONS OUTLOOK?

Assessing Australia's emissions outlook can identify opportunities for economically efficient and environmentally effective emissions reductions, as well as uncertainties, data gaps and challenges to realising those opportunities. This information can contribute to effective policy development. It can also indicate whether Australia is on track to meet its emissions reduction goals and international commitments, and provide an early warning if efforts are falling short.

The Authority must review Australia's progress towards its emission reduction goals annually. The analysis of Australia's emissions outlook in this chapter, together with the analysis in chapters 5, 6 and 12 and Appendix D, fulfills the current legislative requirements for reporting on progress.

The following sections explore possible future trends in sectoral emissions and potential contributions to Australia's emissions reduction goals. They neither prescribe nor imply endorsement of specific outcomes, but instead identify potential paths for future emissions reductions.

## 11.2 MODELLING UNDERPINNING THE EMISSIONS OUTLOOK

The Authority has used economic modelling to explore a range of future scenarios for Australia's economy and emissions. The four core scenarios modelled by Treasury and DIICCSRTE (2013) and described in Chapter 10 involve different levels of incentives for emissions reductions (Box 11.1). The no price scenario includes existing policies such as the RET, energy efficiency standards and land clearing controls, but excludes the carbon price and the CFI. The other three scenarios assume a low, medium and high carbon price, in addition to other existing policies and the CFI.

While the scenarios are largely based on the current legislative arrangements in the Clean Energy Act, the Authority considers the carbon price can be seen as a broad proxy for incentive-based measures. The results show the potential scale and source of emissions reductions available in Australia at different marginal costs (Table 11.1). These four scenarios inform the Authority's assessment of possible emissions outcomes in the remainder of this chapter and in Appendix D.

### BOX 11.1: MODELLED EMISSIONS REDUCTIONS OPPORTUNITIES

The emissions reduction opportunities identified in the modelling reflect projected outcomes under different future carbon prices, relative to projected emissions without a carbon price. Depending on the design, the Authority considers other policies, including the Direct Action Plan, may mobilise similar emissions reductions opportunities. The Treasury and DIICCSRTE modelling reflects:

- Outcomes that might arise when entities subject to the carbon price pay for emissions. If carbon prices are passed through to downstream markets, it may prompt a reduction in demand, leading to lower production of emissions-intensive goods and services. This effect is included in the modelled outcomes.
- The coverage of the carbon price under the current legislation. The Direct Action Plan may cover a different set of activities. In the low, medium and high scenarios, a price incentive applies to all emissions sources except fuel use by light vehicles, decommissioned mines, synthetic gases imported prior to July 2012 and facilities below the coverage threshold (generally 25 kt $CO_2$-e per year). LULUCF, agriculture and waste deposited to landfill before 2012 can access a price incentive for emissions reductions through the CFI.

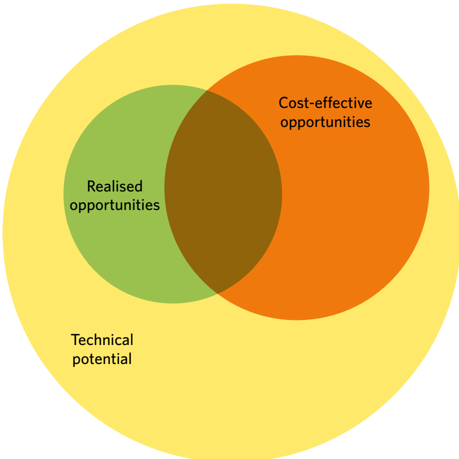
### TABLE 11.1: MARGINAL EMISSIONS REDUCTION COST UNDER DIFFERENT SCENARIOS, 2020 AND 2030 ($/t $CO_2$-e)

| | 2020 | 2030 |
|---|---|---|
| No price scenario | 0 | 0 |
| Low scenario | $6.30 | $54.50 |
| Medium scenario | $26.70 | $54.40 |
| High scenario | $65.20 | $134.90 |

**Note:** Real $2012, rounded to nearest 10 cents. The marginal cost of emissions reductions in 2020 reflects the weighted average of the ACU and the Kyoto unit prices. In 2030, the marginal cost of emissions reduction is the ACU price.
**Source:** Treasury and DIICCSRTE 2013

The modelling provides a useful benchmark to assess the cost of achieving different targets and identifying emissions reduction opportunities in the domestic economy at different prices, given certain policy settings and assumptions. It does not give a complete picture of emissions reductions potential under all possible policies. The actual emissions reductions made in Australia in the future, and the associated economic cost, will depend on a range of factors, including the policies in place. Figure 11.1 explains the range of estimates for emissions reductions and Section 11.3.3 describes the factors influencing Australia's emissions reduction outlook.

**FIGURE 11.1: CATEGORIES OF EMISSIONS REDUCTION OPPORTUNITIES**




There are different ways to consider emissions reduction opportunities:

- technical potential is that which is technically possible, though not necessarily at low cost
- cost-effective opportunities are those that can be realised up to a benchmark of acceptable cost, from either a societal or investor perspective
- realised opportunities are those that are taken up.

Policies can change the relative costs of reducing emissions and can make low-emissions activities and technologies competitive with conventional ones. An effective policy suite will align cost-effective opportunities with realised opportunities. Policy gaps mean that cost-effective opportunities are missed; inefficient policies realise opportunities that are not cost-effective.

**Source:** Climate Change Authority

Modelling, emissions projections and marginal abatement cost curves all make assumptions about technical, cost-effective and realised emissions reduction opportunities. They give a snapshot of potential outcomes at a point in time. Modelling results are significantly influenced by these assumptions and this is reflected in the wide range of emissions reduction estimates (Box 11.2).

The Treasury and DIICCSRTE modelling, for example, considers only a portion of the technical potential for emissions reductions. It focuses on the cost-effective opportunities for Australian emissions reductions in particular sectors at various marginal costs, which together meet a given emissions reduction goal.

**BOX 11.2: WHY DO EMISSIONS REDUCTION ESTIMATES DIFFER?**

The Treasury and DIICCSRTE modelling suggests total domestic emissions reductions in 2020 could be 35, 65 and 134 Mt $CO_2$-e in 2020 (relative to no price scenarios, in low, medium and high scenarios respectively). Only a portion of the technical potential for emissions reductions is realised.

Other studies suggest 2020 emissions reductions may be more or less. ClimateWorks (2010), for example, estimates 'realistic' emissions reduction potential in 2020 is 249 Mt $CO_2$-e, relative to business-as-usual (BAU). By contrast, in a later study, ClimateWorks (2013a) estimates 80 Mt $CO_2$-e of emissions reductions may be realised in 2020 if recent levels of emissions reduction activity are sustained (2013).

Differences between these studies explain the variability in their results, including assumptions in BAU and other scenarios about:

- Technologies and practices available to reduce emissions (this affects 'technical potential'). For example, ClimateWorks (2010) assumed several carbon capture and storage (CCS) demonstration plants would be operating by 2020. By contrast, in the Treasury and DIICCSTRE modelling CCS was found not to be economically viable before 2030.
- The costs of low-emissions technologies, including whether only private or also public or social costs are considered (this affects cost-effective opportunities). ClimateWorks assumed capital costs of low-emissions sources of electricity are generally lower than was assumed in the Treasury and DIICCSRTE modelling. The modelling assumptions were based on ACIL Allen Consulting's (2013) updates to technology costs from the 2012 Australian Energy Technology Assessment (BREE 2012).
- The anticipated consumer response and uptake of low-emissions options (this affects 'realised opportunities'). ClimateWorks (2010 and 2013a) made more detailed and extensive assumptions about energy efficiency potential, and suggests large potential savings, than did the Treasury and DIICCSRTE modelling.

Emissions accounting differences also alter results. The Authority, for example, incorporated updated global warming potentials from the IPCC's Fourth Assessment Report (AR4) in its emission estimates, while ClimateWorks used the global warming potentials specified in the Second Assessment Report (AR2).

## 11.3 OUTLOOK FOR AUSTRALIA'S EMISSIONS

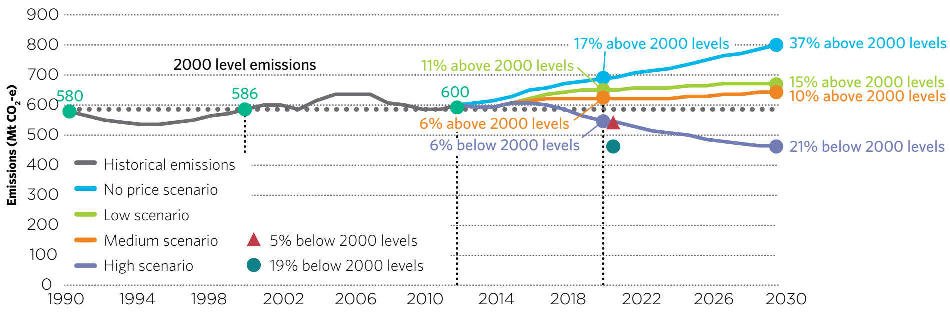
### 11.3.1 AUSTRALIA'S DOMESTIC EMISSIONS LEVELS

Australia's emissions have remained relatively flat since 1990. As discussed in Chapter 6, most of the emissions reductions over that period are attributable to economic factors and policies enacted in the land sector. Between 2008 and 2012, electricity sector emissions have been falling by an average of about 0.8 per cent per year, due to lower demand growth and a shift towards less emissions-intensive generation (gas and renewables).

The current rate of reduction in emissions intensity from both policy and economic drivers is unlikely to reduce overall national emissions to 2020. Under the no price scenario, Australia's emissions are projected to rise to 17 per cent above 2000 levels in 2020 and 37 per cent in 2030. Figure 11.2 shows that with price incentives emissions may fall—and the stronger the incentive, the greater the emissions reductions.

Only under the high scenario are Australia's emissions projected to fall and stay below 2000 levels (Figure 11.2). The high scenario gets closest to the cumulative emissions reductions required to meet Australia's minimum 5 per cent target.

## FIGURE 11.2: AUSTRALIA'S PROJECTED EMISSIONS UNDER DIFFERENT SCENARIOS, 1990–2030



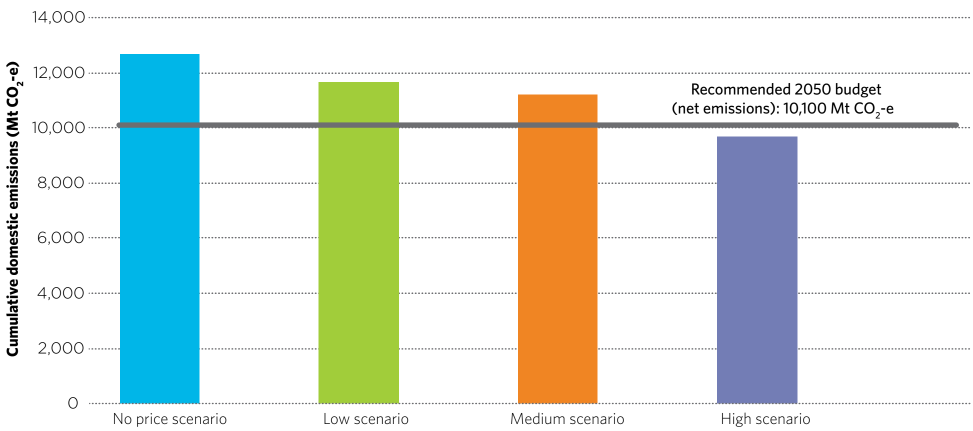

**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

Part C recommends emissions reduction goals for Australia, including a budget for the period 2013–2050 of 10.1 Gt $CO_2$-e. These goals are expressed in net terms, consistent with Australia's international commitments to reduce emissions. To the extent that Australia's domestic emissions are higher than the levels specified in its international commitments, they must be offset by international emissions reductions.

Figure 11.3 shows Australia's projected cumulative emissions over the period 2013–2030, relative to its net emissions budget to 2050. This illustrates that, by 2030, Australia's emissions exceed the recommended budget under all of the modelled scenarios, except the high scenario. This suggests that to stay within the recommended budget, Australia will need to use international emissions reductions to complement domestic reductions.

The high scenario consumes the least of the Authority's recommended emissions budget; the low and medium scenarios use the budget more slowly than the no price scenario. This highlights the role of a strong incentive, or new policy, to reduce Australia's domestic emissions.

## FIGURE 11.3: AUSTRALIA'S RECOMMENDED EMISSIONS BUDGET TO 2050 COMPARED WITH CUMULATIVE DOMESTIC EMISSIONS FROM 2013 TO 2030

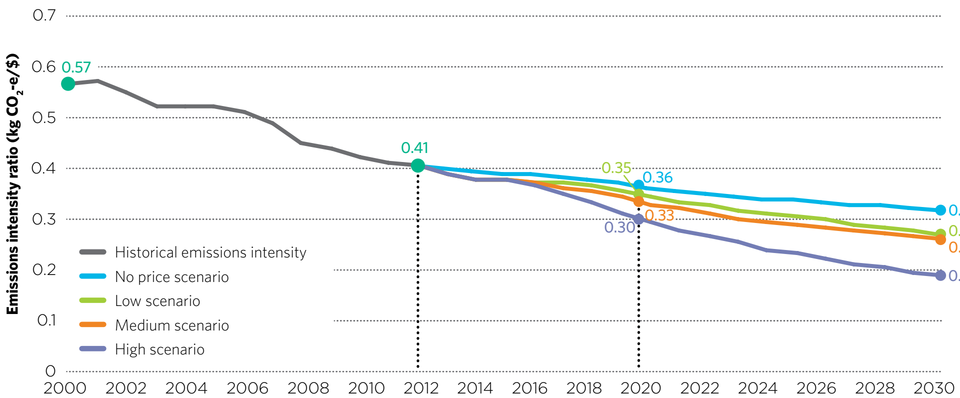



**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## 11.3.2 AUSTRALIA'S DOMESTIC EMISSIONS INTENSITY

The historical trend of falling emissions intensity of the economy, described in Chapter 6, is projected to continue under all scenarios as projected economic growth outpaces emissions growth (Figure 11.4). Economic growth is projected to increase at an average annual rate of about 3.1 per cent between 2013 and 2020, resulting in a similar average rate of emissions intensity reduction over the two decades since 1992.

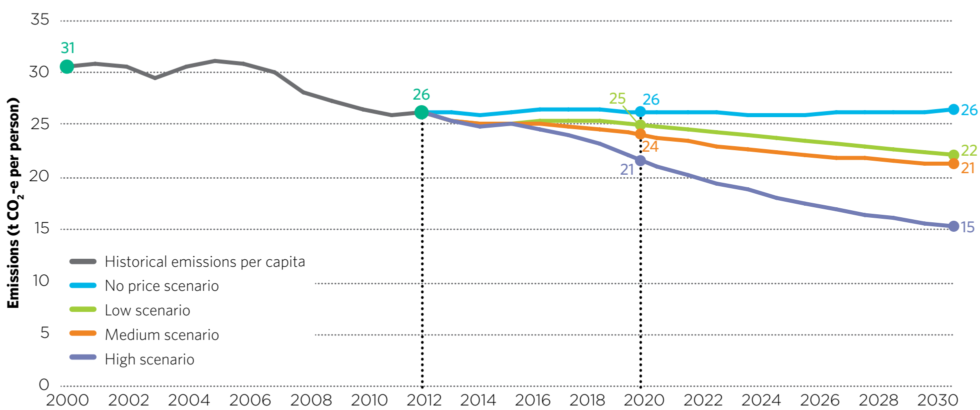
**FIGURE 11.4:** AUSTRALIA'S PROJECTED EMISSIONS PER DOLLAR GDP, 2000–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

Emissions per person are also projected to fall in the low, medium and high scenarios, but rise slightly relative to current levels in the no price scenario (Figure 11.5). In the high scenario, emissions per person are approximately half 2000 levels by 2030.

**FIGURE 11.5:** AUSTRALIA'S PROJECTED EMISSIONS PER PERSON, 2000–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## 11.3.3 FACTORS INFLUENCING THE EMISSIONS OUTLOOK

Several factors will drive Australia's future emissions. Across all scenarios, irrespective of the choice of emissions reduction goals or the level of a price incentive, emissions will be influenced by:

- Broad trends in the macro-economy, such as exchange rates, commodity prices, interest rates, income levels, renewal of building stock and equipment, and population growth. Australia's population and economy are projected to grow and to place upwards pressure on emissions as a result.
- International demand for emissions-intensive commodities and resources, such as beef, LNG and coal. Projected growth in global demand is likely to increase Australian activity in these sectors and the associated emissions.

The type of emissions reductions and the rate at which they are achieved will also be affected by:

- technical progress over time, which can make low-emissions technologies or practices more feasible, and change their relative costs
- the diffusion rate of new technologies and practices, which depends on stock and fleet turnover rates, the timing of retrofit opportunities, and the lead time for training and skills development
- incentives and policies put in place to reduce emissions; for example, in the electricity sector, the RET is significant
- cultural norms and consumer behaviour.

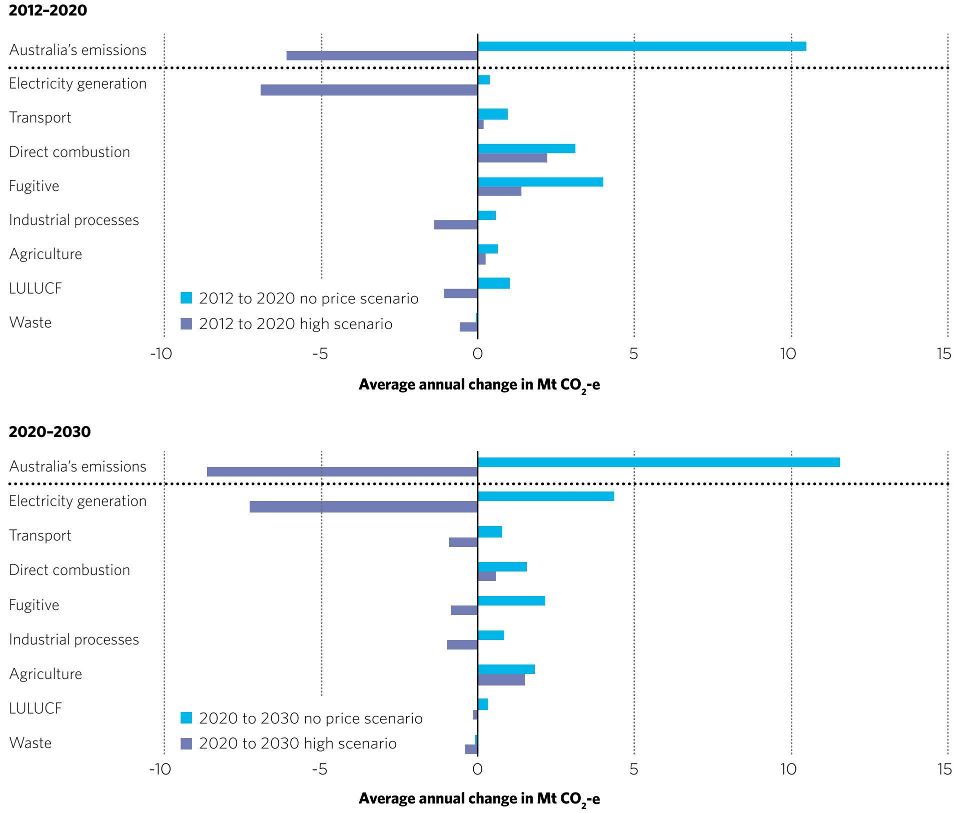
A range of assumptions and baselines are reflected in different estimates for emissions reductions (see Box 11.2). These estimates explore what might happen and where there could be variability, but do not necessarily assess likelihood.

## 11.3.4 SECTORAL OUTLOOK OVERVIEW

Emissions reduction opportunities vary considerably, depending on each sector's proportion of Australia's total emissions (Figure 6.2) and its responsiveness to incentives. For example, the Treasury and DIICCSRTE (2013) suggest that growth in mining and LNG processing will lead to new sources of emissions. These would need to be offset by stronger reductions in other sectors to maintain the same overall pace of reduction.

Figure 11.6 shows the range in projected sectoral emissions outcomes across the modelled scenarios. Without additional policies (no price scenario), emissions in every sector except waste are projected to increase above 2012 levels. Specific sectoral emissions reduction opportunities are discussed further in Section 11.4 and Appendix D.

**FIGURE 11.6: PROJECTED AVERAGE ANNUAL CHANGE IN EMISSIONS, BY SECTOR, 2012–2030**



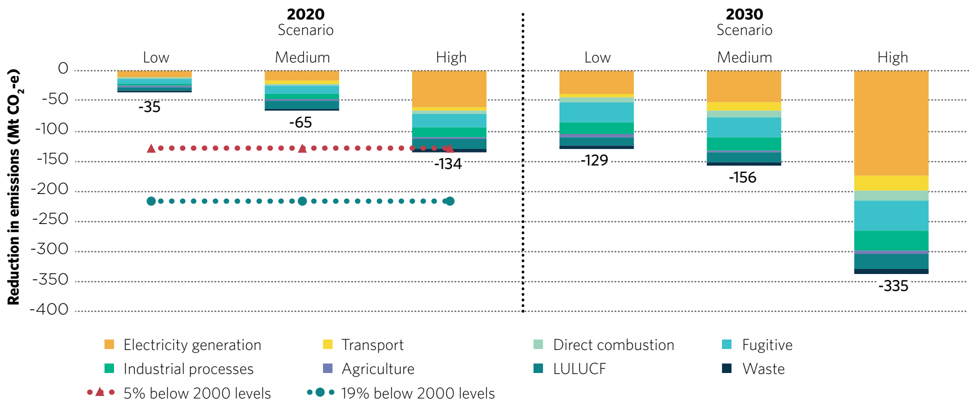

**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

Figure 11.7 and Table 11.2 provide an insight into the emissions reductions that a price incentive (or equivalent) could drive between now and 2030:

- Electricity remains the greatest single sectoral source of emissions under all scenarios. In a no price scenario, its emissions are set to rise from current levels, despite the RET. Electricity also offers the largest opportunity for emissions reductions in response to price incentives, through both a reduction in the emissions intensity of generation and energy efficiency.
- Sectors that are primarily driven by export demand—direct combustion, fugitives and agriculture—present the greatest challenge. Emissions growth is projected for these sectors under all scenarios, with the exception of fugitive emissions, which could fall during the 2020s with a sufficiently high price signal.
- Transport emissions reductions depend on the rate of uptake of fuel-efficient new vehicles and a switch to lower emissions fuels. Without policies to promote these opportunities, transport emissions will grow. Increasing activity in this sector, notably in aviation and road freight, is expected to place upwards pressure on emissions levels. So, too, would a possible move towards synthetic fuels derived from coal, gas and shale.
- Industrial process emissions are projected to be highly responsive to a price incentive and, under the high scenario, could be reduced by 58 per cent on 2000 levels by 2030.

- Greater reforestation and afforestation activities, avoided deforestation and improved land management could deliver emissions reductions from the land sector, especially with a high price incentive, to 2020.
- Waste emissions are projected to remain relatively stable without a price incentive. Emissions reductions are still available and could be realised with an appropriate price incentive.

### FIGURE 11.7: PROJECTED EMISSIONS REDUCTIONS RELATIVE TO THE NO PRICE SCENARIO, 2020 AND 2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

### TABLE 11.2: SECTORAL SHARES OF EMISSIONS REDUCTIONS RELATIVE TO THE NO PRICE SCENARIO, 2020 AND 2030 (PER CENT)

| | | ELECTRICITY | TRANSPORT | DIRECT COMBUSTION | FUGITIVES | INDUSTRIAL PROCESSES | AGRICULTURE | LULUCF | WASTE |
|---|---|---|---|---|---|---|---|---|---|
| 2020 | Low scenario | 25.3 | 6.3 | 3.4 | 24.2 | 13.2 | 4.0 | 17.5 | 6.0 |
| | Medium scenario | 24.1 | 6.9 | 5.5 | 21.3 | 14.7 | 4.0 | 18.9 | 4.8 |
| | High scenario | 43.7 | 4.8 | 5.2 | 15.6 | 11.8 | 2.5 | 13.3 | 3.1 |
| 2030 | Low scenario | 28.3 | 5.4 | 6.8 | 24.4 | 16.2 | 3.2 | 11.0 | 4.7 |
| | Medium scenario | 32.7 | 9.4 | 6.0 | 21.1 | 14.5 | 3.0 | 9.1 | 4.1 |
| | High scenario | 51.9 | 6.9 | 5.0 | 15.2 | 10.1 | 1.9 | 6.7 | 2.4 |

**Note:** Rows may not total 100 per cent due to rounding.
**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## 11.4 SECTORAL OUTLOOK AND EMISSIONS REDUCTION OPPORTUNITIES

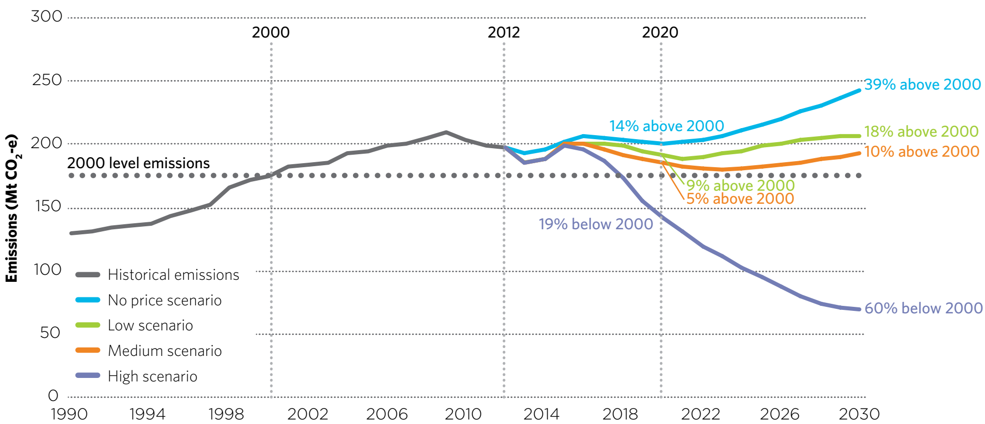
### 11.4.1 ELECTRICITY

Emissions in the electricity sector are released when fuels, such as coal, natural gas and oil, are combusted to generate electricity. This sector includes generation that is connected to electricity grids such as the NEM and generation for use on-site ('off-grid'). The electricity sector accounted for 33 per cent of national emissions in 2012 (Treasury and DIICCSRTE 2013).

Emissions from electricity are projected to rise steadily in a no price scenario, underpinned by economic and population growth. With a price incentive, electricity emissions could stabilise and then fall significantly after 2030 (low and medium scenarios) or, with sufficient incentive, begin to fall in the nearer term (high scenario) (Figure 11.8).

The emissions reductions projected in the low, medium and high scenarios, relative to the no price scenario, reflect a shift towards lower emissions sources of generation and lower electricity demand. The relative costs of generating technologies and fuels, and mitigation policies that affect these costs, will largely determine the timing and magnitude of the shift towards low-emissions generation (ACIL Allen Consulting 2013; BREE 2012a; IEA 2012a).

**FIGURE 11.8:** ELECTRICITY EMISSIONS, HISTORICAL AND PROJECTED, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013 and ACIL Allen Consulting 2013

#### OPPORTUNITIES TO REDUCE ELECTRICITY SECTOR EMISSIONS

Modelling and other analyses suggest that, with incentives in place, the electricity sector could be the single largest source of domestic emissions reductions over the next two decades. The Treasury and DIICCSRTE modelling suggests about half of the domestic emissions reduction opportunities to reach Australia's minimum 5 per cent target could be found in the electricity sector.

Compared to the no price scenario, the modelling suggests the electricity sector could reduce emissions by between 9 and 59 Mt $CO_2$-e in 2020 (in low and high scenarios, respectively) and by between 36 and 174 Mt $CO_2$-e in 2030. ClimateWorks (2010) estimates that the electricity sector has 'realistic reduction' potential of up to 77 Mt $CO_2$-e in 2020, compared to BAU, by reducing the emissions intensity of supply. These estimated emissions reductions are additional to the emissions reductions due to the RET.

The RET has a significant effect on emissions. At its currently legislated level, the RET is estimated to reduce emissions by 102 Mt $CO_2$-e over the period 2012–13 to 2020–21 (CCA 2012). If the RET is not met, or the level of the RET is lowered, this would increase projected emissions and the emissions reduction task to 2020 (see Chapter 9). AEMO's (2013a) forecasts also suggest the RET will play an important role in lowering the emissions intensity of electricity supply over the period to 2020. The Treasury and DIICCSRTE modelling projects that the RET is met, as legislated, in all scenarios.

Price incentives are important both in driving changes in the emissions intensity of supply and reducing demand (ClimateWorks 2013b; Garnaut 2008; IEA 2012a). Recently, emissions reductions have come from both, with estimates that about 40 per cent of the reduction in emissions from the NEM in the year to 2013 was due to lower electricity demand, and 60 per cent to the uptake of lower emissions electricity generation (Pitt & Sherry 2013).

In the near term, most of the electricity sector's emissions reductions are likely to come from reducing electricity demand, driven in part by energy efficiency measures. If barriers to energy efficiency (described below) are overcome, this could play an even larger role.

### REDUCING EMISSIONS THROUGH LOWERING ELECTRICITY DEMAND

Despite declines in the past few years, Australia's per person electricity consumption is well above the OECD average and it lags on energy efficiency (IEA 2012b). Reducing electricity demand, particularly by taking up more efficient technologies and equipment, can:

- offer personal and societal financial savings
- make it easier and less costly to meet Australia's emissions reduction goals, particularly in the near term.

Several sources suggest that reducing electricity demand can reduce emissions at low cost, or even at a positive net present value (Prime Minister's Task Group on Energy Efficiency 2010; PC 2005; Climate Institute 2013). This could particularly benefit disadvantaged consumers, who have more energy-intensive appliances or houses and would be more likely to face the barriers of split incentives or capital constraints to investing in energy efficiency. Changing the profile or level of energy demand could also reduce consumers' electricity bills and offer economic benefits. For example, the AEMC (2012) estimates that reducing peak demand growth could cut system expenditure by at least $4.3 billion over the next decade, mainly through avoided investment in the electricity transmission and distribution network.

Building and equipment choices lock in higher or lower emissions for many years. It may be decades before appliances are replaced or economic retrofits to buildings are possible. Policies targeting new assets will take several years—even decades—to significantly reduce aggregate emissions. The emissions reduced from buildings and appliances between 2020 and 2030 will depend on the policies and standards that are put in place in the next few years.

Evidence suggests that energy efficiency programs (primarily regulatory) have delivered large electricity demand reductions. According to Saddler (2013), these programs accounted for about a third of the observed reductions in demand growth in the NEM since 2006. AEMO reports that continuing the existing and planned building-related energy efficiency measures and minimum energy performance standards for electricity appliances could reduce electricity demand, in 2030, to a level that is about 17 per cent below projected national electricity demand in the Treasury and DIICCSRTE's no price scenario (AEMO 2013b). If such regulations were maintained and expanded, and complemented with some of the initiatives identified in previous reviews (see Table D.5 in Appendix D), it could increase the share of potential emissions reductions taken up.

All else being equal, lower-than-projected electricity demand can reduce emissions and make the emissions reduction task easier. Several downward revisions to demand projections in recent years illustrate this potential (for example, AEMO 2013a, 2013d). ClimateWorks (2013c) describes plausible scenarios for lower electricity demand from households, commercial buildings and industry, which could keep electricity demand at 2012–13 levels in 2020 and deliver up to 23 Mt $CO_2$-e emissions reductions in 2019–20. ACIL Allen Consulting (2013) modelled a low-electricity demand sensitivity, which suggested even larger potential emissions reductions.

### REDUCING EMISSIONS INTENSITY OF ELECTRICITY SUPPLY

At present, Australia's electricity supply is among the most emissions-intensive in the developed world and, since 2007, has exceeded China's electricity emissions intensity (IEA 2013a).

To at least 2020, existing and committed electricity supply is expected to be adequate to meet demand in the NEM (AEMO 2013c). Over this period and into the decade beyond, the RET will play an important role in reducing the emissions-intensity of supply by supporting deployment of low-emissions technologies, including wind and solar. Over this period, the risk of locking in new emissions-intensive generation is relatively low. Longer term, however, clear policy and other signals must be in place to avoid deploying new emissions-intensive generation and to encourage major retrofits that reduce emissions from existing plants.

Additional opportunities to reduce the emissions intensity of the existing generation fleet, dominated by fossil fuel generators, may relate to:

- reducing output—with a price incentive, the recent trend towards mothballing and reducing output from coal-fired power could continue
- retrofitting—upgrading turbines, modifying boiler operations, retrofitting plants with new coal-drying technologies and co-firing with low-emissions fuels. Several Australian generators have suggested they may do so, in a scenario with a price incentive (DRET 2013).

Fuel prices will affect emissions from existing (and future) generators. Rising gas prices make it likely that gas-fired generation in the NEM will decline and remain below current levels until at least the early 2030s (AEMO 2013e). The Treasury and DIICCSRTE modelling projects that, in the no price scenario, the share of coal-fired generation does not change substantially in the period to 2030, and the declining share of gas generation is replaced by renewable sources. Some industry analysis suggests that gas could lose market share to coal-fired generation in the NEM instead of renewable sources (Reputex 2013).

Over time, with innovation and greater deployment, the costs of low-emissions technologies are likely to fall. This will improve their competitiveness and their share of generation. Depending on the relative costs and policy incentives, by the 2030s the growing share of low-emissions generation could include emerging technologies such as geothermal and CCS, which are currently relatively costly and facing other challenges to deployment (see below). Policies, including supporting research and development, could assist.

## CHALLENGES TO REDUCING ELECTRICITY SECTOR EMISSIONS

### Challenges to reducing electricity demand

There are several non-price barriers to reducing electricity demand, identified by the Productivity Commission (2005, 2013), Garnaut (2008), AEMC (2012) and others. There is also considerable consensus about solutions, including:

- electricity consumption information and prices that better reflect actual costs of supply and smart infrastructure to help consumers manage their use
- energy efficiency standards for electrical appliances and buildings. Standards help combat split or perverse incentives for investing in energy efficiency while still allowing consumers the same appliance functionality.

It is important to determine how energy efficiency opportunities can be cost-effectively pursued in the new policy environment. Particular initiatives that have been identified in previous reviews are discussed in Appendix D.

### Challenges to reducing emissions intensity of electricity supply

Several sources of low-emissions electricity generation have already been deployed in Australia, including wind and solar PV. At present, new investments in low-emissions generation are not cost-competitive with existing generation (whose high initial capital costs are now sunk). This, combined with an overcapacity of supply in the NEM and barriers to exit for incumbent generators, means that existing generators could operate for some time. This means there is little incentive for investment in new lower emissions (or any other) electricity generation.

Policy is needed to reduce the emissions intensity of supply. The RET is accelerating deployment of renewable electricity generation; this could be further accelerated by policies that create an additional demand for low-emissions generation. It is important that policies and incentives are stable, given the long life of electricity generation assets.

The deployment of emerging low-emissions technologies, such as geothermal and CCS, is high-risk and capital-intensive. Public or policy support may be required to make deploying these technologies financially viable, unless an additional revenue stream is available. Further, technical, price and logistical challenges have slowed progress on these particular technologies in recent years. As a result, electricity sector experts generally do not expect them to contribute substantial emissions reductions in Australia until the 2030s, even if policy drivers exist to promote investments in lower emissions generation (ACIL Allen Consulting 2013; BREE 2012b).

### Challenges to tracking progress in the electricity sector

Analysing the outlook for the electricity sector is hampered by data gaps. Policy-makers, investors, market participants and consumers could make better decisions if more information was available, including:

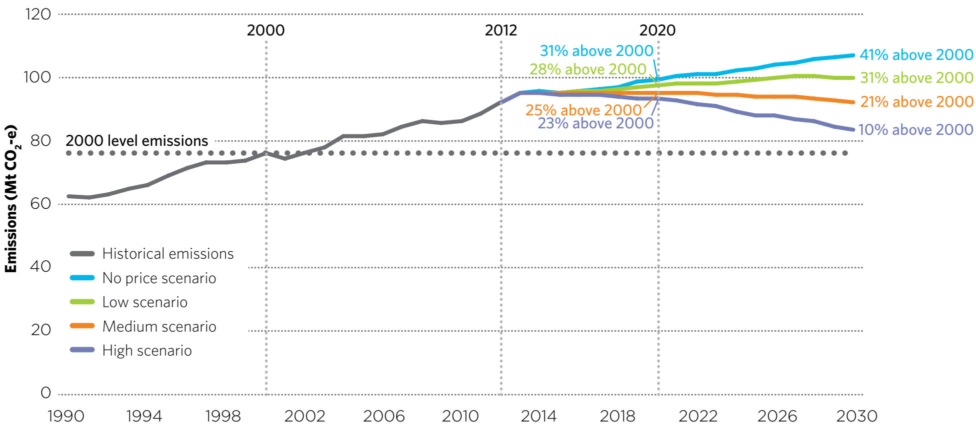
- consistent time series information on the location and time of end-use electricity consumption
- routine collection of granular information on the level and mix of off-grid generation
- earlier publication of the pipeline for grid-connected electricity generation assets, by AEMO and transmission companies.

A detailed analysis of progress in reducing electricity sector emissions is presented in Appendix D3.

## 11.4.2 TRANSPORT

Transport emissions are produced from vehicles combusting fuels to move people and freight, reported across four modes—road, rail, domestic aviation and domestic shipping. International aviation and shipping emissions are excluded from Australia's emissions. Emissions associated with producing and refining liquid and gaseous fuels, as well as generating electricity, are attributed to stationary energy sectors. The transport sector accounted for approximately 15 per cent of Australia's emissions in 2012.

**FIGURE 11.9:** TRANSPORT EMISSIONS, HISTORICAL AND PROJECTED, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013 and Reedman and Graham 2013

Transport sector emissions have increased by 29 Mt $CO_2$-e (46 per cent) since 1990. The Treasury and DIICCSRTE modelling projects that, under all scenarios, transport demand will continue to grow. Under the low, medium and high scenarios, emissions dip or level out to the mid 2030s, due to reduced emissions intensity of passenger and road freight transport (Figure 11.9). After 2030, emissions are projected to increase again as road transport activity continues to grow and price-driven emissions reduction opportunities are exhausted.

### OPPORTUNITIES TO REDUCE TRANSPORT EMISSIONS

Broadly, transport emissions can be reduced in three ways:

- increasing the efficiency of vehicles, through technology improvements in internal combustion engines and rollout of alternative drivetrain vehicles in the case of road vehicles
- reduced emissions intensity of fuels, through low-emissions alternatives to conventional fuels such as biofuels and natural gas
- more efficient demand management—through mode shift from road freight to rail or shipping, and from private vehicles to public and active transport—as well as improved urban planning, transport infrastructure, traffic management and intelligent transport systems.

There are emissions reduction opportunities in all forms of transport. The Treasury and DIICCSRTE modelling suggests that price incentives may be effective in reducing emissions from some sources in the medium to long term, with emissions lower by 23 Mt $CO_2$-e in 2030 under the high scenario relative to the no price scenario.

In this modelling, most of the projected transport emissions reductions due to price incentives result from reduced emissions intensity of heavy vehicles through gains in efficiency and increasing consumption of biofuels in place of liquid fossil fuels. Biofuels could play the largest role in reducing aviation emissions, which could offset strong increases in demand.

Light vehicles are responsible for almost 10 per cent of Australia's total emissions. As mass-produced, dispersed emissions sources, light vehicle emissions reductions may be more effectively realised using efficiency standards (discussed below). Emissions reductions possible through such standards were not included in the modelling presented in Figure 11.9.

Emissions reduction benefits from better managed demand are not modelled; however, several studies (Graham et al. 2012) have identified significant emissions reduction potential for a range of approaches.

### CHALLENGES TO REDUCING TRANSPORT EMISSIONS

Under any scenario, emissions reductions might be slowed or prevented by:

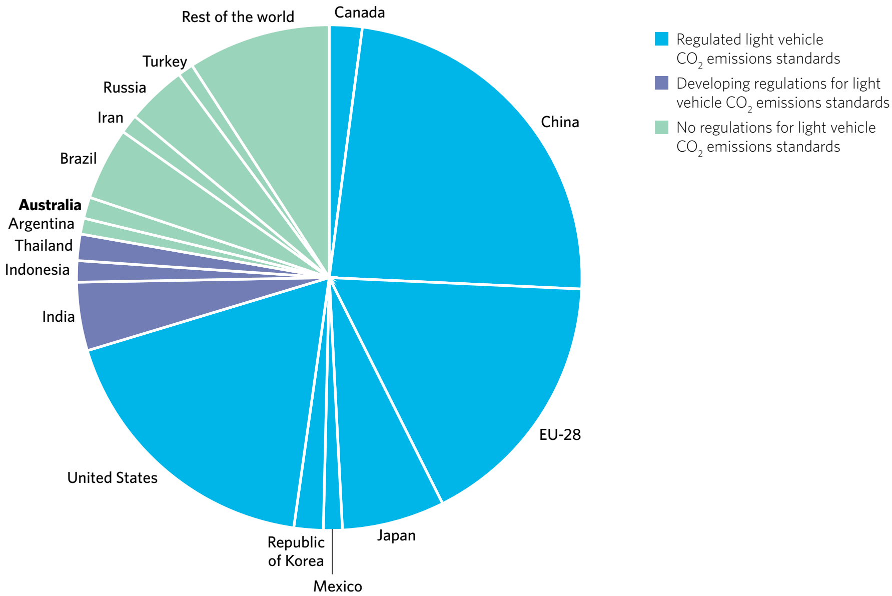
- The rate of turnover of the vehicle fleet—in 2013, the average age of all road vehicles registered in Australia was 10 years (ABS 2013), and trains, aircraft and ships may remain in service for several decades. Transport infrastructure, too, is designed and built for many decades of use.
- The cost of alternative fuels and emerging vehicle technologies—biofuels are currently expensive to produce compared to liquid fossil fuels, and if oil prices are lower than projected this may delay uptake of low-emissions alternatives. The current high purchase price and limited driving range of electric vehicles, for example, relative to internal combustion engine vehicles, is a hurdle to widespread adoption.
- Supply constraints in alternative fuels—the increased production of sustainable biofuels could be limited by a lack of available land and competing food uses for the biofuel crops, though next-generation biofuels may ameliorate this issue.
- The emissions intensity of new energy sources—if the emissions intensity of Australia's electricity supply remains high, it is possible that vehicle electrification could result in a net emissions increase compared with continued use of conventional light vehicles. Emissions could increase if higher emission alternative fuels, such as those derived from gas-, coal- and shale-to-liquid methods, gain market share at the expense of lower emissions fuels.
- The level and cost of infrastructure needed to encourage lower emissions alternative freight and passenger travel—for example, the low population density of Australia's cities (relative to European and Asian standards) presents a challenge to investing in and using alternatives to light vehicles for urban passenger movement.

### A ROLE FOR FLEET-AVERAGE LIGHT VEHICLE $CO_2$ EMISSIONS STANDARDS FOR AUSTRALIA?

Despite having reduced their emissions intensity by 21 per cent over the past decade (NTC 2013), Australia's light vehicles remain among the most emissions-intensive in the world. The Treasury and DIICCSRTE modelling does not include any price incentive or policies targeting vehicle efficiency.

Light vehicle emissions reductions can be realised through fleet-average $CO_2$ emissions standards (or, equivalently, fuel economy standards). Australia considered such standards in 2010 (DIT 2011) but they have not progressed. Over 70 per cent of light vehicles produced in the world today are subject to mandatory $CO_2$ emissions standards, including those sold in the EU, the US, Canada, China, Japan and South Korea (Figure 11.10). Similar standards are under investigation in emerging auto markets such as India, Indonesia and Thailand. Australia's light vehicle fleet is unlikely to maximise available fuel efficiency opportunities if suppliers prioritise auto markets with mandatory standards in place for their more efficient models and variants. Nevertheless, Australia is likely to gain some fuel efficiency benefits as a flow-on effect from standards applied in other auto markets.

**FIGURE 11.10:** SHARE OF GLOBAL VEHICLE MARKETS COVERED BY MANDATORY $CO_2$ EMISSIONS STANDARDS




**Source:** Climate Change Authority calculations based on The International Council on Clean Transportation 2013, Transport Policy.net 2013 (for standards coverage), and OICA 2012 (for vehicle numbers)

The Authority commissioned CSIRO to model the emissions reduction potential of Australia adopting fleet-average $CO_2$ emissions standards that drive a rate of efficiency improvement comparable to that of the EU and US. This modelling showed that up to 14 Mt $CO_2$-e per annum (13 per cent of total transport emissions) could be avoided by 2030 using fleet-average emissions standards introduced from 2018. By 2030, about half of the light vehicle fleet would have been subject to standards. For the entire modelled period (from now to 2050), introducing relatively lenient standards earlier (in 2018) was projected to achieve greater emissions reductions than introducing more stringent standards later (in 2025), emphasising the importance of early action. This is discussed in more detail in Appendix D4.

In overseas markets, fleet-average $CO_2$ standards deliver emissions reductions at a net private saving—the additional vehicle cost is more than offset by fuel savings over the life of the vehicle. Given the global market for automobiles, the cost of efficiency improvements is likely to be broadly comparable across markets (Reedman and Graham 2013). Studies have shown that the cost of the EU's standards to 2020 (95 $gCO_2$/km by 2020) are likely to increase the average vehicle purchase price by about €1,000–1,100 per vehicle (Cambridge Econometrics and Ricardo-AEA 2013). Similarly, in the US, which has enacted standards with a similar rate of efficiency improvement, the increased purchase cost per vehicle in 2020, compared to a baseline year of 2010, is estimated at US$762 (NHTSA 2012).

The CSIRO modelling shows that standards that require the same rate of efficiency improvement in Australia as under EU and US standards—about 5 per cent per annum—would reduce fleet-average fuel consumption by as much as 23 per cent by 2030, offering commensurate reductions in fuel cost and improvements in productivity, all else being equal. This is for the average of all in-service vehicles, not just newer vehicles subject to the standards. Standards could offer a total fleet-average fuel savings of about 3 cents per kilometre by 2030, which equates to $450 per year for a vehicle travelling a typical 15,000 km per year. The savings would be higher for the average newer vehicle subject to the standards.

The CSIRO modelling projects light vehicle fuel consumption could be 12–24 per cent lower in 2030 with standards, which could help drive improvements in transport sector productivity. The modelling also shows that alternative drivetrain vehicles, notably plug-in hybrid electric vehicles and fully electric vehicles, are likely to be deployed sooner if light vehicle $CO_2$ standards are implemented. When operating in electric mode, these vehicles are quiet and have no drive-time emissions. Their deployment will help reduce Australians' exposure to noise and air toxic emissions, with associated health and amenity benefits.

Light vehicle $CO_2$ emissions standards appear to offer significant, low-cost emissions reductions, with potential co-benefits. Fuel savings alone are likely to provide a private payback of just a few years. Implementing light vehicle emissions standards deserves further investigation for Australia.

The emissions reduction potential of Australian light vehicle fleet-average $CO_2$ standards is discussed further in Appendix D.

**RECOMMENDATION**

**R.10** **The government investigate the near-term introduction of fleet-average $CO_2$ emissions standards for light vehicles in Australia as a way to secure significant, cost-effective emissions reductions and related co-benefits.**

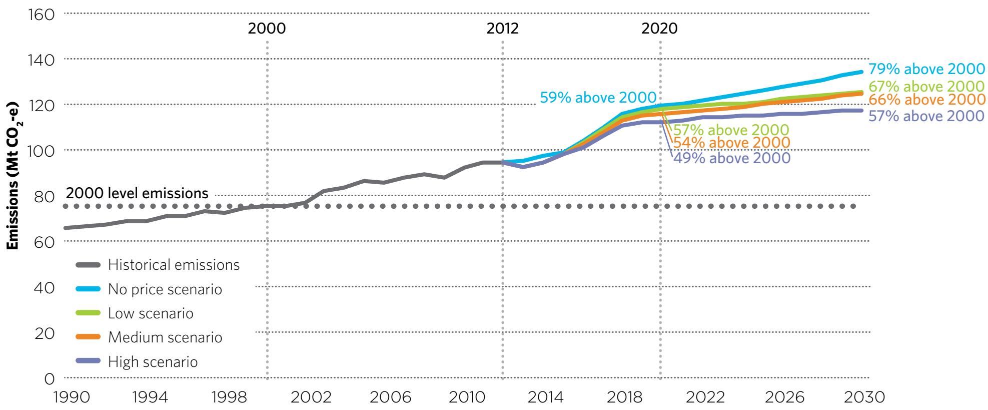
## 11.4.3 DIRECT COMBUSTION

Direct combustion emissions occur when fuels are combusted for stationary energy purposes, such as generating heat, steam or pressure (excluding electricity generation). These emissions are released by large industrial users and small, dispersed residential and commercial consumers. Emissions from direct combustion accounted for 16 per cent of national emissions in 2012 (Treasury and DIICCSRTE 2013).

In each modelled scenario, direct combustion emissions are projected to rise strongly from current levels through to 2030 (Figure 11.11). In absolute terms, under all but the no price scenario, direct combustion emissions increase more than any sector of the Australian economy. This increase is driven by growth in energy extraction industries, including more than 15 LNG production projects in operation, under construction or at initial stages (BREE 2013a).

Price incentives could slow growth to some extent by encouraging greater uptake of low-emissions technologies.

**FIGURE 11.11:** DIRECT COMBUSTION EMISSIONS, HISTORICAL AND PROJECTED, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## OPPORTUNITIES TO REDUCE DIRECT COMBUSTION EMISSIONS

With strong growth projected in energy resources extraction, emissions intensity improvements are unlikely to be enough to reduce overall emissions from the sector. The Treasury and DIICCSRTE modelling suggests price incentives will have a relatively limited effect on direct combustion emissions; much of the growth relates to LNG exports under long-term supply contracts. Even under the high scenario, the sector is expected to reduce emissions by only about 6 per cent (7 Mt $CO_2$-e) in 2020 and 12 per cent (17 Mt $CO_2$-e) in 2030, compared with a no price scenario.

The manufacturing and mining industries produce about three-quarters of direct combustion emissions. Mining activity is projected to grow, even with strong global action on climate change. Emissions reductions could come from improvements in emissions intensity, such as making gas turbines and machinery more efficient, or capturing and using heat from gas turbine exhaust. With a price incentive, new investments could increasingly incorporate low-emissions technologies that could deliver greater emissions reductions in the longer term (Treasury and DIICCSRTE 2013).

The growth in residential and commercial direct combustion emissions, mainly from gas use, could be constrained through more efficient water and space heating appliances and more thermally efficient buildings. George Wilkenfeld & Associates (2009) suggest that ongoing and expanded mandatory efficiency standards for buildings and gas appliances, such as water heaters, could reduce cumulative emissions from residential gas use by 4.5 Mt $CO_2$-e between 2000 and 2020, though households shifting from electric to gas appliances may offset these emission reductions.

Beyond efficiency improvements, the main opportunity to reduce direct combustion emissions could be to substitute alternative lower emissions energy sources, such as biofuels. If the emissions intensity of electricity generation falls, as projected with incentives in place, then moving from direct fuel combustion to electricity could, in the medium to longer term, significantly reduce emissions from residential, commercial and industrial consumers.

## CHALLENGES TO REDUCING DIRECT COMBUSTION EMISSIONS

The challenges to reducing emissions from direct combustion include:

- long-term energy supply contracts in the LNG industry
- investments in long-lived, high-value assets, including plant, equipment and buildings

- barriers to the take-up of energy efficiency, including lack of information on energy consumption and split or perverse incentives for investing in energy efficiency. Standards for gas appliances and buildings, and information provision, have been used to help overcome these non-price barriers.

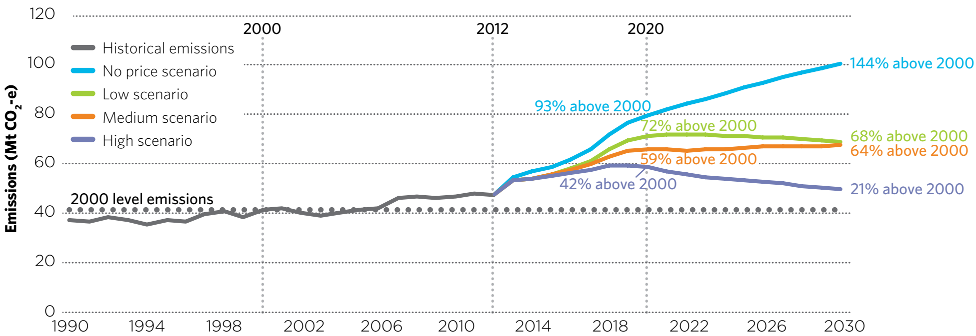
A detailed analysis of progress in reducing direct combustion emissions is presented in Appendix D5.

## 11.4.4 FUGITIVES

Fugitive emissions are greenhouse gases emitted during the extraction, production, processing, storage, transmission and distribution of fossil fuels such as coal, oil and gas. Fugitive emissions accounted for 8 per cent of national emissions in 2012 (Treasury and DIICCSRTE 2013).

Without price incentives, fugitive emissions could rise rapidly, driven largely by strong export demand for LNG and coal (Figure 11.12). Substantial emissions reduction opportunities exist, however. In the modelled scenarios, the fugitive sector is projected to be the second largest source of emissions reductions over the period to 2030, providing 15–24 per cent of total expected emissions reductions, relative to the no price scenario (Treasury and DIICCSRTE 2013).

**FIGURE 11.12:** FUGITIVE EMISSIONS, HISTORICAL AND PROJECTED, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

### OPPORTUNITIES TO REDUCE FUGITIVE EMISSIONS

In the no price scenario, fugitive emissions could more than double, from 48 Mt $CO_2$-e in 2012 to 100 Mt $CO_2$-e in 2030. In low and high scenarios, the modelling shows that the fugitives sector could reduce emissions by 8 and 21 Mt $CO_2$-e in 2020, respectively, compared to the no price scenario. In 2030, the fugitives sector could contribute between 31 and 51 Mt $CO_2$-e emissions reductions.

Despite increased coal and gas production, improvements in emissions intensity could result in fugitive emissions approaching current levels by 2030. Coal mines are responsible for about three-quarters of fugitive emissions; a number of technologies are available to reduce emissions, including pre-draining to capture methane (which is a mature technology) and the oxidisation of ventilation air methane (which is at an early stage of development). With incentives, these technologies may be increasingly deployed after 2020 (ClimateWorks 2013a). In the short term, a price incentive to reduce emissions could encourage the relative expansion of lower emissions mines. It could also drive the deployment of additional pre- and post-mine drainage, where gas could either be flared or used to generate electricity.

CCS in the oil and gas sectors could significantly reduce fugitive emissions, though it is not widespread today. The IEA (2013b) highlights this potential at a global scale. The Gorgon LNG project in Western Australia is expected to capture and inject at least 3 Mt of $CO_2$ annually by 2015 (Chevron 2013). Incentives may encourage deployment of CCS technologies in new projects near geologically suitable injection sites. Recently announced Queensland LNG projects are not expected to use CCS.

Other opportunities to reduce fugitive emissions in the natural gas industry may include equipment changes and upgrades, changes in operational practices, and direct inspection and maintenance (US EPA 2006).

### CHALLENGES TO REDUCING FUGITIVE EMISSIONS

There is strong growth in LNG and coal production, which could outstrip improvements in emissions intensity. Australia's LNG exports totalled 24 million tonnes in 2012 (BREE 2013b), and there are over 15 projects in operation, under construction or at initial stages, with a combined annual production capacity around five times that (BREE 2013a). Coal exports are also projected to grow (BREE 2012b).

Technologies to reduce emissions remain an additional cost for coal, oil and gas producers, compared to conventional production. Their uptake can be accelerated by policies or price incentives.

A detailed analysis of progress in reducing fugitive emissions is presented in Appendix D6.

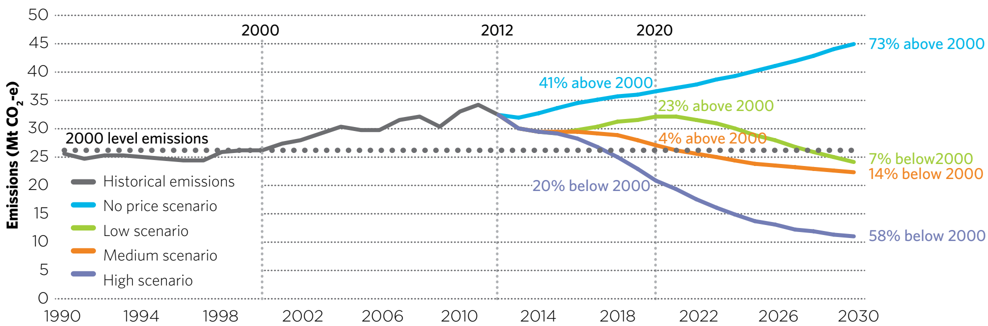
## 11.4.5 INDUSTRIAL PROCESSES

The main sources of industrial process emissions are metal production, such as iron, steel and aluminium; synthetic greenhouse gases, such as those used for refrigeration and as propellants; chemical processes in fertiliser and explosives manufacturing; and mineral production, particularly cement and lime products.

Industrial process emissions exclude energy-related emissions such as those from burning fossil fuels for heat, steam or pressure. Emissions from industrial processes accounted for 5 per cent of Australia's emissions in 2012 (Treasury and DIICCSRTE 2013).

In the no price scenario, industrial process emissions are projected to rise (Figure 11.13). With a price incentive, emissions decrease below 2000 levels by 2030. In scenarios with a price incentive, industrial processes contribute a proportionally large share of domestic emissions reductions by adopting readily available and relatively low-cost, low-emissions substitutes, technologies and process improvements.

**FIGURE 11.13:** INDUSTRIAL PROCESS EMISSIONS, HISTORICAL AND PROJECTED, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

### OPPORTUNITIES TO REDUCE INDUSTRIAL PROCESS EMISSIONS

The industrial processes sector could reduce 2020 emissions by between 5 and 16 Mt $CO_2$-e, compared with the no price scenario (Treasury and DIICCSRTE 2013). Emissions reductions opportunities are projected to be even greater—up to 34 Mt $CO_2$-e—in 2030, which is 75 per cent lower than the no price scenario.

Almost half of the estimated emissions reductions in the industrial processes sector in 2020 and 2030 could be delivered by nitrous oxide conversion catalysts for nitric acid production. This technology was deployed by Orica in 2012, and has been trialled by Wesfarmers since 2011; Wesfarmers (2013) reported that it has reduced nitrous oxide emissions by an average of 85 per cent. ClimateWorks (2013a) estimates that if this technology is taken up more widely it could reduce the emissions intensity of the nitric acid production process by 44 per cent in 2020 compared with today. The regulation of nitric acid plants, including state-based environmental guidelines, is helping to reduce emissions in this sector.

The other significant emissions reduction opportunity is the destruction and replacement of synthetic greenhouse gases. These gases are used mainly in refrigeration and accounted for about 27 per cent of industrial process emissions in 2012. Synthetic greenhouse gases may be superseded by alternative gases that have low to zero global warming potential. The rate of recovery and destruction of these gases, and the associated emission reductions, will depend largely on incentives in place. The rate of recovery is likely to slow following the government's decision to not provide additional financial support, beyond 30 June 2014, to the existing industry-funded and industry-operated destruction incentives program for waste synthetic greenhouse gases and ozone-depleting substances (DoE 2013).

In the longer term, CCS could significantly reduce industrial process emissions. The International Energy Agency (IEA 2013b) suggests that by mid century, about half of the global emissions reductions that it attributes to CCS could be from industries such as cement, hydrogen production, iron and steel.

### CHALLENGES TO REDUCING INDUSTRIAL PROCESS EMISSIONS

Challenges to reducing industrial process emissions include:

- The cost of emissions reduction technologies—financial incentives and other policies can accelerate uptake of technologies to lower emissions, as has occurred in recent years. These incentives could also apply to CCS for industrial applications where the technology is proven but still relatively expensive (IEA 2013c).
- Rising production—particularly in the chemicals sector—that could outstrip improvements in emissions intensity.

A detailed analysis of progress in reducing industrial process emissions is presented in Appendix D7.

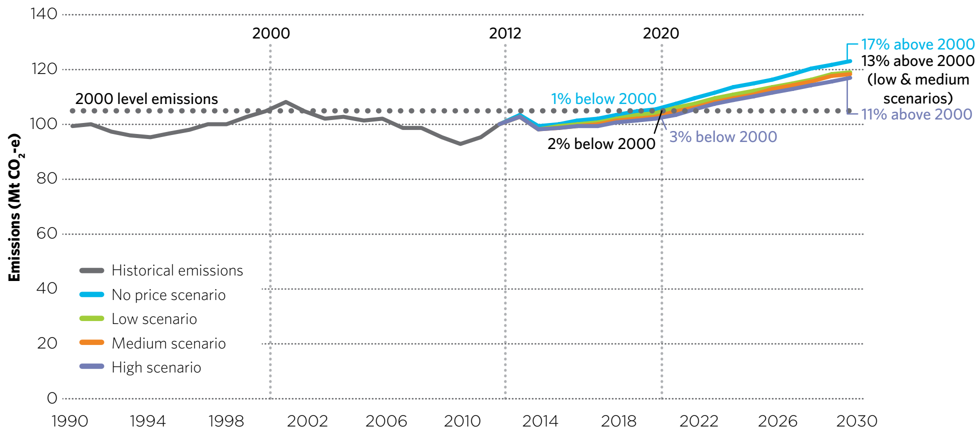
## 11.4.6 AGRICULTURE

Agriculture emissions result from livestock digestive processes (enteric fermentation), manure management, nitrous oxide emissions from cropping and pastureland soils, prescribed burning of savannas and burning of agricultural residues. The agriculture sector accounted for approximately 17 per cent of Australia's emissions in 2012.

Consistent with Australia's Kyoto Protocol Accounting Framework and the categories of reporting used in the National Greenhouse Gas Inventory, agriculture and LULUCF emissions have been evaluated separately in this report. The Authority recognises that these two sectors are interconnected.

Agriculture emissions have increased by 1 per cent since 1990. Under all modelled scenarios, agriculture emissions are projected to increase strongly in the longer term, driven by strong international demand for agricultural commodities, primarily from emerging Asian economies (Figure 11.14). There are incentives such as the CFI, which may reduce agriculture emissions intensity; however, strong projected activity growth means total agriculture emissions could still grow.

**FIGURE 11.14: AGRICULTURE EMISSIONS, HISTORICAL AND PROJECTED, 1990–2030**




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## OPPORTUNITIES TO REDUCE AGRICULTURE EMISSIONS

The Treasury and DIICCSRTE estimates emissions would be about 1 Mt $CO_2$-e and 3 Mt $CO_2$-e lower in 2020 under the low and high scenarios, respectively, relative to the no price scenario. Most of these emission reductions are from livestock.

ClimateWorks (2010) assessed the emissions reduction potential of agriculture and found greater opportunities—reductions of 2–3 Mt $CO_2$-e in 2020 from livestock at a societal cost of \$17/t $CO_2$-e or less. ABARES (2013a) analysis suggests that about 7 Mt $CO_2$-e of emissions reductions, at a cost of \$73/t $CO_2$-e or less, might be available from livestock in 2020. Apart from manure management, however, most of the projected technologies and practices for reducing livestock emissions are still being developed and are not ready for commercial use. The studies referred to have significant differences in assumptions about available technologies, level of uptake and associated costs.

Productivity gains and increasing profitability are the two main drivers for farmers to invest in activities that lower agriculture emissions intensity. Historically, Australia increased annual cropping productivity by 1.5 per cent a year between 1977 and 2011 (ABARES 2013b). In livestock, beef emissions intensity improved by about 10 per cent between 1990 and 2005 (Henry & Eckard 2008).

The dairy industry is focused on reducing its already low emissions intensity further. It has set an industry-wide target of 30 per cent lower emissions intensity by 2020 (Dairy Australia 2013).

## CHALLENGES TO REDUCING AGRICULTURE EMISSIONS

There are limited opportunities to reduce absolute food production emissions given growing demand for Australian agriculture products. Reductions in emissions intensity are expected from new technology and processes in time; however, are unlikely to be enough to offset production growth.

While there are technologies that can reduce emissions intensity in the sector, there are not projected to be sufficient cost-effective emissions technologies available to offset the total growth in emissions. This is the case for greenhouse gas emissions from enteric fermentation in livestock, for example, which was responsible for about two-thirds of emissions from the agriculture sector in 2012 (Treasury and DIICSRTE 2013).

Measuring emission reductions is also an issue; livestock and cropping emissions involve complex interactions within biological systems that are very difficult to measure precisely. A practice that reduces emissions on one farm may have a different effect at another, due to local conditions such as pasture type and weather.

Continued research and technology development is important to support both understanding and uptake of emissions reduction opportunities and general emissions intensity improvements.

Where opportunities to reduce agriculture emissions exist, their uptake can be challenged by limited access to capital. Smaller farms may be unable to achieve economies of scale and may have inadequate access to information about emissions reduction projects. These challenges are exacerbated by the many small and dispersed participants in the sector. A range of approaches could be taken to combat these challenges, such as providing information through rural networks, simplifying methodologies for projects, facilitating access to capital and consolidating projects across many small farms.

A detailed analysis of progress in reducing agriculture emissions is presented in Appendix D8.

## 11.4.7 LAND USE, LAND USE CHANGE AND FORESTRY

Land use, and the biomass the land supports, forms part of the carbon cycle and affects atmospheric $CO_2$ levels. Reporting on the LULUCF sector includes:

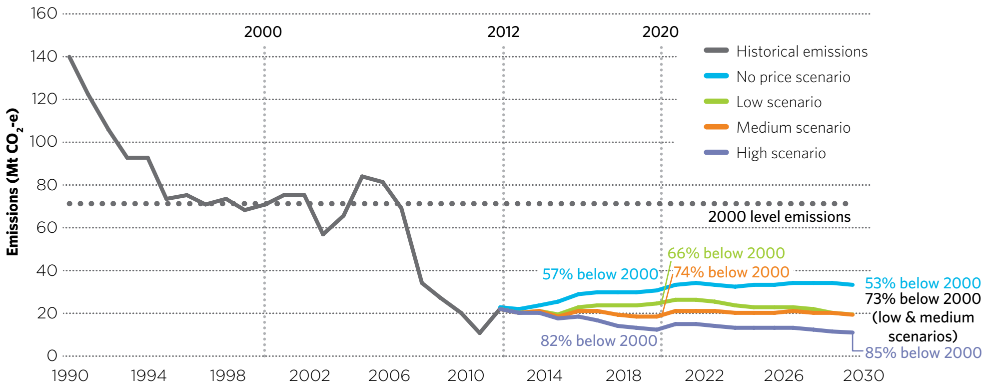
- emissions and sequestration due to the clearance of forested land for new purposes (deforestation)
- new forests on land that was un-forested on 1 January 1990 (afforestation and reforestation)
- other practices that change emissions and sequestration (forest management, cropland management and grazing land management).

Combustion of fossil fuels from forestry and land management activities, such as diesel used in logging machinery, is covered in the direct combustion sector. LULUCF accounted for approximately 4 per cent of Australia's emissions in 2012.

LULUCF has been the biggest sectoral contributor to emissions reductions in Australia since 1990. Net emissions from the sector have declined by 85 per cent from 140 Mt $CO_2$-e in 1990 to 21 Mt $CO_2$-e in 2012. This trend, however, is not projected to continue (Figure 11.15).

Macroeconomic factors, such as farmers' terms of trade and prices of wood commodities, have been the main determinant of LULUCF emissions. The progressive introduction of state and territory land clearing restrictions has also played a significant role in reducing emissions since 1990; most notably, the restrictions introduced in Queensland in 2004 and 2009. Incentives (such as Managed Investment Schemes) boosted forest plantations in the 1990s, but it is unlikely all of these forests will be replanted once harvested. Over the medium to longer term, a combination of subdued forestry demand, reduced land clearing restrictions and pressure from increased cattle herd numbers after 2020 all contribute to projected emissions trends.

**FIGURE 11.15:** LULUCF EMISSIONS, HISTORICAL AND PROJECTED, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## OPPORTUNITIES TO REDUCE LULUCF EMISSIONS

Price incentives could play an important role in LULUCF emissions reductions. Relative to the no price scenario, 12 Mt $CO_2$-e and 14 Mt $CO_2$-e of emissions reductions could be delivered in 2020 and 2030, respectively, under the medium scenario. Under the high scenario, emissions reductions may be 18 Mt $CO_2$-e in 2020 and 23 Mt $CO_2$-e in 2030. Most of the projected emissions reductions in response to the price incentive come from forest management and vegetation regeneration.

Since January 2013, Australia has been required to count net emissions associated with forest management towards its emissions commitments under the Kyoto Protocol, and has also elected to include net emissions associated with cropland management, grazing land management and revegetation activities (see Chapter 7). Cumulatively, over the period from 2013 to 2020, the Treasury and DIICCSRTE modelling projects LULUCF emission reductions associated with these changes of 90 Mt $CO_2$-e irrespective of price incentives. With price incentives, cumulative emission reductions are projected to increase to 116 Mt $CO_2$-e in the low scenario, and up to 126 Mt $CO_2$-e in the medium scenario. Similarly, the ANU Centre for Climate Law and Policy estimates potential LULUCF emissions reductions of 110–115 Mt $CO_2$-e from forest management, cropland management, grazing land management and revegetation activities from 2013 to 2020 (*Issues Paper submission*).

Grundy et al. (forthcoming 2014) finds that, with strong price incentives, non-harvest carbon plantations and native vegetation could greatly increase sequestration to 2050. It also projects low volumes of sequestration before 2030, even with strong price incentives, due in part to probable slow uptake of new land uses and the physical characteristics of carbon sequestration.

From 2031 to 2050, Grundy et al. (forthcoming 2014) projects average annual emission reductions of between 100 and 500 Mt $CO_2$-e would be economically and technically feasible if payments to landholders are broadly consistent with the CFI and the carbon price trajectories in the medium and high scenarios modelled by the Treasury and DIICCSRTE (2013). The upper end of this range suggests there is potential to achieve 80–100 per cent reduction in Australia's emissions in 2050 (compared to 2000 levels) with little or no use of international units, through a combination of land sector credits and emissions reductions in energy and other sectors.

### CHALLENGES TO REDUCING LULUCF EMISSIONS

Historically, land clearing regulations have been an important driver of land sector emissions reductions. The recent dilution of land clearing restrictions in Queensland, New South Wales and, more recently, Western Australia could make it harder to reduce land sector emissions.

LULUCF emissions reductions also face many barriers similar to those of agriculture. Effective methodologies to ensure that emissions reductions are measurable and robust are critical. Substantial research is likely to be required to design effective incentive policies that accurately measure emissions reductions from changed land and forest management practices, and ensure that attributed emissions reductions are robust and permanent.

For smaller scale operations, available returns may be insufficient to make adopting emissions reductions technologies or practices worthwhile, and limited access to capital may also be a barrier. Requirements for 'permanence' in carbon sequestration projects, such as forestry, may also fix land uses for periods of up to a century. For activities such as forestry plantings on pasture lands, landowners will need to consider the value of alternative uses. Projected increased demand for agricultural commodities may make forestry investments less attractive, relative to investing in agriculture.

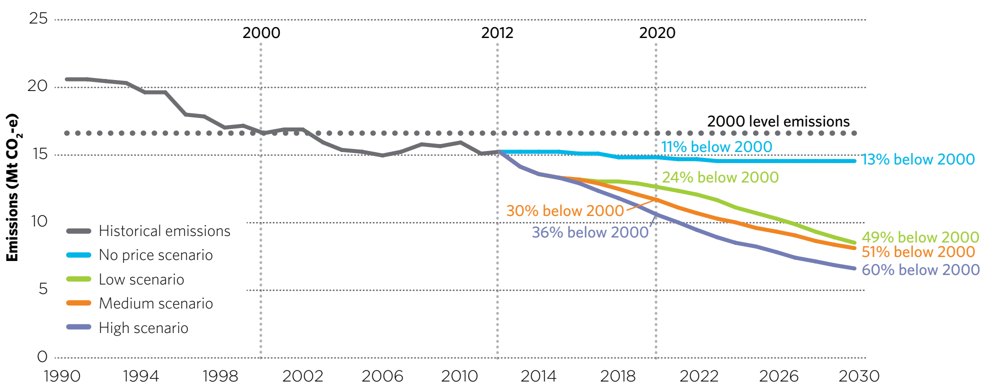
A detailed analysis of progress in reducing LULUCF emissions is presented in Appendix D9.

## 11.4.8 WASTE

Waste includes solid waste and wastewater from residential, commercial and industrial activity. Waste emissions are mainly methane and nitrous oxide, which arise as organic waste decomposes in the absence of oxygen. The waste sector accounted for 3 per cent of Australia's emissions in 2012.

Waste sector emissions have decreased by 26 per cent since 1990 despite population growth and increased waste volumes. Under all modelled scenarios, waste emissions will continue falling (Figure 11.16). In the absence of a carbon price or any new policy measures, waste emissions are projected to fall marginally to about 15 Mt $CO_2$-e in 2030. Further emissions reductions of between 6 and 8 Mt $CO_2$-e (compared to the no price scenario) could be expected under the scenarios with a price incentive.

**FIGURE 11.16:** WASTE EMISSIONS, HISTORICAL AND PROJECTED, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

Gas capture technologies can significantly reduce waste emissions. Historically, both regulatory and market-based measures have successfully driven the deployment of these technologies. Direct regulation of landfills for health and safety purposes has played a major role, as have market incentives. The New South Wales Greenhouse Gas Reduction Scheme and the RET have been important in reducing emissions from landfill. The RET and the CFI are expected to drive further reductions.

### OPPORTUNITIES TO REDUCE WASTE EMISSIONS

The major emissions reduction opportunity for waste is the expansion of alternative waste treatment facilities to reduce waste volumes being sent to landfill. This relies on development of new facilities and installation of new technologies, such as food waste treatment and other thermal energy recovery technologies. Further emissions reductions could be generated by improving gas capture technology efficiency rates at landfill and wastewater facilities, and extending coverage of these technologies to smaller facilities. A price incentive would increase uptake of both gas collection and destruction and alternative waste treatment technologies. The CFI already provides incentives to destroy methane emissions from 'legacy' waste (deposited at landfills before July 2012).

There is some evidence that increasing the cost of landfill disposal makes alternative waste treatment a more attractive option as it drives waste streams away from landfill. This has been addressed via increased landfill levies in some Australian states and in the UK.

### CHALLENGES TO REDUCING WASTE EMISSIONS

Australia has high levels of adoption of conventional emissions reduction technologies such as gas capture and alternative waste treatment relative to other countries.

There are several barriers to realising further emission reductions in the waste sector:

- Installing new technologies involves large capital costs that may take an extended operating period to recover. This suggests that a strong and stable price incentive, or a clear and enforceable regulatory requirement, would be needed to promote investment in these technologies.
- New waste treatment technologies and processes such as food waste treatment and thermal treatment plants may face hurdles of gaining community acceptance, finding suitable available land, meeting local planning requirements and gaining sufficient funding.
- Alternative waste treatment and other emissions reduction technologies require a minimum scale to be cost-effective. Smaller towns in rural and regional areas often do not generate enough waste for local councils to justify the investment.

A detailed analysis of progress in reducing waste emissions is presented in Appendix D10.

## CONCLUSIONS

**C.16** The rate of reduction in emissions intensity since 1990 is not sufficient to drive absolute reductions in Australia's emissions in the period to 2030.

**C.17** Without a price incentive or additional policies, economy-wide emissions are projected to rise to 17 per cent above 2000 levels in 2020 and 37 per cent in 2030.

**C.18** Australia has extensive opportunities to reduce emissions at relatively low costs, but it will take time to replace the stock of buildings, vehicles, equipment and plant. To achieve Australia's emissions reduction goals and avoid locking in future emissions growth, stable, cost-effective and complementary policies need to be in place this decade.

**C.19** Electricity sector emissions are projected to grow strongly without a price incentive or other policy mechanism. With price incentives, the sector could be the single largest source of domestic emissions reductions.

**C.20** Without a price incentive, rapid growth in demand for road transport and domestic air travel is projected to drive increasing transport emissions. Appropriate policies could deliver significant transport emissions reductions.

# USING INTERNATIONAL EMISSIONS REDUCTIONS TO HELP MEET AUSTRALIA'S GOALS

# 12

International emissions reductions are an environmentally sound and cost-effective complement to domestic emissions reductions for Australia.

There are substantial potential benefits to using international reductions to help meet Australia's goals—they could reduce costs, help to address competitiveness concerns and support broader Australian trade and foreign policy objectives. In turn, these benefits could encourage more ambitious action, both in Australia and overseas, giving a better chance of staying below 2 degrees.

There are risks. In particular, that international emissions reductions are not genuine or their use detracts from the task of transitioning Australia's domestic economy to a low-emissions future. These risks are real but, in the Authority's view, they can be effectively managed by good governance, judicious access arrangements and policies that drive domestic emissions reductions.

It is important that Australia begins transitioning from a high- to low-emissions economy in a cost-effective way. As discussed in Chapter 11, there are already policies in place to support this transition. More are needed and they will take time to have an effect. International reductions can play an important role in complementing domestic efforts to help Australia meets its goals, in the immediate period to 2020 and beyond.

If current legislation is repealed and replaced by the Direct Action Plan, the Authority recommends that the government purchase international emissions reductions created under the Clean Development Mechanism (CDM). This mechanism has high standards to ensure its units represent genuine emissions reductions. There is currently a large supply of CDM units available at historically low prices. Australia could choose to limit its purchases to projects with the highest environmental standards and still have access to low-cost, genuine international emissions reductions.

The government has stated it intends to reduce Australia's emissions by 5 per cent domestically, but has not ruled out using some international reductions to meet a target beyond 5 per cent. The Authority recommends international emissions reductions be used to 'fill the gap' between 5 per cent and the recommended 2020 goals. The Authority also considers international reductions could have a role to play in meeting the 5 per cent target.

The Authority recommends the government establish a fund to purchase international emissions reductions to complement domestic reductions under the Direct Action Plan. A fund of about A$210 million to A$850 million should be sufficient to purchase the reductions needed to move beyond the minimum 5 per cent target to the recommended 2020 goals.

There are good reasons for Australia to reduce its domestic emissions and accelerate its transition to a low-emissions economy. Still, climate change is a global phenomenon; from an environmental perspective, there is no special merit in reducing emissions in one country over another. What matters is that the overall quantity of emissions is reduced in line with the global budget. From an economic perspective, it is sensible to reduce emissions in the most cost-effective manner, taking account of both short-term prices and the need for a long-term domestic transition. The trade of international emissions reductions can improve both environmental and economic outcomes.

This concept is recognised in the international climate framework. The Kyoto Protocol allows countries to meet their targets by reducing their own emissions and by purchasing emissions reductions from other countries. Many countries have adopted this approach—the EU, Norway, the UK and New Zealand use international emissions reductions to help meet their climate change goals; the United States and Canada do so at the sub-national level.

This chapter looks at the role international emissions reductions can play in helping achieve Australia's emissions reduction goals. It discusses:

- the benefits and risks of using international emissions reductions
- how Australia can use international emissions reductions to help meet the recommended 2020 goals in a way that maximises the benefits and minimises the risks
- how international emissions reductions could complement the Direct Action Plan to ensure Australia meets its current international commitments and the recommended goals.

## 12.1 BENEFITS OF INTERNATIONAL EMISSIONS REDUCTIONS

There are substantial benefits to using international emissions reductions. Three are of particular interest to Australia:

- providing access to a wider range of cost-effective mitigation opportunities, which lowers the overall cost of meeting Australia's targets
- helping to address competitiveness concerns for industry by equalising the price of emissions reductions across countries
- buying international emissions reductions that are targeted to support other trade, foreign policy and development objectives.

These benefits can lead to a 'virtuous cycle' of greater climate action. By reducing costs and competitiveness concerns, trade in international emissions reductions can make stronger targets more achievable. And, by helping developing countries build robust environmental governance, trade can help them take more action.

Almost all stakeholders, including both industry and environment groups, support using international emissions reductions to complement domestic efforts in Australia.

### 12.1.1 LOWERING COSTS TO MEET AUSTRALIA'S EMISSIONS REDUCTION GOALS

Allowing access to international emissions reductions would lower the cost of Australia's emissions reduction task, making it cheaper to attain any given target. It also means that, for any given cost, stronger targets can be achieved. Trade in emissions reductions gives countries and businesses access to a wider range of emissions reduction opportunities than exist domestically. This improves cost-effectiveness.

Industry groups, including the Business Council of Australia (BCA), support access to international reductions on the grounds that it lowers the cost of meeting Australia's target.

The Authority's analysis (Chapter 10) shows that Australia can achieve the recommended goals at a manageable cost through a mix of domestic and international reductions. A mix is likely to be significantly cheaper than if Australia was to only use domestic reductions. For example, the modelling indicates that under current legislation a carbon price incentive of more than A$65 per tonne would be required by 2020 to meet Australia's minimum 5 per cent target through domestic emissions reductions alone. This is much higher than the current price of international emissions reductions—CDM units, for example, are currently trading at less than A$1 per tonne.

While Chapter 10 shows Australia could meet the recommended goals at relatively low cost, in practice the cost could be even lower than projected by the modelling. The Authority's analysis and cost estimates are based on the price forecast for European units. Emissions reductions, including CDM units, are currently available in large volumes at significantly lower prices. If these were used, the costs of meeting the recommended target would be lower.

### 12.1.2 CONTRIBUTING TO BROADER TRADE AND FOREIGN POLICY OBJECTIVES

Purchases of international emissions reductions can be tailored to advance other government objectives, including trade, foreign policy and development aims. For example, Australia could target purchases to support projects and programs in the region, or encourage greater climate action by supporting the development of the international carbon market and improving environmental governance arrangements in developing countries. This benefit was recognised in the Prime Ministerial Task Group on Emissions Trading report in 2007: 'At the global level, the recognition of [international emissions reductions] created in developing countries can be an effective way of promoting their involvement in global efforts to limit emissions' (p. 111).

Other countries tailor some of their purchases of international emissions reductions in this way. For example:

- Sweden will purchase 500,000 CDM units from a clean cook stove project in Ghana. The project will provide community benefits by curbing local air pollution and reducing household expenses
- the UK will purchase £50 million of CDM units from least developed countries to bolster the international carbon market
- Norway will purchase 30 million CDM units to support CDM projects at risk of financial collapse due to historically low prices.

### 12.1.3 HELPING TO ADDRESS LONG-TERM COMPETITIVENESS CONCERNS

Using international emissions reductions can help to address long-term industry competitiveness concerns by providing a cost-effective source of emissions reductions.

A number of industry stakeholders expressed concern that strong climate action by Australia would adversely affect their competitiveness because local businesses would face a carbon price higher than that of their international competitors. For example, the Cement Industry Federation is not convinced that its competitors will face meaningful carbon costs in the near future (*Draft Report submission*, p. 3).

Depending on policy design, trade in international emissions reductions could help address industry competitiveness concerns by equalising carbon prices (or incentives) across countries. The Australian Industry Group considers that access to international emissions reductions could reduce competitive distortions by ensuring the cost of emissions reductions in Australia is similar to those overseas (*Draft Report submission*, p. 8). If a business has access to international emissions reductions to meet its obligations, it will face the international carbon price, rather than the price that would otherwise have been imposed by the policy. This can help level the international playing field over the longer term.

In turn, if competitiveness concerns are addressed, it can be easier to set stronger emissions reduction goals and foster joint political commitment to action on climate change.

## 12.2 RISKS OF USING INTERNATIONAL EMISSIONS REDUCTIONS

Using international reductions to help meet Australia's goals has some risks:

- spending money on emissions reductions that are not genuine
- carbon market fraud
- costs and disruption in Australia that stem from delaying the domestic transition to a low-emissions economy.

These risks can be effectively managed and they are discussed below, along with strategies to mitigate them.

### 12.2.1 ENVIRONMENTAL INTEGRITY

It is important that international emissions reductions are genuine; otherwise, the environmental integrity of Australia's action is compromised, and public and investor confidence in such arrangements is weakened.

To ensure emissions reductions are genuine, Australia could choose to use international reductions only from credible sources—for example, tried-and-tested mechanisms with strong measurement, reporting and verification arrangements, such as the CDM. The CDM has operated since 2006 and has detailed rules and governance arrangements to ensure its emissions reductions are genuine. Its operation has improved over time, and its Executive Board has made a conscious and consistent effort to identify and address environmental concerns. It now operates with a high level of environmental integrity and has similar governance arrangements and verification processes as Australia's CFI (see Box 12.1).

Many countries target their purchases to particular sources of international emissions reductions. For example, the EU allows international reductions from UNFCCC mechanisms, including the CDM. Within this, it does not accept reductions from projects it considers environmentally or developmentally questionable, such as those involving the destruction of synthetic greenhouse gases (GHG) and large-scale hydroelectric generation projects. Australia adopted similar rules for compliance under the carbon pricing mechanism. Section 12.3 discusses the international emissions reductions Australia could use to meet its 2020 goals to ensure a high level of environmental integrity.

**BOX 12.1: THE CLEAN DEVELOPMENT MECHANISM**

Like the CFI, the CDM is a baseline-and-credit scheme where projects earn credits by reducing emissions below a defined baseline. Project developers present plans and methodologies to the CDM Executive Board for its initial approval. The Board must be satisfied the emissions reductions are 'additional' to what would have occurred without the project, and that the project would not have occurred in the absence of the financial incentive provided by the CDM. The project must also be validated by an independent auditor to ensure the reductions are real, measurable and verifiable. The Board must approve the project before CDM units can be issued. There are periodic independent reviews of projects to verify that emissions reductions continue.

The CDM Executive Board is supported by the UNFCCC secretariat, including its roster of experts, and a number of specialist panels and advisory groups. These groups comprise experts who develop recommendations on the submitted proposals and issue guidelines for new methodologies to assess and inform new projects.

Many of the concerns raised about whether emissions reductions generated from the CDM are genuine relate to the question of 'additionality'—whether the reductions would have happened in the absence of CDM support. As with all baseline-and-credit schemes, it can be difficult to define the counterfactual and determine additionality. Over time, the CDM has developed a sophisticated set of methodologies and rules for determining whether reductions are additional and these are constantly refined. Indeed, some criticism of the CDM arises because of the complexity and expense of proving projects meet these rules.

## 12.2.2 CARBON MARKET FRAUD

Carbon market fraud can cause environmental integrity issues (if, for example, it results in the same emissions reductions being counted twice) and financial loss.

The risk of fraud in the carbon market is no different from other more established markets. For example, the Australian Stock Exchange continues to experience and respond to incidences of fraud. If governments work together, put in place robust governance arrangements, and respond quickly and effectively if fraud does occur, the risk is manageable. Australia can draw on its experience working with foreign governments in other contexts to establish systems to mitigate the risks.

There have been a number of well-publicised incidents of fraud in the EU ETS. In 2010–11, about 2 Mt of EUAs were stolen from individual accounts. The EU responded immediately by suspending trade until new security requirements were implemented. The EU revised its systems to reduce the risk of similar events—replacing the national registries of EU member states with a single EU-wide registry and tightening its rules on proof of identity. To further protect against fraud, the European Commission is seeking to align the rules governing the carbon market with other European financial markets. This means higher integrity standards, simpler access and better transparency for all carbon market participants.

## 12.2.3 DELAYING AUSTRALIA'S TRANSITION TO A LOW-EMISSIONS ECONOMY

An over-reliance on international emissions reductions to meet Australia's goals could delay its transition to a low-emissions economy. A number of stakeholders expressed this concern in the Authority's consultation, including WWF-Australia. The Authority believes it is important to support Australia's transition—as the world takes action on climate change, Australia needs to put in place policies and mechanisms to drive domestic emissions reductions and encourage low-emissions investments. As discussed in Chapter 5, Australia currently has a number of such policies, including:

- the RET to encourage investment and deployment of renewable energy
- land clearing controls
- national, state and territory energy efficiency standards and schemes.

The Authority has identified additional policies that might capture emissions reductions opportunities in Australia (see Chapter 11). A strong and sustained suite of policies will drive domestic emissions reductions that will put Australia on the path to a low-emissions economy. Targets and long-term guidance about Australia's future climate change action will also help to shape expectations and encourage low-emissions investment.

International emissions reductions can complement these domestic efforts. It takes time to develop and implement new policies and there are inherent lags due to the time needed to turn over existing capital stock. It is important Australia puts these policies in place now to drive emissions reductions in the future. However, particularly in the period to 2020, international emissions reductions could play an important complementary and timely role. The balance between domestic and international emissions reductions is likely to change over time as national and global economies move closer to a low-emissions footing.

The Authority considers a balanced approach is appropriate—international emissions reductions should not be used to meet all of Australia's target, but nor should they be excluded. The benefits—lower costs, industry competitiveness and other national objectives—are substantial and, in turn, may drive stronger climate action. The risks can be managed by good governance, judicious access arrangements and policies that drive domestic emissions reductions. A mix of domestic and international reductions will help Australia transition to a low-emissions future, while reducing the costs of meeting the recommended 2020 goals.

## 12.3 INTERNATIONAL EMISSIONS REDUCTIONS TO HELP MEET AUSTRALIA'S 2020 GOALS

Section 12.2 outlines why Australia should use international emissions reductions to complement domestic efforts and help meet its emissions reduction goals. This section considers which international reductions Australia could use to meet its 2020 goals in the context of the government's Direct Action Plan to maximise the benefits and minimise the risks.

There is a wide range of credible international emissions reductions available to help countries meet their goals:

- the UNFCCC and Kyoto Protocol market mechanisms, such as the CDM
- established emissions trading schemes, such as the EU
- bilateral offset mechanisms, whereby countries work together to establish programs and projects that generate emissions reductions.

Until 2020, the most reliable sources of units for Australia are established mechanisms, such as the CDM and the EU ETS. These mechanisms have sophisticated arrangements in place to promote environmental integrity and reduce fraud. In time, other mechanisms may develop and mature, providing further opportunities for Australia. These could be explored for Australia's post-2020 goals.

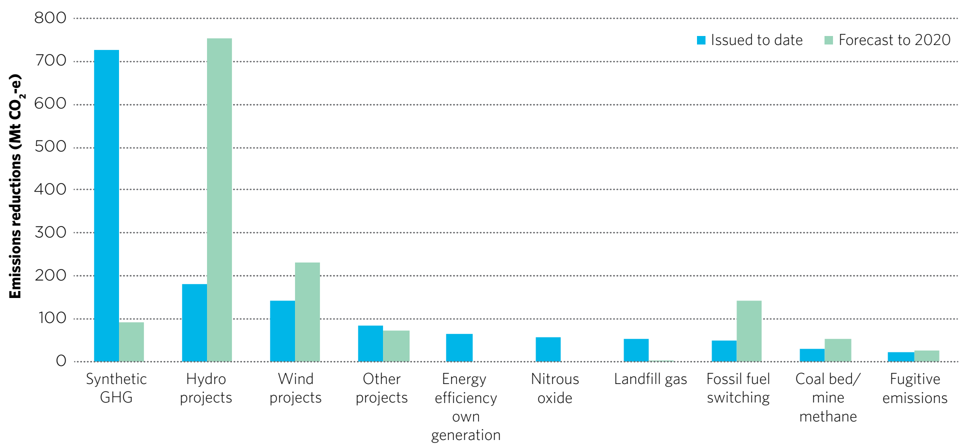
Australia negotiated access to EU allowances as part of the carbon pricing mechanism. If this legislation is repealed, EU allowances are unlikely to be available to Australia, so the Authority has focused its analysis on the CDM.

## 12.3.1 CDM UNITS

The CDM supports a wide range of projects from developing countries. Some of the projects able to produce CDM units include rural electrification projects that use solar panels, the installation of more energy-efficient boilers and power generated from agricultural waste.

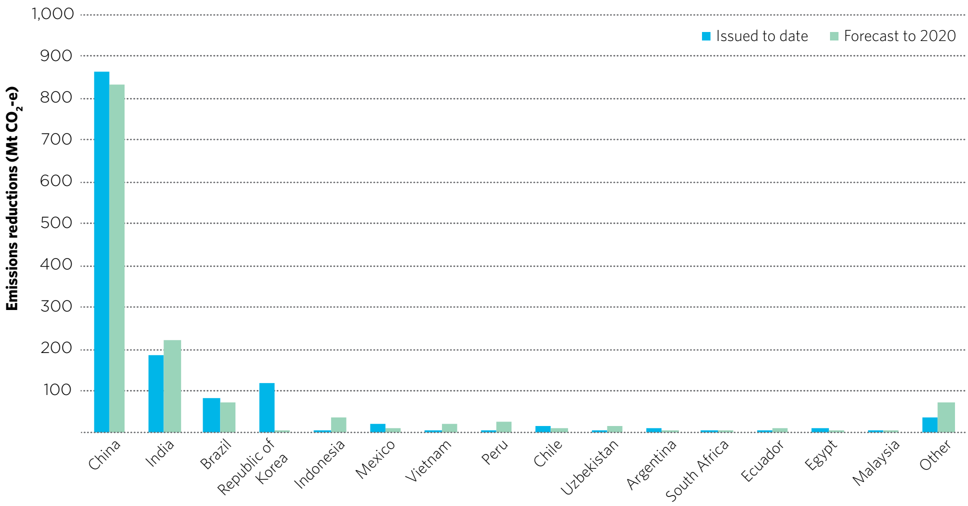
Figure 12.1 shows that most of the CDM units issued to date have come from destroying synthetic GHGs (about 52 per cent of total), hydro (13 per cent) and wind projects (10 per cent). Through to 2020, hydro projects are forecast to become the major source of CDM units (55 per cent of total), followed by wind (17 per cent) and destroying synthetic GHGs produced by industry (7 per cent). The share of synthetic GHG projects declines to 2020 as many markets, including the EU ETS, are refusing to accept them. Figure 12.2 shows that most of the CDM units issued to date are from China (61 per cent), followed by India (13 per cent), the Republic of Korea (8 per cent) and Brazil (6 per cent). China is expected to remain the major source through to 2020.

**FIGURE 12.1:** CDM UNITS BY TECHNOLOGY




**Source:** BNEF 2014

**FIGURE 12.2:** CDM UNITS BY COUNTRY




**Source:** BNEF 2014

## 12.3.2 THE PRICE OF CDM UNITS

There is currently a large number of CDM units available at low cost. The price is now less than A$1 per tonne (BNEF 2014). The low price of CDM units does not imply they are not credible—prices were about A$35 in 2008. Like other tradable commodities, the price movement of CDM units is subject to changing market demand and supply fundamentals. The dramatic decline is largely due to weakened demand from the EU—the main buyer of CDM units. The EU economic crisis has caused EU emissions to fall, so fewer international emissions reductions are required to meet its targets.

A large number of CDM projects was registered when the price was higher and these are still generating credible emissions reductions. If the price rises slightly, more units are likely to be available, as current prices are less than the cost of having credits issued for some projects. BNEF (2014) estimates that a price increase to about A$7 would encourage the supply of at least an additional two billion tonnes of CDM units.

Sufficient CDM units are likely to be available to satisfy both future EU ETS demand and other remaining demand centres, including Australia, without significantly increasing the price.

## 12.3.3 WHICH CDM UNITS TO USE?

To enhance the integrity of the CDM units used, Australia could choose to exclude units from projects with environmental or developmental concerns. This would be similar to the approach taken by the EU, which excludes units from nuclear energy projects, afforestation or reforestation activities, large-scale hydro projects and, from 2013, projects involving the destruction of synthetic GHGs.

The reasons these units are excluded vary. Some are excluded for developmental concerns; for example, large-scale hydroelectric generation projects can displace local communities, and lead to loss of agricultural land and a decline in biodiversity.

Carbon Market Watch, a non-government organisation that monitors the global carbon market, has also raised concerns about coal-fired power plant projects, which could lock in more emissions-intensive infrastructure.

The government could choose to exclude a sub-set of CDM units if it shared these concerns. Even if it did so, the CDM would still be a cost-effective source of emissions reductions. Large amounts of credible units are likely to be available to 2020 at a low cost.

In addition to purchasing units on the secondary market, the government could choose to support the establishment of new projects in specific countries to enhance its trade, foreign policy and aid objectives. The outlays for these purchases are likely to be higher as they would need to cover their establishment costs. However, many such projects are still likely to be cheaper than an increasing reliance on domestic emissions reductions in Australia.

## 12.4 INTERNATIONAL EMISSIONS REDUCTIONS AND THE DIRECT ACTION PLAN

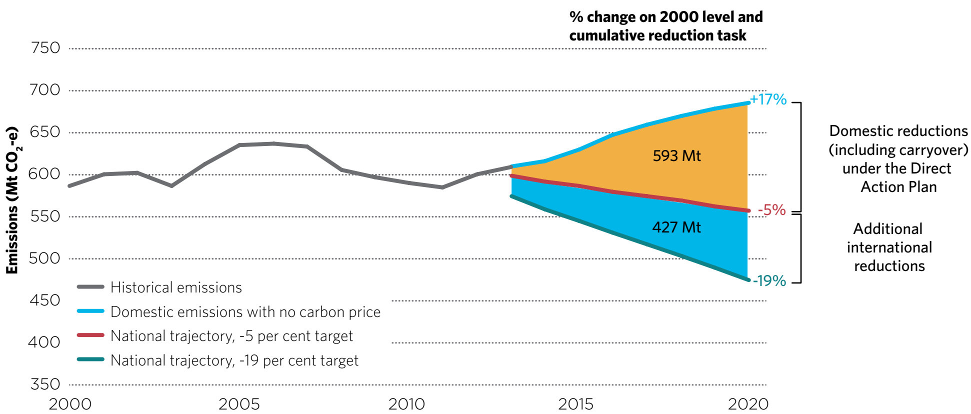
The government intends through its Direct Action Plan to reduce Australia's domestic emissions by 5 per cent from 2000 levels by 2020.

International emissions reductions could be a useful complement to domestic efforts. The central mechanism of the government's Direct Action Plan is the Emissions Reduction Fund. This has a fixed budget and it is unclear precisely how many tonnes of emissions it will reduce. Some analysis (see, for example, RepuTex 2013) suggests the currently committed funding will be insufficient to reduce emissions by 5 per cent. The Authority considers international emissions reductions would be a useful and low-cost way to help ensure Australia achieves its minimum 5 per cent target.

The government has not stated how it would meet stronger targets.

The Authority's analysis shows that there are many opportunities to reduce emissions in Australia, but they are likely to require a relatively high price per tonne. Using international emissions reductions to 'fill the gap' between the 5 per cent domestic reduction and the recommended target would be a cost-effective way for Australia to take responsible climate change action. Figure 12.3 shows the balance of domestic emissions reductions required to meet the 5 per cent target and the additional international reductions used to meet the recommended goals.

**FIGURE 12.3:** EMISSIONS REDUCTIONS REQUIRED TO MEET 5 PER CENT TARGET AND RECOMMENDED GOAL




**Source:** Climate Change Authority based on Treasury and DIICCSRTE (2013)

### 12.4.1 ESTABLISHING A GOVERNMENT FUND

The government could access international emissions reductions by establishing a fund and managing it directly. Other countries have taken this approach; for example, Norway uses the state-owned Nordic Environment Finance Corporation fund to purchase international emissions reductions.

Alternatively, the government could use an intermediary like the World Bank to purchase CDM units based on specified criteria on its behalf. The World Bank has extensive experience in purchasing international emissions reduction units on behalf of governments and companies. The Netherlands and Spain have both provided funding to the World Bank to purchase CDM units on their behalf from a particular set of projects including renewable energy, biomass, energy efficiency improvement, fossil fuel switching, methane recovery and sequestration.

The size of the fund would depend on the volume of international emissions reductions required and their price. As discussed in Section 10.4, if the minimum 5 per cent target is achieved domestically, an additional 427 Mt of reductions would be needed to meet the Authority's recommended 2020 target (Figure 12.3). CDM unit prices of A$0.50 would require a government fund of about A$210 million. If CDM unit prices rose substantially, say to A$2, the required fund would be about A$850 million.

In addition to direct purchase, the government could allow some private purchase of international emissions reductions. The government's Green Paper on the Emissions Reduction Fund leaves open the possibility of using international emissions reductions for 'make-good' and 'safeguarding' arrangements. Many stakeholders support this approach; for example, the Australian Industry Greenhouse Network recommends: 'If companies find themselves with a liability, Direct Action compliance arrangements should consider the possibility of acquittal using CFI permits and/or international permits' (AIGN response to the ERF White Paper Terms of Reference, p. 9).

**RECOMMENDATIONS**

**R.11** The government use international emissions reductions to bridge any gap between domestic reductions achieved under the Direct Action Plan and the recommended 2020 goals.

**R.12** The government establish a fund to purchase Clean Development Mechanism units to complement the Direct Action Plan and help meet the recommended 2020 goals.

# E

# IMPLEMENTATION ISSUES UNDER THE CARBON PRICING MECHANISM

Australia's climate policy settings are under review. The Commonwealth Government has indicated it intends to repeal the carbon price and implement the Direct Action Plan to reduce Australia's emissions.

Nevertheless, under the current legislative arrangements, the Authority is required to recommend caps for the carbon pricing mechanism. The mechanism is the primary way Australia would meet its 2020 targets, imposing a limit on more than half of Australia's emissions. There are many factors to consider when calculating and recommending caps, including the national emissions reduction goals. Chapter 13 examines those factors and calculates caps corresponding to the Authority's recommended 2020 goals.

# CAPS FOR THE CARBON PRICING MECHANISM 13

The Authority is required to recommend five years of annual caps under the Clean Energy Act. While this legislative requirement persists, the Authority acknowledges that the government intends to repeal the carbon price and replace it with the Direct Action Plan to reduce Australia's emissions.

Caps under the carbon pricing mechanism limit emissions from electricity generation, direct combustion, landfills, wastewater, industrial processes and fugitive emissions.

Chapter 13 recommends caps consistent with the Authority's 2020 target recommendations (15 per cent plus carryover). The caps take account of estimated emissions from sources outside caps, uncertainty in emissions estimates, free allocation of emission units and limits on the use of international units. The chapter discusses:

- the carbon pricing mechanism and the role of caps
- considerations in estimating the budget available for caps
- the year-by-year shape of caps.

Further details, including calculation methodologies and data, are set out in Appendix E.

## 13.1 THE CARBON PRICING MECHANISM AND THE ROLE OF CAPS

The carbon pricing mechanism was established under the Clean Energy Act and covers more than half of Australia's emissions. Entities in covered sectors pay the carbon price if they emit at least 25 kt $CO_2$-e annually. The remaining uncovered sectors are subject to an equivalent carbon price or do not face a carbon price (Table 13.1).

**TABLE 13.1:** COVERAGE OF THE CARBON PRICING MECHANISM

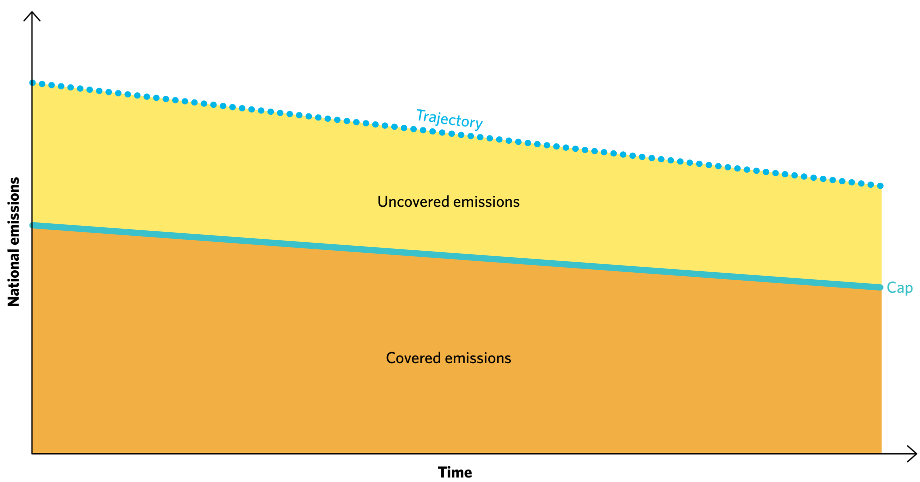
| CARBON PRICING MECHANISM | EQUIVALENT CARBON PRICE | NO CARBON PRICE[2] |
|---|---|---|
| Emissions above the annual 25 kt $CO_2$-e threshold from:<br>• electricity generation<br>• direct combustion[1]<br>• industrial processes<br>• waste deposited since July 2012<br>• fugitive emissions. | Transport fuels used for:<br>• domestic aviation<br>• marine transport<br>• rail transport<br>• business in off-road transport<br>• non-transport business uses.<br>Synthetic greenhouse gases. | Emissions from:<br>• agriculture<br>• LULUCF<br>• waste deposited before July 2012<br>• fugitive emissions from decommissioned mines<br>• conventional road transport<br>• entities in sectors covered by the carbon pricing mechanism that fall below the 25 kt $CO_2$-e threshold |

**Notes:** (1) Direct combustion excludes diesel, which is covered by the equivalent carbon price (unless opted in). (2) Sources in the agriculture, land and waste sectors are eligible to create carbon offsets under the CFI.

Under the existing legislation, the carbon pricing mechanism has a three-year fixed-price period from 1 July 2012 to 30 June 2015. When the fixed-price period ends, the legislation provides for annual caps on emissions covered by the carbon pricing mechanism ('covered emissions'). The gap between the national emissions trajectory and cap allows room in the national emissions budget for emissions from sources outside the carbon pricing mechanism ('uncovered emissions') (Figure 13.1).

The cap determines the total number of Australian carbon units for a particular year to be issued by the government. These units would be provided to entities as a free allocation or sold at auction, generating government revenue.

**FIGURE 13.1:** THE RELATIONSHIP BETWEEN THE TRAJECTORY, CAP AND EMISSIONS




**Source:** Climate Change Authority

If covered emissions exceed the caps, liable entities can purchase international units or domestic offsets to make up the difference. Approved international units can be surrendered to meet up to 50 per cent of an entity's carbon liability; these units include EUAs and Kyoto units (units generated under the Kyoto Protocol). A sub-limit of 12.5 per cent applies to Kyoto units. Domestic offsets or ACCUs are generated under the CFI.

Under the Clean Energy Act, the Authority must recommend five years of caps, taking account of:

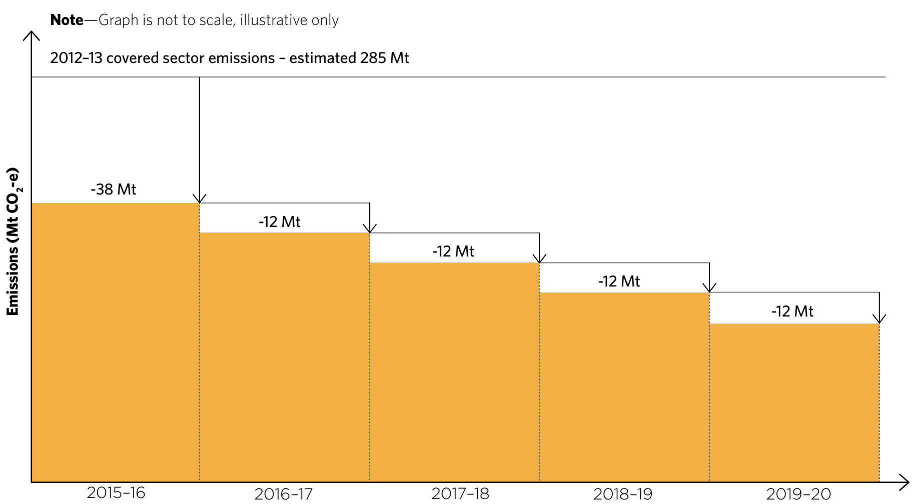
- voluntary action to reduce Australia's greenhouse gas emissions
- estimates of greenhouse gas emissions that are not covered by the Clean Energy Act
- the extent (if any) of non-compliance with the Clean Energy Act and the associated provisions
- the extent (if any) to which liable entities have failed to surrender sufficient units to avoid liability for unit shortfall charge
- any acquisitions, or proposed acquisitions, by the Commonwealth of eligible international emissions units.

The current legislation requires the minister responsible for climate change to take the Authority's advice and recommendations into consideration when setting caps, and to announce caps five years in advance.

In the event that regulations setting the caps are not made or are disallowed, the Clean Energy Act provides for default caps. The first annual default cap equals total emissions covered by the carbon pricing mechanism in 2012–13, minus 38 million tonnes. Following this, for each year that regulations were not made, the annual cap would be 12 Mt less than the previous compliance year (Figure 13.2).

Default caps were originally designed to be broadly consistent with the unconditional 5 per cent target. Since then, the 2000 base year emissions and carryover estimates have been revised up, and projections for covered emissions for 2012–13 have been revised down. Based on the Authority's current assessment, default caps are now broadly consistent with reaching a 15 per cent target in 2020, or 19 per cent including carryover.

**FIGURE 13.2: DEFAULT CAP ARRANGEMENTS UNDER THE CARBON PRICING MECHANISM**




**Source:** Climate Change Authority

## 13.2 OVERVIEW OF THE AUTHORITY'S APPROACH TO CAPS

The Authority's recommended annual caps are consistent with its recommended national budget to 2020 (Box 13.1).

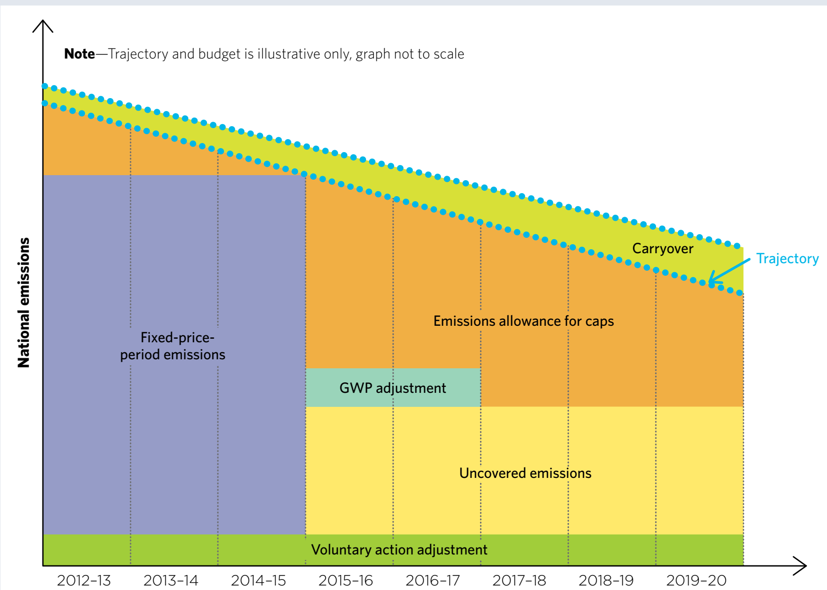
To this end, the Authority takes the national budget for the period 2013–2020 (4,193 Mt $CO_2$-e as recommended in Chapter 9) and adds 116 Mt $CO_2$-e for carryover. It then determines how much of the budget to reserve for emissions from the fixed-price period and uncovered emissions from the flexible-price period. The remainder of the budget is available for caps and can be distributed across the flexible-price period to 2020. This approach gives confidence that Australia's total net emissions will stay within its 2020 budget.

### BOX 13.1: FRAMEWORK FOR CALCULATING CAPS

In determining the number of units available for caps, the Authority has applied the following approach:

Emissions allowance for caps = National emissions budget (2013–2020) **plus** carryover **minus** aggregate emissions from the fixed-price period **minus** uncovered emissions in the flexible-price period **minus** adjustment for Global Warming Potentials (GWPs) **minus** adjustment for voluntary action (see Figure 13.3).

### FIGURE 13.3: FRAMEWORK FOR CALCULATING CAPS




**Note:** The area under the trajectory is equal to the national emissions budget (2013–2020).
**Source:** Climate Change Authority

The Authority has used its best estimate of uncovered emissions, assuming existing legislation, to calculate caps. That is, the share of the budget allocated to uncovered emissions will be determined by a projection of what those emissions will actually be.

An alternative approach, suggested by the Business Council of Australia (BCA), is to set caps based on a relative share of covered and uncovered sectors in BAU emissions. BCA argued that this would 'avoid a disproportionate shifting of the abatement burden onto covered sectors' (*Draft Report submission*, p. 2).

The Authority does not propose to adopt this approach because:

- encouraging equal shares of emission reductions across sectors is the wrong goal—it would not promote efficiency because different sectors have different emissions reduction costs
- it relies on estimates of BAU emissions. Many emissions reduction policies have been in place for years, and have changed Australia's economy and emissions in permanent ways. As a result, BAU becomes an increasingly abstract concept over time
- it would not give a high likelihood of Australia meeting its national emissions budget. If the approach required uncovered sectors to deliver a certain amount of emissions reductions, but no policies were in place to ensure that happened, Australia would breach its budget.

This does *not* mean that the Authority considers that uncovered sectors have no role in meeting the national emissions budget, or that existing policies in uncovered sectors are ideal. The overall policy mix should be reviewed regularly and policies in uncovered sectors should deliver an equivalent incentive to reduce emissions as the covered sectors face.

Even so, the Authority does not consider that its approach would impose a disproportionate burden on covered sectors. Uncovered sectors already contribute to reducing Australia's emissions. For example, between 1990 and 2012, emissions from the land sector (an uncovered sector) fell by 85 per cent, while emissions from electricity (a covered sector) increased by 53 per cent (see discussion in Chapter 6). Further, as discussed in Chapter 10, the level of the cap is not expected to have a material effect on the level of the carbon price (the burden that matters to firms) because of links to international carbon markets. As a result, the level of the cap would be unlikely to materially affect the burden faced by the covered sectors. The most significant impact is, instead, on government revenue—giving the government a good incentive over time to ensure that appropriate policies apply to all sectors.

## 13.3 ESTIMATING EMISSIONS OUTSIDE THE CAPS

To estimate emissions outside the caps, the Authority must consider:

- carryover of emissions rights from the first commitment period of the Kyoto Protocol
- fixed-price-period emissions for the whole economy
- uncovered emissions during the flexible-price period, taking into account
  - emissions that do not face the carbon price
  - emissions that are subject to the equivalent carbon price
  - emissions associated with non-compliance and payment of the shortfall charge
- voluntary action and other adjustments.

The Authority has used the economic modelling discussed in Chapter 10 and Appendix F to estimate emissions. The medium scenario represents the best estimate of global and national economic activity. It provides the best estimate of emissions to 2020 and has been used as the basis for calculating caps. Other scenarios have been used to test whether the resulting caps are robust across a range of possible future carbon market conditions.

## 13.3.1 CARRYOVER FROM THE FIRST COMMITMENT PERIOD OF THE KYOTO PROTOCOL

As outlined in Chapter 7, the Authority recommends carryover from the first commitment period of the Kyoto Protocol be used to strengthen the 2020 target by 4 percentage points. The recommended national emissions budget (2013–2020) is based on a 19 per cent target (15 per cent plus carryover). For the purpose of setting caps, carryover is added to this budget. As a result, the recommended caps are essentially the same as for a 15 per cent target.

## 13.3.2 WHOLE-OF-ECONOMY EMISSIONS DURING THE FIXED-PRICE PERIOD

The Authority has estimated the whole-of-economy emissions that are likely to occur under the three-year fixed-price period, since none of these emissions are covered by the caps. These emissions are subtracted from the national emissions budget for 2013–2020 to determine the emissions available for caps. Based on the modelling, the Authority estimates fixed-price emissions to be 1,784 Mt $CO_2$-e.

## 13.3.3 UNCOVERED EMISSIONS DURING THE FLEXIBLE-PRICE PERIOD

The Authority has estimated the emissions from sources not covered by the carbon pricing mechanism. As set out in Table 13.1, some uncovered emissions do not face a carbon price at all; others face the equivalent carbon price.

### EMISSIONS THAT DO NOT FACE A CARBON PRICE

The Authority has made a best estimate of emissions from sectors that do not face a carbon price, and then added estimated CFI credits and 'below-threshold' emissions.

- The CFI is a carbon offset scheme. CFI projects reduce uncovered emissions, but allow for an equivalent increase in covered emissions through the generation and use of ACCUs. To avoid double-counting, the Authority needs to add the credited emissions reductions back to uncovered emissions.
- Facilities in sectors covered by the carbon pricing mechanism that emit less than the 25 kt $CO_2$-e threshold do not face a liability; these are referred to as 'below-threshold' emissions and fall outside the caps. Below-threshold emissions are difficult to estimate because many of those facilities are not required to report their emissions. The Authority has estimated below-threshold emissions by comparing covered emissions from the national inventory with emissions that are liable under the carbon pricing mechanism.

### EMISSIONS SUBJECT TO AN EQUIVALENT CARBON PRICE

Some liquid fuel use for the transport sector and synthetic GHGs are subject to the equivalent carbon price. The Authority has made a best estimate of emissions from these sectors, deducting estimated 'opt-in' emissions.

'Opt-in' arrangements allow large end-users of fuel to voluntarily take on direct liability under the carbon pricing mechanism rather than face the equivalent carbon price. When entities choose to opt in, their emissions move from outside to inside the caps. This, in turn, makes more of the national emissions budget available for caps. Opting in during the fixed-price period allows liable entities to pay a lower carbon price on average over the year (as they can defer payment of their carbon cost to the end of the financial year rather than pay monthly). These benefits diminish in the flexible-price period; however, companies that opt in still have greater flexibility to manage their carbon liability.

The Authority considers that entities that have already opted in are likely to remain within the carbon pricing mechanism. In the future, some additional entities might opt in, particularly very large fuel users. The Authority has made a best estimate on this basis.

#### EMISSIONS SUBJECT TO NON-COMPLIANCE AND THE SHORTFALL CHARGE

The Authority has considered whether to make an allowance for non-compliance or payment of the shortfall charge. These relate to emissions that should be covered by the cap but may not be. Under the carbon pricing mechanism, liable entities are required to surrender an eligible unit, or pay the shortfall charge, for every tonne they emit. If they choose to pay the shortfall charge or simply do not comply, they would not surrender emission units and those emissions would be outside the cap.

The legislation creates strong incentives for liable entities to comply and surrender eligible units. For example, the unit shortfall charge is double the benchmark average auction price for Australian carbon units during the particular compliance year, making it unlikely that entities would choose to pay the shortfall charge. Non-compliance is also unlikely as legal penalties apply and the rate of compliance for similar legislation has been close to 100 per cent. As a result, most liable entities would be likely to surrender emissions units. The Authority therefore assumes emissions associated with non-compliance and payment of the unit shortfall charge are zero when recommending caps to 2020. If future non-compliance rates proved to be material, caps could be adjusted over time to account for this.

#### CALCULATING UNCOVERED EMISSIONS

Considering all these factors, the Authority estimates uncovered emissions during the flexible-price period to 2020 to be 1,385 Mt $CO_2$-e.

### 13.3.4 VOLUNTARY ACTION AND OTHER ADJUSTMENTS

The Authority has considered:

- accounting discrepancies between the carbon pricing mechanism, the CFI and the national greenhouse gas inventory
- voluntary action—accounting for GreenPower and the voluntary cancellation of renewable energy certificates
- government purchase of international units.

#### ACCOUNTING DISCREPANCIES—CHANGES IN GLOBAL WARMING POTENTIALS

The emissions reporting system used for the carbon pricing mechanism and the CFI is currently based on global warming potentials (GWPs) used to account for emissions in the first commitment period of the Kyoto Protocol. The international community has agreed to update GWP values for targets in the second commitment period; however, the accounting system used in the carbon pricing mechanism and the CFI will not be revised until 2017–18. As a result, there will not be a one-for-one relationship between the existing legislated policy (that is, the carbon pricing mechanism and the CFI) and the national emissions budget for the first two years of the flexible-price period.

The Authority has made its best estimate of this discrepancy and deducted 16 Mt $CO_2$-e from the budget.

#### VOLUNTARY ACTION—ACCOUNTING FOR GREENPOWER AND THE VOLUNTARY CANCELLATION OF RENEWABLE ENERGY CERTIFICATES

As outlined in Section 7.3.3, the Authority considers three types of voluntary action should be recognised as additional to the national target—voluntary cancellation of domestic emissions units, GreenPower purchases and the voluntary cancellation of renewable energy certificates (RECs) created under the RET.

Only GreenPower purchases and the voluntary cancellation of RECs need to be considered when calculating caps. Voluntary cancellation of domestic units reduces caps directly; in contrast, GreenPower purchases and the voluntary cancellation of RECs reduce emissions from electricity generation, which is covered by the caps.

The Authority has made a best estimate of GreenPower purchases and voluntary REC cancellations over the period, and deducted 16 Mt $CO_2$-e from the budget.

### GOVERNMENT PURCHASE OF INTERNATIONAL UNITS

While the carbon pricing mechanism allows liable entities to buy and use certain international units, the government could also purchase international units directly. The Authority recommends government purchase under the proposed new policy arrangements to help meet the recommended target (Chapter 12). This is not necessary under the carbon pricing mechanism as liable entities would buy the units instead. The Authority has therefore assumed no government purchase in its recommended caps.

## 13.4 MANAGING UNCERTAINTY IN EMISSIONS ESTIMATES

All estimates in the previous section are based on projected future levels of emissions. Actual emissions will inevitably be higher or lower than these estimates. If actual emissions are higher than estimated, Australia's emissions could exceed the national budget to 2020. If actual emissions are lower, Australia would more than meet its budget to 2020, and the surplus units could be carried over and used after 2020.

The Authority's objective is to recommend caps to meet the 2020 budget, so its primary concern is whether actual emissions would be higher than estimated. If there is a material risk that uncovered emissions would be higher, the Authority could incorporate a buffer to guard against the risk. This approach has some support among stakeholders.

In the past, national emissions projections have tended to be too high rather than too low. For example, the Authority found that emissions projections for the first commitment period of the Kyoto Protocol overestimated emissions from uncovered sectors by 13 per cent on average. Further, future emissions drivers are reasonably well understood and represented in the models used. This suggests uncovered emissions are unlikely to be higher than estimated in the Authority's modelling.

Emissions trends could vary if policies affecting uncovered emissions change; however, the Authority has made a best estimate based on existing legislative settings. If policies strengthened, this would decrease emissions, and Australia would more than meet its emissions budget.

On balance, given the history of overestimation, the Authority considers there is no need to create an emissions buffer under currently legislated policy.

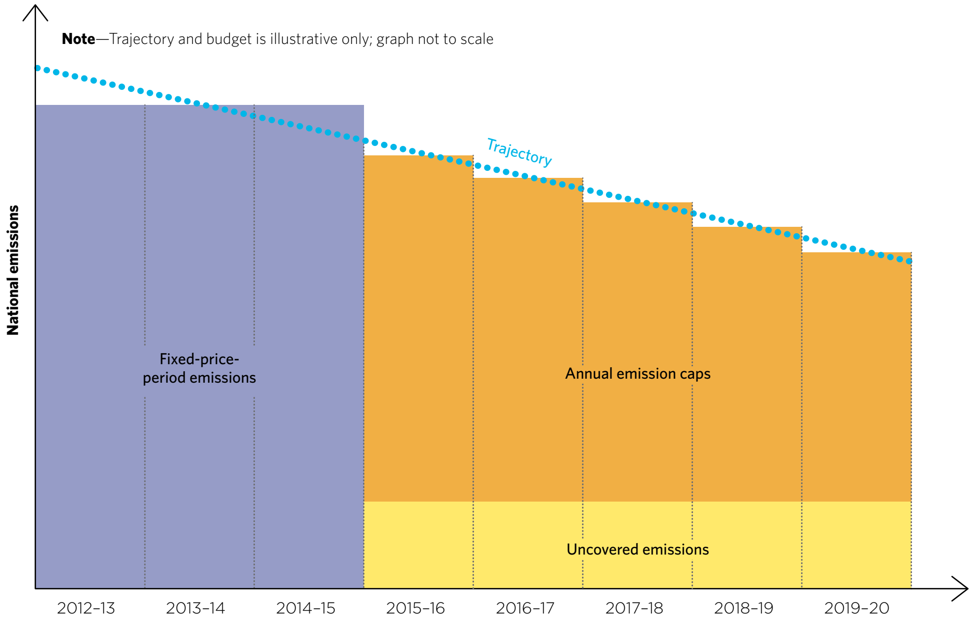
Taking account of the adjustments in Section 13.3, from the total national emissions budget for the period 2013–2020, 1,108 Mt $CO_2$-e is available for caps to 2020.

## 13.5 YEAR-BY-YEAR SHAPE OF CAPS

After estimating the proportion of the 2020 budget available for caps, the Authority needs to consider the year-by-year pathway or 'shape' of caps.

The Authority considers that, in general, the shape of caps should follow the slope of the trajectory on a year-by-year basis (Figure 13.4). This is a straightforward and predictable approach that clearly aligns caps with national emissions reduction goals.

**FIGURE 13.4:** SHAPE OF CAPS—RELEASING CARBON UNITS IN LINE WITH THE TRAJECTORY




**Source:** Climate Change Authority

In some circumstances, it may be appropriate to change the shape of the caps. As stakeholders, including the Australian Industry Group (*Issues Paper submission*, p. 6), noted, it may be appropriate to reshape either when caps are:

- insufficient to accommodate the free allocation and early auction of Australian carbon units
- at a level that could affect the carbon price, due to limits on international units.

## 13.5.1 ENSURING SUFFICIENT UNITS ARE AVAILABLE FOR FREE ALLOCATION AND EARLY AUCTION

To ensure consistency with the design of the carbon pricing mechanism, caps should be large enough to accommodate the allocation of free carbon units under the Jobs and Competitiveness Program and the Energy Security Fund, and the scheduled early auction of carbon units. Where caps based on the slope of the trajectory are not sufficient to cover these allocations, the Authority would redistribute units across the period.

For the Authority's recommended target, caps that follow the trajectory are likely to be sufficient to cover free allocation and early auction, so no reshaping is required.

## 13.5.2 ENSURING SUFFICIENT UNITS ARE AVAILABLE TO MINIMISE THE IMPACT ON THE CARBON PRICE

The Authority identified two potential ways in which caps could influence the level of the carbon price, which could be addressed through shaping caps.

First, caps affect whether the 12.5 per cent sublimit on Kyoto units is binding. Kyoto units are currently cheap and abundant, trading well below European prices. If liable entities are unsure whether they need to use the full 12.5 per cent allowance, the carbon price in Australia could be volatile, fluctuating between the Kyoto unit price and the European price. This could be avoided by shaping caps to ensure the sublimit was binding in every year.

The Authority's analysis indicates the Kyoto sublimit is likely to bind in all years under its recommended target, so there is no need to reshape caps.

Second, caps affect whether the overall 50 per cent limit on international units is binding. This limit applies until 2020. If domestic units are in short supply, and the 50 per cent limit becomes binding, the price of domestic units would need to rise above the European price. Caps could be shaped across the period to minimise the risk that the 50 per cent limit would bind in any year.

The Authority's analysis indicates the 50 per cent import limit is not likely to bind in any year, so there is no need to reshape caps.

## 13.6 RECOMMENDED CAPS

Taking into account the issues discussed in this chapter, caps are recommended for the five years from 2015–16 to 2019–20. Table 13.2 outlines the 2020 budget that is available for caps under its recommended target.

**TABLE 13.2:** BUDGET AVAILABLE FOR CAPS

| | |
|---|---|
| National budget (2013-2020) | 4,193 |
| Carryover (from first Kyoto Protocol commitment period | +116 |
| Fixed-price-period emissions (2013-2015) | –1,784 |
| Uncovered emissions (2016-2020) | –1,385 |
| Global Warming Potentials adjustment | –16 |
| Voluntary action (GreenPower and voluntary cancellation of renewable energy certificates) | –16 |
| Government purchase of international units | 0 |
| **Available for caps** | **1,108** |

**Note:** All figures in Mt $CO_2$-e. Totals may not sum due to rounding. Uncovered emissions include CFI estimates.
**Source:** Climate Change Authority, based on data from Treasury and DIICCSRTE 2013, Department of the Environment 2013, GreenPower 2013 and the Clean Energy Regulator

**RECOMMENDATION**

**R.13** Carbon pollution caps for each of the first five years of the flexible-price period under the carbon pricing mechanism of:

| Year | Cap (Mt $CO_2$-e) |
|---|---|
| 2015–16 | 234 |
| 2016–17 | 228 |
| 2017–18 | 222 |
| 2018–19 | 215 |
| 2019–20 | 209 |

# APPENDICES

# A

# PUBLIC CONSULTATION

The Authority is required to conduct public consultation for all of its reviews.

The Authority engaged with climate scientists, industry, government and non-government organisations and the general public throughout the course of the Targets and Progress Review.

On 1 March 2013, the Authority held a Global Emissions Budgets Roundtable, which was attended by climate experts and Authority members. A summary of the roundtable, as well as presentations made by the experts who attended, is available on the Authority's website.

On 23 April 2013, the Authority released an Issues Paper, which can be accessed on the Authority's website. The Authority made presentations on the Issues Paper at 19 forums around Australia hosted by industry, environment and community organisations. About 70 submissions were received from a wide range of stakeholders as part of the Issues Paper submissions process.

On 12 and 15 August 2013, the Authority hosted stakeholder roundtables on issues relating to the electricity sector.

On 30 October 2013, the Authority released a Draft Report. Feedback was sought from stakeholders on draft recommendations and other issues presented in the report. About 140 stakeholder submissions were received from individuals and organisations, and approximately 12,500 additional submissions were made as part of a GetUp! campaign. The Authority held four stakeholder roundtables in Canberra, Melbourne and Sydney, and made presentations on the Draft Report at seven stakeholder-hosted or public events. A public webinar was conducted on 13 November 2013.

In addition to specific consultation activities, the Authority conducted less formal consultation with interested parties and government agencies. This included one-on-one meetings with interested stakeholders and regular liaison and collaboration with Commonwealth Government agencies. The Authority also consulted with state and territory government departments.

Public consultation was conducted by the Treasury and DIICCSRTE on the economic modelling conducted to support this Review. Public comments on a range of key assumptions for the electricity, fugitive, transport and agriculture sectors were invited between April and May 2013. DIICCSRTE also held two consultation workshops with sectoral experts and received five public submissions on assumptions.

Public submissions made over the course of the review can be accessed through the Authority's website. Stakeholders who made submissions to the Issues Paper and Draft Report are listed on the following pages.

| LIST OF SUBMITTERS | |
|---|---|
| ACT Government Environment Sustainable Development | ACT Greens |
| Act on Climate | AGL Energy Limited |
| Alan Pears | Ali Rayner |
| Alinta Energy | Animal Justice Party |
| Anthony Hudson | ANU Centre for Climate Law & Policy |
| Australian Petroleum Production and Exploration Association | Australian Aluminium Council |
| Australian Chamber of Commerce and Industry | Australian Conservation Foundation |
| Australian Energy Market Operator | Australian Industry Greenhouse Network |
| Australian Industry Group | Australian Petroleum Production and Exploration Association |
| Australian Religious Response to Climate Change | Australian Youth Climate Coalition |
| Baw Baw Sustainability Network | Bridget McIntosh |
| Business Council of Australia | C & L Evans |
| Capricorn Conservation Council | Caroline Le Couteur |
| Cement Industry Federation | Charlene Grainger |
| Chelsea Heights EarthCarers | Chris Bailey |
| Christopher Royal | Clean Energy Council |
| Climate Action Network Australia | Climate and Health Alliance |
| Climate Realists | Climate Sense |
| ClimateWorks Australia | Conservation Council of South Australia |
| Conservation Councils of Australia | Coronium |
| Craig Austin | Dandenong Ranges Renewable Energy Association |
| Danielle Georgette | Darebin Climate Action Now |
| Darebin Climate Action Now on behalf of community climate action groups of Australia | Dave Pepper |
| David Arthur | David Eckstein |
| David Hamilton | David Margerison |
| David Rossiter | David Russell |
| David Strong | David Tranter |
| David White | Deanna Howland |
| Doctors for the Environment Australia | Dominic Eales |
| Don McArthur | Don Young |
| Dr Colleen Watts | Dr Ian McGregor |
| Dr Jeremy Moss | Dr John White |
| Eastern Alliance for Greenhouse Action | Eastern Melbourne Climate Action Group |
| Elsa Mardones | Energy Supply Association of Australia |
| EnergyAustralia | Evan Hunter |

| LIST OF SUBMITTERS | |
|---|---|
| Frank Jotzo | Friends of the Earth Australia |
| Gary Ellett | Gavan Mcdonell |
| GetUp! | GetUp! campaign submissions (over 12,500 submissions received) |
| Gillian King | Giselle Wilkinson |
| Gold Coast and Hinterland Environment Council | Grattan Institute |
| Green Building Council of Australia | Gujji Muthuswamy |
| Harald Winkler | Healesville Environment Watch Inc. /C4 |
| Hydro Tasmania | Iain Murchland |
| Ian Dunlop | Ian Enting |
| Ian Lowe | Institute of Chartered Accountants Australia |
| Investor Group on Climate Change | Jacqueline Fetchet |
| James Ness | James Wight |
| Jane Thompson | Jason Thomas |
| Jim Allen | Joe Hallenstein |
| Joel Dignam | John Gare |
| Julian Stirling | Kate Holmes |
| Kathryn Skelsey | Kim Peterson |
| Lachlan Fraser | Leslie Shirreffs |
| Lighter Footprints Climate Action Group | Logan and Albert Conservation Association |
| Mark Zanker | Marrickville Council |
| Matt Mushalik | Meg Sobey |
| Michael O'Flynn | Mike Wallis-Smith |
| Minerals Council of Australia | Monash Sustainability Institute |
| Mornington Peninsula Shire | Natalie Bragg |
| Nigel Fox | Nimbin Environment Centre |
| Noel Maud | North Queensland Conservation Council |
| Northern Alliance for Greenhouse Action | Optima Trade Pty Ltd |
| Origin Energy Limited | Oxfam Australia |
| Peggy Fisher | Phil Evans |
| Pranee Howland | Public Health Association of Australia |
| Quakers Australia | Queensland Conservation |
| Rathburnie State Nature Refuge | Rebecca Sharpe |
| Regnan Governance Research & Engagement Pty Ltd | Richard Begbie |
| Richard Gardiner | Richard Hayward |
| Rob & Jan Ridgwell | Robin Friday |

| LIST OF SUBMITTERS | |
|---|---|
| Roger M Gifford | Roland Riese |
| Ross Garnaut | Russell Warman |
| Samantha Cooper | Santos |
| Save the Planet | Shiny Things |
| Simon Holmes à Court | Simon Thompson |
| SolarShare | South East Councils Climate Change Alliance |
| Southern Cross Climate Coalition | Steve Tierney |
| Sustainable Business Australia | Sustainable Engineering Society |
| Sustainable Population Australia | Synengco Pty Ltd |
| The Climate Institute | The National Farmers' Federation |
| Tiffany Harrison | Transition Newcastle |
| Uniting Church in Australia | Western Alliance for Greenhouse Action |
| William Crowe | William Menzies |
| William Plain | Wodonga Albury Towards Climate Health |
| Wrights for Action | WWF-Australia |
| Yarrow Andrew | Yasir Assam |

B

# GLOBAL ACTION TO REDUCE GREENHOUSE GAS EMISSIONS

## APPENDIX B1 INTERNATIONAL CLIMATE INSTITUTIONS

### B1.1 UNFCCC

The United Nations Framework Convention on Climate Change entered into force in 1994. With 195 Parties, it has one of the most universal memberships of any international treaty. UNFCCC achievements are set out in Box B.1 below.

The Kyoto Protocol to the UNFCCC was adopted in 1997. This established specific targets for developed (Annex I) countries to reduce their greenhouse gas emissions. For most Annex I Parties, these targets are expressed as a percentage reduction from a 1990 baseline over the period 2008–2012 (the 'first commitment period'). As well as the Kyoto Protocol, countries (developed or developing) can put forward 2020 pledges to reduce or limit emissions under the UNFCCC. Australia has both a Kyoto Protocol target and a target pledge under the UNFCCC.

**BOX B.1: UNFCCC ACHIEVEMENTS**

- All countries have agreed in the UNFCCC to work together to prevent dangerous climate change. A global goal has been agreed of holding the increase in average global temperatures to below 2 degrees above pre-industrial levels. A review of this goal in 2013–15 will consider if it should be strengthened to holding temperature increases to 1.5 degrees.
- There have been two commitment periods of the Kyoto Protocol, an instrument set up under the UNFCCC to set emissions reduction targets for developed countries. In parallel, 99 developing and developed countries have made pledges under the UNFCCC to reduce or limit their emissions.
- At the Conference of the Parties (COP) in Durban in 2011, Parties agreed to work towards a new 'protocol, another legal instrument or an agreed outcome with legal force under the Convention' (UNFCCC Dec 1/CP.17). This will be applicable to all countries and is intended to be negotiated by 2015, with effect from 2020. The details of the new agreement, including its legal form, what it will contain and how it will differentiate between countries, remain to be negotiated.

- The UNFCCC has encouraged better data collection, reporting and transparency of countries' emissions. All countries have measurement, reporting and verification requirements, and most are up to date with their reports. Annex I countries, including Australia, have more stringent requirements than other countries. The least developed countries receive financial and technical support to help them meet their requirements and build their capacity.
- The UNFCCC has created a global market for emissions offsets, the Clean Development Mechanism (CDM). This began in 2006, has registered more than 1,650 projects and is anticipated to produce offsets amounting to more than 2.9 billion tonnes of $CO_2$-e to the end of 2012 (UNFCCC 2013). Participation in the CDM has allowed some countries to build their domestic capacity to take climate action.
- The UNFCCC has created a mechanism to reduce emissions from forestry activities in developing countries. The REDD+ mechanism (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) aims to address the approximately 17 per cent of global emissions from forest activities (United Nations 2009).
- Through the UNFCCC, many developing countries have been given support for their mitigation and adaptation activities. From 2010–12, developed countries agreed to provide US$30 billion in 'fast-start' climate finance. Australia pledged A$599 million as its share of this global effort and has delivered on this commitment. There is also agreement to long-term financing for developing countries' climate actions, with Annex I countries collectively agreeing to provide US$100 billion by 2020 from public and private sources in the context of mitigation action from developing countries.

Ninety-nine countries have made pledges under the UNFCCC. Thirty-seven countries also have targets under the second commitment period of the Kyoto Protocol from 2013–2020—Australia, Belarus, all 28 EU members, Iceland, Liechtenstein, Monaco, Kazakhstan, Norway, Switzerland and Ukraine. Australia's Kyoto Protocol commitment is set out in Box B.2.

Russia, Japan and New Zealand did not take second commitment period targets, and the United States did not take a target in either commitment period. Canada has formally withdrawn from the Protocol. All Annex I countries, including those without targets under the second commitment period of the Kyoto Protocol, have 2020 targets under the UNFCCC.

**BOX B.2: AUSTRALIA'S KYOTO PROTOCOL COMMITMENT AND RECOMMENDED 2020 GOALS**

The Kyoto Protocol uses a budget approach to defining national commitments; these are expressed as a percentage of 1990 emissions. Australia's target for the first commitment period was to limit its average annual emissions to 108 per cent of its 1990 emissions between 2008 and 2012. Australia's average emissions were lower than this target during the first commitment period, resulting in carryover.

Australia's Kyoto target for the second commitment period is 99.5 per cent of its 1990 emissions on average between 2013 and 2020. This is consistent with the minimum unconditional 5 per cent target for 2020, and corresponds to a budget of 4,619 Mt over the period 2013 to 2020.

The Authority's recommended national emissions budget to 2020 defines a cumulative emissions allowance of 4,193 Mt $CO_2$-e for the eight years from 2013 to 2020.

If the Authority's recommended national emissions budget to 2020 was put forward as a new international commitment, it would be equivalent to a Kyoto target of 90.3 per cent of its 1990 emissions on average between 2013 and 2020.

The central feature of UNFCCC negotiations in the next few years will be progress towards a new global agreement on climate change, which is scheduled to be negotiated in 2015 and come into force by 2020.

## B1.2 UNFCCC MARKET MECHANISMS

To help meet their targets, countries can use market-based mechanisms, including the CDM and Joint Implementation (JI). The CDM allows emissions reduction projects in developing countries to earn certified emission reduction (CER) credits, which can be used by countries to meet their targets. JI is similar to the CDM but the credits are generated from countries with Kyoto Protocol targets. For both market mechanisms, projects to reduce emissions are proposed by developers and then reviewed independently by an international body. If the project is approved, credits are granted equal to the amount of emissions avoided due to the project compared to a business-as-usual baseline.

## B1.3 OTHER INTERNATIONAL CLIMATE INITIATIVES

There is a range of cooperative international climate initiatives underway outside of the UNFCCC. These allow countries to exchange practical ideas about reducing emissions and include:

- research and development into low-emissions technologies, such as carbon capture and storage, renewable energy and approaches to reduce emissions from agriculture
- commitments to reduce or phase out fossil fuel subsidies including under the G20
- linking of emissions trading schemes, such as those of the EU and Norway, and proposed links between California and Quebec, and Switzerland and the EU
- bilateral and regional agreements targeting particular areas of climate change policy; for example, short-lived gases such as methane and hydrofluorocarbons through the Climate and Clean Air Coalition, and carbon markets through the World Bank Partnership for Market Readiness.

Other international initiatives that address climate change include the Montreal Protocol on Substances that Deplete the Ozone Layer (the Montreal Protocol), which was designed to 'phase out' a range of gases to protect the ozone layer by destroying them safely and replacing them with substitutes. Many of the gases covered by the Montreal Protocol drive global warming as well as damaging the ozone layer, so the phase-out has had a significant positive impact on climate change. The Montreal Protocol has been one of the most successful international initiatives to reduce greenhouse gas emissions.

Emissions from international aviation and maritime activities are currently not counted towards individual country emissions or targets under the UNFCCC. Both have nearly doubled in the last 10 years. Discussions to reduce emissions from these sectors occur in the International Maritime Organization and the International Civil Aviation Organization.

Examples of different activities, complementary to the UNFCCC, are set out in Table B.1. Australia is part of all of these initiatives.

**TABLE B.1:** INTERNATIONAL INITIATIVES FOR CLIMATE CHANGE

| ORGANISATION | STARTED | NUMBER OF MEMBERS | ACTIVITIES |
|---|---|---|---|
| **International Civil Aviation Organization** | 1944 | 191 member states | A specialised United Nations agency, which regulates air transport, potentially including emissions from international air transport. |
| **International Maritime Organization** | 1948 | 177 member states | A specialised United Nations agency, which regulates international maritime transport, including setting maritime pollution standards. |
| **Montreal Protocol on Substances that Deplete the Ozone Layer** | 1987 | 196 member states | An international treaty to protect the ozone layer by phasing out 'ozone-depleting substances', many of which also cause climate change. There are also ongoing negotiations to cover further greenhouse gases (hydrofluorocarbons) under this treaty. |
| **Global Methane Initiative** | 2004 | 41 partner states and private sector partners | An international public–private initiative to promote methane reduction, and recovery and use of methane as a clean energy source in agriculture, coal mines, municipal solid waste, oil and gas systems, and wastewater. |

| ORGANISATION | STARTED | NUMBER OF MEMBERS | ACTIVITIES |
|---|---|---|---|
| **C40 Cities Climate Leadership Group** | 2005 | 58 affiliated cities, including Sydney and Melbourne | An international group focused on sharing knowledge and technical expertise between cities. It promotes climate best practices in areas such as waste management, emissions accounting and procurement policy. |
| **Group of 20 (G20)** | 2008 | 19 countries and the EU, plus invitees | The G20 is focused on dialogue on financial and economic issues, but discussed climate change in advance of the 2009 COP, and could do so again in the lead-up to the UNFCCC new agreement. |
| **Major Economies Forum on Energy and Climate** | 2009 | 17 countries, all large emitters | Forum promotes candid dialogue among major developed and developing economies to support the UNFCCC negotiations, explore initiatives and joint ventures to lower emissions, including building energy efficiency. |
| **Global Green Growth Institute** | 2010 | 18 founding members | An initiative led by the Republic of Korea to promote green growth in developing countries, including by improving national economic planning to better incorporate environmental and climate objectives. |
| **Climate and Clean Air Coalition** | 2012 | 33 countries plus 36 non-state Partners including the World Bank and the United Nations Environment Programme | Scaling up rapid action to reduce 'short-lived climate pollutants'—substances such as soot, methane and some refrigerants (hydrofluorocarbons). The Coalition focuses its efforts across a range of sectors including the global oil and gas industry, waste sectors, heavy-duty diesel vehicles and engines, and brick production. |
| **The World Bank Partnership for Market Readiness** | 2012 | 29 developed and developing countries | Builds countries' capacity to develop domestic carbon market instruments including carbon taxes and emissions trading.<br>Supports countries through technical workshops, policy dialogues and virtual knowledge platforms on essentials such as data management, measurement, reporting and verification systems, and policy and regulatory frameworks, as well as financial support.<br>Helps countries create effective enabling environments for private sector action on climate change. |

**Sources:** All information sourced from each initiative's website

## APPENDIX B2
## COUNTRIES' CLIMATE ACTION—TARGETS AND POLICIES

Countries' climate targets and policies are mutually reinforcing—targets can encourage policy development, and confidence in implemented policies can encourage a country to set higher targets.

To achieve their goals, countries are implementing a range of climate change measures. These policies include carbon pricing, energy supply and energy demand measures, vehicle standards and action to address land-based emissions. Table B.2 shows an illustrative sample of climate measures in different categories for key countries.

## TABLE B.2: SAMPLE CLIMATE CHANGE POLICIES AND MEASURES IN KEY COUNTRIES

| | POLICIES AND MEASURES | | | | |
|---|---|---|---|---|---|
| **Country** | **Carbon pricing (tax, emissions trading scheme)** | **Energy supply** | **Energy demand** | **Mandatory vehicle standards** | **Land-based activities, including agriculture and forests** |
| **Australia** | Carbon pricing mechanism (under current legislation) | Renewable energy target<br>State-based feed-in tariffs for renewable energy | Appliance and building standards<br>State-based energy efficiency schemes | None. Has effective carbon pricing through differences in fuel tax credits for some transport | Carbon Farming Initiative |
| **China** | Pilot emissions trading schemes planned for seven provinces and cities. The first five began in 2013.<br>Plans to design a national emissions trading scheme or carbon tax | Renewable energy target<br>Feed-in tariff support for solar, wind and biomass power<br>Closure of inefficient small and medium-sized coal plants and industrial facilities | Appliance and building standards<br>Energy efficiency target<br>Industrial energy efficiency retrofits | Vehicle fuel efficiency standards<br>Vehicle emissions standards planned | National reforestation efforts to meet forest coverage target |
| **United States** | Sub-national emissions trading schemes in California and nine north-eastern states (the Regional Greenhouse Gas Initiative); planned in Washington and Oregon | Sub-national renewable energy targets<br>Financial incentives supporting renewable energy<br>Proposed national regulations limiting emissions from fossil fuel power plants | Appliance and building standards<br>Industrial energy efficiency assessments | Vehicle fuel efficiency standards<br>Vehicle emissions standards<br>Renewable fuel production incentives | Support for voluntary action to reduce emissions and increase carbon sequestration |
| **European Union** (28 member states) | Emissions trading scheme | Renewable energy target and support for cogeneration—jointly generating heat and power<br>Feed-in tariffs for renewable energy | Appliance and building standards<br>Energy efficiency target | Vehicle emissions standards<br>Renewable fuel production incentives | EU strategy to improve soil management, including as a carbon sink<br>Land-sector management<br>Landfill emissions control |
| **India** | Small coal tax of about A$0.80 per tonne<br>Energy efficiency trading scheme for power sector | Renewable energy targets | Energy efficiency trading scheme for power sector | Vehicle fuel efficiency standards<br>Vehicle emissions standards pending | Energy efficiency initiatives for agricultural sector include providing subsidised pumps<br>Increasing forestry stock identified as one of 12 major objectives of India's low-carbon strategies under its Five Year Plan |

**POLICIES AND MEASURES**

| Country | Carbon pricing (tax, emissions trading scheme) | Energy supply | Energy demand | Mandatory vehicle standards | Land-based activities, including agriculture and forests |
|---|---|---|---|---|---|
| **Japan** | Carbon tax on fossil fuels<br>Sub-national emissions trading schemes in Tokyo and Saitama; voluntary federal scheme | Renewable energy target<br>Feed-in tariffs for renewable energy | Energy efficiency standards and measures in residential, commercial and building sectors | Vehicle fuel efficiency standards<br>Tax incentives for purchase of lower emission vehicles | Covered under Japan's domestic offsets scheme |
| **Indonesia** | Considering market-based mechanisms for emissions reduction in selected sectors | Renewable energy target | Tax exemptions for energy-efficient technologies<br>Energy intensity target | Vehicle emissions standards | Measures to reduce forest deforestation and degradation through regulations and market-based offsets |
| **Canada** | Sub-national cap-and-trade in Quebec<br>Sub-national taxes and duties on fossil fuels | Standards for coal-fired electricity generation from 2015<br>Renewable energy incentives<br>Remote renewable energy generation incentives | Appliance and building standards<br>Industry energy efficiency incentives | Vehicle emissions and standards and efficiency programs<br>Renewable fuel production incentives | Sub-national offset mechanism in Alberta and Quebec |
| **Republic of Korea** | Emissions trading scheme to start in 2015 | Renewable energy target | Appliance and building standards | Vehicle fuel efficiency and carbon emission standards | |
| **South Africa** | Carbon tax to start in 2015 | Renewable energy target<br>Tax incentives and feed-in tariffs for renewables | Energy efficiency demand-side management programs for residential, commercial and buildings<br>Tax incentive for energy efficiency | Vehicle emissions standards<br>Greenhouse gas emission tax for new vehicles | Focus on adaptation in agriculture |
| **New Zealand** | Emissions trading scheme | Stationary energy covered under the New Zealand emissions trading scheme | Appliance and building standards<br>Commercial and residential energy efficiency schemes | None. Liquid fuels covered under the New Zealand emissions trading scheme | Sustainable Land Management and Climate Work Program covers land management sectors |
| **Norway** | Part of EU emissions trading system<br>Broad-based domestic carbon tax | Renewable energy target<br>Support for cogeneration | Appliance and building standards<br>Energy efficiency target | Renewable fuel production incentives<br>Vehicle emissions standards | |

**Note:** Table is not comprehensive. The existence of a policy or measure does not reveal its effect on emissions; the same types of policies have varying degrees of ambition and effectiveness across countries. Germany and the UK are covered by all EU policies and measures and also have additional nation-specific policies.

**Sources:** All information sourced from countries' National Communications to the UNFCCC; submissions to Partnership for Market Readiness; national government websites; Globe International 2012; IEA 2013; REN21 2013; World Bank 2013

Each of these policies drives emissions reductions, but the cost per tonne of abatement varies widely. The Organisation for Economic Co-operation and Development (OECD 2013) has estimated the net cost to society of a broad range of policy instruments to help assess their relative cost-effectiveness. The study examines policies in five sectors (electricity generation, road transport, pulp and paper, cement and household energy use) across 15 countries including Australia. It finds wide variations in the 'effective carbon price' (the cost to society for each tonne of emissions abated), both across sectors and across countries. Costs range from less than zero to about $1,200 per tonne in the electricity sector, with an even wider variation in other sectors depending on the type of policy used. The study includes measures that were implemented for non-climate reasons, for instance programs to reduce energy bills in low income households.

# APPENDIX B3
# ASSESSMENT OF GOVERNMENT'S TARGET CONDITIONS

## TABLE B.3: ASSESSMENT OF GOVERNMENT'S TARGET CONDITIONS

| REDUCE EMISSIONS BEYOND 5 PER CENT RELATIVE TO 2000 LEVELS | | |
|---|---|---|
| *The government will not increase Australia's emissions reduction target above 5 per cent until:* | | |
| **Condition** | **Circumstances** | **Authority's assessment** |
| *The level of global ambition becomes sufficiently clear, including both the specific targets of advanced economies, and the verifiable emissions reduction actions of China and India* | Since the conditions were set, the level of global ambition has become significantly clearer—99 countries, covering 80 per cent of global emissions, have pledged to reduce or limit their emissions before 2020. Countries have also provided further information clarifying their pledges and the potential emissions reductions outcome.<br>All Annex I Parties have committed to specific targets under the UNFCCC or Kyoto Protocol.<br>Many developing countries, including China and India, have pledged 2020 emissions reductions targets or actions under the UNFCCC. They have also agreed to increased measurement, reporting and verification of their emissions and their pledged action through biennial update reports, including national inventories.<br>Details of pledges can be found at www.unfccc.int. | Condition met |
| *The credibility of those commitments and actions is established, for example, by way of a robust global agreement or commitments to verifiable domestic action on the part of the major emitters including the United States, India and China* | In a series of UNFCCC decisions, countries have agreed to a robust international method for measuring, reporting and verifying emissions, and progress towards pledged targets and actions through biennial reports. This supports the credibility of all countries' commitments and domestic actions. The United States, India and China have all agreed to these rules—the United States released the draft of its first biennial report detailing its emissions and actions to reduce them on 27 September 2013; China and India's first biennial update report is due December 2014.<br>There is clear evidence, as outlined in this report, of domestic action on climate change in support of targets, including in major emitting economies (see Chapter 4). | Condition met |
| *There is clarity on the assumptions for emissions accounting and access to markets* | The Authority's understanding is that this condition was aimed at ensuring Australia was clear on the underlying rules before it committed to a target.<br>Under the second commitment period of the Kyoto Protocol, there is a clear framework for accounting for Australia's target and clear access to Kyoto market units.<br>Australia recently set out the underlying accounting assumptions for its UNFCCC 2020 emissions reduction commitment in its 2013 National Communication and Biennial Report. | Condition met |

| REDUCE EMISSIONS BY 15 PER CENT RELATIVE TO 2000 LEVELS | | |
|---|---|---|
| *International agreement where major developing countries commit to restrain emissions substantially and advanced economies take on commitments comparable to Australia's. In practice, this implies:* | | |
| **Condition** | **Circumstances** | **Authority's assessment** |
| *Global action on track to stabilisation between 510 and 540 ppm $CO_2$-e* | Many studies (Project Catalyst 2010 and a range of studies pending publication) estimate the current 2020 pledges are on track to stabilisation at around 550 ppm $CO_2$-e; however, given the uncertainties surrounding these estimates, stabilisation at 510–540 ppm cannot be ruled out, depending on the level of post-2020 action. | Condition partially met |
| *Advanced economy reductions in aggregate in the range of 15–25 per cent below 1990 levels by 2020* | Most aggregates of Annex I Party pledges suggest they fall partially within this range. For example, den Elzen et al. (2012) estimates aggregate Annex I Party pledges to be in the range of 12–18 per cent below 1990 levels by 2020. Uncertainties surrounding these estimates could pull them up or down. | Condition partially met |
| *Substantive measurable, reportable and verifiable commitments and actions by major developing economies in the context of a strong international financing and technology cooperation framework, but which may not deliver significant emission reductions until after 2020* | All major developing economies have pledged targets and actions under the UNFCCC.<br>As discussed above, these pledges are backed by the new measurement, reporting and verification framework, which requires countries to submit biennial reports detailing their emissions and progress towards their pledge.<br>Since 2009, significant progress has been made on financing and technology cooperation, including a collective commitment by developed countries to provide new and additional resources approaching US$30 billion over 2010–12 and a long-term commitment by developed countries to mobilise jointly US$100 billion per year by 2020 to address the needs of developing countries. | Condition met |
| *Progress towards inclusion of forests (reduced emissions from deforestation and forest degradation) and the land sector, deeper and broader carbon markets, and low carbon development pathways* | There has been significant progress towards developing a framework for reducing deforestation and forest degradation in developing countries, both in the UNFCCC and through bilateral pilot programs. In addition, the Kyoto Protocol second commitment period also sets rules that cover emissions from land-based activities more comprehensively than the first commitment period.<br>Since 2009, many countries have implemented carbon markets and many more have plans to do so (GLOBE 2013).<br>All countries agreed in the Cancún Agreements to establish low-carbon development strategies. | Condition met |

| REDUCE EMISSIONS BY 25 PER CENT RELATIVE TO 2000 LEVELS (UP TO 5 PERCENTAGE POINTS THROUGH GOVERNMENT PURCHASE) | | |
|---|---|---|
| *Comprehensive global action capable of stabilising $CO_2$-e concentration at 450 ppm $CO_2$-e or lower. This requires a clear pathway to achieving an early global peak in total emissions, with major developing economies slowing the growth and then reducing their emissions, advanced economies taking on reductions and commitments comparable to Australia's, and access to the full range of international abatement opportunities through a broad and functioning international market in carbon credits. This would involve:* | | |
| **Condition** | **Circumstances** | **Authority's assessment** |
| *Comprehensive coverage of gases, sources and sectors with inclusion of forests (reduced emissions from deforestation and forest degradation) and the land sector (including soil carbon initiatives (for example, biochar) if scientifically demonstrated) in the agreement* | All Annex I Parties targets comprehensively cover gases, sources and sectors. Non-Annex I Party pledges vary in their coverage of gases, sources and sectors.<br>The Kyoto Protocol second commitment period comprehensively covers greenhouse gases (not covered by the Montreal Protocol), sources and sectors. The second commitment period of the Kyoto Protocol allows countries to elect grazing land, which would include removals from soil carbon initiatives (Australia has chosen to elect grazing land for its second commitment period target).<br>As discussed above, significant progress towards developing a framework for reducing deforestation and forest degradation in developing countries. | Condition partially met |
| *Clear global trajectory, where the sum of all economies' commitments is consistent with 450 ppm $CO_2$-e or lower and with a nominated early deadline year for peak global emissions not later than 2020* | As discussed above, most studies estimate the pledges aggregate to a stabilisation of around 550 ppm $CO_2$-e. These studies generally show that, while a 450 ppm stabilisation is still technically feasible, it would require extensive use of negative emissions technology post-2020.<br>There is no agreed global peaking date. | Condition not yet met |
| *Advanced economy reductions, in aggregate, of at least 25 per cent below 1990 levels by 2020* | As discussed above, den Elzen et al. (2012) considered Annex I Party reductions to aggregate around 12–18 per cent levels. Even accounting for uncertainties that could pull this estimate up, it is unlikely to aggregate to 'at least 25 per cent'. | Condition not met |
| *Major developing economy commitments to slow growth and to then reduce their absolute level of emissions over time, with collective reduction of at least 20 per cent below business as usual by 2020 and a nomination of peaking year for individual major developing economies* | Recent analysis suggests that aggregate major developing economy commitments are currently around 13–16 per cent below business-as-usual by 2020 (den Elzen et al. 2013).<br>Most individual major developing economies have not yet nominated peaking years (South Africa has and many others are actively considering one). | Condition not met |
| *Global action which mobilises greater financial resources, including from major developing economies, and results in fully functioning global carbon markets* | As discussed above, significant work has been done to mobilise greater financial resources; however, the role of major developing economies is unclear.<br>While a wide range of markets has been established in the last few years (GLOBE 2013), they are still developing, and domestic and regional markets are not yet fully linked. | Condition not yet met |

**Note:** The government has defined 'advanced economies' as 'Annex I Parties to the UNFCCC and at least some other high-middle income economies'. The Authority has used Annex I Parties as a proxy for 'advanced economies' in its analysis. Annex I Parties are: Australia, Austria, Belarus, Bulgaria, Canada, Croatia, Czech Republic, Denmark, European Economic Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, and United States of America. The government has defined 'major developing economies' as 'non- members of the Major Economies Forum'. These countries are Brazil, China, India, Indonesia, Republic of Korea, Mexico and South Africa.
**Source:** Climate Change Authority

# APPENDIX B4
# COMPARING 2020 TARGETS

## B4.1 DATA AND ASSUMPTIONS

How Australia's 2020 targets compare with that of other countries is an important question. This appendix considers some of the assumptions and limitations involved in comparing Australia's targets to those of other countries that underpin the analysis in Chapter 4.

In choosing data and a method to compare emissions targets, considerations include:

- limitations on comparing targets expressed in different ways
- assumptions around the 'base year' or defined common reference year for targets.

The four measures used in Chapter 4 provide guidance on the relative ambition of countries' targets; however, these are neither comprehensive nor conclusive, either singularly or together. Many factors influence how ambitious a target is, including the level of development, population growth, access to technology, and industrial base and natural resource endowments.

Each measure requires different data and assumptions to be made, and different assumptions will alter the results. Table B.4 provides a summary. The absolute change requires data on historical emissions. Per person emissions require data on historical emissions and also assumptions on population growth. Emissions intensity requires data on historical GDP and assumptions on future GDP. Business-as-usual (BAU) is the most complex and requires a range of assumptions, many of which are contestable.

**TABLE B.4:** ASSUMPTIONS REQUIRED FOR COMPARING COUNTRIES' EMISSIONS TARGETS

| FORM OF TARGET | ABSOLUTE EMISSIONS TARGET | EMISSIONS INTENSITY TARGET | TARGET RELATIVE TO BAU |
|---|---|---|---|
| **Metric for comparison** | | | |
| Absolute change in emissions | (No assumptions needed, as target framed in this metric—only conversion to common base year necessary) | Assume GDP growth rate | Assume BAU emissions trajectory |
| Change in per capita emissions | Assume population growth rate, apply to absolute change in emissions | | |
| Change in emissions intensity | Assume GDP growth rate | (No assumptions needed, as target framed in this metric) | Assume BAU emissions trajectory and GDP growth rate |
| Reduction in emissions relative to BAU | Assume BAU emissions trajectory | Assume BAU emissions trajectory and GDP growth rate | (No assumptions needed, as target framed in this metric) |

**Source:** Adapted from Jotzo 2010

The Authority has used high-quality and consistent information for as many as countries as possible. Comparisons are limited by the difficulties of finding accurate and comprehensive data for all countries.

Australian data is generally sourced from Commonwealth Government sources, including the Department of the Environment and Treasury. The Authority has used data from a range of sources for other countries. For example, emissions are from the United Nations emissions inventory database (for Annex I Parties) and the Climate Analysis Indicators Tool (CAIT) database (for other countries). The potential risk of using multiple sources is minimised by using data from credible sources that cover most of the countries.

## B4.2 CHOICE OF BASE YEAR

The Authority has chosen 2005 as a base year for the analysis in Chapter 4. Different countries express their targets against different base years. Australia generally uses 2000 levels; 1990 is used by many of the European countries; while China, India and the United States use 2005.

Depending on their circumstances, the perceived strength of different countries' targets will look different depending on the base year. Base years affect the weight given to past effort versus future effort. Earlier base years capture changes that have occurred in the past. This might be emissions growth (for example, due to rapid economic growth) or contraction (possibly due to economic collapse or climate change policies). Taking these factors into account may be particularly justified for countries that, like Australia, have taken on previous commitments from 1990, as they have already accepted the need for action from this point. On the other hand, later base years give a better indication of the future level of effort necessary to achieve the target.

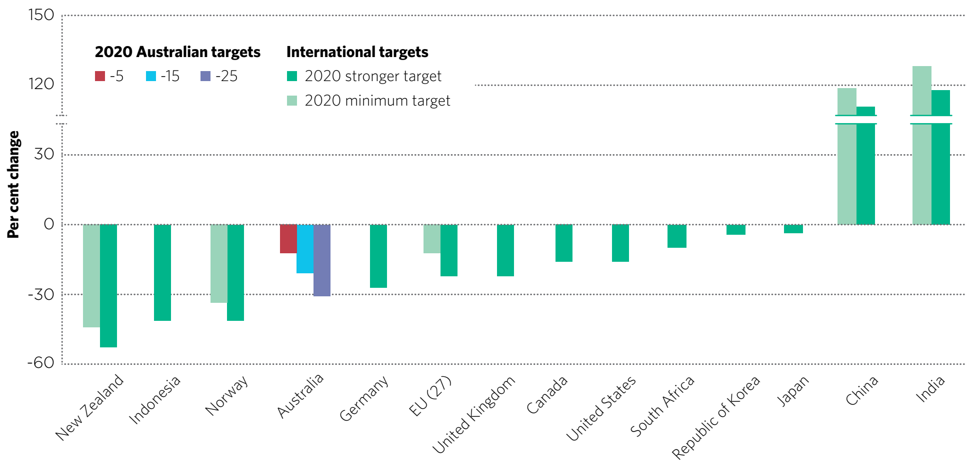
## B4.3 COMPARING AUSTRALIA'S TARGET RANGE WITH THAT OF OTHER KEY COUNTRIES

Each of the four measures the Authority uses to compare countries' targets in the Targets and Progress Review provides a different way of comparing Australia's efforts to others.

**Changes in absolute emissions** show the variation in total emissions levels in a country over time (see Figure B.1). Most developed countries have absolute emissions reduction targets under the UNFCCC. Developing countries' targets may include short-term growth in absolute emissions to allow the country to develop and improve living standards.

An Australian 5 per cent target is not as strong as the targets of New Zealand, Norway, the United States and Canada. A 15 per cent target for Australia implies stronger reductions than the United States and Canada. While a 25 per cent target is at the stronger end of the countries compared, it is not as strong as the targets of New Zealand and Norway.

**FIGURE B.1:** COUNTRIES' 2020 TARGETS RELATIVE TO 2005 LEVELS




**Note:** To allow comparison across all countries, all emissions estimates use assessment report (AR2) methodology. The EU results do not include Croatia; however, this is unlikely to change the results given the relatively small size of its economy and emissions.

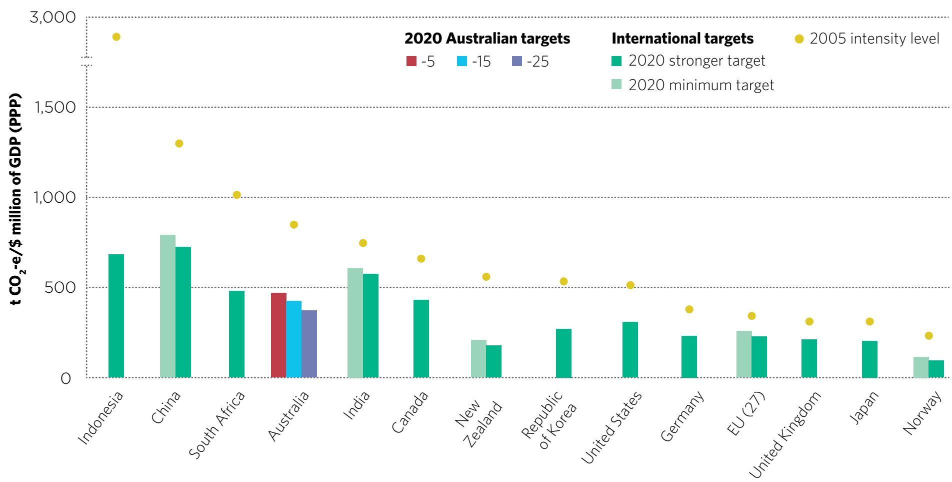
**Sources for figures B.1–B.4 and Figure 4.3 in Chapter 4:** Historical greenhouse gas emissions—Australia: Treasury and DIICCSRTE 2013; Annex I Parties: UNFCCC 2013; remaining countries: WRI 2013. This analysis uses WRI CAIT version 7. This differs from elsewhere in the report because of uncertainties over the accuracy of land use change data and because CAIT 2.0 does not include the full set of anthropogenic activities related to land use change emissions. The version 7 has been previously used in similar analysis and so allows for greater confidence in the land use change data. GDP: IMF 2013; EU (27) GDP for 2020 estimated by CCA from OECD 2013b. Population: Treasury and DIICCSRTE 2013 (Australia); United Nations 2013 (other countries). Projected BAU 2020 emissions: Treasury and DIICCSRTE 2013 where available (EU projection is for EU (25)), otherwise national projections.

**Emissions intensity** reflects the ratio of economy-wide greenhouse gas emissions per unit of GDP (see Figure B.2). Reductions in emissions intensity demonstrate a country's intended rate of economic decarbonisation. China and India have framed their UNFCCC targets as reductions in emissions intensity.

Australia currently has a relatively high emissions intensity compared with other countries, even other developed countries with high levels of fossil fuel production and use, such as the United States and Canada.

All of Australia's targets would result in 2020 emissions intensity levels that are more intensive than most developed countries, including the EU, US and Japanese targets.

**FIGURE B.2: EMISSIONS INTENSITY OF COUNTRIES, 2005 LEVELS AND 2020 TARGETS**




**Source:** See Figure B.1

**Changes relative to BAU emissions levels** give a comparative measure of the effect of targets on emissions and the effectiveness of climate change policies (see Figure B.3). Many developing countries, including South Africa and Indonesia, have 2020 targets as reductions from BAU projections.

Projecting BAU emissions is difficult, and different definitions or assumptions can lead to substantially different estimates. The uncertainty is much higher for developing countries, which are often in the process of building large-scale infrastructure to lift their populations out of poverty. The way such infrastructure is built can have a significant impact on a country's future emissions levels.

Previous work considering targets against BAU scenarios has attempted to grapple with the difficulty of using BAU (see Jotzo 2010 and Pew Center 2011). Jotzo notes the International Energy Agency and Energy Information Administration reflect the continuation of existing policies into the future and exclude potential future policies. These projections of countries' BAU emissions levels will be significantly lower than a BAU scenario that removes the effect of existing climate change policies.

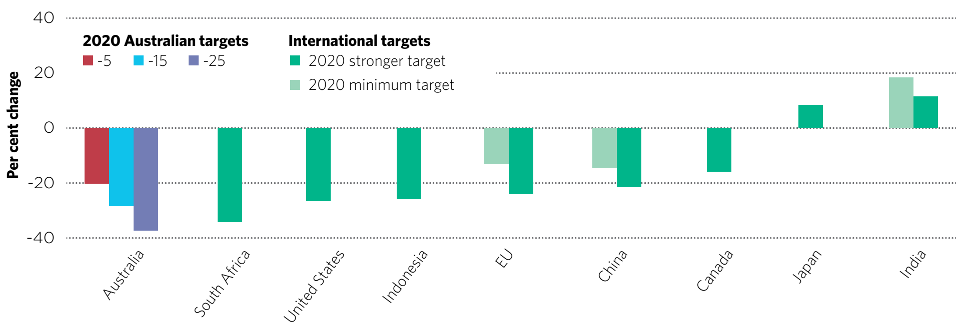
The Treasury and DIICCSRTE 2013 modelling is used for figures B.1–B.4 and Figure 4.3 in Chapter 4 to compare countries' 2020 targets with their projected BAU levels as estimated from the GTEM reference case. The no price scenario from the Monash Multi-Regional Forecasting model (MMRF) is used for Australia. This allows for greater comparability, as each country's BAU projections are based on the same set of assumptions. The Authority's analysis on this metric is limited to only those countries included in the modelling, which means a smaller set of countries than used in the rest of the comparison analysis.

The Republic of Korea's national BAU projections are used to estimate its 2020 target because it is not separately identified in the modelling and it has a target relative to BAU.

In some cases, differences in national BAU projections can arise from countries estimating higher BAU levels than the estimates of external sources. This would then help to make it easier for the country to meet its target. Den Elzen et al. (2013) show that most national BAU projections of developing countries are higher than those estimated by external sources.

An Australian 25 per cent target is estimated to be the strongest reduction from BAU of all the countries compared. An Australian 15 per cent target remains one of the strongest targets of the countries compared. The Australian 5 per cent target is estimated to be not as strong as the targets of South Africa, the US and Indonesia, and stronger than Canada and the EU's minimum targets.

**FIGURE B.3:** PERCENTAGE CHANGE IN EMISSIONS UNDER COUNTRIES' TARGETS RELATIVE TO BAU LEVELS AT 2020



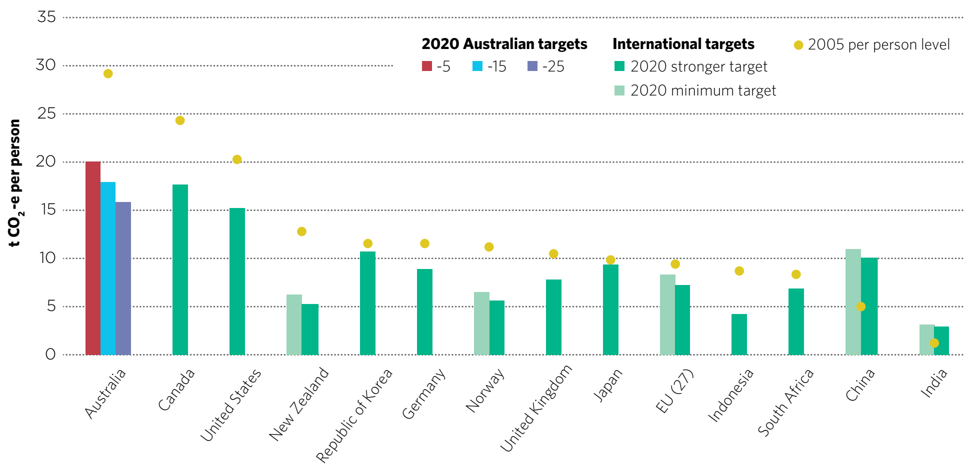

**Note:** The Republic of Korea is not included in Figure B.3 as it is not part of Treasury and DIICCSRTE 2013 modelling. It has a target of 30 per cent below its BAU, which is close to Australia's 15 per cent target.
**Source:** See Figure B.1

**Per person reductions** remove population growth as a variable and provide links to the contraction and convergence and equity discussions in Chapter 8 (see Figure B.4).

Australia has the highest per person emissions in 2005 of the key countries compared.

Australian 5 and 15 per cent targets would see it continue to have the highest per person emissions of the group in 2020. An Australian 25 per cent target means it would have the second-highest emissions per person in 2020 after Canada.

**FIGURE B.4:** PER PERSON EMISSIONS OF COUNTRIES, 2005 LEVELS AND 2020 TARGETS




**Source:** See Figure B.1

C

# SHARING THE GLOBAL EMISSIONS BUDGET

This appendix sets out the approaches to sharing a global emissions budget and complements the discussion in Chapter 8.

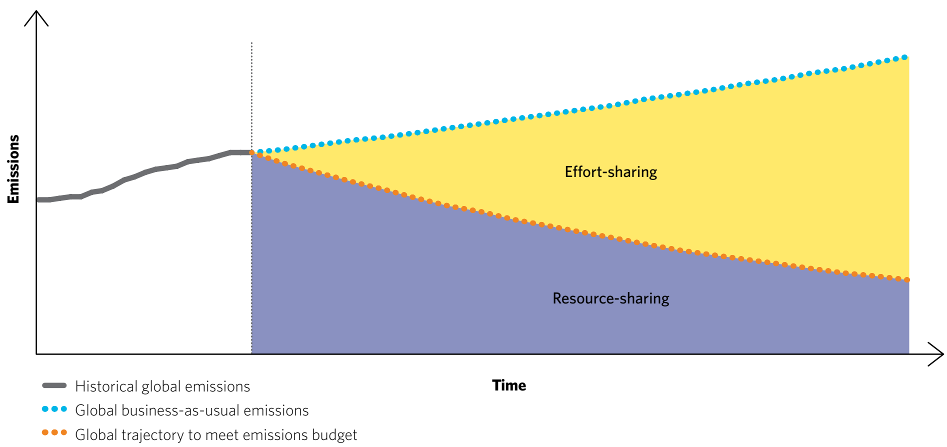
## APPENDIX C1 APPROACHES TO SHARING A GLOBAL EMISSIONS BUDGET

There are two broad approaches to sharing emissions reduction efforts:

- sharing the global emissions budget—'resource-sharing'
- sharing the emissions reductions required to meet that budget—'effort-sharing' (Figure C.1).

In some ways, the two approaches are similar—sharing the remaining budget implicitly sets a mitigation task and vice versa. From a practical perspective, resource-sharing approaches are more straightforward, as they require only an estimate of the global emissions budget and equitable principles. In contrast, effort-sharing also requires an estimate of global emissions in the absence of climate change action; that is, a BAU trajectory. As more countries take more action, this trajectory becomes increasingly abstract and difficult to estimate.

**FIGURE C.1:** RESOURCE-SHARING VERSUS EFFORT-SHARING




**Source:** Climate Change Authority

While almost all of the approaches are conceptually based on the emissions rights of individuals, none would allocate rights directly to individual Australians. Rather, these approaches allocate budgets by starting with principles based on individuals, then aggregating to the national level.

The Authority's recommended emissions reduction goals for Australia, including the budget to 2050, are 'net' goals. That is, they reflect Australia's contribution to global emissions reduction efforts, not a fixed limit on Australia's domestic emissions. To the extent that domestic emissions exceed the budget, they must be offset by genuine emissions reductions purchased from overseas.

## C1.1 RESOURCE-SHARING APPROACHES BASED ON EMISSIONS RIGHTS PER PERSON

The Authority examined four resource-sharing approaches based on equal emissions rights per person in detail. Three involve a gradual move to equal rights per person and the fourth involves immediate equality.

### C1.1.1 CONTRACTION AND CONVERGENCE

Under contraction and convergence, emissions per person contract over time in countries above the global average, and rise over time in countries below the global average, reaching a 'convergence level' of equal per person rights in a specified future year. The convergence year is a key variable in this approach. A shorter convergence period results in smaller budgets for countries that, like Australia, start with above average per person emissions.

The Authority has used 2050 as its preferred convergence year when analysing these approaches, balancing the feasibility of the transition with the goal of equalising per person emissions rights.

### C1.1.2 MODIFIED CONTRACTION AND CONVERGENCE

This approach was proposed by Professor Garnaut in his 2008 Review. It involves two main modifications to simple contraction and convergence:

- fast-growing developing countries are allowed additional growth in their per person emissions rights for a transitional period
- developed countries' rights contract more quickly to provide this headroom (Garnaut 2008, pp. 206–7).

Specifically, it allows developing countries' allocations to grow at half their economic (GDP) growth rate, if that is greater than the growth rate of their allocated emissions under the simple contraction and convergence approach.

Professor Garnaut proposed modified contraction and convergence because some rapidly growing developing countries are already close to the global per person average for greenhouse gas emissions. Under simple contraction and convergence, they would have to either halt growth in their per person emissions very soon or purchase large volumes of emissions reductions from other countries. Garnaut argued that, for these nations, the first is difficult and the second inequitable. The modified approach provides some 'headroom' to allow high-emitting developing countries to make a more gradual adjustment. All countries converge to equal per person rights by 2050.

### C1.1.3 COMMON BUT DIFFERENTIATED CONVERGENCE

Under this variant of contraction and convergence, developing countries are provided headroom through delayed reductions rather than larger allocations. Countries' per person emissions rights begin to fall once they reach a specified threshold of the (time-varying) global average, then move linearly to the convergence level. Regardless of when countries and allocations begin to fall, they have the same amount of time to reach the convergence level.

The threshold level of emissions and the amount of time to reach the convergence level are policy choices that depend on the global emissions budget. For budgets aimed at limiting temperature increases to below 2 degrees, this approach provides no headroom for some higher emitting developing countries (Höhne and Moltmann 2009, p. 25).

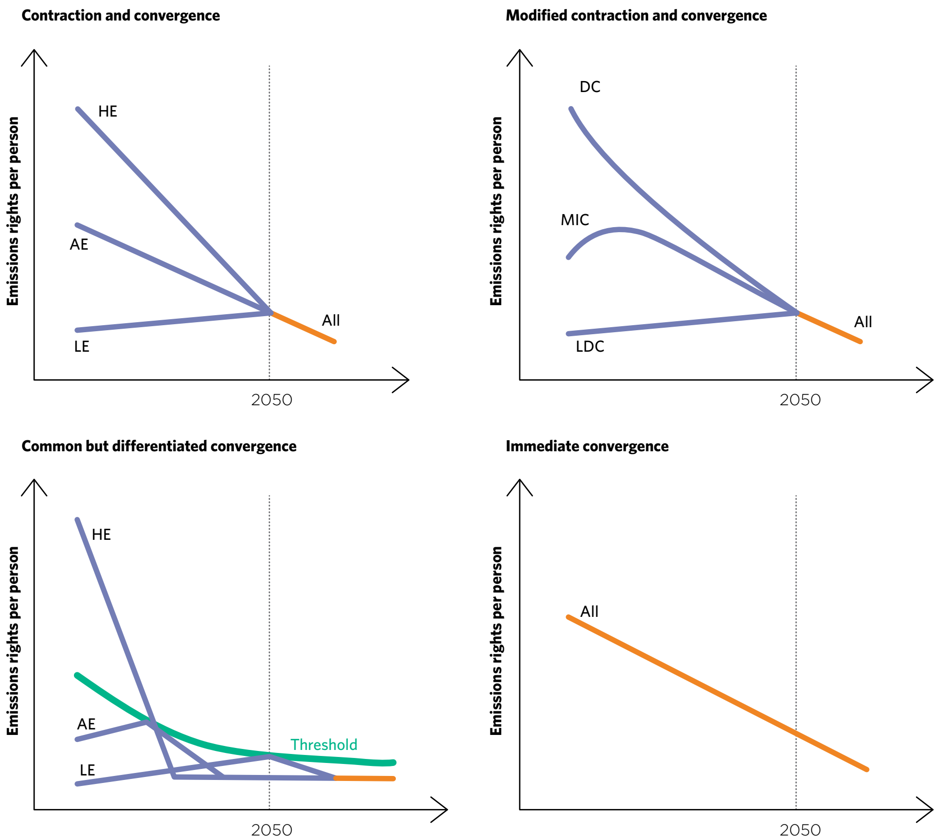
### C1.1.4 IMMEDIATE CONVERGENCE

Contraction and convergence equalises per person emissions rights at a point in the future. Immediate convergence—also referred to as an equal cumulative per person emissions approach—equalises per person rights straight away. The Authority has calculated indicative budgets using this approach, adjusting for changes in countries' share of the global population over time so that each person alive in a given year has an equal share of that year's available emissions.

Some proposals for immediate convergence do not adjust for population changes over time (see, for example, German Advisory Council on Global Change 2009). Instead, they allocate each nation a share of the global emissions budget based on its share of global population in a single 'reference year'. These variants do not really give effect to the principle of equal emissions rights per person, so the Authority has not considered them in detail. Other proposals include historical emissions in the calculations; for example, Jayaraman, Kanitkar and D'Souza (2011) incorporate emissions from 1970. Under this approach, Australia's 2000–2050 emissions budget is negative—Australia's past emissions have already more than exhausted its entitlements, and the right to all ongoing emissions would have to be purchased from countries with positive entitlements. The Authority's view is that distant past emissions should not be included as these occurred when their harmful effects could not be foreseen.

Figure C.2 provides a stylised comparison of these four resource-sharing approaches. It shows how contraction and convergence, and common but differentiated convergence are based on per person emissions levels only, while modified contraction and convergence takes levels of development directly into account. Immediate convergence requires instant equality for all countries regardless of their characteristics.

## FIGURE C.2: COMPARISON OF APPROACHES WITH EQUAL PER PERSON EMISSIONS RIGHTS




| | | | |
|---|---|---|---|
| **HE** | Country with high emissions per person | **DC** | Developed country |
| **AE** | Country with average emissions per person | **MIC** | Middle-income country |
| **LE** | Country with low emissions per person | **LDC** | Less developed country |
| **All** | All countries | | |

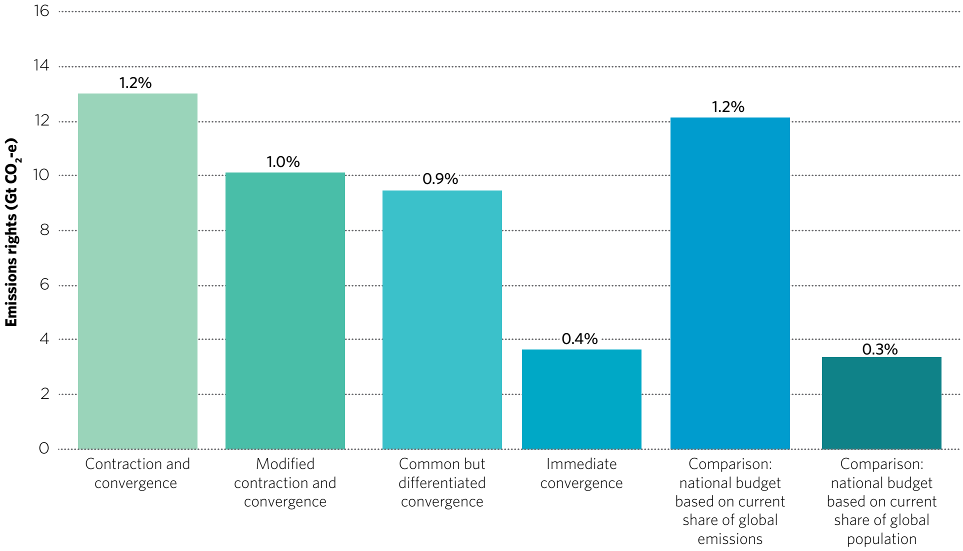
**Source:** Climate Change Authority based in part on Höhne and Moltmann 2009

Figure C.3 illustrates the implications of the four resource-sharing approaches for Australia's long-term national emissions budget. These calculations are based on the share of the global 2 degree budget adopted as a reference in Chapter 3. It also shows two simple budgets to help put the others into perspective:

- a 'status quo share' based on Australia's current share of global emissions
- a 'population share' based on Australia's current share of the global population.

All four approaches give a budget comparable to or smaller than the one based on Australia's current share of global emissions. Modified contraction and convergence provides a budget about 20 per cent smaller than simple contraction and convergence, in part because it allows developing countries a greater share of the global budget. Immediate convergence provides a very small national emissions budget.

**FIGURE C.3:** AUSTRALIA'S LONG-TERM NATIONAL EMISSIONS BUDGET UNDER VARIOUS APPROACHES (Gt $CO_2$-e) AND SHARE OF THE GLOBAL EMISSIONS BUDGET (PER CENT)




**Notes:** National emissions budget for 2013–2050. All approaches share a global emissions budget consistent with a 67 per cent probability of limiting temperature increases to below 2 degrees. Australia's status quo share based on its share of global emissions including LULUCF emissions.
**Source:** Global budget: Authority calculation based on Meinshausen et al. (2009) adjusted using IEA (2013a) and (2013b) and Treasury and DIICCSRTE modelling (2013).
Approaches: Authority calculations based on spreadsheet tool used for the Garnaut Review (2008) with updates for emissions, population and GDP from Treasury and DIICCSRTE modelling (2013) (contraction and convergence, modified contraction and convergence); Höhne and Moltmann (2009) and inputs to spreadsheet tool (common but differentiated convergence); Authority calculations based on Treasury and DIICCSRTE modelling (2013) and IEA (2013b) (other approaches).

The Authority's recommended budget to 2050 is different to that proposed by some stakeholders. The Climate Institute (*Draft Report submission*, p. 2) and WWF-Australia (*Draft Report submission*, p. 6) suggested a 2013–2050 national budget of about 8,400 Mt $CO_2$-e based on a global budget with a 75 per cent probability of keeping warming below 2 degrees. Earlier analysis by Ecofys for WWF-Australia (2013) found budgets for the period 1990–2100 for Australia of between 14,000 and 18,000 Mt $CO_2$-e using different approaches. That analysis was based on a tighter global emissions budget than the Authority used, and a different time period (1990–2100 versus the Authority's 2013–2050).

The next section discusses two effort-sharing approaches. These are not included in Figure C.3 because the share of emissions reduction efforts by each country for the period to 2050 is not available, so comparable long-term national budgets cannot be derived.

## C1.2 EFFORT-SHARING APPROACHES

### C1.2.1 EQUAL PROPORTIONAL EMISSIONS REDUCTION COSTS

This approach seeks to equalise the wellbeing forgone when taking action to reduce emissions. It generally uses GDP as a proxy for wellbeing and allocates mitigation targets among developed countries, so that each incurs the same total emissions reduction cost as a proportion of GDP.

The implications for targets depend critically on whether countries undertake all emissions reductions domestically or use a mix of domestic and international reductions:

- If international emissions reductions cannot be used, developed countries facing higher total emissions reduction costs have weaker targets, and those facing lower costs have stronger targets, so that the cost as a share of GDP is the same in both countries.
- If international emissions reductions can be used, all countries can individually and collectively achieve the emissions reductions at a lower cost, because reductions can take place wherever in the world they are cheapest. Developed countries with higher total costs would still have weaker targets under this approach than those with lower costs; however, the difference in targets would be smaller than without trade.

Few published studies explicitly address the question of relative costs. Among those that do, a common conclusion is that Australia faces relatively high total emissions reduction costs—see, for example, McKibbin, Morris and Wilcoxen (2010), den Elzen et al. (2009) and Treasury (2008). This means that Australia's target under this approach would be relatively weaker than those of developed countries with lower costs.

It is difficult to estimate the national emissions budget that would correspond with this approach, as there is no consensus on the appropriate aggregate effort for developed countries and no generally agreed modelling approach for costs.

### C1.2.2 GREENHOUSE DEVELOPMENT RIGHTS

The Greenhouse Development Rights approach takes differences in capacity within nations explicitly into account (Baer et al. 2008). Each country's share of emissions reductions is based on two things:

- how many people in that country have incomes above a 'development threshold'
- how many emissions those people have generated since 1990.

These are combined in a Responsibility-Capacity Index, which is used to calculate the country's share of the global emissions reduction task. Under this approach, short-term targets for developed countries can be very strong indeed; for Australia, the 2020 target implied is more than 55 per cent below 2000 levels (EcoEquity and Stockholm Environment Institute 2013).

# APPENDIX C2
# AUSTRALIA'S EMISSIONS BUDGET TO 2050

Calculations of Australia's emissions budget to 2050 outlined in Chapter 8 draw on the international modelling from the Global Trade and Environment Model (GTEM) and further information provided by Treasury.

## C2.1 APPROACHES TO SHARING GLOBAL EMISSIONS BUDGETS

Estimates of Australia's long-term national emissions budget use global population projections from GTEM. Estimates for some approaches also use GDP and/or emissions by region from GTEM. The estimates for modified contraction and convergence, and simple contraction and convergence are Authority calculations based on the spreadsheet tool used for the Garnaut Climate Change Review 2008, with updates for emissions, population and GDP from Treasury and DIICCSRTE (2013).

## C2.2 AUSTRALIA'S 2013–2050 NATIONAL EMISSIONS BUDGET

Australia's long-term national emissions budget of 10,100 Mt $CO_2$-e is calculated as follows:

1. The 2000–2050 global emissions budget based on Meinshausen et al. (2009; see Chapter 3) is adjusted to remove global emissions from 2000–2012. Global emissions from 2000–2012 are estimated to be 608 Gt $CO_2$-e, based on International Energy Agency (IEA 2013a), using linear interpolation between 2000, 2005 and 2010 data points and the annualised growth rate for 2005–2010 to estimate 2011 and 2012 global emissions.
2. Projected emissions from international aviation and shipping for 2013–2050 are removed, as these are not allocated to any individual country. These are estimated to be 47 Gt $CO_2$-e based on IEA (2013b). Cumulative emissions to 2035 are calculated using a linear interpolation of aviation and shipping emissions in the IEA's '450' scenario between 2011, 2020, 2030 and 2035. Cumulative emissions from 2036–2050 are estimated by assuming that emissions during this period grow at the IEA's annualised rate for 2020–2035.
3. Australia's share of the resulting 2013–2050 global emissions budget is calculated based on its share (0.97 per cent) of global emissions under a modified contraction and convergence approach. This is an Authority calculation based on the spreadsheet tool used for the Garnaut Climate Change Review 2008 with updates for emissions, population and GDP from the Treasury and DIICCSRTE modelling report.

All emissions in the long-term national emissions budget calculation use GWPs from the IPCC's Second Assessment Report for consistency with the original Meinshausen et al. (2009) global emissions budget. This will tend to underestimate the global and national budget by a small amount; budgets calculated using AR4 GWPs are likely to be slightly larger in $CO_2$-e terms.

# APPENDIX C3
# 2030 TARGETS FOR AUSTRALIA AND SURVEY OF ALLOCATION METHODS

The Authority's recommendations are underpinned by analysis that uses the modified contraction and convergence approach and different global budgets. This gives 2030 targets for Australia, compared with 2000 levels, of:

- 40 per cent reductions using a global emissions budget that gives a 50 per cent chance of staying below 2 degrees of warming
- 50 per cent using a global emissions budget that gives a 67 per cent chance
- 60 per cent using a global emissions budget that gives a 75 per cent chance.

These 2030 reduction levels—which form the recommended trajectory range—are calculated by applying Australia's share of the budget under modified contraction and convergence (0.97 per cent) to different global emissions budgets, then applying straight-line trajectories from 19 per cent reductions in 2020 until the budget is exhausted.

This is broadly consistent with other studies. Höhne et al. (2014) have examined over 40 studies on allocation methods and focused on what they imply for 2030 targets. The results show that to stabilise greenhouse gas concentrations at 450 ppm $CO_2$-e (which gives roughly a 50 per cent chance of staying below 2 degrees), required emissions reductions relative to 2010 levels are:

- approximately 50 per cent for countries that were OECD members in 1990 ('OECD 1990', including North America, Western Europe, Japan, Australia, New Zealand)—with a range of 37–75 per cent reductions
- roughly 33 per cent for Economies in Transition (Eastern Europe, Russian Federation)—with a range of 28–53 per cent reductions
- roughly returning to 2010 levels or slightly below for Asia (East, South and South-East Asia)—with a range between a 7 per cent increase and a 33 per cent reduction.

Their survey of equal per person emissions methods found a 2030 target range of roughly 30–65 per cent reductions for OECD 1990, and roughly 20–65 per cent reductions for Japan, Australia and New Zealand as a sub-group.

These results are also broadly consistent with Professor Garnaut's 2008 review, which suggested that Australia should take on reduction targets of 25 per cent by 2020 and 90 per cent by 2050 below 2000 levels, in the context of global action giving an even (50 per cent) chance of staying below 2 degrees. Further, he found that if global action gave only an even chance of staying below 3 degrees, Australia should still take on reduction targets of 10 per cent by 2020 and 80 per cent by 2050 (Garnaut 2008, p. 283).

# PROGRESS TOWARDS AUSTRALIA'S EMISSIONS REDUCTION GOALS

# D

Australia faces a major task to meet the Authority's recommended emissions reduction goals. Australia's emissions are projected to rise, underpinned by population and economic growth. Strong policies will be needed to turn this around and drive the transition to a lower emissions economy.

Australia has significant emissions reduction opportunities in the domestic economy. A price incentive could drive substantial emissions reductions, particularly in electricity generation, fugitive emissions and industrial processes. The minimum 5 per cent emissions reduction target could be achieved solely through domestic emissions reductions, provided a strong and effective suite of policies is in place. The Authority's recommended 2020 target could be met by complementing domestic emissions reductions with international units. Depending on the policies implemented, the required reduction in emissions could be achieved for relatively small economic cost, and while maintaining economic growth and rising incomes.

Cost-effective and complementary policies must be put in place now and sustained to support the development of a lower emissions economy in the decades beyond 2020. Most of Australia's emissions come from long-lived equipment, buildings and vehicles, which will take time to change. In many cases, policies will not influence the majority of stock until 2030.

The most important sector for potential emissions reductions is electricity. It has the largest share of Australia's emissions and its emissions are projected to grow strongly without price incentives or additional policies. In scenarios with a price incentive, however, the electricity sector is projected to account for the largest share of emissions reductions. The RET is another important driver, as is action to increase the uptake of energy efficiency.

Further emissions reductions are also available. Light vehicle efficiency standards have delivered cost-effective reductions in other markets; their use in Australia warrants investigation. In the near term, targeted policies should be implemented to increase the uptake of energy efficiency more broadly. Depending on policy incentives, in the longer term the land sector could also offer large emissions reductions.

# APPENDIX D1
# EVALUATING PROGRESS

As outlined in Chapter 1, the Clean Energy Act requires the Authority to review Australia's progress towards its medium- and long-term emissions reduction goals. Appendix D, together with chapters 6, 11 and 12, fulfils this legislative requirement.

Appendix D1 sets out the purpose, scope and approach to the review of progress. Appendix D2 highlights the outlook for emissions from the Australian economy as a whole. Appendices D3–D10 outline the outlook for changes in emissions from each sector, expanding on the discussion in Chapter 11.

## D1.1 PURPOSE AND SCOPE OF THE REVIEW

To meet its emissions reduction goals, Australia has implemented a range of policy measures, as discussed in Chapter 5. This Review assesses how Australia is tracking towards its emissions reduction goals, providing important feedback to government on changes taking place in the economy in response to these policy measures and other factors.

This Review focuses on the outlook for emissions across the economy under several scenarios and also considers the outlook for changes in emissions in different sectors. The approach is designed to assess if and how Australia might achieve its emissions reduction targets. Considering the projected outcomes in each sector helps to identify opportunities to transition to a lower emissions economy, and determine the efficiency of policy measures and their impact on different sectors.

The Authority has based its Review on the four scenarios described in Chapter 10 and Appendix F (no price, low, medium and high scenarios). The Authority has also drawn on additional modelling, published material and expert input to provide a broader review of possible future outcomes.

## D1.2 STAKEHOLDER VIEWS ON THE AUTHORITY'S REVIEW

Some stakeholder submissions to the Issues Paper for this Review raised concerns that assessing progress by referring to developments in each sector may imply sector-specific emissions targets or development pathways. There were concerns such an approach could compromise Australia's broad-based strategy to reducing emissions.

The Authority does not recommend binding sector-specific objectives or prescribe pathways, technologies or activities to reach Australia's emissions reduction goals. Rather, the Review synthesises information from multiple sources to better understand possible paths towards emissions reductions and the factors ('contributors') likely to lead to significant changes in emissions. The Authority's analysis considers the likelihood and timing of potential outcomes. This can help identify if Australia is on track to meet its broader national emissions reduction goals, and how those goals may be met.

Some stakeholders called for a focus on policy as a driver of changes in emissions. The Authority has not estimated the change in emissions from any specific policy or legislation, though it has considered the potential of general policy options. The emissions reduction potential of specific policy is generally determined as part of the process of developing or evaluating regulatory instruments. Instead, the Review seeks to identify drivers of change in emissions; across successive annual progress reviews this could identify policies with a significant effect on activity and emissions.

The Review does not explicitly assess the cost-effectiveness of policies, but does identify opportunities for changes in technology or behaviour to increase the uptake of cost-effective emissions reductions in future, and policy options that warrant further investigation. The Authority focuses on the most substantive contributors and drivers of emissions outcomes. While policy is relevant, macroeconomic and other drivers are also important.

## D1.3 FRAMEWORK FOR ANALYSING PROGRESS

The Authority's analytic framework for assessing progress considers:

- Australia's domestic emissions levels and emissions intensity, recent trends and projections
- historical and projected sectoral emissions outcomes, the key contributors to those outcomes, and the underlying economic, policy and technological drivers.

## D1.4 CONSIDERING ACTIVITY AND SUPPLY INTENSITY

In this Review, emissions are disaggregated into activity levels and emissions intensity to give a more comprehensive picture of Australia's progress. For example, emissions in the electricity sector are affected by both the amount of electricity generated (the activity level) and the emissions intensity of generation.

It is important to highlight the extent to which emissions levels, both historical and projected, reflect changing levels of activity compared with the emissions intensity of that activity. This distinction helps illustrate the projected strong growth in activity for most parts of the economy. It is also useful in informing policy, since different policy instruments often focus on either decreasing emissions intensity, or changing demand or activity.

## D1.5 REVIEWING PROGRESS ECONOMY-WIDE AND BY SECTOR

The economy-wide analysis considers the relative contribution of different sectors to changes in domestic emissions, based on taking up emissions reduction opportunities to a certain marginal cost.

The sectoral analysis of progress (appendices D3–D10) identifies potential emissions outcomes in absolute terms and in terms of activity levels and emissions intensity. Sectoral analyses are designed to, over time:

- identify the greatest contributors to changes in sector emissions, including those that affect levels of activity and the emissions intensity of the sector's activity
- track the main contributors to projected emissions outcomes and the drivers that underpin them
- allow comparison between modelled and realised sectoral outcomes, helping to anticipate when contributors or drivers will persist, subside or recur.

The Authority has adopted the same approach to define sectors and organise its sector-level reporting as is used in Australia's National Greenhouse Gas Inventory—electricity generation, transport, direct combustion, fugitives, industrial processes, agriculture, LULUCF and waste.

The Authority also uses complementary analysis of emissions attributed to end-use categories, such as buildings, where it provides additional information or helps consider opportunities for, or barriers to, cost-effective emissions reductions.

## D1.6 ASSESSING EMISSIONS CHANGES AGAINST A FIXED BASELINE

This appendix does not focus on emissions reduction relative to a concept of BAU (or 'no price' scenario). BAU projections depend on the broader economic and policy context at a point in time and, as such, fail to provide a stable and robust basis for tracking progress towards fixed long-term targets. Instead, the Authority uses 2000 as the base year against which to assess changes in emissions. This approach:

- is consistent with the expression of Australia's emissions reduction targets
- avoids the use of a BAU reference, supporting longer term comparison of Australia's progress that remains relevant as the economic conditions and legislative framework change over time
- is easily rebased to alternative reference years, if required.

Australia's total emissions in 2000 were 586 Mt $CO_2$-e.

In contrast to Appendix D, Chapter 11 most often compares emissions projections relative to a counterfactual 'no price' scenario.

## D1.7 SYNTHESISING DATA SOURCES AND QUANTIFYING EMISSIONS

This Review uses historical and projected emissions for the period 1990–2030 from Treasury and DIICCSRTE modelling (2013). In that report:

- the data incorporates National Greenhouse Gas Inventory data for the 2010–11 inventory year and preliminary emissions estimates for 2011–12 and 2012–13
- emissions for 2012 are based on preliminary inventory data and modelled estimates available at the time Treasury and DIICCSRTE modelling was undertaken (March 2013). They do not reflect 2012 or 2013 emissions reported in the June 2013 Quarterly Update of Australia's National Greenhouse Gas Inventory, released in December 2013. The June 2013 Quarterly Update is the source of Australia's estimated carryover from the first commitment period of the Kyoto Protocol. Revisions incorporated in the June 2013 Quarterly Update revise estimated 2012 emissions, but have almost no effect on the rate of growth in emissions between 2011–12 and 2012–13
- the data for emissions for the period 2013–2030 are modelled estimates (see Appendix C)
- historical emissions for the LULUCF sector for the period 1990–2012 are based on an estimate of emissions consistent with the new accounting rules (Article 3.4) agreed for the second commitment period of the Kyoto Protocol
- all emissions data has been converted to $CO_2$-e using global warming potentials from the IPCC Fourth Assessment Report. Historical emissions for LULUCF for the period 1990 to 2012 have been adjusted to be consistent with the new accounting rules agreed for the second commitment period of the Kyoto Protocol. This means historical and projected emissions data throughout the report is directly comparable.

All data in this report is for the financial year ending 30 June unless otherwise indicated. For example, data reported for 2013 is for the financial year 2012–13. All dollar amounts (prices and costs) reported in this appendix are 2012 Australian dollars, unless otherwise stated.

In December 2013, the National Greenhouse Gas Inventory was updated for the 2012–13 year, with refinements to earlier years' emissions levels. For consistency with the modelled scenarios, Appendix D retains the historical emissions data on which the Treasury and DIICCSRTE modelling is based.

Modelling from the Treasury and DIICCSRTE has formed the core data set analysed in this Review, including four core scenarios—one without a carbon price, and three different price levels (Box D.1). The electricity, transport and agriculture sectors were modelled separately in greater detail, and scenarios and sensitivities from these models are also included.

**BOX D.1: MODELLING SCENARIOS USED TO TRACK EMISSIONS PROGRESS**

**No price scenario**—assumes there is no carbon price and no CFI. This scenario includes emissions reductions from pre-existing measures such as energy efficiency measures and the RET.

**Low scenario**—additionally assumes the carbon price and CFI are in place. The carbon price is fixed for two years, then moves to a flexible price. The flexible price begins at \$5.49/t $CO_2$-e in 2015, and grows at 4 per cent per year in real terms to reach \$6.31 in 2020. The price then follows a linear transition to \$54.48 in 2030.

**Medium scenario**—assumes the fixed price for two years, then a flexible price beginning at \$5.49/t $CO_2$-e in 2015, and following a linear transition to \$30.14 in 2020. From 2021, the price follows the international price from the medium global action scenario, which grows at 4 per cent per year in real terms in US dollars.

**High scenario**—assumes the fixed price for two years, then a flexible price beginning at \$5.49/t $CO_2$-e in 2015, and following a linear transition to \$73.44 in 2020. From 2021, the price follows the international price from the ambitious global action scenario, which grows at 4 per cent per year in real terms in US dollars.

The effective carbon price faced by liable entities is lower than the modelled price in the low, medium and high scenarios. Kyoto units such as CERs currently trade at prices well below the prices used in these scenarios and the modelling assumes there is a price difference between CERs and ACUs for the period to 2020. The effective carbon price faced by liable entities is a weighted average of the ACU and CER price, with weights reflecting the CER sub-limit (12.5 per cent of their liability).

Chapter 10 of this Review and Table 3.1 of the Treasury and DIICCSRTE (2013) modelling report provide further details of the scenario assumptions.

It is useful to consider uncertainty when assessing possible future outcomes. Among other things, Australia's emissions may be higher or lower as a result of changes in the level of global action on climate change, the Australian legislative framework, economic growth, demographic factors and technology costs. The Review notes opportunities, risks and barriers to delivering emissions reductions projected in recent modelling and analysis. The Authority considers the four scenarios described earlier, alongside sensitivity analyses and alternative projections, to explore some important variables.

The Authority acknowledges that modelling presents possible future outcomes based on a particular set of assumptions. This analysis has also drawn on additional published sources and expert input to supplement modelling results and give a broader picture of potential futures. Appendix D explores opportunities for greater emissions reductions than those projected, as well as risks and barriers to realising the emissions outcomes projected by the modelling.

This Review provides a more detailed assessment of the outlook for the electricity and transport sectors than for other parts of the economy. In subsequent progress reviews, similarly detailed consideration of emissions from other sectors could be undertaken, over time building an economy-wide picture of possible paths for reductions in emissions.

## D1.8 SELECTING CONTRIBUTORS AND DRIVERS

The Authority analyses progress in terms of contributors and drivers.

### D1.8.1 CONTRIBUTORS

Contributors are changes that directly affect the emissions outcomes. They may include factors that affect emissions intensity, such as changes in process, fuels or technology. Generally, a sector's activity level will be a contributor to its emissions outcomes.

The Authority has focused on contributors to emissions outcomes that are:

- projected to deliver a significant proportion of Australia's changes in emissions by 2050, whether at a point in time or in aggregate (nominally over 5 per cent of domestic emissions changes)
- among the top few contributors to emissions reductions, at a point in time or in aggregate, in a sector.

The Authority has also examined other contributors that:

- could be deployed broadly across the sector under plausible conditions
- are likely to lock in emissions reductions (or increases)
- have a relatively long lead time for deployment
- offer low-cost emissions reductions
- offer significant co-benefits (or disadvantages) outside of their potential emissions impacts
- are explicitly identified by sector experts for other reasons.

### D1.8.2 DRIVERS

Drivers are the underlying factors that promote or impede contributors, but do not directly affect emissions outcomes. Drivers may include factors such the rate of growth in GNI, relative technology costs, population growth or policy.

The underlying drivers are identified to give a sense of the risks, uncertainties, barriers and opportunities to domestic emissions reduction and, therefore, Australia's progress in meeting its emissions reduction goals.

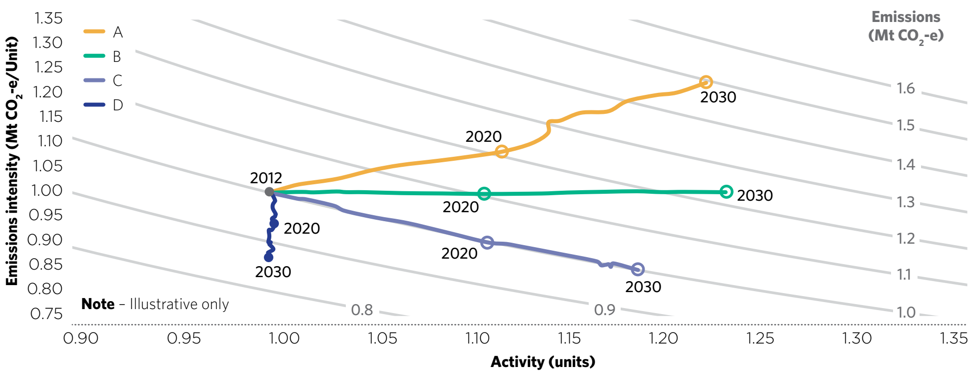
## D1.8.3 ILLUSTRATING PROGRESS

Appendix D introduces two styles of charts to help describe Australia's progress towards its emissions reduction goals.

Australia's emissions are, for the most part, characterised by decreases in emissions intensity offsetting increasing activity. The first chart (Figure D.1) shows changes in emissions intensity against demand-side activity. This highlights whether increasing activity or decreasing supply intensity have the greatest effect on absolute emissions.

The horizontal axis represents total activity levels in the relevant sector. Depending on the sector, activity may be, for example, electricity generated, energy combusted or kilometres travelled. The vertical axis represents the emissions per unit of activity. It is a measure of emissions intensity in the relevant sector. Curved isolines represent absolute emissions levels. The plot(s) on the chart are presented to show the historical and projected changes in activity, emissions intensity and absolute emissions. Date labels indicate the progression of emissions outcomes over time.

**FIGURE D.1: EXAMPLES OF TRENDS IN EMISSIONS INTENSITY AND ACTIVITY**




**Source:** Climate Change Authority

Figure D.1 shows four plot examples:

- Plot A shows a trend of increasing emissions intensity and activity, with corresponding increasing absolute emissions levels.
- Plot B shows a trend of stable emissions intensity coupled with activity growth, leading to increasing levels of absolute emissions.
- Plot C shows a trend of falling emissions intensity balancing increasing activity levels, leading to stable absolute emissions (following the emissions isoline).
- Plot D shows a trend of falling emissions intensity against stable activity levels, leading to a reduction in absolute emissions.

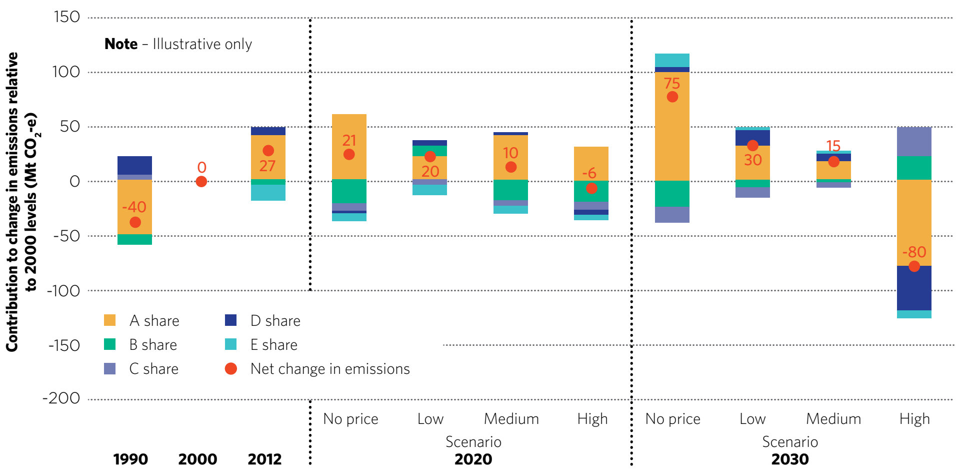
The second chart (Figure D.2) summarises projected emissions outcomes for a given year and the contributors to changes in emissions outcomes, relative to 2000 emissions levels.

Read from left to right, the bars represent the increasing level of price incentive, from the no price scenario to the high scenario, for a given sector.

Each bar is divided into the main contributors to changes in emissions, whether increasing or decreasing emissions, compared to 2000 levels. These contributors may represent changes in activity levels, supply intensity, or the net contribution of a particular subsector or other area of interest.

The net change in emissions—that is, the sum of all the contributors—is represented by the red circles.

**FIGURE D.2: EXAMPLES OF TRENDS IN EMISSIONS INTENSITY AND ACTIVITY, 1990–2030**




**Source:** Climate Change Authority

# APPENDIX D2 WHOLE-OF-ECONOMY

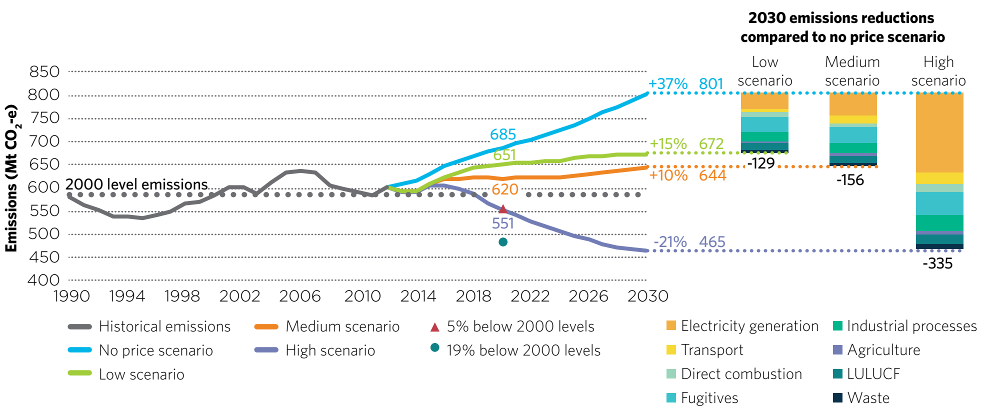
## D2.1 INDICATORS FOR THE AUSTRALIAN ECONOMY

As described in Chapter 6, Australia's domestic emissions have been relatively stable since 2000, despite significant population and economic growth.

Since 2000, Australia's emissions have increased by 2.5 per cent, driven by increases in emissions across most sectors. Emissions reductions from LULUCF have offset most of the increase from the remainder of the economy.

The Treasury and DIICCSRTE modelling projects that between 2000 and 2020 emissions could rise by 17 per cent in the no price scenario and fall by 6 per cent under the high scenario. The gap widens over time—by 2030, emissions could rise by 37 per cent in the no price scenario and fall by 21 per cent under the high scenario (see Figure D.3). The modelling indicates that the electricity sector will account for the largest emissions reduction of any sector in the low, medium and high scenarios, followed by the fugitives sectors.

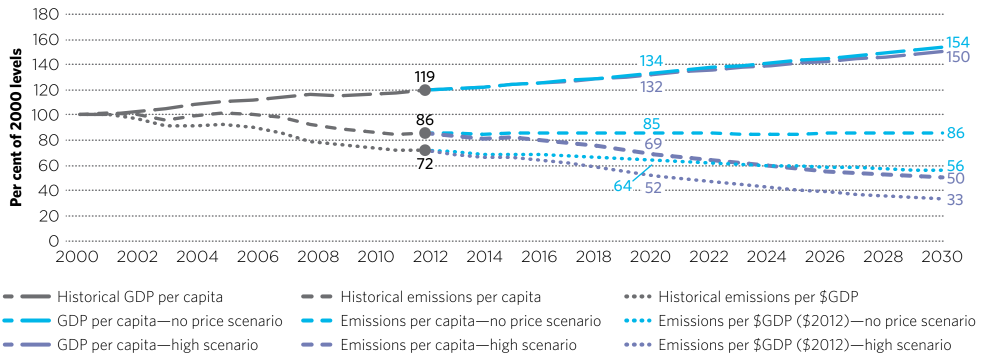
**FIGURE D.3:** AUSTRALIA'S EMISSIONS, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

Emissions intensity of the economy, as indicated by the ratio of domestic emissions to GDP, has reduced 28 per cent since 2000 and is projected by the Treasury and DIICCSRTE, under all scenarios, to decline to 2030 (figures D.4 and D.5)

**FIGURE D.4: AUSTRALIA'S GDP PER PERSON, EMISSIONS PER PERSON AND EMISSIONS INTENSITY, 2000–2030**



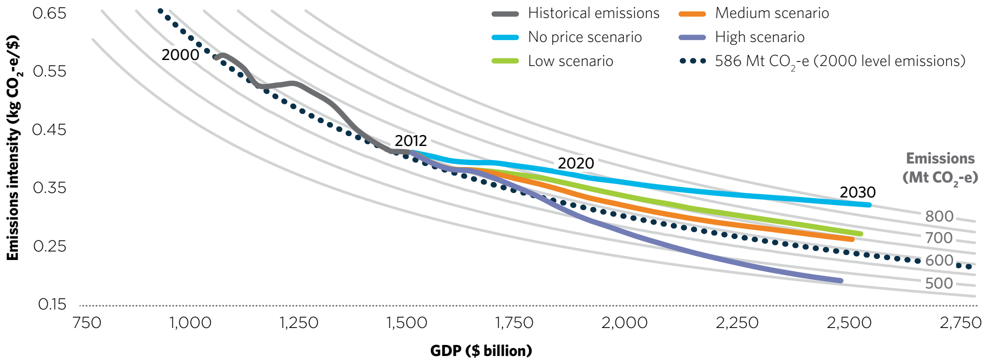

**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

Similarly, the level of emissions per person has fallen by almost 15 per cent since 2000 and is projected to continue to decline in the low, medium and high scenarios; or, in the no price scenario, to remain relatively stable (figures D.4 and D.6). In contrast, as shown in Figure D.4, GDP per person has grown since 2000 and is projected to continue to grow in all scenarios.

Strong global action on climate change and a broad-based price incentive for emissions reductions in Australia could have a relatively limited effect on GDP, depending on the policies implemented. From 2012 to 2030, the Treasury and DIICCSRTE's modelling projects that the economy will grow by between about 65 per cent under a high scenario and 70 per cent under a no price scenario. In contrast, a strong price incentive for emissions reductions could have a substantial impact on the outlook for Australia's emissions. Under the no price scenario, Australia's emissions are projected to rise by as much as 33 per cent relative to 2012 levels. Under the high scenario, however, emissions are projected to fall by about 23 per cent from 2012 to 2030.

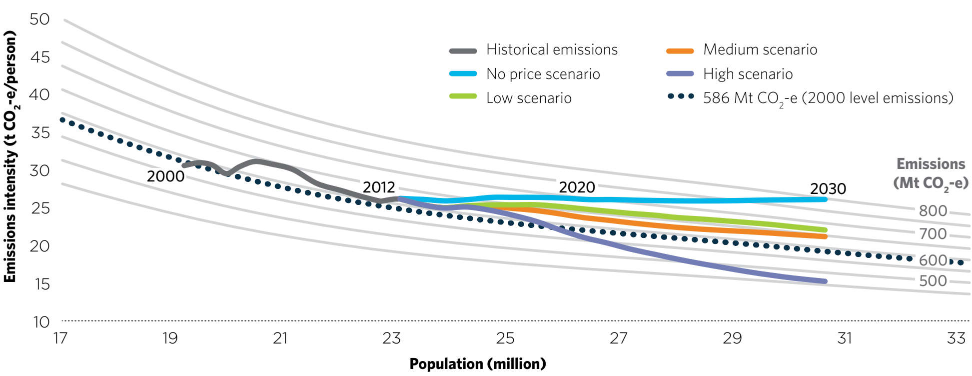
Despite this, under the no price, low and medium scenarios it is projected that domestic emissions reductions will be insufficient for Australia to meet its 2020 target. The high scenario gets closest to cumulative emissions reductions consistent with Australia's 2020 minimum 5 per cent emissions reduction commitment.

**FIGURE D.5:** AUSTRALIA'S EMISSIONS INTENSITY—EMISSIONS PER UNIT GDP ($2012), 2000–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

**FIGURE D.6:** AUSTRALIA'S EMISSIONS INTENSITY—EMISSIONS AND POPULATION, 2000–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

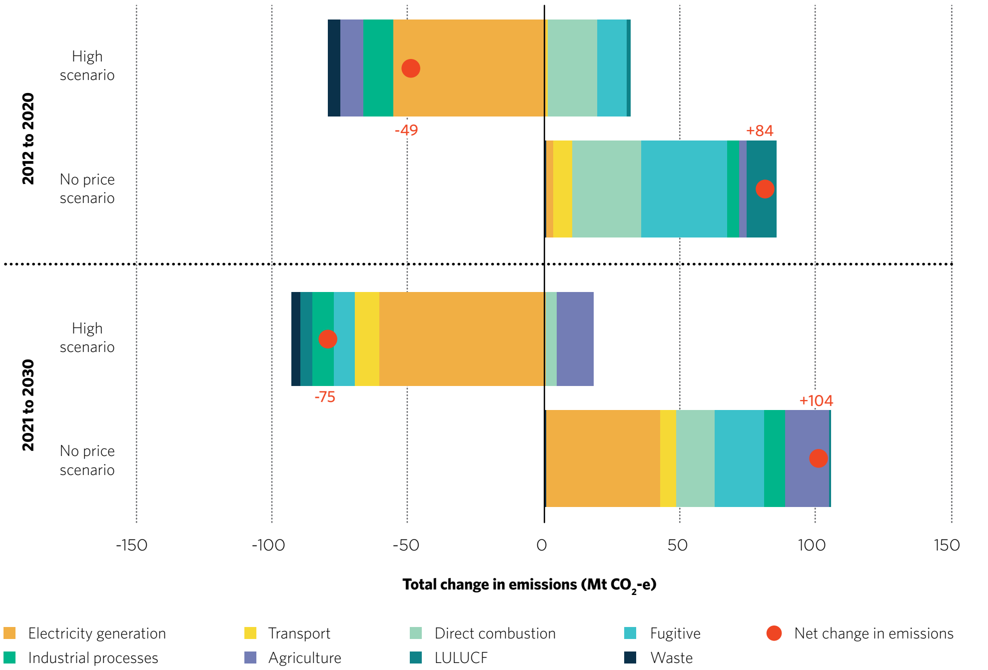
## D2.2 OVERVIEW OF SECTORAL PROGRESS

Electricity generation and direct combustion emissions are projected to continue to account for about half of Australia's total emissions over the period to 2030. Transport, fugitive and agricultural emissions are forecast to make up the majority of the remaining emissions.

The projected growth in direct combustion, fugitive and agricultural emissions is projected to offset reductions in waste, industrial process and electricity emissions over the period to 2030 in all except the high scenario.

Figure D.7 shows that an emissions reduction of about 134 Mt $CO_2$-e could be achieved in 2020 under the high scenario compared to the no price scenario, which is broadly consistent with the minimum reduction required to deliver the unconditional 5 per cent target.

**FIGURE D.7:** CHANGES IN AUSTRALIA'S EMISSIONS—NO PRICE AND HIGH SCENARIOS, 2012–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## D2.3 SECTORAL CONTRIBUTIONS TO EMISSIONS

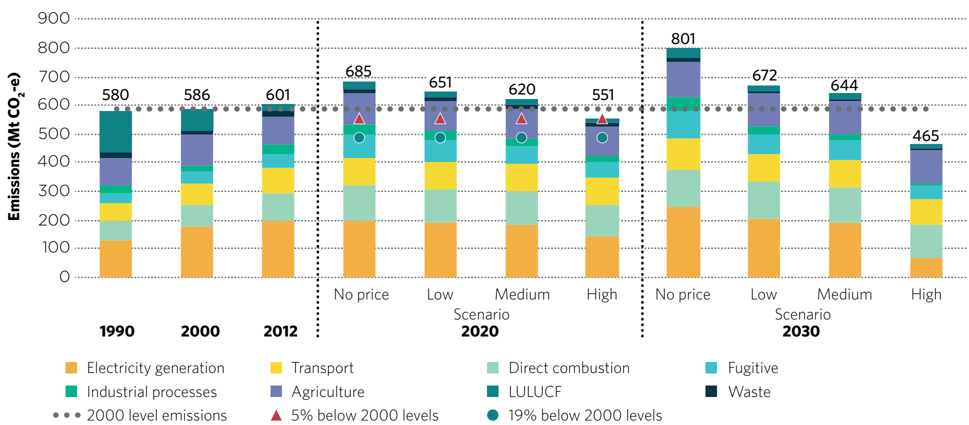
State and Commonwealth regulation has been a major driver of emissions reductions. An 85 per cent reduction in LULUCF emissions, largely due to economic conditions and regulatory restrictions on land clearing, was a key reason why Australia's whole-of-economy emissions were relatively flat between 1990 and 2012. The Treasury and DIICCSRTE modelling does not project similar improvements for this sector in future.

Electricity is the most significant sectoral contributor to emissions. Emissions from electricity generation grew quickly until 2009, when they started to decline. Since then, reduced demand for grid-connected electricity, combined with lower emissions generation, has driven down emissions.

Under the low, medium and high scenarios, reductions in Australia's emissions intensity between 2012 and 2030 are more distributed across the economy than in the past. These sectoral changes are shown in Figure D.8.

- **Electricity**—emissions under the high scenario are projected to decline to 2030, driven by lower demand growth, energy efficiency and a shift towards lower emissions intensity generation. The outlook under the low scenario and no price scenario is for emissions to rise by between 5 and 23 per cent between 2012 and 2030.
- **Transport**—demand is expected to continue to grow, driven by strong growth in road freight and domestic aviation. Modest growth is projected in light passenger vehicle emissions, which are the largest contributor to transport emissions. Increasing use of low-emissions fuels and vehicle efficiency improvements are projected to partially offset activity increases to 2030.
- **Direct combustion and fugitive emissions**—projected to increase to 2030, particularly because of greater gas production driven by foreign demand for Australian LNG and coal. Growth in these sectors could drive most of the net growth in domestic emissions to 2030 under the low scenario; more than offset the net reductions from the rest of the economy under the medium scenario; or significantly offset the net emissions reduction under the high scenario.
- **Industrial processes**—under the low, medium and high scenarios, industrial process emissions are projected to fall by between 25 and 66 per cent from 2012 to 2030, largely due to the deployment of nitrous oxide conversion catalysts, which improve emissions intensity. Under the no price scenario, industrial process emissions are projected to rise by about 40 per cent above 2012 levels by 2030.
- **Agriculture and LULUCF**—increasing export demand for Australian agricultural commodities is projected to drive an increase in emissions from agriculture. Projected emissions from LULUCF depend on the level of incentive for emissions reductions.
- **Waste**—emissions, in all scenarios, are projected to fall through improved waste management; specifically, landfill gas capture and combustion (whether flared or used to generate electricity).

**FIGURE D.8: AUSTRALIA'S DOMESTIC EMISSIONS BY SECTOR, SELECTED YEARS, 1990–2030**




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

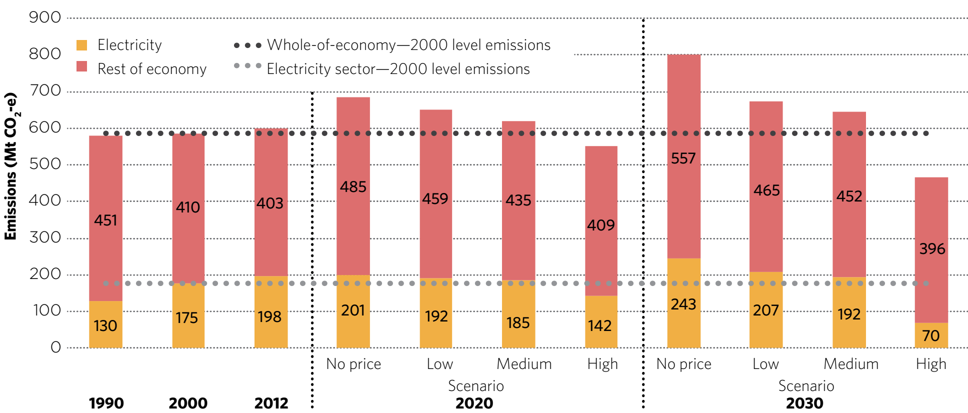
# APPENDIX D3 ELECTRICITY

## D3.1 ELECTRICITY EMISSIONS OVERVIEW

Generating electricity using fossil fuels, such as coal, natural gas and liquid fuels, results in greenhouse gas emissions. This section examines electricity generation supplying electricity grids; for example, the NEM, and electricity generation for private use ('off-grid').

Electricity generation produced 33 per cent of national emissions in 2012—the largest sectoral share (Figure D.9). Electricity generation is projected to remain the largest sectoral emitter until at least 2030, except in the high scenario. It is also projected to be the largest sectoral contributor to emissions reductions in the low, medium and high scenarios.

**FIGURE D.9:** ELECTRICITY GENERATION SECTOR SHARE OF AUSTRALIA'S EMISSIONS, SELECTED YEARS, 1990–2030

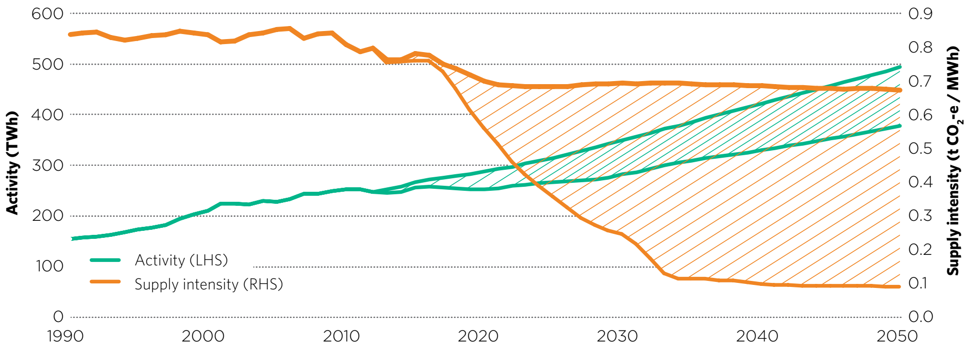



**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

After decades of growth, levels of electricity generation have been relatively stable since 2008. Since then, emissions have declined by an average of almost 1 per cent each year to 2012. The Australian Energy Market Operator (AEMO 2013a) and Treasury and DIICCSRTE (2013) project that electricity demand will start growing again to 2020 and continue to rise after that (Figure D.10).

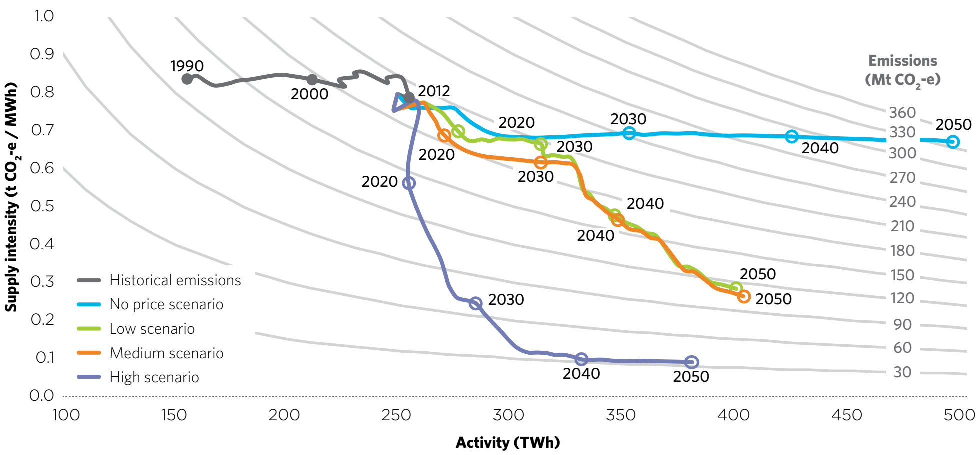
Along with lower demand, the recent emissions decline was also due to a marked downturn in emissions intensity of electricity supply (BREE 2013b; Treasury and DIICCSRTE 2013). ACIL Allen Consulting (2013) projects that this trend may continue in the low, medium and high scenarios, but could stall from 2020 in the no price scenario (Figure D.11).

**FIGURE D.10: ELECTRICITY GENERATION ACTIVITY AND EMISSIONS INTENSITY OF ELECTRICITY SUPPLY—MODELLED RANGE, 1990–2050**




**Note:** Upper and lower line bounds illustrate range of modelled outcomes. Electricity generation activity is 'as generated'.
**Source:** Climate Change Authority calculations using BREE 2013b and results from Treasury and DIICCSRTE 2013

**FIGURE D.11: ELECTRICITY GENERATION ACTIVITY AND EMISSIONS INTENSITY—FOUR SCENARIOS, 1990–2050**




**Note:** Electricity generation activity is 'as generated'.
**Sources:** ACIL Allen Consulting 2013; BREE 2013b; Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

This section describes the most substantive contributors to and drivers of the emissions outcomes projected for the electricity sector. Results of the four scenarios are presented, as modelled by the Treasury and DIICCSRTE 2013. Appendix D3 focuses on grid-connected electricity, which accounted for about 96 per cent of total electricity generation in 2011–12; off-grid electricity generation is analysed specifically where relevant (ACIL Allen Consulting 2013).

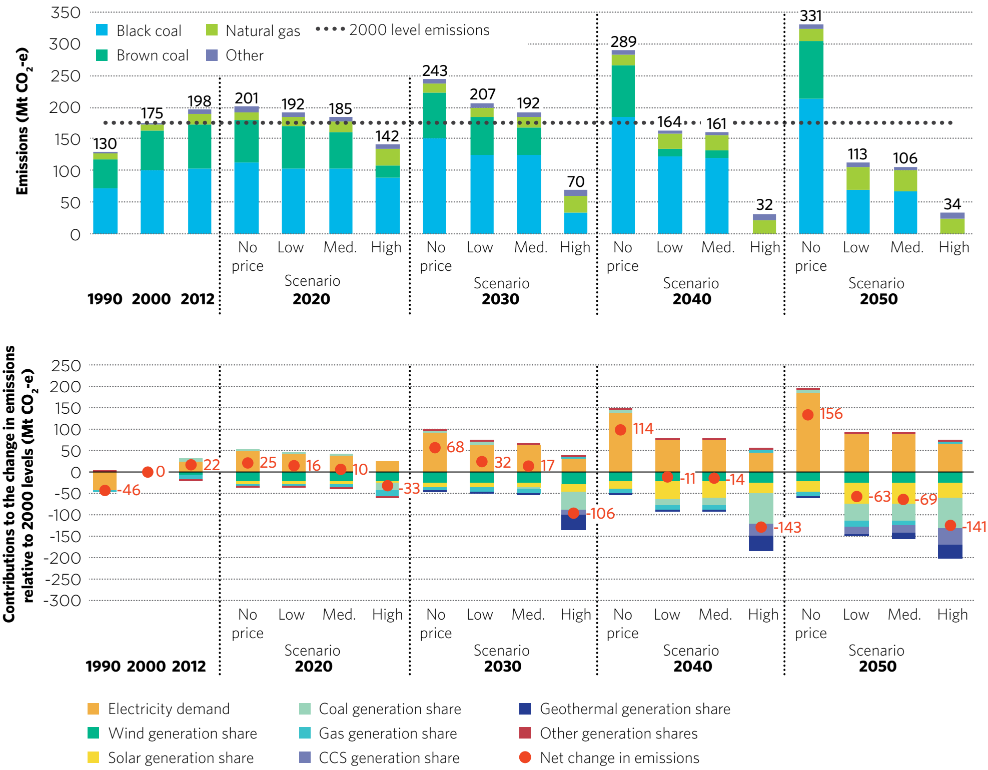
Figure D.12 shows significant growth in electricity sector emissions in the no price scenario, rising to 14 per cent above 2000 levels in 2020, and almost 40 per cent above 2000 levels in 2030.

Targeted policy could substantially reduce the sector's emissions. The Treasury and DIICCSRTE modelling suggests that higher electricity demand could be offset by a lower emissions intensity of supply in the low, medium and high scenarios, thus reducing electricity sector emissions (figures D.10 and D.11). If a price incentive is in place, the modelling projects that:

- In 2020, Australia's electricity sector emissions are reduced from their 2012 levels (198 Mt $CO_2$-e) to between 142 and 192 Mt $CO_2$-e (high and low scenarios, respectively). For the low and medium scenarios, this is a moderate increase on 2000 emissions levels, but for the high scenario it is a 19 per cent reduction.
- In 2030, electricity sector emissions trends are heavily dependent on policy drivers. Emissions could rise to between 192 and 207 Mt $CO_2$-e in 2030 (medium and low scenarios, respectively) or fall under the high scenario to 70 Mt $CO_2$-e in 2030 (60 per cent below 2000 levels).
- In 2050, the low and medium scenarios see emissions fall to about 110 Mt $CO_2$-e (37 per cent below 2000 levels) and to as low as 34 Mt $CO_2$-e under the high scenario (81 per cent below 2000 levels).

Changes in electricity generation activity and the emissions intensity of supply are both important to delivering emissions reductions, although, in the near to medium term, reduction in supply intensity is projected to be the bigger factor. The Treasury and DIICCSRTE modelling projects that, in the medium scenario, the share of electricity emissions reductions due to reduced demand is 36 per cent in 2020 and 40 per cent in 2030.

**FIGURE D.12: CONTRIBUTORS TO ELECTRICITY EMISSIONS, SELECTED YEARS, 1990–2050, AND TO CHANGE IN EMISSIONS RELATIVE TO 2000 LEVELS**




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## D3.1.1 OVERVIEW OF CHANGES IN ELECTRICITY GENERATION EMISSIONS INTENSITY

Emissions intensity of electricity generation declined by about 7 per cent between 2000 and 2012 with further improvement expected in all modelled scenarios. The Treasury and DIICCSRTE projects that, in a no price scenario, the improvement is relatively modest; emissions intensity is about 16 per cent lower than 2000 levels in 2020—primarily as a result of renewables and driven by the RET—but is likely to change little after that.

With incentives in place to reduce emissions, changes in the electricity supply mix could reduce the emissions intensity of supply by up to a third in 2020 and by almost 90 per cent by 2050, compared to 2000 levels (Table D.1).

**TABLE D.1:** EMISSIONS INTENSITY OF AUSTRALIA'S ELECTRICITY SUPPLY, 2000–2050

| | HISTORICAL EMISSIONS INTENSITY ($t\ CO_2$-e/MWh) | | | PROJECTED EMISSIONS INTENSITY ($t\ CO_2$-e/MWh) | | | |
|---|---|---|---|---|---|---|---|
| **Scenario** | **2000** | **2008** | **2012** | **2020** | **2030** | **2040** | **2050** |
| No price | 0.84 | 0.84 | 0.78 | 0.70 | 0.69 | 0.69 | 0.67 |
| Low | | | | 0.70 | 0.66 | 0.48 | 0.28 |
| Medium | | | | 0.69 | 0.62 | 0.47 | 0.26 |
| High | | | | 0.56 | 0.25 | 0.10 | 0.09 |

**Note:** Calculation based on electricity generation 'as generated'.
**Source:** Historical: BREE 2013b, Table O; DCCEE 2012 Projections: Climate Change Authority based on Treasury and DIICCSRTE 2013 data and ACIL Allen Consulting 2013

Figure D.12 shows several contributors to a lower emissions intensity electricity supply, particularly:

- Declining conventional coal-fired generation, which could reduce emissions by between 2 and 56 Mt $CO_2$-e in 2020, relative to 2000 levels. Emissions from coal-fired generation are projected to be higher in 2030 than in 2000, except under the high scenario where they could be almost 130 Mt $CO_2$-e lower.
- Increasing wind and solar generation share, which could contribute to an emissions reduction of about 30 Mt $CO_2$-e in 2020, relative to 2000. Projections suggest that in 2030 increasing wind and solar generation could reduce emissions by between 39 and 51 Mt $CO_2$-e (in no price and high scenarios, respectively), relative to 2000.

CCS and geothermal generation could also contribute significantly in later decades, with an incentive in place, though timing of their deployment remains uncertain. Table D.3 provides further detail of the potential fuel mixes that could lower the emissions intensity of electricity.

The deployment and diffusion of electricity generation technologies will depend on a range of drivers. Exchange rates, technological advances, climate change mitigation policy and electricity prices will affect the relative cost of technologies and the point at which each option becomes economically viable. Until 2020, the mandatory RET is likely to drive steady deployment of renewables, such as wind. Sections D3.3 and D3.4 discuss the opportunities and barriers to realising the potential changes in emissions intensity.

## D3.1.2 OVERVIEW OF CHANGES IN ELECTRICITY DEMAND

Since 2008, growth in electricity generation has slowed (Table D.2). Macroeconomic drivers, weaker global financial conditions and a rising Australian dollar have underpinned softening demand in the industrial sector, with the closure of the Kurri Kurri aluminium smelter in 2012 being one example (AEMO 2013a). Future industrial sector demand for electricity is likely to rise with strong projected growth in activity, but continuation of current energy efficiency improvements could offset growth to some extent (ClimateWorks 2013c). The considerable uncertainty in electricity demand forecasts is discussed further in Section D3.5.2.

Changes in electricity demand are driven, in part, by rising incomes and population, which have historically resulted in increased use of electrical appliances. Over the last two decades, the increased emissions that might be expected from the uptake of new appliances, such as IT and entertainment equipment, have been counteracted by improved efficiency in buildings and appliances.

Efficiency improvements have been driven primarily by policy intervention at various levels of government, particularly minimum energy performance standards for appliances implemented from 1999 and changes to the Building Code of Australia for residential buildings. Uptake of small-scale solar PV has also reduced demand for grid-connected electricity (AEMO 2013a).

Recently, substantial rises in electricity prices—growth of almost 60 per cent in residential prices from 2008 to 2012—have contributed to reduced growth in demand (Saddler 2013). This driver, however, could moderate within a few years (AEMC 2013).

### TABLE D.2: AUSTRALIA'S ELECTRICITY GENERATION, 2000–2050

| | HISTORICAL ELECTRICITY GENERATION (TWh) | | | PROJECTED ELECTRICITY GENERATION (TWh) | | | |
|---|---|---|---|---|---|---|---|
| **Scenario** | **2000** | **2008** | **2012** | **2020** | **2030** | **2040** | **2050** |
| No price | 210 | 243 | 254 | 287 | 351 | 422 | 493 |
| Low | 210 | 243 | 254 | 275 | 312 | 344 | 398 |
| Medium | 210 | 243 | 254 | 269 | 312 | 346 | 401 |
| High | 210 | 243 | 254 | 253 | 282 | 329 | 378 |

**Note:** Electricity generation is 'as generated'.
**Source:** Historical: BREE 2013b, Table O Projections based on ACIL Allen Consulting 2013

The Treasury and DIICCSRTE's modelling projects that Australia's electricity generation will remain steady or rise to 2020 and rise more quickly to 2030, in all scenarios. The effect of the price incentive on projected generation is evident. Electricity generation is about 6 per cent lower in 2020 under the high scenario than the medium scenario. By 2050, electricity generation could be between 80 and 89 per cent higher than in 2000, depending on the level of the price incentive (high and low scenarios, respectively).

Some of the major contributors expected to reduce future emissions, through changing demand in the residential and commercial sectors, have long lead times due to the slow replacement rate of buildings and appliances. These include:

- improvements in building efficiency, which could reduce emissions, relative to 2000 levels, by about 12 Mt $CO_2$-e in 2020 and more in later years as stock turns over
- improvements in the efficiency of electrical appliances, which could reduce emissions, relative to 2000 levels, by about 20 Mt $CO_2$-e in 2020 and more in later years (DCCEE 2010b, p. 23).

Section D3.3 discusses further the opportunities and barriers to the uptake of cost-effective emissions reductions through changing electricity demand and reducing the level of total generation.

## D3.2 EMISSIONS INTENSITY OF ELECTRICITY SUPPLY

### D3.2.1 EMISSIONS INTENSITY OUTCOMES IN AN INTERNATIONAL CONTEXT

Australia's emissions intensity of electricity is among the highest in the developed world. It is about four times the intensity of New Zealand and Canada; almost double the intensity of Germany, the UK and Japan; and considerably higher than that of the US. Since 2007, Australia's electricity supply emissions intensity has exceeded China's (IEA 2013b).

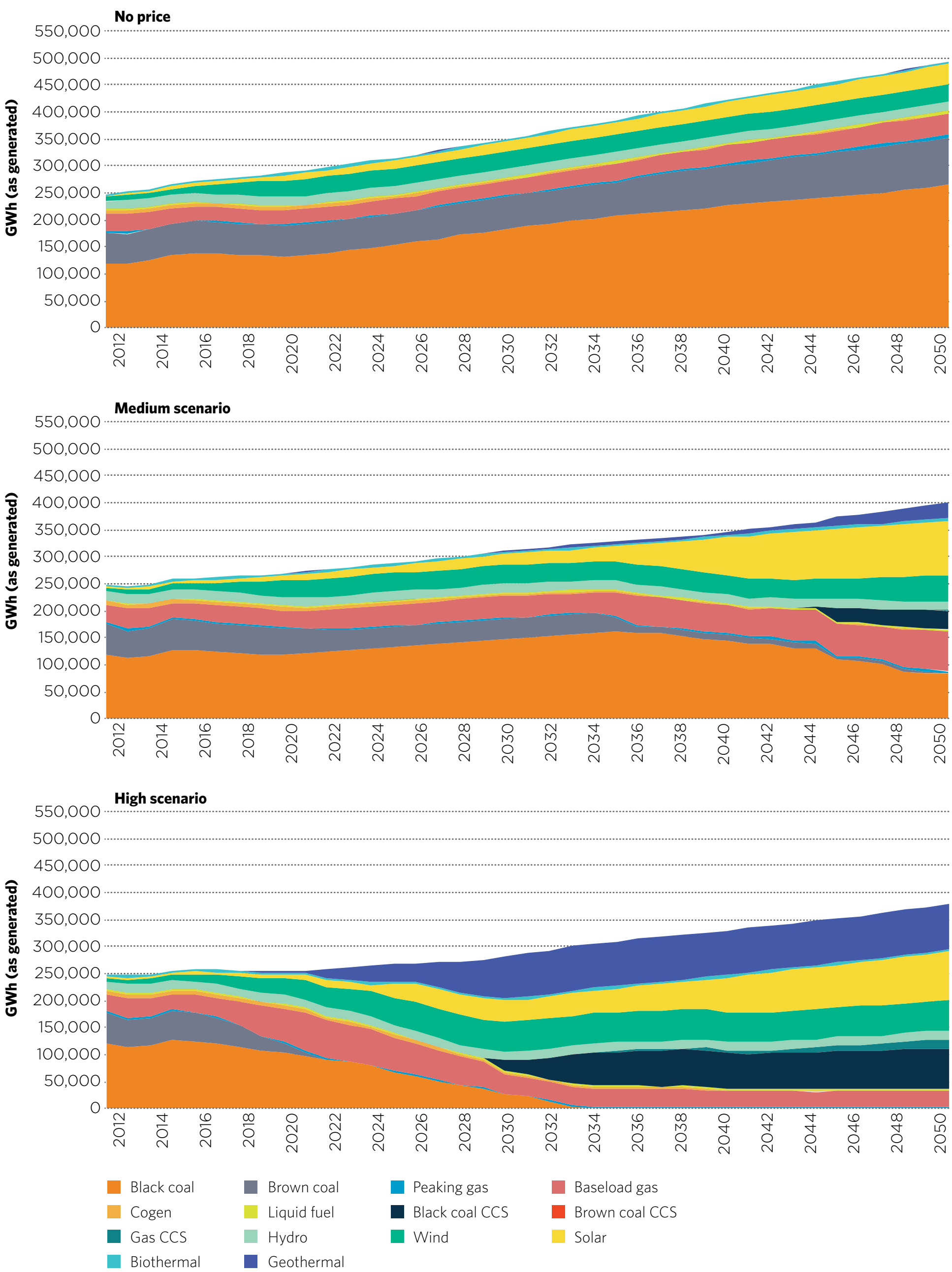
Table D.1 summarises projections for Australia's emissions intensity, which, in all scenarios, reflect some improvement on current and historical levels. Despite these projected improvements, in all except the high scenario Australia's emissions intensity is likely to remain above that of China, the US and the world average in 2035 (IEA 2012a; Treasury and DIICCSRTE 2013).

### D3.2.2 CONTRIBUTORS TO EMISSIONS INTENSITY OF GENERATION

With incentives in place, a range of projections suggest that Australia's electricity supply will become less emissions-intensive as conventional fossil fuel-fired generation loses share to low- and zero-emissions sources. Several technologies could contribute directly to a lower emissions intensity of supply. Changes in the shares of conventional coal-fired generation and renewables could be particularly significant (Figure D.12).

This is illustrated in ACIL Allen Consulting's outlook for Australia's electricity supply in Figure D.14. The projected generation mix is affected significantly by the level of the price incentive. The high scenario projects a substantial increase in the share of generation from renewables and a fall in the share of coal-fired generation. Coal with CCS is also deployed by 2030, bringing the emissions intensity of generation down by over 60 per cent compared to the no price scenario, to 0.25 t $CO_2$-e/MWh. By contrast, the low scenario projects relatively modest changes to the supply mix, with emissions intensity of generation projected to be 0.66 t $CO_2$-e/MWh in 2030. The growth in renewable generation, driven primarily by the RET to 2020, is important in all scenarios, even in the no price scenario, where the generation mix is otherwise projected to be little changed.

**FIGURE D.13:** SHARE OF ELECTRICITY GENERATION BY FUEL TYPE, 2012–2050




**Note:** Based on electricity generation 'as generated'.
**Source:** ACIL Allen Consulting 2013

Uncertainties about the timing and magnitude of declines in emissions-intensive electricity generation and growth in low-emissions generation give rise to a range of potential electricity supply mixes for Australia. Table D.3 presents the projected range of generation shares between the no price and high scenarios.

**TABLE D.3:** SHARE OF ELECTRICITY GENERATION FOR SELECTED FUELS AND TECHNOLOGIES, 2000–2030 (NO PRICE TO HIGH SCENARIO)

| | HISTORICAL | | PROJECTED | |
|---|---|---|---|---|
| **Fuel type** | **2000** | **2012** | **2020** | **2030** |
| **Coal (conventional)** | 83% | 71% | 48–67% | 9–70% |
| **Natural gas (conventional)** | 8% | 15% | 9–25% | 8–14% |
| **Coal and gas with CCS** | Not available | Not available | Not available | Up to 7%<br>Potentially deployed as early as 2030 but as late as mid 2040s |
| **All renewable** | 9% | 11% | 21–24% | 21–69% |
| **Solar** | Negligible | 1% | 3% | 6–14% |
| **Wind** | Negligible | 3% | 11–12% | 9–20% |
| **Geothermal** | Not available | Not available | Not available | Up to 28% |

**Note:** Results are based on shares of generation 'as generated' for four modelled scenarios with various levels of price incentive, as described in Chapter 9. All scenarios include the RET as legislated. 'All renewables' includes hydro, wind, geothermal, biomass, solar PV and solar thermal. Solar water heating is not included.
**Source:** ACIL Allen Consulting 2013

Off-grid electricity generation, which is generally in regional and remote areas, has a different supply mix. Its emissions intensity is currently lower than for Australia's as a whole. In 2012, almost 80 per cent of off-grid generation was produced using gas, reflecting the high proportion of energy and resource operations located in areas supplied by gas pipelines (BREE 2013c). Indications are that gas generation will continue to dominate off-grid electricity generation (ACIL Allen Consulting 2013).

Compared with the national average of almost 10 per cent, the share of renewables in off-grid generation was as little as 2 per cent, with the greatest share in the southern states. In Tasmania, New South Wales, Victoria and the Australian Capital Territory, renewables account for 27 per cent of off-grid generation (BREE 2013c, p. 19).

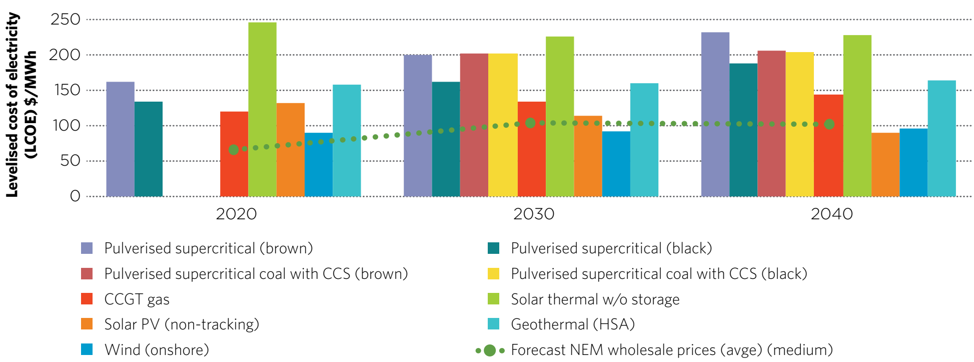
## D3.2.3 DRIVERS OF EMISSIONS INTENSITY OF GENERATION

Several drivers will influence the deployment and diffusion of technologies that determine the emissions intensity of electricity supply. The primary determinant of the supply mix—and how quickly emissions-intensive generators decline and low-emissions generators grow—will be the relative cost of generation from different sources. Coal currently dominates Australia's electricity supply because it has the lowest marginal costs of operation.

Multiple drivers change the business cases of electricity generation projects. Modelling suggests that policy is a critical influence. The presence of a price incentive for emissions reduction, and the level of that incentive, can make different sources more or less competitive. This is evident from the greater share of low-emissions generation in scenarios with a higher price incentive. The effect of the RET, which provides an additional revenue stream to support the deployment of renewable sources, is also apparent to the 2020s. If the RET was reduced or not met, the emissions intensity of generation would be higher than that projected here.

Other drivers include exchange rates, commodity prices, interest rates, and rates of deployment and learning. In the near term, the levelised cost of electricity (LCOE) from different technologies will also be driven by fuel costs and the value of RET certificates. Given uncertainties about these many drivers, there is a range of estimates about costs of future generation. Figure D.14 reflects one view from the Bureau of Resource and Energy Economics (BREE 2012). In its 2013 *AETA Update*, BREE revises down its estimates for LCOE for renewable generation, particularly post-2030. The projected improvement in cost is especially significant for solar thermal, even without a price incentive (BREE 2013d, p. 62).

**FIGURE D.14: PROJECTED COST OF SELECTED GENERATION TECHNOLOGIES (WITH A CARBON PRICE), IN 2020, 2030 AND 2040**




**Notes:** Assumes a price incentive around the levels in the Treasury and DIICCSRTE's 2013 medium scenario. Solar thermal is compact linear Fresnel reflector (CLFR) without storage; solar PV is fixed (no tracking). Brown coal prices are for Vic.; black coal, gas, wind and solar are for NSW; geothermal is in SA.

**Source:** ACIL Allen Consulting 2013 medium scenario ('central scenario') (for NEM prices); BREE 2012 (for LCOE)

To at least 2020, relatively stable demand for grid-connected electricity makes it unlikely that there will be significant investment in electricity generation, except in response to policy drivers such as the RET (AEMO 2013g). During this period, existing generators, which have already amortised their initial capital investment, will be likely to continue to operate. This means that the risk of 'lock-in' of new high-emissions generation is relatively low for the next 10 years.

Longer term, as economic activity grows and electricity demand rises, new generation will be needed. Capital and regulatory hurdles aside, lower cost generation sources will be taken up more quickly and deployed more widely. Given the long operating life of electricity generators, future fleet investment choices are likely to influence Australia's emissions for decades. Investment plans of major energy sector players, however, suggest building new emissions-intensive coal-fired plants is unlikely (see, for example, AGL 2013, pp. 37–8).

When the drivers that affect technology costs change, so do the projected electricity generation mix and projected emissions, as shown in Table D.4. Findings of ACIL Allen Consulting's (2013) modelling sensitivities include:

- A higher price incentive will see greater emissions reductions. The share of coal will fall more quickly and coal-fired plants retire sooner, and the share of low-emissions electricity generation, including renewables and CCS, could be larger.
- A higher price for gas, oil and coal will have an uncertain effect on emissions, depending on the relative prices for these fuels at different times. Since fuel prices usually comprise a greater share of generation costs for gas-fired generators than coal-fired generators, higher fuel prices may disadvantage gas over coal. Higher fuel prices would also disadvantage fossil-fuelled generators over renewables by the late 2020s, leading to a fall in emissions.
- Faster cost reductions for solar PV would lead to its greater deployment, probably at the expense of coal, with corresponding falls in emissions for at least two decades.

**TABLE D.4:** EFFECT OF SENSITIVITIES ON GENERATION SHARE AND EMISSIONS, RELATIVE TO MEDIUM SCENARIO, IN 2030

| | WIND | SOLAR | GAS (CONVENTIONAL) | COAL (CONVENTIONAL) | COAL (CCS)* | EMISSIONS |
|---|---|---|---|---|---|---|
| Higher incentives for emissions reduction ('high scenario') | ↑ | ↑ | ↑ | ↓ | ↑ | ↓ |
| Higher fuel price (gas, coal, oil) | ↑ | ↑ | ↓ | - / ↓ | - | - / ↓ |
| Geothermal and CCS unavailable | - | - | - | ↑ | - | - |
| Faster learning rates or lower costs for solar PV | - | ↑ | - | ↓ | - | ↓ |
| Higher electricity demand | - | - | ↑ | ↑ | - | - / ↑ |

*Geothermal and CCS are not projected to be deployed at a significant rate by 2030 in the medium scenario, nor under any sensitivity except the high scenario.

**Note:** Changes are relative to projected generation in the medium scenario.
**Source:** ACIL Allen Consulting 2013

Another determinant of investment is the stability of policy and the amount of information available to investors in electricity generation assets. Clear and stable incentives for emissions reductions are important. Uncertainty could lead to suboptimal investment in an electricity supply mix over the long term (Investment Reference Group 2011). Recent analysis estimates that, by 2050, uncertainty about carbon pricing after 2020 could result in Australian wholesale electricity prices 17 per cent higher than they would be in an environment of policy certainty (CSIRO 2013, pp. 40, 52).

Investor confidence could be increased by publishing more information on the pipeline for grid-connected electricity generation assets. This data could also assist policy-makers. One way to do this may be through a rule change that allows AEMO and transmission companies to disclose connection applications from generation proponents, to avoid the risk of its public list of generation committed for construction being out of date or incomplete.

## D3.3 EMISSIONS REDUCTION OPPORTUNITIES FROM EXISTING GENERATION

### D3.3.1 FOSSIL-FUELLED GENERATION

To at least 2020, existing and committed electricity supply is expected to be adequate to meet demand in the NEM (AEMO 2013b). This, combined with uncertainty in policy and fuel prices, is likely to lead to only incremental or small-scale change in the electricity sector.

In the near term, the main opportunities to reduce the emissions intensity of the existing generation fleet may relate to:

- reducing output
- retrofitting
- fuel prices.

#### REDUCING OUTPUT

The recent trend in coal-fired generation has been for plants to reduce output rather than retire. Since 2009, over 2,000 MW of coal-fired generation has been mothballed and coal-fired asset utilisation was down, with black coal falling from 86 to 79 per cent between 2007 and 2013 (ClimateWorks 2013b, p. 25). Some black coal-fired plants are operating as low as 30–45 per cent of capacity (Pitt & Sherry 2013). If stable demand and policy uncertainty delay investment in large new sources of supply, this pattern may continue until the early 2020s. AEMO estimates that between 3,100 and 3,700 MW—or up to 12 per cent—of coal-fired capacity connected to the NEM may be removed by 2020 in scenarios without or with a carbon price (2013g, p. iv).

It is possible that some generators would change business models to run plants as intermediary generation, or operate during summer when wholesale prices are generally higher, rather than close completely (CCA 2013). A wide range of modelling studies suggest this is possible, with conventional coal projected to remain in Australia's electricity supply mix for decades, even if a price incentive to reduce emissions exists.

Exit costs could present a barrier to retiring existing fossil fuel plant. Clean-up and remediation requirements, which take effect upon closure, could cost hundreds of millions of dollars, improving the case for operating for longer, even at reduced output (AECOM 2012; Colomer 2012).

There is a consistent outlook, across a range of modelling studies, that when a price incentive for emissions reduction exists, coal-fired generation falls. ACIL Allen Consulting (2013) suggests that the share of generation from conventional coal could fall from 71 per cent now to as low as 48 per cent in 2020 and 9 per cent in 2030 (Table D.3). Timing is uncertain, but ACIL Allen Consulting (2013) projects the fall will occur in the late 2030s for black coal and as soon as the early 2020s for brown coal, in the low and medium scenarios. Under a high scenario, coal-fired generation would fall earlier and more sharply. In contrast, without a price incentive, ACIL Allen Consulting (2013) projects coal could continue to be about 70 per cent of generation in 2030. Some analysts suggest that, without price incentives, existing coal-fired generators (particularly brown coal) could gain market share, partly at the expense of gas-fired generators, which face rising fuel costs (RepuTex 2013).

## RETROFITTING

Some fossil fuel generators may also be retrofitted to operate with lower emissions intensity. Several Australian coal-fired generators have indicated plans to upgrade turbines, modify boiler operation and investigate coal-drying technologies to improve thermal efficiency and reduce emissions (DRET 2013).

Retrofitting low-efficiency coal-fired units to operate with high-efficiency, low-emissions coal technologies is another option. This is likely to be relatively costly, but the IEA suggests it could be considered on a case-by-case basis and could potentially reduce the emissions intensity of coal-fired generation to 0.67–0.88 t $CO_2$/MWh (IEA 2012d, p. 15).

There also appears to be significant potential to retrofit existing fossil fuel plants with hybrid technologies. Co-firing with lower emissions fuels not only cuts emissions but also overcomes traditional barriers to renewable energy, including land availability, capital and transmission costs. An early step has already been taken by the 2,000 MW black coal Liddell Power Station, which has installed an 18 MW solar thermal array to heat water to create steam, thus reducing the need to burn coal for that purpose, cutting emissions by approximately 5,000 tonnes each year (EcoGeneration 2013). In addition, Liddell can co-fire coal with biomass and recycled oil (Macquarie Generation 2012). In their Clean Energy Investment Plans submitted to the Commonwealth Government, other generators, including Loy Yang, indicate that they are investigating the potential for co-firing (DRET 2013).

## FUEL PRICES

For existing fossil fuel generation technologies, fuel prices are a major determinant of cost and will affect how coal- and gas-fired generation contribute to Australia's supply mix. As Australia's gas production booms and eastern Australia prepares to export LNG for the first time, gas price rises are anticipated, though the timing and precise levels are uncertain (Wood and Carter 2013). In some scenarios, even with a price incentive in place, the Treasury and DIICCSRTE modelling suggests that projected increases in gas prices could make existing gas power plants more costly than coal-fired power. Modelling of a high gas price suggests the share of base-load gas generation could fall below its current share and below its projected share in 2020 or 2030 in the medium scenario. This trend could also occur if coal prices fell, as observed in the UK during 2012 (Kerai 2013).

Overseas, lower cost gas is increasing its share in electricity generation by displacing coal, and reducing emissions as a result. In the US, increasing generation from natural gas contributed to a decline in emissions from electricity generation of 4.6 per cent in 2011 compared to the previous year (US EPA 2013). Australia's gas prices are considerably higher—and likely to rise more in coming years—making this change in supply mix less likely. AEMO, for example, does not foresee an increase on current levels of gas use in Australia's eastern states until about 2030 (AEMO 2013f).

Major electricity sector players report that it may not be economical to build a large new grid-connected gas-fired power plant for the foreseeable future (CCA 2013). This is reflected in AEMO's *Gas Statement of Opportunities*, which suggests the use of gas in electricity generation will fall significantly over the next few years, as gas prices rise (AEMO 2013f).

The economic viability of new coal-fired generation facilities may be undermined by difficulty in obtaining low-cost finance, if the international trend of withdrawing finance to coal-fired generators extends to Australia. In mid 2013, the US Export-Import Bank, the World Bank and European Investment Bank, which together provided more than $10 billion for coal projects in the last five years, announced they would withdraw from financing conventional coal (Drajem 2013).

## D3.3.2 GENERATION FROM RENEWABLE ENERGY

ACIL Allen Consulting (2013) projects significant amounts of renewable generation under a range of scenarios (see Table D.3). The RET drives the deployment of renewable energy to 2020 in all scenarios, including the no price scenario. The addition of a carbon price in the low, medium and high scenarios results in significantly more renewable generation. Figure D.13 shows that after 2020 the increase in renewables is projected to be much greater with a higher price incentive.

Wind is likely to increase its share of the supply mix in the near term. To 2020, wind is expected to provide about 84 per cent of new generation capacity, largely reflecting the impact of the RET (AEMO 2013g). In late 2012, 65 per cent of the 3,000 MW of planned installed electricity capacity at an advanced stage of development was wind (BREE 2013a).

Australia's solar resource is one of the best in the world and theoretically capable of generating enough electricity to meet its demand (Geoscience Australia and ABARES 2010). Solar PV systems might offer consumers financial savings by reducing consumption of grid-connected electricity. The value of solar PV is likely to be greatest for users with an electricity demand profile that matches system output, such as commercial premises (Wood et al. 2012). Solar PV's low reliance on water makes it viable even in dry and remote locations, and in a future with potential disruption to water supply (see Box D.2).

**BOX D.2: CLIMATE CHANGE EFFECTS ON ELECTRICITY SUPPLY**

Climate change will affect future opportunities to change the electricity supply mix and reduce emissions. Its impacts, particularly water shortages and extreme weather, affect electricity demand, generation and transportation (Foster et al. 2013; Senate Environment and Communications References Committee 2013). Sources of generation that use large amounts of water, including coal-fired and nuclear power, geothermal and bioenergy, will be disadvantaged in a context of water shortages (IEA 2013c).

Over the last decade, Australian electricity supply has been disrupted by floods and bushfires. The output of hydroelectric and coal-fired generators, which use large amounts of water for steam production and cooling, have been reduced and could fall again with drought. With water shortages and more extreme climate events expected (see Chapter 2), the extraction of coal and unconventional gas, generation from certain sources, and the transmission and distribution of electricity could be disrupted more often (IEA 2013c; US DoE 2013).

Solar generation is projected to play a large role in Australia's future generation mix, particularly in scenarios with a price incentive to reduce emissions. The medium scenario suggests that solar generation could increase its share from about 3 per cent in 2020 to about 20 per cent in 2040 and 25 per cent in 2050. Most of the expected growth is large-scale generation.

If costs continue to fall, solar PV could become increasingly cost-competitive with conventional sources of generation. ACIL Allen Consulting (2013) modelled a sensitivity that reduced the costs, per annum, of large-scale solar PV by 10 per cent to 2020 and 5 per cent to 2030. The results showed that solar PV could generate almost six times as much electricity in 2020 and 35 times as much in 2030, when compared to 2012.

## D3.4 REDUCING EMISSIONS WITH EMERGING GENERATION AND STORAGE OPTIONS

Current excess generation capacity, combined with uncertainty about emissions reduction policy and fuel costs, makes it unlikely that new electricity generation technologies will emerge in Australia, at scale, before at least 2020.

Large uncertainties remain about the timing, costs and viability of new low-emissions sources of electricity generation, particularly CCS and geothermal. Previous modelling suggested a greater role for these technologies (for example, SKM-MMA 2011 and ROAM 2011). In contrast, ACIL Allen Consulting (2013) suggests that in the low or medium scenarios, neither CCS nor geothermal will contribute a significant share of generation until about 2040. The high scenario suggests, however, that geothermal and CCS may emerge as early as 2017 and 2030, respectively.

The technology and business models necessary to widely deploy electric storage are changing rapidly, making cost and uptake highly uncertain.

### D3.4.1 CARBON CAPTURE AND STORAGE FOR COAL- AND GAS-FIRED GENERATION

CCS is not yet operating at a large scale[1] for electricity generation anywhere in the world, though it has been deployed in the gas processing and industrial sectors (see appendices D6 and D7). The gradual progress in developing large-scale projects is evident in the Global Carbon Capture and Storage Institute's status reports. Between 2010 and 2013, the number of operational projects did not change and the total $CO_2$ capture capacity of all identified large-scale integrated projects fell (2013c, p. 2). In 2013, the IEA warned that current efforts to develop CCS are 'insufficient' and called for 'urgent action … to accelerate its deployment' (2013a, pp. 1, 10). The IEA suggests that multiple demonstration projects, each sequestering about 0.8 Mt $CO_2$-e annually, are needed this decade if CCS is to fulfil its emissions reduction potential, consistent with limiting average global temperature increases to 2 degrees (2013a, p. 9).

There are two key challenges to the widespread deployment of CCS for electricity generation. The first is financial—the significant cost to build and operate the technology at a large scale (IEA and GCCSI 2012). The minimum cost for a large-scale CCS plant in Australia will likely be several billion dollars (GCCSI 2013d). The financial barrier may be overcome if an additional revenue stream is available to offset costs of the project, such as enhanced oil recovery (EOR) or a commercial application in other production processes, or if public or policy support is available (GCCSI 2013b).

The second key challenge is the integration of technological components at scale (IEA and GCCSI 2012). The logistical, practical and commercial challenges are likely to be overcome as experience grows, and CCS projects already illustrate this.

1 Large scale is taken to be annual sequestration of at least 0.8 Mt $CO_2$-e for coal-fired power plants and 0.4 Mt $CO_2$-e for gas-fired plants (GCCSI 2013c).

There is broad consensus that CCS technology will be first commercially deployed overseas and Australia will be a 'technology taker'. International developments are likely to set the timing of commercial CCS deployment in Australia. In particular:

- **China**—in many of its significant strategic development and scientific documents, the Chinese Government has expressed strong support for deployment of CCS. China is the only global region where the number of large-scale integrated CCS projects increased between 2011 and 2013, many of them driven by state-owned energy companies (GCCSI 2013a, 2013c).
- **North America**—about 70 per cent of the world's active large-scale integrated CCS projects are here. Canada's Boundary Dam and Mississippi Power's Kemper County projects are expected to operate from early 2014 (GCCSI 2013c; BNEF 2013). Success with these projects would be an important milestone towards the commercialisation of CCS and cost reductions. North America has particular potential because of its high level of committed public support, the commercial opportunities for EOR and an existing $CO_2$ pipeline, which together lower costs and commercial risk (Abellera 2012). New emissions intensity regulations for power plants could provide further incentives.

Australia, with its unique geology, cannot rely on international developments to facilitate storage, however, and will need local expertise.

## D3.4.2 GEOTHERMAL ENERGY

Australia's geothermal resource is relatively deep and it is uncertain how and when energy can be extracted reliably, at reasonable cost. Expert estimates of the date of commercial deployment of geothermal energy have been repeatedly revised back. AEMO (2013g) recently suggested commercial geothermal energy developments would not appear in the NEM until after the late 2030s.

The development of Australia's geothermal energy remains at the exploration and demonstration stage; the most developed project is the 1 MWe Habanero Pilot Plant in South Australia, which produced Australia's first Enhanced Geothermal Systems (EGS) generated power during a 160-day trial in 2013. Engineering challenges remain for Australia's geothermal energy, including repeatedly creating heat reservoirs, improving drilling practices and equipment, and enhancing flow rates (Wood et al. 2012).

A major barrier for the development of geothermal generation is the capital outlay needed to trial technology at a large scale. Present estimates suggest a 100 MW hot sedimentary aquifer (HSA) geothermal plant could cost about $700 million (BREE 2012, p. 54). Government funding has played a central role to date. ARENA has committed funding towards demonstration of larger power stations which, if taken up, could provide an opportunity to better understand project costs and the ability to overcome engineering challenges at scale.

## D3.4.3 NUCLEAR FISSION

Under different circumstances, nuclear fission could play a role in a low-emissions electricity supply mix, as it does overseas. This is apparent in analyses, such as the CSIRO eFutures, in a scenario with a moderate emissions reduction incentive. Even if nuclear power was legalised in Australia, a range of barriers to its deployment remain for large-scale projects (Commonwealth of Australia 2006). These include:

- Regulatory and planning requirements—in 2012, Wood et al. concluded that 'the lead time to deploy a nuclear power plant in Australia is between 15 and 20 years' because of the need to create legal and regulatory frameworks, and because of time necessary for planning and construction (p. 71). BREE recently estimated that nuclear energy could not be constructed in Australia until 2020 at the earliest (2013d).
- Community opinion—it seems that public support would be essential for nuclear power to be viable, though public acceptance remains uncertain and has historically been hostile to the domestic development of nuclear energy (National Academies Forum 2010).
- Workforce availability—Australia lacks personnel with the knowledge and capability to plan, construct and operate nuclear power generation. There is also a looming global shortage of these skills (Commonwealth of Australia 2006; OECD 2012).

Nuclear project costs for Australia are uncertain and vary widely, but high costs appear a barrier to deployment in the near term. Recent estimates for developed country nuclear energy projects range from $3–6 million per megawatt (overnight cost, in Wood et al. 2012, p. 711). These costs are high compared to other existing sources of generation. Like geothermal and CCS, nuclear power is capital-intensive and may be difficult for the private sector to finance (Citigroup Global Markets 2009). A report prepared for the Prime Minister in 2006 concluded that to be competitive with existing generation, nuclear power would require a carbon price (Commonwealth of Australia, p. 6). BREE's *2013 AETA Model Update* suggested capital costs of nuclear had risen further since its previous estimates (BREE 2012).

At present, it seems doubtful that planning and capital requirements for nuclear power could be overcome soon enough for it to compete with other low-emissions technologies for which costs are falling, such as solar thermal with storage. If small modular reactors become commercially viable in the short term, however, they could offer a less costly form of nuclear technology than large-scale plant (BREE 2012). Modular reactors also reduce construction timeframes and could allow for more flexible deployment, including in remote locations.

## D3.4.4 ELECTRIC STORAGE AND CHANGES TO THE ELECTRICITY GRID

Modular storage lends itself well to supporting the generally modest changes expected in Australia's electricity supply and demand over the next decade. Storage options include batteries (such as those in electric cars) and compressed air. Affordable storage could dramatically improve the economic viability of renewables with variable generation, particularly off-grid (Marchment Hill Consulting 2012). CSIRO analysis suggests that the availability of storage as a backup technology could contribute up to an additional 10 per cent to renewable share and about 20 Mt $CO_2$-e emissions reductions in 2050 (Graham, Brinsmead and Marendy 2013, p. 17).

Storage has been used successfully at scale, such as in Australia's Smart Grid, Smart City project, but remains relatively costly. A recent EPRI study suggested break-even capital costs of energy storage of between $1,000 and $4,000 per kilowatt (2013, p. v). As with other emerging technologies, overseas developments are relevant to Australia. If California's target for up to 1.3 GW of storage is realised by 2020, cost improvements are likely to occur (Reddall and Groom 2013). Government support in Germany and Japan is also accelerating deployment of small-scale and large-scale electric storage, respectively (Parkinson 2013b, 2013c). The CSIRO (2013) estimates that battery costs may halve by 2030, leading to electric storage becoming more widespread. The Authority agrees with the CSIRO's suggestion that BREE's Australian Energy Technology Assessment should track developments in small-scale generation and storage technologies.

Australia can learn from successful overseas business models. In New Zealand, for example, electricity distribution network businesses are deploying and operating solar PV and battery storage systems, with leasing arrangements (Parkinson 2013a). Their recent emergence in Australia may increase further uptake of PV, particularly in the commercial sector (Photon Energy 2013). Such business models may help overcome capital hurdles to cost-effective investment. Changes to energy market regulation in Australia could encourage distribution businesses to invest in storage when cost-effective (see Table D.5).

The analysis of electricity sector in this Review is based on modelling and other sources that assume a broad continuation of the existing centralised structure of Australia's electricity supply. As small-scale and renewable generation increase and costs of electric storage fall, closer examination of a smarter and more decentralised energy system is warranted. The CSIRO's Future Grid Forum provides one such analysis. Across its four scenarios, it projects:

- declines in grid-connected electricity generation from about 2040, with on-site generation to provide between 18 and 45 per cent of generation by 2050
- decreasing electricity sector emissions to 55–89 per cent below 2000 levels by 2050 (CSIRO 2013, p. 15).

**BOX D.3:** A ZERO-EMISSIONS SUPPLY MIX?

Modelling by the Treasury and DIICCSRTE illustrates a potential supply mix where the electricity sector (and other sectors) responds to emissions reduction incentives, at lowest cost and within existing policy parameters. Other studies consider a possible zero-emissions electricity supply mix. For example, AEMO published an exploratory study of a 100 per cent renewables mix, which suggested that there are no technical barriers to such an outcome by 2050. That scenario could be possible without any electrical storage, though it could require 'generation with a nameplate capacity of over twice the maximum customer demand' or a large contribution from biofuel, which faces considerable barriers (AEMO 2013c, p. 4).

With growing deployment of renewables, there is evidence that a generation mix dominated by renewable energy is technically possible. King Island, for example, produces 65 per cent of electricity consumed from renewables, primarily wind. It plans to move towards 100 per cent, combining this generation with solar, biodiesel, battery storage and smart grid technologies (Guevara-Stone 2013). Other studies of high penetration of intermittent renewables, such as solar PV, have found that solutions to grid integration issues, such as new system invertors or electric storage, are available—though at a cost (Brundlinger et al. 2010; Energy Networks Association 2011). Storage that is integrated into large-scale renewables generation, such as solar thermal, is also available.

## D3.5 ELECTRICITY DEMAND

### D3.5.1 ACTIVITY EMISSIONS OUTCOMES

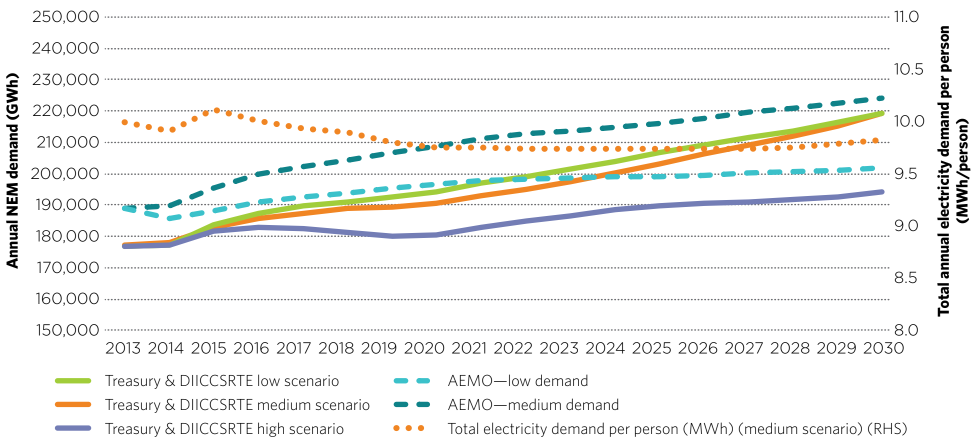
Activity throughout the economy will affect the levels of electricity demand and the level of emissions. Historically, growth in electricity sector emissions has increased as a result of strong growth in electricity demand (thus increasing total generation levels). From 1990 until a few years ago, Australia's rate of increase in electricity generation was higher than most developed countries and well above the OECD average (IEA 2013b, p. 107). In 2011, Australia's annual electricity consumption, per person, was about 11 MWh, above the OECD average of 8 MWh—though lower than the electricity-intensive economies of Canada and the US (IEA 2012b, pp. 70, 74).

The short-term outlook is for Australia's growth in electricity demand to increase (driven largely by the Queensland resource sector), as illustrated for the NEM in Figure D.15. Many electricity industry stakeholders suggest that, based on their observations of drivers of electricity demand, the low-demand scenario from AEMO is more likely than its medium-demand scenario, and even this may be an overestimate (CCA 2013). AEMO recently revised its short-term forecasts for NEM demand downwards (AEMO 2013e). Electricity demand is projected to remain stable or fall between 2012 and 2020 with a strong emissions reduction incentive in the Treasury and DIICCSRTE's high scenario.

Even though overall electricity demand is projected to grow, per person electricity consumption is projected to fall to about 9.8 MWh in 2030 in the medium scenario. By contrast to NEM and total Australian electricity demand, it is likely that off-grid electricity generation will grow more rapidly, as it has in recent years, driven largely by an increasing number of remote resource projects.

Figure D.15 reinforces the fact that changes in electricity generation activity are affected by the level of incentive to reduce emissions. Resulting decreases in demand could provide significant emissions reductions.

**FIGURE D.15: PROJECTED CHANGE IN NEM DEMAND AND PER PERSON ELECTRICITY CONSUMPTION, 2013–2030**




**Note:** Based on sent out generation for NEM only (which accounts for about 86% of total domestic demand), ACIL Allen Consulting 2013, for 2011–12.
**Sources:** AEMO 2013a; Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013 and the medium scenario from ACIL Allen Consulting 2013

Recently, there has been heightened uncertainty in electricity demand projections, as actual consumption continues to deviate from long-term trends. Several downward revisions to demand projections in recent years illustrate this in the NEM (AEMO 2013a, 2013e). If electricity demand is even lower than projected, it will reduce the size of Australia's emissions reduction task, all else being equal. Some plausible scenarios for lower electricity demand from households, commercial buildings and industry could keep electricity demand at 2012–13 levels in 2020 and deliver up to 23 Mt $CO_2$-e emissions reductions in 2019–20 (ClimateWorks 2013c, pp. 3, 10).

## D3.5.2 CONTRIBUTORS AND DRIVERS

Electricity demand is the function of a long list of drivers. Near-term influences on electricity demand are as diverse as the time of year, weather, use of electrical appliances and personal income. Longer term drivers include population growth composition and geographic distribution, electricity prices, economic growth, interest rates and exchange rates, climate change impacts, renewal of building stock, and commercial and industrial activity (Yates and Mendis 2009).

Policies, including energy performance standards, have significantly reduced electricity demand. Some analyses suggest energy efficiency policies have been responsible for more than a third of electricity demand reduction in the NEM between 2006 and 2013 (see, for example, Saddler 2013). Such policies can continue to reduce demand and electricity sector emissions. Because it can be years or decades before equipment and buildings are turned over, future emissions reductions achieved through reduced energy demand will be influenced by the policies and standards put in place in the near term.

### INDUSTRIAL DEMAND

In the medium scenario, the Treasury and DIICCSRTE (2013) projects stable or modestly increasing industrial electricity demand due to:

- new activity in major LNG projects in Queensland, coming online from 2014 to 2016
- declining activity in energy-intensive manufacturing, particularly aluminium production, as existing contracts for relatively low-priced electricity end
- potential reductions in demand through improvements to processes and technologies
- additional changes in the composition of the economy, which will see some electricity-intensive industries contract and others expand.

Industrial activity will be driven by several underlying factors, including commodity prices, exchange rates, fuel prices, management processes and the age of infrastructure.

Energy efficiency among large industrial users has increased significantly in recent years and saved users hundreds of millions of dollars. This has been, in part, driven by the Commonwealth Government's Energy Efficiency Opportunities Program (Department of Industry 2013). It is possible that continued efficiency improvements will reduce industrial electricity use and associated emissions. If the improvements in industrial energy efficiency since 2007–08 are maintained, ClimateWorks estimates that it could reduce electricity sector emissions by about 6 Mt $CO_2$-e between 2012 and 2020 (2013c, pp. 6, 13).

A sizeable portion of industrial electricity demand is not connected to major electricity grids. BREE reports that the resources and energy sectors, for example, consume off-grid electricity equivalent to about 5 per cent of total national electricity demand (2013c, p. 7). A shift towards off-grid electricity generation has been recently observed and some expect this to continue (ClimateWorks 2013c).

### RESIDENTIAL AND COMMERCIAL DEMAND

Since 2008, electricity demand has been flat, despite economic and population growth. Recently, residential, commercial and light-industrial demand for grid-connected electricity has fallen, contributing to emissions reduction. As described in Chapter 6, this has been driven by energy efficiency policy interventions, an increase in household solar PV generation and energy conservation behaviour in response to higher electricity prices (AEMO 2013a; DCCEE 2012; Saddler 2013). While projected growth in population and GNI will put upwards pressure on future electricity consumption, other drivers will dampen demand. Though it is possible the rebound effect could increase demand to some extent, policy and consumer behaviour make it possible that residential and commercial demand, per person, may have peaked for the foreseeable future.

Energy performance standards for buildings and electrical appliances are becoming more stringent and are steadily expanding to cover new products, delivering energy savings, corresponding emissions reductions and cost savings. At the same time, those that been in place for many years are having a noticeable impact over time as the stock of appliances and buildings is turned over and the most inefficient, energy-intensive stock is phased out (Saddler 2013). AEMO reports that, in 2029–30, minimum energy performance standards for electrical appliances could save about 42 TWh and building-related energy efficiency measures could save about 16 TWh electricity (AEMO 2013d, pp. 5–46). The impact could be increased by improving the monitoring and enforcement of building and appliance standards to ensure that they deliver intended energy saving outcomes (DCCEE 2010a).

Driven by standards but also changing preferences, consumers are beginning to move towards less energy-intensive appliances. Large energy savings can come from technology-switching, such as replacing plasma with LCD and LED televisions; incandescent with fluorescent and LED lighting; conventional electric-resistive water heaters with solar and heat pump systems; and desktop computers with laptops and tablets.

Consumers could further reduce or shift time of demand if governments and regulators make available the information, price incentives and technology discussed in D3.5.3.

#### POTENTIAL NEW SOURCES OF ELECTRICITY DEMAND

There could be emerging sources of electricity demand from activities that currently use other sources of energy. The uptake of electric vehicles in road transport, already underway, may appreciably increase grid electricity demand from about the mid 2020s. Under the high scenario, where there is a stronger incentive for electric vehicles, electricity consumed for transport in 2050 could be almost double that under all other scenarios (Treasury and DIICCSRTE 2013). Similarly, a shift from gas turbines and motors to electric motors in industry could increase electricity demand. This could see activity and emissions shift from the transport and direct combustion sectors, respectively, to the electricity sector. The relative prices of fuels—petrol, diesel, gas and coal, and electricity—are likely to affect the rate and timing of these shifts. A gas to electricity shift could also be triggered by a possible gas supply shortfall in some locations, as early as 2018–19, and rising gas prices (AEMO 2013f). It is possible that desalination will also present a new source of electricity demand, particularly in a future where water is likely to be scarcer (Foster et al. 2013).

### D3.5.3 FURTHER OPPORTUNITIES FOR COST-EFFECTIVE EMISSIONS REDUCTION

Changing energy demand could offer some of the cheapest opportunities for reducing electricity sector emissions (ClimateWorks 2013a; Garnaut 2008; Prime Minister's Task Group on Energy Efficiency 2010). It can be quick to implement, particularly using existing technologies and practices, and savings can be significant and provide rapid returns on investment (UNEP 2013).

The opportunity to reduce emissions from lowering electricity demand is particularly important in the short term. The IEA's modelling offers a perspective on the global potential—it projects that energy efficiency measures, through improved lighting and appliances, could provide about 40 per cent of estimated global emissions reductions in 2020[2] (2013c, p. 54). This is reinforced by UNEP, which points out that improved energy efficiency is one of the characteristics common to scenarios that allow the world to meet a 1.5 or 2 degree target (2013, p. xiii).

2 Based on a scenario that limits global emissions concentrations to 450 ppm in 2050.

The Treasury and DIICCSRTE modelling framework does not reflect all the opportunities to reduce electricity demand. International experience and other analyses show that there are unrealised opportunities to lower electricity sector emissions by reducing electricity demand through energy efficiency. Compared to countries with similar GDP per capita and human development index rankings, Australia lags on energy efficiency and productivity. The IEA reported that, in both 2009 and 2011, Australia has been behind other countries including the US, the UK, Japan and Canada in implementing applicable IEA recommendations (IEA 2012c, p. 478). Though Australia performs comparatively well on lighting, appliance and equipment improvements, the IEA noted that buildings offer a particular opportunity for improvement (2012c, p. 1,223). Box D.4 discusses this potential.

**BOX D.4: EMISSIONS REDUCTION OPPORTUNITIES IN BUILDINGS**

About 18 per cent of Australia's emissions are accounted for by buildings' use of grid-supplied electricity. Slightly more than half are attributable to residential buildings, and the rest to commercial premises (ClimateWorks 2013c, p. 12).

Building-related emissions can be reduced by improving the thermal performance of the building envelope, increasing the efficiency of equipment and appliances, and increasing generation of energy on-site from renewables (such as solar PV) or gas:

- Improving building efficiency could reduce emissions, relative to 2000 levels, by 12 Mt $CO_2$-e in 2020.
- Improving the efficiency of electrical appliances could reduce emissions, relative to 2000 levels, by 20 Mt $CO_2$-e. The greatest savings are likely to come from water heaters; lighting; heating, ventilation and air conditioning (HVAC) systems; motors and other electrical equipment (ClimateWorks 2013c; Wilkenfeld 2009).

Many of these opportunities are likely to be low cost or have a positive net present value (Beyond Zero Emissions 2013; ClimateWorks 2010, 2013c; IEA 2012b, 2013c).

The average life of commercial building stock is 50 years; residential properties are around double that. Many of the decisions that impact energy use, and emissions, are either locked in at construction or become more expensive to change (Climate Policy Initiative 2013b). Whether significant emissions reductions opportunities from buildings are realised between 2020 and 2030 will depend on the policies and standards already in place and put in place this decade.

Energy efficiency could deliver economic benefits, as highlighted by the IEA (2013c) and others, by avoiding costs for fuel extraction, transport, generation and transmission. For Australia as a whole, an extra 1 per cent annual improvement in energy efficiency to 2030 could generate an additional $26 billion in GDP (The Climate Institute 2013, p. 7). Reduced demand can lead to lower electricity prices and substantial financial benefits for consumers. Savings can particularly benefit low-income consumers, who are more likely to have energy-intensive appliances or homes, and renters who have an interest in low-running costs but are subject to the appliance and building choices of landlords, who have an interest in lowering capital expenditure.

Economic benefits can also come from demand management—where consumers' consumption is constrained or shifted to a different time, particularly when demand is at its peak. Sometimes it can also improve service quality by reducing pressure on the electricity distribution grid. The Productivity Commission (2013, p. 21) estimated that critical peak pricing and other benefits from rolling out smart meters could save some households \$100–\$200 a year. The AEMC (2012) estimated that reducing peak demand growth could cut total system expenditure by between \$4.3 and \$11.8 billion over the next decade. If demand is simply shifted, the impact on emissions is uncertain, but overall reductions could lower electricity sector emissions.

## D3.5.4 CHALLENGES—AND POTENTIAL SOLUTIONS—TO MORE EFFICIENT ELECTRICITY DEMAND

ClimateWorks analysis suggests that many of the cost-effective reductions in Australia's electricity demand may remain untapped. Their projections suggest 29 Mt $CO_2$-e of emissions reductions in 2020 and millions of dollars in annual financial savings could be forgone in the buildings sector alone (ClimateWorks 2013a, p. 51; 2013c, p. 14).

There is a range of recognised barriers to the take-up of cost-effective reductions in electricity demand, identified by the Productivity Commission (2005), Garnaut (2008) and others. Recent analyses, including the Australian Energy Market Commission's 2012 *Power of Choice* review, have found that many barriers remain. Barriers and their potential solutions are shown in Table D.5.

### TABLE D.5: MAJOR BARRIERS TO ENERGY EFFICIENCY AND DEMAND MANAGEMENT WITH POTENTIAL SOLUTIONS

| BARRIERS TO ENERGY EFFICIENCY AND DEMAND MANAGEMENT | POTENTIAL SOLUTIONS |
|---|---|
| **Lack of detailed information on electricity consumption**<br>Lack of data on the time and location of electricity use:<br>• limits consumers' understanding of the relationship between electricity use and costs, and the potential benefits of reducing or changing their use<br>• constrains effective policy design<br>• makes it difficult for proponents of demand-side management to identify and communicate potential paybacks from specific demand-side investments<br>• impedes efficient decision-making of electricity market participants. | Install interval meters to collect data on the location and time of use of electricity. To support their efficient deployment:<br>• apply a minimum standard for smart meters<br>• proceed with the rollout in defined situations, such as new connections or replacements.<br>Make detailed electricity consumption data more readily available:<br>• Give consumers access to their load profile data, including to share with third parties. Amend the National Electricity Rules as suggested by AEMC (2012, p. 57) to make this process easy and timely.<br>• Distribution network businesses to provide historical electricity load data at substation level upon request, for a reasonable cost (as being considered by AEMC).<br>• Undertake a cost-benefit analysis of a potential new market information role for AEMO in aggregating consumer data from electricity retailers and distributors, as considered by AEMC 2012. |

| BARRIERS TO ENERGY EFFICIENCY AND DEMAND MANAGEMENT | POTENTIAL SOLUTIONS |
|---|---|
| **Electricity prices are inflexible and do not reflect costs of supply**<br>Most consumers do not pay electricity prices that accurately reflect the cost of supply at the time of use. Also, pricing does not reflect costs of supplying electricity to a particular location. Current 'average' network pricing can encourage higher consumption at peak times and increase electricity bills over the long term. | Deploy interval meters to facilitate efficient network pricing.<br>Accelerate assessments of retail competition, as agreed by the Council of Australian Governments, to allow the removal of retail price caps where effective retail competition exists (Standing Council on Energy and Resources 2012). This has already occurred in Victoria and South Australia.<br>Adopt critical peak pricing, as recommended by the PC (2013, p. 335). Phase in flexible and efficient pricing more broadly, including a distribution network usage charge that varies by time of day. Allow consumers to opt in to cost-reflective tariffs as recommended by the AEMC (PC 2013, p. 427). |
| **Split or perverse incentives for investing in energy efficiency or demand management**<br>The benefits of saving energy are not fully captured by any one party, so building owners, consumers, electricity retailers and distributors do not have sufficient motivation to invest in energy efficiency. | Introduce a measure, such as the demand response mechanism proposed by AEMC, to pay consumers or third parties for demand reductions via the wholesale electricity market (AEMC 2012, pp. 115–6).<br>Regulatory reform to encourage distribution businesses to invest in demand-side options currently includes:<br>• the 1 January 2013 introduction of the Regulatory Investment Test (RITD) that requires distribution businesses to consider and assess all credible demand-side options (above a $5 million threshold) before choosing the best investment option to meet their network's needs<br>• the introduction of Standing Council on Energy and Resources-agreed recommendations arising from AEMC's 2012 *Power of Choice* review, specifically around incentives for distribution businesses to undertake demand management projects<br>• the introduction of incentives for non-network and network solutions to be considered on a level field. |

**Sources:** Barriers identified in AEMC 2012; Dunstan, Sharpe and Downes 2013; Garnaut 2008; PC 2005 and 2013; Prime Minister's Task Group on Energy Efficiency 2010

There is considerable consensus about the solutions set out in Table D.5, but implementation has not yet occurred. Despite the in-principle commitment by the Council of Australian Governments (COAG) to remove retail price caps, roll out interval meters nationally and introduce more cost-reflective pricing, progress has been slow. Without these core actions, consumers cannot make the best choices about how they use electricity and manage spending, and third parties are constrained in identifying investments in energy efficiency and demand management with the greatest benefits.

In the near term, the Authority supports additional action that will help increase the uptake of energy efficiency opportunities by consumers, suppliers and energy service companies. Building and equipment choices lock in higher or lower emissions for many years; as stock is renewed, it is important that it is replaced with efficient options to capture the available emissions reduction opportunities.

In addition, priorities could include initiatives that have been identified in previous reviews, including:

- collecting and publishing more detailed electricity consumption data, particularly related to end use within buildings, where there are positive net benefits for consumers
- completing retail competition reviews and removing retail price regulation where effective retail competition exists
- the Australian Energy Regulator implementing standard regulatory arrangements for interval meters
- proceeding with the rollout of interval meters for new connections and replacements
- where possible, accelerating the response time of AEMC to rule change requests arising from independent reviews, including the SCER and PC.

## D3.6 CHALLENGES TO TRACKING PROGRESS IN THE ELECTRICITY SECTOR

The Authority considers that the best common measure of electricity activity is electricity 'sent out', but historical data (to 1990) is not available on this basis in a disaggregated, rigorous form. In order to compare historical and projected activity data, the Authority has used electricity 'as generated'. 'Sent out' electricity leaves the power station, 'as generated' includes electricity consumed by the power station itself in its own operations.

The major drivers of reduced electricity demand are known but their relative contribution to changing demand is unclear. More detailed, consistent time series information on end-use electricity consumption could help these drivers be better understood, allowing for improved demand projections and more effective policy design.

Information gaps also make it difficult to track progress in off-grid electricity generation. Off-grid electricity accounts for about 6 per cent of Australia's electricity generation, and is mainly consumed by the mining and manufacturing sectors (ABS 2012). The level and mix of off-grid generation is a source of uncertainty because granular data is not collected routinely or systematically.

BREE's inaugural report (2013c) on regional and remote electricity is a welcome source of new information. BREE 'intends to report on the demand and supply of electricity in off-grid Australia on a regular basis' (2013c, p. 40). The Authority endorses this plan. Detailed reporting of off-grid generation will inform policy, planning and private investment. It could also aid planning for the potential implications of a shift from gas, which is currently the dominant fuel, and identify opportunities to deploy lower emissions generation over time (ACIL Allen Consulting 2013; ABS 2012).

# APPENDIX D4 TRANSPORT

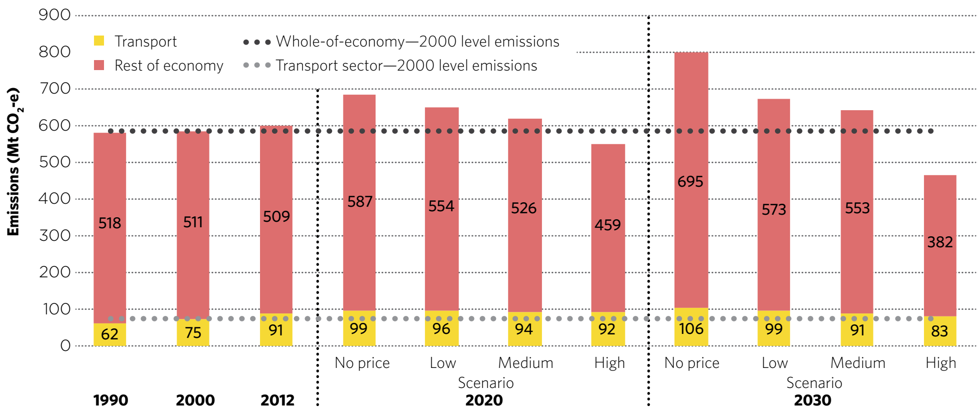
## D4.1 TRANSPORT EMISSIONS OVERVIEW

Transport greenhouse gas emissions are produced by vehicles combusting fuels to move people and freight. Australia's transport emissions are reported across four modes—road, rail, domestic aviation and domestic shipping. International aviation and shipping emissions are excluded from Australia's national inventory. Emissions associated with producing and refining liquid and gaseous fuels, as well as generating electricity, are attributed to stationary energy and fugitives sectors.

Transport accounted for 91 Mt $CO_2$-e (15 per cent) of Australia's emissions in 2012. Under the medium scenario, transport is projected to account for a similar proportion of total emissions in 2020, reducing to 14 per cent in 2030, as shown in Figure D.16.

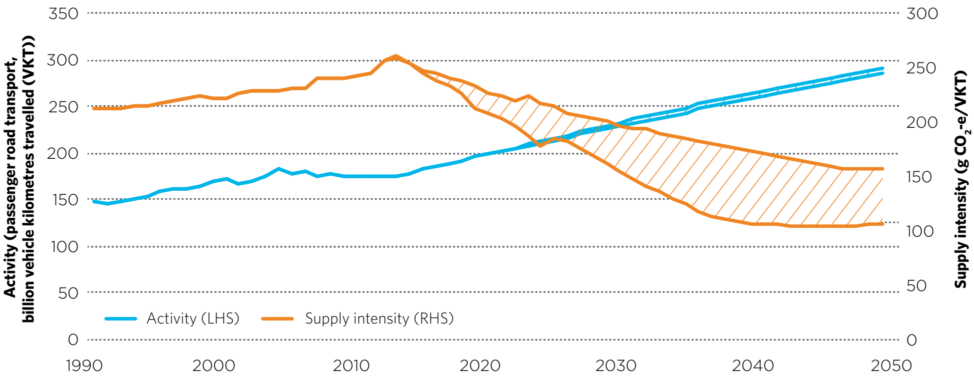
Australia's per capita transport emissions are higher than those of most other countries (IEA 2013a, p. 106). Australia's urban form, low population density and long intercity distances make it heavily reliant on road transport and domestic aviation. To the extent that these factors are fixed, most of the Australian population and business will continue to depend on these transport modes.

**FIGURE D.16: TRANSPORT SHARE OF AUSTRALIA'S EMISSIONS, SELECTED YEARS, 1990–2030**



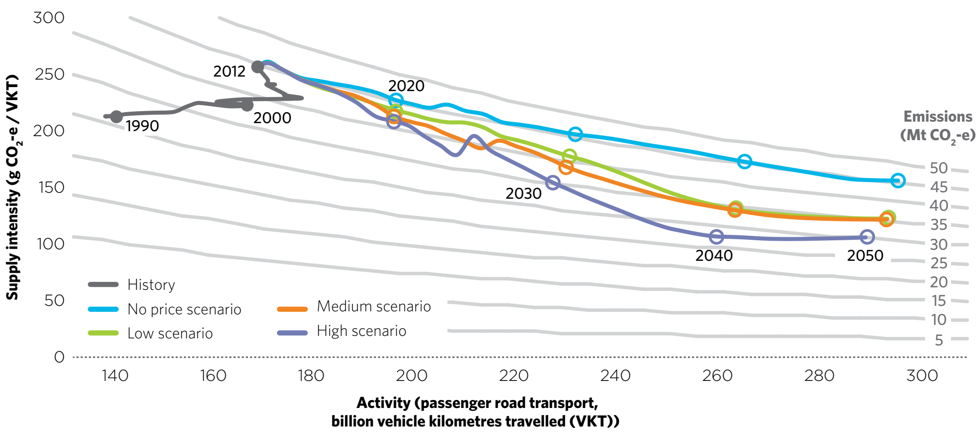

**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## FIGURE D.17: PASSENGER ROAD TRANSPORT ACTIVITY AND EMISSIONS INTENSITY—MODELLED RANGE, 1990–2050




**Note:** Upper and lower line bounds illustrate range of modelled outcomes.
**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013 and Reedman and Graham 2013a

## FIGURE D.18: PASSENGER ROAD TRANSPORT ACTIVITY AND EMISSIONS INTENSITY—FOUR SCENARIOS, 1990–2050




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013 and Reedman and Graham 2013a

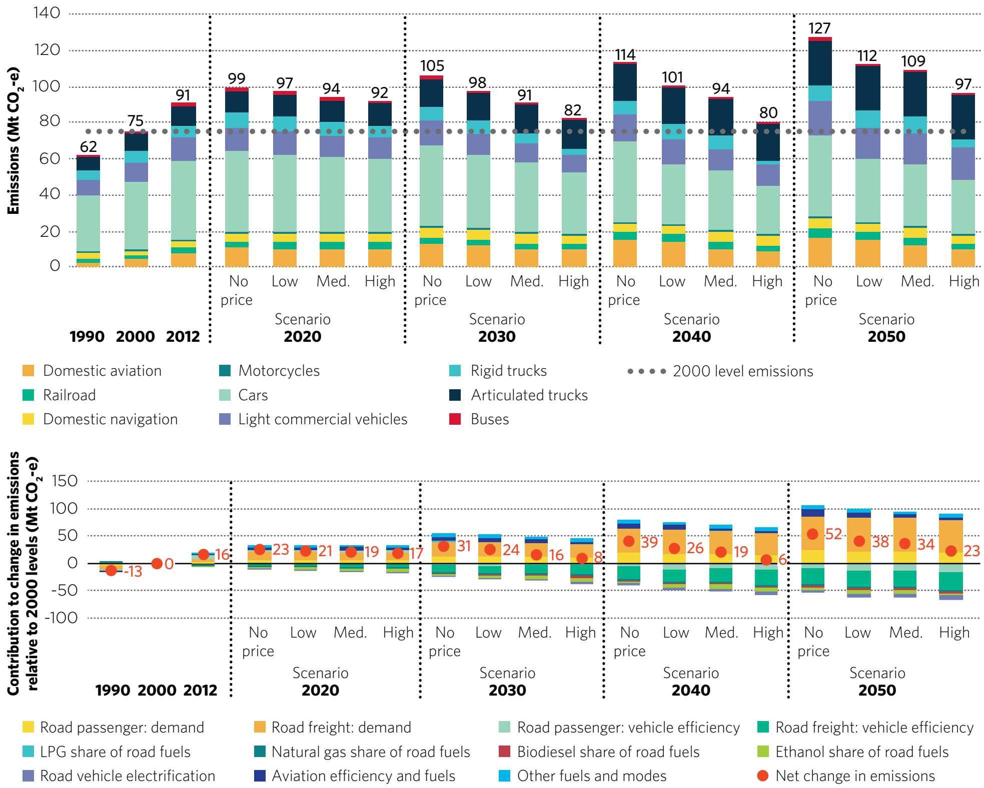
In all scenarios modelled by the Treasury and DIICCSRTE (2013), considerable growth in road and aviation activity is projected. Passenger road transport activity is expected to increase substantially from about 179 billion to 290 billion vehicle kilometres between now and 2050 (Figure D.17).

Under scenarios with a price incentive, the emissions intensity of passenger road transport is projected to decline significantly between now and 2030, and eventually stabilise between 2040 and 2050, as shown in Figure D.18.

Beyond 2035, however, emissions intensity improvements are not expected to offset growth in the transport task, resulting in growing transport emissions. Continuing growth in activity is estimated to drive up transport emissions to between 97 and 127 Mt $CO_2$-e in 2050, as presented in Figure D.19. This is higher than the 2000 level of 75 Mt $CO_2$-e in all scenarios.

## D4.2 TRANSPORT EMISSIONS OUTCOMES, CONTRIBUTORS AND DRIVERS

**FIGURE D.19: CONTRIBUTORS TO TRANSPORT EMISSIONS, SELECTED YEARS, 1990–2050, AND TO CHANGE IN EMISSIONS RELATIVE TO 2000 LEVELS**




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013 and Reedman and Graham 2013a

Demand for transport is driven by population growth, economic activity and costs associated with travel (DCCEE 2012, p. 25).

Road transport accounted for 77 Mt $CO_2$-e (84 per cent) of all transport emissions in 2012. This includes light vehicles (motorcycles, cars and light commercial vehicles) and heavy vehicles (rigid and articulated trucks and buses). Light vehicles accounted for 57 Mt $CO_2$-e (63 per cent) of total transport emissions and 10 per cent of Australia's economy-wide emissions. Passenger vehicles accounted for most of the transport task and, as a consequence, are the largest contributor to emissions, as represented in Figure D.20. Australia's per capita light vehicle ownership and use is stabilising, making population growth a dominant driver for future growth in passenger road transport.

Road freight is the second-largest contributor to emissions. It includes a diverse range of activities, such as freight hauled between cities by large articulated trucks, transport of goods between retail and distribution centres, and point-to-point courier movements. The road freight task is growing quickly—between 2001 and 2009, it grew by 37 per cent, from 139 billion tonne-kilometres to 191 billion tonne-kilometres (BITRE 2012, p. 49), driven by increased wealth and economic activity.

Domestic aviation activity, dominated by passenger transport, increased by 80 per cent between 2001 and 2011 (BITRE 2012, p. 89) and is projected to approximately double from 2011 levels by 2030 (DCCEE 2012, p. 15). This strong growth in domestic aviation has been largely driven by broader economic growth and increasing passenger preference for air travel over road or rail. Most classes of air travel have become more affordable—real costs of business, restricted economy and discount airfares have fallen, while real median and average incomes have increased (BITRE 2013 and PC 2013, p. 60). Domestic aviation accounts for more than half of non-road transport emissions (8 Mt $CO_2$-e) and emissions from rail and domestic shipping each account for about 3 Mt $CO_2$-e (Treasury and DIICCSRTE 2013).

In the Treasury and DIICCSRTE (2013) modelling, price incentives apply to only a minority of transport emissions, including those from heavy on-road vehicles from 2014–15. Incentives for light vehicle emissions reduction are not modelled. Emissions from light vehicles are, however, influenced by the incentives applied to other subsectors, which may lead to spillovers of technology improvements and use of lower emissions fuels.

The largest modelled contributors to emissions reduction in transport relate to vehicle efficiency improvements, vehicle electrification and the uptake of low-emission fuels, including sustainable biofuels, in road passenger and freight. These are reflected in Figure D.19.

Vehicle emissions intensity, expressed in grams of $CO_2$ per kilometre (g $CO_2$/km), serves as a robust proxy for vehicle efficiency across conventional fuel types. The emissions intensity of new light road vehicles (including light commercial vehicles) sold in Australia has improved by 21 per cent from 252 g $CO_2$/km in 2002 to 199 g $CO_2$/km in 2012 (NTC 2013, p. 5). This has been driven by technology advances and consumer preferences. Continued improvement is projected to reduce the transport emissions intensity of new vehicles to 2050 in all scenarios.

The projected uptake of electric road vehicles, already underway but expected primarily after 2020, also contributes to the reduction of transport emissions. The emissions attributable to electric vehicles will depend on the source of the electricity, so net emissions reduction from vehicle electrification will depend on the emissions intensity of the electricity supply (Garnaut 2008, p. 519). In 2050, electric road vehicles are projected to deliver a transport sector emissions reduction of between 2 Mt $CO_2$-e and 6 Mt $CO_2$-e per annum under the low and high scenarios, respectively, compared to the no price scenario.

The broad adoption of lower emission fuels, notably sustainable biofuels, could reduce transport emissions. Under the low and high scenarios, respectively, biofuels are projected to provide 10–20 per cent of Australia's road transport fuel needs by 2030, resulting in an emissions reduction of between 2 and 8 Mt $CO_2$-e per annum over 2000 levels, compared to the no price scenario.

## D4.3 PROGRESS IN TRANSPORT EMISSIONS REDUCTION

Broadly, transport emissions can be reduced in three ways:

- increasing the efficiency of vehicles, through engine and vehicle technology improvements and take-up of alternative drivetrains in the case of road vehicles
- reducing emissions intensity of fuels, through low-emissions alternatives to conventional fuels such as sustainable biofuels and natural gas
- making demand management more efficient through mode shift—from road freight to rail or shipping, and from private vehicles to public and active transport—as well as improved urban planning, transport infrastructure, traffic management and intelligent transport systems.

### D4.3.1 INCREASING THE EFFICIENCY OF VEHICLES

The CSIRO modelling suggests light vehicle efficiency improvements could offer approximately 18–19 Mt $CO_2$-e of emissions reductions per year by 2050 (Graham et al. 2012b, pp. 40–2). Light vehicle efficiency improvements are expected under a BAU setting, as consumer preferences are influenced by factors such as fuel prices. Improvements can also be significantly increased by regulations on vehicle carbon dioxide emissions.

There are fewer opportunities to reduce heavy vehicle emissions. Projections suggest that, compared to current practice, there is potential to reduce emissions through efficiency gains by up to 5 Mt $CO_2$-e per year by 2050 (Graham et al. 2012b, p. 45). Adoption of low-rolling resistance tyres and regenerative braking systems may offer another 2 Mt $CO_2$-e of cost-effective emissions reductions per year by 2050 (Graham et al. 2012b, p. 46).

Given the long lifetimes of ships, locomotives and aircraft, there are also fewer opportunities to improve energy efficiency through stock turnover of these vehicles. The largest emissions reduction opportunities for non-road vehicles, compared to current practice, are through technology advances such as engine efficiency and vessel weight, which could reduce transport emissions by about 7 Mt $CO_2$-e per year by 2050 (Graham et al. 2012b, pp. 49, 52 and 54).

By way of comparison, domestic aviation and shipping emissions were about 8 Mt $CO_2$-e and 3 Mt $CO_2$-e, respectively, in 2012.

#### VEHICLE ELECTRIFICATION

Road vehicle electrification, combined with a decarbonised electricity sector, offers substantial emissions reduction potential. Vehicles need not be fully electric—there are various degrees of electrification, such as stand-alone hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs).

The emissions of purely electric vehicles (EVs) and PHEVs—when operating in full electric mode—are represented in the electricity sector rather than transport. Their fuel cycle emissions intensity compared to internal combustion engine vehicles (ICEVs) and HEVs depends on the emissions intensity of the electricity grid and relative vehicle efficiencies. Typical mass-produced EVs are more than twice as energy efficient as ICEVs.

With a low-emissions electricity supply, the electrification of light and heavy vehicles could offer emissions reductions of between 23 and 25 Mt $CO_2$-e in 2050 (Graham et al. 2012b, pp. 40, 47). One of the current barriers to the take-up of EVs is their high up-front cost compared with ICEVs and HEVs (although operating costs are much lower). Given assumed technology improvements and cost reductions, the cost of owning an EV could reach parity with an ICEV by the late 2020s (Graham et al. 2012a, p. 25).

## FLEET-AVERAGE EMISSIONS STANDARDS FOR LIGHT VEHICLES

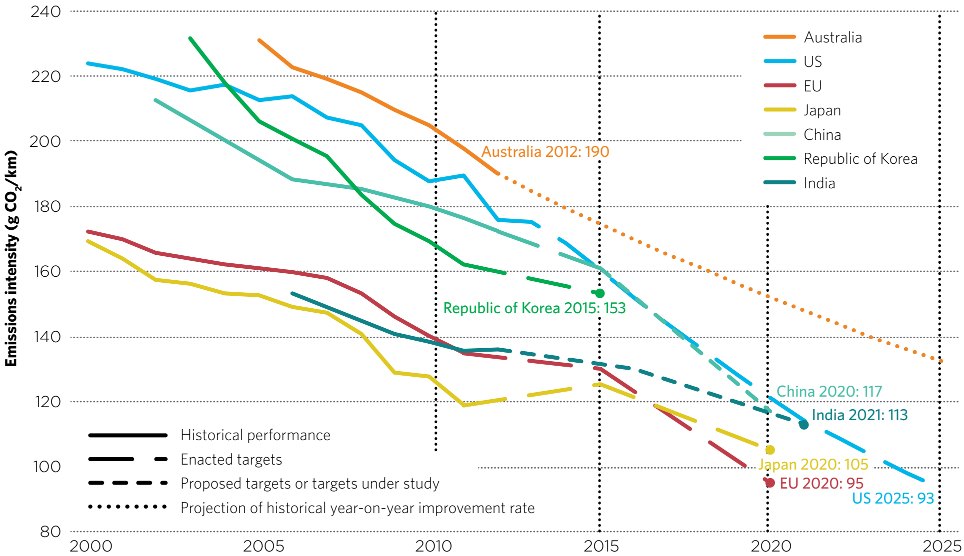
Despite recent improvements, Australia has not made the same gains as other auto markets in light vehicle fuel efficiency and $CO_2$ emissions. At 190 g $CO_2$/km, on average, light passenger vehicles sold in Australia in 2012 were 44 per cent more emissions-intensive than those sold in the same year in the EU, which averaged 132 g $CO_2$/km (NTC 2013, p. 24; European Environment Agency 2013, p. 3).

Adoption of standards on vehicle fuel efficiency and $CO_2$ emissions has led to improvements in vehicle efficiency worldwide. Regulations and targets intended to significantly improve on BAU outcomes are in place or being established in major markets such as the EU, the US, Canada, China, Japan and South Korea. About three-quarters of light passenger vehicles sold in the world today are subject to regulated $CO_2$ emissions standards or, equivalently, fuel economy standards (see Figure 11.10 in Chapter 11).

The EU has several policies to reduce $CO_2$ emissions from new vehicles, including a fleet-average target of 95 g $CO_2$/km for new light passenger vehicles by 2020, and is considering a target of 73 g $CO_2$/km by 2025 (European Commission 2013). The implied reduction rates under these targets are about 4 per cent per year between now and 2020, and about 5 per cent per year between 2020 and 2025.

The US has implemented standards targeting the fuel economy of light vehicles, with equivalent[3] average $CO_2$ intensity targets of 139 g $CO_2$/km by 2020 and 109 g $CO_2$/km by 2025. The implied reduction rates under these targets are about 5 per cent per year between now and 2025.

**FIGURE D.20:** COMPARISON OF PASSENGER VEHICLE $CO_2$ EMISSION RATE PROJECTIONS, 2000–2025




**Source:** Adapted from ICCT 2013 and NTC 2013

3 Conversion factor applied to convert US CAFE tested mpg to New European Drive Cycle tested g $CO_2$/km (ICCT 2012).

Australia has previously considered adopting fleet-average $CO_2$ emissions standards, and has regulations that require manufacturers and importers to display the fuel consumption and $CO_2$ emissions of new vehicles for sale (DIT 2011). As discussed in Chapter 11, the Authority recommends that the Commonwealth Government investigates implementing fleet-average $CO_2$ emissions standards for Australia.

Although most light vehicles sold in Australia are imported from countries with fuel efficiency standards, there is a risk that Australia will not receive the full benefit of those standards. The most fuel-efficient vehicles and model variants are typically allocated to markets with mandatory standards (DIT 2011, p. 8). If Australia pursued a similar rate of improvement in its fleet-average emissions as that required by the EU 2020 target, new light passenger vehicles sold in Australia in 2020 would be about 20 per cent more efficient than those sold today. Adopting a target comparable to the EU's (95 g $CO_2$/km by 2020) could reduce the emissions intensity of new light passenger vehicles, on average, to about half of today's level.

**BOX D.5: HOW DO FLEET-AVERAGE EMISSIONS STANDARDS WORK?**

A single fleet-wide target, based on vehicle $CO_2$ emissions intensity, is applied across all new light vehicle sales for a given year. Targets are tightened over time and are designed to drive greater vehicle efficiency improvements than would have occurred under BAU.

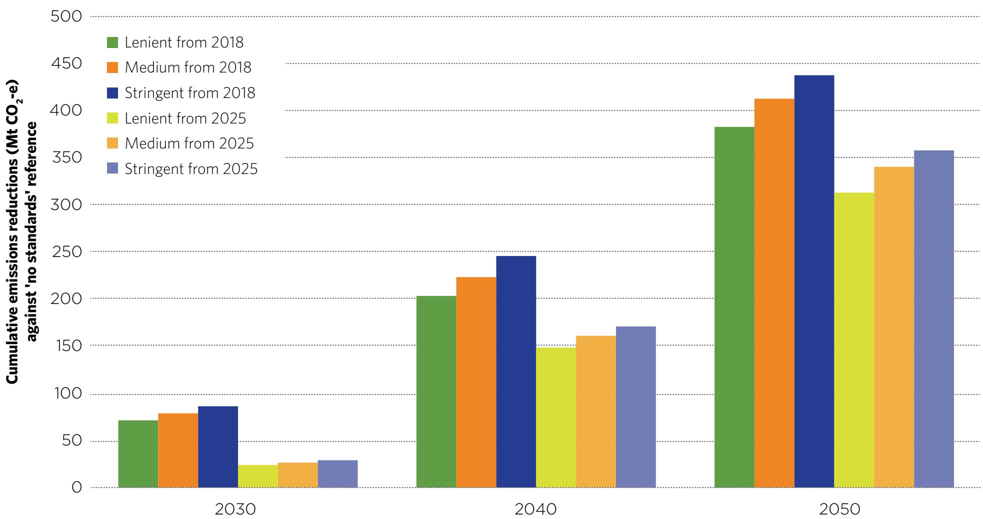
The target for individual suppliers is determined according to a mathematical relationship between $CO_2$ emissions and a particular vehicle attribute (usually mass or size). Suppliers can market models above or below the fleet target value applicable to a particular vehicle, as long as the average emissions intensity of all their models sold in a given year meets their target as determined by the mathematical relationship. This approach provides flexibility for suppliers and enables them to choose the most cost-effective technologies to achieve their targets.

A flat target that imposes the same limit on all suppliers is simpler in design but likely to lead to inequities given the different sectors of the market that the various suppliers occupy. Attribute-based standards provide a more equitable distribution of responsibility while still achieving the desired emissions reductions from the fleet overall. Attribute-based targets mean that fleet-average emissions standards do not drive the phase-out of large vehicles if there is a market demand for such vehicles; rather, it places pressure on suppliers to improve the efficiency of their vehicles. Attribute-based targets are applied in other vehicle markets; in the US, standards are set according to average vehicle size (footprint), while in the EU standards are based on average vehicle mass.

The Authority commissioned the CSIRO to model the emissions reduction potential of Australia adopting fleet-average $CO_2$ emissions standards that drive a rate of efficiency improvement comparable to other markets. Improvement over the last decade has been about 2.3 per cent per year on average (NTC 2013, p. 5). The CSIRO modelled lenient, medium and stringent standards, reflected by annual improvement rates of 3.5, 5 and 6.5 per cent respectively.

The CSIRO modelling showed that, by 2030, up to 14 Mt $CO_2$-e per annum (13 per cent of total transport emissions in that year) could be avoided using fleet-average $CO_2$ emission standards introduced in 2018. For the entire modelled period (from now until 2050), introducing relatively lenient standards in 2018 was projected to achieve greater emissions reductions than introducing stringent standards in 2025, emphasising the importance and value of early action in transitioning Australia's light vehicle fleet to lower emissions vehicles. Figure D.21 shows the cumulative emissions reductions available.

**FIGURE D.21: CUMULATIVE LIGHT VEHICLE EMISSIONS REDUCTIONS WITH $CO_2$ EMISSIONS STANDARDS, COMPARED TO BAU PROJECTIONS, 2030–2050**




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013 and Reedman and Graham 2013b

$CO_2$ emissions standards could offer net benefits to vehicle owners, as well as public benefits in reducing emissions. Mandatory $CO_2$ emissions standards are considered one of the most cost-effective strategies to reduce transport emissions (DIT 2011, p. 3).

The impact of emissions standards on vehicle costs in Australia will generally be determined by global vehicle markets (Reedman and Graham 2013b, p. 5). As a result, international evidence provides some useful insights for Australia. The Authority considers, based on analysis done in other markets, the overall private cost of vehicle emissions standards for Australia at levels comparable to international action may be negative (that is, delivering net savings)—even after higher vehicle purchase costs are taken into account.

In Europe, for example, under a 2020 target of 95g $CO_2$/km by 2020, the real purchase price of the average car is projected to be €1,100 more. Real fuel costs for the average car, however, will be about €400 less per year (Cambridge Econometrics and Ricardo-AEA 2013, p. 3). In the US, the National Highway Traffic Safety Administration (NHTSA) projects the latest Corporate Average Fuel Economy (CAFE) standards will deliver average net benefits of about US$3,400 (for cars) and US$4,700 (for light trucks) for vehicles manufactured in 2025 (NHTSA 2012, p. 978). These estimates do not take into account the social benefits arising from the reduction in emissions.

Fuel and operating savings, however, are specific to each market. According to CSIRO modelling of standards for Australia, a saving of 4 cents per kilometre is projected by the time the majority of the fleet has been subjected to $CO_2$ standards (after 2035). At about 15,000 km per year travel—typical for Australia—the annual savings are close to $600. This suggests $CO_2$ standards in Australia could give consumers a private return on investment comparable to that in the US or EU.

ClimateWorks (2010, p. 78) suggests that, in Australia to 2020, a standard of 140 g $CO_2$/km could deliver societal savings of up to $74 per tonne of $CO_2$ avoided, and achieve annual emissions reductions of 5.5 Mt $CO_2$, with benefits to the economy of about $400 million. The potential savings increase to $85 per tonne of $CO_2$ for a standard of 120 g $CO_2$/km, which could deliver emissions reductions of 6.3 Mt $CO_2$ and economic benefits of about $535 million.

Standards could have substantial complementary benefits:

- Reduced fuel consumption will lower costs and increase transport productivity. CSIRO modelling projects that under a lenient standard starting in 2018, about 161 PJ less transport energy, of all types, will be required in 2030 and about 275 PJ less in 2050. Petroleum consumption alone will be reduced by about 170 PJ per annum by 2050, which decreases Australia's projected petroleum needs in 2050 by about 5 per cent (BREE 2012, p. 46).
- Standards are projected to bring alternative drivetrains, such as plug-in electric vehicles, to Australian roads more quickly, with associated health and amenity benefits from reduced noise and air pollution. CSIRO modelling projects that under a medium standard starting in 2018, over one-quarter of all light vehicle travel will be undertaken by alternative drivetrain vehicles by the early 2040s, compared to about 7 per cent without standards.

Implementing $CO_2$ standards in Australia may be done at relatively low administrative cost. It may require new legislation but is not expected to introduce additional vehicle testing relative to current requirements.

## D4.3.2 REDUCED EMISSIONS INTENSITY OF FUELS

Oil is the main energy source for transport (IEA 2013b, p. 572). Alternative transport fuels with potentially lower emissions intensity are both available and in development, including liquid biofuels and gaseous fuels. Synthetic fuel alternatives are also in development or are available overseas, including coal-to-liquid, gas-to-liquid and shale oil-to-liquid, most of which could have higher emissions intensity than conventional fuels.

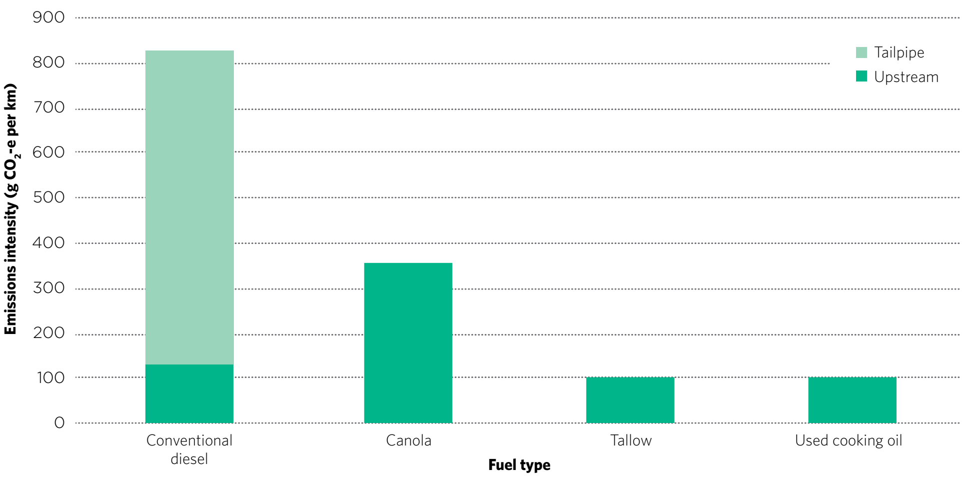
The growth of a low-emission fuels market depends on the cost and availability of these fuels as alternatives. Some modelled scenarios project a significant increase in biofuel use; however, there is a risk that future oil prices and biofuel supply constraints could prompt Australia to exploit fuels that have higher lifecycle emissions, in order to meet its transport fuel needs. Improving vehicle efficiency and electrification of transport mitigates this risk.

Natural gas may increase its share of the transport fuels mix; however, it is likely to depend on the relative pricing of natural gas to alternatives. Liquefied petroleum gas is not projected to gain significant future additional market share for road vehicles or locomotives; however, future prices of alternatives may change this outlook.

### BIOFUELS

Biofuels are considered zero-carbon under international accounting standards but, depending on the feedstock, the upstream emissions associated with producing biofuels can be higher than for fossil fuels (PC 2011, p. 7). In Australia, however, even after lifecycle process emissions are taken into account, biofuels are lower in emissions intensity than fossil-derived fuels (Figure D.22).

**FIGURE D.22:** UPSTREAM AND DOWNSTREAM EMISSIONS OF DIESEL FUELS




**Note:** Representative of a truck consuming 10 MJ/km of fuel energy (Beer et al. 2007, p. 50).
**Source:** Adapted from Beer et al. 2007, p. 92

The potential of biofuels may be limited by the availability of appropriate feedstock. First-generation or conventional biofuels are produced from grain-based feedstocks. Second-generation biofuels (including Australian biofuels) are produced from waste materials and co-products of food production, reducing the potential for food displacement or other unsustainable environmental outcomes. A newer second-generation biofuel—algal biofuel—produced from algae that can be grown in water bodies such as waste streams or the ocean, has the potential to be a sustainable alternative to conventional diesel. Algal biofuel is currently in the research and development stage and not yet commercially available (CSIRO 2013). Increased use of biofuels may diminish the emissions reduction potential of improved vehicle efficiency; however, this effect is limited by the availability of appropriate feedstock. Ultimately, both biofuels and efficient vehicles could help reduce Australia's emissions and its reliance on petroleum imports.

With a price incentive, adopting sustainable biofuels for road transport could reduce annual emissions by up to 3 Mt $CO_2$-e per year by 2050. Increased biofuel use could diminish the potential for emissions reductions from vehicle electrification and vice versa.

For rail and domestic shipping, the use of biofuels could offer the largest emissions reduction opportunity, totalling 2–4 Mt $CO_2$-e per year by 2050 (Graham et al. 2012b, pp. 53, 55). This is also the case for domestic aviation, where biofuels have the potential to reduce emissions by 6 Mt $CO_2$-e in 2050 (Graham et al. 2012b, p. 50).

Current supply of feedstock in Australia is not expected to be enough to meet substantial increases in demand (Wild 2011), and other potential sources may be favoured to supply a growing market for biofuels.

Regulatory drivers, such as New South Wales's biofuel mandates, can support increased biofuel use, but may not guarantee the biofuel is produced sustainably.

### D4.3.3 MORE EFFICIENT DEMAND MANAGEMENT AND MODE SHIFTS

There is potential for emissions reductions through mode shifts from road freight to rail and shipping. Based on international research, rail and shipping offer lower emissions intensity transport, at an average of 23 g $CO_2$ per tonne-km and 5–13 g $CO_2$ per tonne-km, respectively. By comparison, road freight averages 120 g $CO_2$ per tonne-km (Cristea et al. 2011, p. 38). Coupled with improved freight logistics, mode shift could reduce freight emissions by up to 5 Mt $CO_2$-e per year by 2050 (Graham et al. 2012b, p. 82).

Rail is the primary mode to move bulk freight, such as coal and iron ore. It plays less of a role in moving other freight, where its share, compared with long-haul road vehicles, is less than 10 per cent in the two largest corridors—between Sydney and Melbourne, and Sydney and Brisbane (BITRE 2009, p. 6). Investment in road infrastructure has brought more time-efficient and cost-effective road freight along these commercial routes. Rail becomes cost-competitive with road over distances longer than 1,000 kilometres, but transit time increases at a higher rate than for road freight (BITRE 2009, p. 8). Investment in rail infrastructure along these corridors could reduce transit time and costs, and improve rail's share of freight transport. However, there are long timeframes for investment and payback, which are a barrier to a broader uptake of rail freight transport.

Passenger mode shift from private vehicles to public and active transport also offers emissions reduction opportunities, with options ranging from increased use of public transport infrastructure to measures that encourage cycling and walking. It is estimated that switching from private car to other transport modes could offer emissions reductions of up to 7 Mt $CO_2$-e per year by 2050 (Graham et al. 2012b, pp. 69, 70, 72).

Australia's cities are more sparsely populated than most cities of the world (DIT 2013, p. 112), which presents a challenge to broader use of public and active transport. The potential for passenger mode shift is difficult to quantify—users' mode selection depends on the alternative transport options available and, potentially, policies and programs that influence travel behaviour change.

Emissions reductions could also be achieved through intelligent transport systems (ITS). ITS comprise a range of information and communications technologies that can be applied to optimise travel patterns, including traffic management. It is estimated that, if adopted, intelligent traffic management could reduce emissions by about 3 Mt $CO_2$-e per year by 2050 (Graham et al. 2012b, p. 80). Austroads, the association of Australian and New Zealand traffic authorities, is developing an ITS architecture to facilitate consistent and interoperable ITS delivery. The project, which is scheduled to be completed in 2016, will establish the regulatory and operational framework for ITS in Australia (Austroads 2013).

# APPENDIX D5
# DIRECT COMBUSTION

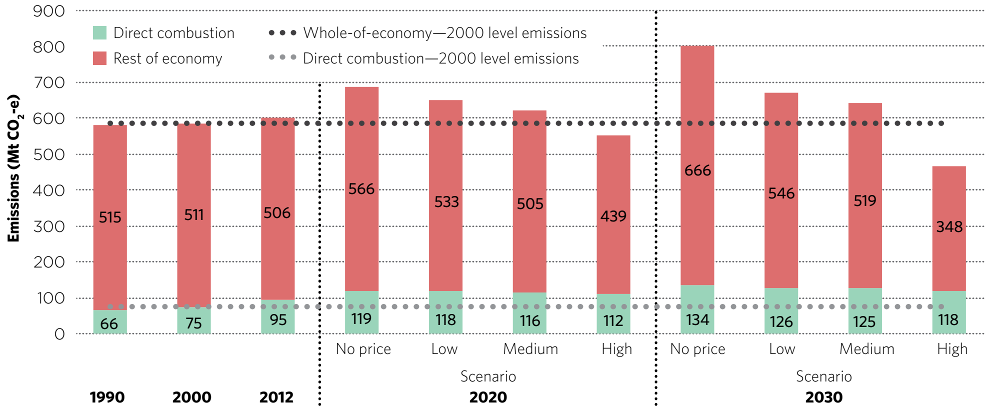
## D5.1 DIRECT COMBUSTION EMISSIONS OVERVIEW

Direct combustion is burning fuels for stationary energy purposes, such as generating heat, steam or pressure. It excludes fuels combusted for electricity generation.

Australia's direct combustion emissions were 75 Mt $CO_2$-e in 2000 and 95 Mt $CO_2$-e in 2012. This represented 13 per cent and 16 per cent of total Australian emissions in 2000 and 2012.

The oil and gas industries, metal manufacturing and households are large contributors to direct combustion emissions. The balance of emissions can be attributed to other industrial and commercial use.

**FIGURE D.23:** DIRECT COMBUSTION SHARE OF AUSTRALIA'S EMISSIONS, SELECTED YEARS, 1990–2030



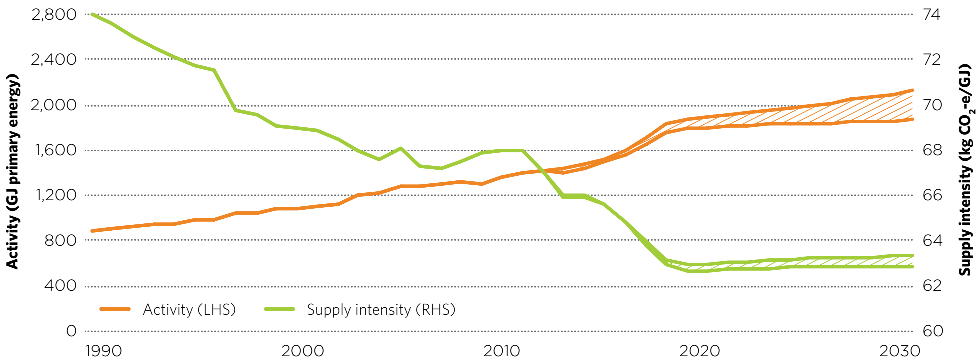

**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

Australia's rapidly expanding LNG industry is expected to be the main contributor to direct combustion emissions growth, particularly in the next few years. By 2020, direct combustion emissions are projected to be 49–59 per cent higher than 2000 levels, and 57–79 per cent higher by 2030 (Figure D.23).

From 2012 to 2030, direct combustion is projected to be responsible for the largest absolute increase in emissions in any sector of the Australian economy—driven primarily by LNG production—except under the no price scenario.

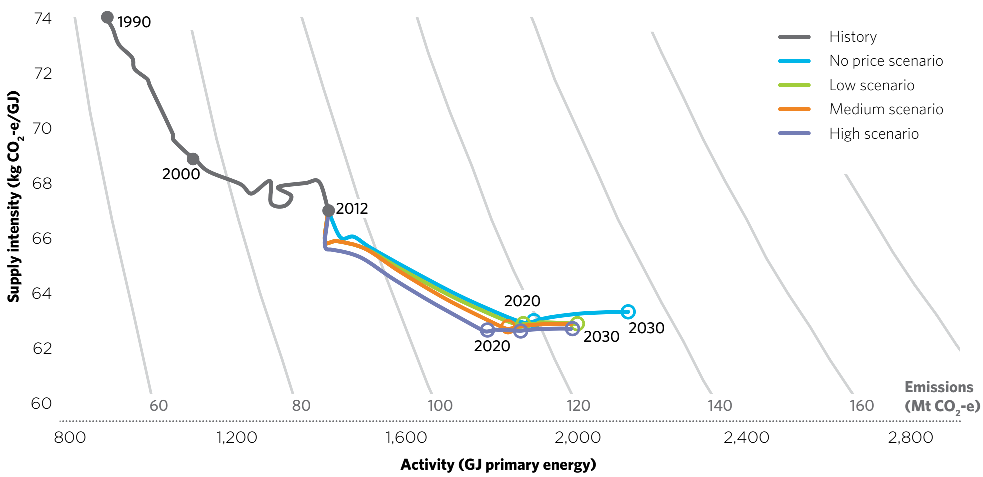
Emissions levels are closely correlated with the total energy content of fuel combusted. Direct combustion emissions intensity improved moderately between 2000 and 2012; a trend projected to continue across all scenarios to 2030 (figures D.24 and D.25), as natural gas takes an increasing share of the total primary energy mix.

**FIGURE D.24: DIRECT COMBUSTION ACTIVITY AND EMISSIONS INTENSITY, 1990–2030**




**Note:** Upper and lower line bounds illustrate the range of modelled outcomes.
**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

**FIGURE D.25: HISTORICAL AND PROJECTED DIRECT COMBUSTION ACTIVITY AND EMISSIONS INTENSITY, 1990–2030**

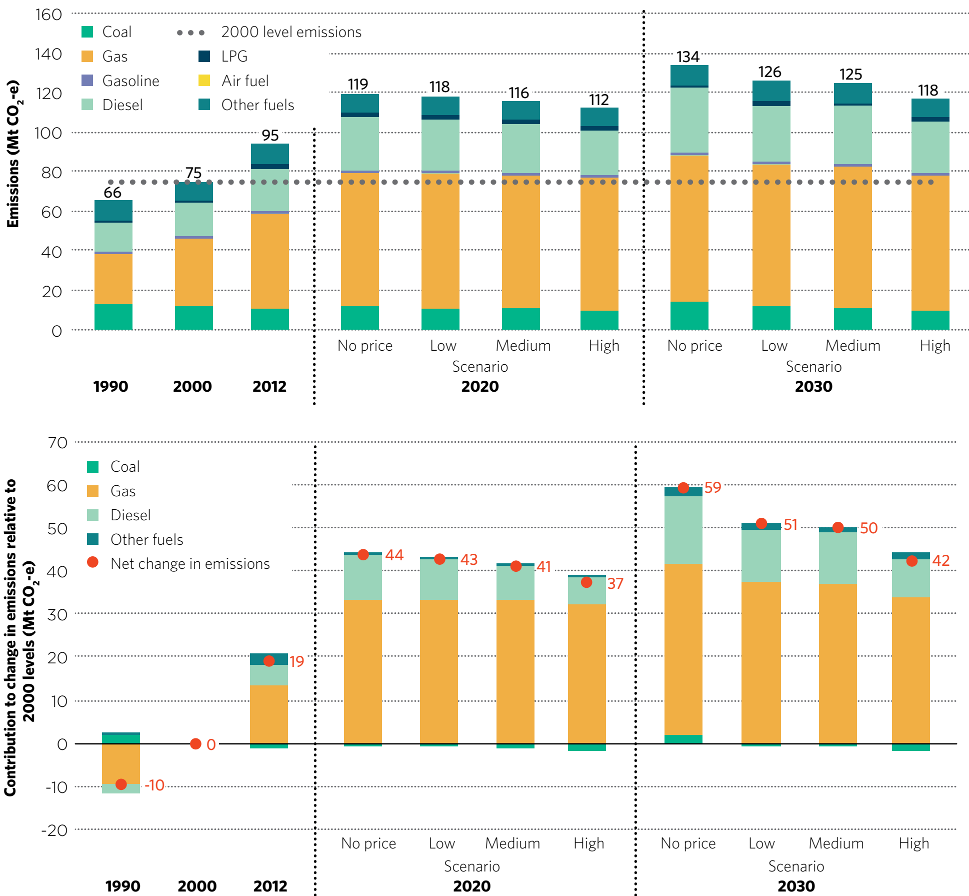



**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## D5.2 DIRECT COMBUSTION EMISSIONS OUTCOMES, CONTRIBUTORS AND DRIVERS

Direct combustion emissions from LNG production relate to onsite use of natural gas to fuel stationary equipment, particularly the compression turbines used to liquefy natural gas. Figure D.26 shows the modelled impact of price incentives on direct combustion emissions. All scenarios show strong emissions growth to 2020—the lowest projection in 2020 is almost 50 per cent higher than 2000 levels. The opportunity for emissions reductions, regardless of the level of incentive, is somewhat limited by long-term supply contracts in the growing LNG industry. While LNG exports totalled 24 million tonnes in 2012 (BREE 2013a, p. 24), there is over 114 million tonnes of annual LNG production capacity in operation, under construction or at initial stages in Australia (BREE 2013a, pp. 32–33) (Table D.6).

**FIGURE D.26: CONTRIBUTORS TO DIRECT COMBUSTION EMISSIONS, SELECTED YEARS, 1990–2030, AND TO CHANGE IN EMISSIONS RELATIVE TO 2000 LEVELS**




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## TABLE D.6: AUSTRALIAN LNG PROJECTS

| EXISTING | CAPACITY (MILLION TONNES/YEAR) | COMPLETION |
|---|---|---|
| **North West Shelf (WA)** | 16.3 | Operating |
| **Pluto (WA)** | 4.3 | Operating |
| **Darwin LNG (NT)** | 3.7 | Operating |
| **UNDER CONSTRUCTION** | **CAPACITY (MILLION TONNES/YEAR)** | **COMPLETION** |
| **Gorgon (WA)** | 15.6 | 2015 |
| **Australia Pacific LNG (Qld)** | 9.0 | 2015 |
| **Wheatstone (WA)** | 8.9 | 2016 |
| **Queensland Curtis LNG (Qld)** | 8.5 | 2014 |
| **Ichthys (NT)** | 8.4 | 2017 |
| **Gladstone LNG (Qld)** | 7.8 | 2015 |
| **Prelude Floating LNG (WA)** | 3.6 | 2017 |
| **FEASIBILITY STAGE** | **CAPACITY (MILLION TONNES/YEAR)** | **COMPLETION** |
| **Scarborough Floating LNG (WA)** | 6.0 | 2018+ |
| **Gorgon LNG Train 4 (WA)** | 5.2 | 2018+ |
| **Bonaparte Floating LNG (NT)** | 3.0 | 2018+ |
| **Browse Floating LNG (WA)** | N/A | 2018+ |
| **PROPOSED** | **CAPACITY (MILLION TONNES/YEAR)** | **COMPLETION** |
| **Arrow LNG (Qld)** | 8.0 | 2017+ |
| **Sunrise (NT)** | 4.0+ | 2017+ |
| **Cash Maple (NT)** | 2.0 | 2018+ |
| **Equus (WA)** | N/A | 2018+ |

**Source:** BREE 2013a

More generally across the industrial, residential and commercial sectors, energy efficiency is likely to play an increasingly important role across all forms of direct combustion, somewhat constraining growth in emissions.

## D5.3 PROGRESS IN DIRECT COMBUSTION EMISSIONS REDUCTION

### D5.3.1 NATURAL GAS INDUSTRY

The projected increase in direct combustion emissions results from large increases in LNG exports and limited opportunities to improve the emissions intensity of LNG production. Demand for Australian fossil fuel exports such as LNG is driven by global commodity prices and the exchange rate, as well as global and regional economic growth.

Improvements in emissions intensity may come from energy efficiency gains in turbines and other machinery. Australia Pacific LNG (2010, p. 25) notes that the most fuel-efficient turbines result in approximately 25 per cent less greenhouse gas emissions compared with commonly used turbines around the world. Additionally, heat captured from a gas turbine's exhaust may be used in the LNG liquefaction process to augment gas-fired boilers.

### D5.3.2 ALUMINA REFINING

Non-ferrous metal manufacturing, principally alumina refining, is the second-largest source of direct combustion emissions.

Between 2005 and 2012, direct combustion emissions from alumina refining stayed at about 8 Mt $CO_2$-e (Treasury and DIICCSRTE 2013), despite a 21 per cent increase in alumina production (BREE 2013b). This improvement in emissions intensity is largely due to fuel-switching from coal to gas.

Between 2012 and 2020, direct combustion emissions from alumina refining are projected to increase by 18 per cent to 10 Mt $CO_2$-e (Treasury and DIICCSRTE 2013) as production increases (BREE 2012b, p. 48). Further improvement in emissions intensity may come from process refinements. Opportunities vary, from co-generation plants, whose waste heat can generate steam for use in the alumina refining process (DRET 2008, p. 8), to systems optimisation, which more efficiently controls the use of natural gas (DRET 2013, p. 2). Absolute emissions reductions, or large gains in emissions intensity, may be limited unless fossil fuel combustion is replaced by lower emissions sources (DCCEE 2012, p. 14).

### D5.3.3 RESIDENTIAL SECTOR

Continued regulatory improvements to the thermal efficiency of residential homes and the energy efficiency of household appliances, such as hot water systems, could represent significant emissions reduction opportunities. George Wilkenfeld and Associates (2009, p. 40) project that equipment energy efficiency standards affecting residential gas use may save 4.5 Mt $CO_2$-e between 2000 and 2020. There may be an increase in sectoral emissions, however, as conventional electric resistive water heaters are phased out. The effect on direct combustion emissions will depend on householders' preferences for gas, solar or heat pump water heaters, and choices between gas and electric heat pump space heating. The overall effect on emissions will also depend on the emissions intensity of electricity generation and the relative improvements in appliance efficiency.

# APPENDIX D6
# FUGITIVE EMISSIONS

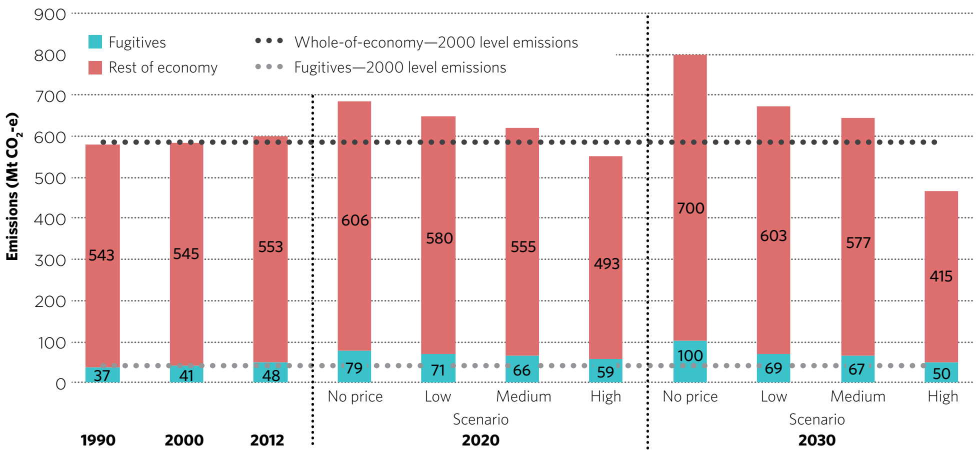
## D6.1 FUGITIVE EMISSIONS OVERVIEW

Fugitive emissions are greenhouse gases emitted during the extraction, production, processing, storage, transmission and distribution of fossil fuels such as coal, oil and gas. Fugitive emissions do not include emissions from fuel combustion.

Australia's fugitive emissions were 41 Mt $CO_2$-e in 2000 and increased to 48 Mt $CO_2$-e in 2012 (Treasury and DIICCSRTE 2013). This represented 7 and 8 per cent of Australia's total emissions in 2000 and 2012, respectively (Figure D.27). Almost three-quarters of 2012 fugitive emissions were from the coal industry, with the balance from the oil and gas industry.

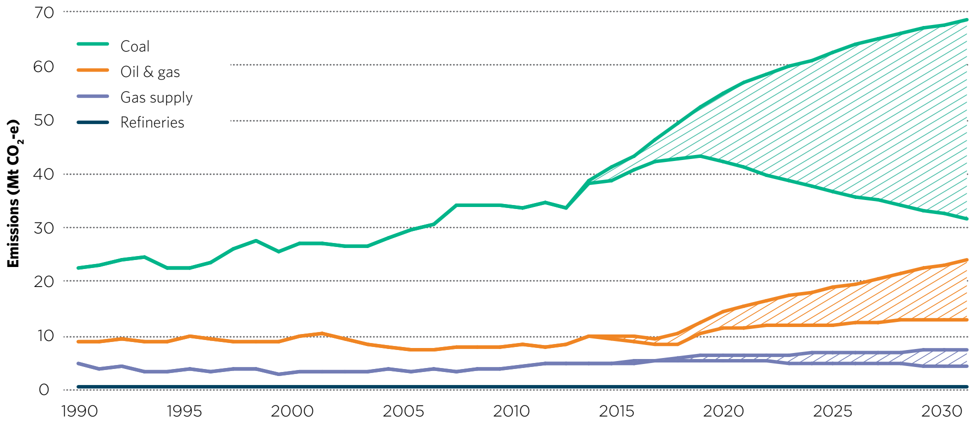
The Treasury and DIICCSRTE modelling (2013) projects fugitive emissions will increase relative to 2000 levels by 2030 under all scenarios. Growth ranges from an 8 Mt $CO_2$-e to 59 Mt $CO_2$-e increase under the high and no price scenarios, respectively (Figure D.27). The projected increase reflects growth in coal and LNG production, driven by strong global demand for Australia's energy resources. The scenarios project a wide range of possible future fugitive emissions levels in 2030 (Figure D.28).

**FIGURE D.27:** FUGITIVE SHARE OF AUSTRALIA'S EMISSIONS, SELECTED YEARS, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

**FIGURE D.28:** HISTORICAL AND PROJECTED FUGITIVE EMISSIONS, 1990–2030




**Note:** Upper and lower line bounds illustrate the range of modelled outcomes.
**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## D6.2 FUGITIVE EMISSIONS OUTCOMES, CONTRIBUTORS AND DRIVERS

Figure D.29 shows the projected fugitive emissions outcomes for each modelled scenario. All scenarios project a steep increase in emissions to 2020, but diverge in the decade post-2020. By 2030, emissions are projected to be 21 per cent above 2000 levels in the high scenario and 144 per cent above in the no price scenario. This reflects the potential for strong incentives to enhance the economic attractiveness of emerging emissions reduction processes, such as the oxidisation of ventilation air methane in coal mining.

Future fugitive emissions are projected to be driven by growing coal and gas production in response to increased global energy demand. If there is increased global action on climate change, production of fossil fuels (particularly coal) is projected to grow at a slower rate (Treasury and DIICCSRTE 2013). This effect is incorporated in all the scenarios modelled and is most pronounced in the high scenario.

### D6.2.1 COAL INDUSTRY

Fugitive emissions in the coal industry depend on the level of coal production and the greenhouse gas content of the coal seams being mined. ClimateWorks (2013, p. 36) notes that some of the more emissions-intensive mines generate up to 0.8 t $CO_2$-e of fugitive emissions per tonne of coal produced.

Underground mines are typically more emissions-intensive than surface mines because deeper coal seams are subject to greater pressures, which prevents the natural escape of emissions through cracks and fissures (US EPA 2006a, p. 1). In Australia, underground coal mines are around seven times more emissions-intensive than surface mines on average—they contributed 19 per cent to Australian coal production in 2010–11 but 62 per cent of coal fugitive emissions (DCCEE 2012).

Between 2000 and 2012, Australia's raw coal production increased by 36 per cent (BREE 2013b), while fugitive emissions from coal increased by 24 per cent (Treasury and DIICCSRTE 2013), suggesting improved emissions intensity.

Although price incentives for emissions reduction are projected to affect the emissions intensity of production, growth in Australia's fugitive emissions will continue to be driven largely by global demand for Australian coal. For example, BREE (2012, pp. 36, 51) projects total black coal production to increase from 11,700 PJ in 2012–13 to 18,000 PJ in 2049–50, and domestic black coal consumption to decrease from 1,200 PJ to 478 PJ.

## FIGURE D.29: CONTRIBUTORS TO FUGITIVE EMISSIONS, SELECTED YEARS, 1990–2030, AND TO CHANGE IN EMISSIONS RELATIVE TO 2000 LEVELS


**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

### D6.2.2 OIL AND GAS INDUSTRY

Fugitive emissions in the gas industry include gas venting, gas flaring and losses associated with the transmission and distribution of gas.

Between 2000 and 2012, fugitive emissions from natural gas production decreased 18 per cent and emissions from natural gas transmission and distribution increased by 55 per cent (Treasury and DIICCSRTE 2013). Overall, fugitive emissions from the gas industry remained steady over the period, despite natural gas (and ethane) production doubling between 2000 and 2012 (BREE 2013b). Oil production decreased over this period; however, its relatively small contribution to emissions means it is not driving changes in emissions.

The Grattan Institute (2013, p. 4) identifies several trends driving increased demand for gas, including:

- economic growth in China, India and the Middle East, leading to increased energy demand generally
- several countries changing their policies on nuclear power, notably Australia's major trading partner Japan, following the Fukushima nuclear incident, leading to increased demand for alternative energy sources
- climate change concerns making gas-fired power plants more attractive, as they emit less greenhouse gases than coal-fired power plants.

These factors contribute to a strong growth outlook—Australian gas production is projected to increase by 184 per cent between 2012–13 and 2049–50 (BREE 2012), considerably larger than the growth in domestic consumption.

## D6.3 PROGRESS IN FUGITIVE EMISSIONS REDUCTION

### D6.3.1 COAL INDUSTRY

There are several emissions reduction technologies the coal industry could use to reduce fugitive emissions, though their implementation may require a price incentive or technological maturation. The US EPA (2006a, p. 2) identified three main measures:

- degasification to capture methane
- enhanced degasification to capture low-grade methane and purify it
- oxidisation of ventilation air methane (when methane in a mine's ventilation air is oxidised to generate heat or produce electricity).

A price incentive could encourage uptake of these technologies. For example, ClimateWorks (2013) estimates reducing emissions from ventilation air methane oxidisation costs about \$17/t $CO_2$-e. A price incentive could also drive a shift in Australian coal production towards less gassy mines.

The level of coal mining activity will be the main driver of fugitive emissions. The Treasury and DIICCSRTE (2013) suggests Australia's coal production level will be more responsive to global action to reduce emissions than to Australia's domestic price incentive. With strong global action on climate change, domestic coal production is projected to be flat from 2020 before falling towards the end of that decade. With weaker action, Australia's production is projected to continue to grow.

## D6.3.2 OIL AND GAS INDUSTRY

The US EPA (2006b, p. 2) identified three main fugitive emissions reduction measures for the natural gas industry:

- Equipment changes and upgrades—including pneumatic control devices, which operate valves and control pressure, flow or liquid levels. These devices can be retrofitted or replaced to 'bleed' less natural gas into the atmosphere, or used with compressed air instead of pressurised natural gas (Copenhagen Consensus on Climate 2009, p. 22).
- Changes in operational practices—including avoiding the venting of methane before pipeline maintenance or repairs. This may mean recompressing the gas during maintenance and repairs or using surge vessels, which clear the pipeline of methane for short periods (Ecofys 2009, p. 27).
- Direct inspection and maintenance—including identifying and addressing leaks across the natural gas transmission and distribution network. Infrared cameras can find methane emissions and, if coupled with emissions measurement technologies such as pressure sensors, allow leaks to be tracked and rectified (Clean Air Task Force 2009, p. 16).

CCS could significantly reduce fugitive emissions from oil and gas extraction and processing, though it is not yet widespread (IEA 2013, p. 19). The Gorgon LNG project in Western Australia is expected to capture and inject as much as 3.4 Mt $CO_2$ annually from 2015 (Chevron 2013). Queensland LNG projects are unlikely to use CCS.

The demonstrated reserves of coal seam gas (CSG) in Australia are substantial and estimated to be 31 per cent of Australia's gas resources (BREE 2013a), with deposits concentrated in Queensland and New South Wales. The CSIRO and Department of the Environment are undertaking a project to gather preliminary field measurements of fugitive emissions from CSG. This is a first step to establishing methods for assessing Australia-specific fugitive emissions from CSG (CSIRO 2013).

# APPENDIX D7 INDUSTRIAL PROCESSES

## D7.1 INDUSTRIAL PROCESS EMISSIONS OVERVIEW

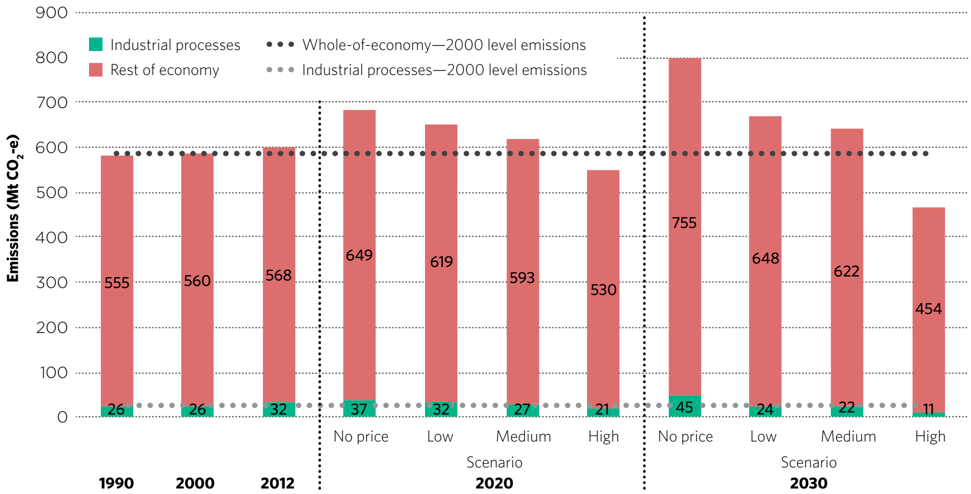
The main sources of industrial process emissions are:

- metal production in iron, steel and aluminium products
- synthetic greenhouse gases from refrigeration and air conditioning use
- chemical processes in fertiliser and explosives manufacturing
- mineral production, primarily in the cement industry.

Industrial process emissions exclude energy-related emissions such as the burning of fossil fuels for electricity, heat, steam or pressure. These emissions are attributed to electricity, direct combustion or transport.

Australia's industrial process emissions accounted for 32 Mt $CO_2$-e (5 per cent) of Australia's emissions in 2012 (Figure D.30).

**FIGURE D.30:** INDUSTRIAL PROCESS SHARE OF AUSTRALIA'S EMISSIONS, SELECTED YEARS, 1990–2030



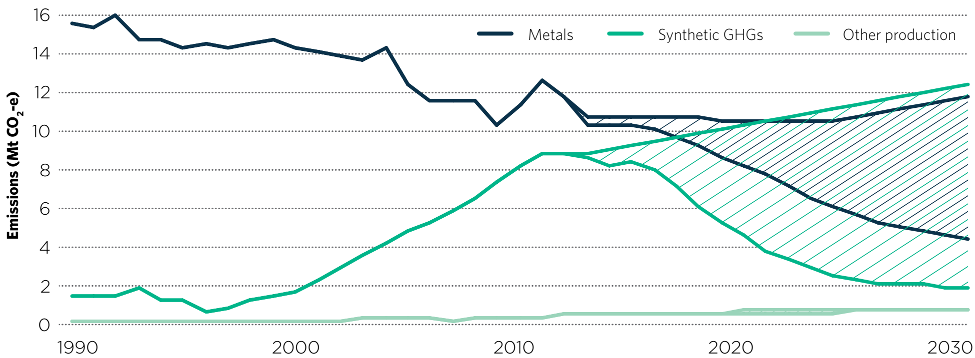

**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

From 1990 to 2012, industrial process emissions increased by almost 7 Mt $CO_2$-e, due to increased use of synthetic greenhouse gases and growing chemical production. This was partly offset by lower metal production and improved metal processing.

In 2012, industrial process emissions comprised metal production (37 per cent), synthetic greenhouse gases (27 per cent), chemical processing (19 per cent), mineral production (15 per cent) and other production (2 per cent).

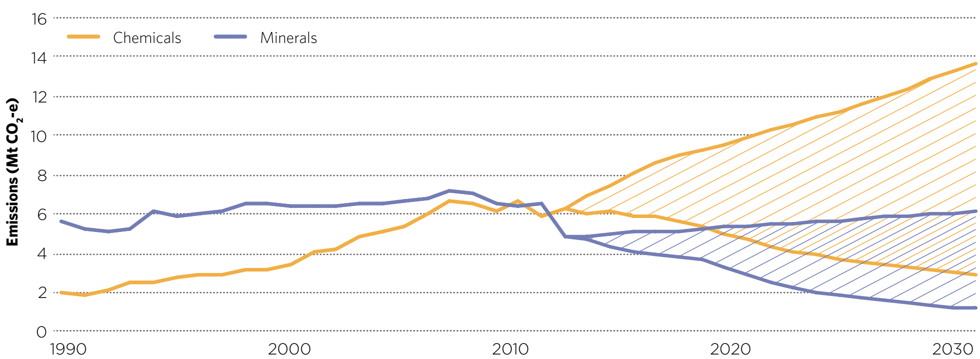
The Treasury and DIICCSRTE modelling projects industrial process emissions to be lower, relative to 2000 levels, by 2–4 Mt $CO_2$-e in 2030 under the low and medium scenarios, respectively, and by 15 Mt $CO_2$-e (59 per cent) under the high scenario. Emissions are reduced through improved chemical processing and the transition to alternative refrigerant gases.

### FIGURE D.31: PROCESS EMISSIONS FROM METAL PRODUCTION, SYNTHETIC GREENHOUSE GASES AND OTHER PRODUCTION, 1990–2030



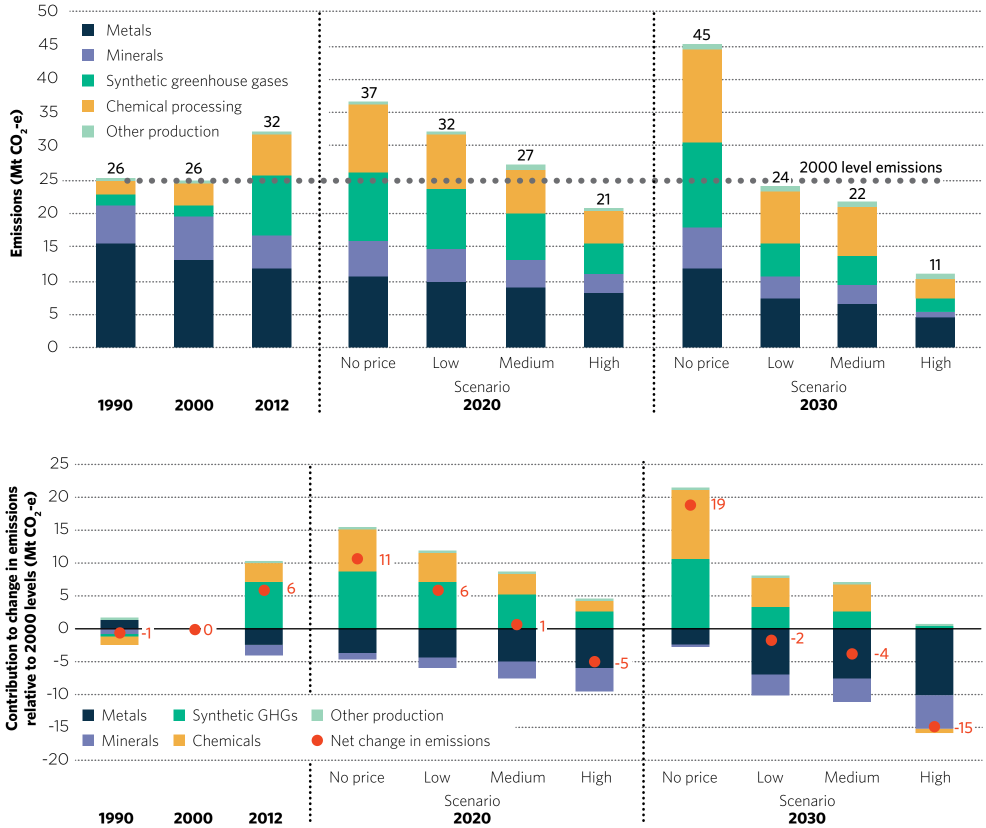

**Note:** Upper and lower line bounds illustrate the range of modelled outcomes.
**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

### FIGURE D.32: PROCESS EMISSIONS FROM CHEMICAL AND MINERAL PRODUCTION, 1990–2030




**Note:** Upper and lower line bounds illustrate the range of modelled outcomes.
**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

**FIGURE D.33: CONTRIBUTORS TO INDUSTRIAL PROCESS EMISSIONS, SELECTED YEARS, 1990–2030, AND TO CHANGE IN EMISSIONS LEVELS RELATIVE TO 2000 LEVELS**




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## D7.2 INDUSTRIAL PROCESS EMISSIONS OUTCOMES, CONTRIBUTORS AND DRIVERS

The majority of the projected emissions reduction in 2030 results from installing nitrous oxide conversion catalysts, recovering and destroying synthetic greenhouse gases, and replacing ozone-depleting substances and refrigerants with lower emitting alternatives. Metals and minerals processing emissions are projected to decline with a price incentive.

Nitrous oxide conversion catalysts offer substantial emissions reduction opportunities, particularly in the context of growing chemical production. Ammonia production emissions are expected to increase in line with expanding explosives production for use in the mining sector and growing demand for fertilisers as the agriculture sector continues to recover from prolonged drought (IBISWorld 2013, p. 9). Planned projects would increase current ammonium nitrate production capacity by over 60 per cent to 1,300 kilotonnes per annum by 2020 (ClimateWorks 2013, p. 49).

ClimateWorks (2013, p. 49) estimates nitrous oxide conversion catalysts could lower nitric acid emissions intensity by 44 per cent in 2020. The cost of conversion catalysts means that incentives or regulation may be needed to drive broad adoption.

According to the Treasury and DIICCSRTE modelling, between 2012 and 2020, synthetic greenhouse gas emissions (used as propellants and refrigerants) are projected to decrease by about 2 Mt $CO_2$-e under the medium scenario and 4 Mt $CO_2$-e under the high scenario. Moving to less emissions-intensive refrigerant gases could deliver a further 6 Mt $CO_2$-e of emissions reduction by 2020.

Metal production emissions decreased by 4 Mt $CO_2$-e to 12 Mt $CO_2$-e between 1990 and 2012, as a result of reduced iron and steel production and improved metal processing. In particular, aluminium emissions intensity fell by over 60 per cent between 1990 and 2011 due to reductions in perfluorocarbon (PFC) emissions. PFC reduction opportunities have been largely taken up; only 20 grams of PFC were emitted per tonne of aluminium produced in 2011, compared with over 450 grams in 1990 (DIICCSRTE 2013, p. 168).

Metal production has contracted recently, as a result of the closure of one of Bluescope Steel's Port Kembla steelworks in 2011 and Norsk Hydro's Kurri Kurri aluminium operations in 2012. The Treasury and DIICCSRTE (2013) modelling projects metal emissions will decrease to between 4 and 7 Mt $CO_2$-e in 2030 under all price scenarios, or otherwise remain steady at 2012 levels under the no price scenario. Mineral production emissions largely result from the cement industry. ClimateWorks (2013, p. 32) reports that cement emissions intensity reduced by 11 per cent between 2002 and 2012, and has the potential to decrease by a further 6 per cent by 2020, from increasing substitution of supplementary materials in clinker production. Plans to import more clinker, in place of domestic production, would limit the expansion of domestic production and emissions (Adelaide Brighton 2013, p. 17; Treasury and DIICCSRTE 2013, p. 66).

## D7.3 PROGRESS IN INDUSTRIAL PROCESS EMISSIONS REDUCTION

### D7.3.1 CHEMICAL PROCESSES

Conversion catalysts reduce nitrous oxide emissions from producing nitric acid, a feedstock for explosives and fertilisers. These catalysts are proven technology, deployed in Australia by Orica in 2012 and trialled by Wesfarmers since 2011. Both Orica (2013, p. 22) and Wesfarmers (2013, p. 39) report that this technology has reduced their nitrous oxide emissions by over 80 per cent. Incitec Pivot (2012, p. 23) installed nitrous oxide conversion catalysts at its newly constructed Moranbah Plant in 2012, which has capacity to produce 330 kilotonnes of ammonium nitrate per annum. ClimateWorks (2013) projects widespread adoption of nitrous oxide conversion catalysts in nitric acid production by 2020.

These catalyst technologies are relatively cost-effective (US EPA 2010, p. 9). Their take-up could be encouraged with a price incentive as well as state-based environmental regulations for nitric acid plants, some of which already exist.

There are currently no low-emissions substitutes in the production of ammonia. Natural gas is the main feedstock used in ammonia production and this is unlikely to change for the foreseeable future—natural gas has the most desirable qualities for ammonia manufacturing (International Fertilizer Industry Association 2013).

Synthetic rutile and titanium dioxide production emissions contribute a very small component of chemical sector emissions and are projected to remain stable to 2030.

## D7.3.2 SYNTHETIC GREENHOUSE GASES

The Treasury and DIICCSRTE modelling projects a reduction in synthetic greenhouse gas emissions of up to 6 Mt $CO_2$-e in 2020, compared to the no price scenario, mainly from the Destruction Incentives Program and switching to less emissions-intensive refrigerant gases such as carbon dioxide and ammonia. In contrast, ClimateWorks (2013, p. 47) projects that reportable synthetic greenhouse gas emissions could be about 4 Mt $CO_2$-e higher in 2020 if recent trends continue, largely due to the progressive replacement of ozone-depleting substances with sulphur hexafluoride ($SF_6$) and hydrofluorocarbons (HFCs).

Ozone-depleting greenhouse gases, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are not recorded in Australia's National Greenhouse Gas Inventory (NGGI). These gases are managed through the Montreal Protocol, an international environmental protection agreement that sets out binding obligations for phasing out ozone-depleting substances.

Synthetic greenhouse gases that do not deplete the ozone layer, such as $SF_6$ and HFCs, are recorded in the NGGI and covered by the Kyoto Protocol. As a result, switching from ozone-depleting gases to these gases has increased industrial process emissions reported in the NGGI. Between 2000 and 2012, synthetic greenhouse gas emissions increased by 7 Mt $CO_2$-e. Despite the increase in emissions reported in the NGGI, the shift to $SF_6$ and HFCs has contributed to a net climate benefit (DCCEE 2012, p. 4).

Refrigerants Reclaim Australia (RRA) administers an industry-funded program that collects, reclaims and destroys waste and unwanted refrigerants and ozone-depleting substances. RRA (2013, p. 4) recovered about 4,445 tonnes of refrigerant gases between July 1993 and June 2012, avoiding emissions of about 10 Mt $CO_2$-e (including ozone-depleting substances). Projected rates of recovery of refrigerant gases are expected to reach over 900 tonnes per year by 2020, approximately doubling present rates (RRA 2013, p. 9). The rate of recovery may slow, given the Commonwealth Government's decision to not continue financial support, beyond 30 June 2014, in addition to the existing industry-funded and -operated Destruction Incentives Program (DoE 2013).

## D7.3.3 METAL PRODUCTION

Aluminium, iron and steel production accounts for the majority of emissions in the metal sector. Future production levels are uncertain. BREE (2013, p. 150) projects iron and steel production will continue to decline in the short term, while ClimateWorks (2013) estimates production will stabilise. No new metal projects are expected in the near term.

There are only two major producers of iron and steel in Australia—Arrium and Bluescope Steel. The closure of one of Bluescope Steel's two blast furnaces at its Port Kembla plant in 2011 reduced its annual steel-making production by about 2.6 million tonnes and Australia's crude steel production by almost 30 per cent in 2011–12 (Bluescope 2011, p. 5; ClimateWorks 2013, p. 31). This was due to the 'record high Australian dollar, low steel prices and high raw material costs', compounded by weak steel demand, though 'not related to the Federal Government's proposed carbon tax' (Bluescope 2011, p. 5). Similar factors, including overcapacity in the aluminium industry, led to the 2012 closure of the Kurri Kurri plant (Norsk Hydro 2012).

Weaker domestic construction activity and the high Australian dollar, combined with the weak international steel market, are expected to continue to suppress metal production to 2014. In the medium to long term, these factors are expected to improve (Arrium 2013, p. 13).

ClimateWorks (2013, p. 48) projects that the emissions intensity of metal production will remain stable to 2020, as the industry is characterised by mature technologies with high capital intensity and long investment cycles. At present, there are 'no near to mid-term technology improvements that will deliver large step reductions in carbon steelmaking emissions' (Arrium 2011, p. 24). As noted above, after substantial PFC emissions reductions from aluminium since 1990, there is limited opportunity for further improvement in aluminium emissions intensity (ClimateWorks 2013, p. 47).

CCS technology requires significant capital expenditure but offers large emissions reduction potential. Pilot projects are currently operating in Japan and Korea (IEA 2013, p. 19).

## D7.3.4 MINERAL PRODUCTION

The Cement Industry Federation (CIF 2013) notes over half of the emissions associated with cement manufacturing are attributed to clinker production. Progress is being made to reduce emissions and increase production through greater use of supplementary materials such as cement extenders, flyash and slag. Since 2003, industry use of these materials increased by 68 per cent, reaching over 3 million tonnes in 2012 (ClimateWorks 2013, p. 32; CIF 2012, p. 15).

Adelaide Brighton (2012, p. 19) increased its clinker substitution to almost 16 per cent in 2012, avoiding nearly 0.5 Mt $CO_2$-e of emissions by using waste materials that would otherwise be placed in landfill. Boral is also increasing its clinker substitution through proprietary technology to reduce the emissions intensity of concrete by over 40 per cent (ClimateWorks 2013, p. 51).

In future, plans to import clinker are likely to reduce domestic emissions from cement production and transfer emissions that would have occurred in Australia to the exporting country. Adelaide Brighton (2013, p. 17) intends to import all its white clinker from Malaysia from 2015. Similarly, Boral (2013, p. 14) has increased its clinker imports to almost 30 per cent after closing its Waurn factory in 2012.

# APPENDIX D8 AGRICULTURE

## D8.1 AGRICULTURE EMISSIONS OVERVIEW

Agriculture emissions are those from:

- livestock digestive processes (enteric fermentation)
- manure management
- nitrous oxide emissions from cropping and pastureland soils
- prescribed burning of savannas and burning of agricultural residues.

Livestock emissions are primarily methane, whereas emissions from cropping activities are primarily nitrous oxide from applying fertilisers, dung, manure and crop residues to soils.

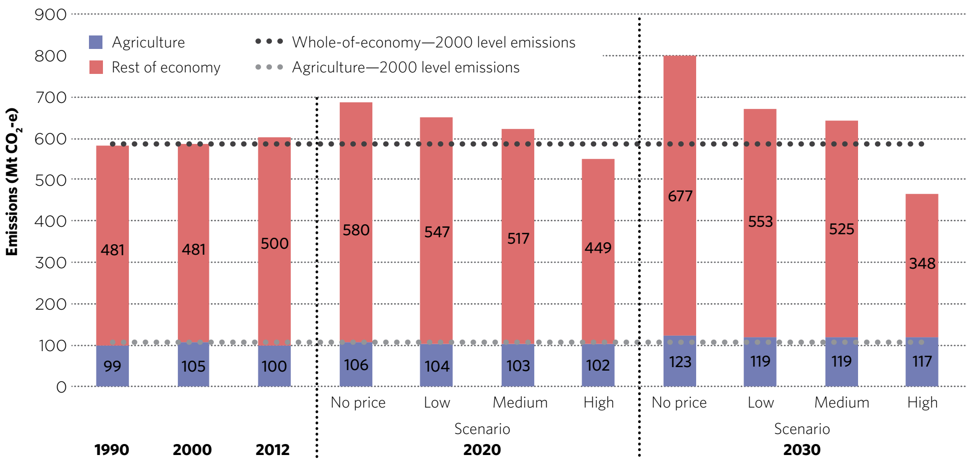
Combustion of fossil fuels in farming and cropping activities is covered under other sectors (electricity, direct combustion and transport).

Activities that change carbon sequestration in agricultural soils are covered under LULUCF, discussed in Appendix D9. Consistent with Australia's Kyoto Protocol Accounting Framework and the categories of reporting used in the National Greenhouse Gas Inventory, a distinction has been made between agriculture and LULUCF emissions in this report, though the two sectors are closely connected.

Agriculture accounted for 17 per cent of total Australian emissions in 2012 (Figure D.34). About three-quarters were from livestock, mostly from enteric fermentation. The remainder were shared relatively evenly between cropping and savanna burning.

The share of agriculture emissions is projected to remain relatively stable until 2030 under the medium scenario. Agriculture emissions are projected to be just 6 Mt $CO_2$-e lower (5 per cent), under the high scenario, compared to the no price scenario, in 2030.

**FIGURE D.34:** AGRICULTURE SHARE OF AUSTRALIA'S EMISSIONS, SELECTED YEARS, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

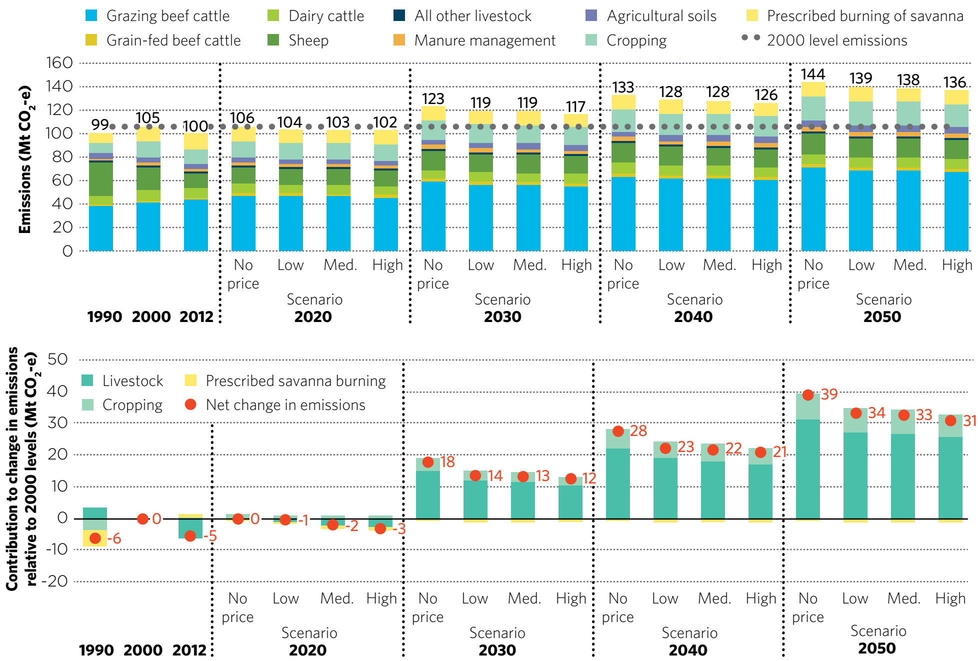
From 1990 to 2012, agriculture emissions increased from 99 to 100 Mt $CO_2$-e. They peaked at 108 Mt $CO_2$-e in 2001 before gradually declining to 93 Mt $CO_2$-e in 2010 and then increasing to current levels. The peak in emissions was largely driven by strong industry returns that increased beef cattle population, before prolonged years of drought led to a significant reduction in livestock. The breaking of the drought in 2010 has seen farmers rebuild livestock population (DIICCSRTE 2013, p. 213).

Compared with 2012 emissions levels, agriculture sector emissions are projected to be relatively stable from 2012 to 2020, and then increase substantially to 2030 under all scenarios. The Treasury and DIICCSRTE modelling projects that agriculture emissions will be 18 Mt $CO_2$-e higher in 2030 under the medium scenario, and 23 Mt $CO_2$-e higher under the no price scenario.

## D8.2 AGRICULTURE EMISSIONS OUTCOMES, CONTRIBUTORS AND DRIVERS

Figure D.35 sets out actual agriculture emissions by subsector from 1990 and projections to 2050 for each scenario modelled by the Treasury and DIICCSRTE. It also sets out the contribution of different subsectors to changes in agriculture sector emissions from 2000 levels.

**FIGURE D.35:** CONTRIBUTORS TO AGRICULTURE EMISSIONS, SELECTED YEARS, 1990–2050, AND TO CHANGE IN EMISSIONS RELATIVE TO 2000 LEVELS




**Note:** 'Other factors' includes adjustments due to the broader economic effects of the carbon price. The effect is less than 1 per cent of emissions.
**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## D8.2.1 CONTRIBUTORS

The major contributor to emissions in the agriculture sector is livestock numbers. ABARES (2011, p. 6) projects that total livestock population will grow substantially from 2008 to 2030—beef cattle numbers by 7 million (28 per cent), sheep numbers by 10 million (14 per cent) and poultry numbers by 15 million (16 per cent).

Dairy cattle emissions accounted for about 8 Mt $CO_2$-e, or 8 per cent, of total agriculture emissions in 2012. The Treasury and DIICCSRTE modelling projects that these emissions will remain relatively stable to 2020. Similarly, ABARES (2011, p. 6) projects stable dairy cattle numbers of about 2.6 million.

Australia has made steady progress in reducing livestock emissions intensity (that is, emissions per tonne of livestock produce, such as meat, wool and milk). Henry and Eckard (2008, p. 30) reported that between 1990 and 2005, beef emissions intensity reduced by about 10 per cent. The dairy industry has also reduced its emissions intensity. Dairy Australia (2013, p. 9) reported that in 2011 the carbon footprint for Australian farm gate milk was one of the lowest in the world at 1.11 kg $CO_2$-e per kilogram.

While there are technologies and changed farming practices that can reduce emissions intensity in the sector, total emissions are projected to grow. ABARES (2011, p. 6) projects that livestock emissions intensity will continue to decrease to 2030 but not enough to offset the substantial increase in livestock population. Where opportunities to reduce agriculture emissions exist, their uptake can be challenged by limited access to capital and information.

Agriculture emissions are also affected by the amount of crop production, as reflected in the rate of fertiliser application. By 2015, cropping activities are projected to overtake prescribed burning of savanna as the second-largest subsector in agriculture emissions (Figure D.35).

Savanna burning is projected to contribute a small reduction in emissions from 2020 to 2030, encouraged partly by the CFI.

## D8.2.2 DRIVERS

The primary drivers of emissions from the agriculture sector are commodity prices and weather conditions. Drought was a major factor in the fall in agriculture emissions between 2000 and 2012 (see Figure D.35).

Improved weather conditions and export demand are expected to drive emissions growth in the short to medium term. Prices for agricultural commodities have stabilised at historically high levels in recent years following a peak in 2010 (derived from Reserve Bank of Australia 2013). Australian beef and veal exports are expected to increase in the period from 2012 to 2018, reflecting increased demand from the US and some smaller emerging markets (ABARES 2013c, p. 89). Prices for major cropping outputs (grains and oilseeds) are projected to remain above their historical average to 2018, while demand for dairy commodities is also expected to grow over this period (ABARES 2013c, p. 42). Over the longer term, sustained growth in export demand from emerging economies is projected to drive growth in livestock and cropping production and the associated emissions (DAFF 2013, p. 33).

The CFI is the main driver of projected emissions reductions. The effects of the CFI on absolute emissions levels are projected to be relatively small compared to the macroeconomic drivers for farm production discussed above. The Treasury and DIICCSRTE modelling suggests that total agriculture emissions are relatively unresponsive to price incentives under the CFI. The National Farmers' Federation (2013, *Draft Report submission,* p. 5) noted that productivity and profitability is the main driver for farmers to invest in lower emissions activities, as the financial returns from increased production are greater than those from the CFI.

## D8.2.3 AGRICULTURE EMISSIONS REDUCTION POTENTIAL

The Treasury and DIICCSRTE modelling projects that under the medium scenario, agriculture emissions would be approximately 3 Mt $CO_2$-e (2 per cent) lower than in the no price scenario in 2020 and 5 Mt $CO_2$-e (4 per cent) lower in 2030, and slightly lower in 2030 under the high scenario. This constitutes a relatively small reduction in the trend of growing agriculture emissions in the projections.

The Treasury and DIICCSRTE modelling assumes that additional livestock emissions reduction opportunities would be taken up by 2020, including herd management, animal feed supplementation, feedlot finishing and pasture improvements. In contrast, separate analysis by ClimateWorks (2013a, p. 36) finds less potential reductions from livestock in 2020; it estimates 0.3 Mt $CO_2$-e of emissions reduction, attributable to methane capture and destruction from manure at piggeries.

Analysis from ABARES (2013a, p. 23) suggests about 7 Mt $CO_2$-e emissions reductions are available from livestock in 2020 at the carbon prices in excess of $70 per t $CO_2$-e. Its study suggests further emissions reductions at this marginal cost would be modest in 2030, and that even with high price incentives, only limited additional emissions reductions would be available for livestock by 2030 (Box D.6).

**BOX D.6:** CFI DRIVERS AND BARRIERS

The primary driver of emissions reduction from the CFI is the revenue project providers receive. The ABARES cost curves for livestock methane emissions reduction show that the cost of technologies to reduce livestock emissions rises steeply. For example, large dairy farms may start to adopt anti-methanogenic vaccines at a price as low as $35 per tonne, while sheep farms may not find this practice economical until a price of $175 per tonne (ABARES 2013a, p. 26). This technology is still in the early stage of development.

Potential project providers will estimate the future value of emissions units when assessing the financial viability of projects. Uncertainties in economic forecasts and in the future policy environment could have substantial effects on the assessed viability of emissions reduction projects, particularly for those that have a long payback period.

The availability of methodologies for CFI projects, and the ease of compliance with those methodologies, will be another important driver of emissions reductions uptake. There are currently seven approved methodologies for agriculture emissions (four for destroying methane from dairy and piggery manure, two for savanna burning and one for dietary additives to reduce emissions from dairy cows).

There is a range of other barriers to uptake of emissions reduction opportunities under the CFI, including limited access to capital, lack of scale economies on many farms and difficulty accessing information about emissions reduction projects. These challenges may be exacerbated by the presence of many small and dispersed participants in the sector. There were about 135,000 farm businesses in Australia in 2010–11, with 55 per cent reporting agricultural operations value of under $100,000 (ABS 2012).

Ways to reduce these barriers include ensuring ready access to information using existing rural information networks, simplifying methodologies for projects, and facilitating access to capital and project providers to consolidate projects across multiple small farms.

## D8.3 PROGRESS IN AGRICULTURE EMISSIONS REDUCTION

### D8.3.1 EXPORT DEMAND

In the longer term, demand for agricultural commodities in emerging Asian economies is projected to be a strong driver of agricultural production and emissions. ABARES (2013d, p. 16) projects that demand for agrifood commodities will double between 2007 and 2050 in Asia, and increase by 48 per cent in the rest of the world. Increased wealth and changes in diets in emerging economies are expected to drive the greatest increases in demand for high-value agriculture products such as vegetables and fruit, meat, dairy products, cereals and fish. Australia is likely to be in a good position to meet increased demand from Asian economies due to its geographic proximity and comparative advantages in producing several high-value agricultural products. ABARES projects that Australia's production of agrifood products will increase by 77 per cent from 2007 to 2050 (Linehan et al. 2013, p. 3).

### D8.3.2 PRODUCTION EFFICIENCY IMPROVEMENTS

International research suggests that improvements in agricultural productivity can reduce emissions per unit of production (Tubiello et al. 2013). This is supported by evidence in Australia where broadacre productivity grew by an average rate of 1.5 per cent a year between 1977 and 2011, while dairy productivity grew by 1.6 per cent over the same period (ABARES 2013b, p. 200). Further, between 2007 and 2010, there was a 10 per cent increase in the number of farmers using a one-pass sowing system to prepare cropland, which improved production yields by reducing soil and water erosion, water use and fertiliser application rates (Barson et al. 2012, p. 3).

The UNEP Emissions Gap Report (2013, p. 35) identified farming practices proven to reduce greenhouse gas emissions, including direct seeding under the mulch layer of the previous season's crop to reduce soil disturbance and fertiliser use. The National Farmers' Federation highlighted benefits of this practice, noting that retaining trash in sugar cane production has almost halved fertiliser use rates compared with 1990 (2013, *Draft Report submission,* p. 5).

There are further opportunities to reduce livestock emissions through increasing productivity and efficiency. These include improving the quality of pasture in grazing, introducing fertiliser inhibitors in feedlots to reduce livestock emissions, and investing in drainage and irrigation to improve soil cultivation (ABARES 2013a, p. 11).

Dairy Australia (2013, p. 9) plans to reduce industry emissions intensity by 30 per cent by 2020. With a growing population and increased consumption of dairy products, production growth is likely to offset intensity improvements, leading to rising net emissions.

Continued investment in research and development may assist to maintain productivity and emissions efficiency improvements to 2050 for Australian agriculture (Carberry et al. 2010, p. iv).

# APPENDIX D9
# LAND USE, LAND USE CHANGE AND FORESTRY

## D9.1 LULUCF EMISSIONS OVERVIEW

LULUCF-related emissions and sequestration are caused by human-induced changes in forest cover since January 1990. These include:

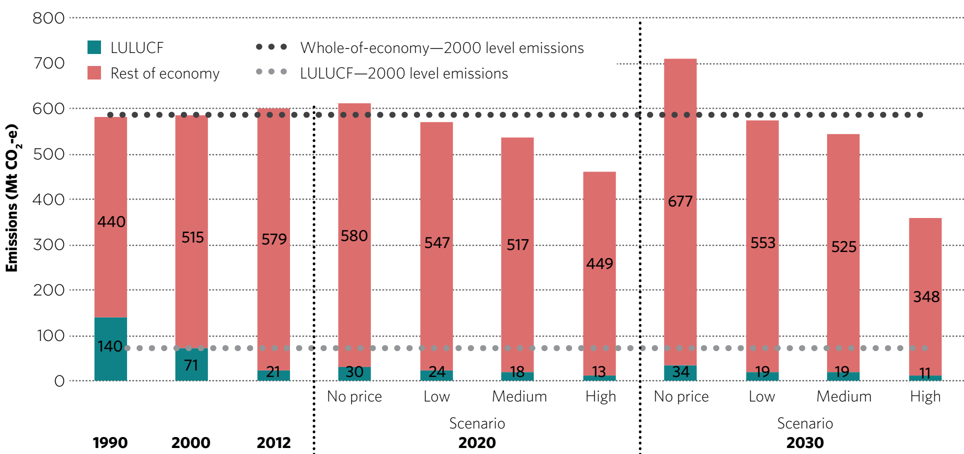
- deforestation—emissions from clearing forested land for new purposes
- afforestation and reforestation—sequestration of carbon dioxide from the atmosphere through new forestry plantings on land that was unforested on 1 January 1990
- forest management—practices that increase sequestration in forests.

Combustion of fossil fuels from forestry activities, such as in logging machinery, is covered in other sectors.

Since January 2013, Australia has counted net emissions associated with forest management, cropland management, grazing land management and revegetation towards its emissions commitments under the Kyoto Protocol. LULUCF emissions presented in this section have been revised to be consistent with these new accounting rules.

LULUCF has been the biggest sectoral contributor to emissions reduction in Australia since 1990. Net emissions declined by about 85 per cent from 140 to 21 Mt $CO_2$-e in 2012 (Figure D.36).

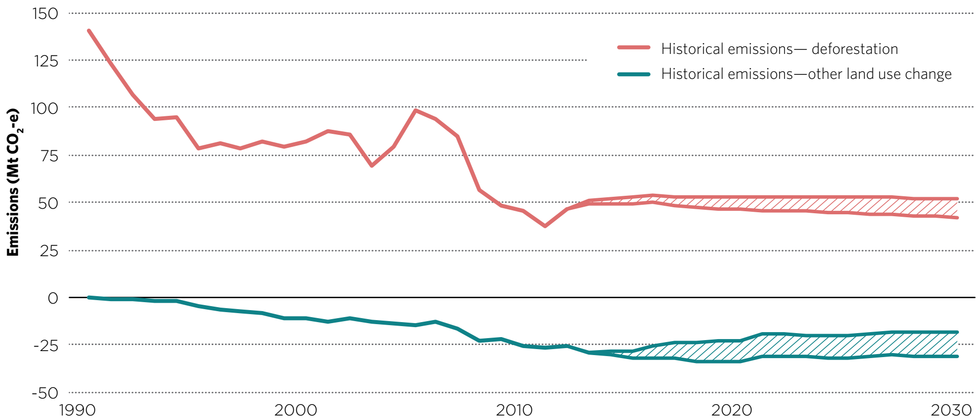
**FIGURE D.36:** LULUCF SHARE OF AUSTRALIA'S EMISSIONS, SELECTED YEARS, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

The Treasury and DIICCSRTE modelling projects that net LULUCF emissions could decrease to 13 Mt $CO_2$-e in 2020 and 11 Mt $CO_2$-e in 2030 in the high scenario, or otherwise increase to 30 Mt $CO_2$-e in 2020 and 34 Mt $CO_2$-e in 2030 in the no price scenario (Figure D.36).

**FIGURE D.37: DEFORESTATION AND OTHER LAND USE CHANGE EMISSIONS AND SEQUESTRATION, 1990–2030**

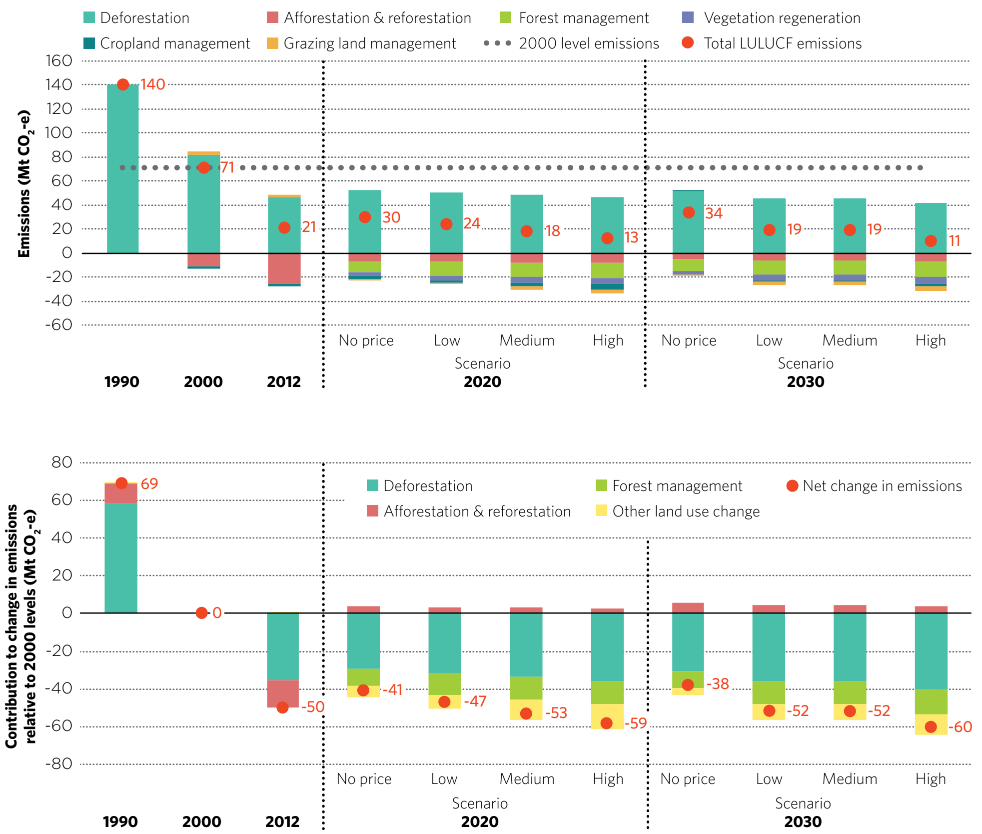



**Note:** Negative emissions reflect carbon sequestration. Upper and lower line bounds illustrate the range of modelled outcomes.
**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## D9.2 LULUCF EMISSIONS OUTCOMES, CONTRIBUTORS AND DRIVERS

Figure D.38 shows actual LULUCF emissions and removals by subsector from 1990 to 2030. The vast majority of LULUCF emissions and removals, both current and projected, are from forestry activities (deforestation, reforestation and afforestation, and forest management). Non-forestry activities (cropland and grazing land management and revegetation) are much smaller sources of emissions and removals.

**FIGURE D.38:** CONTRIBUTORS TO LULUCF EMISSIONS, SELECTED YEARS, 1990–2030, AND TO CHANGE IN EMISSIONS RELATIVE TO 2000 LEVELS




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

## D9.2.1 OUTCOMES

The Treasury and DIICCSRTE modelling projects net LULUCF emissions may decrease by 2 Mt $CO_2$-e to 19 Mt $CO_2$-e from 2012 to 2030 under both the low and medium scenario, and decrease to 11 Mt $CO_2$-e under the high scenario. Under the no price scenario, emissions are projected to increase to 34 Mt $CO_2$-e in 2030.

Over the period from 2013 to 2020, the Treasury and DIICCSRTE modelling projects cumulative LULUCF emissions reductions associated with the Kyoto Protocol accounting changes and additional land management acitivities of 90 Mt $CO_2$-e irrespective of price incentives. Cumulative emissions reductions are projected to rise to 126 Mt $CO_2$-e in the medium scenario. Similarly, the ANU Centre for Climate Law and Policy estimates potential LULUCF emissions reductions of 110–115 Mt $CO_2$-e from forest management, crop land management, grazing land management and revegetation activities from 2013 to 2020 (*Issues Paper submission*, pp. 12–14).

Since 1990, deforestation emissions have declined, reflecting economic factors and also the strengthening of state and territory restrictions on land clearing regulations over the period. Between 1990 and 2011, emissions fell by over 100 Mt $CO_2$-e to 38 Mt $CO_2$-e, before increasing to 47 Mt $CO_2$-e in 2012. The Treasury and DIICCSRTE modelling projects deforestation emissions will increase to 50 Mt $CO_2$-e in 2013, remain steady to 2020, and gradually decline to 46 Mt $CO_2$-e in 2030 under both the low and medium scenarios. Under the no price scenario, emissions are projected to increase to 52 Mt $CO_2$-e in 2030, peaking at 54 Mt $CO_2$-e in 2016. Recent relaxation of land clearing restrictions in New South Wales, Queensland and Western Australia may contribute to increasing emissions.

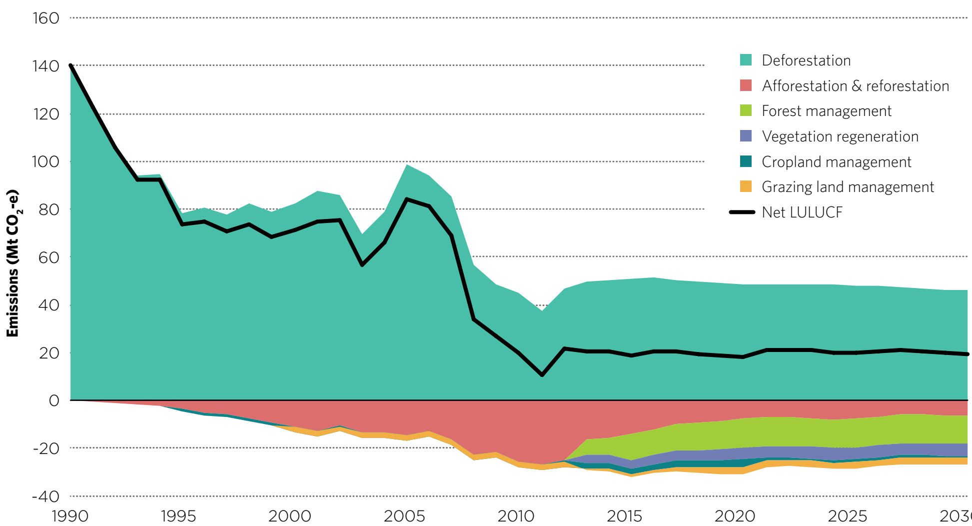
According to the Treasury and DIICCSRTE modelling, sequestration from reforestation and afforestation increased from 11 Mt $CO_2$-e in 2000 to 25 Mt $CO_2$-e in 2012. This was in part driven by economic conditions and forest Managed Investment Schemes, which allowed investors to deduct 100 per cent of their investment against taxable income earned elsewhere. Regulations governing these schemes were tightened in 2007 and have contributed to a reduction in tree plantation investments. ClimateWorks (2013, p. 21) reported the area of plantation forests cleared in 2012 exceeded new plantings, resulting in a reduction in the total plantation estate for the year.

The Treasury and DIICCSRTE modelling projects afforestation and reforestation sequestration will decrease to below 10 Mt $CO_2$-e in 2020 and 2030 under all scenarios. Many of the plantations established in the early 2000s were short-term pulpwood and are nearing readiness for harvest. Due to policy uncertainty and long investment returns from tree plantations, ClimateWorks (2013, p. 31) projects a significant proportion of harvested forest land will not be returned for reforestation over the next 5 to 10 years and will instead be converted to other land use.

## D9.2.2 CONTRIBUTORS AND DRIVERS

The main contributors to emissions and sequestration in the LULUCF sector are clearing land, planting land or forestry management (Figure D.39).

**FIGURE D.39: LULUCF EMISSIONS AND SEQUESTRATION (MEDIUM SCENARIO), 1990–2030**




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

Major drivers of these activities are agricultural and forestry commodity prices; input costs; and state, territory and Commonwealth land clearing regulations.

Land use decisions are influenced by relative prices of forestry and agricultural commodities. Policies, including the CFI, can affect the economic returns from these activities (see Box D.7). Historically, tax concessions for forestry have been effective in driving investment in sequestration through higher rates of afforestation and reforestation. This was witnessed in the early 2000s where Managed Investment Schemes significantly increased new tree plantations.

Commodity prices are affected by factors such as structural timber demand; demand for paper; production of paper, paperboard, plantation woodchips and pulp in developing countries; and paper recycling.

**BOX D.7: EMISSIONS REDUCTION OPPORTUNITIES UNDER THE CFI**

Current CFI methodologies for LULUCF projects cover different types of forestry and revegetation activities, including environmental plantings, human-induced regeneration of native forests, native forest protection and reforestation.

Over 260,000 ACCUs (including Kyoto- and non-Kyoto-approved)—each worth at least one tonne $CO_2$-e reduction—have been issued to LULUCF projects (as at January 2014). Projected emissions reductions from the CFI between 2012 and 2030 are detailed in Appendix C of the Treasury and DIICCSRTE report (2013).

ClimateWorks (2013, p. 40) identified a range of possible CFI projects that could potentially reduce emissions by over 10 Mt $CO_2$-e in 2020. Net Balance (2013, p. 8) suggested that including a co-benefit standard in the CFI could also broaden the market and increase the uptake of CFI projects.

## D9.3 PROGRESS IN LAND SECTOR EMISSIONS REDUCTION

Currently, most land cleared in Australia is used for cattle grazing, but in the past large areas of land have also been cleared for cropping (DIICCSRTE 2013a, p. 7). Previously, the value of agricultural products has strongly influenced decisions to clear additional forested areas, with a lag of about a year between moves in agricultural prices and land clearing activities. Both farmers' terms of trade and the amount of land clearing have decreased between the early 1970s and 2011 (DIICCSRTE 2013c, p. 8).

Land clearing, taxation and land use regulations in states and territories can influence expected returns or how easily land can be cleared or reforested. The introduction of stronger state and territory land clearing regulations in the mid 1990s reduced the rate of deforestation and emissions. This, along with economic conditions, contributed to the change in the rate of first-time clearing of undisturbed forest—which fell from 74 per cent of total land area cleared in 1990 to 35 per cent in 2011 (DIICCSRTE 2013a, p. 7).

Land clearing restrictions introduced in Queensland in 2004 and strengthened in 2009 have had the largest impact on deforestation emissions in Australia. While Queensland still has the largest deforestation emissions of any state or territory, these fell from 34 Mt $CO_2$-e in 2007 to 19 Mt $CO_2$-e in 2011 (DIICCSRTE 2013b, p. 29).

In 2013, both Queensland and New South Wales relaxed their land clearing restrictions, making it easier for farmers to clear trees and natural vegetation, and expand cropping operations. This is expected to put some upward pressure on emissions, although relatively stable projections for cattle numbers to 2020 suggest that this pressure will be limited in the short to medium term (Centre for International Economics 2013, pp. 21–22).

Western Australia also relaxed its land clearing restrictions during 2013. Farmers are now allowed to increase their annual land clearing rate for specified purposes from 1 to 5 hectares without a permit (Jacobs 2013).

In Tasmania, the Tasmanian Forest Agreement protects 500,000 hectares of World Heritage-listed forests from deforestation. In December 2013, the Commonwealth Government provided funding to the council overseeing this agreement for another six months. Potential changes to this agreement could increase deforestation emissions (Commonwealth 2013, p. 980).

A range of policies have been used to reduce LULUCF emissions in other countries (see Box D.8).

**BOX D.8: INTERNATIONAL APPROACHES TO LULUCF**

Other countries have adopted regulatory and pricing approaches to preserve forests. Measures are generally designed to meet a broad range of environmental and conservation objectives, rather than solely aiming to reduce emissions.

Brazil provides an example of a regulatory approach. In the early 2000s, deforestation accounted for about 75 per cent of Brazil's total emissions. Deforestation emissions have decreased by 82 per cent to 2011, due to stronger law enforcement, technology systems and prevailing lower agricultural prices (Climate Policy Initiative 2013, p. 7).

New Zealand provides an example of a price-based approach to LULUCF. Its Emissions Trading Scheme (ETS) was introduced in 2008 and is estimated to have reduced emissions by 77 Mt $CO_2$-e between 2008 and 2012. This is in addition to existing forestry rules that limit the ability to harvest New Zealand native forests (New Zealand Ministry for the Environment 2013).

The Canadian province of Alberta has also adopted a price-based approach. The Alberta Offsets System, which has some similarities to the Australian CFI, provides offset credits for projects in several sectors, including LULUCF, and is used by large-emitting facilities to meet their emissions intensity reduction obligations. LULUCF activities that have approved protocols include afforestation and conservation cropping. California also includes forestry projects in its compliance offsets program under the California Cap and Trade Program, which commenced in January 2013.

## D9.3.1 OTHER ESTIMATES OF LAND SECTOR EMISSIONS REDUCTIONS

Grundy et al. (forthcoming 2014) reports that with strong price incentives non-harvest carbon plantations and native vegetation could greatly increase sequestration to 2050. It also reports low volumes of sequestration before 2030, even with strong price incentives, due in part to probable slow uptake of new land uses and the physical characteristics of carbon sequestration.

From 2031 to 2050, Grundy et al. (forthcoming 2014) finds average annual emission reductions of between 100 and 500 Mt $CO_2$-e would be economically and technically feasible if payments to landholders are broadly consistent with the CFI and the carbon price trajectories in the medium and high scenarios modelled by the Treasury and DIICCSRTE (2013). The upper end of this range suggests there is potential to achieve 80–100 per cent reduction in Australia's emissions in 2050 (compared to 2000 levels) with little or no use of international units, through a combination of land sector credits and emissions reductions in energy and other sectors.

Emission reductions from reforestation and afforestation is projected to decline in the decades after 2050 as plantings mature. Many of the LULUCF emissions reduction opportunities could create substantial co-benefits such as reduced erosion, protection of biodiversity and improved water quality.

## D9.3.2 BARRIERS TO EMISSIONS REDUCTION

The uptake of CFI emissions reduction projects by landowners or investors depends on the amount of revenue generated and the level of risk they are willing to accept. In the case of forestry, the revenues generated will need to be sufficient to offset the opportunity cost of alternative land uses.

Specific risks and uncertainties for the CFI include:

- Relative agricultural commodity prices—high terms of trade for agricultural output may work against investing in CFI projects that involve forestry on potential agricultural land. Previous estimates of reforestation potential have indicated that landowners would typically only consider reforesting non-irrigated dryland, which has relatively low agricultural returns (Burns et al. 2011, p. 24).
- Price of emissions units—a volatile or uncertain market for emissions units can be a disincentive for landowners considering participating in CFI projects. Under the CFI, landowners and investors receive ACCUs for carbon sequestration projects as trees or soils sequester carbon from the atmosphere. Once the trees or soils have stored as much carbon as they can, the project ceases to receive returns, but landowners may continue to incur management costs (Burns et al. 2011, p. 13).
- Permanency—CFI projects that sequester carbon are required to maintain that sequestration 'permanently' (for 100 years in the case of forestry projects), which may dampen the uptake of projects. Land value can be adversely affected due to limitations on its future use (ClimateWorks 2013, p. 44).
- Capital constraints—some projects will require significant upfront investment. For instance, reforestation projects generally require significant capital upfront for land preparation and planting, but will make returns over an extended time period as the forest grows.

New tree plantations have high upfront investment costs, a long project life and long payoff periods given the time taken for trees reach their peak sequestration rate. To offset some of this risk, strong financial incentives may be needed to drive investment. This is supported by Grundy et al. (2014 forthcoming), which finds that very little carbon sequestration would be supplied to 2050 at gross payments, equivalent to a carbon price, below \$40/t $CO_2$-e, with potential supply expanding with payments in the range from \$40–\$80/t $CO_2$-e. Further, Polglase et al. (2011, pp. 2, 20) found that gap payments may be necessary to encourage tree plantings on marginal land where biodiversity co-benefits may be greatest.

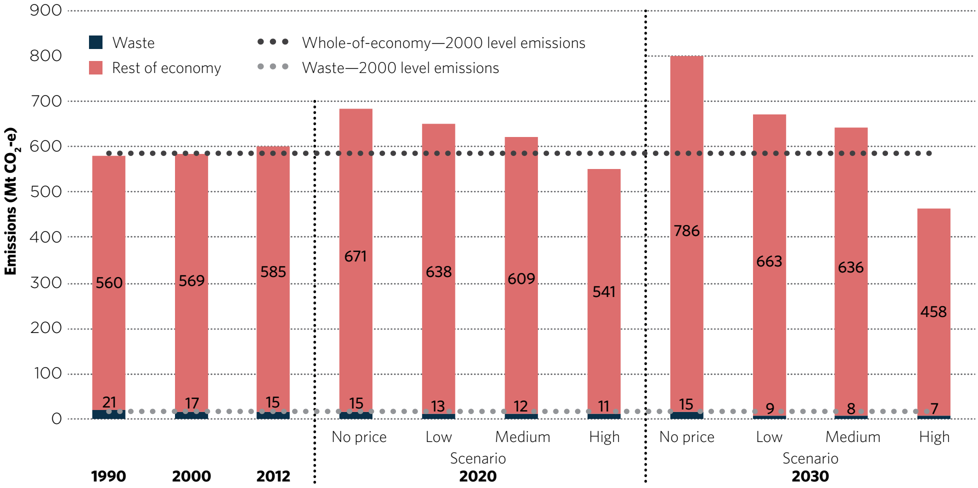
# APPENDIX D10 WASTE

## D10.1 WASTE EMISSIONS OVERVIEW

Waste includes solid waste and wastewater from residential, commercial and industrial activity. Waste emissions are primarily methane and nitrous oxide, which arise as organic waste decomposes in the absence of oxygen. Emissions from solid waste in landfill comprise about 80 per cent of the sector's emissions, with wastewater accounting for about 20 per cent, and incineration and other sources for the remainder.

The waste sector is a relatively small contributor to Australia's emissions, accounting for about 15 Mt $CO_2$-e (3 per cent) of the national emissions total in 2012 (Figure D.40). The Treasury and DIICCSRTE modelling projects waste emissions could be about 1 per cent of total national emissions to 2030 under the medium scenario.

**FIGURE D.40:** WASTE SHARE OF AUSTRALIA'S EMISSIONS, SELECTED YEARS, 1990–2030

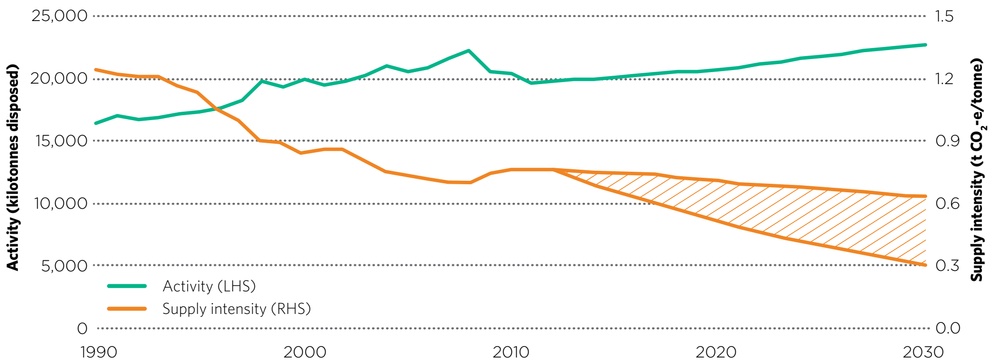



**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

Waste sector emissions have decreased by about 8 per cent (just over 1 Mt $CO_2$-e) since 2000, continuing the trend seen in sectoral emissions since 1990 (26 per cent decrease). This has been due to a range of policies and regulations that have diverted waste from landfill and the uptake of emissions reduction technologies, including capturing emissions for electricity generation.

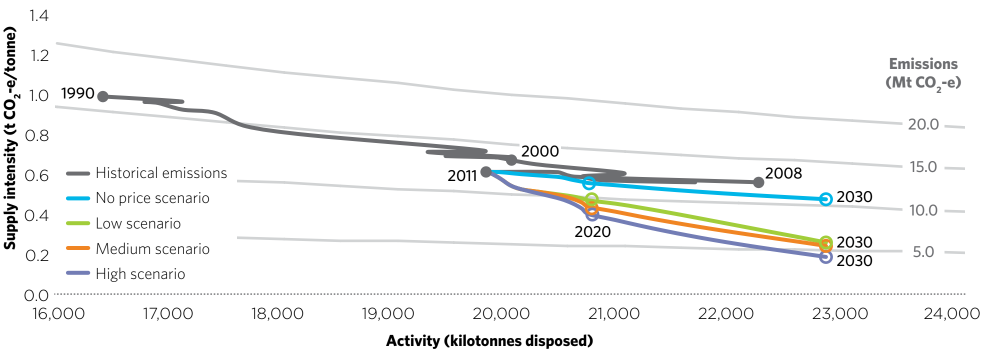
Since 2000, emissions intensity of wastewater has declined by about 14 per cent and the emissions intensity of landfill by about 8 per cent (Figure D.41). In 2008, there was a large increase in the diversion of waste, resulting in a large reduction in solid waste volumes sent to landfill.

**FIGURE D.41:** SOLID WASTE EMISSIONS INTENSITY, 1990–2030




**Note:** Upper and lower line bounds illustrate the range of modelled outcomes.
**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

**FIGURE D.42:** EMISSIONS INTENSITY OF LANDFILL, 1990–2030




**Source:** Climate Change Authority calculations using results from Treasury and DIICCSRTE 2013

The Treasury and DIICCSRTE modelling projects total waste emissions will stabilise at about 15 Mt $CO_2$-e by 2030 under a no price scenario, despite increases in total waste generated. Under the other modelled scenarios, emissions are projected to fall even further to between 7 and 9 Mt $CO_2$-e (Figure D.43).

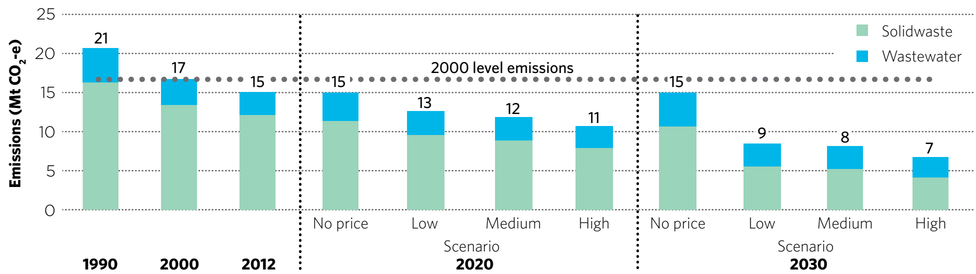
Solid waste emissions intensity is projected to fall about 30 per cent from 2000 levels to 0.47 t $CO_2$-e per tonne of waste under the no price scenario by 2030, and to 0.18 t $CO_2$-e per tonne under the high scenario (Figure D.41).

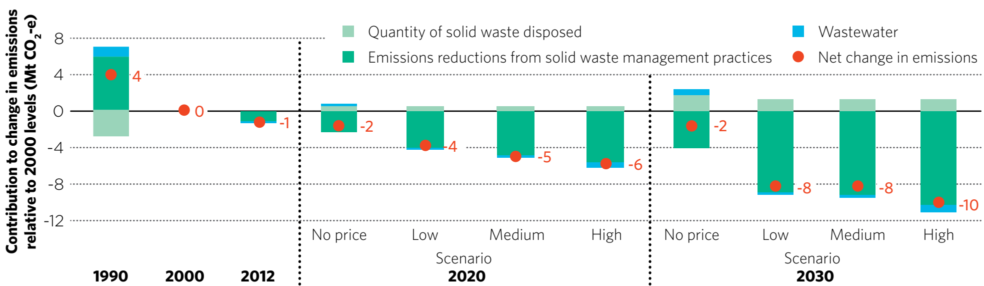
## D10.2 WASTE EMISSIONS OUTCOMES, CONTRIBUTORS AND DRIVERS

Since 1990, waste emissions have steadily fallen due to a range of local, state and national policies and schemes targeting the waste sector. These varied interventions have ranged from direct regulations, such as local planning laws, to market-based incentives, including the CFI, the NSW Greenhouse Gas Reduction Scheme (GGAS), the RET and the carbon pricing mechanism. These interventions have driven the diffusion of emissions-reducing technologies to landfill waste and wastewater facilities, as well as greater recycling, composting and other alternative waste treatments.

The main contributor to emissions from the waste sector is the volume of waste, which is driven by growth in population and economic activity. The main contributors to emissions reductions in the sector are the level of waste diverted for recycling or alternative waste treatments, and the extent to which the methane generated by decomposing waste is captured and destroyed. Figure D.43 shows the contribution of the two major waste streams to total waste emissions under the different modelled scenarios. Solid waste emissions comprise landfill emissions, incineration emissions and composting emissions; wastewater emissions comprise industrial, domestic and commercial wastewater.

**FIGURE D.43:** CONTRIBUTORS TO WASTE EMISSIONS, SELECTED YEARS, 1990–2030, AND TO CHANGE IN EMISSIONS RELATIVE TO 2000 LEVELS




**Source:** Climate Change Authority calculations using data from Treasury and DIICCSRTE 2013

Despite continued increases in recycling and other alternative waste treatments, the Treasury and DIICCSRTE's modelling projects the volume of waste deposited at landfills could grow by 14 per cent (3 Mt $CO_2$-e) from 2000 levels by 2030, due to continued population and economic growth. Over the same period, in the low and high scenarios emissions can be reduced by between 58 and 70 per cent on 2000 levels. This includes a projected decline in solid waste emissions intensity of between 63 and 73 per cent on 2000 levels by 2030. Under these scenarios, emissions will fall by 4–5 Mt $CO_2$-e from 2000 levels by 2020, and 8–9 Mt $CO_2$-e by 2030 (Figure D.43).

Wastewater volumes are projected to grow by nearly 50 per cent on 2000 levels by 2030. Over the same period, the Treasury and DIICCSRTE modelling shows that under the same low and high scenarios, emissions can be reduced by between 10 and 20 per cent on 2000 levels. This equates to a projected decline in wastewater emissions intensity of between 40 and 46 per cent on 2000 levels by 2030. Under these scenarios, emissions will fall by 0.1–0.6 Mt $CO_2$-e from 2000 levels by 2020, and 0.3–0.7 Mt $CO_2$-e by 2030 (Figure D.43).

**BOX D.9: WASTE TO ENERGY**

Methane from decomposing waste can be captured from landfills or waste collection ponds and combusted to generate electricity. The electricity can be used on site or supplied to the electricity grid. Captured methane from waste is classed as biogas, a renewable source, and the emissions reductions derived from the displacement of fossil fuels are reflected in the stationary energy sector.

## D10.3 PROGRESS IN WASTE EMISSIONS REDUCTION

### D10.3.1 WASTE EMISSIONS REDUCTION OPPORTUNITIES

The largest contributors to further emissions reduction in the waste sector are expected to be continued diversion of waste from landfill, methane capture and waste-to-energy. These activities are driven by a range of regulatory drivers, policy drivers and market-based incentives.

Alternative waste treatments have grown significantly since 1990, resulting in a significant amount of waste being diverted away from landfill (see Table D.7). Since this time, a major driver for the growth of alternative waste treatments has been the impact of regulatory frameworks. These have operated at all levels of government and span local planning controls, environmental safeguards and community standards, and have served to direct waste streams away from landfill where feasible.

Australian states and territories have adopted a broadly similar hierarchy of waste resource management options, in the following order:

- avoiding unnecessary resource consumption as the first preference
- adopting alternative waste treatments, including reuse
- reprocessing, recycling and energy recovery
- disposing via landfill or effluent streams.

Some states have embodied this hierarchy into legislation such as the *Waste Avoidance and Resource Recovery Act 2001* (NSW).

Strategic policy frameworks have also been developed at all levels of government. The National Waste Policy, for instance, is a major national policy that was endorsed by COAG in 2009, and sets Australia's waste management and resource recovery direction to 2020. In partnership with the states and territories, the policy establishes strategic direction and best practice in the areas of waste avoidance and waste diversion.

The management of waste continues to be a strong policy focus for state governments. For example, New South Wales recently released its Draft Waste Avoidance and Resource Recovery Strategy to 2021, for public consultation. The draft strategy includes targets for reducing waste generation, litter and landfill, and increasing recycling rates. Victoria recently released two draft waste strategies detailing how the state will invest in waste infrastructure and maximise resource recovery.

Recycling and other waste diversion activities are projected to increase under a no price scenario, contributing to the emissions reductions outlined earlier. In the future, waste avoidance and alternative waste treatments are expected to be crucial in offsetting the growing quantity of waste generated that would otherwise be sent to landfill. With appropriate policies, incentives and funding in place, Blue Environment (2011, p. 8) estimates that by 2030 as much as 70 per cent of all solid waste could be slated for resource recovery, reducing as much of 80 per cent of emissions.

Since the late 1990s, there has been a growing number of market-based schemes established in many jurisdictions across Australia to encourage the reduction of waste and emissions. The diffusion of emissions capture and waste-to-energy technologies is influenced by demand, technology costs and regulations, and also by other market-based schemes that provide price incentives, such as the RET. Since 2001 under the RET, waste facility operators have been able to earn certificates for capturing waste methane for electricity generation.

### TABLE D.7: TOTAL NATIONAL GENERATION OF WASTE AND DISPOSAL TO LANDFILL, 1940–2007

| YEAR | 1940 | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2007 |
|---|---|---|---|---|---|---|---|---|
| **Waste generated (kt)** | 9,600 | 10,100 | 15,200 | 17,700 | 17,100 | 16,400 | 25,600 | 42,700 |
| **Disposed to landfill (kt)** | 9,600 | 10,100 | 15,200 | 17,700 | 17,100 | 16,400 | 19,600 | 21,300 |
| **Landfilled portion** | 100% | 100% | 100% | 100% | 100% | 100% | 77% | 50% |

**Source:** Modified from Department of the Environment, Water, Heritage and the Arts 2010

ClimateWorks (2013, p. 23) noted that between 2001 and 2011 waste operators were credited with over 6 GWh of electricity generation under the RET, representing more than 7 per cent of large-scale renewable energy generation. Waste-to-energy technologies have grown sufficiently in scale and may soon contribute about 800 GWh of electricity into the NEM annually (SKM-MMA 2012, p. 77). There is enough generation capacity from captured methane to power more than 200,000 homes, with an additional 45 MW of new landfill electricity generation projects currently in development, and a further 18 MW under assessment.

The modelling undertaken by the Treasury and DIICCSRTE includes the impact of the RET in all scenarios. Under the no price scenario, the small emissions reduction projected to 2030 can be attributed to a combination of factors, including the continuing impact of the RET.

In addition to the national RET, state-based schemes promoting effective treatment or diversion of waste have also contributed to the diffusion of emissions reduction technologies. The GGAS operated in New South Wales from 2003 to 2012 and gave operators credits to capture emissions and certificates for electricity generation from landfill gas, similar in function to the RET. This scheme helped to incentivise the uptake of landfill gas capture technologies by giving landfill operators additional revenue streams via the market for offset credits. This scheme was closed in 2012. The CFI now offers incentives for eligible landfill gas capture projects.

The CFI provides price incentives for the reduction of emissions associated with legacy waste (waste deposited prior to 1 July 2012). Since its introduction, the CFI has registered more projects related to waste than from any other sector. According to the Clean Energy Regulator (2013), the CFI has 69 registered waste projects involving gas capture, combustion and diversion in January 2014. These projects have resulted in about 3.9 million Australian carbon credit units being issued, representing a reduction in emissions of almost 4 Mt $CO_2$-e. Given that only legacy waste is eligible for CFI credits, the CFI is projected to be most pronounced in the first few years of operation, and will decline into the future as the emissions from legacy waste decline.

The price difference between landfilling and alternative waste treatments is expected to shrink under the low, medium and high scenarios, which would make alternative waste treatment a more attractive option. There is some evidence that reducing the price difference of landfill relative to alternative waste treatments drives waste streams away from landfill (PC 2006, pp. 153–7). This has previously been addressed via increased landfill levies in some Australian states and in the UK (UK Committee on Climate Change 2013, p. 218).

## D10.3.2 BARRIERS TO WASTE EMISSIONS REDUCTION

Due to a range of pricing, demand and regulatory differences across states and municipalities, the level of landfill diversionary activity differs, indicating that additional emissions reduction opportunities may exist.

The installation of new technologies involves large capital costs that may take an extended period of operation to recover. This suggests that a strong and stable price incentive or a clear and enforceable regulatory requirement would be needed to further incentivise investment in these technologies.

New waste treatment technologies and processes, such as food and electronic waste treatment and thermal treatment plants, may also face hurdles from community acceptance, land availability, local planning requirements and funding.

The level of demand can also be a barrier to effective waste diversion or emissions reduction, as towns in rural and regional areas often do not generate enough waste for operators to justify investing in costly alternative waste treatment facilities or technologies.

E

# CALCULATING CAPS— ASSUMPTIONS, METHODS AND TESTS

## APPENDIX E1 INTRODUCTION

Under current legislation, the Authority is required to recommend annual caps under the carbon pricing mechanism to 2020. Chapter 13 sets out the relevant considerations and associated analysis.

This appendix presents the assumptions and methods used to estimate emissions, calculate caps and test the robustness of recommended caps against a range of possible futures. It draws extensively on the results of the economic modelling discussed in Chapter 10 and Appendix F.

All emissions are presented using Fourth Assessment Report (AR4) global warming potentials unless otherwise stated.

All references to covered emissions refer to emissions covered by the carbon pricing mechanism.

## APPENDIX E2 DEFAULT CAPS

As outlined in Chapter 13, the Authority calculated default caps using the Liable Entities Public Information Database (CER 2014a) figure for 2012–13 covered emissions (Table E.1).

**TABLE E.1:** CALCULATION OF DEFAULT CAPS

| | 2012–13 | 2013–14 | 2014–15 | 2015–16 | 2016–17 | 2017–18 | 2018–19 | 2019–20 |
|---|---|---|---|---|---|---|---|---|
| **Covered emissions** | **285** | | | | | | | |
| Default caps | | n/a | n/a | 247 | 235 | 223 | 211 | 199 |

**Note:** All figures in Mt $CO_2$-e.
**Source:** Covered emissions 2012–13 from Liable Entities Public Information Database (CER 2014a)

To estimate the 2020 target implied by the default caps, the Authority calculated the total 2013–2020 emissions budget corresponding to these default caps (Table E.2). The national emissions budget is almost equal to the budget for a 2020 target of 15 per cent below 2000 levels (excluding carryover), or 19 per cent (including carryover).

**TABLE E.2:** 2013–2020 NATIONAL EMISSIONS BUDGET IMPLIED BY DEFAULT CAPS

| | |
|---|---|
| Caps (2015-2020) | 1,108 |
| Fixed-price-period emissions (2013-2015) | +1,784 |
| Uncovered emissions (2016–2020) | +1,385 |
| Global Warming Potentials adjustment | +16 |
| Voluntary action (GreenPower and voluntary cancellation of renewable energy certificates) | +16 |
| Government purchase of international units | 0 |
| Carryover (from first Kyoto Protocol commitment period) | –116 |
| **National carbon budget (2013-2020)** | **4,194** |

**Note:** All figures in Mt $CO_2$-e. Totals do not sum due to rounding. Uncovered emissions include CFI estimates.
**Source:** Climate Change Authority based on Treasury and DIICCSRTE 2013 and GreenPower 2013

# APPENDIX E3 ASSUMPTIONS AND METHODS FOR ESTIMATING EMISSIONS OUTSIDE THE CAPS

This appendix sets out the emissions estimates used to calculate caps and, where relevant, explains the method used to derive those estimates.

## E3.1 WHOLE-OF-ECONOMY EMISSIONS DURING THE FIXED-PRICE PERIOD

The Authority has estimated Australia's domestic emissions for the fixed-price period (Table E.3). The estimate is based on the medium scenario from the modelling. Two additional adjustments were made to ensure the estimates are consistent with current legislative settings:

- the estimate of 2014–15 fixed-price emissions is based on the three-year fixed-price sensitivity test, which assumes the legislated fixed price applies in 2014–15. In contrast, the medium scenario assumes a floating price in 2014–15
- the estimate of 2013–14 and 2014–15 emissions is adjusted based on the heavy on-road vehicle sensitivity test, which assumes the equivalent carbon price does not apply to heavy on-road vehicles. In contrast, the medium scenario assumes the equivalent carbon price applies to heavy on-road vehicles from 2014.

**TABLE E.3:** EMISSIONS DURING THE FIXED-PRICE PERIOD (2012–13 TO 2014–15)

| | 2012–13 | 2013–14 | 2014–15 |
|---|---|---|---|
| National emissions | 593.07 | 593.04 | 597.57 |
| Adjustment for heavy on-road vehicles (add) | n/a | 0.06 | 0.20 |
| **Total fixed-price emissions** | **1,783.93** | | |

**Note:** All figures in Mt $CO_2$-e. Adjustment for heavy on-road vehicles in 2013-14 reflects forward-looking behaviour by some entities. Numbers may not sum due to rounding.
**Source:** Treasury and DIICCSRTE 2013

## E3.2 CREDITS FROM THE CARBON FARMING INITIATIVE

CFI credits for the flexible-price period are based on the medium price scenario (Table E.4), adjusted (increased) to include projects that have transitioned to the CFI from existing national and state-based schemes. This has been subtracted from the national emissions budget when calculating caps. The estimate takes into account:

- emerging information on the cost of eligible emissions reduction activities
- CFI project uptake rates
- the development of new CFI methodologies.

Credits are assumed to be generated in the year the emissions reductions occur. Further information on the CFI is provided in Appendix C of the Treasury and DIICCSRTE modelling report.

**TABLE E.4:** ASSUMED CREDITS FROM THE CFI (2015–16 TO 2019–20)

| 2015–16 | 2016–17 | 2017–18 | 2018–19 | 2019–20 | TOTAL |
|---|---|---|---|---|---|
| 11.35 | 12.54 | 14.46 | 15.73 | 16.99 | **71.07** |

**Note:** All figures in Mt $CO_2$-e. Numbers may not sum due to rounding.
**Source:** Climate Change Authority analysis based on data from Treasury and DIICCSRTE 2013 and the Clean Energy Regulator

## E3.3 OPT-IN EMISSIONS

The Authority has estimated opt-in emissions and added these to the budget available for caps (Table E.5). The estimate has been developed based on data on applications for opt-in from the Clean Energy Regulator, and estimates from the modelling exercise on how these emissions might change over time. It is also informed by discussions with liable entities that have not yet applied to opt in, but may do so in the future.

Opt-in emissions reduce uncovered sector emissions and from this point forward are excluded from the estimate of uncovered sector emissions.

**TABLE E.5:** OPT-IN EMISSIONS (2015–16 TO 2019–20)

| 2015–16 | 2016–17 | 2017–18 | 2018–19 | 2019–20 | TOTAL |
|---|---|---|---|---|---|
| 15.41 | 13.63 | 13.95 | 14.23 | 14.50 | **71.72** |

**Note:** All figures in Mt $CO_2$-e.
**Source:** Climate Change Authority analysis based on data from Treasury and DIICCSRTE 2013

## E3.4 BELOW-THRESHOLD EMISSIONS

The Authority has estimated below-threshold emissions for sectors other than waste, and deducted this from the budget available for caps (Table E.6). The estimate has been developed by comparing historical emissions from covered activities with liable emissions under the carbon pricing mechanism using data from the Clean Energy Regulator. The estimate is also informed by the modelling exercise, including the growth rate of covered emissions from the medium price scenario. Below-threshold emissions for the waste sector are included in the total estimate of uncovered emissions (Table E.6).

Below-threshold emissions increase uncovered sector emissions and from this point forward are included in the estimate of uncovered sector emissions.

**TABLE E.6:** BELOW-THRESHOLD EMISSIONS (2015–16 TO 2019–20)

| 2015–16 | 2016–17 | 2017–18 | 2018–19 | 2019–20 | TOTAL |
|---|---|---|---|---|---|
| 2.37 | 2.40 | 2.42 | 2.45 | 2.47 | **12.12** |

**Note:** All figures in Mt $CO_2$-e. Numbers may not sum due to rounding.
**Source:** Treasury and DIICCSRTE 2013

## E3.5 UNCOVERED EMISSIONS DURING THE FLEXIBLE-PRICE PERIOD

The Authority has estimated emissions from sources not covered by the carbon pricing mechanism, based on the medium price scenario. This estimate includes below-threshold emissions and excludes opt-in emissions. The Authority adjusted these estimates to remove the impact of the equivalent carbon price on heavy on-road vehicles (so the final estimate reflects emissions levels with no equivalent carbon price on heavy on-road vehicles) (Table E.7).

**TABLE E.7:** UNCOVERED EMISSIONS DURING THE FLEXIBLE-PRICE PERIOD (2015–16 TO 2019–20)

| | 2015–16 | 2016–17 | 2017–18 | 2018–19 | 2019–20 |
|---|---|---|---|---|---|
| Uncovered emissions | 260.11 | 261.86 | 261.21 | 260.16 | 259.81 |
| Adjustment for heavy on-road vehicles (add) | 0.35 | 1.22 | 1.99 | 3.11 | 3.61 |
| **Total uncovered emissions** | **1,313.44** | | | | |
| **Total uncovered emissions including CFI** | **1,384.50** | | | | |

**Note:** All figures in Mt $CO_2$-e.
**Source:** Treasury and DIICCSRTE 2013

## E3.6 ADJUSTMENT FOR ACCOUNTING DISCREPANCIES—CHANGES IN GLOBAL WARMING POTENTIALS

Different global warming potential (GWP) values will be used to calculate emissions in the carbon pricing mechanism and in Australia's national emissions budget until 2017–18, when the rules are harmonised. The Authority estimated the discrepancy arising from this difference for 2015–16 and 2016–17 (Table E.8), and deducted it from the budget available for caps. A small residual discrepancy relating to waste sector emissions will continue after 2016–17. This discrepancy is not material, so no further adjustment has been made.

The estimate is based on the projected level of emissions covered by the carbon pricing mechanism in the medium price scenario. Emissions are estimated using both sets of GWPs (the IPCC AR2 values are used for the carbon pricing mechanism, and AR4 values for the national emissions budget), and the differences summed.

**TABLE E.8:** GLOBAL WARMING POTENTIALS ADJUSTMENT (2015–16 AND 2016–17)

| | 2015–16 | 2016–17 | TOTAL |
|---|---|---|---|
| Covered emissions (AR2) | 350.21 | 351.20 | |
| Covered emissions (AR4) | 358.06 | 359.35 | |
| **Difference** | **7.85** | **8.15** | **16.00** |

**Note:** All figures in Mt $CO_2$-e.
**Source:** Treasury and DIICCSRTE 2013

## E3.7 ADJUSTMENT FOR VOLUNTARY ACTION

The Authority estimated the emissions reductions associated with GreenPower purchases and the voluntary cancellation of Renewable Energy Certificates (RECs) for the period 2012–13 to 2019–20 (Table E.9), and deducted this from the national emissions budget when calculating caps. This helps ensure GreenPower and the voluntary cancellation of RECs deliver emissions reductions additional to Australia's national target.

The estimate of GreenPower purchases is based on 2011 purchases (the latest available audited data) from the GreenPower administrator. It is assumed that GreenPower remains a constant share of total electricity demand over the period to 2019–20. Emissions reductions associated with GreenPower are calculated based on the average emissions intensity of the electricity grid on a state-by-state basis. Electricity demand and emissions intensity are based on the medium scenario.

The estimate for the voluntary cancellation of RECs is based on the average cancellation for 2010, 2011 and 2012 from the Clean Energy Regulator. It is also assumed that the voluntary cancellation of RECs remains a constant share of total electricity demand over the period to 2019–20. Emissions reductions associated with the voluntary cancellation of RECs are calculated based on the national average emissions intensity of the electricity grid. Electricity demand and emissions intensity are also based on the medium scenario.

**TABLE E.9:** ADJUSTMENT FOR VOLUNTARY ACTION (2012–13 TO 2019–20)

| | 2012–13 | 2013–14 | 2014–15 | 2015–16 | 2016–17 | 2017–18 | 2018–19 | 2019–20 |
|---|---|---|---|---|---|---|---|---|
| GreenPower | 1.77 | 1.78 | 1.88 | 1.87 | 1.85 | 1.82 | 1.78 | 1.75 |
| Voluntary cancellation of RECs | 0.25 | 0.25 | 0.27 | 0.26 | 0.25 | 0.24 | 0.23 | 0.23 |
| **Total** | **16.47** | | | | | | | |

**Note:** All figures in Mt $CO_2$-e. Numbers may not sum due to rounding.
**Source:** Based on GreenPower 2013, Treasury and DIICCSRTE 2013 and the Clean Energy Regulator

## E3.8 CARRYOVER FROM THE FIRST COMMITMENT PERIOD OF THE KYOTO PROTOCOL

The carryover from Australia's first commitment under the Kyoto Protocol (for the period 2008–12) is estimated to be 121.5 Mt $CO_2$-e (DoE 2013). This is calculated by comparing Australia's assigned amount against domestic emissions for the 2008–12 period. This estimate is then reduced by 5.1 Mt $CO_2$-e to account for the estimated emissions reductions from relevant voluntary action (GreenPower purchases and the Greenhouse Friendly program) for the same period.
The Commonwealth Government has already cancelled 2.3 Mt $CO_2$-e of assigned amount units (CER 2014b). This means Australia has an estimated 116.4 Mt $CO_2$-e to carryover.

# APPENDIX E4
# ASSUMPTIONS AND METHODS FOR YEAR-BY-YEAR SHAPE OF CAPS

As outlined in Chapter 13, the Authority's general preference is to have caps that follow the shape of the national trajectory. To determine the annual caps, the total budget available for caps is distributed across the flexible-price period at the same declining percentage rate as the national trajectory.

The annual caps are then assessed to ensure they are sufficient to accommodate free allocation and early auction of carbon units, and to avoid impacts on the carbon price.

## E4.1 FREE ALLOCATION AND EARLY AUCTION

The Authority estimated the number of carbon units required for free allocation under the Jobs and Competitiveness Program by analysing production levels for eligible industries in the medium scenario. Free allocation under the Energy Security Fund, and early auction of carbon units, are scheduled according to regulations and previous government policy. Table E.10 summarises the annual requirements, which are well below the recommended caps in every year.

**TABLE E.10:** CARBON UNITS REQUIRED FOR FREE ALLOCATION AND EARLY AUCTION (2015–16 TO 2019–20)

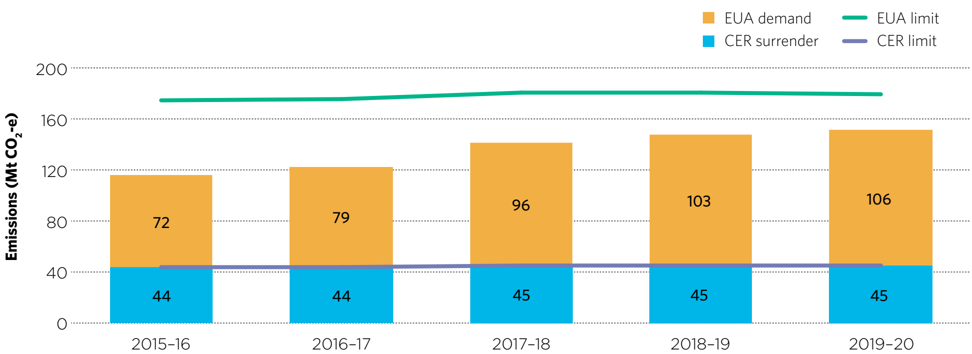
| | 2015–16 | 2016–17 | 2017–18 | 2018–19 | 2019–20 |
|---|---|---|---|---|---|
| Jobs and Competitiveness Program (estimate) | 106 | 108 | 108 | 106 | 105 |
| Energy Security Fund | 42 | 42 | 0 | 0 | 0 |
| Early auction | 40 | 20 | 0 | 0 | 0 |
| **Total** | **188** | **169** | **108** | **106** | **105** |

**Note:** All figures in Mt $CO_2$-e. Numbers may not sum due to rounding.
**Source:** Based on Treasury and DIICCSRTE 2013 data

## E4.2 MINIMISING CARBON PRICE EFFECTS DUE TO IMPORT LIMITS

Caps calculated for the 15 per cent target plus carryover are robust across all carbon price scenarios (low, medium and high). The 12.5 per cent sublimit on Kyoto units binds in every year, and the overall 50 per cent limit on international units does not bind in any year. Figure E.1 illustrates the result for the medium scenario.

**FIGURE E.1:** IMPORT LIMIT TESTING UNDER A 19 PER CENT TARGET, MEDIUM SCENARIO

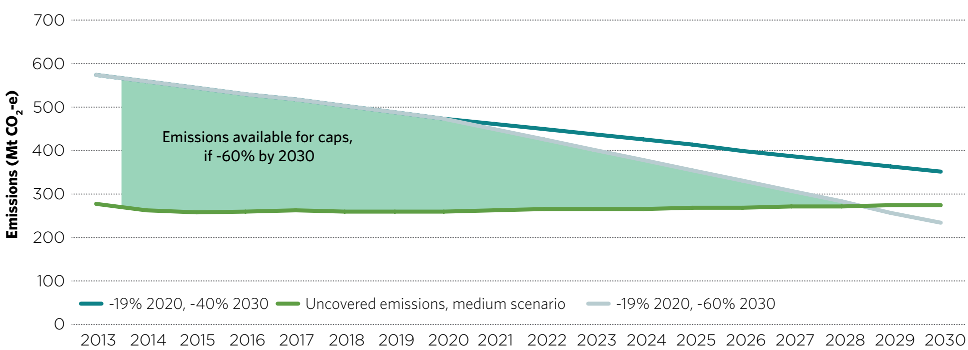



**Source:** Based on Treasury and DIICCSRTE 2013 data

# APPENDIX E5
# OUTLOOK FOR CAPS BEYOND 2020

Based on current legislation, the budget available for caps would continue to decline after 2020. Caps would become increasingly tight to 2030 (Figure E.2) and, for the lower (more ambitious) bound of the trajectory range, decline to zero by 2029. The uncovered emissions estimate used here is based on current legislation and the medium scenario. Any new policies, or higher prices, could reduce uncovered emissions and increase the budget available for caps.

**FIGURE E.2:** ESTIMATED BUDGET AVAILABLE FOR CAPS, 2013–2030




**Note:** Uncovered emissions estimate is indicative; it does not include all the adjustments discussed in this Appendix.
**Source:** Climate Change Authority; Treasury and DIICCSRTE 2013

F

# HOW ECONOMIC MODELLING IS USED IN THIS REVIEW

The Authority requested assistance from Treasury and DIICCSRTE to provide input to its economic analysis for the Targets and Progress Review. The Treasury and DIICCSRTE undertook economic modelling of different climate change mitigation scenarios in close consultation with the Authority. The modelling was also used as a basis for the government's 2013 emissions projections (DoE 2013).

This appendix outlines how the modelling was used to inform different parts of this Review.

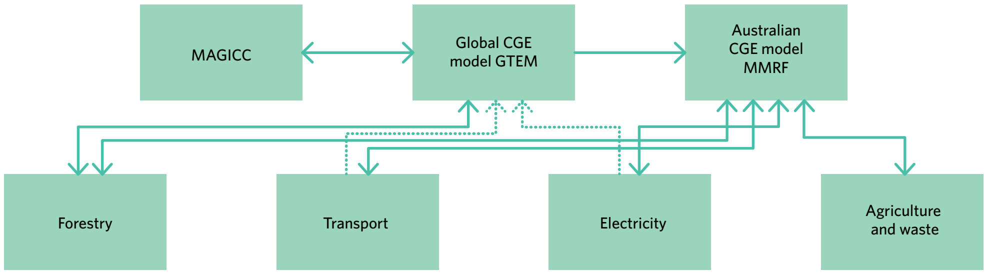
Treasury and DIICCSRTE (2013) and the consultants' reports on the electricity, transport and agriculture sectors are published on the Authority's website.

## APPENDIX F1 MODELLING APPROACH

The Treasury and DIICCSRTE modelling report uses a suite of models because no single model adequately captures the global, national, state and sectoral dimensions or focuses on all relevant aspects of mitigation policy in Australia.

The suite includes two top-down, computable general equilibrium (CGE) models developed in Australia—the GTEM and the Monash Multi-Regional Forecasting (MMRF) model. These are economy-wide models that capture the interactions between different sectors and among producers and consumers. The model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC) is used to estimate atmospheric concentrations based on the emissions trajectories from the international scenarios. Sector-specific models for electricity generation (undertaken by ACIL Allen Consulting), transport (CSIRO), agriculture (CIE) and forestry and waste (DIICCSRTE) are used to complement the CGE models, enriching the understanding of the economy's likely response to climate change mitigation policy (Figure F.1). The Treasury and DIICCSRTE modelling report and consultants' reports provide further detail on the use of these models and their integration.

**FIGURE F.1:** HOW THE SUITE OF MODELS FITS TOGETHER




**Note:** A solid arrow indicates direct transfer of results as an input/output; a dashed arrow indicates use of results for calibration.
**Source:** Treasury and DIICCSRTE 2013

# APPENDIX F2 SCENARIOS

The modelling investigates the future economic and emissions outlook for Australia. As outlined in Chapter 10, assumptions about policy settings are especially challenging as Australia's are currently being revised. The modelling assesses the economic impacts of achieving different targets in the context of the current legislative settings. Assuming the carbon pricing mechanism is in place, a key uncertainty is the future level of the carbon price. Assumptions about the level of international action and the extent of international permit trading are important determinants of the level of Australia's carbon price. These assumptions also affect the prices of the goods Australia imports and exports, and have implications for energy exports in particular.

Two international action scenarios are modelled. They assume the world takes action to stabilise atmospheric concentrations of greenhouse gases at levels of either around 550 or 450 ppm $CO_2$-e in the long term. These international scenarios form the backdrop for the domestic modelling. Further detail is provided in Chapter 2 of the Treasury and DIICCSRTE modelling report.

Economic activity and emissions are projected for three scenarios with carbon pricing and the CFI, and for one scenario in which there is neither carbon pricing nor the CFI. The Australian carbon price scenarios are further outlined in Box 10.1 of Chapter 10 and the Treasury and DIICCSRTE modelling report.

The international scenarios form the backdrop for the domestic scenarios (Table F.1). The ambitious international action scenario forms the backdrop for the high scenario; the carbon price is sufficient to drive the cuts in global emissions required to give a 50 per cent probability of limiting warming to no more than 2 degrees. The medium international action scenario forms the backdrop to the medium and low scenarios; the lower carbon price drives more gradual cuts in global emissions, resulting in additional warming.

**TABLE F.1: INTERNATIONAL AND DOMESTIC SCENARIOS MODELLED**

| INTERNATIONAL ACTION SCENARIO | DOMESTIC ACTION SCENARIO |
|---|---|
| Ambitious action—stabilisation around 450 ppm $CO_2$-e | High scenario |
| Medium action—stabilisation around 550 ppm $CO_2$-e | Medium scenario* |
| Medium action—stabilisation around 550 ppm $CO_2$-e | Low scenario |
| Medium action—stabilisation around 550 ppm $CO_2$-e | No price scenario |

*Referred to as 'central' price scenario in the Treasury and DIICCSRTE modelling report.

The high, medium and low domestic action scenarios assume Australia has a fixed carbon price in 2012–13 and 2013–14, and then moves to a flexible price. A sensitivity analysis on the medium scenario is also modelled, with a fixed price in 2014–15 and a flexible price starting in 2015–16, in accordance with the current legislation. This changes emissions levels in 2014–15, which affects the cap calculations presented in Part E and Appendix E. However, it has no material impact on the economic results, so it is not used in the analysis in chapters 10, 11 and 12.

DIICCSRTE engaged consultants to undertake detailed modelling of Australia's electricity, transport and agriculture sectors. The consultants also undertook a range of sensitivity analyses for each sector. Further detail on this modelling is provided in the consultants' reports published on the Authority's website.

## APPENDIX F3 EMISSIONS DATA

Historical and projected emissions for the period 1990 to 2030 are taken from the Treasury and DIICCSRTE modelling report.

In the modelling, historical emissions data for the period 1990 to 2011 are based on the National Greenhouse Gas Inventory report 2010–11 (DIICCSRTE 2013a); these have been converted to $CO_2$-e values using GWPs from the IPCC's Fourth Assessment Report (AR4) to permit simple comparison over the full period. Emissions in 2000 of 585.88 Mt $CO_2$-e are used as the basis for the emissions reductions targets and trajectories. For 2012, historical emissions are based on preliminary estimates of the National Greenhouse Gas Inventory, with the exception of waste and LULUCF emissions, which are modelled estimates. Historical emissions for LULUCF for the period 1990 to 2012 are adjusted to be consistent with the new accounting rules agreed for the second commitment period of the Kyoto Protocol. Emissions data for the period 2013 to 2030 are modelled estimates. Further details are provided in Box 6.1.

## APPENDIX F4 AUSTRALIAN ACTION IN A GLOBAL CONTEXT

The modelling is used to inform part of the analysis of countries' targets presented in Chapter 4. The modelling is used for Figure 4.3 and in Appendix B to compare countries' 2020 targets with their projected BAU emissions. The BAU emissions are estimated from the GTEM reference case for some countries, and the domestic emissions for Australia are estimated from the no price scenario from MMRF. All Australian population estimates are from GTEM. Further information on the other data used for the comparison analysis can be found in Appendix B.

# APPENDIX F5
# FORM AND SCOPE OF GOALS

Net emissions reductions due to the election of optional land-use activities from bottom-up modelling undertaken by DIICCSRTE are used in chapters 7 and 11 and Appendix D to calculate the implications of land sector accounting changes for Australia's 2020 target.

The impact on the 2020 target is calculated as follows:

1. The total additional emissions reduction over 2013–2020 provided by land sector accounting changes (under Article 3.4 of the Kyoto Protocol including forest management) is calculated as the difference between the 2013 modelling projections with and without Article 3.4 including forest management (see Appendix B of the Treasury and DIICCSRTE modelling report).
2. Projected emissions reductions are identified from CFI projects in forest management, crop land management, grazing land management and revegetation. These are subtracted from the total additional emissions reduction in (1), giving 90 Mt $CO_2$-e of emissions reduction that would occur because of the Article 3.4 changes, regardless of policy incentives.
3. The resulting cumulative emissions reduction from (2) is converted to an equivalent strengthening in the 2020 target that would result in the same cumulative emissions reduction over the period 2013–2020.

This calculation is not affected by changes in global warming potentials since the 2012 projections, as the relevant emissions are carbon dioxide only.

# APPENDIX F6
# AUSTRALIA'S EMISSIONS BUDGET TO 2050

Calculations of Australia's emissions budget to 2050 outlined in Chapter 8 draw on the international modelling from GTEM and further information provided by Treasury. Details are in Appendix C.

# APPENDIX F7
# ECONOMIC IMPLICATIONS OF AUSTRALIA'S EMISSIONS REDUCTION GOALS

The modelling is a key input to the Authority's analysis of economic impacts. All domestic scenarios are used to assess the outlook for the Australian economy and domestic emissions, in the context of different levels of international action and carbon prices.

## F7.1 GNI ADJUSTMENT FOR THE HIGH SCENARIO

The modelling was used to estimate the GNI impacts of moving to a stronger target.

The scenarios reported in the Treasury and DIICCSRTE modelling report assumed a 5 per cent target for the central- (referred to as 'medium' in this Review) and low-price scenarios, and a 25 per cent target for the high-price scenario.

To assess the impact of moving from the minimum 5 per cent target to a 19 per cent target, the Authority requires GNI levels for a 5 per cent target for all price scenarios. The Authority adjusted the GNI results for the high-price scenario to remove the costs of achieving the stronger 25 per cent target, using the following method:

1. The cost of the additional imports was added back. A 5 per cent target requires fewer international emissions reductions to be purchased than a 25 per cent target. For example, in 2020 it requires 41 million fewer Kyoto units and 76 million fewer European Union allowances (EUAs) to be purchased. This increases GNI in 2020 by $5.9 billion.
2. The positive terms of trade effect was added back (this stems from lower international transfers associated with imports, and is the same effect described in Section 3.7.2 of the modelling report). This effect is 0.3 times the cost of imports, increasing GNI in 2020 by an additional $1.8 billion.

The additional revenue impact described in Section 3.7.2 of the modelling report is not included in the modelling scenarios and did not need to be removed for the Authority's estimate of the 5 per cent target.

This methodology was used to adjust GNI in each year of the flexible-price period. Throughout Chapter 10, the adjusted GNI for the high scenario is used.

## F7.2 CALCULATING THE GNI COSTS OF STRONGER TARGETS

Starting from the common 5 per cent target, the methodology discussed in Section 10.3.1 was used to calculate the impact of moving to stronger targets. The costs are based on the additional imports required to move from 5 per cent to the recommended target; specifically, the difference in annual caps for a 5 per cent and a 19 per cent target. Table F.2 shows the average annual GNI growth rate between 2013 and 2020 for each of the price scenarios.

**TABLE F.2:** AVERAGE ANNUAL GROWTH IN GNI PER PERSON 2013–2020

| TARGET | HIGH SCENARIO | MEDIUM SCENARIO | LOW SCENARIO |
|---|---|---|---|
| 5 per cent | 0.73% | 0.80% | 0.82% |
| 19 per cent including carryover | 0.67% | 0.78% | 0.82% |

## F7.3 ASSESSING THE IMPACT OF AUSTRALIA'S TARGET ON THE INTERNATIONAL CARBON PRICE

A central question in analysing the economic implications of Australia's emissions reduction goals under the current legislation is whether its choice of 2020 target would have an impact on the international carbon price. As outlined in Chapter 10, for this analysis we have assumed that Australia's decision to move to a stronger target would not have a material impact on the international carbon price.

Under the current legislative settings, limits on the use of Kyoto units and the ability to bank units for future use mean the Australian carbon unit price is expected to track the European price. The majority of stakeholders consider that Australia will have little or no impact, because changes in Australian demand would not be big enough to shift the European market. The European Union emissions trading system (EU ETS) covers roughly 2,000 Mt $CO_2$-e (European Commission 2013), while the Australian carbon pricing mechanism covers about 300 Mt $CO_2$-e, making the European market almost seven times bigger than the Australian market. Further, the European market currently has a substantial surplus of roughly two billion units, in part due to the sustained economic downturn. As a result, a stronger Australian target will reduce the supply of Australia's domestic units, but have only a small impact on aggregate demand for international units.

The Authority has consulted extensively on this question, including with market analysts and traders, and liable entities. Many stakeholders, including the Australian Industry Group and the Investor Group on Climate Change, indicated Australian carbon prices would be likely to follow European prices.

Some analysts consider that a stronger target in Australia would increase the international price. For example, in August 2013 Bloomberg New Energy Finance (BNEF) projected that Australia moving to a 15 per cent target could increase the Australian carbon unit price by an average of $7.80 (2020 Australian dollars) (€4.70) over the period 2016–20 when compared to its 5 per cent scenario (2013a). Under this scenario, BNEF forecast an Australian carbon unit price of $80.40 in 2020, compared to $71.60 in 2020 under a 5 per cent target (in 2020 Australian dollars).

Other stakeholders suggested that the European price is largely contingent on the outcomes of proposed EU ETS structural reform, and finalisation of Europe's emissions reduction goals for the post-2020 period. These reforms could change the underlying demand and supply balance for European allowances, in which case additional demand from Australia may have a modest price impact.

Even if Australia's target did have a price effect, the scale of the projected change would not be expected to materially change domestic economic activity or impacts on Australian businesses and households. Moreover, the scale of the projected change is small relative to the scale of uncertainty in the carbon price itself. In July 2013, analyst forecasts of the carbon price in 2020 ranged from roughly $6 to $80 (RepuTex 2013; BNEF 2013b)—a much wider range than any potential impact of a stronger Australian target on the international price.

The Authority has considered three carbon price scenarios spanning a wide range of possible future market conditions, which provide a robust basis to illustrate the potential costs. Table F.2 illustrates the GNI impacts for the different price scenarios, which show the potential range of impacts if Australia was to have an effect on the international price.

## F7.4 IMPACT OF THE TARGET IS DIFFERENT TO IMPACT OF THE CARBON PRICE

As discussed in Section 10.3.4, the impact of the target is different to the impact of the carbon price. There is a common misconception that stronger targets mean much higher economic costs, with greater distributional consequences. This is not the case under the current legislation, where the carbon price is not expected to be materially affected by the target.

In determining the economic impact of the target, both the policy choice and the level of the target are relevant. Under the current legislation, economy-wide costs are quite small; the economy continues to grow and incomes continue to rise, even with a strong target. However, under a different policy the impacts could be different. The results from the medium scenario, with illustrative 5 and 25 per cent targets, demonstrate the scale of potential effects.

## F7.4.1 POLICY CHOICE

Depending on Australia's policy choice, costs may not be very transparent (for example, raising general tax revenue can have diffuse effects) and may be higher than under the current legislation.

Current legislated policy applies a carbon price to certain emissions sources (including electricity generation, direct combustion, landfills and industrial processes). This increases the cost of these emissions-intensive activities and shifts the economy towards lower emissions activity.

The carbon price imposes costs at the individual commodity level (for example, higher electricity prices); the whole-of-economy level (for example, lower GDP growth) and household income level (for example, lower GNI per capita growth).

Table F.3 shows the scale of these effects, using the results from the no price scenario compared to the medium scenario (with a 5 per cent target).

**TABLE F.3: ELECTRICITY PRICES AND ECONOMIC IMPACTS WITH A 5 PER CENT 2020 TARGET IN DIFFERENT SCENARIOS**

| | ELECTRICITY PRICES (RESIDENTIAL RETAIL) | GNI PER CAPITA | GDP |
|---|---|---|---|
| **2012 levels** | Varies across markets | $62,350 | $1.475 trillion (2012) |
| **No carbon price** | Changes to residential retail electricity prices over the period 2012–2020 vary across jurisdictions, ranging from:<br>• 24% above 2012 levels in 2020 in Queensland (an increase of $50 per MWh) to<br>• 1% below 2012 levels in 2020 in Tasmania (a fall of $1 per MWh). | $66,700 (2020)<br>0.84% average annual growth to 2020 | $1.882 trillion (2020)<br>3.10% average annual growth (2012–2020) |
| **Medium scenario** | Changes to residential retail electricity prices over the period 2012–2020 vary across jurisdictions, ranging from:<br>• 35% above 2012 levels in 2020 in Queensland (an increase of $73 per MWh) to<br>• 7% above 2012 levels in 2020 in the Northern Territory (an increase of $18 per MWh). | $66,450 (2020)<br>0.80% average annual growth to 2020 | $1.877 trillion (2020); 0.31% lower than no price<br>3.06% average annual growth (2012–2020) |

**Note:** GNI per capita figures are rounded to the nearest $50.
**Source:** Climate Change Authority based on Treasury and DIICCSRTE (2013) and ACIL Allen Consulting (2013)

Removing the carbon price will unwind these economic impacts. Alternative policy will have its own impacts. More detail would be required to estimate impacts for the Direct Action Plan. If new policy was less efficient than a carbon price, the impact on GDP and GNI would be greater. Distributional effects, including the impact on electricity prices, would depend heavily on policy choice.

## F7.4.2 LEVEL OF THE TARGET

Under the current legislation, a stronger target is expected to lead to more imports of international emissions units. Australia is small compared to the global carbon market, so is not expected to have material impact on the carbon price. As a result, a stronger target is not projected to have material direct impact on the economy, liable entities or the prices of goods and services such as electricity. The main economic impact of the target choice arises from international transfers associated with imports, and lower government revenue from having fewer units to auction.

Table F.4 shows the scale of these effects using the results from the medium scenario, assuming a 5 and 25 per cent target.

**TABLE F.4: ELECTRICITY PRICES AND ECONOMIC IMPACTS WITH A 5 AND 25 PER CENT TARGET IN THE MEDIUM SCENARIO**

| | ELECTRICITY PRICES | GNI PER CAPITA | GDP |
|---|---|---|---|
| **2012 levels** | Varies across markets | $62,350 | $1.475 trillion (2012) |
| **5 per cent target** | Residential retail tariff in 2020 is about 10% higher than in the no price scenario (ACIL Allen Consulting 2013). Ranges from:<br>• 1.4% in Darwin-Katherine Interconnected System to<br>• 13% in Victoria. | $66,450 (2020)<br>0.80% average annual growth to 2020 | $1.877 trillion (2020)<br>3.06% average annual growth |
| **25 per cent target** | Same as for 5 per cent | $66,250 (2020)<br>0.76% average annual growth | Same as for 5 per cent |

**Note:** GNI per capita figures are rounded to the nearest $50
**Source:** Climate Change Authority based on Treasury and DIICCSRTE (2013) and ACIL Allen Consulting (2013)

# APPENDIX F8 AUSTRALIA'S EMISSIONS OUTLOOK

The Review of Australia's emissions outlook and progress towards its medium- and long-term goals draws on the four scenarios from the modelling (no price, low, medium and high) to show the scale and source of emissions reductions that may be elicited with different price incentives. The sensitivity analysis from the bottom-up models is also used. The Authority's approach to reporting sectoral projections is outlined below.

## F8.1 INTEGRATING SECTORAL AND ECONOMY-WIDE MODEL PROJECTIONS

### F8.1.1 EMISSIONS LEVELS

The Authority has used emissions levels as reported in the Treasury and DIICCSRTE modelling report for all sectors for the period 2013 to 2030.

The approaches used to estimate sub-sector level emissions depend on the level of detail available from different models:

- for transport, agriculture and electricity (for example, emissions from coal-fired electricity generation), the Authority has used sub-sector ratios from the sectoral models to apportion emissions
- for all other sectors, sub-sector emissions are based on information from Treasury and DIICCSRTE modelling.

### F8.1.2 TIMEFRAME FOR PROJECTIONS

The Treasury and DIICCSRTE modelling provides emissions projections for the period 2013 to 2030. The sectoral models provide emissions projections from 2031 to 2050 for electricity, transport and agriculture.

As evident from the Treasury and DIICCSRTE modelling report and the consultants' reports, there are small differences between some of the projected emissions from the sectoral models and the projected sectoral emissions from MMRF. For consistency over time, and where appropriate, the Authority has derived emissions from electricity and transport for the period 2013 to 2050 by applying the growth rates from the sectoral models to the level of emissions in 2030 from the Treasury and DIICCSRTE modelling report. Other sector emissions and economy-wide emissions are not projected beyond 2030.

### F8.1.3 ADDITIONAL SUBSECTOR DETAIL

Some activity and any additional subsector details (for example, fuel shares) have been sourced from the sectoral models and the Treasury and DIICCSRTE:

- electricity supply mix is based on ACIL Allen Consulting (2013) using as-generated gigawatt hours for projections, and BREE (2013) for historical disaggregation
- transport fuel use and modal shares are based on Reedman and Graham (2013) for projections, and BITRE (2011) and BREE (2013) for historical disaggregation
- agriculture activity is based on CIE (2013)
- direct combustion activity is based on Treasury and DIICCSRTE emissions data and National Greenhouse Gas Accounts (DIICCSRTE 2013b) rebased to AR4 GWPs
- waste production activity is based on data sourced from DIICCSRTE.

## F8.2 ATTRIBUTING CHANGES IN EMISSIONS SINCE 2000 DUE TO CHANGES IN ACTIVITY OR EMISSIONS INTENSITY

The Authority developed an approach to attribute estimated changes in emissions over a period between simultaneous factors, such as between a change to activity level and a change to emissions intensity. The results are presented in Appendix D. This approach has been used for electricity and transport sectors only. For all other sectors, changes in emissions are based on absolute emissions changes and do not distinguish the contribution of changes in activity from changes in intensity.

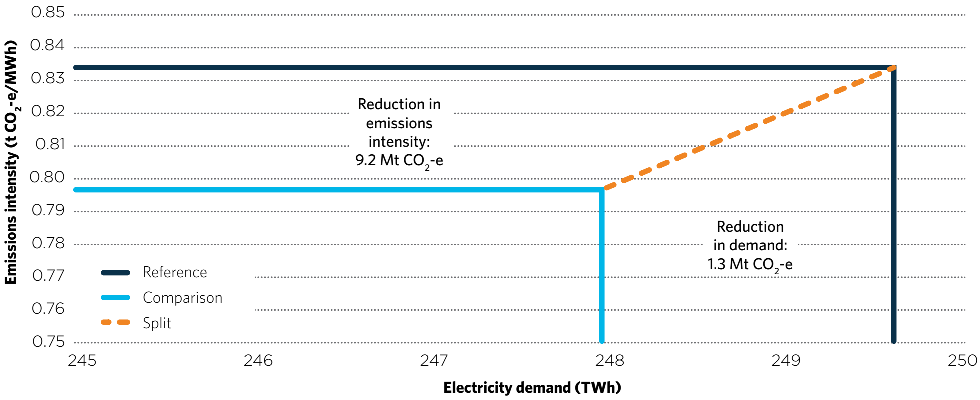
Activity levels and emissions intensity at the start and end of the period are used as reference points. The year 2000 is used as the primary start point, as it is the base year for Australia's national emissions reduction goals.

The method is designed to:

- facilitate analysis of the factors contributing to changes in emissions and highlight the largest contributors
- ensure all changes in emissions could be attributed to contributors without double-counting—and, as a result, be additive, so that:
  - the sum of changes attributed to each contributor is equal to the total change across all contributors
  - the sum of changes attributed to consecutive time periods is equal to the total change from the start to the end of the whole period.

Figure F.2 illustrates the method, apportioning a reduction in emissions between lower activity and lower emissions intensity.

**FIGURE F.2:** HOW CHANGES IN EMISSIONS ARE QUANTIFIED AND ATTRIBUTED




**Source:** Climate Change Authority

Figure F.2 compares demand and supply intensity in a given year against a reference year. The total change in emissions is represented by the area between the reference and comparison curves—in this example, 10.5 Mt $CO_2$-e. Part of the change is attributed to the small reduction in demand—1.3 Mt $CO_2$-e. The remainder is attributed to the reduction in supply-side emissions intensity—9.2 Mt $CO_2$-e.

## APPENDIX F9 CAPS FOR THE CARBON PRICING MECHANISM

The caps calculations presented in Chapter 13 and Appendix E draw on the emissions projections from the modelling. Details of the scenarios used and associated calculations are provided in Appendix E.

# LIST OF RECOMMENDATIONS AND CONCLUSIONS

| RECOMMENDATIONS AND CONCLUSIONS | NUMBER | PAGE |
|---|---|---|
| **Chapter 2** | | |
| Australia is vulnerable to climate change and will face increasingly severe impacts under higher levels of warming. It is in Australia's national interest to contribute to the global goal of limiting warming to below 2 degrees. | C.1 | 42 |
| **Chapter 3** | | |
| Limiting global emissions to keep warming to below 2 degrees is still feasible, but only with immediate and strong international action—especially by the major emitting economies. | C.2 | 46 |
| A global emissions budget that provides at least a likely (67 per cent probability) chance of limiting warming to less than 2 degrees above pre-industrial levels is used as a reference for the Review. This equates to a global budget of no more than 1,700 Gt $CO_2$-e emissions of Kyoto gases from 2000 to 2050. | C.3 | 51 |
| **Chapter 4** | | |
| There is a significant trend to increased global action to reduce greenhouse gas emissions. All the major emitting economies, including China and the United States, have 2020 emissions reduction goals backed by domestic policies and measures. This trend will need to continue and accelerate if the world is to keep warming below 2 degrees. | C.4 | 74 |
| The Authority's analysis of the government's target conditions show that the conditions for moving beyond 5 per cent have been met. Whether the conditions for 15 per cent have been met is unclear—some elements have been met; others are marginal. The conditions for a 25 per cent target have not been met at this time. While the Authority has taken these conditions into account, it is also required to examine a broader range of considerations. | C.5 | 74 |
| Considering a range of measures, an Australian 5 per cent target lags behind the targets of key countries considered in this Review. A stronger 2020 target of 15 per cent plus carryover is broadly comparable with other countries' targets, including that of the United States. This is especially the case given Australia's high level of development, relative wealth and governance capacity. | C.6 | 74 |
| **Chapter 5** | | |
| Australian governments at all levels have implemented a wide range of policies to reduce emissions over the last two decades, and there has been considerable change in the suite of policies over time. | C.7 | 83 |
| **Chapter 6** | | |
| Australia has made progress towards decarbonising its economy—the emissions intensity of the economy (emissions per unit of GDP) has fallen by about 50 per cent since 1990. | C.8 | 97 |
| The falling emissions intensity is in part due to the changing composition of the economy, away from emissions-intensive manufacturing. Policy has also played an important role, particularly in the land and electricity sectors. | C.9 | 97 |

| RECOMMENDATIONS AND CONCLUSIONS | NUMBER | PAGE |
|---|---|---|
| **Chapter 7** | | |
| A coordinated set of emissions reduction goals for the short, medium and long term would provide a more predictable environment for businesses and others to act. An appropriate set of goals for Australia comprises:<br>• A short-term target for 2020, and an emissions budget and trajectory to 2020 providing a clear course for short-term action.<br>• A trajectory range to 2030 and a national emissions budget to 2050, providing guidance for longer term planning, subject to periodic review to respond to new information and changing circumstances. | C.10 | 104 |
| The trajectory range and the national budget to 2050 be reviewed at least every five years. There could be additional reviews to take account of major developments; for example, in 2016 to take account of international developments on the post-2020 framework. As part of these reviews, the trajectory range would be extended to maintain a similar period of guidance over time, and short-term targets and trajectories would be set within the existing range. | R.1 | 106 |
| The periodic reviews of the trajectory range and the national budget to 2050 have particular regard to the following general criteria—changes in or new information about climate science, the level and pace of international action, and economic factors. | R.2 | 106 |
| The government recognise voluntary action by cancelling one Kyoto Protocol unit for each tonne of emissions reductions achieved in the period 2013–2020 through:<br>• the voluntary cancellation of domestic units,<br>• the voluntary cancellation of renewable energy certificates, and<br>• GreenPower purchases. | R.3 | 109 |
| The best use of Australia's carryover from the first Kyoto Protocol commitment period is to strengthen the 2020 emissions reduction target. | C.11 | 111 |
| **Chapter 8** | | |
| A national carbon budget for the period 2013–2050 of 10.1 Gt $CO_2$-e. | R.4 | 117 |
| **Chapter 9** | | |
| A minimum 2020 emissions reduction target of 15 per cent below 2000 levels. | R.5 | 124 |
| Australia's carryover from the first commitment period of the Kyoto Protocol be used to raise the 2020 emissions reduction target by 4 percentage points, giving a 2020 target of 19 per cent. | R.6 | 124 |
| An indicative national trajectory for the period 2013–2020 that follows a straight line to the 2020 target. This line starts at Australia's first commitment period target under the Kyoto Protocol (108 per cent of 1990 levels) in 2010, and ends at 19 per cent below 2000 levels in 2020. | R.7 | 124 |
| A national carbon budget for the period 2013–2020 of 4,193 Mt $CO_2$-e. | R.8 | 124 |
| Beyond 2020, Australia continue to reduce emissions within a trajectory range bounded by the paths to 40 and 60 per cent below 2000 levels in 2030. | R.9 | 126 |
| **Chapter 10** | | |
| Australia's emissions reduction task for 2013 to 2020 is projected to be 593 Mt for the minimum 5 per cent target. This is substantial but achievable, and smaller than the 754 Mt task previously projected. If Australia reduced emissions by 754 Mt over the period to 2020, it would now reach an 11 per cent target. | C.12 | 133 |
| Stronger targets can be achieved with relatively small impacts on national income and economic growth, depending on policy design. Under the current legislation, moving from a 5 per cent to a 19 per cent target (15 per cent plus carryover) is projected to slow annual growth in GNI per person to 2020 from 0.80 per cent to 0.78 per cent. | C.13 | 137 |
| Using some international emissions reductions to meet Australia's emissions reduction goals reduces costs to the economy, businesses and households. Using a mix of domestic and international emissions reductions to meet the minimum 5 per cent target could halve the impact on GDP compared to only using domestic emissions reductions. | C.14 | 142 |

| RECOMMENDATIONS AND CONCLUSIONS | NUMBER | PAGE |
|---|---|---|
| The costs of reducing emissions and how those costs are distributed through the economy are determined more by policy choice than the particular emissions reduction target. Careful policy design can help businesses and households respond to the challenges of moving to a low-emissions future. | C.15 | 144 |
| **Chapter 11** | | |
| The government investigate the near-term introduction of fleet-average $CO_2$ emissions standards for light vehicles in Australia as a way to secure significant, cost-effective emissions reductions and related co-benefits. | R.10 | 166 |
| The rate of reduction in emissions intensity since 1990 is not sufficient to drive absolute reductions in Australia's emissions in the period to 2030. | C.16 | 176 |
| Without a price incentive or additional policies, economy-wide emissions are projected to rise to 17 per cent above 2000 levels in 2020 and 37 per cent in 2030. | C.17 | 176 |
| Australia has extensive opportunities to reduce emissions at relatively low costs, but it will take time to replace the stock of buildings, vehicles, equipment and plant. To achieve Australia's emissions reduction goals and avoid locking in future emissions growth, stable, cost-effective and complementary policies need to be in place this decade. | C.18 | 176 |
| Electricity sector emissions are projected to grow strongly without a price incentive or other policy mechanism. With price incentives, the sector could be the single largest source of domestic emissions reductions. | C.19 | 176 |
| Without a price incentive, rapid growth in demand for road transport and domestic air travel is projected to drive increasing transport emissions. Appropriate policies could deliver significant transport emissions reductions. | C.20 | 176 |
| **Chapter 12** | | |
| The government use international emissions reductions to bridge any gap between domestic reductions achieved under the Direct Action Plan and the recommended 2020 goals. | R.11 | 186 |
| The government establish a fund to purchase Clean Development Mechanism units to complement the Direct Action Plan and help meet the recommended 2020 goals. | R.12 | 186 |
| **Chapter 13** | | |
| Carbon pollution caps for each of the first five years of the flexible-price period under the carbon pricing mechanism of:<br>Year — Cap (Mt $CO_2$-e)<br>2015–16 — 234<br>2016–17 — 228<br>2017–18 — 222<br>2018–19 — 215<br>2019–20 — 209 | R.13 | 199 |

# LIST OF BOXES, FIGURES AND TABLES

# GLOSSARY

| | |
|---|---|
| **2 degree goal** | A global goal to limit global average warming to less than 2 degrees above pre-industrial levels. |
| **accounting framework** | The rules that specify how to estimate greenhouse gas emissions and what emissions count towards an emissions reduction target. |
| **agriculture emissions** | Emissions resulting from livestock digestive processes (enteric fermentation), manure management, nitrous oxide emissions from cropping and pastureland soils, prescribed burning of savannas and burning of agricultural residues. |
| **Annex I countries/Parties** | Industrialised countries and economies in transition listed in Annex I to the United Nations Framework Convention on Climate Change. |
| **Assessment Report** | Comprehensive assessment of the state of climate change science published by the Intergovernmental Panel on Climate Change. |
| **Australian carbon unit** | An emissions unit established by the *Clean Energy Act 2011* (Cth), issued for the purposes of the carbon pricing mechanism. The total number of units issued each year does not exceed the cap. |
| **business-as-usual emissions trend** | Emissions that would occur without any policy intervention (or additional policy intervention). |
| **cap** | The year-by-year limit on emissions from sources covered by the carbon pricing mechanism. |
| **carbon capture and storage** | Technologies that capture carbon dioxide emissions from energy production or industrial processes, and inject it below land or the sea into underground geological formations. |
| **carbon dioxide equivalent** | A measure that quantifies different greenhouse gases in terms of the amount of carbon dioxide that would deliver the same global warming. |
| **Carbon Farming Initiative** | An Australian emissions offset scheme that credits emissions reductions from certain sources, such as forestry and agriculture, that are not covered by the carbon pricing mechanism. |
| **carbon price** | The price of an emissions unit. |
| **carbon pricing mechanism** | An emissions trading scheme that puts a price on Australia's greenhouse gas emissions. It was introduced under the Clean Energy Act and applies to Australia's biggest emitters (called 'liable entities'). |
| **carryover** | The accounting framework under the Kyoto Protocol that allows a country performing better than its Kyoto target to 'carry over' the extra emission units to the next commitment period. |
| **Certified Emission Reduction** | An emissions unit issued under the Clean Development Mechanism, for emissions-reduction projects in developing countries. These CERs can be traded and sold, and used by industrialised countries to help meet their emissions reduction targets under the Kyoto Protocol. |
| **cumulative average growth rate** | A constant rate of growth that delivers equivalent change over a period. |
| **climate system** | A highly complex system consisting of five major components—the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere, and the interactions between them. |
| **commitment period** | The timeframe of binding national goals under the Kyoto Protocol. The first commitment period was five years from 2008–2012. The second commitment period is eight years from 2013–2020. |
| **covered emissions** | Emissions from sources covered by the carbon pricing mechanism. |

| | |
|---|---|
| **Direct Action Plan** | The government's proposed policy to reduce greenhouse gas emissions and establish a clean-up and environment conservation program. A central element of the plan is the Emissions Reduction Fund. |
| **decarbonise** | The process of reducing emissions; for example, in an economy or sector. |
| **direct combustion emissions** | Emissions released when fuels are combusted for stationary energy purposes, such as generating heat, steam or pressure (excluding electricity generation). These emissions are released by large industrial users, and by small, dispersed residential and commercial consumers. |
| **electricity emissions** | Emissions released when fuels, such as coal and natural gas, are combusted to generate electricity. |
| **eligible international emissions unit** | An international unit that is accepted for compliance under the carbon pricing mechanism, including Kyoto Protocol-certified reduction units, emissions reduction or removal units, and other units identified by the government under the legislation. |
| **emissions budget** | A cumulative emissions allowance over a period of time. |
| **emissions intensity** | A measure of the amount of emissions associated with a unit of output; for example, emissions per unit of gross domestic product. |
| **emissions reduction** | The act or process of limiting or restricting greenhouse gas emissions. |
| **Emissions Reduction Fund** | A $3 billion fund proposed by the government to allocate money through a reverse auction to emissions reduction tenders to projects designed to reduce emissions. |
| **emissions reduction goal** | Any emissions reduction objective, such as an emissions reduction target or target range, an emissions budget or an emissions trajectory. Includes a pledge to reduce or limit emissions made under the United Nations Framework Convention on Climate Change. |
| **emissions reduction target** | A goal for national emissions in a specific year. |
| **emissions rights** | The rights of individuals or countries to emit greenhouse gases. |
| **emissions trading scheme** | A market-based approach to reducing emissions that places a limit on emissions allowed from all sources covered by the scheme. Emissions trading allows entities to trade emissions units with other entities. In general, trading can occur at the domestic, international and intra-company levels. |
| **emissions unit** | Represents a unit of one metric tonne of carbon dioxide equivalent. |
| **equivalent carbon price** | Part of the carbon pricing arrangements established under the Clean Energy Act. Applies to certain liquid fuels and synthetic greenhouse gases through adjustments to fuel excise arrangements, and to the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (Cth). The equivalent carbon price paid will be equal to the effective carbon price paid by liable entities under the carbon pricing mechanism. |
| **European Union Allowance** | An emissions unit issued in the European Union Emissions Trading System. |
| **fleet-average $CO_2$ emissions standards** | A policy requiring vehicle suppliers to meet an efficiency standard (expressed as carbon dioxide emissions), based on the average size or weight of all new vehicles they sell (a fleet-average). This approach allows suppliers flexibility to sell a mix of vehicles that aligns with their commercial strategy and consumer preferences. |
| **fugitive emissions** | Greenhouse gases emitted during the extraction, production, processing, storage, transmission and distribution of fossil fuels such as coal, oil and gas. |

| | |
|---|---|
| **global emissions budget** | The total amount of emissions projected to result in a given rise in global temperature. Budgets are expressed in terms of probabilities to reflect uncertainties about the exact temperature effect of a given amount of emissions. The Authority has adopted a 67 per cent chance of causing warming of less than 2 degrees as its reference for Australia's goals. |
| **global warming** | Used interchangeably with climate change. |
| **global warming potential** | An index measuring the radiative forcing of a well-mixed greenhouse gas in the atmosphere, relative to carbon dioxide, in order to compare its equivalent contribution to global warming. |
| **greenhouse gas** | Any gas (natural or produced by human activities) that absorbs infrared radiation in the atmosphere. Key greenhouse gases include, carbon dioxide, water vapour, nitrous oxide, methane and ozone. |
| **gross domestic product** | A measure of the value of economic production in the economy. |
| **gross national income** | An economic measure that reflects gross domestic product, the terms of trade and international income transfers. |
| **industrial** | The period after 1750. |
| **industrial process emissions** | Emissions from industrial processes including metal production, synthetic greenhouse gases, chemical processes, mineral production and other processes. Excludes emissions from combustion for energy purposes. |
| **Intergovernmental Panel on Climate Change** | An international scientific body operating under the auspices of the United Nations. Its role is to review, assess and synthesise the latest information on climate change. |
| **land use, land use change and forestry (emissions)** | Emissions associated with human-induced changes in land use, such as deforestation, afforestation and forest management. |
| **Kyoto gases** | Greenhouse gases covered under the Kyoto Protocol. These are: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$). The second commitment period also includes nitrogen trifluoride ($NF_3$). |
| **Kyoto Protocol** | An international agreement adopted under the United Nations Framework Convention on Climate Change in 1997. It includes binding national targets for developed countries and flexible mechanisms including the Clean Development Mechanism (CDM). |
| **Kyoto unit** | Emissions units eligible for compliance with Kyoto Protocol targets—these include assigned amount units (AAUs), certified emission reduction units (CERs), emission reduction units (ERUs) and removal units. |
| **marginal price of emissions reduction** | The cost of reducing emissions by one additional tonne. |
| **Megawatt electric** | Electrical power output of a generator in megawatts, as distinct from other power outputs such as heat generated. |
| **national carbon budget** | Australia's cumulative emissions allowance over a period of time, referred to in the Clean Energy Act. This report uses 'national emissions budget' to mean the same thing. |
| **National Greenhouse Gas Inventory** | An annual time series compilation of Australia's emissions data, prepared by the Department of Environment in line with UNFCCC guidelines. |
| **net targets** | The recommended emissions reduction goals are net of trade. This means that any international emissions reductions Australia buys will count as reductions towards its target—but any emissions reductions sold overseas cannot be counted. Emissions in Australia could be higher than the target if offset by purchases of international emissions reductions. |
| **parts per million** | A measure of the concentration of greenhouse gases in the atmosphere. One part per million is equivalent to one cubic centimetre of gas per cubic metre of air. |
| **pre-industrial** | The period before 1750. |

| | |
|---|---|
| **radiative forcing** | A measure of the influence that a factor has on the energy balance of the climate system. Positive forcing tends to warm the surface, while negative forcing tends to cool it. |
| **Renewable Energy Target** | A Commonwealth Government scheme that places a legal obligation on electricity retailers and large electricity users to buy a certain proportion of their electricity from renewables-based generation. |
| **stationary energy emissions** | Emissions from electricity generation and direct combustion. |
| **target conditions** | The conditions the Commonwealth Government has specified in relation to its emissions reduction target range for 2020, and reflected in international agreements. |
| **terms of trade** | The ratio of the price of a country's exports, relative to its imports. |
| **trajectory** | An indicative year-by-year emissions pathway to an emissions goal. |
| **trajectory range** | A range within which future targets and trajectories may be set. |
| **transport emissions** | Emissions from vehicles, combusting or otherwise, converting fuels to move people and freight, reported across four modes—road, rail, domestic aviation and domestic shipping. International aviation and shipping emissions are excluded from Australia's national inventory. |
| **uncovered emissions** | Emissions from sources not covered by the carbon pricing mechanism; includes emissions covered by the equivalent carbon price. |
| **unit shortfall charge** | If a liable entity under the carbon pricing mechanism does not surrender a sufficient number of emissions units then they must pay a charge equal to the unit shortfall multiplied by a specified amount greater than one. The charge provides an incentive to surrender sufficient units. |
| **United Nations Framework Convention on Climate Change** | An international treaty that commits signatory countries (Parties) to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human-induced interference with the climate system. |
| **voluntary action** | The autonomous decision of individuals, companies or governments to reduce greenhouse gas emissions, such as to offset emissions to be carbon-neutral. |
| **waste emissions** | Emissions, mainly methane and nitrous oxide, that arise as organic waste decomposes in the absence of oxygen. |

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **ACU** | Australian Carbon Unit, issued under the carbon pricing mechanism |
| **ACCU** | Australian Carbon Credit Unit, issued under the Carbon Farming Initiative |
| **AR2** | Second Assessment Report of the Intergovernmental Panel on Climate Change |
| **AR4** | Fourth Assessment Report of the Intergovernmental Panel on Climate Change |
| **BAU** | business-as-usual |
| **$CO_2$** | carbon dioxide, a greenhouse gas |
| **$CO_2$-e** | carbon dioxide equivalent |
| **CCS** | carbon capture and storage |
| **CDM** | Clean Development Mechanism of the Kyoto Protocol |
| **CER** | Certified Emission Reduction unit, created under the Clean Development Mechanism |
| **CFC** | chlorofluorocarbon |
| **CFI** | Carbon Farming Initiative |
| **CGE** | computable general equilibrium (model) |
| **$CH_4$** | methane, a greenhouse gas |
| **COAG** | Council of Australian Governments |
| **CSG** | coal seam gas |
| **DIICCSRTE** | Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education |
| **DoE** | Department of the Environment |
| **EEO** | energy efficiency opportunities |
| **EOR** | enhanced oil recovery |
| **EU** | European Union |
| **EUA** | European Union Allowance, emissions rights issued under the EU ETS |
| **EU ETS** | European Union Emissions Trading System |
| **EV** | electric vehicle |
| **GDP** | gross domestic product |
| **GGAS** | Greenhouse Gas Reduction Scheme, a New South Wales policy to reduce emissions |
| **GNI** | gross national income |
| **GJ** | gigajoule (energy, one billion ($10^9$) Joules) |
| **Gt** | gigatonne (mass, one billion ($10^9$) metric tonnes) |
| **GTEM** | global trade and environment model |

| | |
|---|---|
| **GW** | gigawatt (power, one billion ($10^9$) watts) |
| **GWh** | gigawatt-hour (energy, equal to 3.6 TJ) |
| **GWP** | global warming potential |
| **HCFC** | hydrochlorofluorocarbon, a greenhouse gas |
| **HEV** | hybrid electric vehicle |
| **HFC** | hydrofluorocarbons, a greenhouse gas |
| **ICEV** | internal combustion engine vehicle |
| **IEA** | International Energy Agency |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **Kt** | kilotonne (mass, one thousand metric tonnes) |
| **LCOE** | levelised cost of electricity |
| **LNG** | liquefied natural gas |
| **LULUCF** | land use, land use change and forestry |
| **MMRF** | Monash Multi-Regional Forecasting (model) |
| **MJ** | megajoule (energy, one million ($10^6$) Joules) |
| **Mt** | megatonne (mass, one million metric tonnes) |
| **MW** | megawatt (power, one million watts) |
| **MWe** | megawatt electric |
| **MWh** | megawatt hour (energy, equal to 3.6 GJ) |
| **$N_2O$** | nitrous oxide, a greenhouse gas |
| **NEM** | National Electricity Market |
| **NGER** | National Greenhouse and Energy Reporting |
| **NGGI** | National Greenhouse Gas Inventory |
| **PFC** | perfluorocarbon, a greenhouse gas |
| **PHEV** | plug-in hybrid electric vehicle |
| **PJ** | petajoules (energy, $10^{15}$ joules) |
| **ppm** | parts per million |
| **PPP** | purchasing power parity |
| **QELRO** | quantified emission limitation or reduction objective, form of national carbon budget used in the Kyoto Protocol |
| **REC** | renewable energy certificates |
| **RET** | Renewable Energy Target |
| **$SF_6$** | sulphur hexafluoride, a greenhouse gas |
| **t** | tonne (mass, one metric tonne) |
| **TJ** | terajoules (energy, $10^{12}$ joules) |
| **TWh** | terawatt-hour (energy, equal to 3.6 PJ) |
| **UNEP** | United Nations Environment Programme |
| **UNFCCC** | United Nations Framework Convention on Climate Change |

# REFERENCES

## PART A


**Chapter 1**

*Clean Energy Act 2011* (Cth).

*Climate Change Authority Act 2011* (Cth).

**Chapter 2**

**Australian Council of Social Service (ACOSS) 2013**, *Submission to the Repeal of the Carbon Tax Draft Legislation and Consultation Paper*, viewed 10 December 2013, Canberra, http://acoss.org.au/images/uploads/ACOSS_Submission_to_Senate_Inquiry_into_the_Clean_Energy_Legislation_Bill_2013.pdf.

**Australian Taxation Office (ATO) 2012**, *Flood levy information for individuals*, viewed 30 January 2014, Canberra, www.ato.gov.au/Individuals/Dealing-with-disasters/In-detail/Flood-levy/Flood-levy-information-for-individuals/.

**Bambrick, H, Dear, K, Woodruff, R, Hanigan, I & McMichael, A 2008**, *The impact of climate change on three health outcomes—temperature-related mortality and hospitalisations, salmonellosis and other bacterial gastroenteritis, and population at risk from dengue*, prepared for the Garnaut Climate Change Review, viewed 10 September 2013, Canberra, www.garnautreview.org.au/CA25734E0016A131/WebObj/03-AThreehealthoutcomes/$File/03-A%20Three%20health%20outcomes.pdf.

**Black, RE, Allen, LH, Bhutta, ZA, Caulfield, LE, de Onis, M, Ezzati, M, Mathers, C & Rivera, J 2008**, 'Maternal and Child Undernutrition—Global and Regional Exposures and Health Consequences', *The Lancet*, vol. 371, pp. 243–60.

**Bureau of Meteorology (BoM) 2013**, *Special Climate Statement 43—extreme heat in January 2013*, viewed 1 August 2013, Canberra, www.bom.gov.au/climate/current/statements/scs43e.pdf.

**BoM 2014**, *Annual Climate Statement 2013*, issued 3 January 2014, viewed 6 January 2014, Canberra, www.bom.gov.au/climate/current/annual/aus/2013/?ref=marketing.

**Canadell, JG, Le Quere, C, Raupach, MR, Field, CB, Buitenhuis, ET, Ciais, P, Conway, TJ, Gillett, NP, Houghton, RA & Marland, G 2008**, 'Contributions to accelerating atmospheric $CO_2$ growth from economic activity, carbon intensity, and efficiency of natural sinks', *Proceedings of the National Academy of Sciences*, vol. 104, no. 47, pp. 18,867–70.

**Centre for Climate and Energy Solutions 2012**, *Climate Change and Hurricane Sandy,* viewed 9 October 2013, Washington D.C., www.c2es.org/docUploads/Hurricane-Sandy-Fact-Sheet-Oct-2012.pdf.

**Centre for the Epidemiology of Disasters (CRED) 2011,** *Annual Disaster Statistical Review 2010—The Numbers and Trends,* prepared by Guha-Sapir, D, Vos, F, Below, R & Ponserre, S, Brussels.

**CRED 2013,** *Annual Disaster Statistical Review 2012—The Numbers and Trends,* prepared by Guha-Sapir, D, Hoyois P & Below, R, Brussels.

**Climate Commission 2013a**, *The Critical Decade 2013—Climate change science, risks and responses*, Commonwealth of Australia, Canberra.

**Climate Commission 2013b,** *Angry Summer,* viewed 30 July 2013, Canberra, http://climatecommission.gov.au/wp-content/uploads/130408-Angry-Summer-report.pdf.

**Climate Institute 2012,** *Coming Ready or Not—Managing climate risks to Australia's infrastructure*, The Climate Institute, Sydney.

**Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2010,** *Climate change—science and solutions for Australia,* eds. Cleugh, H, Stafford Smith, M, Battaglia, M & Graham, P, CSIRO Publishing, Melbourne.

**CSIRO and BoM 2012**, *State of the Climate 2012,* prepared by CSIRO and BoM, Canberra.

**De'Ath, G, Fabricius, KE, Sweatman, H & Puotinen, M 2012**, 'The 27-year decline of coral cover on the Great Barrier Reef and its causes', *Proceedings of the National Academy of Science,* vol. 109, no. 44, pp. 17,995–9.

**Department of Climate Change and Energy Efficiency 2011**, *Climate Change Risks to Coastal Buildings and Infrastructure—A Supplement to the First Pass National Assessment,* viewed 10 December 2013, Canberra, http://climatechange.gov.au/climate-change/adapting-climate-change/australias-coasts-and-climate-change/xxxx-adapting-coastal--2.

**Department of Defence 2013,** *Defence White Paper 2013,* viewed 8 August 2013, Canberra www.defence.gov.au/whitepaper2013/docs/WP_2013_web.pdf.

**Garnaut, R 2008**, *The Garnaut Climate Change Review—Final Report,* Commonwealth of Australia, Cambridge University Press, Melbourne.

**Gillard, J 2011**, Press clip announcing introduction of flood levy, www.smh.com.au/business/levy-to-pay-for-56b-flood-bill-20110127-1a64x.html.

**Grumm, RH 2011**, 'The Central European and Russian Heatwave Event of July–August 2010', *American Meteorological Society*, October 2011, pp. 1,285–96.

**Hennessy, KJ, Whetton, PH, Walsh, K, Smith, IN, Bathols, JM, Hutchinson, M & Sharples, J 2008** 'Climate change effects on snow conditions in mainland Australia and adaptation at ski resorts through snowmaking', *Climate Research,* vol. 35, pp. 255–70.

**Hoegh-Guldberg, O, Mumby, PJ, Hooten, AJ, Steneck, RS, Greenfield, P, Gomez, E, Harvell, CD, Sale, PF, Edwards, AJ, Caldeera, K, Knowlton, N, Eakin, CM, Iglesias-Prierto, RH, Muthiga, N, Bradbury, R, Dubi, A & Hatziolos, ME 2007**, 'Coral reefs under rapid climate change and ocean acidification', *Science,* vol. 318, pp. 1,737–42.

**Intergovernmental Panel on Climate Change (IPCC) 1990**, *Climate Change—The IPCC Scientific Assessment,* eds. Houghton, JT, Jenkins, GJ & Ephraums, JJ, Cambridge University Press, Cambridge, New York and Melbourne.

**IPCC 2007a,** *Climate Change 2007—The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge University Press, Cambridge and New York.

**IPCC 2007b,** *Summary for Policymakers in Climate Change 2007—Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge University Press, Cambridge and New York.

**IPCC 2013a,** *Working Group I Contribution to the IPCC Fifth Assessment Report, Climate Change 2013—The Physical Science Basis, Summary for Policy Makers (SPM),* Cambridge University Press, Cambridge and New York.

**IPCC 2013b,** *Working Group I Contribution to the IPCC Fifth Assessment Report, Climate Change 2013—The Physical Science Basis, Final Draft Underlying Scientific-Technical Assessment,* Cambridge University Press, viewed 11 October, Cambridge and New York, http://ipcc.ch/report/ar5/wg1/.

**IPCC 2013c,** *Working Group I Fact Sheet,* viewed 26 November 2013, Cambridge and New York, www.climatechange2013.org/images/uploads/WG1AR5_FactSheet.pdf.

**King, D, Apan, A, Keogh, D & Thomas, M 2014,** 'Adaptation and resilience in two flood-prone Queensland communities', in Boulter, S, Palutikof, J, Karoly, D, Guitart, D (eds), *Natural Disasters and Adaptation to Climate Change,* Cambridge University Press.

**Lenton, TM, Held, H, Kriegler, E, Hall, JM, Luch, W, Rahmstorf, S & Schellnhuber, HJ 2008,** 'Tipping elements in the Earth's climate system', *Proceedings of the National Academy of Sciences,* vol. 105, no. 6, pp. 1,786–93.

**Lewis, SC & Karoly, DJ 2013,** 'Anthropogenic contributions to Australia's record summer temperature of 2013', *Geophysical Research Letters*, vol. 40, pp. 3,705–9.

**Lewis, SC & Karoly DJ 2014,** 'Australia's hottest year was no freak event—humans caused it', *The Conversation*, 6 January 2014, viewed 7 January 2014, n.p., http://theconversation.com/australias-hottest-year-was-no-freak-event-humans-caused-it-21734.

**Lloyd, SJ, Kovats, RS & Chalabi, Z 2011,** 'Climate Change, Crop Yields and Undernutrition—Development of a Model to Quantify the Impact of Climate Change on Child Undernutrition', *Environmental Health Perspectives,* vol. 119, pp. 1,817–23.

**Lucas, C, Hennessy, K, Mills, G, Bathols, J 2007,** *Bushfire weather in southeast Australia—recent trends and projected climate change impacts,* consultancy report prepared for the Climate Institute of Australia, viewed 6 January 2014, Canberra, www.triplehelix.com.au/documents/TCIBushfirefullreport-1.pdf.

**Met Office and JBA Risk Management Limited 2012,** *UK Flooding April–July 2012,* viewed 10 October 2013, London, www.metoffice.gov.uk/media/pdf/e/s/JBA_and_Met_Office_Bulletin_UK_Flooding_April_July_2012.pdf.

**National Aeronautics and Space Administration (NASA) 2013,** 'Surging Elbe in Wittenburg', viewed 9 October 2013, n.p., http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=81368.

**National Climate Change Adaptation Research Facility (NCCARF) 2013,** *Adapting the community sector for climate extremes—Extreme weather, climate change & the community sector: Risks and adaptations*, prepared by Mallon, K, Hamilton, E, Black, M, Beem, B & Abs, J, Gold Coast, viewed 16 December 2013, www.nccarf.edu.au/sites/default/files/attached_files_publications/Mallon_2013_Adapting_community_sector.pdf.

**National Snow and Ice Data Centre (NSIDC) 2012,** 'Arctic sea ice extent settles at record seasonal minimum', viewed 8 August 2013, n.p., http://nsidc.org/arcticseaicenews/2012/09/arctic-sea-ice-extent-settles-at-record-seasonal-minimum/.

**Schaeffer, M, Hare, B, Rocha, M & Rogelj, J (Climate Analytics) 2013,** *Adequacy and feasibility of the 1.5 degree long-term global limit*, viewed 2 August 2013, Berlin, www.climateanalytics.org/sites/default/files/attachments/news/Adequacy%20%26%20feasibility%20of%201.5c%20long-term%20global%20limit%20-%20July%202013-v2.pdf.

**Shepherd, A, Ivins, ER, Geruo, A, Barletta, VR, Bentley, MJ, Bettadpur, S, Briggs, KH, Bromwich, DH, Forsberg, R, Galin, N, Horwath, M, Jacobs, S, Joughin, I, King, MA, Lenaerts, JTM, Li, J, Ligtenberg, SRM, Luckman, A, Luthcke, SB, McMillan, M, Meister, R, Milne, G, Mouginot, JP, Muir, A, Nicolas, J, Paden, J, Payne, AJ, Pritchard, H, Rignot, E, Rott, H, Sorensen, LS, Scambos, TA, Scheuchl, B, Schrama, EJO, Smith, B, Sundal, AV, van Angelen, J, van de Berg, WJ, van den Broeke, MR, Vaughan, DG, Velicogna, I, Whar, J, Whitehouse, PL, Wingham, DJ, Yi, D, Young, D, & Zwally, HJ 2012,** 'A reconciled estimate of ice-sheet mass balance', *Science,* vol. 338, pp. 1,183–9.

**Smith, JB, Schneider, SH, Oppenheimer, M, Yohe, GW, Hare, W, Mastrandrea, MD, Patwardhan, A, Burton, I, Corfee-Merlot, J, Magadza, CHD, Fussell, H, Pittock, AB, Rahman, A, Suarez, A & Van Ypersele, JP 2009**, 'Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) "reasons for concern"', *Proceedings of the National Academy of Sciences,* vol. 106, no. 11, pp. 4,133–7.

**Stern, N 2006**, *Stern Review on the Economics of Climate Change—a report to the Prime Minister of the United Kingdom and Exchequer on the Economics of Climate Change*, London.

**Trenberth, KE 2012**, 'Framing the way to relate climate extremes to climate change', *Climatic Change,* vol. 115, pp. 283–90.

**Trewin, B & Vermont, H 2010**, 'Changes in the frequency of record temperatures in Australia, 1957–2009', *Australian Meteorological and Oceanographic Journal,* vol. 60, pp. 113–19.

**World Meteorological Organisation (WMO) 2011**, *Weather extremes in a changing climate*, viewed 23 July 2013, Geneva, http://library.wm'o.int/pmb_ged/wmo_1075_en.pdf.

### Chapter 3

**Climate Change Authority 2013**, *Caps and Targets Review Issues Paper*, Melbourne.

**den Elzen, MGJ, van Vuuren, DP & van Vliet, J 2010**, 'Postponing emissions reductions from 2020 to 2030 increases climate risks and long term costs—a letter', *Climatic Change*, vol. 99, pp. 313–20.

**Department of Innovation, Industry, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013**, *Australian National Greenhouse Accounts—National Inventory Report 2011 (Volume 1)*, Canberra.

**German Advisory Council on Global Change (WGBU) 2009**, *Solving the climate dilemma—The budget approach—special report 2009,* German Advisory Council on Global Change, Berlin.

**International Energy Agency (IEA) 2012a**, *$CO_2$ emissions from fuel combustion—2012 edn*, Organisation for Economic Co-operation and Development, Paris.

**IEA 2012b**, *World Energy Outlook 2012*, Organisation for Economic Co-operation and Development, Paris.

**IEA 2013**, *Redrawing the energy-climate map*, Organisation for Economic Co-operation and Development, Paris.

**Intergovernmental Panel on Climate Change (IPCC) 2013**, *Working Group I Contribution to the IPCC Fifth Assessment Report, Climate Change 2013—The Physical Science Basis Summary for Policy Makers (SPM),* Cambridge.

**Meinshausen, M, Meinshausen, N, Hare, W, Raper, S, Frieler, K, Knutti, R, Frame, D & Allen, M 2009**, *'Greenhouse-gas emission targets for limiting global warming to 2 °C', Nature,* vol. 458, pp. 1,158–63.

**Raupach, M, Harman, I, & Canadell, J 2011**, *Global climate goals for temperature, concentrations and cumulative emissions*, CAWCR technical report no. 042, Canberra.

**Rogelj, J, Hanaoka, T, Hare, W, Jiang, K, Lowe, J, Matthews, B, Meinshausen, M, Riahi, K & van Vuuren, D 2011**, 'Emissions pathways consistent with a two degree temperature limit', *Nature Climate Change,* vol. 1, pp. 413–18.

**Rogelj, J, McCollum, D, O'Neill, B, & Riahi, K 2012**, '2020 emissions levels required to limit warming to below 2°C', *Nature Climate Change,* vol. 3, pp. 405–12.

**Rogelj, J, Meinshausen, M & Knutti, R 2012**, 'Global warming under old and new scenarios using IPCC climate sensitivity range estimates', *Nature Climate Change,* vol. 2, pp. 248–53.

**Rogelj, J 2013**, *Scenario Note—Pathways towards Returning Warming to below 1.5°C by 2100: Briefing Note to the Climate Institute,* Climate Analytics gGmbH, Berlin.

**Rogelj, J, McCollum, DL, Reisinger, A, Meinshausen, M & Riahi, K 2013**, 'Probabilistic cost estimates for climate change mitigation', *Nature,* vol. 493, pp. 79–83.

**United Nations Environment Programme (UNEP) 2013**, *The Emissions Gap Report*, UNEP, Nairobi.

**World Bank 2012**, *Turn down the heat—why a 4 degree warmer world must be avoided,* Washington D.C.

**Chapter 4**

**Australian Bureau of Statistics (ABS) 2013**, *International trade in goods and services*, Catalogue 5368.0, August, ABS, Canberra.

**Bureau of Resource and Energy Economics (BREE) 2013a**, *2013 Australian energy update*, July, BREE, Canberra.

**BREE 2013b**, *Energy in Australia 2013,* BREE, Canberra.

**Commonwealth of Australia 2013**, *Australia's sixth national communication on climate change—a report under the United Nations Framework Convention on Climate Change*, Canberra.

**den Elzen, M, Roelfsema, M, Hof, A, Böttcher, H & Grassi, G 2012** *Analysing the emission gap between pledged emission reductions under the Cancún Agreements and the 2°C climate target*, PBL Netherlands Environmental Assessment Agency, Copenhagen.

**Department of Foreign Affairs and Trade (DFAT) 2013**, *Country and region factsheets*, viewed 6 September 2013, Canberra, www.dfat.gov.au/geo/fs/aust.pdf.

**Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013**, *China—action on climate change*, viewed 2 October 2013, Canberra, www.climatechange.gov.au/sites/climatechange/files/files/international/13029WEBchina013May.pdf.

**Department of State, United States 2014**, *2014 Climate Change Report*, viewed 20 January 2014, Washington D.C., www.state.gov/e/oes/climate/ccreport2014/.

**Garnaut, R 2013**, *Dog days—Australia after the boom*, Century, Melbourne.

**GLOBE International 2013,** *Climate legislation study—a review of climate change legislation in 33 countries*, third edition, Climate and Development Knowledge Network, Antony Rowe, Chippenham.

**International Energy Agency (IEA) 2012**, *Key world energy statistics*, IEA, Paris.

**IEA 2013a**, *Policies and measures database,* viewed 20 December 2013, Paris, www.iea.org/policiesandmeasures/.

**IEA 2013b**, *Medium-term coal market report 2013,* IEA, Paris.

**International Monetary Fund (IMF) 2013**, *World economic outlook database, October,* viewed 8 January 2014, Washington D.C., www.imf.org/external/pubs/ft/weo/2013/02/weodata/index.aspx.

**Li Gao 2013**, 'Press questions to Li Gao, Deputy Director General, Department of Climate Change, National Development and Reform Commission, People's Republic of China Nov 14, 2013', Youtube, viewed 18 December 2013, n.p., www.youtube.com/watch?v=FHN3UPiOX1U.

**Mathews, J & Tan, H 2013** 'China roars ahead with renewables', *The Conversation,* viewed 17 December 2013, n.p., http://theconversation.com/.

**Network for Climate and Energy Information 2012**, *China's latest energy consumption data reveals new opportunities and challenges*, viewed 30 July 2013, n.p., www.chinafaqs.org/blog-posts/chinas-latest-energy-consumption-data-reveals-new-opportunities-and-challenges-0.

**Organisation for Economic Co-operation and Development (OECD) 2013**, *Economic outlook database,* June, viewed 18 August 2013, Paris, http://stats.oecd.org/.

**PBL 2013,** *Assessment of climate and energy policies of major emitting countries*, PBL, viewed 20 December 2013, Copenhagen, www.pbl.nl/en/publications/assessment-of-climate-and-energy-policies-of-major-emitting-countries.

**Project Catalyst 2010,** *Taking stock—the emission levels implied by the pledges to the Copenhagen Accord*, Briefing Paper, February, Project Catalyst, Brussels.

**Renewable Energy Policy Network for the 21st Century (REN21) 2013**, *Renewables 2013 global status report*, REN21 Secretariat, Paris.

**Rogelj, J & Meinshausen, M 2010,** 'Copenhagen Accord pledges are paltry', *Nature*, vol. 464, 22 April, pp. 1,126–8.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate change mitigation scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**United Nations 2013**, *World population prospects—the 2012 revision*, United Nations, New York.

**United Nations Development Programme (UNDP) 2012,** *Human development index—2012 rankings*, viewed 17 December 2013, New York, http://hdr.undp.org/en/statistics/.

**United Nations Environment Programme (UNEP) 2013**, *The Emissions Gap Report*, UNEP, Nairobi.

**United Nations Framework Convention on Climate Change (UNFCCC) Secretariat 2011,** *Compilation of economy-wide emissions reduction targets to be implemented by parties included in Annex I to the Convention*, FCCC/SB/2011/INF.1/Rev.1, 7 June.

**UNFCCC Secretariat 2013,** *Compilation of information on nationally appropriate mitigation actions to be implemented by Parties not included in Annex I to the Convention*, FCCC/SBI/2013/inf.12/rev.2, 28 May 2013.

**UNFCCC Secretariat 2013,** *Greenhouse Gas Inventory Data*, UNFCCC, June, viewed 1 August 2013, n.p., http://unfccc.int/ghg_data/ghg_data_unfccc/items/4146.php.

**United States Energy Information Administration (US EIA) 2013,** *How many alternative fuel and hybrid vehicles are there in the US?,* viewed 6 August 2013, Washington D.C., www.eia.gov/tools/faqs/faq.cfm?id=93&t=4.

**World Bank 2013,** *Mapping carbon pricing initiatives 2013*, World Bank, Washington D.C.

**World Resources Institute (WRI) 2013a,** CAIT 2.0 (Climate analysis indicators tool) World Resources Institute, viewed 6 January 2014, Washington D.C., http://cait.wri.org.

**WRI 2013b,** *Can the US get there from here? Using existing federal laws and state action to reduce greenhouse gas emissions*, viewed 5 August 2013, Washington D.C., http://pdf.wri.org/can_us_get_there_from_here_full_report.pdf

## PART B

### Chapter 5

**Australian Energy Market Operator (AEMO) 2013,** *National Electricity Forecasting Report for the National Electricity Market*, Melbourne.

**Australian Renewable Energy Agency (ARENA) 2013**, *Annual Report 2012-13*, Canberra.

***Building Energy Efficiency Disclosure Act 2010*** (Cth).

**Büchs, M, Bardsley, N and Duwe, S 2011,** 'Who bears the brunt? Distributional effects of climate change mitigation policies', *Critical Social Policy,* vol. 31, pp. 285–307.

**Climate Change Authority (CCA) 2012,** *Renewable Energy Target Review—Final Report,* Melbourne.

**Clean Energy Finance Corporation (CEFC) 2013,** *Annual Report 2012–13*, Sydney.

*Clean Energy Act 2011* (Cth).

Clean Energy Regulator (CER) 2013, *Register of Offsets Projects,* viewed 10 January 2014, www.cleanenergyregulator.gov.au/Carbon-Farming-Initiative/Register-of-Offsets-Projects/Pages/default.aspx.

Commonwealth of Australia 2013, *Mid-year Economic and Fiscal Outlook—2013–14*, Canberra.

Department of the Environment (DoE) 2013, *Emissions Reduction Fund Green Paper*, Canberra.

Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013, *Australia's Sixth National Communication on Climate Change,* Canberra.

*Greenhouse and Energy Minimum Standards (GEMS) Act 2012* (Cth).

International Monetary Fund (IMF) 2013, *Energy Subsidy Reform—Lessons and Implications,* Washington D.C.

Organisation for Economic Co-operation and Development (OECD) 2013, *Climate and Carbon—Aligning Prices and Policies*, Environment Policy Paper No. 1.

Productivity Commission (PC) 2011, *Carbon Emission Policies in Key Economies—Research Report*, Melbourne.

Wilkins AO, R 2008, *Strategic Review of Australian Government Climate Change Programs*, Canberra.

**Chapter 6**

Australian Energy Market Operator (AEMO) 2012, *Carbon Price—Market Review*, Melbourne.

AEMO 2013, *Carbon Dioxide Equivalent Intensity Index*, viewed 11 October 2013, www.aemo.com.au/Electricity/Settlements/Carbon-Dioxide-Equivalent-Intensity-Index, Melbourne.

Australian Bureau of Statistics (ABS) 2013a, *Australian National Accounts—National Income, Expenditure and Product,* Catalogue 5206.0, ABS, Canberra.

ABS 2013b, *Population Projections, Australia, 2012 (base) to 2101 (series B),* Catalogue 3220.0, ABS, Canberra.

Bureau of Resources and Energy Economics (BREE) 2012, *Economic Analysis of End-use Energy Intensity in Australia,* Canberra.

BREE 2013a, *Australian Energy Statistics*, Canberra.

BREE 2013b, *Beyond the NEM and SWIS—2011–12 Regional and Remote Electricity in Australia, October 2013*, Canberra.

Clean Energy Council (CEC) 2012, *Clean Energy Australia Report 2012,* Melbourne.

ClimateWorks 2013, *Tracking Progress Towards a Low Carbon Economy—National Progress Report,* ClimateWorks Australia, Melbourne.

Department of the Environment (DoE) 2013, *Australian National Greenhouse Accounts: Quarterly Update of Australia's National Greenhouse Gas Inventory, June Quarter 2013,* Canberra.

Frontier Economics 2013, *Client briefing—post hoc ergo propter hoc: Federal Government claims carbon price success.*

Reputex 2013, *Policy brief—renewable energy and the carbon price,* Melbourne.

Saddler, H 2013, *Power down—why is electricity consumption decreasing?,* The Australia Institute, Institute Paper No. 14, December 2013.

Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013, *Climate change mitigation scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**Vivid Economics 2013,** *Analysis of electricity consumption, electricity generations emissions intensity and economy-wide emissions,* report prepared for the Climate Change Authority, London.

## PART C

### Chapter 7

*Clean Energy Act 2011* (Cth).

**Clean Energy Regulator (CER) 2014,** *Supporting the Kyoto Protocol,* CER, Canberra, viewed 13 January 2014, www.cleanenergyregulator.gov.au/ANREU/reports-and-publications/Pages/default.aspx.

**Commonwealth of Australia 2009,** *Parliamentary debates: House of Representatives: official Hansard*, vol 16, pp. 11,205–11,209

**Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *The impact of Kyoto accounting changes on the QELRO and targets,* fact sheet, DIICCSRTE, June 2013, viewed 30 January 2014, www.climatechange.gov.au/international/negotiations/history-negotiations/kyoto-protocol/impact-kyoto-accounting-changes-qelro-and-targets.

**National Emissions Trading Taskforce 2007,** *Possible Design for a National Greenhouse Gas Emissions Trading Scheme: Final framework report on scheme design*, prepared by the National Emissions Trading Taskforce.

**Prime Ministerial Task Group on Emissions Trading 2007,** *Report of the Task Group on Emissions Trading*, Department of Prime Minister and Cabinet, Commonwealth of Australia, Canberra.

### Chapter 8

**Garnaut, R 2008**, *The Garnaut Climate Change Review—Final Report,* Commonwealth of Australia, Cambridge University Press, Melbourne.

**Macintosh, A 2013,** *Mitigation targets, burden sharing and the role of economic modeling in climate policy*, Centre for Climate Law and Policy (CCLP) working paper series 2013/1, Australian National University CCLP, Canberra.

**Stern, N 2012,** *Ethics, equity and the economics of climate change*, Centre for Climate Change Economics and Policy Working Paper No. 97/Grantham Research Institute on Climate Change and the Environment Working Paper No. 84, London.

**United Nations Framework Convention on Climate Change (UNFCCC),** opened for signature 16 March 1992 (entered into force 21 March 1994), art. 3.

### Chapter 9

**Department of Climate Change and Energy Efficiency (DCCEE) 2012,** *Australia's emissions projections*, DCCEE, Canberra.

**Fankhauser, S, Bowen, A, Calel, R, Dechezleprêtre, A, Grover, D, Rydge, J, & Sato, M 2012,** *Who will win the green race? In search of environmental competitiveness and innovation*, Grantham Research Institute on Climate Change and the Environment, London, viewed 9 January 2013, www2.lse.ac.uk/GranthamInstitute/.

**Garnaut, R 2008**, *The Garnaut Climate Change Review—Final Report,* Commonwealth of Australia, Cambridge University Press, Melbourne.

**Höhne, N, Den Elzen, M & Escalante, D 2014,** 'Regional GHG reduction targets based on effort sharing: a comparison of studies', *Climate Policy*, vol. 14, issue 1, 2014, pp. 122–47.

**Rogelj, J, McCollum, DL, Reisinger, A, Meinshausen, M & Riahi, K 2013,** 'Probabilistic cost estimates for climate change mitigation', *Nature*, vol. 493, 3 January, pp. 79–83.

**Treasury 2008,** *Australia's Low Pollution Future—The Economics of Climate Change Mitigation,* Treasury, Canberra.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate Change Mitigation Scenarios*, modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**Chapter 10**

**ACIL Allen Consulting 2013,** *Electricity Sector Emissions—Modelling of the Australian Electricity Generation Sector*, report to the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, Canberra.

**Carbon Disclosure Project (CDP) 2013,** *Use of internal carbon price by companies as incentive and strategic planning tool—A review of findings from CDP 2013 disclosure,* CDP North America, New York.

**Daley, J & Edis, T 2010,** *Markets to Reduce Pollution—Cheaper than Expected,* Grattan Institute, Melbourne.

**Department of Climate Change and Energy Efficiency (DCCEE) 2012,** *Australia's emissions projections*, DCCEE, Canberra.

**Department of the Environment (DoE) 2013,** *Emissions Reduction Fund Green Paper*, DoE, Canberra.

**Dolman, B & Gruen, D 2012,** *Productivity and Structural Change,* 41st Australian Conference of Economists, Canberra.

**Garnaut, R 2008**, *The Garnaut Climate Change Review—Final Report,* Commonwealth of Australia, Cambridge University Press, Melbourne.

**Treasury 2011,** *Strong growth, low pollution*, Treasury, Canberra.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate change mitigation scenarios*, modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

## PART D

**Chapter 11**

**ACIL Allen Consulting 2013,** *Electricity Sector Emissions—Modelling of the Australian Electricity Generation Sector*, report to the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, Canberra.

**Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2013a,** *Costs and Potential of Agricultural Emissions Abatement in Australia*, Canberra.

**ABARES 2013b,** *Agriculture Productivity—Agriculture Commodities March Quarter 2013,* Canberra.

**Australian Energy Market Commission (AEMC) 2012,** *Power of Choice Review—Giving Consumers Options in the Way They Use Electricity,* Final Report, Sydney.

**Australian Energy Market Operator (AEMO) 2013a,** *National Electricity Forecasting Report for the National Electricity Market,* Melbourne.

**AEMO 2013b,** *2013 Forecasting Methodology Information Paper—National Electricity Forecasting,* Melbourne.

**AEMO 2013c,** *Electricity Statement of Opportunities for the National Electricity Market,* Melbourne.

**AEMO 2013d**, *National Electricity Forecasting Report Update for the National Electricity Market,* November, Melbourne.

**AEMO 2013e,** *Gas Statement of Opportunities for Eastern and South-Eastern Australia,* Melbourne.

**Bureau of Resources and Energy Economics (BREE) 2012a,** *Australian Energy Technology Assessment Model—Levelised Cost of Electricity (LCOE) Calculations,* version 1, 31 July 2012, Canberra.

**BREE 2012b,** *Australian Energy Projections, 2049–50,* December, Canberra.

**BREE 2013a,** *Gas Market Report,* Canberra.

**BREE 2013b,** *Resources and Energy Statistics Annual 2013,* Canberra.

**Cambridge Econometrics and Ricardo-AEA 2013,** *An Economic Assessment of Low Carbon Vehicles,* London.

**Chevron 2013,** *Frequently Asked Questions About Climate Change,* viewed 9 January 2014, www.chevron.com/globalissues/climatechange/faq/.

**Climate Change Authority (CCA) 2012,** *Renewable Energy Target Review—Final Report,* Melbourne.

**Climate Institute 2013,** *Boosting Australia's Energy Productivity,* Sydney.

**Climate Policy Initiative 2013,** *The Policy Climate,* viewed 7 October 2013, http://climatepolicyinitiative.org/publication/the-policy-climate/.

**ClimateWorks 2010,** *Low Carbon Growth Plan for Australia,* ClimateWorks Australia, Melbourne.

**ClimateWorks 2013a,** *Tracking Progress Towards a Low Carbon Economy—National Progress Report,* ClimateWorks Australia, Melbourne.

**ClimateWorks 2013b,** *Tracking Progress Towards a Low Carbon Economy—Power,* ClimateWorks Australia, Melbourne.

**ClimateWorks 2013c,** *Tracking Progress Towards a Low Carbon Economy—Supplementary Analysis: Grid-Supplied Electricity Scenarios,* ClimateWorks Australia, Melbourne.

**Dairy Australia 2013,** *Australian Dairy Industry Sustainability Framework Progress Report 2013,* Melbourne.

**Department of Climate Change and Energy Efficiency (DCCEE) 2013**, *Stationary Energy Emissions Projections 2012,* Canberra.

**Department of Energy, Resources and Tourism (DRET) 2013,** *Clean Energy Investment Plans,* viewed 7 January 2014, www.industry.gov.au/EnergySecurity/fund/.

**Department of Environment (DoE) 2013,** *Destruction Incentives Program for Waste Synthetic Greenhouse Gases and Ozone Depleting Substances,* viewed 12 January 2014, www.environment.gov.au/topics/environment-protection/ozone/destruction-incentives-program.

**Department of Infrastructure and Transport (DIT) 2011,** *Light Vehicle $CO_2$ Emission Standards for Australia—Discussion Paper,* Canberra.

**Garnaut, R 2008**, *The Garnaut Climate Change Review—Final Report,* Commonwealth of Australia, Cambridge University Press, Melbourne.

**George Wilkenfeld & Associates 2009,** *Prevention is Cheaper Than Cure—Avoiding Carbon Emissions Through Energy Efficiency: Projected Impacts of the Equipment Energy Efficiency Program to 2020,* Sydney.

**Graham, P, Gargett, D, Evans, C, Cosgrove, D & Ritzinger, A 2012,** *Greenhouse Gas Abatement Potential of the Australian Transport Sector: Summary Report from the Australian Low Carbon Transport Forum*, CSIRO, Australia.

**Grundy, M, Bryan, B, Hatfield-Dodds, S, Nolan, M, Brennan McKellar, L & McCallum, R, (forthcoming 2014),** *Assessing the potential contribution of voluntary land sector plantings to achieving net Australian greenhouse emissions reductions,* CSIRO Sustainable Agriculture Flagship, Brisbane.

**Henry, B & Eckard, R 2008,** 'Greenhouse Gas Emissions in Livestock Production Systems', *Australian Tropical Pastures Conference,* April, pp. 28–32.

**The International Council on Clean Transportation (ICCT) 2013,** *Global Passenger Vehicle Standards*, viewed 23 December 2013, http://theicct.org/info-tools/global-passenger-vehicle-standards.

**International Energy Agency (IEA) 2012a,** *Energy Technology Perspectives,* IEA/OECD, Paris.

**IEA 2012b,** *Progress Implementing the IEA 25 Energy Efficiency Policy Recommendations—2011 Evaluation,* IEA/OECD, Paris.

**IEA 2013a,** *$CO_2$ Emissions from Fuel Combustion—Highlights,* 2013 Edition, IEA/OECD, Paris.

**IEA 2013b,** *Technology Roadmap—Carbon Capture and Storage,* IEA/OECD, Paris.

**IEA 2013c,** *Global Action to Advance Carbon Capture and Storage—A Focus On Industrial Applications,* IEA/OECD, Paris.

**National Transport Commission (NTC) 2013,** *Carbon Dioxide Emissions from New Australian Vehicles 2012—Information Paper,* Canberra.

**Organisation Internationale des Constructeurs d'Automobiles (OICA) 2012,** *PC World Sales,* viewed 23 December 2013, http://oica.net/wp-content/uploads/pc_sales_2005-2012.xls.

**Pitt & Sherry 2013,** *Carbon Emissions Index—Cedex*, July, Pitt & Sherry, Canberra.

**Prime Minister's Task Group on Energy Efficiency 2010,** *Report of the Prime Minister's Task Group on Energy Efficiency*, Department of Climate Change and Energy Efficiency, Canberra.

**Productivity Commission (PC) 2005,** *The Private Cost Effectiveness of Improving Energy Efficiency*, Inquiry Report no. 36, Canberra.

**PC 2013,** *Electricity Network Regulatory Frameworks,* Productivity Commission Report no. 62, Canberra.

**Reedman, L & Graham, P 2013,** *Sensitivity Analysis of Modelling of Light Vehicle Emission Standards in Australia*, Report No. EP1312837, CSIRO, Australia.

**RepuTex 2013,** *Coal Generation—Moving Out of the Crosshairs: Outlook for the Fuel Mix Across the NEM FY13-20,* RepuTex Market Intelligence, Market Update, 21 November, Melbourne.

**Saddler, H 2013,** *Power Down—Why is Electricity Consumption Decreasing?,* Institute paper no. 14, The Australia Institute, Canberra.

**Sinclair Knight Merz (SKM) 2013,** *A Review of Subsidy and Carbon Price Approaches to Greenhouse Gas Emissions Reduction,* report to The Climate Institute, Sinclair Knight Merz, Melbourne.

**Transport Policy.net 2013,** *Mexico—Light-Duty: Fuel Economy and GHG,* viewed 24 December 2013, http://transportpolicy.net/index.php?title=Mexico:_Light-duty:_Fuel_Economy_and_GHG.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate Change Mitigation Scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**United States National Highway Traffic Safety Administration (NHTSA) 2012,** *Corporate Average Fuel Economy for MY 2017-MY 2025 Passenger Cars and Light Trucks: Final Regulatory Impact Analysis,* Washington, D.C.

**United States Environmental Protection Agency (US EPA) 2006,** *Global Mitigation of Non-$CO_2$ Greenhouse Gases*, Washington, D.C.

**Wesfarmers (Wesfarmers Limited) 2013**, *Sustainability Report 2013,* Perth.

### Chapter 12

**Bloomberg New Energy Finance (BNEF) 2014,** *Will 2014 be the last year for UN offsets?,* 3 January.

**Prime Minister's Task Group on Emissions Trading 2007,** *Report of the task group on emissions trading,* Department of the Prime Minister and Cabinet, Canberra, ACT.

**RepuTex Carbon 2013**, *Abatement supply & ERF prices,* Webinar, 11 December, Melbourne.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate change mitigation scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

## PART E

### Chapter 13

**Clean Energy Regulator (CER) 2014,** *Liable Entities Public Information Database for financial year 2012–13,* last updated 10 January 2014, Clean Energy Regulator, Canberra, viewed 23 January 2014, www.cleanenergyregulator.gov.au/Carbon-Pricing-Mechanism/Liable-Entities-Public-Information-Database/LEPID-for-2012-13-Financial-year/Pages/default.aspx.

***Clean Energy Act 2011*** (Cth).

**Department of the Environment (DoE) 2013**, *Australia's National Greenhouse Accounts—Quarterly Update of Australia's National Greenhouse Gas Inventory, June Quarter 2013*, Canberra.

**National GreenPower Steering Group 2013**, *National GreenPower Accreditation Program–Annual Compliance Audit for 1 January 2011 to 31 December 2011,* prepared by Clear Environment, Sydney.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate change mitigation scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

## APPENDICES

### Appendix B

**den Elzen, M, Hof, A & Roelfsema, M 2013,** 'Analysing the greenhouse gas emission reductions of the mitigation action plans by non-Annex I countries by 2020', *Energy Policy,* vol. 56, pp. 633–43.

**Department of Innovation, Industry, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013**, *Australian National Greenhouse Accounts—National Inventory Report 2011 (Volume 1)*, Canberra.

**GLOBE International 2013,** *Climate legislation study—a review of climate change legislation in 33 countries*, third edition, Climate and Development Knowledge Network, Antony Rowe, Chippenham.

**International Energy Agency (IEA) 2012,** *$CO_2$ emissions from fuel combustion*, 12th edn, Paris.

**IEA 2013,** *Policies and measures database,* viewed 20 December 2013, Paris, www.iea.org/policiesandmeasures/.

**International Monetary Fund (IMF) 2013,** *World economic outlook database*, October, viewed 8 January 2014, Washington D.C., www.imf.org/external/pubs/ft/weo/2013/02/weodata/index.aspx.

**Jotzo, F 2010,** 'Comparing the Copenhagen targets', *CCEP Working Papers*, no. 0110, Centre for Climate Economics and Policy, The Australian National University, Canberra.

**Organisation for Economic Co-operation and Development (OECD) 2013,** *Economic outlook database,* June, viewed 18 August 2013, Paris, http://stats.oecd.org/.

**Pew Center 2011,** 'Common metrics—comparing countries' climate pledges', viewed 4 August 2013, Washington D.C., www.c2es.org/docUploads/country-pledge-brief.pdf.

**Renewable Energy Policy Network for the 21st Century (REN21) 2013,** *Renewables 2013 global status report*, REN21 Secretariat, Paris.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate change mitigation scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**United Nations 2013,** *World population prospects—the 2012 revision*, United Nations, New York.

**World Bank 2013,** *Mapping carbon pricing initiatives 2013*, World Bank, Washington D.C.

**World Resources Institute (WRI) 2010,** CAIT 7.0 (Climate analysis indicators tool), World Resources Institute, Washington D.C., Archived version.

**WRI 2013,** CAIT 2.0 (Climate analysis indicators tool) World Resources Institute, viewed 6 January 2014, Washington D.C., http://cait.wri.org.

**Appendix C**

**Baer, P, Athanasiou, T, Kartha, S & Kemp-Benedict, E 2008,** *The Greenhouse Development Rights Framework. The right to development in a climate constrained world, Revised second edition,* Heinrich Böll Foundation, Christian Aid, EcoEquity and the Stockholm Environment Institute, Berlin.

**den Elzen, M, Höhne, N, Hagermann, M, van Vliet, J & van Vuuren, DP, in cooperation with Netherlands Environmental Assessment Agency and Ecofys 2009,** *Sharing developed countries' post-2012 greenhouse gas emission reductions based on comparable efforts,* Netherlands Environmental Assessment Agency (PBL), PBL publication number 500114014, Bilthoven and The Hague.

**EcoEquity and Stockholm Environment Institute 2013,** Greenhouse development rights online calculator, calculator version 2.0.3, data version 6.6.2, viewed 1 October 2013, www.gdrights.org/calculator.

**Garnaut, R 2008**, *The Garnaut Climate Change Review—Final Report,* Commonwealth of Australia, Cambridge University Press, Melbourne.

**German Advisory Council on Global Change 2009,** *Solving the climate dilemma—The budget approach*, Special Report 2009, German Advisory Council on Global Change, Berlin.

**Höhne, N, Den Elzen, M & Escalante, D 2014,** 'Regional GHG reduction targets based on effort sharing: a comparison of studies', *Climate Policy,* vol. 14, issue 1, 2014, pp. 122–47.

**Höhne, N & Moltmann, S 2009,** *Sharing the effort under a global carbon budget,* report by Ecofys commissioned by WWF International, Köln.

**International Energy Agency (IEA) 2013a,** *World energy outlook,* Organisation for Economic Co-operation and Development (OECD)/IEA, Paris.

**IEA 2013b,** *$CO_2$ Emissions from fuel combustion (2013 edition),* OECD/IEA, Paris.

**Jayaraman, T, Kanitkar, T & Dsouza, M 2011,** 'Equitable access to sustainable development: An Indian approach', in *Equitable access to sustainable development—Contribution to the body of scientific knowledge. A paper by experts from BASIC countries*, Beijing, Brasilia, Cape Town and Mumbai.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate change mitigation scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**Appendix D**

***Electricity***

**Abellera, C 2012,** An Update on CCS Public Funding Support, *Insights,* Global CCS Institute, viewed 5 September 2013, www.globalccsinstitute.com/insights/authors/chesterabellera/2012/02/07/updateccspublicfundingsupport.

**Australian Bureau of Statistics (ABS) 2012,** *Energy Use, Electricity Generation and Environmental Management, Australia, 2011–12,* Catalogue 4660.0, ABS, Canberra.

**ACIL Allen Consulting 2013,** *Electricity Sector Emissions—Modelling of the Australian Electricity Generation Sector*, report to the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, Canberra.

**AECOM 2012,** *Statement of Qualifications—Power Plant Decommissioning Services,* USA.

**Australian Energy Market Commission (AEMC) 2012**, *Power Of Choice Review—Giving Consumers Options in the Way They Use Electricity: Final Report*, Sydney.

**AEMC 2013,** *Electricity Price Trends Final Report—Possible Future Retail Electricity Price Movements: 1 July 2012 to 30 June 2015,* 22 March, Sydney.

**Australian Energy Market Operator (AEMO) 2013a**, *National Electricity Forecasting Report for the National Electricity Market*, Melbourne.

**AEMO 2013b**, *Electricity Statement of Opportunities for the National Electricity Market,* Melbourne.

**AEMO 2013c,** *Executive Briefing—100 Per Cent Renewables Study: Draft Modelling Outcomes,* Melbourne.

**AEMO 2013d**, *2013 Forecasting Methodology Information Paper—National Electricity Forecasting,* Melbourne.

**AEMO 2013e,** *National Electricity Forecasting Report Update for the National Electricity Market*, November, Melbourne.

**AEMO 2013f**, *Gas Statement of Opportunities for Eastern and South-Eastern Australia*, Melbourne.

**AEMO 2013g**, *National Transmission Network Development Plan for the National Electricity Market 2013*, December, Melbourne.

**AGL 2013,** *2013 Annual Report*, AGL Energy Limited, North Sydney.

**Beyond Zero Emissions**, *Zero Carbon Australia Buildings Plan*, Melbourne.

**Bloomberg New Energy Finance (BNEF) 2013**, *CCS Market Outlook Q1 2013—The Gap Widens: North America Versus the Rest of the World,* Bloomberg Finance L.P, n.p.

**Bureau of Resources & Energy Economics (BREE) 2012**, *Australian Energy Technology Assessment Model—Levelised Cost of Electricity (LCOE) Calculations,* version 1, 31 July 2012, Canberra.

**BREE 2013a**, *Energy in Australia,* Canberra.

**BREE 2013b**, *Australian Energy Statistics,* Canberra.

**BREE 2013c**, *Beyond the NEM and the SWIS—2011–12 Regional and Remote Electricity In Australia,* Canberra.

**BREE 2013d,** *Australian Energy Technology Assessment 2013 Model Update, December,* Canberra.

**Brundlinger, R, Mayr, C, Fechner, H, Braun, M, Ogimoto, K, Frederiksen, K, Kroposki, B, Graditi, G, MacGill, I, Turcotte, D & Perret, L 2010,** *Bringing Together International Research on High Penetration PV in Electricity Grids—the New Task 14 of the IEA Photovoltaic Power Systems Programme,* International Energy Agency, Paris.

**Citigroup Global Markets 2009**, *New Nuclear—the Economics Say No,* 9 November, Citigroup Global Markets, n.p.

**Climate Change Authority (CCA) 2013**, *Progress Review: Electricity Sector Progress in Reducing Emissions*, industry workshops, Melbourne and Canberra, 12 & 15 August 2013.

**Climate Institute 2013,** *Boosting Australia's Energy Productivity,* New South Wales.

**Climate Policy Initiative 2013**, *The Policy Climate,* viewed 7 October 2013, http://climatepolicyinitiative.org/publication/the-policy-climate/.

**ClimateWorks 2010**, *Low Carbon Growth Plan For Australia*, ClimateWorks Australia, Melbourne.

**ClimateWorks 2013a**, *Tracking Progress Towards a Low Carbon Economy—National Progress Report, ClimateWorks Australia,* Melbourne.

**ClimateWorks 2013b**, *Tracking Progress Towards a Low Carbon Economy—Power, ClimateWorks Australia,* Melbourne.

**ClimateWorks 2013c**, *Tracking Progress Towards a Low Carbon Economy—Buildings, ClimateWorks Australia,* Melbourne.

**ClimateWorks 2013d**, *Tracking Progress Towards a Low Carbon Economy—Supplementary Analysis: Grid-Supplied Electricity Scenarios, ClimateWorks Australia,* Melbourne.

**Colomer, N 2012**, *Clean Up—Financing the Retirement and Remediation of Coal-Fired Power Plants,* December 2012, Saber Partners, viewed 4 October 2013, www.StructuredFinanceNews.com.

**Commonwealth of Australia 2006**, *Uranium Mining, Processing and Nuclear Energy—Opportunities For Australia? Report to the Prime Minister by the Uranium Mining, Processing and Nuclear Energy Review Taskforce,* December, Canberra.

**Commonwealth Science and Industrial Research Organisation (CSIRO) 2013**, *Change and Choice—the Future Grid Forum's Analysis of Australia's Potential Electricity Pathways to 2050*, Newcastle, NSW.

**Department of Climate Change and Energy Efficiency (DCCEE) 2010a**, *Supplementary Discussion Paper on Compliance Obligations and Enforcement Measures for the Proposed National Legislation for Minimum Energy Performance Standards (MEPS) and Energy Labelling*, report number 2010/05, Canberra.

**DCCEE 2010b**, *Australia's Emissions Projections 2010,* Canberra.

**DCCEE 2012**, *Stationary Energy Emissions Projections 2012,* Canberra.

**Department of Industry (DoI) 2013**, *Energy White Paper—Issues Paper to Inform Preparation of a White Paper*, Canberra.

**Drajem, M 2013**, *Coal at Risk as Global Lenders Drop Financing on Climate, Bloomberg,* viewed 7 August 2013, www.bloomberg.com/news/20130805/coalatriskasgloballendersdropfinancingonclimate.html.

**Department of Energy, Resources & Tourism (DRET) 2013**, *Clean Energy Investment Plans,* viewed 7 January 2014, http://industry.gov.au/Energy/EnergySecurity/fund/Pages/default.aspx.

**Dunstan, C, Sharpe, S & Downes, J 2013**, *Investing in Savings: Finance and Cooperative Approaches to Electricity Demand Management,* a scoping study for the Clean Energy Finance Corporation, Institute for Sustainable Futures, Sydney.

**EcoGeneration 2013**, *Solar Augmentation Project at Liddell Power Station, EcoGeneration,* January/February 2013, http://ecogeneration.com.au/news/solar_augmentation_project_at_liddell_power_station/079478/.

**Electric Power Research Institute (EPRI) 2013**, *Cost-Effectiveness of Energy Storage in California, Application of the EPRI Energy Storage Valuation Tool to Inform the California Public Utility Commission Proceeding R. 10-12-007*, Technical Update, June 2013, Palo Alto, California.

**Energy Networks Association 2011**, *Impacts and Benefits of Embedded Generation in Australian Electricity Distribution Networks*, Energy Networks Association, Sydney.

**Environment & Communications References Committee 2013**, *Recent Trends in and Preparedness for Extreme Weather Events,* The Senate, Canberra.

**Foster, J, Bell, WP, Wild, P, Sharma, D, Sandu, S, Froome, C, Wagner, L, Misra, S & Bagia, R 2013**, *Analysis of Institutional Adaptability to Redress Electricity Infrastructure Vulnerability Due to Climate Change*, National Climate Change Adaptation Research Facility, Gold Coast, Queensland.

**Garnaut, R 2008**, *The Garnaut Climate Change Review—Final Report,* Commonwealth of Australia, Cambridge University Press, Melbourne.

**George Wilkenfeld & Associates 2009,** *Prevention is Cheaper Than Cure—Avoiding Carbon Emissions Through Energy Efficiency: Projected Impacts of the Equipment Energy Efficiency Program to 2020,* January.

**Geoscience Australia & ABARE 2010,** *Australian Energy Resource Assessment,* Canberra.

**Global Carbon Capture & Storage Institute (GCCSI) 2013a,** *Country Snapshots,* Global CCS Institute, viewed 5 September 2013, www.globalccsinstitute.com/location.

**GCCSI 2013b,** *Key Topics*, Global CCS Institute, viewed 5 September 2013, www.globalccsinstitute.com/keytopics/statusccs.

**GCCSI 2013c**, *The Global Status of CCS: Update January 2013,* Canberra.

**GCCSI 2013d,** *Proceedings from the 2012 CCS Cost Workshop, 25–26 April 2012,* Palo Alto, California.

**Graham, P, Brinsmead, T & Marendy, P 2013,** *eFuture Sensitivity Analysis 2013,* CSIRO, Melbourne.

**Grundy, M, Bryan, B, Hatfield-Dodds, S, Nolan, M, Brennan McKellar, L, & McCallum, R, (forthcoming 2014),** *Assessing the potential contribution of voluntary land sector plantings to achieving net Australian greenhouse emissions reductions,* CSIRO Sustainable Agriculture Flagship, Brisbane.

**Guevara-Stone, L, 2013,** 100% Renewables: the King Island Example, *The Conversation,* 9 August.

**International Energy Agency (IEA) 2012a,** *World Energy Outlook,* IEA/OECD, Paris.

**IEA 2012b,** *IEA Scoreboard 2011—Implementing Energy Efficiency Policy: Progress and Challenges in IEA Member Countries,* IEA/OECD, Paris.

**IEA 2012c,** *Progress Implementing the IEA 25 Energy Efficiency Policy Recommendations—2011 Evaluation*, IEA/OECD, Paris.

**IEA 2012d,** *Technology Roadmap: High Efficiency, Low-Emissions Coal-Fired Power Generation*, IEA/OECD, Paris.

**IEA 2013a,** *Technology Roadmap: CCS,* IEA/OECD, Paris.

**IEA 2013b,** *$CO_2$ Emissions from Fuel Combustion—Highlights,* 2012 Edition, IEA/OECD, Paris.

**IEA 2013c,** *Redrawing the Energy-Climate Map—World Energy Outlook Special Report,* IEA/OECD, Paris.

**IEA and GCCSI 2012,** *Tracking Progress in Carbon Capture and Storage,* report to the third Clean Energy Ministerial, OECD/IEA/GCCSI, n.p.

**Investment Reference Group 2011,** *A Report to the Commonwealth Minister for Resources and Energy,* Department of Resources, Energy & Tourism, Canberra.

**Kerai, M 2013,** *Coal in 2012,* Department of Energy and Climate Change, UK Government, viewed 6 January 2014, www.gov.uk/government/uploads/system/uploads/attachment_data/file/170721/et_article_coal_in_2012.pdf.

**Macquarie Generation 2012,** *Annual Report,* Hunter Region, NSW.

**Marchment Hill Consulting 2012**, *Energy Storage in Australia: Commercial Opportunities, Barriers and Policy Options,* report to the Clean Energy Council, version 1.

**National Academies Forum 2010,** *Understanding the Formation of Attitudes to Nuclear Power in Australia,* National Academies Forum, Melbourne.

**Organisation for Economic Co-operation and Development (OECD) 2012,** *Nuclear Education and Training: From Concern to Capability*, Nuclear Energy Agency, Paris.

**Parkinson, G 2013a,** Future Grid: Networks Focus on Solar Storage for Customer, *RenewEconomy,* 8 August.

**Parkinson, G 2013b,** Japanese Energy Giants Rush Into Storage as Solar Booms, *RenewEconomy,* 4 December.

**Parkinson, G 2013c,** Germany Finances Major Push Into Home Battery Storage for Solar, *RenewEconomy,* 7 November.

**Photon Energy 2013,** *Photon Energy Investments Revolutionises Australian Solar Market,* press release, 9 December.

**Pitt & Sherry 2013,** Cedex, *Carbon Emissions Index, Data to September 2013 Quarter NEM Update,* Data to November 2013, Melbourne.

**Prime Minister's Task Group on Energy Efficiency 2010,** *Report of the Prime Minister's Task Group on Energy Efficiency*, Department of Climate Change and Energy Efficiency, Canberra.

**Productivity Commission (PC) 2005,** *The Private Cost Effectiveness of Improving Energy Efficiency*, inquiry report no. 36, Canberra.

**PC 2011,** *Carbon Emissions Policies In Key Economies,* research report (appendix L), Canberra.

**PC 2013,** *Electricity Network Regulatory Frameworks,* Productivity Commission Report no. 62, Canberra.

**Reddall, B & Groom, N 2013,** The Energy Storage Holy Grail, *Business Spectator,* viewed 26 August, www.businessspectator.com.au.

**RepuTex 2013,** *Coal Generation: Moving out of the Crosshairs, Outlook for the Fuel Mix Across the NEM FY13-20,* RepuTex Market Intelligence, Market Update, 21 November, Melbourne.

**ROAM 2011,** *Projections of Electricity Generation in Australia to 2050,* report to The Treasury, Queensland.

**Saddler, H 2013,** *Power Down: Why is Electricity Consumption Decreasing?*, Institute paper no. 14, The Australia Institute, Canberra.

**SKM-MMA 2011,** *Carbon Pricing and Australia's Electricity Markets,* report to The Treasury, Melbourne.

**Standing Council on Energy & Resources 2012,** *Report to COAG,* November 2012, viewed 20 August 2013, https://scer.govspace.gov.au/files/2012/12/SCERReporttoCOAGFINAL28November2012.pdf.

**Treasury and Department of Industry, Innovation, Climate Change, Science (DIICCSRTE),** *Research and Tertiary Education) 2013, Climate Change Mitigation Scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**United Nations Environment Programme (UNEP) 2013**, *The Emissions Gap Report*, UNEP, Nairobi.

**United States Environmental Protection Agency (US EPA) 2013,** *National Greenhouse Gas Emissions Data,* viewed 20 August 2013, www.epa.gov/climatechange/ghgemissions/usinventoryreport.html.

**United Stated Department of Energy (US DoE) 2013,** *US Energy Sector Vulnerabilities to Climate Change and Extreme Weather,* DoE/PI0013, Washington, D.C.

**Wood, T & Carter, L 2013,** *Getting Gas Right, Australia's Energy Challenge*, Grattan Institute, Melbourne.

**Wood, T, Edis, T, Morrow, H & Mullerworth, D 2012,** *No Easy Choices: Which Way to Australia's Energy Future? Technology Analysis*, Grattan Institute, Melbourne.

**Yates, A & Mendis, P 2009,** *Climate Change Adaptation for the Electricity Sector: Handbook,* Australian Security Research Centre, Curtin, ACT.

***Transport***

**Austroads 2013,** *Network Operations Network Program 2012–2016,* viewed 1 December 2013, www.austroads.com.au/network-operations.

**Beer, T, Grant, T & Campbell, P 2007,** *The Greenhouse and Air Quality Emissions of Biodiesel Blends In Australia*, CSIRO, Australia.

**Bureau of Infrastructure, Transport & Regional Economics (BITRE) 2009**, *Road and Rail Freight: Competitors or Complements?,* viewed 1 December 2013, www.bitre.gov.au/publications/2009/files/is_034.pdf.

**BITRE 2012,** *Australian Infrastructure Statistics Yearbook,* Canberra

**BITRE 2013,** *Airfares Time Series from October t992 To September 2013,* viewed 21 August 2013, www.bitre.gov.au/statistics/aviation/air_fares.aspx.

**Bureau of Resources and Energy Economics (BREE) 2012,** *Australian Energy Projections to 2049—2050,* Canberra.

**Cambridge Econometrics and Ricardo-AEA 2013**, *An Economic Assessment of Low Carbon Vehicles*, London.

**ClimateWorks 2010**, *Low Carbon Growth Plan for Australia*, ClimateWorks Australia, Melbourne.

**Cristea, A, Hummels, D, Puzello, L, & Avetisyan, M 2012,** *Trade and the Greenhouse Gas Emissions from International Freight Transport,* National Bureau of Economic Research, Cambridge, M.A.

**Department of Climate Change and Energy Efficiency (DCCEE) 2012**, *Transport Emissions Projections 2012,* Canberra.

**Department of Infrastructure and Transport (DIT) 2011,** *Light Vehicle $CO_2$ Emission Standards for Australia—Discussion Paper,* Canberra.

**DIT 2013**, *State of Australian Cities 2013,* Canberra.

**European Commission 2013**, *Reducing $CO_2$ Emissions from Cars,* fact sheet, viewed 21 August 2013, ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm.

**European Union European Environment Agency 2013**, *$CO_2$ Emissions Performance of Car Manufacturers In 2012,* viewed 1 December 2013, www.eea.europa.eu/publications/co2-emissions-performance-of-car-1/at_download/file.

**Façanha, C, Blumberg, K & Miller, J 2012**, *Global Transportation Energy and Climate Roadmap—the Impact of Transportation Policies and Their Potential to Reduce Oil Consumption and Greenhouse Gas Emissions,* International Council on Clean Transportation, Washington, D.C.

**Garnaut, R 2008**, *The Garnaut Climate Change Review—Final Report,* Commonwealth of Australia, Cambridge University Press, Melbourne.

**Graham, P, Gargett, D, Evans, C, Cosgrove, D & Ritzinger, A 2012a,** *Greenhouse Gas Abatement Potential of the Australian Transport Sector—Summary Report from the Australian Low Carbon Transport Forum,* CSIRO, Australia.

**Graham, P, Gargett, D, Evans, C, Cosgrove, D & Ritzinger, A 2012b,** *Greenhouse Gas Abatement Potential of the Australian Transport Sector—Technical Report from the Australian Low Carbon Transport Forum,* CSIRO, Australia.

**Greenville, J, Pobke, C, & Rogers, N 2013,** *Trends in the Distribution of Income in Australia,* Productivity Commission staff working paper, Productivity Commission, Canberra.

**The International Council on Clean Transportation (ICCT) 2013,** *Global Passenger Vehicle Standards—Test Cycle Conversion Tool,* viewed 1 December 2013, www.theicct.org/info-tools/global-passenger-vehicle-standards.

**International Energy Agency (IEA) 2013a,** *$CO_2$ Emissions from Fuel Combustion—Highlights,* 2013 Edition, IEA/OECD, Paris.

**IEA 2013b,** *World Energy Outlook,* IEA/OECD, Paris.

**National Transport Commission (NTC) 2013,** *Carbon Dioxide Emissions from New Australian Vehicles 2012—Information Paper,* Canberra.

**New South Wales Government Office of Biofuels,** *Biofuels in New South Wales,* fact sheet, viewed 21 August 2013, www.biofuels.nsw.gov.au.

**Productivity Commission (PC) 2011,** *Carbon Emission Policies In Key Economies, Appendix M: Road transport fuels,* Research Report, Canberra.

**Reedman, L & Graham, P 2013a,** *Transport Sector Greenhouse Gas Emissions Projections 2013–2050,* CSIRO, Australia.

**Reedman, L & Graham, P 2013b,** *Sensitivity Analysis of Modelling of Light Vehicle Emission Standards in Australia,* CSIRO, Australia.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate Change Mitigation Scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**Transportation National Highway Traffic Safety Administration (NHTSA) 2012,** *Corporate Average Fuel Economy For MY 2017–MY 2025 Passenger Cars and Light Trucks: Final Regulatory Impact Analysis,* Washington, D.C.

**Wild, A 2011,** *Biofuels and Competition In Australia,* viewed 21 August 2013, www.csiro.au/Outcomes/FoodandAgriculture/biofuelsandcompetition.aspx.

***Direct combustion***

**Australia Pacific LNG 2010,** *Environmental Impact Statement Volume 4—LNG Facility, Chapter 14: Greenhouse Gases,* viewed 21 August 2013, www.aplng.com.au/pdf/eis/Volume_4/Vol_4_Chapter14_GreenhouseGas.pdf.

**Bureau of Resources and Energy Economics (BREE) 2011,** *Australian Energy Projections to 2035,* Canberra.

**BREE 2012a,** *Australian Bulk Commodity Exports and Infrastructure: Outlook to 2025,* Canberra.

**BREE 2012b,** *Australian Energy Projections to 2050,* Canberra.

**BREE 2013a,** *Gas Market Report,* Canberra.

**BREE 2013b,** *Resources and Energy Statistics Annual 2013,* Canberra.

**ClimateWorks 2013,** *Tracking Progress Towards a Low Carbon Economy—Industry,* ClimateWorks Australia, Melbourne.

**Department of Climate Change and Energy Efficiency (DCCEE) 2012,** *Stationary Energy Emissions Projections,* Canberra.

**Department of Resources, Energy and Tourism (DRET) 2008,** *Energy Efficiency Opportunities Industry Leader Case Study—Alcoa Pinjarra*, Canberra.

**DRET 2013,** *Case Studies in Systems Optimisation to Improve Energy Productivity,* Canberra.

**George Wilkenfeld & Associates 2009,** *Prevention is Cheaper than Cure—Avoiding Carbon Emissions through Energy Efficiency: Projected Impacts of the Equipment Energy Efficiency Program to 2020,* Sydney.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate Change Mitigation Scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

***Fugitives***

**Blomen, E & Gardiner, A 2009,** *Methane from Fugitive Emissions,* Ecofys, Utrecht, The Netherlands.

**Bureau of Resources and Energy Economics (BREE) 2012,** *Australian Energy Projections to 2050,* Canberra.

**BREE 2013a,** *Gas Market Report,* Canberra.

**BREE 2013b,** *Resources and Energy Statistics Annual 2013,* Canberra.

**ClimateWorks 2013,** *Tracking Progress Towards a Low Carbon Economy—Industry,* ClimateWorks Australia, Melbourne.

**Chevron 2013,** *Frequently Asked Questions about Climate Change,* viewed 9 January 2014, www.chevron.com/globalissues/climatechange/faq/.

**Commonwealth Science and Industrial Research Organisation (CSIRO) 2013**, *Fugitive Emissions from Coal Seam Gas,* viewed 9 January 2014, www.csiro.au/Outcomes/Energy/Fugitive-emissions-from-coal-seam-gas.aspx.

**Department of Climate Change and Energy Efficiency (DCCEE) 2012,** *Fugitive Emissions Projections,* Canberra.

**Hardisty, P, Clark, T, & Hynes R 2012,** *Life Cycle Greenhouse Gas Emissions from Electricity Generation—A Comparative Analysis of Australian Energy Sources,* Energies 5.

**International Energy Agency (IEA) 2013,** *Technology Roadmap—CCS,* IEA/OECD, Paris.

**Kemfert, C & Schill, W 2009,** *An Analysis of Methane Mitigation as a Response to Climate Change,* Copenhagen Consensus of Climate, Copenhagen.

**Pettus, A 2009,** *Methane—Tapping the Untapped Potential,* Clean Air Taskforce, Boston.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate Change Mitigation Scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**United States Environmental Protection Agency (US EPA) 2006a,** *Global Mitigation of Non-$CO_2$ Greenhouse Gases,* Washington D.C.

**US EPA 2006b,** *Options for Reducing Methane Emissions from Pneumatic Devices in the Natural Gas Industry,* Washington D.C.

**Wood, T & Carter, L 2012,** *Getting Gas Right—Australia's Energy Challenge,* Grattan Institute, Melbourne.

***Industrial processes***

**Adelaide Brighton Limited 2012,** *Sustainability Report 2012,* Sydney.

**Adelaide Brighton Limited 2013,** Annual General Meeting, 22 May 2013, Sydney.

**Arrium 2011,** Delivering Sustainable Opportunities, *Onesteel Limited Sustainability Report 2011,* Sydney.

**Arrium 2013,** *Realising Value from Growth 2013 Annual Report,* Sydney.

**Bluescope (Bluescope Steel Limited) 2011,** *Annual Report 2010–2011,* Melbourne.

**Boral Limited 2013,** *Boral Review 2013 Annual Report*, Sydney.

**Bureau of Resources and Energy Economics (BREE) 2013,** *Resources and Energy Quarterly March 2013,* Canberra.

**Cement Industry Federation (CIF) 2013,** *Cement Emissions,* viewed 20 August 2013, http://cement.org.au/SustainabilityNew/ClimateChange/CementEmissions.aspx.

**ClimateWorks Australia 2013,** *Tracking Progress Towards a Low Carbon Economy—Industry,* Melbourne.

**Department of Climate Change and Energy Efficiency (DCCEE) 2012,** *Industrial Processes Emissions Projections 2012,* Canberra.

**Department of the Environment (DoE) 2013,** *Destruction Incentives Program for Waste Synthetic Greenhouse Gases and Ozone Depleting Substances,* viewed 12 January 2014, www.environment.gov.au/topics/environment-protection/ozone/destruction-incentives-program.

**Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *National Inventory Report 2011 Vol. 1,* Canberra.

**IBISWorld 2013,** *IBISWorld Industry Report C1831 Fertiliser Manufacturing in Australia,* Melbourne.

**Incitec (Pivot Limited) 2012,** *Sustainability Report 2012,* Melbourne.

**International Energy Agency (IEA) 2013,** *Global Action to Advance Carbon Capture and Storage—A Focus on Industrial Applications,* Paris.

**International Fertilizer Industry Association 2013,** *Emissions from Production,* viewed 14 November 2013, www.fertilizer.org/ifa/HomePage/SUSTAINABILITY/Climate-change/Emissions-from-production.html.

**Norsk Hydro 2012,** *Norsk Hydro Will Close The Kurri Kurri Aluminium Plant,* viewed 20 August 2013, www.hydro.com/en/Pressroom/News/Archive/Stockexchangeannouncements/2012/HydrowillclosetheKurriKurrialuminiumplant/.

**Orica (Orica Limited) 2013,** *Sustainability Report 2013,* Melbourne.

**Refrigerant Reclaim Australia (RRA) 2013,** *Annual Report 2011–12,* Canberra.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate Change Mitigation Scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**Wesfarmers (Wesfarmers Limited) 2013,** *Sustainability Report 2013,* Perth.

**United States Environmental Protection Agency (US EPA) 2010,** *Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Nitric Acid Production Industry,* North Carolina.

***Agriculture***

**Australian Bureau of Agricultural & Resource Economics and Sciences (ABARES) 2011,** *Reference Case Projections of Australian Agricultural Activity and Greenhouse Gas Emissions: 2007–08 to 2029–30,* February 2011, Canberra.

**ABARES 2013a,** *Costs and Potential of Agricultural Emissions Abatement in Australia*, Canberra.

**ABARES 2013b,** *Agricultural Productivity*, March quarter 2013, Canberra.

**ABARES 2013c,** *Agricultural Commodities,* March quarter 2013, Canberra.

**Australian Bureau of Statistics (ABS) 2012,** *Australian Social Trends,* cat. no. 4102.0, ABS, Canberra.

**Barson, M, Mewett, J & Paplinska, J 2012,** *Land Management Practice Trends in Australia's Broadacre Cropping Industries,* CSIRO, Canberra, pp. 1–11.

**Carberry, P, Keating, B, Bruce, S & Walcott, J 2010**, *Technological Innovation and Productivity in Dryland Agriculture in Australia—A Joint Paper Prepared By ABARES and CSIRO,* July, Canberra.

**ClimateWorks Australia 2013a,** *Tracking Progress Towards a Low Carbon Economy—Land-use & Waste,* Melbourne.

**Dairy Australia 2013,** *Australian Dairy Industry Sustainability Framework Progress Report 2013,* Melbourne.

**Department of Agriculture, Fisheries and Forestry (DAFF) 2013,** *Australian Food Statistics 2011–12,* Canberra.

**Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *National Inventory Report 2011 Vol. 1,* Canberra.

**Henry, B & Eckard, R 2008,** 'Greenhouse Gas Emissions in Livestock Production Systems', *Australian Tropical Pastures Conference,* April, pp. 28–32.

**Linehan, V, Thorpe, S, Gunning-Trant, C, Heyhoe, E, Harle, K, Hormis, M & Harris-Adams, K 2013,** *Global food production and prices to 2050: scenario analysis under policy assumptions,* ABARES conference paper 13.6, Canberra.

**Reserve Bank of Australia (RBA) 2013,** *Index of Commodity Prices July 2013,* viewed 23 September 2013, www.rba.gov.au/statistics/frequency/commodity-prices/2013/icp-0713.html.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate Change Mitigation Scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**Tubiello, F, Salvatore, M, Rossi, S & Ferrara, A 2012**, 'Analysis of Global Emissions, Carbon Intensity and Efficiency of Food Production, Studi & Ricerche Research Papers', *Energia*, Ambiente e Innovazione, 45/2012, pp. 87–93.

**United Nations Environment Programme (UNEP) 2013**, *The Emissions Gap Report*, UNEP, Nairobi.

***Land use, land use change, and forestry (LULUCF)***

**Burns, K, Hug, B, Lawson, K, Ahammad, H & Zhang, K 2011,** 'Abatement Potential from Reforestation under Selected Carbon Price Scenarios', *ABARES*, Canberra, pp. 4–28.

**Centre for International Economics (CIE) 2013,** *Australian Agricultural Emissions Projections to 2050*, Canberra.

**Clean Energy Regulator (CER) 2013,** *Register of Offsets Projects,* viewed 11 December 2013, www.cleanenergyregulator.gov.au/Carbon-Farming-Initiative/Register-of-Offsets-Projects/Pages/default.aspx.

**Climate Policy Initiative 2013,** *The Policy Climate*, San Francisco.

**ClimateWorks Australia 2013,** *Tracking Progress Towards a Low Carbon Economy—Land-use and Waste*, Melbourne.

**Commonwealth of Australia 2013,** *The Senate Questions Without Notice Forestry*, 5 December 2013, Canberra, p. 980.

**Department of Climate Change and Energy Efficiency (DCCEE) 2009,** *Drivers of Land Clearing in Australia*, Canberra.

**Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013a,** *National Inventory Report 2011 Vol. 2*, Canberra.

**DIICCSRTE 2013b,** *Australian National Greenhouse Accounts, State & Territory Greenhouse Gas Inventories 2010–11*, Canberra.

**DIICCSRTE 2013c,** *Australian National Greenhouse Accounts, Australian Land Use, Land Use Change and Forestry Emissions Projections to 2030*, Canberra

**Grundy, M, Bryan, B, Hatfield-Dodds, S, Nolan, M, Brennan McKellar, L, & McCallum, R, (forthcoming 2014).** *Assessing the potential contribution of voluntary land sector plantings to achieving net Australian greenhouse emissions reductions*, CSIRO Sustainable Agriculture Flagship, Brisbane.

**Jacobs, A (Minister for Environment, Western Australia) 2013,** Land Clearing Changes to Reduce Red Tape, media release, Parliament House, Perth, 3 December 2013, viewed 8 December 2013, www.mediastatements.wa.gov.au/pages/StatementDetails.aspx?listName=StatementsBarnett&StatId=8001.

**New Zealand Ministry for the Environment 2013,** *New Zealand's Net Position under the Kyoto Protocol*, viewed 15 September 2013, www.mfe.govt.nz/issues/climate/greenhousegasemissions/netposition.

**Polglase, P, Reeson, A, Hawkins, C, Paul, P, Siggins, A, Turner, J, Crawford, D, Jovanovic, T, Hobbs, T, Opie, K, Carwardine, J & Almeida, A 2011,** *Opportunities for Carbon Forestry in Australia: Economic Assessment and Constraints to Implementation,* CSIRO, Canberra.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate Change Mitigation Scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

***Waste***

**Blue Environment 2011,** *Waste Sector Emission Parameters—Projections to 2030, for Department of Climate Change & Energy Efficiency*, Melbourne.

**ClimateWorks Australia 2013,** *Tracking Progress Towards a Low Carbon Economy—Land-use and Waste*, Melbourne.

**Productivity Commission (PC) 2006,** *Waste Management*, Productivity Commission Inquiry Report no. 38, Canberra.

**SKM-MMA 2012,** *Modelling of the Renewable Energy Target, Report to the Climate Change Authority*, Melbourne.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate Change Mitigation Scenarios*, modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**UK Committee on Climate Change (UK CCC) 2013,** *Meeting Carbon Budgets: 2013 Progress Report to Parliament*, London.

**Appendix E**

**Clean Energy Regulator (CER) 2014a,** *Liable Entities Public Information Database for financial year 2012–13*, last updated 10 January 2014, Canberra, viewed 23 January 2014, www.cleanenergyregulator.gov.au/Carbon-Pricing-Mechanism/Liable-Entities-Public-Information-Database/LEPID-for-2012-13-Financial-year/Pages/default.aspx.

**CER 2014b,** *Published information—voluntary cancellations,* CER, Canberra, viewed 13 January 2014, www.cleanenergyregulator.gov.au/ANREU/reports-and-publications/Pages/default.aspx.

**Department of Environment (DoE) 2013,** *Australia's abatement task and 2013 emissions projections*, Canberra.

**National GreenPower Steering Group 2013,** *National GreenPower Accreditation Program—Annual Compliance Audit for 1 January 2011 to 31 December 2011,* prepared by Clear Environment, Sydney.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate change mitigation scenarios*, modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

**Appendix F**

**ACIL Allen Consulting 2013,** *Electricity Sector Emissions—Modelling of the Australian Electricity Generation Sector*, report to the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, Canberra.

**Bloomberg New Energy Finance (BNEF) 2013a,** *Would a –15% target lift Australia's carbon price?,* BNEF, Sydney.

**BNEF 2013b,** *Australia Deep Dive—one year, none the wiser,* BNEF, Sydney.

**Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2011,** *Road vehicle-kilometres travelled: estimation from state and territory fuel sales*, Report 124, Department of Infrastructure and Transport, Canberra.

**Bureau of Resources & Energy Economics (BREE) 2013,** *2013 Australian energy statistics*, BREE, Canberra.

**Centre for International Economics (CIE) 2013,** *Australian agricultural emissions projections to 2050*, CIE, Canberra.

**Department of the Environment (DoE) 2013,** *Australia's abatement task and 2013 emissions projections*, DoE, Canberra.

**Department of Innovation, Industry, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013**, *Australian National Greenhouse Accounts—National Inventory Report 2011 (Volume 1)*, Canberra.

**DIICCSRTE 2013b,** *National Greenhouse Accounts Factors—July 2013, DIICCSRTE, Canberra*.

**European Commission 2013,** *Allowance and caps,* European Commission, Brussels, viewed 1 October 2013, http://ec.europa.eu/clima/policies/ets/cap/index_en.htm.

**Reedman, L & Graham, P 2013,** *Transport sector greenhouse gas emissions projections 2013–2050,* Report No. EP139979, CSIRO, Australia.

**RepuTex 2013**, *Carbon Price Outlook—Early Start in Australia?,* Reputex, Melbourne.

**Treasury and the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) 2013,** *Climate change mitigation scenarios,* modelling report provided to the Climate Change Authority in support of its Caps and Targets Review, Canberra.

# INDEX

**V**



**W**

# NOTES

CLIMATE
CHANGE
AUTHORITY

LEVEL 10
90 COLLINS STREET
MELBOURNE

GPO BOX 1944
MELBOURNE VIC 3001

FREECALL
1800 475 869

EMAIL
ENQUIRIES@CLIMATECHANGEAUTHORITY.GOV.AU

**CLIMATE**
CHANGE
**AUTHORITY.GOV.AU**