



Australian Government
Climate Change Authority

POLICY OPTIONS FOR AUSTRALIA'S ELECTRICITY SUPPLY SECTOR SPECIAL REVIEW RESEARCH REPORT

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CONTENTS

Acknowledgements	ii
Chair’s foreword	7
Summary	8
Chapter 1. About this research report	12
1.1. Introduction.....	12
1.2. The challenge of climate change	12
1.3. The Climate Change Authority and its Special Review	13
1.4. Scope	13
1.5. Structure of this report.....	14
Chapter 2. The electricity sector and Australia’s emissions reduction goals	15
2.1. Electricity, emissions and climate policy	15
2.2. Current climate policies and near-term emissions outlook.....	18
2.3. The role of the electricity sector in Australia’s emissions reduction goals	19
2.4. Opportunities for reducing electricity emissions	23
2.5. Electricity markets: key background	24
2.5.1. Market structure and wholesale markets	24
2.5.2. Retail electricity prices.....	25
2.5.3. Electricity demand	27
2.5.4. Capacity	29
Chapter 3. Possible policies and approach to assessment	31
3.1. Policy options to reduce Australia’s electricity sector emissions.....	31
3.2. The Authority’s approach to comparing policies.....	34
3.3. Modelling commissioned for this Review.....	37
Chapter 4. Assessing policy options for Australia’s electricity supply sector	43
4.1. Comparing the performance of policies to reduce electricity emissions	43
4.1.1. Environmental effectiveness	44
4.1.2. Cost effectiveness	46
4.1.3. Equity.....	48
4.2. The Authority’s view: a market mechanism	52
4.3. What type of market mechanism?	52
4.3.1. Environmental effectiveness	53
4.3.2. Cost effectiveness	55
4.3.3. Equity.....	57
4.3.4. Options for market mechanisms: summary.....	58

Chapter 5. Should there be additional policies in the sector?	59
5.1. Is there a case for policies in addition to a market mechanism?	59
5.2. Possible additional policies	60
5.2.1. Exit and technology pull policies	61
5.2.2. Emissions standards for new generators	65
Appendix A Terms of reference	67
Appendix B Framework for evaluating electricity sector policies	68
Appendix C Modelling commissioned for this review	70
Appendix C.1 Electricity sector modelling	70
Modelling approach	70
Scenarios and sensitivities	71
Key inputs and assumptions	73
Technology costs	73
Key estimated impacts	74
Generation mix	75
Emissions	76
Prices	77
Generator profits	80
Resource cost and cost of abatement	81
Appendix C.2 Peer review of modelling	83
Appendix C.3 Economy-wide modelling	84
Modelling approach	84
Scenarios	85
Key inputs and assumptions	86
Electricity modelling inputs to economy-wide modelling	87
Economy-wide modelling results	89
Glossary of Terms	96
Abbreviations and Acronyms	101
References	104

FIGURES

Figure 1 Average cost of abatement by policy, 2 degrees, 2020–2050	10
Figure 2 Australian electricity generation by source, 2000–2014	16
Figure 3 Emissions and emissions intensity by generator type, 2014–15	16
Figure 4 Australian renewable electricity generation by type, 2000–2014	17
Figure 5 Emissions intensity of electricity generation, 2 degree pathways	22
Figure 6 Australia’s electricity system	24
Figure 7 Price setting in the wholesale market	26

Figure 8	Breakdown of average national residential electricity price, 2014–15	27
Figure 9	Operational electricity demand, NEM and WEM, 2006–2016.....	28
Figure 10	Emissions intensity scheme: baseline, credit and liabilities	34
Figure 11	Emissions by policy, 2 degrees, 2020–2050.....	44
Figure 12	Emissions by policy, high demand sensitivity, 2020–2050	45
Figure 13	Average cost of abatement by policy, 2 degrees, 2020–2050.....	47
Figure 14	Average residential retail price by policy, 2 degrees, 2020–2050	49
Figure 15	Average wholesale electricity price by policy, 2 degrees, 2020–2050.....	50
Figure 16	Difference in NPV of gross profits for incumbent coal generators from reference case, 2 degrees, 2020–2050.....	51
Figure 17	Change in capacity of large-scale renewable and low-emissions technologies, 2 degrees, 2020–2050.....	52
Figure 18	Total supply-side and demand-side emissions reductions by policy, 2 degrees, 2020– 2050	54
Figure 19	Percentage change in various economic metrics, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050.....	56
Figure 20	Average cost of abatement, policy options and combinations, 2 degrees, 2020–2050	62
Figure 21	Resource costs of technology pull policies relative to reference case, 2 degrees, 2020–2050.....	64
Figure 22	Average emissions intensity of new generators, by type	66
Figure 23	Technology capital cost comparison	74
Figure 24	Emissions by policy scenario, 2 degrees, 2020–2050	76
Figure 25	Emissions intensity by policy scenario, 2 degrees, 2020–2050.....	77
Figure 26	Average wholesale electricity price by policy, 2 degrees, 2020–2050.....	78
Figure 27	Average residential retail price by policy, 2 degrees, 2020–2050	79
Figure 28	Average annual residential customer spending, relative to reference, 2 degrees, 2020–2050.....	79
Figure 29	Difference in NPV of gross profits for incumbent coal generators, relative to reference, 2 degrees, 2020–2050	80
Figure 30	Resource costs relative to the reference scenario, 2 degrees, 2020–2050	82
Figure 31	Average cost of abatement by policy, 2 degrees, 2020–2050.....	83
Figure 32	Iterative modelling using CGE and electricity sector models	85
Figure 33	Average residential electricity prices by scenario, economy-wide modelling, 2020– 2050	88
Figure 34	Change in electricity demand, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050.....	89
Figure 35	Change in Australian domestic emissions, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050	90
Figure 36	Personal and company income tax rates by scenario, economy-wide modelling	91

Figure 37	Percentage change in various economic metrics, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050.....	93
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TABLES

Table 1	Major climate change policies—large-scale electricity supply sector	20
Table 2	Electricity sector policies analysed, by category	31
Table 3	Description of electricity sector policies.....	33
Table 4	Summary of CGE modelling policy scenarios	40
Table 5	Related modelling studies overview	41
Table 6	Projections of gross national income, economy-wide modelling, relative to cap and trade (lump sum), 2020–2050	56
Table 7	Relationship between modelling questions, sensitivities and policies	72
Table 8	Key modelling assumptions for core scenarios.....	73
Table 9	Share of generation by technology type, 2 degrees, 2030 and 2050	75
Table 10	Overview of macroeconomic assumptions, economy-wide modelling.....	87
Table 11	Share of generation by technology type by scenario, economy-wide modelling, 2030 and 2050	89
Table 12	Projections of gross national income, economy-wide modelling, relative to cap and trade (lump sum), 2020–2050	92
Table 13	Change in sectoral gross value added, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050.....	94

BOXES

BOX 1	ELECTRICITY RELIABILITY, SECURITY AND INTERMITTENT RENEWABLE GENERATION	21
BOX 2	WHOLESALE ELECTRICITY MARKETS AND INTERACTION WITH CLIMATE POLICIES	26
BOX 3	IMPORTANT ELECTRICITY TERMS	29
BOX 4	SMALL-SCALE TECHNOLOGIES: DRIVERS OF UPTAKE AND IMPLICATIONS FOR CLIMATE POLICY	32
BOX 5	EMISSIONS INTENSITY SCHEME: OVERVIEW.....	34
BOX 6	SUPPLY- AND DEMAND-SIDE EMISSIONS REDUCTIONS FROM SUPPLY-SIDE POLICIES	54
BOX 7	RENEWABLE ENERGY TARGETS, LOW EMISSIONS TARGETS, AND CONTRACTS FOR DIFFERENCE: EXPLORING TECHNOLOGY PULL POLICIES	64

CHAIR'S FOREWORD

The Climate Change Authority has today released a research report on options to reduce emissions from the electricity generation supply sector as part of the Authority's Special Review into Australia's climate policy. The analysis in this report has informed the Authority's final recommendations on policies for the electricity sector outlined in 'Report Three' of the Special Review (*Towards a climate policy toolkit: Special Review on Australia's climate goals and policies*). This report was originally intended for consultation and is now being released as a research report alongside Report Three.

This report focuses on the key sector of electricity which accounts around one-third of Australia's emissions and is a key driver of our economic growth and prosperity. Of course, electricity is only one part of the climate change challenge—other sectors will need to play their part. Significant emissions reductions opportunities elsewhere in the economy will need to be realised and the Authority has considered electricity emissions reductions as part of a toolkit of policies to achieve economy wide emissions reductions.

Policy options for Australia's electricity supply sector compares the performance of different policies that could be applied to the electricity sector to meet a demanding emissions reduction constraint consistent with limiting warming to 2 degrees.

The Authority is of the view that Australia cannot make the transition to a lower emissions economy without taking strong action over coming decades to decarbonise the electricity sector.

With this in mind, the Authority has indicated in this report its view that a market mechanism of some sort should be implemented in the electricity sector. Economic analysis, including the Authority's modelling, suggests that a market mechanism for electricity would allow Australia to meet its targets at a lower cost to the community than would be possible without such a policy in the toolkit.

Market mechanisms can take many forms. In its second report of the Special Review, the Authority characterised carbon taxes, baseline and credit, cap and trade and emissions intensity schemes as options for a market mechanism. In that report, these policies are compared along with other policies to reduce emissions, for example, 'technology pull' policies such as renewable energy targets, voluntary pricing or offsets, regulation, information programs and innovation support.

The Authority intends for the analysis and modelling in this report to help support and inform the continuing debate on how best to reduce emissions in the key sector of electricity generation. I thank the many organisations and individuals that made submissions on these matters or participated in experts groups that provided invaluable help and guidance on this work.

Wendy Craik AM

SUMMARY

Why has the Authority published this report?

The Authority has released this report as part of the work on emissions reduction policies for Australia's electricity supply sector for its Special Review into Australia's post-2020 climate policy. The Authority's Special Review comes at an important time. The Paris Agreement means Australia, along with other countries, aims to strengthen the ambition of its emissions reduction goals over time.

This report and Report Three of the Special Review build on the Authority's *Draft report on Australia's climate policy options* ('Report Two' of the Special Review). That report, released for consultation in November last year, set out possible emissions reduction policies for Australia.

More than 65 individuals and organisations made submissions on Report Two. There was strong support for the Authority's proposed approach to evaluating policies, and support from across the community for clear, stable, long-term climate policy that can be scaled up over time to deliver Australia's commitments under the Paris Agreement. On the electricity sector, most of the submissions supported a market mechanism of some form to reduce emissions. There were some proposals, including from electricity supply businesses, for implementing additional policies—for example, retirement of existing high-emissions coal-fired generation.

Why the electricity supply sector?

As Australia's largest source of emissions and a significant source of emissions reduction opportunities, the sector is important for realising Australia's overall emissions reduction goals. The big opportunities for reducing emissions rely on investors having the confidence to take different investment decisions—for example, choosing zero- or low-emissions generation over high-emissions generation. Without climate policy, the lower emissions options are often more expensive overall so, to change their decisions, investors need to be confident that climate policy can 'switch' the economics of these types of generation over the life of the investment, which can be decades.

Climate policies should also be flexible enough to perform well in a range of circumstances as the sector and wider economy could change over coming decades.

Where does this report fit in?

This report focuses on policies in the large-scale electricity supply sector (the 'supply side'). There are several important, related policy areas—such as electricity demand including energy efficiency and innovation—which are not considered here. These are considered in Report Three of the Special Review, in addition to the potential impacts on the competitiveness of Australian businesses that could result from emissions reductions policy. This analysis does not assess current policies to reduce emissions, including the current Renewable Energy Target, Emissions Reduction Fund and safeguard mechanism.

The terms of reference for the Special Review required the Authority to consider, among other things, whether Australia should introduce an emissions trading scheme. As outlined in Report Three, the Authority has sought to answer this question by comparing the performance of emissions trading

schemes with other possible policies and considering how policies could interact with each other, particularly in the key sector of electricity generation.

To that end, this report assesses possible emissions reduction policies for the electricity supply sector against the Authority's evaluation principles. Given the importance of long-term, stable policy architecture in a sector facing other changes and challenges over the coming decades, the Authority has placed particular emphasis on policies being able to respond flexibly to changes and their ability to be scaled up over time.

To make this assessment the report draws on analysis—including new modelling of the electricity sector and the Australian economy commissioned for the Special Review—as well as submissions to Report Two.

The Authority has assessed three broad 'families' of possible electricity sector policies:

- 'Market mechanisms', in particular carbon taxes, cap and trade schemes and emissions intensity schemes.
- 'Technology pull policies' policies that encourage the deployment of additional renewable and/or low-emissions generation. These policies vary in their technology eligibility (for example whether they support only renewable generation or also allow other zero- or low-emissions sources) and their design (for example whether eligible generators receive tradable certificates or a payment from the government).
- Regulation: on entry and/or exit of generators, such as standards for the emissions performance of new or existing power stations, regulated closure of old, emissions-intensive generators, and facility-level absolute emissions baselines for emissions-intensive generators.

The Authority's assessment is structured around the following questions:

- Is meeting a 2 degree consistent emissions budget in the electricity sector feasible and what might this cost?
- Should there be a market mechanism of some kind in the electricity sector? If not, what policy or policies should be used to reduce emissions?
- If there is a market mechanism in the sector, what are the relative strengths and weaknesses of different market mechanisms?
- If there is a market mechanism, should there be other climate policies in the electricity supply sector?
- If so, which policy or policies and why?

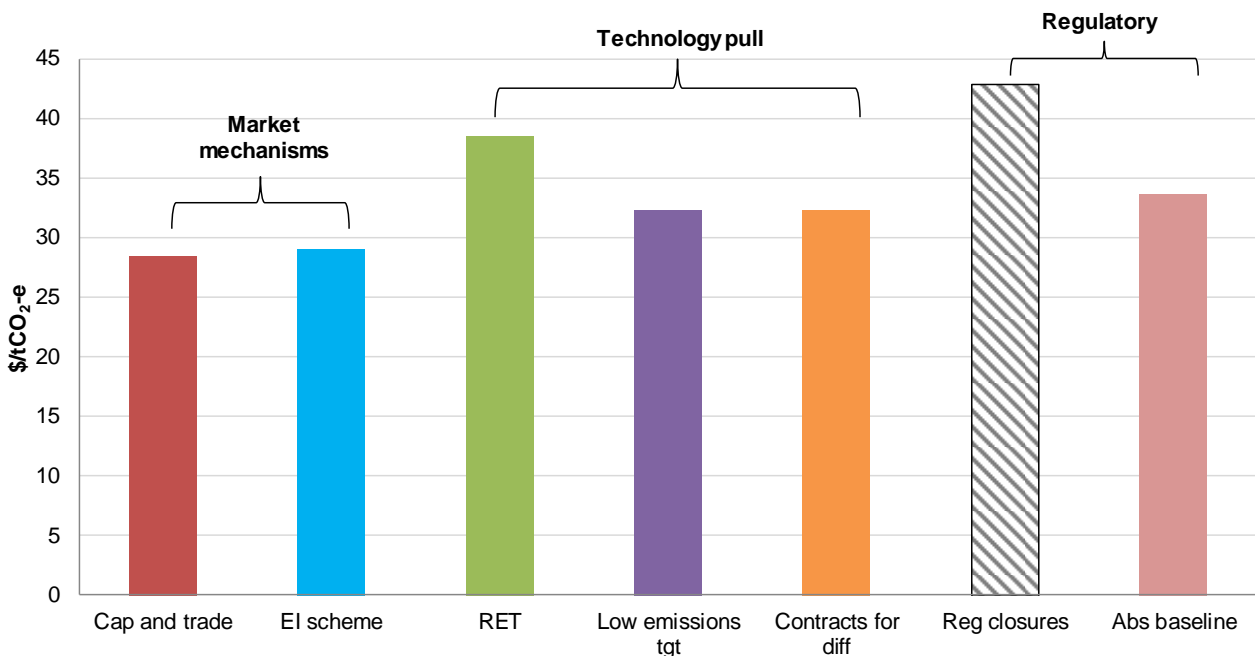
[A market mechanism should be implemented in the electricity sector](#)

The Authority's view is that Australia should implement a market mechanism of some form in the electricity sector. This is based on the assessment of the performance of policies against the three core evaluation principles of cost effectiveness, environmental effectiveness and equity (Chapter 4). Overall, the Authority finds that:

- All policy options are capable of achieving deep emissions reductions in the electricity sector, but market mechanisms are more flexible and scalable.
- Among the policies, technology pull and regulatory policies have greater costs and risks than market mechanisms, especially when used alone or to meet demanding targets.

- Economic analysis, including the Authority’s modelling, suggests that a market mechanism for electricity would allow Australia to meet its targets at a lower cost to the community than would be possible without such a policy in the toolkit. For example, based on the direct cost of reducing emissions using each policy, market mechanisms are projected to have the lowest costs (Figure 1).
- All supply-side emissions reduction policies will affect some groups, however these impacts can be addressed in a number of ways (Chapter 4). For all possible policies, before any assistance is provided, achieving Australia’s long-term emissions reduction goals is likely to increase electricity prices for consumers to some extent and change the relative value of generators’ plant.
- This analysis and modelling considered action in the electricity sector only. The costs in the electricity sector would likely be lower if a market mechanism was part of a broader policy toolkit that included other targeted measures to reduce emissions in other sectors of the economy including measures like energy efficiency, offsets and regulation. Furthermore, in practice, emissions reductions can be lower cost than modelling suggests.

Figure 1 Average cost of abatement by policy, 2 degrees, 2020–2050



Note: See Table 3 in Chapter 3 for a summary of the policies. ‘EI scheme’ = emissions intensity scheme; ‘RET’ = Renewable energy target; ‘Low emissions tgt’ = Low emissions target; ‘Contracts for diff’ = contracts for difference; ‘Reg closures’ = regulated closures, ‘Abs baseline’ = absolute baselines. Average direct cost of abatement over 2020–2050 using a seven per cent discount rate for resource costs. Direct costs are the additional costs arising from the policy in the electricity sector. Emissions not discounted. Figures account for the reduction in welfare from a fall in electricity demand compared to the reference case resulting from increased retail electricity prices. The regulated closures policy breaches the common cumulative emissions budget by about 200 Mt CO₂-e or 15 per cent, so the cost of abatement here is not directly comparable with other policies. See Appendix C.1. All dollar figures in this report are in 2014 Australian dollars unless otherwise specified.

Source: Climate Change Authority based on Jacobs 2016c.

A market mechanism could cover sectors other than electricity supply, and submissions to Report Two noted the importance of coverage choices for the effectiveness of market-based schemes. The Authority has considered the use of market mechanisms in other sectors, as well as other important design features such as the use of international credits and permits and issues of transition, in Report Three.

Which type of market mechanism?

While there are differences between the market mechanisms assessed in this report, they have much in common in terms of operation and impacts. In particular, each can readily be scaled to drive stronger emissions reductions in electricity supply at lower cost than alternative policies.

The Authority's economy-wide modelling compared the relative performance of cap and trade and emissions intensity schemes and assessed the impact of these schemes on both direct and indirect costs. Direct costs are the additional costs above those that would have occurred in the absence of the policy, such as the added cost of investing in a low-emissions electricity generation plant rather than a high-emissions one. In addition to their direct costs, policies often involve indirect costs, including those due to interactions with the tax system. Taxes and price rises generally dampen economic activity. These indirect costs are more important to the cost effectiveness of policies than has been generally recognised (Goulder 2013). The modelling suggests that the performance of different policies with respect to indirect costs depends in part on how revenue is recycled. Overall:

- Cap and trade schemes, carbon taxes and emissions intensity schemes have similar cost effectiveness. Recycling revenue through tax cuts is likely to be somewhat more cost-effective than an emissions intensity scheme, while 'lump sum' revenue recycling (for example through increases in government payments) is likely to be the least cost-effective of the three.
- An emissions intensity scheme tends to have a smaller impact on electricity prices than a cap and trade scheme, and so is likely to cause smaller tax interaction effects, and a smaller effect on economic activity.
- In contrast, a cap and trade scheme with auctioning or a carbon tax can raise significant amounts of revenue and, in that case, the equity effects will depend heavily on how this revenue is recycled.

Possible additional policies

The report considers the case for adding other policies to a market mechanism in the electricity generation sector. Such policies could include technology pull policies that target the entry of low-emissions generation, or policies that regulate the entry or exit of high-emissions generators.

In principle, additional regulatory or technology pull policies can reduce the costs of new low emissions technologies through targeted support and provide additional investor confidence. On the other hand, adding policies to a market mechanism can increase costs and the complexity of the regulatory environment. The prospect of new policies being implemented can also add to uncertainty as investors may delay new investment until the measures are designed and in place. Chapter 5 uses the Authority's evaluation principles to compare possible additional policies, drawing on the Authority's and other recent modelling.

CHAPTER 1. ABOUT THIS RESEARCH REPORT

The Authority has released this report as part of the work on emissions reduction policies for Australia's electricity supply sector for its Special Review into Australia's climate policy. This chapter outlines the context and purpose of this report. It outlines the challenge of climate change and why it is in Australia's interest to continue to contribute to global efforts to avoid dangerous impacts of climate change. It provides some background information about the Authority and the Special Review and explains why the Authority has devoted particular attention to the electricity supply sector.

1.1. Introduction

This research report forms part of the Authority's Special Review into Australia's emissions reduction policies, which was commissioned by the then Minister for the Environment in December 2014. This report sets out the Authority's detailed analysis of the electricity supply sector, which informed its conclusions and recommendations for the electricity sector in *Towards a climate policy toolkit: Special Review on Australia's climate goals and policies* (hereafter 'Report Three' of the Special Review). Report Three also sets out the Authority's policy conclusions and recommendations for other sectors.

The Authority has benefited from stakeholder feedback and would like to thank all the organisations and people who made submissions to the Special Review.

1.2. The challenge of climate change

Climate change is a serious global challenge, and poses major risks to the Australian community, economy and environment. Climate change is already having effects in Australia and around the world.

Human activity is causing the climate to warm. Some activities, such as burning fossil fuels and clearing land, produce greenhouse gases, which trap heat like a greenhouse. As concentrations of greenhouse gases increase, more heat is retained and the climate gets warmer. While there is global scientific consensus that humans are the dominant cause of warming since the mid-20th century (95 to 100 per cent certainty), the climate system is complex and there are uncertainties, particularly around how much the climate will change in the future, the pace of change, and the likely impacts of that change (IPCC 2014).

Australia is already experiencing the effects of climate change. As more greenhouse gases are released and the climate continues to change, these impacts will become more severe. In Australia, we are likely to see higher temperatures, reduced snow cover, and increased frequency and intensity of fires, floods and droughts, with effects varying between regions (Hennessy et al. 2008; CSIRO 2011; Steffen et al. 2014). As temperatures rise and Australia's rainfall patterns change, Australia's agricultural production is likely to be affected—with some previously productive areas becoming marginal (CSIRO 2011).

The global community is acting to address climate change. At the Paris United Nations Framework Convention on Climate Change (UNFCCC) conference in December 2015, 195 countries agreed to a

global goal to hold the increase in global average temperatures to ‘well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 degrees Celsius... recognising that this would significantly reduce the risks and impacts of climate change’ (UNFCCC 2015).

These temperature goals are significant. With less than 2 degrees of warming, Australia is more likely to be able to adapt to and manage the impacts of climate change, such as additional sea level rise and more frequent heatwaves and drought (CSIRO 2011). Beyond 2 degrees, these impacts become much more severe and adaptation can be expected to become increasingly challenging and costly.

Sustained global action is required to limit global warming to ‘well below 2 degrees’. While the world is not yet on track to achieve this goal, countries are making progress and their efforts are increasing over time. Emissions reduction targets and policies that allow Australia to play its part in this international response are a prudent risk management strategy, given likely climate change impacts on Australia.

1.3. The Climate Change Authority and its Special Review

The Climate Change Authority provides independent, expert advice to the Australian Government and Parliament on policies and measures to reduce the risks of climate change. The Authority comprises nine members, including the Chief Scientist, and one associate member for this Special Review.

This report forms part of the Authority’s wide-ranging Special Review into Australia’s climate change action. The terms of reference for the Special Review (Appendix A) require the Authority to consider, among other things, whether Australia should introduce an emissions trading scheme. Reports from the Special Review are available on the Authority’s website.

- The first draft report (CCA 2015a) focused on Australia’s emissions reduction targets for the period beyond 2020. Following consultations with stakeholders, the Authority recommended targets for 2025 and 2030.
- The second draft report (hereafter ‘Report Two’) set out policy options for how Australia could meet its targets (CCA 2015b). The report described and discussed a range of options and proposed a framework for evaluating policies based on the principles of cost effectiveness, environmental effectiveness and equity. Many organisations and individuals made submissions which have helped to inform the electricity research report and are available on the Authority’s website.
- Report Three of the Special Review recommends what action Australia should take to implement outcomes flowing from the Paris climate conference in 2015. It recommends a policy toolkit for Australia to reduce its emissions, taking into account cost effectiveness, environmental effectiveness, equity and international competitiveness of Australia and Australian firms.

1.4. Scope

This report presents the Authority’s electricity sector analysis which informed Report Three of the Special Review. The Authority’s objective through this analysis was to help identify effective post-2020 policies to reduce emissions in the electricity sector.

The electricity sector will play an important role in Australia meeting its emissions reduction targets. The sector currently accounts for the largest share—around one-third—of Australia’s total greenhouse gas emissions. Emissions reductions in the sector are technically feasible with currently known technologies (ClimateWorks Australia et al. 2014; CCA 2014c; IEA 2015e), and research suggests deep reductions are likely to be more cost-effective in electricity supply than in some other sectors (Bruckner et

al. 2014). As the sector is characterised by long-lived capital investments, credible and consistent policy is important to provide the signals required for reducing the emissions intensity of electricity supply over time. These factors mean the sector provides a valuable case study for comparing policy options to reduce emissions, including their relative costs and benefits, effectiveness in reducing emissions and impacts on different groups.

This report assesses possible emissions reduction policies for the electricity sector against the Authority's evaluation principles. To make this assessment the report draws on analysis—including new modelling of the electricity sector and the Australian economy commissioned for the Special Review—as well as submissions to Report Two.

The Authority considered the terms of reference for the Special Review would be best met by comparing emissions trading to a wide range of other policies, including other 'market mechanisms' similar to emissions trading, as well as policies that encourage the deployment of low-emissions technologies or the closure of older, emissions-intensive power plants. The Authority's assessment is therefore structured around the following questions:

- Is meeting a 2 degree consistent emissions budget in the electricity sector feasible and what might this cost?
- Should there be a market mechanism of some kind in the electricity sector? If not, what policy or policies should be used to reduce emissions?
- If there is a market mechanism policy in the sector, which market mechanism should be implemented?
- If there is a market mechanism, should there be other climate policies in the electricity supply sector?
- If so, which policy or policies and why?

1.5. Structure of this report

The rest of this report is structured as follows:

- Chapter 2 provides an overview of the importance of electricity sector reductions for Australia's overall emissions reduction goals, and current emissions and policies in the sector.
- Chapter 3 outlines the policy options the Authority has considered, the evaluation framework used to compare these options, and explains the modelling commissioned for this Review.
- Chapter 4 compares the policy options against the evaluation framework. It draws on the Authority's qualitative and quantitative analysis, including the Authority's commissioned modelling.
- Chapter 5 considers the case for applying multiple policies in the sector, and applies the Authority's evaluation framework to assess policy combinations.

CHAPTER 2. THE ELECTRICITY SECTOR AND AUSTRALIA'S EMISSIONS REDUCTION GOALS

This chapter provides background for the Authority's consideration of electricity sector policy options. It gives an overview of current emissions and policies, the importance of electricity sector reductions for Australia's overall emissions reduction goals, and the opportunities for reducing emissions in the sector. Two insights are that:

- Australia has substantial, cost-effective opportunities to reduce electricity sector emissions as part of national action to contribute to global efforts to reduce emissions.
- Many changes—such as the availability of battery storage technology—are occurring in the sector. Changes happening at the same time but for reasons other than climate change policy will continue to affect the sector. This means policy must be flexible enough to perform well even if factors such as technology development and uptake, or electricity demand, are different to current expectations.

In order to compare the performance of climate policy options it is necessary to understand their impacts on electricity generators and consumers. Section 2.5 of this chapter provides some background material.

2.1. Electricity, emissions and climate policy

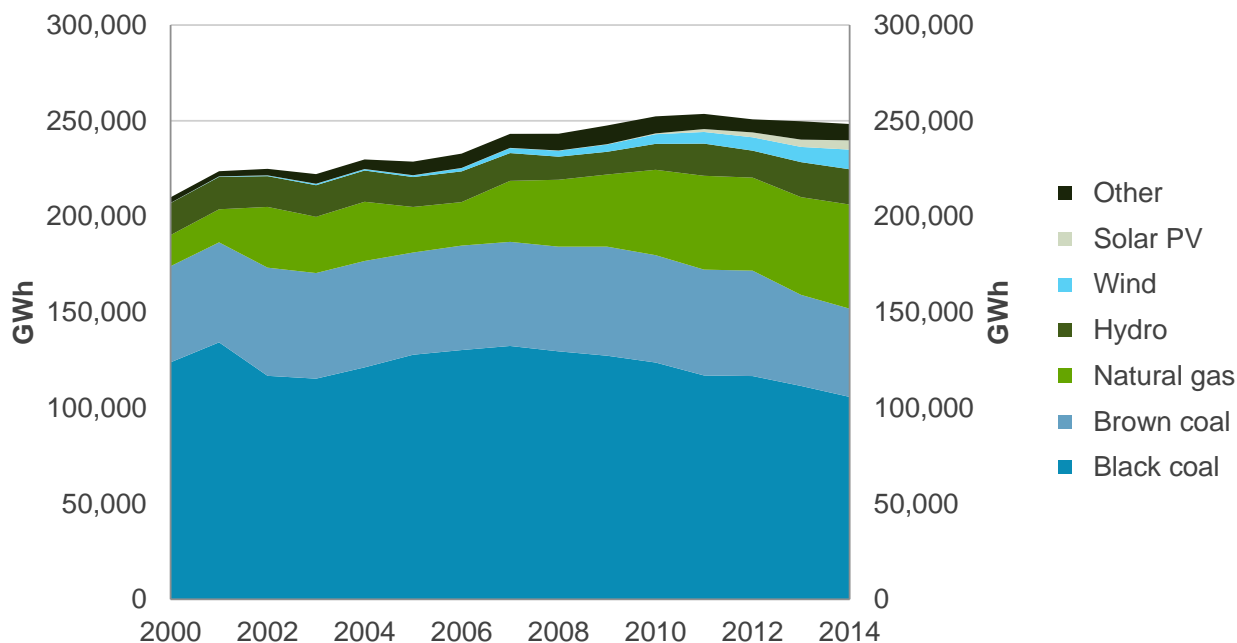
Electricity is a fundamental part of Australia's society and economy, used by households to power homes and by businesses to produce goods and services. About half of all Australian electricity is consumed by large industrial users, and roughly one quarter each from households and other businesses (DIIS 2015a).

The process of generating electricity currently contributes the largest share—about one-third—of Australia's emissions. In 2013–14, black coal was the largest single source of generation, contributing 43 per cent of total generation (Figure 2), followed by natural gas (22 per cent), brown coal (19 per cent) and renewables (15 per cent) (DIS 2015).¹

Of the generation sources that produce emissions, brown coal is the most emissions-intensive—that is, it produces the most greenhouse gas emissions per unit of generation—followed by black coal and gas (Figure 3). The total emissions from each fuel depend on the emissions intensity of the fuel itself and what share of total generation it makes up. For gas in particular, the type of plant will affect the emissions intensity of the generation. Coal produces around 88 per cent of generation emissions, 35 per cent from brown coal and 53 per cent from black coal (Figure 3). Gas produces around 12 per cent of generation emissions.

¹ Electricity terms, such as generation, are defined in Box 3 at the end of this chapter and a complete glossary is at the end of the report.

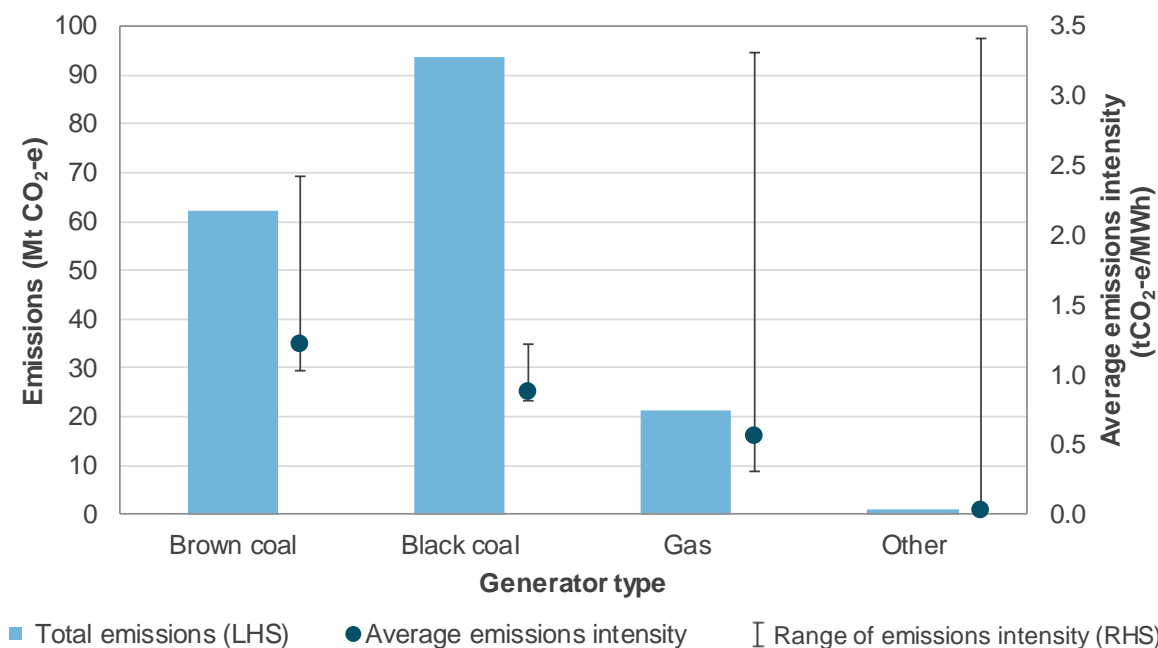
Figure 2 Australian electricity generation by source, 2000–2014



Note: Years refers to financial years ending June. ‘Other’ comprises generation from oil products, multi-fuel power plants, bagasse, wood, biogas and geothermal. Solar photovoltaic (PV) includes rooftop solar. Generation is ‘as generated’ and includes distributed and off-grid generation.

Source: Climate Change Authority based on DIS 2015.

Figure 3 Emissions and emissions intensity by generator type, 2014–15



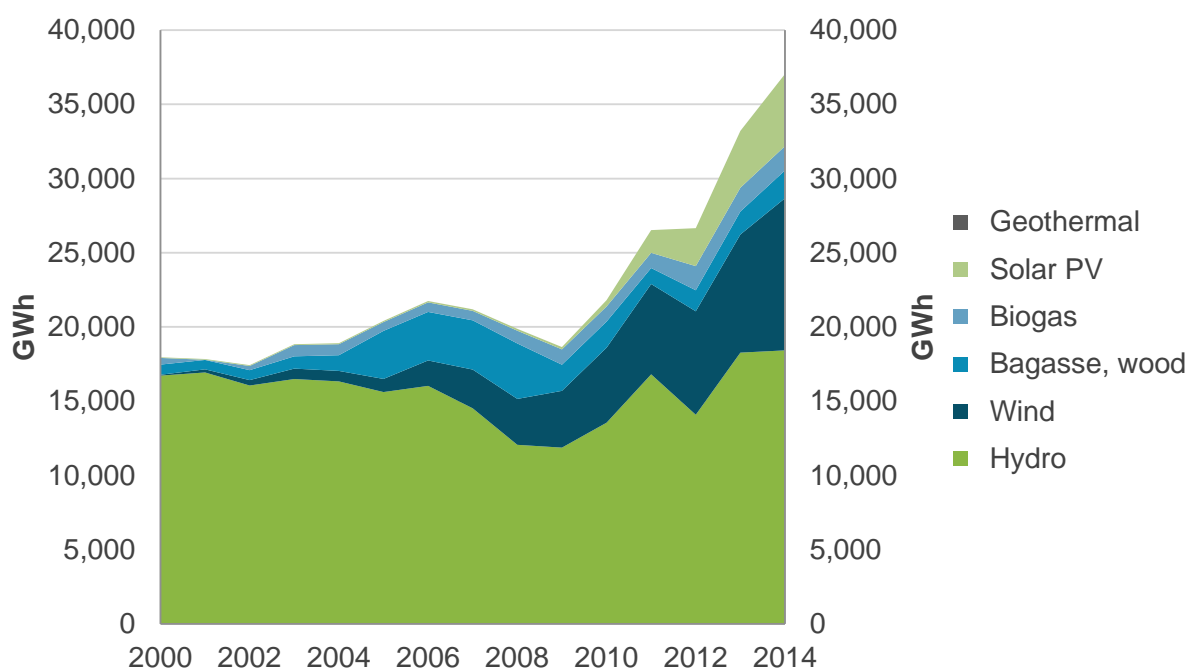
Note: ‘Gas’ includes generation combining gas and liquid fuels. ‘Other’ comprises generation from renewable sources, liquid fuels (other than when in combination with gas), waste coal mine methane and unknown multiple sources. Average emissions intensities are weighted by generation; vertical lines show ranges for each generator type. Generation includes distributed and off-grid generation. Emissions are measured as ‘scope 1’ (not including indirect emissions from energy purchased). Generation is ‘as generated’ (not ‘sent out’).

Source: Climate Change Authority based on CER 2016.

Looking at the 15 per cent of generation produced by renewables, hydro generation was the largest source of renewable generation in 2013–14, contributing 50 per cent of total renewable generation

(Figure 4). Wind made up 28 per cent of renewable generation in the same year, followed by solar PV (13 per cent), bagasse and wood (five per cent), biogas (four per cent) and geothermal (less than one per cent). Wind and PV generation have risen substantially over the five years to 2013–14. Wind generation has doubled and solar PV increased ten-fold. Wind has been driven by the Commonwealth’s Large-scale Renewable Energy Target (Expert Panel 2014) while rooftop PV uptake has been influenced by incentives (such as the Small-scale Renewable Energy Scheme and state-based schemes) and other factors such as rapidly falling technology costs (Table 1 and Box 4).

Figure 4 Australian renewable electricity generation by type, 2000–2014



Note: Years refers to financial years ending June. Solar PV includes rooftop solar. Generation is ‘as generated’ and includes distributed and off-grid generation.

Source: Climate Change Authority based on DIS 2015.

The role of the RET in deploying large-scale renewable generation to date illustrates an important point: without climate policies, using and investing in low-emissions generation is often not the most financially attractive option for electricity businesses. When comparing the overall cost of energy from new plants, the cheapest zero-emissions plants (wind power) are similar to, but still more expensive than, the cheapest fossil-fuel plants (APGT 2015). But pre-existing coal plants have both low operating costs, and large fixed and ‘sunk’ costs that cannot be recovered if the plant closes (Appendix F of Jacobs 2016c; Frontier Economics 2015, pp. iv, 22, 23). Together these mean that many existing emissions-intensive plants are very cheap to continue to run, making it hard for new, cleaner plants to displace them from the market. This makes it challenging for climate policy to ‘switch the economics’ of generator costs so that zero- and low-emissions technologies are the most financially attractive to use and invest in. Achieving this requires well-designed, stable and durable policy.

Two features of the electricity sector have important implications for climate policy design.

First, the electricity sector is undergoing substantial change regardless of domestic climate policy. Innovations in technology and shifts in consumer preferences mean the size and structure of the sector could change a great deal over coming decades irrespective of climate policy. For example:

- The Australian electricity sector could change significantly in the decades to 2050, influenced by ‘megashifts’ such as the advent of low-cost battery storage reducing the need for large-scale

electricity generation (CSIRO 2013; Graham et al. 2015). Electricity networks—the ‘poles and wires’ connecting the electricity system—will likely perform a range of critical roles and be important enablers of these changes. Predicting the future is always uncertain, however, so debate remains about the nature, likelihood and timing of such shifts.

- After decades of steady growth, electricity demand² across much of Australia fell for consecutive years. Starting in 2008–09 demand fell in the National Electricity Market covering most of Australia’s east coast, and from 2011–12 electricity demand growth slowed in the South-West Interconnected System in Western Australia (Section 2.5.3). In both cases, this was despite a growing economy and population. Electricity demand is forecast to increase again over the near term, however the outlook remains uncertain. (AEMO 2016e, p. 17). These potential changes and uncertainties mean that, in order to be effective and durable, climate policies must be flexible in order to perform well in a variety of possible futures.

The second feature of the electricity sector important for climate policy design is that electricity sector climate policies affect the operation of existing electricity markets. This means that, to ensure an orderly transition to a lower-emissions system, climate policies need to be designed with the operation of electricity markets in mind. The importance of integrating climate and energy policy has been recognised by many stakeholders, and was emphasised by the COAG Energy Council:

[Australian energy Ministers have] agreed to a national, cooperative effort to better integrate energy and climate policy, with a clear focus on ensuring that consumers and industry have access to low-cost, reliable energy as Australia moves towards a lower-emissions economy.

The successful integration of carbon and energy policies will be critical to meeting Australia’s emissions reduction target of 26 to 28 per cent below 2005 levels by 2030. Ministers will develop a national approach to connect environmental outcomes and energy policy in the interests of consumers. (COAG Energy Council 2015, pp. 1–2)

At its December 2015 meeting, the COAG Energy Council tasked officials with examining potential impacts of the integration of carbon policies with the energy sector (COAG Energy Council 2015).

This research report recognises the importance of energy-climate policy interactions, and notes that the integration of energy and climate policy is a large issue with many different facets. The report makes some observations on these different facets by way of background (Box 1) and discusses how different policies have different effects on the existing incentives for dispatch, entry and exit of generation (Section 4.1.2).

2.2. Current climate policies and near-term emissions outlook

Several Commonwealth, state and territory climate change policies currently operate in the electricity sector; Table 1 identifies major policies, focusing on the large-scale electricity supply sector. These include:

- the Renewable Energy Target, which increases the amount of renewable generation capacity by creating a market for additional renewable energy
- the Emissions Reduction Fund, which consists of a voluntary mechanism to purchase emissions reductions, and a regulatory ‘safeguard’ mechanism aimed at ensuring emissions reductions purchased by the fund are not offset by emissions growth beyond business as usual elsewhere in the economy.

² ‘Electricity consumption’ and ‘electricity demand’ are used interchangeably in this report.

Several states and territories have specific renewable energy goals or are planning additional targets and policies.

- The Australian Capital Territory Government has a legislated goal to source 100 per cent renewable generation by 2020 (Government of the ACT 2016), underpinned by its contracts for difference policy (Table 1).
- The South Australian Government has committed to source 50 per cent renewable generation by 2025 (Department of Environment, Water and Natural Resources 2014).
- The Queensland Government is investigating a credible pathway to achieve a goal of 50 per cent renewable generation by 2030 (Queensland Government 2016). The Queensland Renewable Energy Expert Panel released an issues paper in May 2016 to inform the development of these pathways (Queensland Renewable Energy Expert Panel 2016).
- The Victorian Government has committed to generate 25 per cent of its electricity from renewable sources by 2020, rising to 40 per cent by 2025. It has also announced that it will provide long-term contracts to support new projects through an auction scheme (Victorian Government 2016).

The latest official emissions projections, which extend to 2020, project emissions from electricity generation to be broadly flat over that period.³ Given this outlook, the sectoral baseline established under the Emissions Reduction Fund safeguard mechanism is not expected to be breached before 2020, so the safeguard will most likely not constrain electricity generation facilities' emissions. This means the main Commonwealth emissions reductions policy in the electricity generation sector is the Large-Scale Renewable Energy Target of 33,000 GWh of renewable electricity by 2020.

2.3. The role of the electricity sector in Australia's emissions reduction goals

As discussed in Chapter 1, Australia, along with the international community, has agreed to a global goal of limiting warming to well below 2 degrees and to pursue efforts to limit warming to 1.5 degrees. Electricity supply businesses and many environmental groups commented in their Report Two submissions on the importance of the electricity sector for Australia making its contribution to global emissions reduction goals. The Australian Energy Council—the body representing electricity generators and retailers—observes that keeping the rise to less than 2 degrees is 'likely to require Australia and other developed countries to reach net zero greenhouse gas emissions over the next few decades' and that 'the magnitude of the transformation to meet this goal should not be underestimated' (Report Two submission, p.1).

The electricity sector features prominently in Australian and international research on achieving the global goal, with a consistent finding that limiting warming to no more than 2 degrees would require virtual decarbonisation of global electricity systems by 2050 (Bruckner et al. 2014, p. 516; IEA 2015c, p. 3; DDPP 2015, p. 9).

The electricity sector is important for three reasons:

- It accounts for a significant share of current emissions—one-third of Australia's total emissions and 28 per cent of total global emissions (Audoly et al. 2014, p. 1; DoE 2015b, p. 9).
- Significant reductions in electricity sector emissions are technically feasible with currently known technologies, and more cost-effective than cuts in some other sectors (Bruckner et al. 2014, p. 516; IEA 2015e; ClimateWorks Australia et al. 2014).

³ The most recent official projections go to 2020, the previous (2014–15) official projections (DoE 2015), extended to 2030 and projected emissions from electricity generation would grow 11 per cent on 2020 levels over the decade.

- Low- and zero-emissions electricity generation can be a precursor to feasible, least-cost emissions reductions for the sectors that use energy, such as industry, buildings and road transport (CCA 2014a, p. 17; ClimateWorks Australia et al. 2014, pp. 69,120; ClimateWorks Australia & ANU 2014, p. 25).

Table 1 Major climate change policies—large-scale electricity supply sector

Jurisdiction	Policy	Details
Commonwealth	Renewable Energy Target (RET)	<p>The RET aims to ensure that at least 20 per cent of Australia’s electricity generation comes from renewable resources by 2020. It works by creating a market for additional renewable electricity that supports investment in new renewable generation capacity.</p> <p>The RET places a legal obligation on entities that purchase wholesale electricity (mainly electricity retailers) to surrender a certain number of certificates each year. These certificates are generated by accredited renewable power stations and eligible small-scale technologies. Each certificate represents one megawatt hour (MWh) of renewable generation.</p> <p>Since 2011, the RET has operated as two schemes—the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES). The LRET has fixed annual targets for the amount of large-scale renewable energy; these targets rise to 33,000 GWh in 2020 and stay constant at that level until the scheme ends in 2030. The SRES has no fixed annual targets; rather, liable entities are obliged to purchase all of the certificates generated from the installation of eligible small-scale systems. Assistance under the SRES will phase out gradually from 2017 and ends in 2030.</p>
Commonwealth	Emissions Reduction Fund (ERF) crediting and purchasing mechanism	<p>The ERF crediting and purchasing mechanism is a voluntary scheme aimed at encouraging emissions reduction activities in the economy at lowest cost across all sectors. The crediting mechanism involves businesses, community organisations, local councils and others undertaking eligible activities that reduce emissions, and receiving ‘credits’ for the reductions. To be eligible, the activity must conform to the requirements of an emissions reduction ‘method’. Methods have been established for a range of activities including reducing emissions from electricity generation. Credits are issued once emissions reductions occur.</p> <p>The Government uses a competitive process to purchase credits at the lowest available cost. The Government has committed \$2.55 billion for purchasing credits, with further funding to be considered in future budgets.</p>
Commonwealth	Emissions Reduction Fund (ERF) safeguard mechanism	<p>The safeguard mechanism is a regulatory measure aimed at ensuring emissions reductions purchased through the ERF crediting and purchasing mechanism are not offset by emissions growth beyond business as usual elsewhere in the economy. The policy requires large emitters to keep their net emissions below a baseline level. It started on 1 July 2016 and applies to around 140 large businesses that have facilities with direct emissions of more than 100,000 t CO₂-e per year.</p> <p>The electricity sector has a sectoral baseline set at 198 Mt CO₂-e, the highest level of reported emissions over the five years to 2013–14. If the sectoral emissions baseline is breached, individual baselines will come into effect which would be based on each facility’s highest level of emissions over the five years ending in 2013–14.</p> <p>Baselines can be increased to accommodate factors including economic growth, and will also be set for new investments.</p>
Australian Capital Territory	Large-scale contracts for difference with reverse auction	<p>The ACT government’s large-scale contracts for difference policy was established to assist the ACT Government in achieving its legislated renewable energy consumption target of 100 per cent renewables by 2020. Under the policy, new renewable energy projects bid in a reverse auction for 20 year contracts with the government. The ACT aims to contract a total of 650 MW of renewable capacity to help meet its target.</p> <p>This scheme is funded through a retail tariff added to electricity bills.</p>

Source: Climate Change Authority based on CCA 2014b, s. 2.2.1 and Box 1; DoE 2014, 2016a, 2016b; Government of the ACT 2016; Government of the ACT 2011.

Box 1 Electricity reliability, security and intermittent renewable generation

Two important aspects of electricity market operation are its reliability (broadly speaking, whether capacity is adequate to meet demand) and its security (broadly speaking, the ability of the power system to continue operating within defined technical limits even if a major piece of power system infrastructure fails).

The Australian community expects very high levels of electricity reliability and security and these have generally been maintained through two decades of electricity market disaggregation, privatisation and competition (Reliability Panel 2015). Until recently, electricity markets have not had to integrate large quantities of intermittent renewable generation. But as wind and solar PV generation increase, integration is becoming more of a focus.

This integration is already underway, and is most notable in the South Australian region of the National Electricity Market (NEM). In 2014–15, intermittent wind generation contributed about 33 per cent of South Australia's large-scale electricity generation—one of the highest shares in the world (AER 2015; AEMO & Electranet 2016). While 75 per cent of South Australia's large-scale generation came from wind generation on some single days in 2014, wind generation tends to be lower at times of South Australian peak demand, and made up on average about 10 per cent of South Australia's large-scale generation in the summers of 2010–11 to 2014–15 (AEMO & Electranet 2014; AEMO 2015d; AER 2015).

There are some public concerns about the increase in intermittent generation and its potential impact on electricity market reliability. Common concerns are that intermittency reduces power system reliability and that renewable generation's very low operating costs tend to lower wholesale prices and erode revenues and profitability for other generators. However, both the NEM and the Western Australian Wholesale Electricity Market (WEM) include mechanisms that seek to deliver reliability in the presence of substantial generation from intermittent sources. This is because non-intermittent generators, which step in to cover the lulls in the wind and sun, receive income for providing this backup. In the WEM this is through a capacity payment from the market operator. In the NEM, features include price caps (that is, maximum spot prices) set to encourage investment in the generators required for reliability, and financial hedging contracts which have the effect of smoothing generator revenues through time.

Separately from reliability, the energy market institutions and network companies are taking action to ensure the power system remains secure with increased shares of intermittent renewables (AEMO & Electranet 2016). This includes investigating the best way to maintain previously abundant services that may become scarce with changes in the generation mix, such contributions to the resistance of the power system to changes in frequency (its 'inertia'). As these actions are required regardless of new post-2020 climate policies, their costs were not specifically assessed as part of the Authority's evaluation of climate policy options.

Two recent events in South Australia have been linked to increasing penetration of renewables:

- On the night of 1 November 2015 up to 160 MW of South Australian customer load was interrupted for approximately one hour as a result of a disconnection in the transmission link to Victoria (AEMO 2016d). The event is an example of a security incident rather than a reliability shortfall and is unrelated to renewable generation.
- During 2015 several coal and gas generating plants in South Australia announced their intentions to close or temporarily withdraw in 2016 and 2017 (AGL Energy 2014; Alinta Energy 2015). These decisions were affected by multiple factors, including the loss of market share to renewables supported by the Renewable Energy Target. The resulting consolidation of non-intermittent generation led to a sharp increase in new contract prices for large electricity customers in late 2015 (ASX 2016). Prices partially eased in early 2016 before rising again during May, June and July (ASX 2016). AGL subsequently reversed its decision to withdraw its Torrens Island 'A' units, citing tightening supply following the retirement of other generators (AGL Energy 2016).

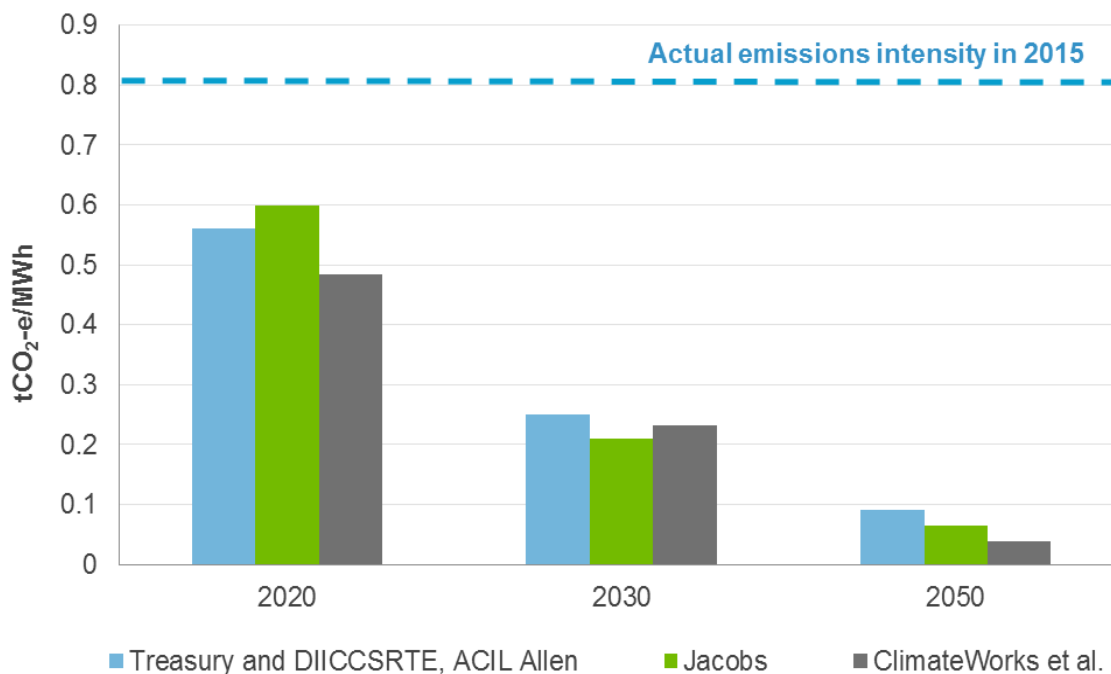
Both the reliability and security of the power system are being considered as part of work by officials for the COAG Energy Council (Section 2.1).

The Intergovernmental Panel on Climate Change has found that, in cost-effective pathways consistent with less than 2 degrees of warming, the electricity sector is projected to decarbonise more rapidly than the industry, buildings and transport sectors (Bruckner et al. 2014, p. 516). In the majority of these pathways, the global share of low-emissions generation (renewable, nuclear and carbon capture and storage (CCS)) in the electricity supply is projected to increase from its current level of about 30 per cent to more than 80 per cent by 2050. While renewable and nuclear power always play an important role in these global analyses, the role of CCS varies greatly but never exceeds a 50 per cent share (Bruckner et al. 2014, p. 560).

Available studies consistently find that Australia has opportunities to achieve cost-effective reductions in electricity sector emissions as part of national action consistent with limiting warming to 2 degrees. Figure 5 compares the projected emissions intensity of the Australian electricity supply in 2020, 2030 and 2050 across three recent exercises investigating 2 degree consistent pathways. Each exercise is slightly different, for example they investigate different policy scenarios, some allow the use of

international permits or credits, and so on. The common finding is that the electricity sector can contribute deep, cost-effective emissions reductions as part of national action to meet global temperature goals.

Figure 5 Emissions intensity of electricity generation, 2 degree pathways



Note: Data for Jacobs and ClimateWorks are averages across multiple scenarios; see Section 3.3 for further detail on the policies from Jacobs' modelling. Emissions intensity data are direct emissions per MWh generated.
Source: All data are calculations by the Climate Change Authority. Actual emission intensity in 2015 based on DoE 2015b, pp. 9–10. The Treasury and DIICSRTE, ACIL Allen based on the Treasury and DIICSRTE 2013 and ACIL Allen Consulting 2013. Jacobs based on Jacobs 2016c. ClimateWorks et al. based on ClimateWorks Australia et al. 2014.

In all of these studies, the emissions intensity of electricity generation is projected to fall rapidly, from 0.81 t CO₂-e/MWh in 2015 (Climate Change Authority based on DoE 2015b, pp. 9–10) to around 0.25 t CO₂-e/MWh or lower by 2030 and below 0.1 t CO₂-e/MWh by 2050. This broad trend is projected to hold even in the case of weaker action to reduce emissions. Scenarios consistent with limiting warming to 3 degrees project the emissions intensity of generation would fall to 0.66 t CO₂-e/MWh or lower by 2030, and below 0.3 t CO₂-e/MWh by 2050 (ACIL Allen Consulting 2013, p. 42; Climate Change Authority based on Jacobs 2016c).⁴

Substantial decarbonisation of electricity supply can facilitate emissions reductions in other sectors, as electricity can displace their direct use of fossil fuels (IEA 2014b, pp. 127–128; DDPP 2015, pp. 8–10). Recent Australian work suggests:

- In industry, emissions could fall 60 per cent on 2012 levels by 2050, driven by substantial electrification of industrial processes (ClimateWorks Australia & ANU 2014, p. 25).
- Emissions from Australian buildings could be virtually eliminated by 2050 through a combination of energy efficiency and switching from gas to electricity for all heating, hot water and cooking (ClimateWorks Australia et al. 2014, p. 120).

⁴ This weaker action scenario is included merely for the purpose of testing model sensitivity and does not reflect the Authority's endorsement of a three-degree temperature increase as a policy objective.

- Emissions from road transport, which currently accounts for the vast majority of transport emissions, could be reduced by about 70 per cent by 2050 with a substantial shift towards electric and hybrid light vehicles (CCA 2014a, p. 17; ClimateWorks Australia et al. 2014, p. 69).

Current trends in Australia's electricity sector are not consistent with these projected pathways to deep emissions reductions. The Australian electricity generation sector is currently dominated by emissions-intensive generation: in 2013, the emissions intensity of Australia's electricity supply was around 85 per cent above the OECD average and around 11 per cent above that of China (Climate Change Authority based on IEA 2015a, pp. 66–68, 102–04 and IEA 2014a). Electricity emissions are projected to remain flat to 2020 (DoE 2015b, p. 9), with the emissions intensity of generation declining by 10 per cent over 2015 to 2020 (Climate Change Authority based on DoE 2015b, pp. 9–10).

2.4. Opportunities for reducing electricity emissions

Significant reductions in electricity sector emissions are technically feasible with currently known technologies. Five broad 'levers' to reduce emissions are available:

- 'Fuel switching' across existing plant, for example generating more electricity from existing lower emissions gas-fired plant and less from coal-fired plant.
- Improving the efficiency of existing plant, ranging from operational practices such as reducing coal moisture, through to equipment refurbishment or major plant upgrades.
- Retiring higher-emissions plant, such as brown and black coal-fired generators.
- Building new zero- or low-emissions plant, such as renewable energy, or combined-cycle gas with or without CCS.
- Reducing electricity demand, such as through energy efficiency.

The first four of these opportunities come from changes in electricity supply—the focus of this report. Since the cost of supply-side policies can increase retail electricity prices, they can also deliver 'demand-side' emissions reductions (Box 6 in Chapter 4) as consumers respond by reducing electricity use, for example through greater use of efficient appliances and building fittings. More broadly, improving energy efficiency can often provide substantial low cost, and sometimes financially beneficial, ways of reducing Australia's emissions (see for example CCA 2015b, p. 26). The Authority has considered energy efficiency policies in Report Three of its Special Review.

The size of the emissions reductions of the four supply-side opportunities varies, which has implications for policy design. In Australia, the potential for emissions reductions from improving efficiency in existing fossil-fuelled plants is relatively small (ClimateWorks Australia 2011, p. 3; RepuTex 2015). Fuel-switching is more important for reducing emissions from the existing generation fleet, but influencing retirements and the emissions intensity of new plant are most important for substantial reductions over the longer term (see for example: CCA 2014c; ClimateWorks Australia et al. 2014; Jacobs 2016c). In submissions to Report Two, a broad range of organisations highlighted the importance of progressively retiring high-emissions plant and/or building new renewable (or near-zero emissions) generation.

The importance of these two levers—retiring higher emission plant and building new zero- or low-emissions plant—means that choices about which long-lived assets to invest in and retire are the most important for emissions reductions. This in turn means that investors' beliefs about the longevity and stability of climate policy are very important for achieving cost-effective emissions reductions. As noted by AGL Energy:

For the electricity generation sector, with long investment horizons and large upfront capital costs, well telegraphed and consistent policy that provides reasonable insight into the investment environment over the medium term is a pre requisite to minimise the impact of emission reductions on energy consumers. (Report Two submission, p.2)

2.5. Electricity markets: key background

The rest of this chapter is a short ‘primer’ on the electricity sector. It covers some important market issues that affect how climate policies work in the sector, including definitions for some important electricity terms (Box 3). Readers familiar with the Australian electricity sector may wish to skip the section.

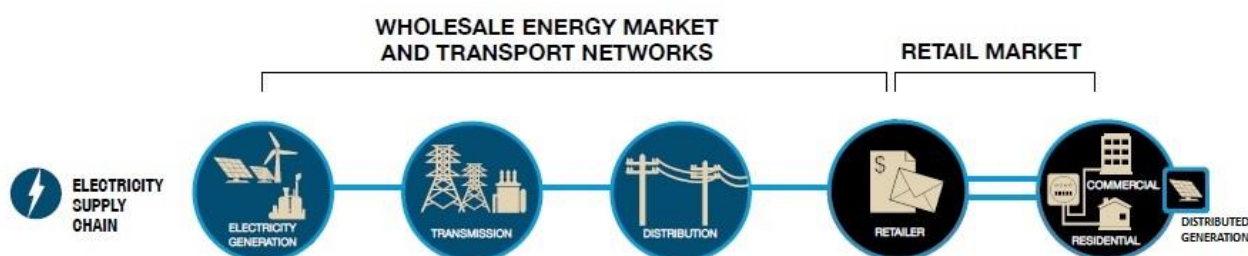
2.5.1. Market structure and wholesale markets

The National Electricity Market (NEM) and Western Australia’s South-West Interconnected System (SWIS) are the largest electricity markets in Australia covering about 86 per cent and eight per cent of Australian demand, respectively (AECOM 2013, p. 4). The NEM stretches along the east coast of Australia, servicing large portions of Queensland, New South Wales, Victoria, South Australia, Tasmania and the Australian Capital Territory while the SWIS covers south-west Western Australia.

Outside the NEM and SWIS, generation occurs in smaller networks including Western Australia’s North-West Interconnected System and the Darwin-Katherine Interconnected System, as well as other small, micro and off-grid arrangements mainly in Western Australia, the Northern Territory and Queensland. In both the NEM and Western Australia’s Wholesale Electricity Market (WEM, the wholesale market supplying the SWIS) generators compete to sell electricity. There are differences between the operation of the NEM and the WEM. The major difference is the NEM is an ‘energy-only market’ where generators rely on the wholesale electricity price and contracts based on wholesale prices as their primary source of income. The WEM operates as an ‘energy and capacity market’—generators can receive income from both the electricity price and the capacity they make available.

Figure 6 illustrates the physical electricity system and its supporting markets. Large-scale generators such as coal-fired power plants or wind farms create electricity, which is transported through networks to consumers. These networks (the ‘poles and wires’) have two parts: high-voltage, long-distance transmission lines and a lower voltage distribution network. Electricity retailers purchase electricity on behalf of consumers. Some consumers—including around 14 per cent of households in 2014—generate some of their own electricity from rooftop solar PV (ABS 2014).

Figure 6 Australia’s electricity system



Source: Climate Change Authority adapted from AEMC 2016.

In both the NEM and SWIS, generators compete in wholesale markets to generate electricity and retailers compete for customers.⁵ The transmission and distribution networks operate as regulated monopolies. The impact of a climate policy on wholesale markets is a driver of its overall impact on the electricity system. While the objective of many climate policies is to ‘switch the economics’ in favour of lower-emissions generation, different policies do this in different ways, so have different effects on the relative costs of different types of generators and the average wholesale price. Box 2 provides an overview of wholesale market operation and the effects of different climate policies.

2.5.2. Retail electricity prices

The prices of electricity for final consumers (‘retail prices’) are of special interest because—along with the amount of electricity consumed—they determine electricity costs for households and businesses. The costs of electricity generation, networks and retail businesses are all passed on to consumers in their electricity prices, so climate policies that have different impacts on generation and retail businesses will have different impacts on retail electricity prices.

In 2014–15, on average across Australia, network costs made up 47 per cent of an average residential electricity bill, while generation and retail business costs made up 28 and 19 per cent, respectively (Figure 8). The costs of complying with Commonwealth, state and territory environmental policies, such as the RET, and state- and territory-based renewable and energy efficiency schemes, contributed the remaining six per cent. Average retail electricity prices increased by around 70 per cent in real terms from 2006 to 2013 (Climate Change Authority based on ABS 2015, p. 26), but by about one per cent per year from 2012–13 to 2014–15 (Climate Change Authority based on AEMC 2014, 2015b).⁶ The significant increases experienced over the past decade have been largely due to increased investment in distribution networks to add to and replace aging network infrastructure (DIIS 2015b) to meet demand at peak times and increased reliability standards. Over 2015–16 to 2017–18, the Australian Energy Market Commission (AEMC) projects a fall in network costs but growth in market costs, including wholesale and retail business costs, with average overall prices remaining flat or rising slightly in most jurisdictions (AEMC 2015b).⁷

⁵ In the SWIS, customers who use less than 50 MWh are not ‘contestable’ and are supplied by the government-owned retailer, Synergy.

⁶ The AEMC’s national average electricity retail price data is the most detailed and comprehensive Australian data on retail electricity price movements. However, as this data is only available from 2010, estimates from the Consumer Price Index are used to calculate price changes over periods starting before 2010.

⁷ After the latest AEMC retail price trends report was published, the Australian Competition Tribunal handed down a decision that the Australian Energy Regulator must revisit its decision on NSW and ACT distributors’ revenue determinations. This revision is likely to lead to higher prices in NSW and the ACT than projected in the AEMC report.

Box 2 Wholesale electricity markets and interaction with climate policies

In Australia's wholesale electricity markets, generators compete to be dispatched by bidding the quantity of electricity they are willing to supply and the price they want to receive for their generation for each dispatch interval (five minutes in the NEM and half an hour in the WEM). The market operator dispatches the cheapest combination of bids to meet demand that is feasible given the network's capacity. All dispatched generators receive the market clearing price at their location, which is the price of the most expensive dispatched generator.

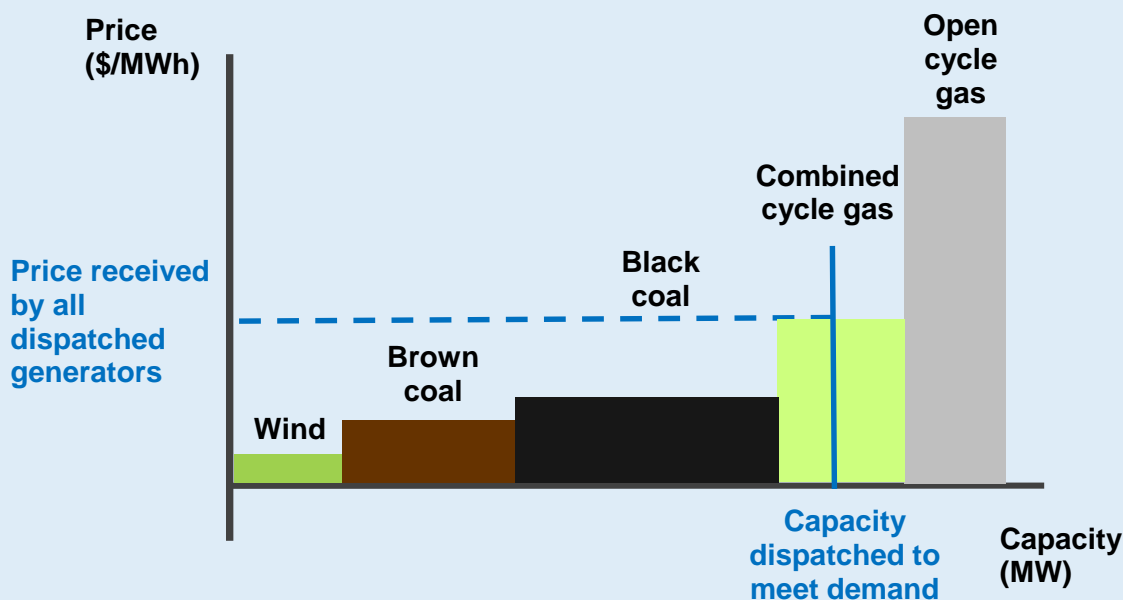
Most electricity markets have a price floor and price cap to ensure consumers and producers are protected from extreme price volatility. In the NEM for 2015–16, the price floor is $-\$1,000/\text{MWh}$ and the price cap was $\$13,800/\text{MWh}$. In 2015–16 average prices ranged from $\$46$ to $103/\text{MWh}$ across NEM jurisdictions (AEMO 2016a).

The specific bids made by each generator are a combination of several factors including their short-run operating costs and plant technology.

- Coal fired generators have high start-up costs but relatively low operating costs, so they are able to bid low to ensure they are dispatched. There are two types of coal in Australia: brown coal and black coal. Victorian brown coal is the easiest to mine and has the lowest generation costs when emissions are not priced. Slightly more expensive black coal generation dominates in Queensland and New South Wales and provides significant supply in Western Australia.
- Gas and liquid fuelled generators are usually relatively quick to start and flexible. Australian natural gas is more expensive than coal. In this class, combined-cycle gas turbines (CCGT) have the highest capital costs but are more efficient and therefore have lower fuel costs. Open-cycle gas turbines (OCGT) and reciprocating engine generators have lower capital costs and are very quick to start but have lower efficiency, so these generators typically operate in a peaking role. Some older gas fuelled generators use a steam boiler similar to a coal generator, but this technology is no longer used in new plants.
- Some renewable generators, such as wind generators, have no fuel costs so they are able to make low bids to ensure they are dispatched. Other renewable generators, such as most hydroelectric generators, are generally able to rapidly increase production in response to market prices and can also bid into the market at relatively low prices.

Figure 7 shows a stylised wholesale electricity market in a typical moderate demand situation. The ranking of plants from cheapest to most expensive is called the 'merit order'. In this example, the dispatched gas generation sets the wholesale clearing price. In a period of lower or higher (peak) demand, the clearing price would be set by a lower or higher cost generator, respectively.

Figure 7 Price setting in the wholesale market



Note: Stylised illustration.

Source: Climate Change Authority.

Different types of climate policies work differently with the wholesale market. For example:

- A cap and trade or emissions intensity scheme changes the operating costs of fossil-fuel generators in proportion to their emissions intensity. That is, for the same amount of generation, a brown coal generator will have larger carbon costs than a black coal generator because brown coal is more emissions-intensive (Figure 3). This change in relative costs can change the merit order of generators, so that less emissions-intensive generators become cheaper than more emissions-intensive ones. The lower emissions generation is dispatched more than it was before, lowering emissions.
- A policy to encourage additional renewable energy, such as a RET, subsidises new renewable generation. A RET (Table 1) provides eligible generators with an additional income stream so they can bid into the wholesale market at lower (subsidised) prices. The amount of low-cost renewable capacity tends to increase and becomes an increasing share of the generation required to meet demand, lowering overall emissions. The exact impact of a RET on emissions depends on which generation the renewables tend to displace: displacing gas would have less of an impact on emissions than displacing coal. In contrast to a cap and trade scheme, a RET leaves the costs *among* fossil-fuel generators unchanged.

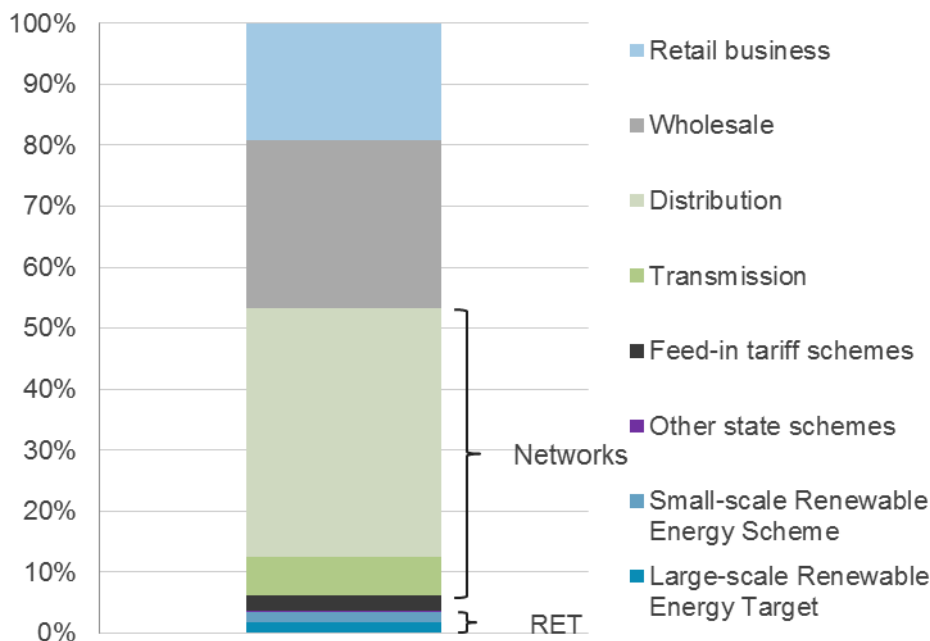
These two types of policies have different impacts on wholesale prices in the short term:

- A cap and trade scheme increases wholesale prices as fossil fuelled generators face higher costs.
- A RET tends to decrease wholesale prices due to the addition of new, low cost and subsidised renewable capacity.

In both cases, all generators that are dispatched receive the new wholesale price—higher for cap and trade and emissions intensity schemes (but to a lesser extent for emissions intensity schemes, as explained in Box 5), but lower for a RET.

The effect on final consumer prices and on the overall cost of the electricity system will be different to the impacts on the wholesale market. For example, the costs of subsidies under a RET are passed on to consumers by retailers. For RETs with higher targets, the increased costs can more than offset the lower wholesale prices, so that the retail prices may be higher overall. The impact of different policies on wholesale and retail prices is discussed further in Chapter 4 and Box 7.

Figure 8 Breakdown of average national residential electricity price, 2014–15



Note: Based on 2014–15 national weighted average residential electricity price, cents per kilowatt hour costs. National numbers are averages of jurisdictional results. Breakdown between retail business and wholesale is a Climate Change Authority calculation using the most recent (2012–13) data for the split between the two. While the AEMC no longer publishes separate retail business and wholesale components, the split between the two is likely to have remained stable.

Source: Climate Change Authority based on AEMC 2013, 2015b.

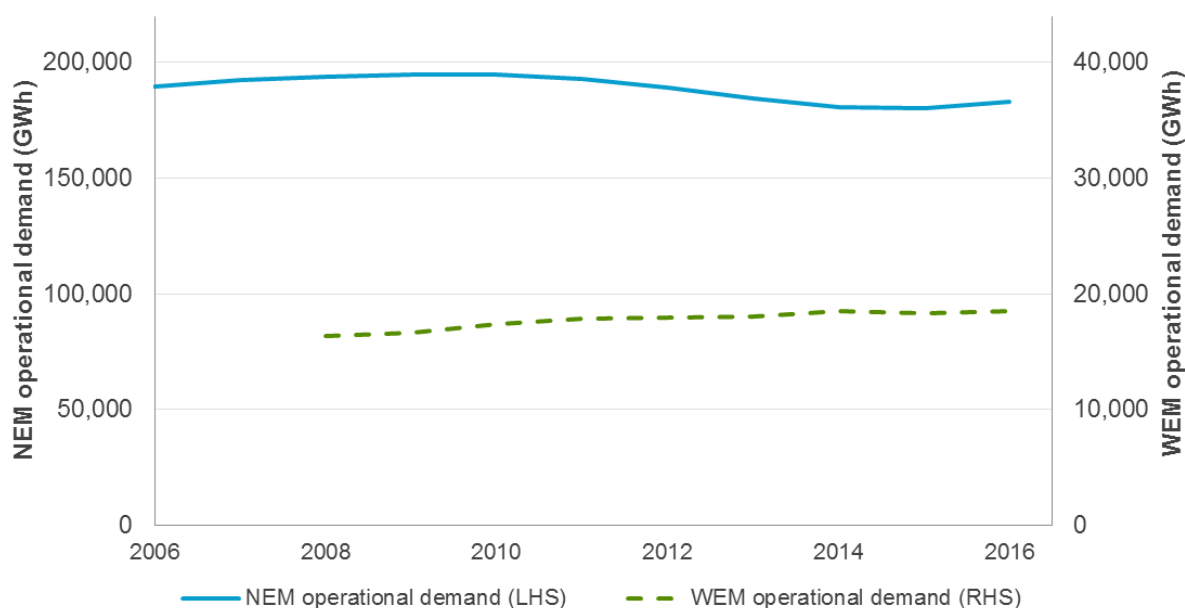
2.5.3. Electricity demand

Electricity demand is of interest for climate policy because the level of demand determines the emissions from a given generation mix. With the current generation mix, growth in electricity demand

would mean higher electricity sector emissions and therefore a larger task for any climate policy to meet emissions reduction targets.

Figure 9 shows operational demand (that is, electricity from the grid including transmission losses and excluding generation from rooftop PV) in the NEM and WEM. In the NEM, demand declined from its peak in 2008–09 and fell at an average rate of 1.5 per cent per year in the five years to 2014–15, despite a growing population and economy (AEMO 2015c, p. 8). Growth in operational demand in the WEM slowed from 2011–12. In the NEM, the fall in demand was not just driven by a shift towards rooftop PV. Underlying demand, which includes generation from rooftop PV, fell by about 1.5 per cent per year over 2009–10 to 2013–14 (Climate Change Authority based on AEMO 2015b). Demand fell across all three consumer categories in the NEM—commercial, residential and industrial—with different factors driving the falls in each case (AEMO 2015c, p. 9).

Figure 9 Operational electricity demand, NEM and WEM, 2006–2016



Note: Years refer to financial years ending June.

Source: Climate Change Authority based on Independent Market Operator 2015; AEMO 2015b, 2016e, 2016b.

- In the residential and commercial sectors, operational demand fell due to growing uptake of rooftop solar, but underlying demand also fell, driven by greater energy efficiency—encouraged through government schemes including appliance energy efficiency standards, and responses to rapidly increasing electricity prices (AEMO 2015c, p. 9).
- In the industrial sector, operational demand decreased overall from 2010–11, but varied across sub-sectors, increasing in some such as coal and metal ore mining, while decreasing in others such as aluminium smelting, steel making, vehicle manufacturing and other manufacturing (AEMO 2015c, p. 9).

Electricity demand is forecast to increase again over the near term, however the outlook remains uncertain. The latest official projections for the NEM to 2020 forecast slightly growing operational demand, mainly due to the ramp-up of liquefied natural gas projects in Queensland. A slight reduction is forecast between 2020 and 2030, with increasing solar PV and improving energy efficiency offsetting population increases and a small increase business demand (AEMO 2016e, p. 17).

2.5.4. Capacity

The amount of installed generation capacity is of interest for climate policy as some emissions reduction policies—such as renewable energy targets—work through adding additional supply. For these policies, the level of capacity relative to demand determines the distribution of the policy costs between electricity consumers (through higher prices) and existing fossil-fuel generators (through lower prices and profits). Both the recent fall in electricity demand and increased renewable capacity have contributed to a period of oversupply in Australian electricity markets. The Australian Energy Market Operator’s (AEMO’s) annual assessments indicate this oversupply is being reduced as asset owners respond to market signals by closing or temporarily withdrawing plants because they are not profitable. In 2014, AEMO noted the NEM would have surplus capacity of 7,400 MW (AEMO 2015a, p. 3) or about 14 per cent of total 2014 NEM capacity by 2023–24 (Climate Change Authority based on AEMO 2015a, pp. 3, 11). However, generators are expected to withdraw (or have recently withdrawn) around 4,000 MW of capacity from the market by 2022 (Climate Change Authority based on AEMO 2016c, p. 15). AEMO assumes a further 1,400 MW of capacity will exit in line with the electricity sector playing its part in meeting Australia’s 2030 emissions target (AEMO 2016c, p. 5).

Box 3 Important electricity terms

This box provides a quick reference for key electricity terms which are commonly used (and confused). A complete glossary is at the end of the report.

Term	Definition	Not to be confused with
Baseload generator	A plant that generally operates when able, due to low variable operating costs. Baseload power may be non-intermittent (e.g. coal) or intermittent (e.g. wind).	Non-intermittent generator
Capacity	A measure of power or demand at a point in time, typically measured in gigawatts (GW) or megawatts (MW). For an individual generator it measures the maximum amount of electricity that can be produced under nominated conditions.	Generation, energy
Distributed generator	A generating unit, such as rooftop PV, within the premises of a distribution network customer. Often used interchangeably with ‘embedded generator’ in general use.	Large-scale generator
Generation	The amount of electrical energy produced or used over a period of time, typically measured in gigawatt hours (GWh) or megawatt hours (MWh).	Capacity, demand
Intermittent generator	A generator whose output is not readily predictable within periods relevant for the market operator. Examples are solar generators, wave generators, wind generators and hydro generators without any material storage capability. A non-intermittent generator is any generator that is not intermittent.	Peaking generator
Large-scale generator	A generating facility such as a coal-fired power plant or a wind generator that participates in the wholesale electricity market.	Baseload generator, distributed generator
Operational demand	All electricity demanded by residential, commercial and industrial consumers, from the electricity grid, including distribution and transmission losses and ‘auxiliary loads’ (the electricity required to generate electricity).	Underlying demand
Peaking generator	A generator whose marginal or opportunity costs are higher than baseload generators and are therefore dispatched infrequently. In Australia, open-cycle gas turbines and limited-storage hydro generators typically operate in a peaking role.	Intermittent generator
Reliability	The power system’s ability to continue supplying sufficient power to satisfy customer demand.	Security of supply
Security of	The power system’s ability to continue operating within defined	Reliability

supply	technical limits even if a major power system element, such as a generator or interconnector, fails.	
Underlying demand	All electricity demanded by residential, commercial and industrial consumers whether or not from the electricity grid. Includes demand met by distributed generation including rooftop PV.	Operational demand

CHAPTER 3. POSSIBLE POLICIES AND APPROACH TO ASSESSMENT

Chapter 2 outlined the opportunities to reduce emissions in the electricity sector, the role of the sector in contributing to Australia’s emissions reduction goals and the importance of stable, durable policy for realising the emissions reduction opportunities. This chapter considers which policies are available to realise these opportunities and outlines how the Authority compared them using the principles of cost effectiveness, environmental effectiveness and equity. The final section introduces the electricity market and economy-wide modelling commissioned by the Authority to help it evaluate policies.

3.1. Policy options to reduce Australia’s electricity sector emissions

Report Two of the Authority’s Special Review outlined the different types of policies that Australia could use to achieve its emissions reduction targets.

In its consideration of electricity sector policies, the Authority focused on policies broadly representative of those proposed and discussed in Australia in recent years. Table 2 shows how these relate to the policy types outlined in Report Two.

Table 2 Electricity sector policies analysed, by category

Report Two policy category	Policies examined for the electricity sector
Market mechanisms	Carbon tax; cap and trade scheme; emissions intensity scheme; baseline and credit scheme
Voluntary pricing	Not assessed
‘Technology pull’ policies	Renewable energy target Low emissions target Contracts for difference
Regulation	Absolute baselines Regulated closures Emissions standards for new generators
Information	Not considered
Innovation	All modelled policies encourage deployment of low-emission technologies. The technology pull policies target them explicitly.

Source: Climate Change Authority.

This report focuses on three broad ‘families’ of possible policies:

- ‘Market mechanisms’, in particular carbon taxes, cap and trade schemes, and emissions intensity schemes.
- ‘Technology pull policies’: a type of policy that encourages the deployment of additional renewable and/or low-emissions generation. These vary in their technology eligibility (for example, whether they accept only renewable generation or also allow other zero- or low-emissions sources) and their

design (for example, whether eligible generators receive tradable certificates or a payment from consumers or the government).

- Regulation on entry and/or exit of power plant. For example, standards for the emissions performance of new or existing power stations, mandated closure, or facility-level absolute emissions baselines for emissions-intensive generators (that is, where each generator has a baseline for their total emissions that they must not exceed).

These policies are focused on:

- the supply side of the power sector, but also deliver some emissions reductions through reducing electricity demand (Box 6 in Chapter 4). Other policies could be used that directly target electricity demand. Policies can, for example, target barriers to energy efficiency to drive emissions reductions not encouraged by price changes alone—see Report Three of the Special Review.
- large-scale electricity supply. While the balance may shift towards small-scale generation in coming decades, decarbonising the large-scale generation mix is likely to remain very important for reducing emissions in the sector (Box 4).

Box 4 Small-scale technologies: drivers of uptake and implications for climate policy

Making deep emissions reductions in the electricity sector will mean reducing emissions through both large- and small-scale generation.

The vast majority of small-scale generation is rooftop PV, which is popular with households and business for many reasons, including for reducing electricity bills. Rooftop PV systems experienced a boom during 2009 to 2012 due to falls in system costs, policy incentives such as generous state-based feed-in tariffs, and consumers seeking to avoid rising electricity prices. As policy support has been wound back or closed to new entrants, installation rates have declined from their peaks (Green Energy Markets 2016, p. 12). Projected falls in battery storage costs may mean ‘PV plus storage’—rather than exporting the electricity from household solar systems—could also become financially attractive to households, with the CSIRO estimating that storage could be financially viable in seven years with the current electricity pricing structure (Brinsmead et al. 2015, p. iv).

While uptake of rooftop PV and battery storage is likely to continue, uptake rates will depend on several factors including:

- how fast costs of PV and storage fall in the future
- which consumers will buy them (for example, new business models, such as solar leasing, can remove the upfront costs of small-scale systems, and open the products to new customer segments including landlords) and
- a wide range of policies that influence the relative attractiveness of small-scale systems by changing the relative price of retail electricity, from the level of remaining feed-in tariffs to the future extent of cost-reflective network pricing.

The CSIRO’s Future Grid Forum (CSIRO 2013; Graham et al. 2015) explored how small-scale generation could evolve. The Forum investigated scenarios for four different possible futures for the electricity system that explore how customer preferences might interact with changes in technology and policy. Looking across these scenarios, the projected share of on-site generation (mostly rooftop PV) in 2050 ranges from around 25 to 45 per cent (the current share is just under 10 per cent) (Graham et al. 2015, p. 100).

These possibilities raise two questions for climate policy makers: how might a continued shift towards small-scale generation affect the emissions reduction task required of Australia’s future climate policy, and whether this has any implications for the choice of policy? Modelling commissioned by the Authority for this review (Section 3.3) sheds some light on both these questions.

On the size of the policy task, one scenario modelled for the Authority investigates emissions in a higher solar PV, higher storage, lower overall (‘underlying’) electricity demand scenario where no additional climate policies are implemented. In this scenario, electricity sector emissions are projected to fall around 30 per cent from their current level by around 2030, then remain broadly flat to 2050 (Climate Change Authority based on DoE 2015b and Jacobs 2016c). This suggests that, while trends towards distributed generation and batteries will reduce the task of climate policy, changing the large-scale generation mix is still important for making large emissions reductions in the sector to meet a 2 degree consistent emissions reduction goal over the period to 2050.

The implication for policy choice is the need for policy to be flexible to changes in technology availability, use, cost, and changes in operational electricity demand (Chapter 4 and Chapter 5).

In this analysis, the Authority does not consider information policies or voluntary offsets policies in detail. Information policies are not included as information about emissions reduction options is not a major barrier in the electricity sector on the supply side. Qualitative analysis of voluntary offsets policies to reduce electricity supply emissions indicates it is feasible, but may not be well suited for use as the main policy to scale up emissions reductions over time given the potential fiscal cost of such an approach.

Some of these policies will be more familiar (for example, a renewable energy target or cap and trade scheme); some maybe less so. Table 3 explains the policies in more detail, focusing on those analysed in the modelling commissioned for this Review (Section 3.3) and Box 5 provides an overview of the emissions intensity scheme.

Table 3 Description of electricity sector policies

Type	Option	How it works
Market mechanisms	Emissions intensity scheme	Government sets an emissions intensity baseline (in emissions per unit of electricity generated). Generators below the baseline get permits to sell; generators above the baseline must buy permits for excess emissions. Trade in permits determines their price, creating an incentive to reduce emissions.
	Cap and trade scheme	Government sets an emissions limit (the cap). Generators surrender a permit for each tonne of emissions. Government may auction permits, allocate them free of charge, or use a combination of both. Trade in permits determines their price, creating an incentive to reduce emissions.
	Carbon tax	Government sets a price per unit of greenhouse gas emissions. Generators pay that price for their emissions; this creates an incentive to reduce emissions if the cost of doing so is lower than the emissions price.
Technology pull policies	Renewable energy target	Government sets a target for new renewable generation. Eligible generators get certificates to sell, which electricity retailers buy to meet their target obligations. Trade in certificates determines their price, which subsidises new renewables.
	Low emissions target	Government sets a target for new low-emissions generation. Eligible generators get certificates to sell (scaled in line with their emissions intensity), which electricity retailers buy to meet their target obligations. Trade in certificates determines their price, which subsidises new low-emissions generation.
	Contracts for difference	Government sets a required quantity of new zero- or low-emissions generation. Low-emissions generators bid for long-term 'contracts for difference' with the government which partially or fully specify the price per MWh received by generators. This bidding process takes place through a reverse auction and so can also be termed 'auctions for contracts for difference'.
Regulation	Absolute baselines	Government specifies separate emissions baselines for each generator with above average emissions intensity. Generators must reduce their emissions to the baseline level. Mandated emissions standards for new generators.
	Regulated closures	Government specifies closure dates for all coal-fired generators. Generators must close or retrofit with CCS by this date. Mandated emissions standards for new generators.

Note: This overview table presents basic, generic descriptions of the different policy types modelled for this review and for simplicity avoids discussions of exemptions from liability, the use of international emissions permits or offset credits, and other design features. Carbon taxes and cap and trade schemes with full auctioning are very similar in economic models, so only one was modelled. For description of the specific designs adopted in the Authority's commissioned modelling see Appendix C.

Source: Climate Change Authority.

Box 5 Emissions intensity scheme: overview

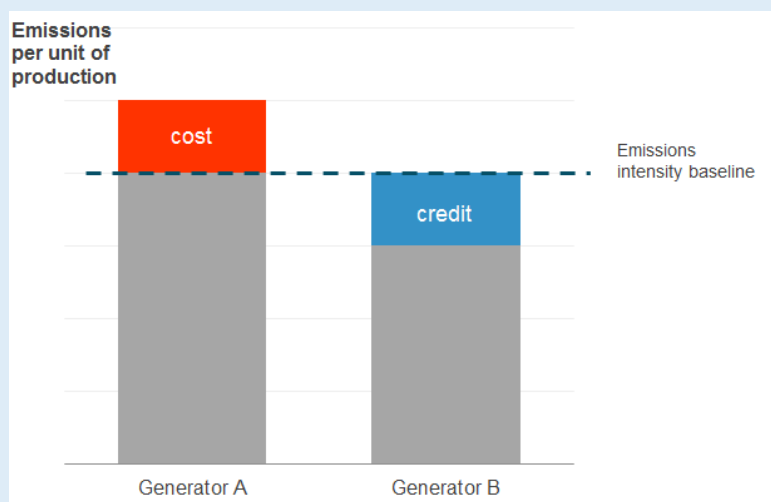
The emissions intensity scheme is a form of market mechanism that has much in common with a cap and trade scheme. The aim of an emissions intensity scheme is to drive least-cost emissions reductions (through trade), with lower direct costs to firms and lower indirect costs to the economy (compared to a cap and trade scheme with auctioning). It uses a mix of penalties and subsidies to change incentives.

In its simplest form, the government sets a baseline emissions intensity target. All liable firms receive the same free allocation of permits per unit of production (effectively a production subsidy). Lower-emitting firms receive extra permits that they can sell; higher-emitting firms need to purchase permits for emissions above the baseline. Trade establishes a price on emissions, changing relative generation prices and ensuring that emissions are reduced where it is cheapest to do so. Put simply, the scheme rewards below-baseline producers and penalises above-baseline ones.

The baseline could be set to achieve the desired level of emissions, based on projected output, and could decline over time to help achieve the economy-wide target. If the baseline was reduced to zero, the scheme would have an effect equivalent to a cap and trade scheme.

An emissions intensity scheme was proposed during the development of an Australian cap and trade scheme (Frontier Economics 2009). Under this proposal the electricity sector would receive free permits based on benchmark baselines. The government would set a sectoral emissions intensity baseline in emissions per unit of output. Each generator would receive an allocation of permits calculated by multiplying the emissions intensity baseline by the generator's actual individual output (Figure 10). Each credit represents one tonne of emissions. Generators with emissions above their allocation must purchase and surrender permits. Generators with emissions below their allocation can sell their spare permits, or bank them for future periods.

Figure 10 Emissions intensity scheme: baseline, credit and liabilities



Note: Stylised illustration.

Source: Climate Change Authority based on Frontier Economics 2009.

The impacts of permit allocation on consumers depends on the specific method of allocation. Under an emissions intensity scheme, allocations are conditional on the generator producing output. This means relative to a cap and trade scheme with auctioning, an emissions intensity scheme would have less impact on prices. As a result, it would create less need to provide assistance to emissions-intensive trade-exposed firms and low-income households, and have smaller indirect (tax-related) effects on the economy. It would also drive fewer demand-side emissions reductions.

In contrast, 'grandfathering' allocates permits according to generators' historical output levels, regardless of their actual level of output. Any generator can use their permits themselves, or sell them. The price generators would receive for selling a permit is its 'opportunity cost', which is incorporated in generators' wholesale costs and therefore passed on to consumer electricity prices.

Further comparisons of market mechanisms are in Sections 4.1 and 4.3, and Table 7.

3.2. The Authority's approach to comparing policies

In Report Two of the Special Review the Authority sought feedback on an evaluation framework to compare and assess emissions reduction policy options. The framework is based on the principles set out in the *Climate Change Authority Act 2011* (Cth) and comprises three key principles:

1. Cost effectiveness: policies should help Australia meet its emissions reduction goals at least cost as efforts are scaled-up over time, taking account of: the *direct costs* of reducing emissions; the costs

of *administering and complying* with policies; and *indirect costs* of policies on the economy as a whole.

2. Environmental effectiveness: policies should achieve real emissions reductions, at the national and global level.
3. Equity: policy design should take account of—and support an equitable distribution of—impacts and risks across households, businesses and communities.

As outlined in Report Three, stakeholders generally endorsed the Authority's evaluation framework, agreeing that the principles above are a robust basis for assessment of policies. Some stakeholders suggested additional criteria for consideration.

- Some energy sector stakeholders—including the Australian Energy Council (formerly the Energy Supply Association of Australia), the Energy Networks Association (ENA) and Origin Energy—noted the importance of energy reliability and security, and the ENA suggested including these in the evaluation framework. The Authority agrees that policies' consistency with electricity reliability and other aspects of market operation are important for the cost effectiveness of electricity sector climate policy and has considered this in its evaluation.
- Some stakeholders—including WWF Australia, ClimateWorks and Local Government NSW—highlighted policy scalability and/or flexibility as important criteria. The Authority agrees that these are important and considers them when assessing both cost effectiveness and environmental effectiveness. See Report Three for further discussion.

In this report, the Authority considers how these general principles relate to the electricity sector. The rest of this section outlines some issues of particular importance. The relatively longer discussion of cost effectiveness should not necessarily be interpreted as implying the Authority places greater weight on this criterion; rather it is because of the additional explanation of the underpinning concepts. The full list of factors that the Authority has considered is at Appendix B.

The terms of reference for the Special Review (Appendix A) require the Authority to consider the possible effects of an emissions trading scheme or other policies with similar effect on the international competitiveness of Australian businesses. Emissions reduction policies in the electricity sector can increase prices for electricity consumers, including trade-exposed businesses, which may in turn affect the competitiveness of those sectors in global markets. These potential impacts are discussed briefly in Section 4.1.1; policy options to address international competitiveness are discussed in Report Three of the Special Review.

When considering the **cost effectiveness** of electricity sector policies, the Authority places particular emphasis on policies' ability to respond flexibly to changes. The Paris Agreement architecture requires all Parties to review and progressively increase their emission reduction commitments every five years, with reference to the global emissions goals, so it is important that Australia's policies can be scaled up to meet targets at least cost to the community. The long-term nature of the challenge means it is also important that policies have the flexibility to adjust and cost-effectively reduce emissions in light of unforeseen changes in technology costs and availability, and electricity demand. Also important to flexibility (noting that these are also discrete policy choices and views differ as to their merits) is whether policies can be linked internationally with a cap and trade, emissions intensity or other scheme, can use international permits or credits, or can cover sectors other than electricity.

The Authority is drawing on commissioned electricity sector and economy-wide modelling (discussed further in the next section) to estimate both the direct and indirect costs of policy options, as well as their cost per unit of emissions reduced.

- Direct implementation costs are the additional costs above those that would have occurred in the absence of the policy, such as the added cost of investing in a low-emissions electricity generation plant rather than a high-emissions one. These are measured by the ‘resource cost’ of the policy in the electricity sector, before considering its emissions reductions. This takes into account the net change in fuel costs, operational expenditure, capital expenditure, and retirement costs, adjusted for the reduction in demand due to the policy. For example, policies which result in more low-emissions plant being built tend to require greater capital expenditure, but can have lower fuel costs than a situation with no policy.
- The cost per unit of emissions reduced is measured through the ‘cost of abatement’. This measures the overall cost effectiveness of each policy in reducing emissions. It is calculated by dividing the resource costs relative to the reference scenario by the emissions reductions achieved by the policy.
- In addition to their direct costs, policies often involve indirect costs, including those due to interactions with the tax system. Taxes and price rises generally dampen economic activity. These indirect costs are more important to the cost effectiveness of policies than has been generally recognised (Goulder 2013) and are discussed further in Section 3.3.
- Both direct and indirect costs are captured through indicators such as changes in macroeconomic measures such as Gross National Income (GNI) and Gross Domestic Product (GDP). GNI and GDP are widely used to assess the total economic cost of a policy change. GNI is generally preferred in this report as an indicator of economic welfare as it is a better measure of the purchasing power and living standards of Australians than GDP. This is because GNI estimates the total income of Australians, including that earned abroad but excluding that of persons from overseas in Australia, while GDP reflects the total economic output of the domestic economy. GNI also includes changes in the ability of Australians to purchase imports when the relative prices of imports and exports (the ‘terms of trade’) changes. Changes in wholesale and residential electricity prices affect consumption and investment decisions across the economy and therefore GDP and GNI.

Further information on the cost effectiveness measures is at Appendix C.

While the focus here is *comparing* policies using cost effectiveness as a guide, this does not include an assessment of the benefits they provide. Benefits not measured include: the climate-related economic, health and environmental benefits of avoided warming; and specific co-benefits of policies, such as avoided air pollution due to reduced coal combustion.

The key aspects of **environmental effectiveness** the Authority considers are how overall emissions and emissions intensity change under the policy, and whether a policy can achieve the desired emissions reductions with certainty. Policy scalability and robustness are important here, as they are for cost effectiveness.

The Authority’s consideration of **equity** includes the distribution of the costs and benefits of the policy, for example its impacts on household electricity costs, and profits of incumbent generators. Also relevant is whether a policy creates or consumes revenue (and in turn whether revenue is available for assisting affected groups).

3.3. Modelling commissioned for this Review

The Authority commissioned two sets of economic modelling to inform its consideration of policy options for Australia's electricity supply sector. The modelling provides a quantitative comparison of policy options on a like-for-like basis. The Authority engaged:

- Jacobs Group to undertake electricity market modelling of a wide range of mitigation policy options and
- Victoria University to undertake computable general equilibrium (CGE) modelling of the economy-wide implications of a subset of electricity sector mitigation policies.

Detailed reports with modelling results from Jacobs and Victoria University are available at www.climatechangeauthority.gov.au.

Electricity market modelling

Jacobs' modelling compares the performance of a range of policies across measures including emissions, electricity prices, resource costs and their distribution. In order to facilitate a like-for-like comparison of policies, the modelling uses common input assumptions and constrains each policy scenario to achieve the same emissions budget over 2020 to 2050. The emissions budget was set at a level consistent with Australia and the world taking action to limit global warming to no more than 2 degrees by the end of the century.

Jacobs modelled a range of policies, some of these policies will be more familiar (for example, a renewable energy target or cap and trade scheme); some maybe less so. These policies are explained in greater detail in Table 3.⁸ Jacobs also modelled the performance of policy combinations, and examined the robustness of policies through sensitivity analysis. The sensitivities were chosen to assist in comparing the performance of policies only and should not be interpreted as policies the Authority would recommend. Sensitivities modelled were:

- Low demand—a shift to both lower demand drawn from the grid (that is, lower 'operational' demand, due to higher penetration of rooftop PV) and lower overall ('underlying') electricity demand. Battery storage costs decline faster than in the core policy scenarios.
- High demand—underlying electricity demand grows faster, on average, than currently projected, for example due to electrification of the transport and industrial sectors.
- Technology sensitivity—nuclear, CCS and geothermal technologies never become available in Australia. Battery storage costs decline at the same rate as in the low demand scenario.
- Weaker emissions budget—consistent with limiting warming to no more than 3 degrees. This scenario is included merely for the purpose of testing model sensitivity and does not reflect the Authority's endorsement of a three degree temperature increase as a policy objective.

The corresponding reference cases each assume that existing state policies, the Small-scale Renewable Energy Scheme and the 33,000 GWh Large-scale Renewable Energy Target remain in place.

Further details on the policies and policy combinations, reference cases and sensitivities are in Appendix C.1.

⁸ Carbon taxes and cap and trade schemes with full auctioning are very similar in economic models including Jacobs', so only one policy was modelled. The modelling results are informative for both policies.

It is important to note that the modelling does not aim to predict future outcomes; rather it is intended to provide high-level insights to inform policy choice. This means that the modelling makes a range of assumptions and simplifications. For example, some details of the electricity sector that are important for short-term outcomes, but small in absolute terms over the period to 2050, are omitted. This does not materially affect policy comparisons. Where the assumptions are most important for making policy comparisons—such as the level of electricity demand or the availability of technologies—Jacobs' work in the sensitivity scenarios explores how the performance of policies change when assumptions are varied.

To test the robustness of the policy comparisons in Jacobs' modelling, the Authority commissioned HoustonKemp to undertake an independent peer review. HoustonKemp assessed whether the assumptions and approach might advantage one policy option over another. Overall, HoustonKemp found that the modelling had been conducted to a high standard of rigour and that the critical policy comparisons drawn by Jacobs were robust (HoustonKemp 2016). Appendix C.2 provides further details on the peer review.

Economy-wide modelling

Electricity sector policies will have effects on the broader economy that are not captured by electricity sector modelling. These effects could change the relative ranking of policy options examined in the electricity market modelling, so are relevant for comparing the performance of electricity sector climate policies.

Two particular effects might change the relative cost effectiveness of different market mechanisms. These are:

- tax interaction effects
- revenue recycling.⁹

Taxes are necessary for governments to fund their spending programs. However, in general, taxes discourage economic activity and, hence reduce economic value. For example, income tax will, at some point, discourage people from working. If people work less this reduces economic activity and diminishes the value of the economy. Corporate taxes have a similar effect on discouraging activity. At some point taxes on the profit of firms will discourage investors from taking investment risks because taxes erode too much of the returns. If investors do not devote resources to building new business this will diminish the value of the economy because there will be fewer jobs and less innovation.

Emissions reduction policies that have the effect of increasing energy prices act like a tax in that they raise the price of goods and services and this reduces either disposable income or investor returns. The fact that this effect comes on top of existing taxes means that the lost economic value is magnified because the additional impost discourages even more valuable consumption and lower cost production. This magnification of lost economic value due to emissions reduction policies being imposed as well as existing taxes is known as the 'tax interaction effect'.

Revenue recycling refers to how governments use revenue raised by emissions reduction policies. Some policies raise substantial revenue to recycle; other policies do not. Further, the manner in which revenue is recycled can have important economic effects: using revenue to cut existing taxes is likely to increase economic output more than making 'lump sum' payments to households. Lump sum payments

⁹ Other indirect effects can arise, such as through changes in Australia's terms of trade. However, these are less likely to affect the relative cost effectiveness of policies and so are not the focus here.

are payments such as pensions. While they return government revenue to households, resulting in an increase in consumption, they have a minimal effect on economic efficiency.

To examine these economy-wide effects and ensure they are considered in its assessment of policy options, the Authority commissioned Victoria University to undertake economy-wide CGE modelling of different market mechanisms. The modelling projects the overall impact of electricity sector climate policies on economic activity across the economy (as measured by GDP and GNI), employment, investment and trade outcomes.

Victoria University modelled three policy scenarios to examine these effects. These are:

- a cap and trade scheme with lump sum revenue recycling ('cap and trade (lump sum)')
- a cap and trade scheme with revenue recycling through tax cuts ('cap and trade (tax cuts)') and
- an emissions intensity scheme.

When comparing between scenarios the cap and trade (lump sum) scenario is used as the reference case.

Comparing results from the two cap and trade scenarios illustrates the economic effects of recycling revenue in different ways. Using carbon revenue to fund tax cuts will tend to improve economic efficiency when compared to returning it to households through lump sum payments.

Comparing the emissions intensity and cap and trade (lump sum) scenarios provides insights into the size of the tax interaction effect. An emissions intensity scheme tends to have a smaller impact on electricity prices than a cap and trade scheme or a carbon tax, and so is likely to cause smaller tax interaction effects, and a smaller effect on economic activity.

The three scenarios are summarised in Table 4.

The policy scenarios are the same as or closely based upon electricity sector modelling scenarios consistent with limiting temperature increases to no more than 2 degrees. Changes were made to the scenario design where they were important for making a like-for-like comparison between policies at the economy-wide level. The main changes were:

- The carbon price used in all three scenarios was the same. This approach makes it easier to compare the economy-wide effects of market mechanisms.
- Australia can purchase international permits or credits at the prevailing carbon price. Using the same carbon price means that Australian domestic emissions may vary between scenarios. To allow a like-for-like policy comparison, differences in costs between the scenarios must be due to differences in policy design rather than in their level of emissions reductions. This is achieved by allowing purchases of international permits or credits so that the scenarios achieve a common net national emissions budget.

Table 4 Summary of CGE modelling policy scenarios

Policy scenario	Treatment of electricity sector	Treatment of other emitting sectors	Treatment of carbon price revenue
Cap and trade with lump sum revenue recycling ('cap and trade (lump sum)')	A carbon price consistent with limiting global warming to 2 degrees. All permits are auctioned.	A carbon price consistent with limiting global warming to 2 degrees. All permits are auctioned.	All revenue recycled through lump sum payments to households.
Cap and trade with revenue recycling through tax cuts ('cap and trade (tax cuts)')	A carbon price consistent with limiting global warming to 2 degrees. All permits are auctioned.	A carbon price consistent with limiting global warming to 2 degrees. All permits are auctioned.	Electricity sector revenue recycled through income and company tax cuts. All other revenue recycled through lump sum payments to households.
Emissions intensity scheme	A carbon price consistent with limiting global warming to 2 degrees. Generators are allocated free permits in proportion to their electricity output and a government-set intensity baseline.	A carbon price consistent with limiting global warming to 2 degrees. All permits are auctioned.	All revenue recycled through lump sum payments to households. Revenue from electricity sector is negligible due to free allocations of permits to generators.

Note: Lump sum payments are government payments such as pensions. While they return government revenue to households, resulting in an increase in consumption, they have a minimal effect on economic efficiency.

Source: Climate Change Authority.

The modelling results should be treated as indicative and used primarily to assess relative policy costs at a high level, rather than to make precise estimates of policy impacts. There are two main reasons for this.

- First, while the modelling provides some insights to the tax interaction effect and revenue recycling, some important economic relationships are only captured at a relatively high level—in particular, how the tax system and workers respond to changes in real wages.
- Second, as the modelling does not capture all relevant equity impacts, its insights into cost effectiveness should be balanced against other considerations. For example, the impact of changes in electricity prices on low-income households cannot be explored in this modelling, but is considered qualitatively as part of the Authority’s assessment of the equity impacts of different policy options.

For more detail on the scenario design, modelling methodology and assumptions see Appendix C.3.

Related modelling exercises

There have been many recent studies using electricity sector models to explore climate policies in the Australian electricity sector. Each study focuses on different questions, and so is designed differently.

Given its aim of comparing policies to inform policy choice, the Authority’s commissioned modelling has investigated the largest range of climate policies and sensitivities on Australia’s electricity sector in recent history.

Table 5 provides an overview of some prominent modelling exercises and how they relate to the Authority’s commissioned modelling. While each exercise has different input assumptions and a different modelling approach, which contribute to different results, the Authority’s modelling has features in common with other exercises investigating 2 degree consistent emissions reductions in the sector. For example, projected changes in the emissions intensity of generation over time are similar in Jacobs’

modelling and ClimateWorks' Pathways to deep decarbonisation in 2050 study (ClimateWorks Australia et al. 2014).

Table 5 Related modelling studies overview

Organisation, year, study (modeller/s)	Main purpose; policy; target/s
<p>Climate Change Authority, 2016, <i>Policy options for Australia's electricity supply sector</i> (Jacobs, Victoria University)</p>	<p>Purpose: compare the relative merits of a wide range of climate change policies for the electricity sector, including robustness tests.</p> <p>Policies explored: cap and trade scheme, emissions intensity scheme, renewable energy target, low emissions target, contracts for difference, regulated closures, facility specific absolute baselines, combinations of policies. CGE modelling of some policies.</p> <p>Core emissions target: electricity sector emissions budget 2020–2050 consistent with a likely chance of limiting warming to 2 degrees.</p> <p>Alternate emissions targets: electricity sector emissions budget 2020–2050 consistent with a likely chance of limiting warming to 3 degrees. This scenario is included merely for the purpose of testing model sensitivity and does not reflect the Authority's endorsement of a three degree temperature increase as a policy objective.</p>
<p>The Climate Institute, 2016, <i>Electricity sector impacts of policies to cut emissions of greenhouse gases</i> (Jacobs)</p>	<p>Purpose: test a range of policies and policy combinations against emission reductions for the electricity sector to play its part in achieving the below 2 degrees goal.</p> <p>Policies explored: carbon pricing, regulated closure, clean energy target (renewable energy target with CCS also eligible), combinations of policies.</p> <p>Core emissions target: electricity sector emissions budget 2020–2050 consistent with a likely chance of limiting warming to 2 degrees.</p>
<p>South Australian Nuclear Fuel Cycle Royal Commission, 2016, <i>Computational general equilibrium modelling assessment</i> (Ernst and Young; Victoria University)</p>	<p>Purpose: assess the potential economic impacts on the South Australian and Australian economies resulting from additional investment in nuclear fuel cycles.</p> <p>Policies explored: two scenarios: expanded ERF from 2020 to 2030 plus a carbon price from 2030 to 2050; carbon price from 2017 to 2050.</p> <p>Core emissions targets: Australia's emissions budget is consistent with a likely chance of limiting warming to 2 degrees.</p> <p>Alternate emissions targets: Australia's emissions budget is consistent with a likely chance of limiting warming to 1.5 degrees.</p>
<p>Energy Networks Association, 2016, <i>Australia's climate policy options</i> (Jacobs)</p>	<p>Purpose: quantify the impacts of alternative policy approaches to achieve the national 2030 emissions reduction target. The analysis focuses on achieving this in stationary energy activities covering both electricity and direct combustion.</p> <p>Policies explored: renewable energy target, extended energy efficiency schemes, extended safeguard mechanism with absolute baselines, low emissions target plus an emissions intensity baseline and credit scheme, carbon price, combinations of policies (for high ambition scenarios).</p> <p>Emissions targets: the sector's emissions are 26 to 28 per cent below 2005 levels by 2030 or 45 per cent below 2005 levels by 2030.</p>
<p>GetUp! and Solar Citizens, 2016, <i>The homegrown power plan</i> (University of Technology Sydney Institute of Sustainable Futures)</p>	<p>Purpose: explore how the energy system should change for Australia to transition to a 100 per cent renewable future, including electricity, heating, transport and industry.</p> <p>Policies explored: two alternative 2050 renewable energy targets modelled (primary energy, across all sectors): 70% renewable energy by 2050 and 100 per cent renewable energy by 2050. Both renewable scenarios cover all sectors (including power, heating, transport and industrial processes) and assume a target of doubling energy productivity by 2030.</p> <p>Emissions targets: Scenario 1: 50 per cent reduction on 1990 energy-related CO₂ emissions by 2035, 70 per cent reduction by 2050. Scenario 2: 30 per cent emissions reduction on 1990 levels by 2030, 75 per cent on 1990 levels by 2040, full decarbonisation of power, industry and transport by 2050.</p>
<p>Melbourne Energy Institute (MEI), 2016, <i>Least cost, utility scale abatement from Australia's NEM</i> (MEI)</p>	<p>Purpose: explore the least cost greenhouse gas abatement pathways for the electricity system at different abatement targets.</p> <p>Policies explored: no explicit policies modelled for most scenarios, one scenario explored a renewable energy target. Other scenarios include technology, fuel price and discount rate sensitivities.</p> <p>Emissions targets: five sectoral abatement targets set at 20, 40, 60, 80 and 100 per cent below 2000 levels by 2050.</p>

Organisation, year, study (modeller/s)	Main purpose; policy; target/s
CSIRO, 2015, <i>Australia's National Outlook 2015</i> (CSIRO)	<p>Purpose: provide evidence to enable Australia to navigate the challenges involved in achieving sustainable prosperity by investigating a wide range of potential futures.</p> <p>Policies explored: four national and international abatement scenarios (very strong, strong, moderate and none) with corresponding carbon prices.</p> <p>Emissions targets: Australia's emissions budget is consistent with a likely chance of limiting warming to 2 degrees (very strong abatement), 3 degrees (strong and moderate abatement) and 6 degrees (no abatement).</p>
Energy Networks Association and CSIRO, 2015, <i>Electricity network transformation roadmap: Future Grid Forum - 2015 refresh</i> (CSIRO)	<p>Purpose: set out pathways for transition of Australia's electricity networks to 2050.</p> <p>Policies explored: carbon price with existing RET, carbon price with 100 per cent RET by 2050 (four carbon price scenarios explored).</p> <p>Core emissions target: Australia's emissions budget is consistent with a likely chance of limiting warming to 3 degrees.</p>
ClimateWorks, 2014, <i>Pathways to deep decarbonisation in 2050: How Australia can prosper in a low carbon world</i> (CSIRO; ANU; Victoria University)	<p>Purpose: investigate how Australia can transition to a low carbon economy.</p> <p>Policies explored: the modelling uses an implied carbon price as a stylistic representation of a suite of emissions reduction policies. Three technology constraints were modelled (100 per cent renewables, renewables and nuclear with no CCS, and renewables and CCS with no nuclear).</p> <p>Core emissions target: Australia's emissions budget is consistent with a likely chance of limiting warming to 2 degrees.</p>
Expert Panel (Warburton Review), 2014, <i>Review of the Renewable Energy Target Scheme</i> (ACIL Allen)	<p>Purpose: examine the design of the RET scheme (as legislated in 2014) and options for revising the scheme to test the impacts of various RET design scenarios on metrics including the electricity generation mix, electricity and certificate prices, emissions and resource costs.</p> <p>Policies explored: various RET targets, and a no RET scenario.</p> <p>Core emissions targets: none.</p>
Climate Change Authority, 2014, <i>Targets and Progress report</i> (ACIL Allen; the Treasury; DIICSRTE)	<p>Purpose: recommend emissions reductions goals for Australia and identify Australia's progress towards targets.</p> <p>Policies explored: three carbon price paths (high, medium and low).</p> <p>Core emissions target: five per cent below 2000 levels by 2020 and 80 per cent below 2000 levels by 2050.</p> <p>Alternate emissions target: 25 per cent below 2000 levels by 2020 and 80 per cent below 2000 levels by 2050.</p>
Frontier Economics, 2009, <i>The economic impacts of the CPRS and modification to the CPRS</i> (Frontier Economics)	<p>Purpose: examine opportunities to improve the proposed Carbon Pollution Reduction Scheme (CPRS).</p> <p>Policies explored: CPRS (cap and trade scheme), CPRS with higher protection for emissions-intensive trade-exposed industries (EITEI), emissions intensity scheme.</p> <p>Core emissions target: five per cent below 2000 levels by 2020 and 60 per cent below 2000 by 2050 (CPRS and CPRS with higher EITEI support).</p> <p>Alternate emissions target: 10 per cent below 2000 levels by 2020 and 60 per cent below 2000 levels by 2050 (emissions intensity scheme).</p>

Source: Climate Change Authority based on Frontier Economics 2009; Treasury and DIICSRTE 2013; ACIL Allen Consulting 2013; ClimateWorks Australia et al. 2014; Expert Panel 2014; Graham et al. 2015; CSIRO 2015, Jacobs 2016a, 2016c; Teske et al. 2016; Adams 2016; Ernst & Young 2016.

CHAPTER 4. ASSESSING POLICY OPTIONS FOR AUSTRALIA'S ELECTRICITY SUPPLY SECTOR

This chapter uses the Authority's evaluation framework to compare the policy options introduced in Chapter 3. It addresses two core questions:

- Should there be a market mechanism in the electricity supply sector?
- If yes, which type of market mechanism should be implemented given their relative strengths and weaknesses?

The Authority's analysis indicates that market mechanisms have a greater capacity to deliver large emissions reductions cost-effectively while remaining robust to different possible future conditions than other policy types.

The distribution of costs under market mechanisms varies across the specific type of policy: an emissions intensity scheme has lower price effects, while a cap and trade scheme or carbon tax has higher prices, but also raises revenue which can be used to provide assistance where appropriate.

The Authority's view is that a market mechanism of some form is desirable in the electricity sector.

4.1. Comparing the performance of policies to reduce electricity emissions

This chapter considers which policy option is best suited to being the primary policy for reducing emissions in the electricity supply sector. Chapter 5 examines the potential to use policies in combination.

The electricity sector's characteristics—measurable emissions, relatively small number of large emissions sources, and sophisticated investors operating in generally competitive generation markets—suggest that market mechanisms are feasible and more cost-effective than alternatives.

The following sections compare the performance of the policy options described in Table 3 of Chapter 3 against the core criteria of environmental effectiveness, cost effectiveness and equity. Overall, the Authority finds that:

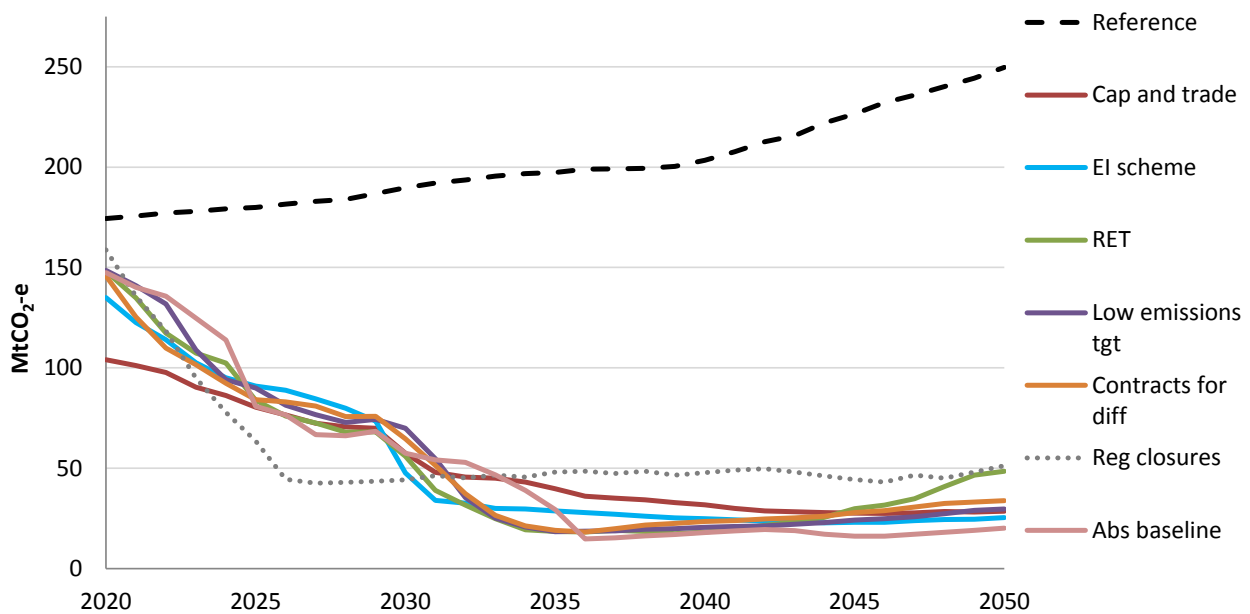
- While all policy options are capable of achieving deep emissions reductions in the electricity sector, technology pull and regulatory policies have greater costs and risks than market mechanisms.
- A market mechanism for the sector could allow Australia to meet its targets at a lower cost to the community than would be possible without such a policy in the toolkit.
- All supply-side mitigation policies have costs as well as benefits, however these can be addressed in a number of ways. Achieving substantial emissions reductions over the longer term is likely to increase electricity prices for consumers and change the relative value of generators' plant.

- Equity concerns can be dealt with through policy choice—as the scale and distribution of costs varies across the options available—and through other measures, such as targeted assistance or energy efficiency policies which can improve electricity affordability.

4.1.1. Environmental effectiveness

The key measures of a mitigation policy’s environmental effectiveness are the volume of emissions reductions it can achieve and the likelihood of the policy achieving the reductions across a range of circumstances. Jacobs’ modelling finds that almost all of the policies analysed are capable of achieving deep emissions reductions consistent with a likely chance of limiting warming to 2 degrees (Figure 11). This suggests that the main differences between policies are their costs, the distribution of costs and their risks.

Figure 11 Emissions by policy, 2 degrees, 2020–2050



Note: Emissions from the NEM and WEM. Emissions comprised of direct emissions (from combustion of fuels in electricity generation) and indirect emissions (emitted during processing and supply of fuel to power stations). The regulated closures policy breaches the emissions budget by about 200 Mt CO₂-e or 15 per cent.

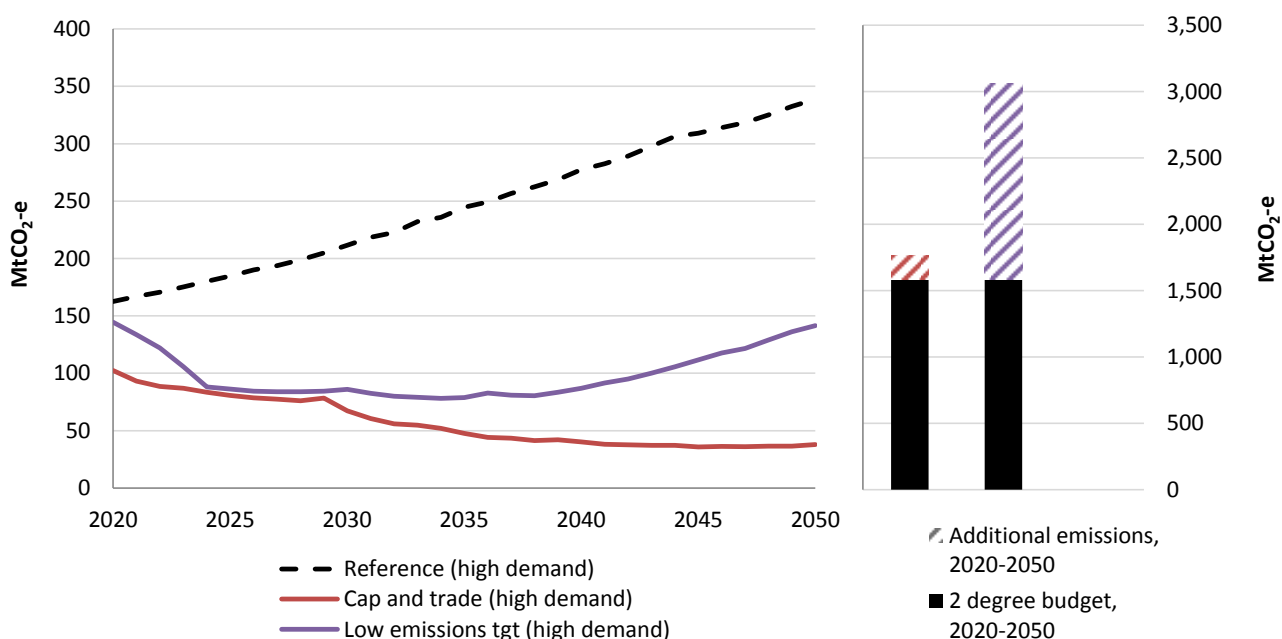
Source: Jacobs 2016c.

In Jacobs’ modelling all policies, except regulated closures, limited 2020–2050 cumulative emissions to about 1,600 Mt CO₂-e or about a quarter of the emissions in the reference case. The regulated closures scenario was about 15 per cent over this limit—even with rapid closure of all existing coal-fired generators by 2027, restrictions on gas-fired generation and a prohibition on new coal without CCS, the scenario was unable to achieve the emissions budget. This is because, in the absence of other policy mechanisms, coal is replaced with a large amount of gas-fired generation rather than renewables. In practice another policy might be introduced alongside closures, however the Authority’s modelled policy combinations suggest regulated closures may still struggle to achieve deep emissions reductions (Section 5.2).

Technology pull and regulatory policies can be less flexible to changing circumstances than market mechanisms, which can affect their environmental effectiveness. For example, the technology pull policies have more difficulty constraining emissions if electricity demand is much higher than currently projected. The Authority’s modelling explored this through a sensitivity analysis—cap and trade and low

emissions target policies were modelled with high demand (which could arise, for example, through faster uptake of electric vehicles than currently expected). The cap and trade policy constrains emissions throughout the period, whereas in the low emissions target scenario emissions increase rapidly once the low emissions targets are met (Figure 12). In practice it is possible that, if demand proved significantly higher than first projected, the low emissions target would be adjusted or some other policy would be introduced to help meet the national emissions reductions target. Nevertheless, the result highlights some of the risks associated with policies that do not directly constrain emissions, particularly when implemented in isolation.

Figure 12 Emissions by policy, high demand sensitivity, 2020–2050



Note: Emissions from the NEM and WEM. Emissions comprise direct emissions (from combustion of fuels in electricity generation) and indirect emissions (emitted during processing and supply of fuel to power stations). The chart on the left hand side shows emissions over time and the chart on the right hand side shows cumulative emissions from 2020–2050. As outlined in Section 3.3, the cap and trade policy was modelled as a carbon tax and the results are informative for each type of policy. Under a cap and trade scheme the additional emissions reductions could be obtained through domestic offsets or international permits or credits. Cumulative emissions are about 75 per cent higher in the low emissions target policy than in the cap and trade policy. The reference case (high demand) assumes, like the core reference case, strong global action to reduce emissions, and no additional climate policies in the Australian electricity sector. It has higher electricity demand than the core reference case. See Appendix C.1.

Source: Jacobs 2016c.

A further aspect of environmental effectiveness is the risk of carbon leakage. Carbon leakage is the shift of production of goods or services and their associated greenhouse gas emissions to another country. This can erode the environmental effectiveness of Australia’s emissions reduction efforts. While there is no risk of direct carbon leakage from the electricity sector—as there is no export or import of electricity from or to Australia—mitigation policies in the electricity sector can increase prices for electricity consumers. If the electricity price increases result in Australian businesses losing market share to international competitors, this could reduce output (and the associated emissions) in Australia, and increase output in other countries. If those countries do not have economy-wide binding emissions constraints, the increase in output could also increase emissions, eroding the environmental effectiveness of Australia’s policy. In the absence of additional measures, policies that cause the largest increase in prices may have the largest potential competitiveness effects. A range of design features

could be employed to address competitiveness concerns. The Authority's recommendations on measures to address competitiveness are in Report Three of the Special Review.

4.1.2. Cost effectiveness

Direct costs

Economic theory and analysis suggests that market mechanisms are generally lower cost than:

- regulation (particularly more prescriptive forms), because market mechanisms leave it up to firms (and sometimes individuals) to decide how emissions can most easily and cheaply be reduced, and those firms have better information regarding their emissions reduction opportunities than government (Stavins 2003)
- technology pull policies—such as a RET—because market mechanisms can be applied to a broader set of emissions reduction opportunities and target emissions reductions directly (Garnaut 2008, p. 354).

This is consistent with results from the Authority's modelling: the market mechanisms are projected to have the lowest resource costs and costs per unit of emissions reductions ('cost of abatement') under the 2 degrees emissions budget (Figure 13) and the weaker 3 degrees emissions budget.¹⁰ The technology pull policies have relatively high resource costs because they only provide direct encouragement for one of the five emissions reduction opportunities discussed in Section 2.4—building new zero- or low-emissions plants. This means that other and potentially cheaper emissions reduction options—such as fuel switching and closure—are not directly targeted. Like the technology pull policies, a regulated closures policy provides direct encouragement for only one of the five emissions reduction opportunities—retiring higher emissions generators—so has higher overall costs of meeting emissions budgets.

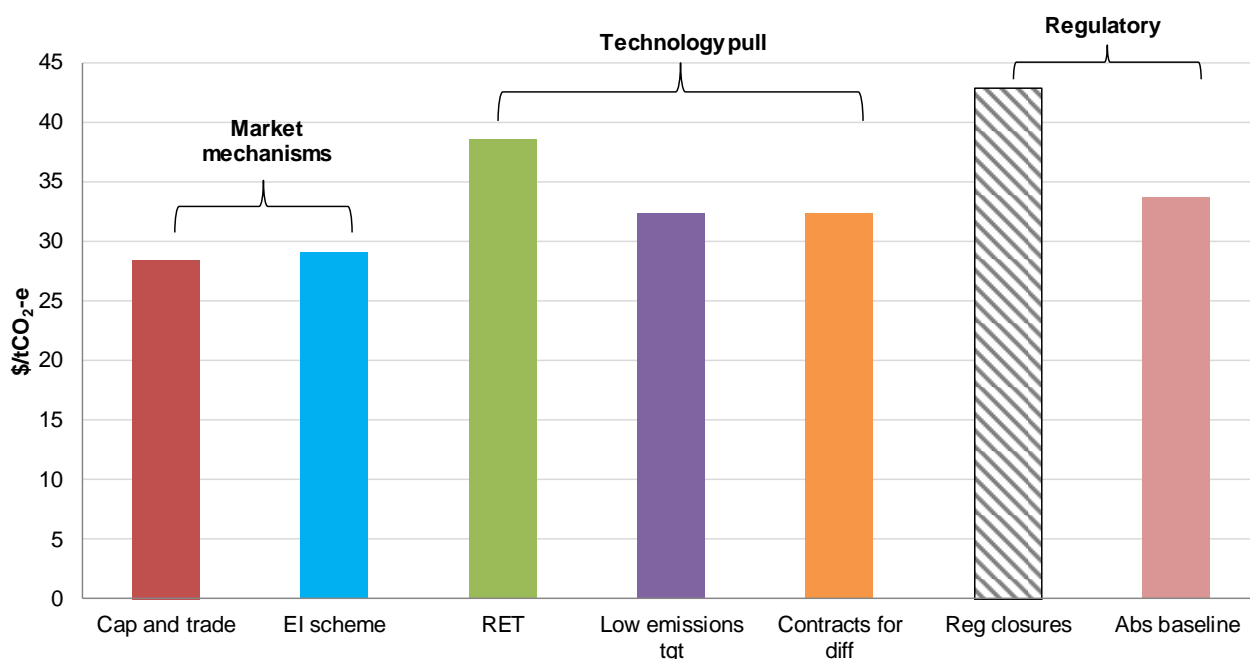
The Authority's qualitative analysis and Jacobs' modelling also suggest market mechanisms can be more flexible to changing demand and technology costs than other policies, strengthening their relative cost effectiveness. For instance, if a new low-emissions technology becomes available that is cheaper than current technologies, but a climate policy only supports current technologies, then the cost of the policy will increase compared to a technology neutral policy. Similarly, regulatory policies that mandate exit or constrain output from particular generators are unlikely to adjust rapidly to changing demand. For example, if generators are shut down and demand is higher than policy makers expect, this may create risks to reliability of supply and increase costs.

Another aspect of the cost effectiveness of a policy is its interaction with electricity market operation. As noted in Section 2.1, electricity sector climate policies affect the operation of existing electricity markets and should be designed with the operation of electricity markets in mind. There are four aspects to efficient market operation that can be affected by climate policies: generator exit, generator entry, electricity dispatch and system reliability. As noted above, policies which allow market participants to determine what and when new investment or exit is desirable are likely to be lower cost, because participants have better information to underpin their investment decisions than government. Additionally, policies that place quantitative limits or requirements on generation, or provide incentives for generation that are not linked to market conditions, may be higher cost. For instance, if a policy supports new generation irrespective of the market price it may incentivise generation when demand is

¹⁰ The three-degree scenario is included merely for the purpose of testing model sensitivity and does not reflect the Authority's endorsement of a three-degree temperature increase as a policy objective.

low, moving the market away from the least-cost generation mix supply and increasing overall costs. System reliability is discussed in Box 1 and its treatment in Jacobs' modelling is outlined in Appendix C.1. Finally, linking mitigation schemes—both domestically and internationally—can reduce the costs of the scheme (CCA 2014d, 2014c; McKibbin 2015). For example, the use of domestic offsets from uncovered sectors may provide a low-cost way to reduce emissions in the electricity sector. That said, restricting the use of international permits and credits may improve certainty for investors in Australian low-emissions generation assets. In general, linking is easier with policies that involve markets of tradable permits and directly observable prices. Linking is harder to do with some technology pull or regulatory policies. The Authority has addressed linking in more detail in Report Three of the Special Review.

Figure 13 Average cost of abatement by policy, 2 degrees, 2020–2050



Note: Average cost of abatement over 2020–2050 using a seven per cent discount rate for resource costs. Emissions not discounted. Figure accounts for the reduction in welfare from a fall in electricity demand resulting from increased retail electricity prices. The regulated closures policy breaches the common cumulative emissions budget by about 200 Mt CO₂-e or 15 per cent, so the cost of abatement here is not directly comparable with other policies. For further details on the cost of abatement method, see Appendix C.1. All dollar figures reported in this report are in 2014 Australian dollars unless otherwise specified.

Source: Climate Change Authority based on Jacobs 2016c.

Several stakeholders that made submissions to Report Two of the Special Review noted the importance of adopting a low-cost policy such as a market mechanism. The Energy Users Association of Australia (EUAA) submitted that:

The mechanism used to achieve Australia's emissions targets should be market-based. Market-based instruments allow businesses greater flexibility in meeting their objectives at least-cost. Policy should be technology neutral in order to avoid picking winners and potentially shifting away from the least-cost solution, and care should be taken when designing policy to consider the costs of compliance and assurance. (Report Two submission, p. 2)

Similarly, the Australian Energy Council (AEC) submitted that:

Typically, market-based policies are best-placed to uncover the sources of lowest cost abatement, and we consider that the main policy instrument or instruments should leverage the power of markets to exploit distributed information. (Report Two submission, p. 1)

Further, the World Wildlife Fund (WWF) suggested that ‘a price on carbon emissions is widely recognized by economists as the most cost-effective way of driving down economy-wide emissions’ (Report Two submission, p. 3).

Indirect costs

As discussed in Section 3.3, electricity sector policies will have effects on the broader economy that are not captured by analysis of the electricity sector in isolation. The effects could change the relative ranking of policy options, so are relevant for comparing the performance of electricity sector climate policies. For example, policies with similar direct costs that differ in their effect on electricity prices will cause different levels of indirect costs through the tax interaction effect. Conversely, policies that raise revenue can generate indirect economic benefits if some of that revenue is used to reduce distorting taxes.

The Authority’s modelling and qualitative analysis suggests that:

- some indirect costs are likely to occur regardless of the policy option applied, although the level of indirect cost will depend on the actual policy used
- for all policies, achieving Australia’s long-term emissions reduction goals is likely to increase consumer electricity prices, however this does not automatically mean increased spending by households or lower real household incomes. For example, targeted assistance and energy efficiency policies can improve electricity affordability even with increased electricity prices.

Section 4.3.2 discusses the indirect costs of different market mechanisms in more detail, drawing on the Authority’s economy-wide modelling described in Section 3.3.

4.1.3. Equity

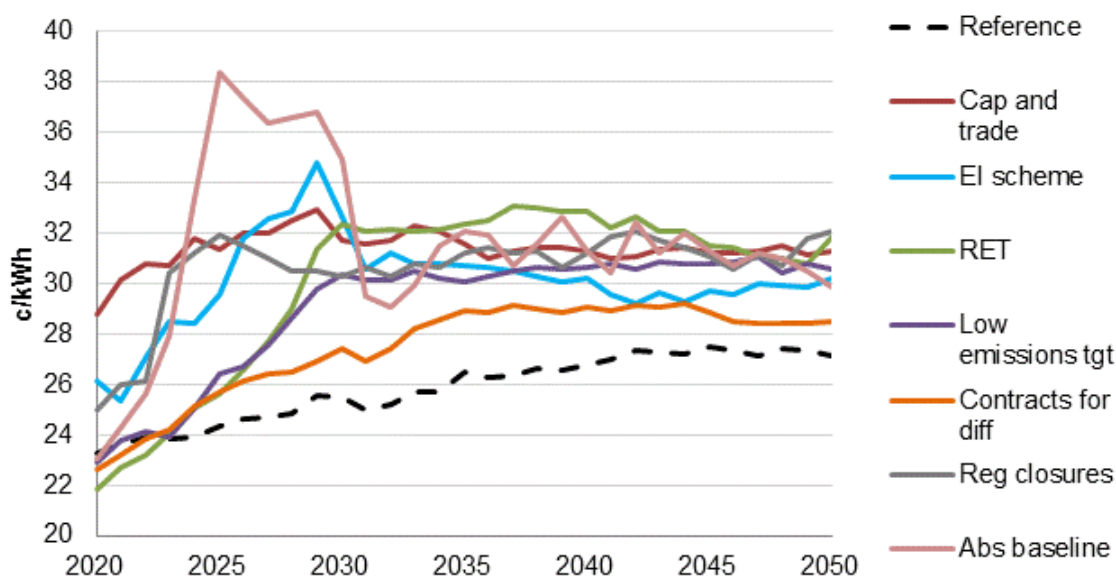
Equity considerations—that is, the distribution of costs and benefits—are also important. There are three main groups affected by emissions reduction policies in the electricity sector:

- electricity users (including households, commercial and industrial customers, and large energy-intensive users)
- generation asset owners and investors
- workers and communities in regions strongly affected by the policy.

As discussed above, achieving Australia’s long-term emissions reduction goals is likely to increase consumer electricity prices, however these impacts can be addressed in a range of ways. Some policies, such as a cap and trade scheme with auctioning or a carbon tax, are able to raise revenue which can be used to ameliorate the economic impacts. For instance, a cap and trade scheme could raise revenue which could compensate low-income households. Other policies, such as an emissions intensity scheme, may have smaller price effects and therefore create fewer equity concerns in the first place. Section 4.3 explores the economy-wide equity impacts of raising revenue versus muting retail price impacts in more detail. Looking more broadly at electricity affordability, the CSIRO recently found that, over the period to 2050, management of peak demand and associated network infrastructure costs

are projected to have a much larger influence on electricity affordability than climate action (CSIRO 2015, p. 16). Figure 14 shows the projected impacts on consumer retail prices across a range of policy options from Jacobs' modelling.^{11,12} Contracts for difference, one of the technology pull policies, generally has the lowest projected retail prices. Several factors influence this result, including the assumption that the capacity auctions are perfectly competitive, and that the long-term contracts generators sign with government can slightly reduce investors' cost of capital (Box 7 and Jacobs 2016c).

Figure 14 Average residential retail price by policy, 2 degrees, 2020–2050



Note: Prices are volume weighted using average hourly prices weighted by hourly generation shares. Volume weighted prices are calculated for each region of the NEM and WEM and a system wide average is derived by weighting each region price by the proportion of each region's energy demand to total energy demand. The regulated closures policy breaches the emissions budget by about 200 Mt CO₂-e or 15 per cent. The cap and trade scheme raises revenue which could be used to assist consumers with higher electricity prices; for other policies assistance could be drawn from general revenue.

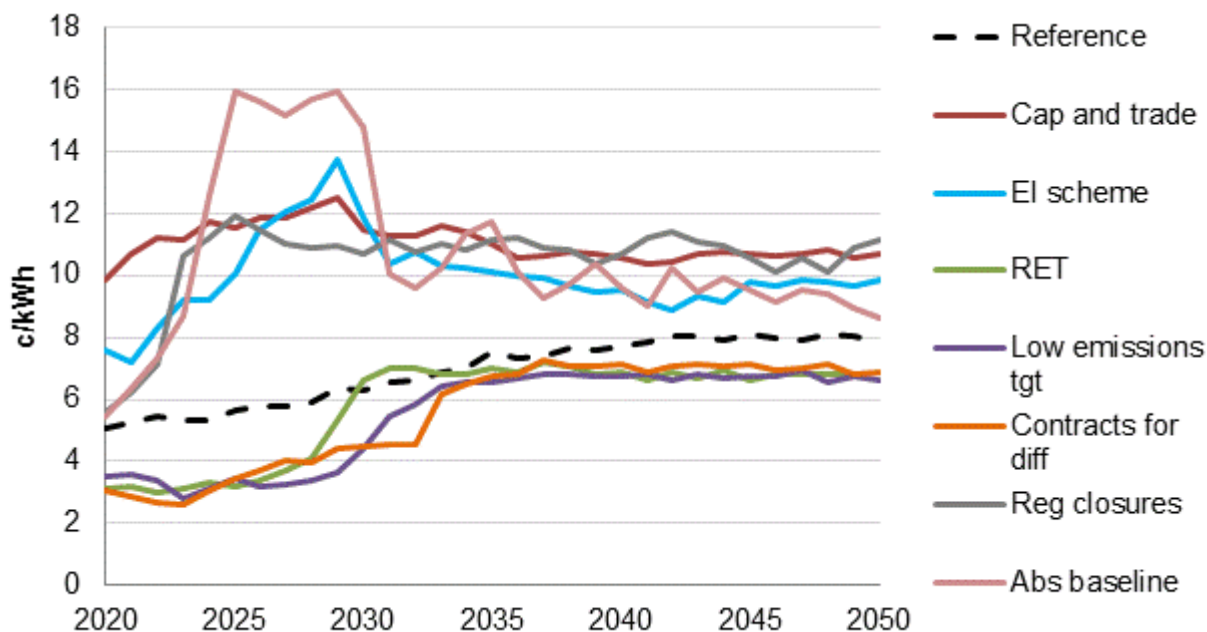
Source: Jacobs 2016c.

Emission reduction policy options have very different effects in the wholesale market. These, along with changes in market share, determine the changes in profits for incumbent generators. Technology pull policies tend to lower wholesale prices by directly subsidising eligible generators that generally bid low prices in the wholesale market (Box 2). Market mechanisms increase wholesale prices because generators have to pay for some or all of their emissions. Regulatory policies also tend to increase wholesale prices because they constrain output from low cost fossil-fuel generators. Figure 15 shows these wholesale market effects with estimates from Jacobs' modelling.

¹¹ This figure shows the projected impact of the policy options on electricity prices for residential customers. For industrial customers the relative difference in prices between policies will be the same, but will represent a larger percentage increase than for residential customers because industrial tariffs are lower. Modelled residential retail electricity prices are likely to differ from actual tariffs depending on a range of factors, including a user's location and consumption volume. The projected change in tariff between a policy scenario and the reference case will broadly reflect the expected nation-wide effects of the policy on residential retail tariffs.

¹² The absolute baselines scenario had a sustained price spike during the 2020s as illustrated in both Figure 14 and Figure 15. Over 2024–2030, new renewables are required to replace the declining output from existing plant. These renewables cause sharp increases in wholesale prices because they have only a short window to recover enough of their fixed costs before lower-cost technologies (gas CCS and geothermal) can be deployed from 2030. This increase is passed on to consumers in their retail prices. That is, the projected price spike is a function of policy design (declining limits on existing above-average emissions-intensity plants) combined with assumptions about the availability of new technologies and investors' knowledge of and expectations about future technologies and prices.

Figure 15 Average wholesale electricity price by policy, 2 degrees, 2020–2050



Note: Prices are volume weighted using average hourly prices weighted by hourly generation shares. Volume weighted prices are calculated for each region of the NEM and the WEM and a system wide average is derived by weighting each regional price by the ratio of each region’s energy demand to total demand. The regulated closures policy breaches the emissions budget by about 200 Mt CO₂-e or 15 per cent.

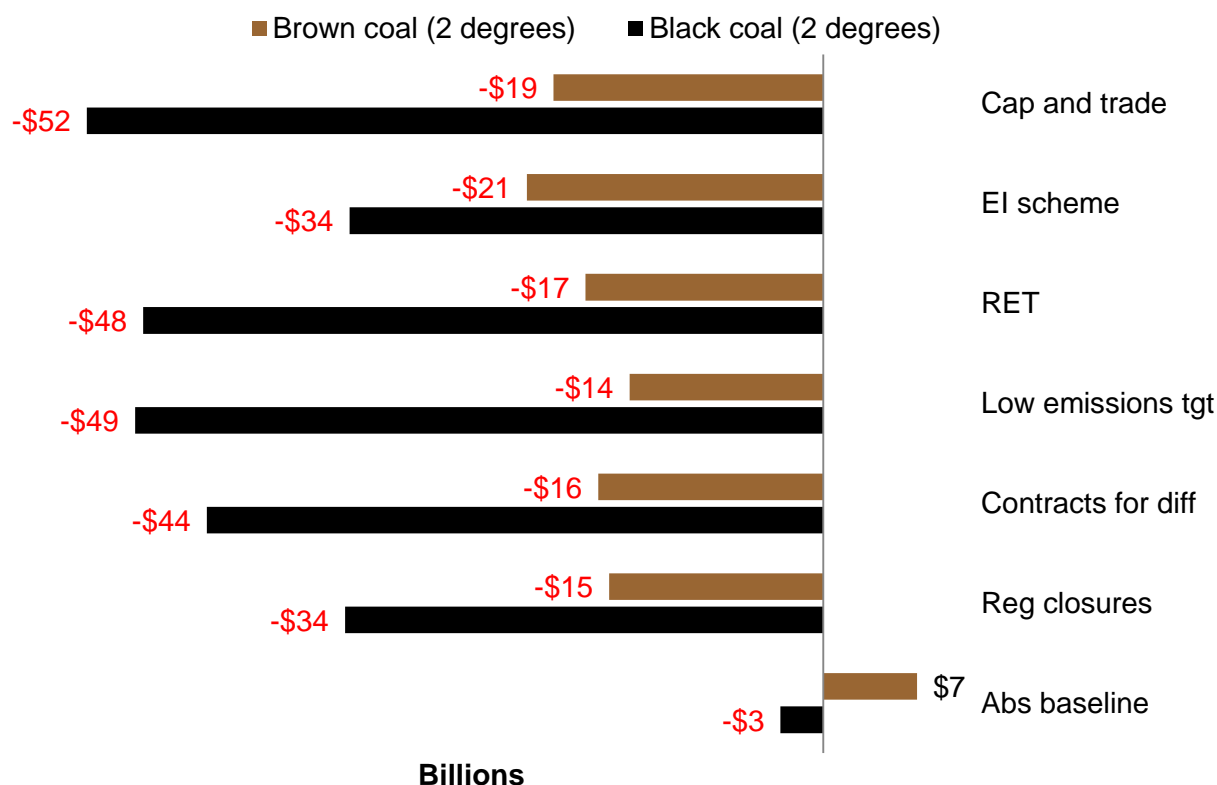
Source: Jacobs 2016c.

Most electricity sector climate policies are likely to reduce gross profits¹³ for owners of incumbent coal generators, while creating opportunities for investment in new zero- and low-emissions assets. Jacobs’ modelling finds that the projected change in profits for incumbent coal generators is similar across policies except absolute baselines (Figure 16). The technology pull policies suppress wholesale prices—and hence profits—while market mechanisms and regulatory closure policies substantially reduce output from some incumbent generators. In contrast, the absolute baselines policy raises wholesale prices in the 2020s, while incumbent generators continue to generate at relatively high levels, resulting in improved profits. Projected impacts on other incumbent generators are discussed in Appendix C.1.

With the exception of absolute baselines, declining profits may result in the closure of incumbent brown and black coal-fired generators. For example, Jacobs’ modelling projects relatively rapid closure of incumbent coal-fired generators across almost all policies. Some closures are likely even without any climate policy, due to the age of assets and broader shifts in the Australian economy. Still, some climate policy will accelerate closure, affecting regional employment and local communities. The Authority has considered regional impacts in Report Three of the Special Review.

¹³ Gross profit is a concept related to costs, and for a generator is the difference between total revenue less all operating costs.

Figure 16 Difference in NPV of gross profits for incumbent coal generators from reference case, 2 degrees, 2020–2050

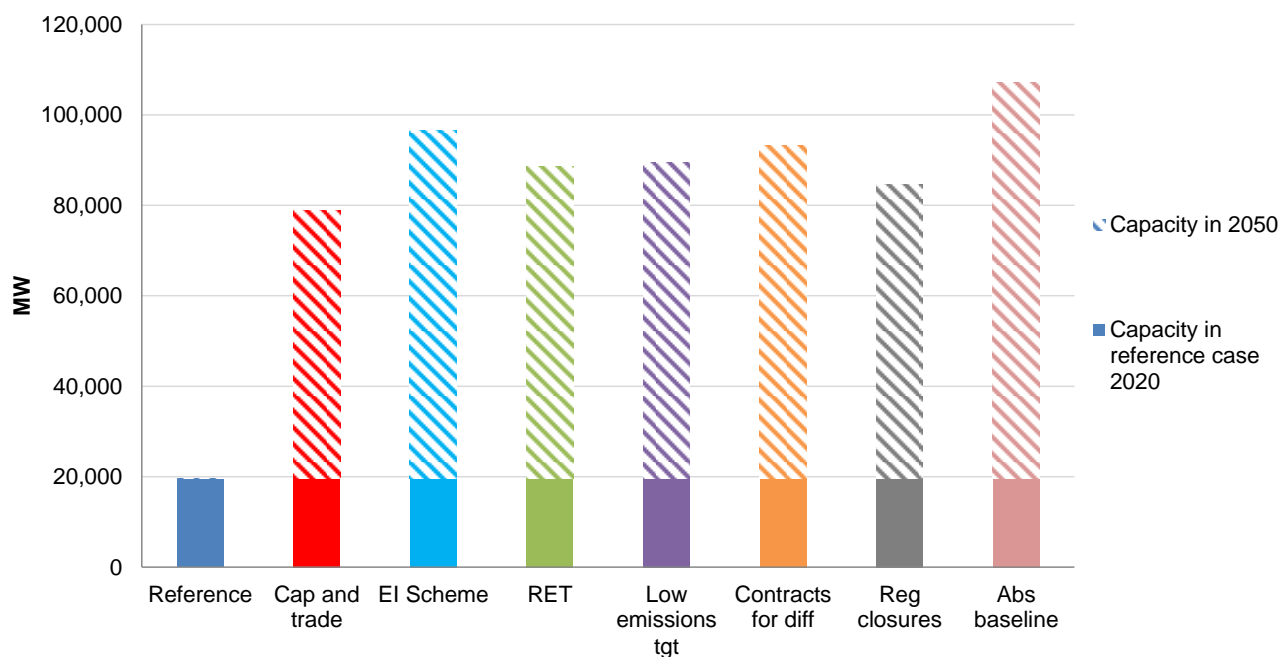


Note: NPV of gross profits calculated with seven per cent discount rate and discounted to 2020 levels. Gross profit is a concept related to costs, and for a generator is the difference between total revenue, which consists of pool revenue, contract revenue and certificate revenue (where applicable), less all operating costs, including fuel costs, fixed and variable operating costs and emissions costs. Gross profits for reference case are adjusted for new entrants using a generation to capacity ratio. The regulated closures policy breaches the common cumulative emissions budget, so the change in profits may not be directly comparable with other policies. The reference case assumes strong global action to reduce emissions, and no additional climate policies in the Australian electricity sector. Revenue raised under the cap and trade scheme is not redistributed in the modelling. For further information on interpreting gross profits measures, see Section C.3.3 of Jacobs’ modelling report (Jacobs 2016c).

Source: Climate Change Authority based on Jacobs 2016c.

The closure of incumbent coal generators also creates opportunities for new investment in renewable and other low-emissions generators. In Australia, most electricity companies own a portfolio of generators and generator types, so would experience both gains and losses from the sector. Figure 17 shows a large amount of additional zero- and low-emissions capacity is projected to be added in all policy scenarios in Jacobs’ modelling.

Figure 17 Change in capacity of large-scale renewable and low-emissions technologies, 2 degrees, 2020–2050



Note: Change in large-scale generation capacity including hydro, wind, large-scale solar, biomass, geothermal, gas with CCS and nuclear. Around 140 MW of renewable capacity is installed in the reference case after 2020.
Source: Climate Change Authority based on Jacobs 2016c.

4.2. The Authority’s view: a market mechanism

The Authority’s view is that Australia should implement a market mechanism of some form in the electricity supply sector. A market mechanism in the sector would allow Australia to meet its targets at a lower cost to the community than would be possible without such a policy in the toolkit. The sector’s characteristics (measurable emissions, relatively small number of large emissions sources, sophisticated profit-seeking investors operating in generally competitive generation markets) suggest market mechanisms will be feasible and more cost-effective than the alternatives. In addition, market mechanisms can be scaled to achieve deep emission cuts, and are flexible to changing market and technology conditions. The equity impacts of market mechanisms vary based on the design of the specific policy and are explored in the next section.

4.3. What type of market mechanism?

Report Two of the Special Review discussed four market mechanisms:

- cap and trade scheme
- emissions intensity scheme
- carbon tax
- baseline and credit scheme.

When assessing the policies against the Authority’s core principles of cost effectiveness, environmental effectiveness and equity in that report, the Authority noted particular drawbacks with some baseline and credit schemes on equity grounds. In particular, where baselines are set to historical emissions and trading below baselines is permitted, they may provide windfall gains to liable firms, and that the

difficulties in setting historical baselines can lead to inequities between firms and industries. Stakeholder feedback on Report Two has also revealed little support for such baseline and credit schemes in the electricity sector.

The remainder of this chapter focuses on the relative performance of the remaining three schemes. Where the assessment draws on the Authority's commissioned modelling, the results for a cap and trade scheme are informative about the performance of either a cap and trade scheme or a carbon tax.

In consultations on Report Two of the Special Review a number of stakeholders expressed a preference for a cap and trade scheme out of all the market mechanisms put forward by the Authority. For example, Shell Australia stated:

Shell supports a cap-and-trade emissions trading system (ETS) because the policy is economically efficient, well understood, and in wide-spread use throughout the world. As such, it generally carries acceptable costs and can more easily be linked to international market-based CO₂ emission reduction programs, further increasing their cost-effectiveness (personal communication 7 March 2016).

Origin Energy identified that an emissions intensity scheme would moderate impacts on wholesale and retail electricity prices (Report Two submission, pp. 4–5).

While there are differences between these policies, they have much more in common in terms of operation and impacts than they have features that distinguish them. Each option for a market mechanism uses an explicit carbon price; each can readily be scaled to drive stronger emissions reductions in electricity supply at lower cost than alternative policies. Each can only perform well, and drive the necessary changes in investment, if there is policy stability and credibility, and if the policy is well designed and implemented.

Overall:

- All three market mechanisms are capable of achieving deep emissions reductions in the sector.
- All three policies have similar cost effectiveness, with their relative performance depending on how carbon revenue from a cap and trade scheme or carbon tax is recycled. Recycling revenue through tax cuts is likely to be more cost-effective than an emissions intensity scheme, while lump sum revenue recycling is likely to be the least cost-effective of the three.
- Cap and trade and emissions intensity schemes have different distributional impacts, particularly for electricity consumers. An emissions intensity scheme will not increase electricity prices as much as a cap and trade scheme, and so would have a smaller short-term impact on equity. By contrast, a cap and trade scheme with auctioning can raise significant amounts of revenue. In this case, the equity effects will depend heavily on how this revenue is recycled.

4.3.1. Environmental effectiveness

As illustrated in Figure 11, all three market mechanisms considered are capable of achieving deep emissions reductions in the electricity sector.

Another aspect of environmental effectiveness is the ability of a policy to deliver targeted emissions outcomes with confidence. Some stakeholders would suggest that, because of their cap on the quantity of emissions, cap and trade schemes provide greater certainty about the level of emissions reductions than the other two schemes. While this is true in theory, the difference may not be as clear-cut in

practice. This is because carbon taxes and emissions intensity schemes could be adjusted over time to achieve the emissions reductions needed to meet a national target.

As discussed in in Box 5 in Chapter 3, an emissions intensity scheme would have less impact on prices than a cap and trade scheme, resulting in, among other things, fewer demand-side emissions reductions. That said, the Authority’s modelling indicates that the share of demand-side abatement in the electricity sector was relatively small in either case (Box 6), and demand-side policies can be added to any of the market mechanisms explored here.

Box 6 Supply- and demand-side emissions reductions from supply-side policies

Emissions reductions from electricity sector policies can be separated into demand-side and supply-side reductions. In the Authority’s modelling of policy scenarios consistent with limiting warming to below 2 degrees, the vast majority of the cumulative emissions reductions to 2050 are attributable to reducing the emissions intensity of electricity supply.

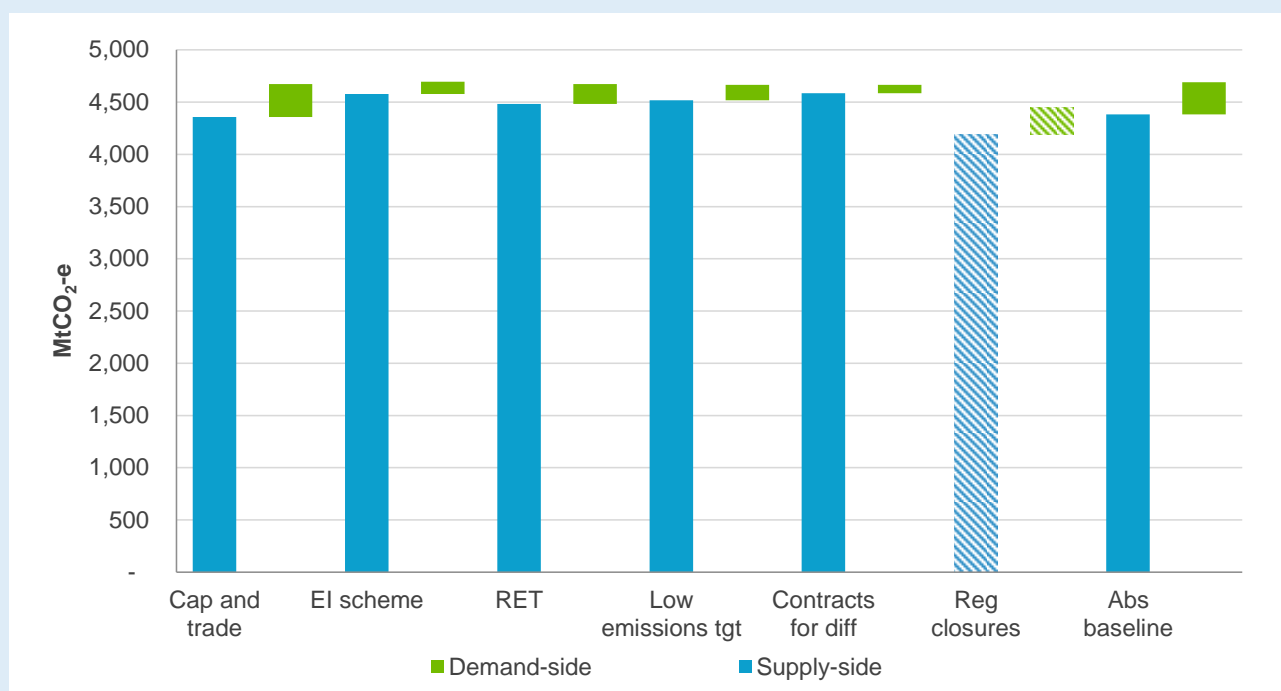
Given the supply-side focus of the Authority’s analysis, no policies explicitly targeting demand-side emissions reductions were modelled, so the only demand-side emissions reductions in the scenarios come from consumers reducing electricity demand in response to rising electricity prices. Figure 18 shows the breakdown in cumulative emissions reductions in each policy scenario. Across all the scenarios, up to 10 per cent of total projected emissions reductions to 2050 are from the demand side. Policies with larger increases in retail electricity prices, such as cap and trade schemes and absolute baselines, have higher shares of demand-side reductions.

In the earlier years of the policy, a larger share of emissions reductions would be expected from the demand side, in part because the electricity supply is more emissions-intensive. For example, demand-side emissions reductions are up to 20 per cent of projected reductions under the policy scenarios over the period to 2030.

The Authority’s analysis indicates that the low demand-side emissions reductions shares in this modelling are broadly consistent with other recent investigations of 2-degree consistent emissions reductions from Australia’s electricity supply sector when these are achieved through policies with a predominantly supply-side focus. Examples include modelling for the Authority’s Targets and Progress Review (ACIL Allen Consulting 2013) and the Commonwealth Treasury (Treasury 2011).

Demand-side policies can readily be added to any of the supply-side policies explored here, and are considered in Report Three of the Special Review.

Figure 18 Total supply-side and demand-side emissions reductions by policy, 2 degrees, 2020–2050



Note: Emissions from the NEM and WEM. Chart includes both direct and indirect emissions, including transport and fugitive emissions from supply. The regulated closures policy breaches the common cumulative emissions budget by about 200 Mt CO₂-e or 15 per cent.

Source: Climate Change Authority based on Jacobs 2016c.

4.3.2. Cost effectiveness

The Authority's electricity sector modelling shows that, considering costs in the electricity sector only, market mechanisms are the most cost-effective policy options.

However, as discussed in Section 3.3, there are several indirect effects that could have an important effect on the cost effectiveness of market mechanisms. These effects are the indirect cost of tax interaction effects and the indirect benefit of recycling carbon revenue. Importantly, these effects will vary between different market mechanisms and so could affect their relative cost effectiveness, including both direct and indirect costs.

Recognising the importance of these indirect effects for overall cost effectiveness, the CGE modelling commissioned by the Authority compares the economy-wide costs of different market mechanisms. It examines three scenarios (Table 4, Chapter 3):

- a cap and trade scheme with lump sum revenue recycling ('cap and trade (lump sum)')
- a cap and trade scheme with revenue recycling through tax cuts ('cap and trade (tax cuts)') and
- an emissions intensity scheme.

These comparisons take into account direct costs, indirect costs from the tax interaction effect, and indirect benefits from revenue recycling, providing an overall assessment of the cost effectiveness of different policies.

Table 6 summarises the overall cost effectiveness of the three policy options modelled. As explained in Section 3.2, the Authority has primarily used GNI to assess economy-wide cost effectiveness, as it is a better (albeit imperfect) measure of Australia's economic welfare than GDP. These results show that:

- The relative performance of cap and trade compared to an emissions intensity scheme depends on how revenue from the cap and trade scheme is recycled. A cap and trade scheme with all revenue recycled through tax cuts is likely to be more cost-effective than an emissions intensity scheme, while a cap and trade scheme with lump sum revenue recycling is likely to be the least cost-effective of the three.
- An emissions intensity scheme reduces tax interaction effects relative to a cap and trade scheme. Compared to the cap and trade (lump sum) scenario, an emissions intensity scheme can increase GNI by around 0.15 per cent by muting the impact on electricity prices relative to a cap and trade scheme, which in turn stimulates investment and activity in a range of electricity-using sectors.
- Recycling revenue through tax cuts delivers benefits, as illustrated by comparing the two cap and trade scenarios. Recycling revenue through tax cuts can increase GNI by around 0.33 per cent relative to recycling through lump sum payments. This occurs because tax cuts can increase economic output by increasing investment and employment, whereas lump sum payments do not.
- While large in absolute terms, the differences between the scenarios are small in the context of the overall economy.

Table 6 Projections of gross national income, economy-wide modelling, relative to cap and trade (lump sum), 2020–2050

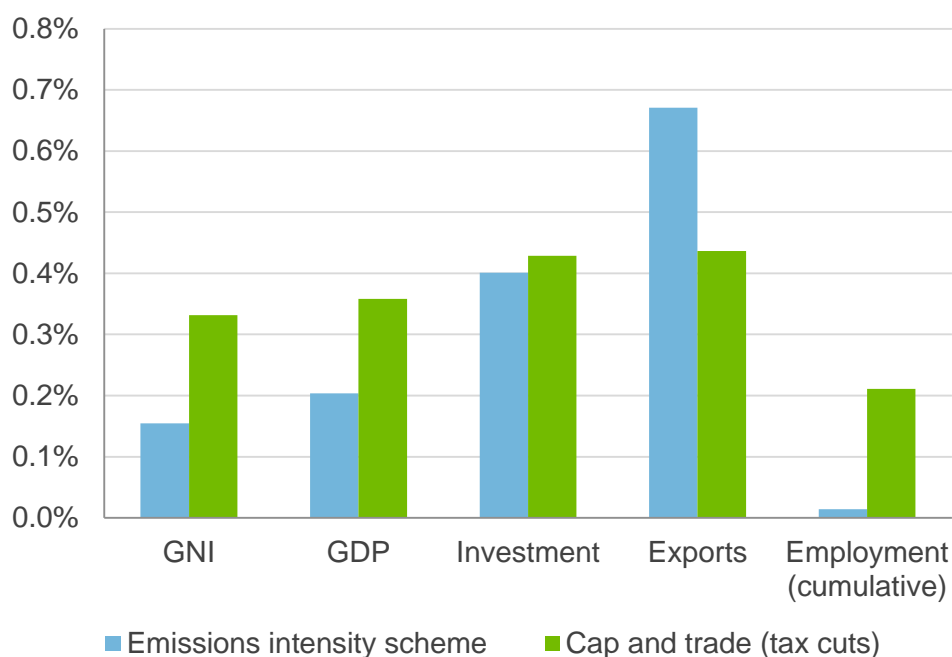
Scenario	Unit	GNI in 2030	GNI in 2050	Cumulative discounted GNI, 2020–2030	Cumulative discounted GNI, 2020–2050
Emissions intensity scheme, absolute change	\$bn	\$3	\$7	\$20	\$45
Emissions intensity scheme, percentage change	%	0.13%	0.18%	0.14%	0.15%
Cap and trade (tax cuts), absolute change	\$bn	\$5	\$13	\$51	\$97
Cap and trade (tax cuts), percentage change	%	0.25%	0.36%	0.35%	0.33%

Note: Cumulative discounted gross national income is calculated using a seven per cent discount rate. Dollar figures are in 2014 Australian dollars.

Source: Climate Change Authority based on Adams 2016 and Jacobs 2016d.

Figure 19 compares the three policies on a range of economic metrics. It shows that either an emissions intensity scheme or recycling revenue through tax cuts will increase economic output (as measured by GNI or GDP), investment, exports and employment relative to a cap and trade scheme with lump sum recycling. While using carbon revenue to cut taxes improves economic output and employment more than an emissions intensity scheme, investment outcomes are broadly similar and an emissions intensity scheme increased exports relative to the cap and trade scenarios.

Figure 19 Percentage change in various economic metrics, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050



Note: GNI, GDP, investment and exports are calculated as a present value over the period 2020 to 2050, using a seven per cent discount rate. Employment is a cumulative undiscounted figure over the period 2020 to 2050.

Source: Climate Change Authority based on Adams 2016 and Jacobs 2016d.

As noted in Section 3.3, these results should be treated as indicative due to generalisations and simplifications within the model used, such as the representation of the tax system and how workers

respond to changes in real wages. Nevertheless, they give credible indications of how policy choice may be affected by considering indirect costs and benefits alongside direct costs.

The schemes have different potential effects on equity, which are discussed in Section 4.3.3. Importantly, altering the design of the policies to address equity impacts could reduce their overall cost effectiveness. This is particularly the case when assessing the economic benefit of using carbon revenue to cut taxes. For example, using revenue to fund direct payments to households or to provide assistance to emissions-intensive trade-exposed industries would reduce the potential tax cut and therefore the potential efficiency gain.

4.3.3. Equity

As discussed in Section 4.1.3, three main groups can be affected by electricity sector emissions reduction policies:

- electricity users (including both households and businesses)
- generation asset owners and investors
- workers and communities in regions strongly affected by the policy.

Effects on generation asset owners and investors were considered in Section 4.1.3 and are not discussed further here. As noted in Section 3.3, the Authority's economy-wide modelling does not directly shed light on equity issues for households in different income groups. This is because the model effectively assumes all households have average incomes for the sake of simplicity. The modelling does provide insight into the effects of different approaches on different economic sectors; these results are at Appendix C.3. The rest of this section draws on the Authority's modelling and qualitative analysis to make some observations on the equity impacts of different market mechanisms on electricity users and affected regions.

All market mechanisms considered are projected to result in an increase in electricity prices, with flow-on effects to a range of electricity users that can be addressed in a number of ways. Before any other assistance, lower income groups would tend to be more affected than others because they tend to spend a higher portion of their income on electricity and have less capacity to pay for increases in costs. These changes in electricity prices will also affect industries differently, depending on how much electricity they use, which in turn could flow on to workers and communities.

Market mechanisms differ in their ability to address these equity effects, and several general observations can be made:

- An emissions intensity scheme will not increase electricity prices as much as a cap and trade scheme, and so would have a smaller short-term impact on equity. In effect it assists all electricity users, including both households and businesses.
- In contrast, a cap and trade scheme with auctioning can raise significant amounts of revenue, which can be used to address equity impacts. In this case, the equity effects will depend heavily on how this revenue is recycled.
- In practice policy makers can recycle revenue in various ways to reflect their desire for equity and efficiency. It is straightforward to address equity concerns by using revenue to increase government payments such as pensions and family benefits. Tax cuts are better suited to improving economic efficiency than equity. While they could be targeted to lower tax brackets to assist lower-income

workers, this approach cannot readily assist taxpayers earning below the tax-free threshold, the unemployed or those outside the labour force.

- Because a range of government benefits change automatically with changes in consumer prices, the equity impacts of electricity price rises will be ameliorated even without additional assistance. This also means that if revenue from a market mechanism is not used (or available) to fund increased payments it would tend to worsen the government's fiscal position. The long-run effects of this on both equity and efficiency will depend on whether future governments reduce spending or increase taxes to compensate for this change.
- An emissions intensity scheme is likely to reduce adjustment pressures on workers and communities that are reliant on these industries. This is because an emissions intensity scheme typically results in lower electricity prices than a cap and trade scheme, and so supports electricity-intensive industries.

4.3.4. Options for market mechanisms: summary

Market mechanisms have more in common than features that distinguish them from each other. Each can achieve least cost emissions reductions on a large scale and are more cost-effective than technology pull or regulatory policies. However, market mechanisms can only perform well, and drive the necessary changes in investment, if they are well designed and there is policy stability and credibility.

The economy-wide cost effectiveness of market mechanisms is sensitive to how carbon revenue (if any) is recycled. An emissions intensity scheme could be more cost-effective than a cap and trade scheme or carbon tax where revenue is recycled in a lump sum manner. Conversely, this appears unlikely to be the case if most carbon revenue is recycled through tax cuts. However, all of these differences are small when considered in the context of the overall size of the economy and subject to some uncertainty.

All policies examined affect consumers in some way, however the impacts can be addressed in a number of ways. An emissions intensity scheme has a smaller effect on electricity prices, and therefore on consumers, than a cap and trade scheme or carbon tax. By contrast, a cap and trade scheme with auctioning or a carbon tax can ameliorate the equity effects of electricity price increases by providing payments to groups of concern, such as low-income households.

This analysis indicates that choosing between different market mechanisms involves balancing cost effectiveness and equity objectives. The Authority has taken the view that is also important to consider issues related to the public interest including public acceptance of measures, the likelihood that emissions reduction policies will assist with investment certainty and the transition from current measures to new or enhanced measures is predictable. The Authority's conclusions and recommendations on a market mechanism for the electricity generation sector are set out in Report Three of the Special Review.

CHAPTER 5. SHOULD THERE BE ADDITIONAL POLICIES IN THE SECTOR?

Chapter 4 outlined the Authority’s view that a market mechanism of some form should be applied in the electricity supply sector to help reduce Australia’s emissions. This chapter provides an overview of the Authority’s analysis and modelling of policies in addition to a market mechanism for the sector. Section 5.1 outlines the case for and against additional policies and Section 5.2 provides a short overview of potential additional policies.

5.1. Is there a case for policies in addition to a market mechanism?

Chapter 4 outlined the Authority’s view that a market mechanism of some form should be applied in the electricity supply sector to help reduce Australia’s emissions. This chapter provides an overview of the Authority’s analysis and modelling of policies in addition to a market mechanism for the sector.

If investors are uncertain about whether a given policy like a market mechanism will remain in place, its impact on investment decisions—and therefore emissions reductions—could be compromised. Even over the short term, market mechanisms can help reduce Australia’s emissions because they influence operational decisions in the electricity supply sector (O’Gorman & Jotzo 2014). But if investors expect the impact of future climate policies to be uncertain, they may be less likely to take decisions in the 2020s consistent with a least cost route to decarbonising the supply sector over the period to 2050.

In principle, this policy risk could be mitigated by applying well-designed supporting policies. While the risk of policy uncertainty can apply to all types of climate policy, the particular history of emissions reduction policies in Australia may mean that investors would value greater assurance that climate policy will endure. In this case, it is useful to consider whether adding policies to a market mechanism could reduce policy uncertainty. The additional policies could target the kinds of long-lived entry and exit decisions which would otherwise be affected by policy uncertainty. For example:

- As a technology pull policy deliberately encourages more investment in new low-emissions plant than would happen under a market mechanism alone, it could reduce more emissions from electricity generation than a market mechanism would by itself (CCA 2012, p. 27).
- Even if an additional policy simply reinforces outcomes driven by a market mechanism, rather than changing the outcome, it may still provide benefits—for example by increasing confidence and potentially reducing investors’ cost of capital. One example is a technology-neutral regulation ruling out the most emissions-intensive types of new plant (Section 5.2.2).

In this chapter the Authority focuses on additional policies for technology entry and exit, where entry relates to deploying available technologies. The Authority has considered innovation policy more broadly, including early stage research and development, in Report Three of the Special Review.

An important consideration against adding policies to a market mechanism is the potential increase in costs to affected groups and Australia as a whole. Adding policies may raise compliance costs for liable parties in the medium term, including through an increase in complexity of the regulatory environment.

When asking whether or not additional policies increase the overall costs of climate policy, it is important to consider what would have happened without the policy, noting the impact of policy uncertainty on investment decision-making. The Authority's electricity modelling indicates that, in a 'first best' situation where all investors believe policy is durable and there is no uncertainty, adding policies to a market mechanism raises overall costs. If some investors do not, at least initially, view policy as durable, adding policies will not necessarily raise the expected medium-term economy-wide costs of reducing emissions. This is because uncertainty about the direction of future climate policy increases risks of long-term decisions (AEMC 2015a, p. 23), which can raise generators' costs (McKibbin 2015, p. 25; AEMC 2015a, p. 23). This suggests that, to the extent that actions by government, including additional policies, can reduce risks, they have the potential to reduce the overall cost of policies over the medium term. For example, policies like mandatory emissions standards for new generators could help avoid 'lock-in' of long-lived, emissions-intensive assets. On the other hand, the prospect of new policies being implemented can also add to uncertainty as investors may delay new investment until the measures are designed and in place.

Of those submissions in response to Report Two that commented specifically on the choice of electricity sector policy instruments, many argued for or suggested a potential role for policies to work alongside a market mechanism in the sector. This included submissions by generators (AGL Energy, EnergyAustralia, Hydro Tasmania and Origin Energy).

AGL Energy stated that 'a range of policies are likely to be needed', while Origin Energy expressed support for the Authority's 'toolbox' approach, and supported regulation to complement a market mechanism (Report Two submissions, p. 3, pp. 1, 3–4). The Australian Energy Council said that the main policy instrument should be market-based because such policies discover and exploit the lowest cost abatement, but that there 'may still be a role for complementary policies that entail modest regulation', noting that such policies would 'require careful consideration' (Report Two submission, p. 1).

5.2. Possible additional policies

This section provides an overview of the types of policies that could be implemented in addition to a market mechanism. Additional policies could focus on targeting entry of low-emissions generation and/or exit of emissions-intensive generation. Both can be achieved through either regulation or other market-based measures. For example:

- standards can regulate entry (for new generators) or exit (regulated closure of old emissions-intensive generators)
- technology pull policies such as a renewable energy target can target entry or encourage exit (to remove emissions-intensive coal plants).

Entry and exit policies could be viewed as either complements or substitutes to each other. In practice this depends on the specifics of the policy design and the level of ambition of each policy: if policies are perceived to be credible, a very strong version of one policy can make the other redundant. For example, a technology pull policy with a very large target will encourage exit of fossil fuelled generation by lowering their revenues and profitability.

Many countries with a market mechanism have implemented policies alongside it in the electricity supply sector (IEA 2015d; ICAP 2015; Nachmany et al. 2015), with objectives such as encouraging additional low-emissions generation and realising greater decarbonisation in the electricity sector more quickly than would be obtained with the market mechanism alone. The interactions between market

mechanisms and other policies require careful consideration to ensure policies are genuinely complementary and decisions as to whether to implement one or more of these measures is finely balanced.

Many Report Two submissions supported additional policies in the electricity sector, including the Investor Group on Climate Change and the Centre for Resources, Energy and Environmental Law. All electricity generators which made Report Two submissions supported consideration of explicit mechanisms for the exit of older, emissions-intensive power stations, citing the perverse outcomes of high-emissions generators remaining in the market. For example, EnergyAustralia stated that:

Barriers to the closure of excess capacity...conspire to keep the most emissions intensive generators operating in the market for longer than necessary for security of supply, effectively 'crowding out' new investment in low and renewable energy generation... The pros and cons of different options for Government facilitation of the orderly exit of high emission electricity generation ought to be evaluated as part of the carbon policy development process.

(Report Two submission, p. 3).

On technology pull policies, several stakeholders, including environmental organisations, support a continued or enlarged RET, and electricity generators are in favour of continuing incentives for deploying renewables but most did not suggest particular policy mechanisms. The Australian Chamber of Commerce and Industry noted that the RET had been successful in encouraging wind and solar investment, but with relatively high cost of abatement. The Energy Networks Association cited preliminary results from modelling commissioned from Jacobs which found that a policy package that included a low emissions target could lower overall costs of reducing emissions in the stationary energy sector.

The next section uses the Authority's evaluation framework to compare technology pull and exit policies as potential additions to a market mechanism.

5.2.1. Exit and technology pull policies

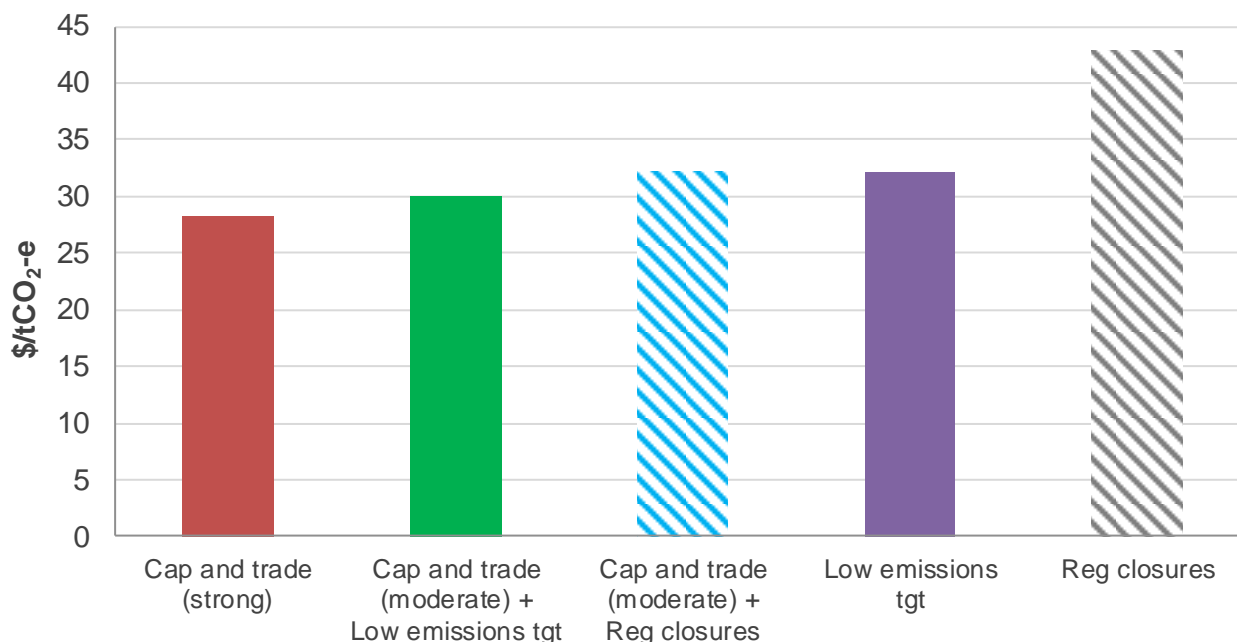
The Authority's modelling suggests technology pull policies may be a better addition to a market mechanism than a regulated closures policy, however, this result may be more sensitive to the specifics of the scenario than the results for individual policies discussed in Chapter 4.

The Authority's modelling compared two policy combinations: a cap and trade scheme (with a 'moderate carbon price' here meaning lower than that modelled in the core scenarios) with regulated closure, and a cap and trade (moderate carbon price) scheme with a technology pull policy (the low emissions target). In each combination, the 'additional' policy (closure rates or technology targets) was set with the objective that the combination achieved the same emissions budget as the strong (2 degree) carbon price.

Figure 20 presents the cost of abatement of policy options and combinations, and suggests that adding the low emissions target produces more emissions reductions at a similar average cost than adding a regulated closures policy targeting coal generators. This is because the low emissions target can realise more emissions reduction opportunities than closure alone. While both the 'cap and trade plus low emissions target' and 'cap and trade plus regulated closures' combinations encourage similar rates of exit for higher-emissions plant, the regulated closures combination does not meet the demanding emissions budget. This is because neither the moderate carbon price nor regulated closures can encourage enough new very low-emissions plant over new gas generation. This problem could be

addressed if a stringent new entrant standard was added to the ‘cap and trade plus regulated closure’ combination. However, the design of a standard affecting gas generation would need careful consideration to avoid perverse outcomes (Section 5.2.2).

Figure 20 Average cost of abatement, policy options and combinations, 2 degrees, 2020–2050



Note: Average cost of abatement over 2020–2050 using a seven per cent discount rate for resource costs. Emissions not discounted. Figures account for the reduction in welfare from a fall in electricity demand resulting from increased retail electricity prices. Regulated closures scenario and ‘cap and trade + regulated closures’ scenario breach the common cumulative emissions budget, so resource costs here underestimate costs of meeting the emissions budget using those policies. See Appendix C for further details.

Source: Climate Change Authority based on Jacobs 2016c.

On equity, projected changes in consumer electricity prices relative to the reference case are similar between the two combinations, however the ‘cap and trade plus regulated closures’ results are likely an underestimate as the policy breached the emissions budget (Jacobs 2016c).

Other recent work exploring policy combinations in the Australian electricity sector finds that the most environmentally effective addition to a moderate carbon price is both regulated closure and a technology pull policy. The Climate Institute (TCI) commissioned Jacobs to investigate the impact of different policies on the electricity sector (Jacobs 2016b; TCI 2016). TCI argues that an internationally linked carbon pricing mechanism consistent with achieving Australia’s national 2030 emissions reduction target, while sending an important signal to the broader economy, would be unlikely to initiate the transformation of the electricity sector consistent with achieving net zero emissions. Because the higher carbon prices required to reduce emissions in the electricity sector over the 2020s are considered unlikely to be politically feasible, having separate policies to decarbonise the power sector is desirable (Report Two submission, p. 4). TCI’s commissioned modelling explores the environmental performance of policy combinations during the 2020s given their view that any carbon price during the 2020s may be low and expected by investors to remain low. It compares a weak carbon price to a weak carbon price plus regulated closure, a weak carbon price plus a technology pull policy, and a combination of all three. TCI finds that the three-policy combination drives the most emissions reductions over the 2020s.

Comparing these two modelling exercises suggests that the level of the carbon price and investors' expectations of future carbon prices are factors in the different results. The targets for the technology pull policy are also larger in absolute terms, and extend for longer, in the Authority's policy combination. While the family of technology pull policies share many similarities, the type and specific design do matter for performance. Design choices—such as which technologies are eligible and whether and how targets can be adjusted—can have large effects on the cost effectiveness and robustness of the policy. For example, expanding eligibility beyond renewables can lower costs, while target design can influence the policy's ability to respond to unexpected changes in the electricity sector (Box 7).

Exit policies can also be price-based. Recently Jotzo & Mazouz (2015) proposed a mechanism for regulated exit of highly emissions-intensive brown coal plant. Interested generators could bid for the payment they required to close and a designated regulator would choose the most (if any) cost-effective bid. The payment for a successful closing generator would come from the remaining power stations in proportion to their emissions. While bidding for a closure payment is voluntary, the other generators would face a mandatory charge to pay for the bidding plant to close, if a bid were successful.

Emissions reductions realised by the policy would depend on which generator closed, how long it would have continued to operate without the policy, and the emissions intensity of the remaining generators that would make up for the closing plant's output. Indicative estimates are reductions of 2–7 Mt CO₂ per year for five to 15 years (around 1–4 per cent of current annual emissions from the sector) (Climate Change Authority calculation from Jotzo & Mazouz 2015, p. 16, DoE 2015b, p. 9).

Jotzo and Mazouz note that the first best policy in the sector would be a market mechanism, and offer their proposal as a short-term, pre-2020 measure applying to brown coal plants, which could be implemented if detailed analysis confirmed it delivered net benefits (Jotzo 2016, Jotzo & Mazouz 2015, pp. 7,14).

Several stakeholders, including Origin Energy and WWF Australia, suggested in their Report Two submissions that the proposal be considered further.

The Authority makes two observations:

- First, the Authority's analysis of regulated closure indicates that using it to achieve a large post-2020 emissions reduction goal in the absence of other measures in the electricity sector would entail higher costs than other policies and would not offer a direct incentive for new low-emissions plant to be built (Chapter 4).
- Second, managing the risks would need to be carefully considered if such a change were adopted. For example, even if the government stated that only a few generators at most would be assisted, others may ignore economic reasons to exit in the hope of receiving assistance. Providing incentives for closure could set a precedent not just for the electricity sector but more broadly.

Box 7 Renewable energy targets, low emissions targets, and contracts for difference: exploring technology pull policies

All three technology pull policies explored in this report work to encourage additional low-emissions generation, however, specific design features can have a large impact on the performance of each policy. This box explores technology pull policies and two design features—technology eligibility and target setting—that are important for performance.

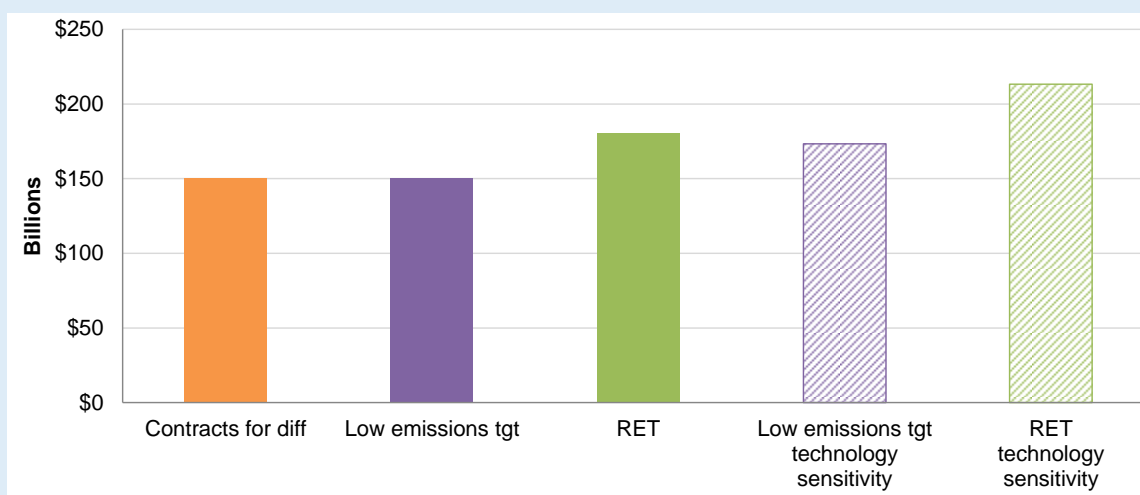
Technology pull policies operate by providing revenue for eligible low-emissions generators. Renewable energy targets and low emissions targets set a specific quantity of eligible generation, while contracts for difference partially specify the price received by eligible generators. As explained in Box 2:

- Subsidising these generators allows them to make low bids into the electricity market, which lowers the wholesale price of electricity and the profitability of incumbent generators to the point of withdrawal in some cases.
- Consumers pay for the scheme through a surcharge on electricity bills.

The net impact on consumer spending depends on which impact (lower wholesale prices or the retail surcharge) dominates; this in turn depends in part on the size of the targets. In modelling for the 2014 Warburton RET review, ACIL Allen found that a 30 per cent renewable energy target would reduce average annual household spending by around \$17 over 2015 to 2040, relative to the situation of no RET (Climate Change Authority based on ACIL Allen Consulting 2014, p. ix). In contrast, the large targets explored in the Authority’s modelling result in higher projected consumer electricity prices (Figure 14).

Technology eligibility varies between the policies, with wider eligibility lowering the costs of meeting a given emissions goal. Comparing the resource cost of the RET and the low emissions target in the Authority’s modelling show how expanding eligibility to more zero- and low-emissions technologies lowers the overall costs (Figure 21). Even if non-renewable zero-emission technologies, such as CCS or nuclear, are never available in Australia, widening eligibility can still have benefits. The Authority’s technology sensitivity indicates that expanding eligibility by providing partial credits to gas generators lowers projected resource costs by around 20 per cent (Figure 21).

Figure 21 Resource costs of technology pull policies relative to reference case, 2 degrees, 2020–2050



Note: Each bar represents the net present value of the change in resource costs relative to the reference case over 2020–2050, adjusted for the reduction in demand due to the increase in electricity prices. This is equivalent to the present value of the welfare costs of the policy relative to the reference case before emissions reduction benefits are considered, discounted at the social discount rate of seven per cent. In the technology sensitivity, CCS, geothermal and nuclear technologies were unavailable and battery storage costs decline faster than in the core scenarios.

Source: Jacobs 2016c.

Technology pull policies with fixed targets are less flexible to changing market conditions, which could affect the robustness of the policy. For instance, a low emissions target or RET may have generation targets fixed for more than a decade in advance. This means the policies could have quite different impacts on the electricity market if, say, electricity demand is very different to expectations. These policies could incorporate more flexibility through medium-term target ‘gateways’: that is, near-term targets could be fixed, but medium-term targets would be initially set as ranges. As the amount of generation purchased through auctions could alter annually without affecting contracts already signed, contracts for difference have flexibility to adjust to changing market conditions.

The ACT Government has implemented contracts for difference alongside the Commonwealth RET, and the Queensland Government plans to fund large-scale solar projects using a similar mechanism (Government of the ACT 2011; Department of Energy and Water Supply 2015). The Victorian Government is currently considering a similar approach. Successful generators sign long-run contracts with the government; having the government as counterparty may reduce the weighted average cost of capital for investments made under the policy, and therefore costs to electricity consumers.

5.2.2. Emissions standards for new generators

There may be merit in considering a technology-neutral emissions standard for new generators alongside a market mechanism to help facilitate new investments in the sector. While a market mechanism can encourage new low-emissions investment, a standard implemented alongside it may help increase confidence and reduce risk (and potentially reduce capital costs) to investors, with minimal extra regulatory burden, even if no investment in new high-emissions plants were planned.¹⁴ This may support long term, capital heavy, low-emissions investments made over the 2020s.

Standards for new generators have been implemented in several countries. Canada has an emissions standard for new and existing coal-fired generation, which effectively means no new coal could be built without CCS (Climate Change Authority based on Government of Canada 2015). The United States has emissions standards for both new coal and baseload gas-fired generation—effectively permitting only coal-fired generators with CCS and efficient combined-cycle gas plants as baseload gas (Climate Change Authority based on US EPA 2015).¹⁵ Recently, the International Energy Agency identified ‘progressively reducing the use of the least-efficient coal-fired power generating plants and banning the construction of new ones’ as one of five energy sector actions that could help move global emissions from their current trajectory to one consistent with limiting warming to two degrees (IEA 2015b, pp. 68–69).¹⁶

Standards can be difficult to set and adjust as technologies change. Even if a standard were technology-neutral (by for example referring to a given level of emissions intensity), setting it requires consideration of the costs and benefits of setting it at different levels. The costs are a function of the expected costs of generation technologies; if these do not proceed as expected, the costs of the standard will be higher or lower than intended.

In addition, the level of any standard and its interactions with other electricity policies would require careful consideration. As discussed in Section 5.1, a standard could simply reinforce outcomes driven by a market mechanism, rather than change the outcome, but could still provide benefits if it increased confidence and helped ‘de-risk’ low-emissions investments. If the standard were set at a level that affected the choice of new plant, some relevant considerations would be:

- If a standard were set at a level that discouraged gas peaking generation, it would discourage gas plants that are used infrequently but valuable to the reliability of the electricity system as a whole.
- In some cases the standard might risk extending the life or encouraging expansions of existing emissions-intensive generators (for example, if new highly efficient but still emissions-intensive plant were prohibited by the standard).

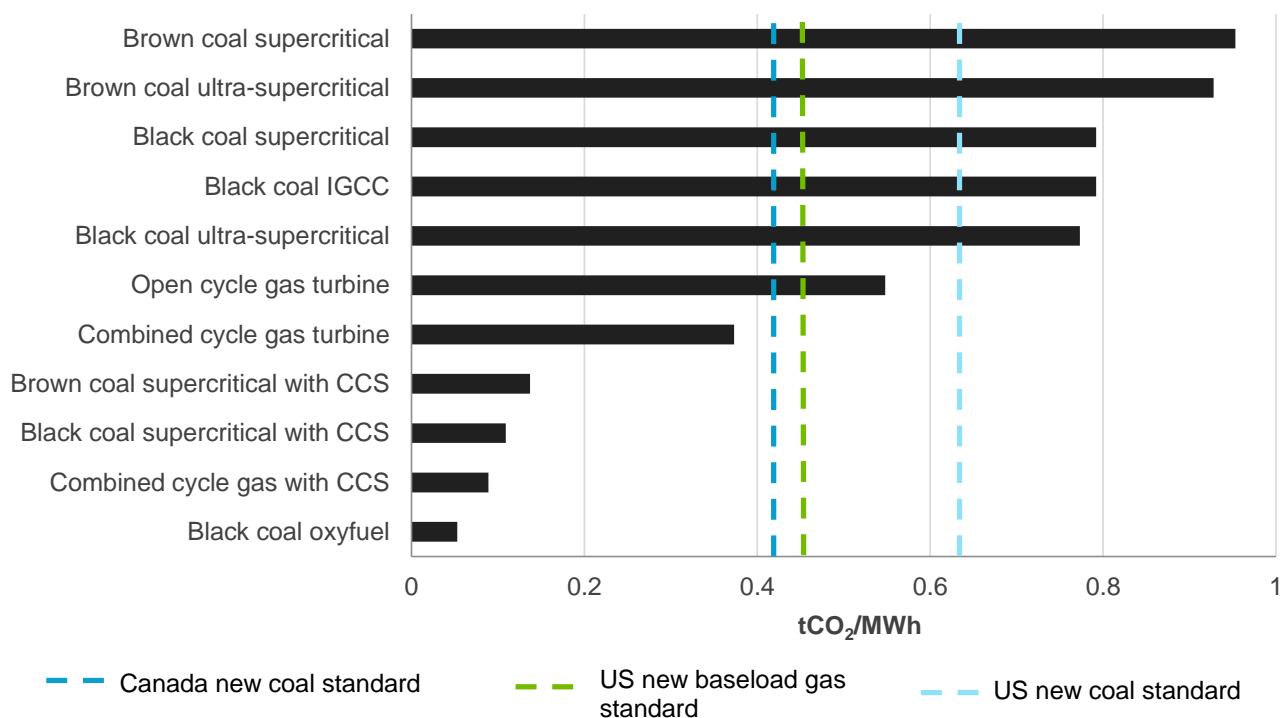
Figure 22 illustrates the emissions intensity of different fossil fuel technologies which would be affected by existing US and Canadian standards.

¹⁴ The latest AEMO figures indicate that out of all proposed capacity additions to the NEM over the next 10 years, none will be coal-fired generators (AEMO 2016c, p. 17). ‘Proposed’ includes publically announced and advanced projects only and is a less definite stage than ‘committed’.

¹⁵ In the United States, new coal-fired plants have a performance standard of 1,400 lb CO₂/MWh-gross, new baseload gas plants have a performance standard of 1,000 lb CO₂/MWh-gross and non-baseload gas plants have a standard of 120 lb CO₂/MMBtu.

¹⁶ The others are increased energy efficiency through strengthening and broadening standards, increased investment in renewables, the phase out of fossil fuel subsidies, and reducing fugitive emissions from fossil fuel exploration, transport and production.

Figure 22 Average emissions intensity of new generators, by type



Note: Emissions intensity is calculated based on direct emissions from combustion of fuels in electricity generation. Emissions intensities are based on new plant; existing plants may have higher emissions intensities.

Source: Climate Change Authority based on Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations 2015 (Government of Canada 2015); US EPA 2015; APGT 2015.

In the Australian context, emissions standards for new generators have been considered by both Commonwealth and state governments:

- Requirements that new coal-fired plants must be CCS-ready and be retrofitted after CCS became economically and technically viable were adopted and subsequently set aside by the Queensland and Western Australian governments (DRET 2010; Department of Parliamentary Services 2011).
- Plant-specific voluntary emissions standards were implemented and set aside by the Commonwealth Government (Australian Greenhouse Office 2000, 2006).
- Technology neutral emissions standards were considered by the Commonwealth and South Australian governments and a coal-specific emissions standard was considered by Victoria, but none of these were implemented (RenewablesSA 2010; DRET 2010; Department of Parliamentary Services 2011).

Several stakeholders, including AGL Energy, noted their support for an emissions intensity standard for new generators in their submissions to Report Two of the Special Review (Report Two submission, p. 3).

APPENDIX A TERMS OF REFERENCE



15 DEC 2014

COMMONWEALTH OF AUSTRALIA

SPECIAL REVIEW BY THE CLIMATE CHANGE AUTHORITY

By this written instrument I, Greg Hunt, Minister for the Environment, request that the Climate Change Authority conduct a review under section 59 of the *Climate Change Authority Act 2011*, as below:

- Assess whether Australia should have an Emission Trading Scheme in the future and what conditions should trigger the introduction of such a scheme.
- This review must consider:
 - whether the USA, China, Japan, Republic of Korea and the EU have established ETSS or equivalent schemes that have similar effect;
 - Australia's international commitments and undertakings under the United Nation's Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to which Australia is a party;
 - whether Australia should introduce an ETS that does not harm Australian businesses international competitiveness; and
 - what future emissions reduction targets Australia should commit to as part of an effective and equitable global effort to achieve the objective of the UNFCCC (Article 2) or subsequent agreement to which Australia is a party.

Timing

- The Authority should issue a draft report on what future emissions reduction targets Australia should agree to for public consultation by 30 June 2015.
- The Authority should issue a draft report on an Emissions Trading scheme for public consultation by 30 November 2015.
- The Authority should issue a final report by 30 June 2016 recommending what action Australia should take to implement outcomes flowing from the Paris conference.

Dated 10 December 2014

A handwritten signature in blue ink, appearing to read 'Greg Hunt', written over a horizontal line.

Greg Hunt

Minister for the Environment

APPENDIX B FRAMEWORK FOR EVALUATING ELECTRICITY SECTOR POLICIES

In Report Two of the Special Review the Authority sought feedback on an evaluation framework to compare and assess emissions reduction policy options. That framework is based on the principles set out in the *Climate Change Authority Act 2011* (Cth) and comprises the three key principles of cost effectiveness, environmental effectiveness and equity.

The aspects of cost effectiveness, environmental effectiveness and equity the Authority considers particularly relevant to assessing electricity sector policy are:

- Cost effectiveness—flexibility
 - Can the policy be designed to use international units and/or domestic offsets for compliance purposes?
 - Can the policy be ‘fully linked’ with an emissions trading or other scheme internationally (that is, could units in either policy be surrendered in either scheme)?
 - Can it be scaled—adjusted up or down for the desired level of emissions reductions?
 - Can it cover sectors other than electricity if desired?
 - Can it adjust to unexpected external changes, for example in technology availability or cost or electricity demand?
- Cost effectiveness—efficiency and administration
 - What is the cost of the policy to the community as a whole, overall and per unit of emissions reduced?
 - Is the policy administratively straightforward to implement?
 - How large is the compliance cost due to the policy?
 - How does the policy affect sectors producing substitutes for electricity?
 - How large are the ‘indirect’ costs of the policy outside the electricity sector?
 - Is the policy consistent with management of risk in the market, for example using tools such as forward contracts?
 - How would investments made under the policy be affected if the policy were abolished?
 - Is it consistent with efficient market operation in relation to market dispatch, entry, and exit and customer reliability?
- Environmental effectiveness
 - How do emissions and emissions intensity change under the policy?
 - Does it achieve the desired emissions reductions with certainty?

- Equity
 - What is the distribution of the costs and benefits of the policy, for example on household electricity bills, and profits of incumbent generators?
 - Does the policy create or consume revenue (before assistance)?

APPENDIX C MODELLING COMMISSIONED FOR THIS REVIEW

Appendix C.1 Electricity sector modelling

Modelling approach

This section provides an overview of the electricity sector modelling the Authority commissioned Jacobs to undertake to help inform the Authority's policy recommendations in the Special Review. Jacobs' full modelling report is available on the Authority's website.

To facilitate a like-for-like comparison of policies, the modelling constrains each policy scenario to achieve the same cumulative emissions over 2020–2050, and uses common input assumptions. In the seven core scenarios, the emissions budget was set at a level consistent with the world taking action to limit global warming to no more than 2 degrees. A weaker emissions budget (consistent with 3 degrees) was examined as part of the sensitivity analysis. This scenario is included merely for the purpose of testing model sensitivity and does not reflect the Authority's endorsement of a three degree temperature increase as a policy objective.

The modelling covers the National Electricity Market (NEM) and the Wholesale Electricity Market (WEM) of Western Australia which currently make up about 94 per cent of Australia's electricity demand (AECOM 2013, p. 4). Section 1.3 of Jacobs' Modelling Report (Jacobs 2016c) provides further details on the modelling approach.

It is important to note that the modelling does not aim to predict future outcomes; rather it is intended to provide high-level insights to inform policy choice. To do this, the modelling makes a range of assumptions and simplifications. Some assumptions omit features that are important for short-term outcomes in the electricity sector, but are small in absolute terms over the longer time horizons that are the focus of this work, so excluding them does not materially affect the comparative projections. Some other assumptions, such as the level of electricity demand, and the availability and costs of electricity generation technologies, are important for the results. In these cases, the impact of varying the assumption is explored through sensitivity analysis. In general, the level of uncertainty around the projections increases over the modelling horizon. Jacobs' modelling is 'partial' rather than 'general' equilibrium, so it does not incorporate the second-round or 'indirect' effects¹⁷ of these policies on the wider economy. These effects were considered for two scenarios—see Section 3.3 and Appendix C.3 of this report. Section 1.4 of Jacobs' modelling report (Jacobs 2016c) provides further guidance on interpreting the modelling.

The proposed policies, modelling assumptions and approach were released for public feedback in the May 2015 consultation paper *Modelling illustrative electricity sector emissions reduction policies* (Jacobs 2015), which was published on the Authority's website.

¹⁷ Examples of second-round or indirect effects include interactions of the policies with the taxation system, the substitution of goods between industries and the movement of workers around the economy.

Scenarios and sensitivities

Jacobs modelled seven individual policy scenarios and a reference case. Table 3 in Chapter 3 explains these policies in more detail. These policies are broadly representative of those proposed and discussed for the sector in recent years.

The policy scenarios were compared to a reference case which incorporates the current Renewable Energy Target (both the Large-scale Renewable Energy Target (LRET) and Small-scale Renewable Energy Scheme (SRES)) and state-based policies affecting the sector (current at the time of modelling).¹⁸ It is important to note that the reference case is not a projection of the sector under a ‘business as usual’ future, but designed so that differences between the reference and policy cases are due to the policies, rather than the policies and other features. To achieve this, both the reference case and policy cases assume strong global action to reduce emissions, with the reference case assuming no new policies in the Australian electricity sector. Each policy scenario:

- assumes policies are announced in 2017–18 and start in 2019–20, so results match the reference case to 2018–19, but deviate thereafter. In practice, reaction and build times may be longer than presumed as investors and stakeholders consider the uncertainties, and labour and resource availability may constrain how quickly new builds can occur.
- like the reference case, includes the current LRET and SRES trajectories from 2020 to 2030.
- assumes all prospective zero- and low-emissions technologies—including nuclear—are available to achieve the emissions budget.
- excludes the sector from the Emissions Reduction Fund’s safeguard and crediting mechanisms.
- omits the use of offsets from other sectors, or international permits or credits in meeting the emission budget for electricity generation. The ability to surrender such units can reduce compliance costs and is an important potential design feature of some of the policies analysed. However, if offsets or international permits or credits were included in the modelling, the results could be dominated by expected future offset or unit prices and would be less informative about the relative effects of the policies themselves. The economy-wide modelling (Appendix C.3) incorporates some use of international permits or credits.
- generally applies the same design for policy features such as coverage thresholds, limits on banking and borrowing of permits, and so on (specific design features are in Table 8). This helps ensure that differences in results are driven by material differences between the policies.
- is tested to ensure it meets current standards for electricity system reliability. Jacobs subjected modelled plant entry to current NEM and WEM output-based probabilistic reliability standards, as well as conducting an additional deterministic test.

Jacobs also tested the performance of combinations and the robustness of individual policies to changes in key assumptions. Table 7 sets out the key questions explored and the policy scenarios investigated in each case. As with all of the modelled scenarios, the sensitivities have been chosen to assist in comparing the performance of policies only and should not be interpreted as policies that the Authority would recommend.

¹⁸ This includes the Australian Capital Territory’s current 100 per cent renewable energy target and supporting auctions, but doesn’t include Victoria’s renewable energy target of 40 per cent by 2025, or Queensland’s renewable energy target of 50 per cent by 2030.

Further details on the scenarios and sensitivities are available in Sections 2.2 and 2.3 of Jacobs' Modelling Report (Jacobs 2016c).

Table 7 Relationship between modelling questions, sensitivities and policies

Questions	Explore through	Scenarios	Key assumptions and design
How do individual policies compare on key metrics when meeting the same cumulative emissions budget?	Core scenarios: modelling each policy separately with common inputs and a common emissions budget	All	Strong global action, affecting fuel prices and technology learning rates (2 degrees) Policies calibrated to meet 2 degree emissions budget Technology availability (constant across all scenarios except technology sensitivity): <ul style="list-style-type: none"> • CCS and geothermal can be deployed from 2030 • Nuclear can be deployed from 2035
Will combinations of policies perform better than individual policies?	Policy combinations	Cap and trade and low emissions target Cap and trade and regulated closures Regulated closures and low emissions target	Strong global action affecting fuel prices and technology learning rates (2 degrees) The first policy in each combination is fixed; the other varies so the combination meets the 2 degree emissions budget. When fixed: <ul style="list-style-type: none"> • Carbon price consistent with likely chance of 3 degrees warming • Regulated closures of all coal capacity by 2030 (regulated closures limited to coal-fired generators)
Does a large shift to distributed generation and storage change the relative performance of policies? If actual electricity demand is lower than projected, does this change the relative performance of policies?	Sensitivity: low demand (higher penetration of PV and storage; lower underlying electricity demand)	Reference case Cap and trade Low emissions target (planned but not run: LET targets exceed electricity demand)	Strong global action, affecting fuel prices and technology learning rates (2 degrees) Uses policy parameters from the core modelling scenarios (that is, policy parameters are an input not an output as per most other runs) Lower electricity demand sourced from AEMO and IMO Faster reductions in battery storage costs Relaxed upper bounds on share of households and businesses that can install PV
If actual electricity demand is higher than projected, does this change the relative performance of policies?	Sensitivity: high electricity demand (electrification of other sectors and increased penetration of electric vehicles)	Reference case Cap and trade Low emissions target	Strong global action, affecting fuel prices and technology learning rates (2 degrees) Uses policy parameters from the core modelling scenarios (that is, policy parameters are an input not an output as per most other runs) High electricity demand based on ClimateWorks Australia et al. (2014) for NEM and Independent Market Operator (2015) high demand scenario for the WEM
Does changing costs and/or availability of key large-scale technologies change the relative performance of policies?	Sensitivity: technology sensitivity	Reference case Cap and trade Low emissions target Renewable energy target	Strong global action, affecting fuel prices and technology learning rates (2 degrees) Policies calibrated to meet 2 degree emissions budget No nuclear, CCS or geothermal deployment Faster reductions in battery storage costs
Would less ambitious emissions targets change the relative performance of policies?	Sensitivity: weaker emissions budget	All	Weaker global action, affecting fuel prices and technology learning rates (3 degrees) ¹⁹ Policies calibrated to meet 3 degree emissions budget

Source: Climate Change Authority.

¹⁹ This scenario is included merely for the purpose of testing model sensitivity and does not reflect the Authority's endorsement of a three degree temperature increase as a policy objective.

Key inputs and assumptions

Table 8 provides an overview of the key modelling assumptions. Another standard assumption adopted in the modelling is that investors have ‘perfect foresight’. That is, the future paths of all variables are known with certainty. Investment decisions, for example, are made with complete knowledge of future fuel and capital costs. The impacts of uncertainty on policy choice are considered through sensitivities and the Authority’s qualitative evaluation.

For further details on the modelling assumptions see Appendix C of Jacobs’ modelling report (Jacobs 2016c).

Table 8 Key modelling assumptions for core scenarios

Modelling assumption	Description
General assumptions	
Emissions budget	In order to facilitate a like-for-like comparison of policies, the modelling constrains each policy scenario to achieve the same cumulative emissions over 2020–2050. The emissions budget is set at a level consistent with the world taking action to limit global warming to no more than 2 degrees, and covers both direct (emissions from combustion of fuels in electricity generation) and indirect emissions (emitted during processing and supply of fuel to power stations).
Electricity demand	The core electricity demand projection for the modelling is based on the series from the Department of the Environment’s 2014–15 emission projections (DoE 2015a). These official projections use a total electricity demand series developed by pitt&sherry (2015) and ACIL Allen Consulting (2015).
Commodity prices (coal and gas) and technology costs	From 2020, commodity prices and technology costs based on consistent backdrop involving concerted global action to limit global warming to no more than 2 degrees.
Policy-specific assumptions	
Cap and trade	Applies to all generators, full auctioning of permits, no banking or borrowing of permits.
Emissions intensity scheme	Applies to all generators, emissions intensity baseline declines linearly from 2020, unlimited banking of permits, borrowing limit of 10 per cent of permits.
Renewable energy target	Eligibility limited to new large-scale renewable generators and brownfield projects on existing sites. New LRET trajectory additional to the existing LRET.
Low emissions target	Eligibility includes all generators with emissions below 0.6 t CO ₂ -e/MWh (the baseline). Eligible generators with above-zero emissions earn partial certificates in proportion to their emissions intensity relative to the baseline. Target additional to the existing LRET.
Contracts for difference	Eligibility limited to new renewables, new fossils with CCS, CCS retrofits and nuclear. Twenty year contracts; tariff payed through an energy-based customer levy.
Regulated closures	Applies to coal-fired and gas generators. Aged-based closure of coal generators that do not undergo CCS retrofit. Gas generators subject to an annual emissions limit of 2,200 t CO ₂ -e/MW capacity. No new coal without CCS.
Absolute baselines	Applies to all generators with above average emissions intensities. No new coal or gas without CCS.

Source: Climate Change Authority.

Technology costs

This section compares Jacobs’ technology costs with those from two other recent studies:

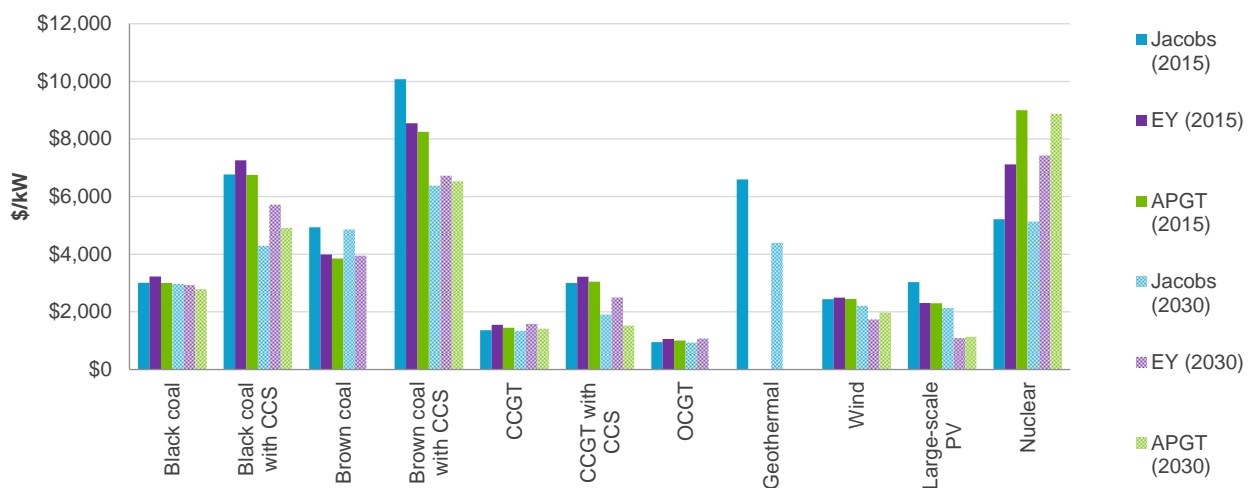
- The Australian Power Generation Technology (APGT) study steered by CO2CRC, CSIRO, Australian Renewable Energy Agency, Australian Government: Department of Industry and Science, and Anlec R&D using consultants including the Electric Power Research Institute.

- Modelling for South Australia’s Nuclear Fuel Cycle Royal Commission conducted by Ernst & Young (EY).

Figure 23 compares selected capital costs for technologies in both 2015 and 2030 across all three studies. Capital costs for all technologies—except for nuclear—are projected to fall in real terms over time due to ‘learning by doing’ as installed capacity increases; learning rates are slower with mature technologies. The capital costs across all three studies are broadly similar with the exception of nuclear, brown coal and large-scale solar generators.

- Relative to Jacobs, the 2015 capital cost of a brown coal plant is around 20 per cent lower in the APGT and EY studies.
- Jacobs’ nuclear capital costs were about half that suggested by the APGT study; nuclear costs in the EY study are midway between the two. Further discussion of Jacobs’ nuclear cost assumptions is in Appendix C.4.6 of Jacobs’ modelling report (Jacobs 2016c).
- Jacobs’ capital costs for large-scale solar are around 25 per cent higher in 2015 and around 50 per cent higher in 2030 than the APGT and EY studies.

Figure 23 Technology capital cost comparison



Note: All studies adopt costs consistent with 2 degrees global action scenario. In addition to the capital costs above, the EY report also publishes overnight capital costs for nuclear that include project development and licensing costs.
Source: Climate Change Authority based on APGT 2015; Jacobs 2016c; Ernst & Young 2016.

Key estimated impacts

The following section summarises the key estimated impacts of the different policy scenarios on:

- share of generation by technology type
- emissions from the electricity sector
- wholesale and retail electricity prices, and household spending
- generator profits
- cost to society, including resource costs and cost of abatement.

This summary compares results of the individual policies under the 2 degrees emissions budget. The complete set of modelling results—including policy combinations and sensitivities—are available in Jacobs’ modelling report.

The seven policy scenarios may be classified into three broad categories:

- ‘market mechanisms’—cap and trade and the emissions intensity schemes. These policies put a price on emissions to change the relative price of high- and low-emissions generation.
- the ‘technology pull’ policies—RET, low emissions target and contracts for difference. These policies change the generation mix by subsidising renewable and/or low-emissions generation.
- the ‘regulatory’ policies—regulated closures and absolute baselines. These policies change the generation mix by reducing output from high-emissions generators through regulation.

Generation mix

Meeting the 2 degrees emissions budget causes large changes in the mix of generating plants in Australia (Table 9). In the reference case, which assumes no new climate policies, coal-fired power remains the dominant source of generation. In the policy scenarios, however, coal generation and capacity is projected to reduce rapidly, reaching near zero between 2025 and 2040 (depending on the policy scenario).

Table 9 Share of generation by technology type, 2 degrees, 2030 and 2050

Scenario	2030				2050			
	Coal	Gas	Renewable	Other low emission	Coal	Gas	Renewable	Other low emission
Reference	63%	12%	24%	0%	53%	28%	19%	0%
Cap and trade	3%	41%	46%	10%	0%	8%	65%	27%
EI scheme	5%	24%	52%	19%	0%	6%	69%	25%
RET	16%	9%	74%	0%	4%	15%	81%	0%
Low emissions tgt	20%	5%	70%	5%	1%	5%	72%	22%
Contracts for diff	19%	6%	72%	2%	2%	6%	73%	19%
Reg closures	0%	32%	66%	2%	0%	21%	62%	17%
Abs baseline	21%	3%	76%	1%	0%	1%	71%	28%

Note: Rows may not sum up to 100 due to rounding. ‘Other low-emission’ is gas CCS and nuclear (coal CCS was available but not deployed in any scenario).

Source: Jacobs 2016c.

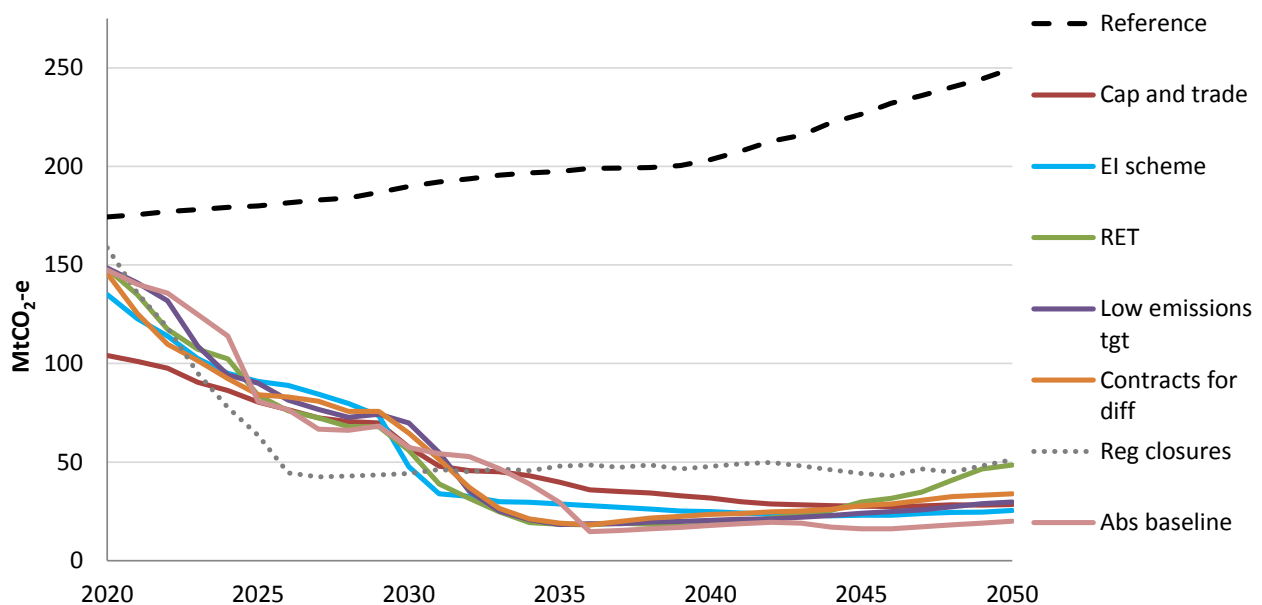
In all the policy scenarios, the lower share of coal generation is largely replaced with renewable energy and other low-emissions generation. Renewable energy is projected to make up between 60 and 80 per cent of the generation mix by 2050. The level of renewable energy is highest in the technology pull scenarios due to these policies directly providing a subsidy for renewable technologies. Renewable generation is lower in the market mechanism scenarios, where gas generation increases in the early years, and low emission technologies such as CCS and nuclear increase their share later. Small-scale solar PV is adopted at high levels across all scenarios including the reference case.

Current reliability standards are met in all policy scenarios despite increasing shares of intermittent renewable generation. After 2030 gas-fired peaking plants are projected to have an important role providing reserve capacity to meet these requirements.

Emissions

Each policy was required to meet the demanding emissions budget. Annual emissions were allowed to vary across policies so long as the overall emissions budget was met, however emissions and emissions intensities are projected to fall sharply in the 2020s in all policy scenarios (Figure 24 and Figure 25). This indicates that even though the costs of low-emissions technologies fall over time, early action is required to meet the emissions budget. If action is delayed for too long, the emissions intensity of the generation fleet would stay high for too long and the emissions budget would be exceeded. This relatively rapid change in intensity is consistent with other studies that have explored strong decarbonisation of Australia’s electricity sector (ClimateWorks Australia et al. 2014; CCA 2014c; TCI 2016).

Figure 24 Emissions by policy scenario, 2 degrees, 2020–2050



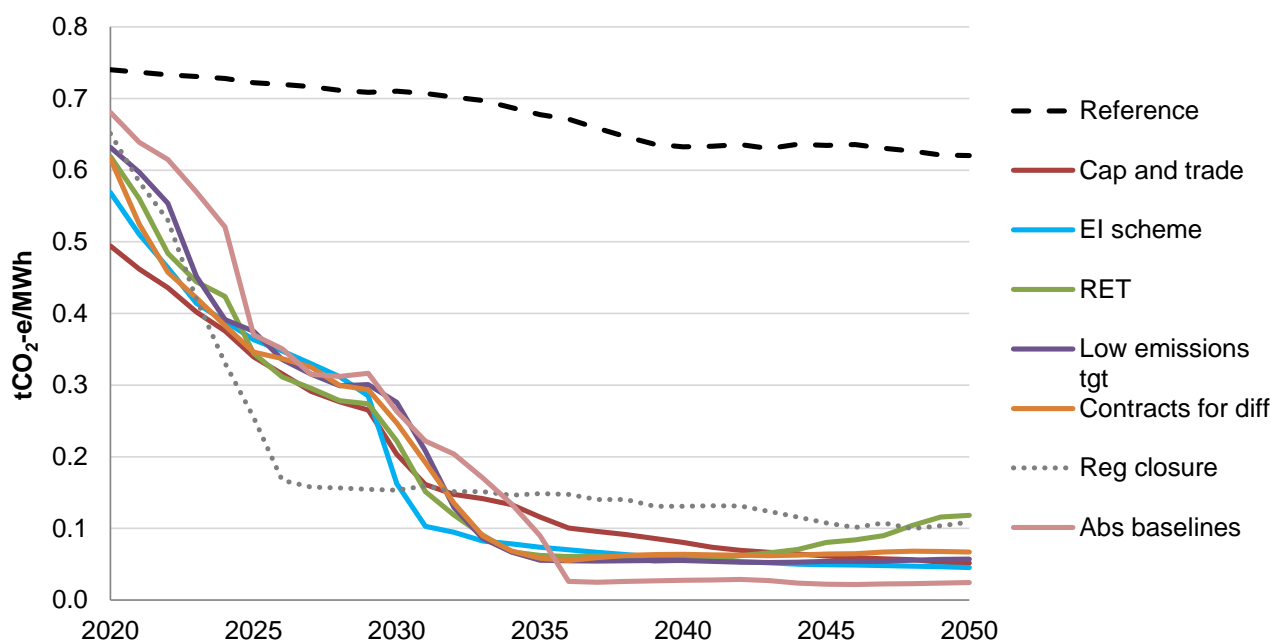
Note: Emissions from the NEM and WEM. Emissions comprise direct emissions (from combustion of fuels in electricity generation) and indirect emissions (emitted during processing and supply of fuel to power stations). The regulated closures policy breaches the emissions budget by about 200 Mt CO₂-e or 15 per cent.

Source: Jacobs 2016c.

In the absence of new policies, emissions are projected to be substantially higher in the reference case than in the policy scenarios. Emissions in the reference scenario grow by around 1.2 per cent per year, which is lower than the rate of growth in demand for that scenario. The emission intensity of generation falls slightly due to the increasing projected share of gas-fired generation.

Regulated closures is the only scenario that does not achieve the budget; cumulative emissions exceed the budget by about 15 per cent (227 Mt CO₂-e). Even with rapid closure of all coal by 2027, emissions are not projected to fall to the same level as the other policy scenarios. This is because, in the absence of other policy mechanisms, coal is replaced with a large amount of gas-fired generation rather than renewables.

Figure 25 Emissions intensity by policy scenario, 2 degrees, 2020–2050



Note: Emissions intensity of the NEM and WEM. Emission intensity is based on direct emissions (from combustion of fuels in electricity generation) and electricity demand. The regulated closures policy breaches the emissions budget by about 200 Mt CO₂-e or 15 per cent.

Source: Climate Change Authority based on Jacobs 2016c.

Prices

This section provides an overview of the projected effects of the policy options on wholesale and retail prices.

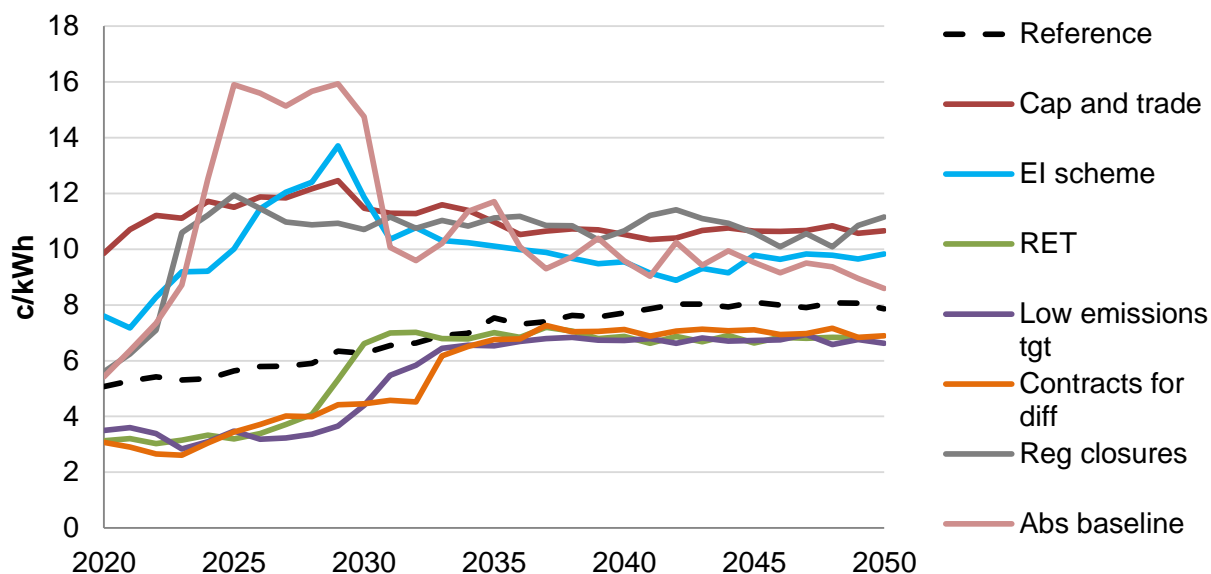
The type of mitigation policy has a large effect on projected wholesale electricity prices (Figure 26). For the policy scenarios, wholesale prices:

- are generally the highest in the cap and trade scenario. This reflects the impact of the carbon price on the dispatch costs of fossil fuel plants.
- also rise in the emission intensity scenario but are 12 per cent lower than the cap and trade scenario in present value terms. This is because of the production subsidy provided by free allocation of permits up to the baseline.
- also rise for the regulatory scenarios as they restrict dispatch of low cost but high-emissions plant. In the absolute baselines policy there is a price spike from 2024 to 2030.²⁰
- are below or around the reference scenario prices for the technology pull policies. These policies provide a subsidy to generators with low operating costs, suppressing wholesale prices over the modelling period.

For further detail about how different policies affect wholesale prices see Box 2 in Chapter 2.

²⁰ For this period wholesale prices are projected to be higher than under any other policy. Over 2024–2030 new renewables are required to replace the declining output from existing plant. These renewables cause sharp increases in wholesale prices because they have only a short window to recover enough of their fixed costs before lower-cost technologies (gas CCS and geothermal) can be deployed from 2030. That is, the projected price spike is a function of the modelled policy design (declining limits on existing above-average emissions-intensity plants) combined with assumptions about the availability of new technologies and investors' knowledge of and expectations about future technologies and prices.

Figure 26 Average wholesale electricity price by policy, 2 degrees, 2020–2050



Note: Prices are volume weighted using average hourly prices weighted by hourly generation proportions. Volume weighted prices are calculated for each region of the NEM and the WEM and a system wide average is derived by weighting each regional price by the ratio of each region's energy demand to total demand. The regulated closures policy breaches the emissions budget by about 200 Mt CO₂-e or 15 per cent.

Source: Jacobs 2016c.

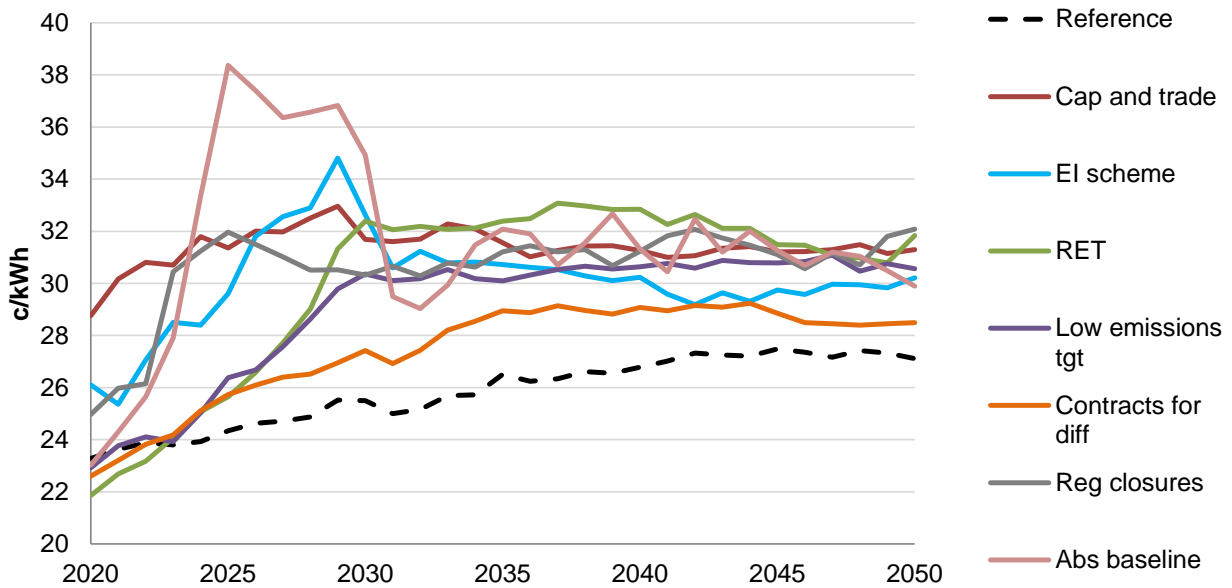
Retail prices are made up of the costs of generating, transmitting, distributing and selling electricity to end users (Section 2.5.2). Climate policies affect only some of these components:

- Market mechanisms and regulatory policies raise wholesale prices, but leave other components unaffected.
- Technology pull policies lower wholesale prices, but raise the retail components of prices as the costs of subsidising technology are borne by retailers and passed on to consumers. In the core policy scenarios, the second effect dominates and overall retail prices are projected to rise.
- Climate policies do not materially affect network costs, which in 2014–15 made up 47 per cent of residential customer bills (AEMC 2015b).

For all policies, achieving Australia's long-term emissions reduction goals is likely to increase consumer electricity prices; these impacts can be addressed in a range of ways. In Jacobs' modelling average retail prices are projected to be about five to 25 per cent higher in the policy scenarios than in the reference scenario (Figure 27).²¹ Projected changes in electricity costs are the product of projected changes in retail price and electricity consumed. Jacobs' modelling uses estimates from Australian data on how electricity demand responds to changes in price to project changes in electricity demand. Average annual residential electricity spending is projected to increase by between \$50 and \$200 per year depending on the policy (Figure 28). Electricity spending as a share of household income is projected to remain around 2.2 per cent for the reference case and averages between 2.3 per cent and 2.6 per cent in the policy scenarios over the period to 2050 (Jacobs 2016c). As noted above, these projections exclude policies such as energy efficiency measures which could be implemented alongside electricity sector climate policy and can improve electricity affordability even with increased electricity prices. Other recent modelling suggests the largest influences on future electricity affordability may be network infrastructure costs rather than climate action (CSIRO National Outlook p.16).

²¹ This is calculated as the percentage difference between the present value of prices in the policy and reference case.

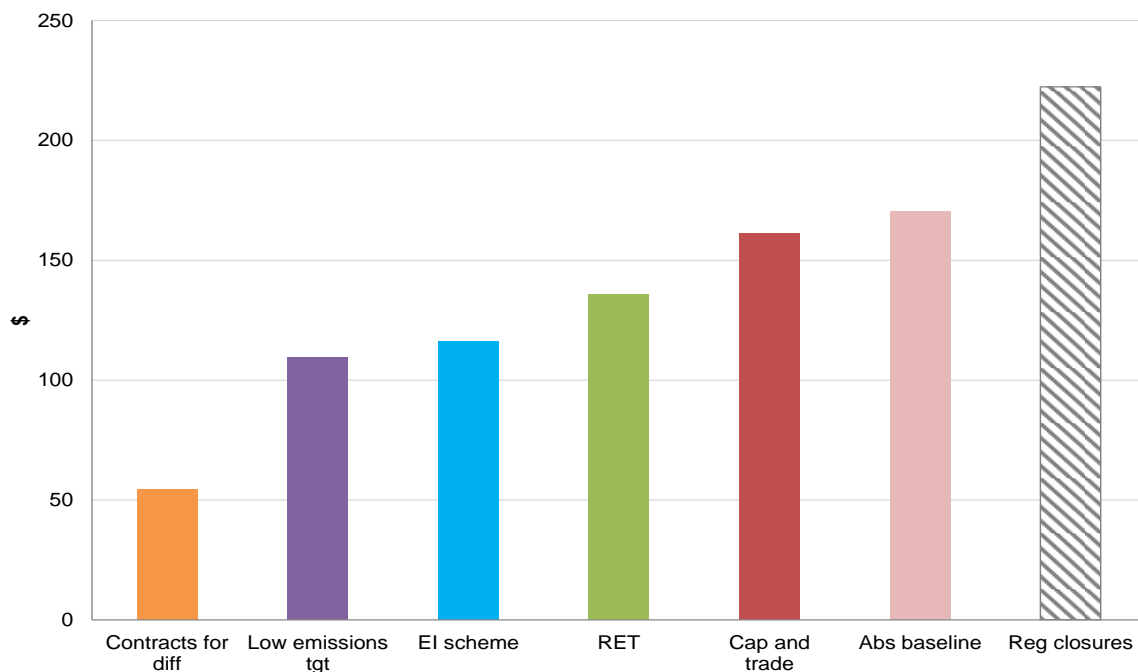
Figure 27 Average residential retail price by policy, 2 degrees, 2020–2050



Note: Prices are volume weighted using average hourly prices weighted by hourly generation shares. Volume weighted prices are calculated for each region of the NEM and WEM and a system wide average is derived by weighting each region price by the proportion of each region’s energy demand to total energy demand. The regulated closures policy breaches the emissions budget by about 200 Mt CO₂-e or 15 per cent. The cap and trade scheme raises revenue which could be used to assist consumers with higher electricity prices; for other policies assistance could be drawn from general revenue.

Source: Jacobs 2016c.

Figure 28 Average annual residential customer spending, relative to reference, 2 degrees, 2020–2050



Note: Figures relative to reference case calculated by subtracting the reference case spending from the policy case spending. The regulated closures policy breaches the emissions budget by about 200 Mt CO₂-e. The cap and trade scheme raises revenue which could be used to assist consumers with higher electricity prices, for other policies assistance could be drawn from general revenue.

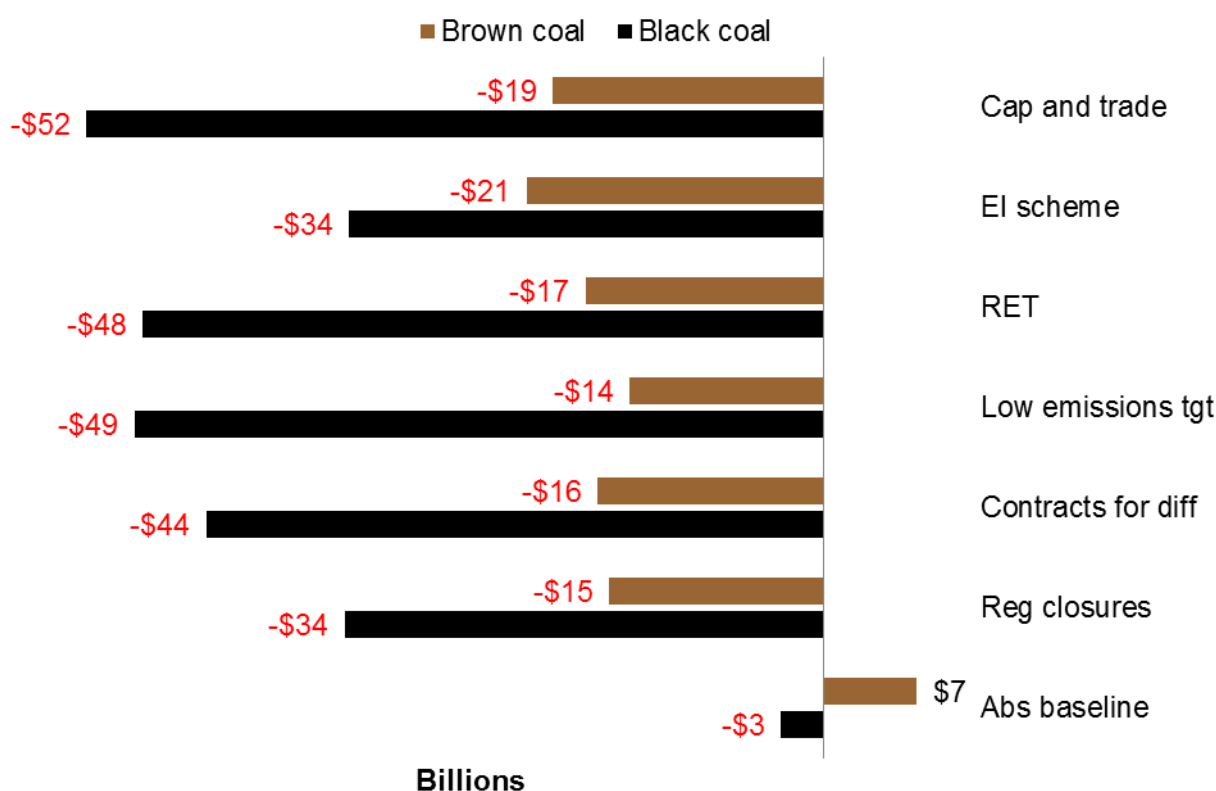
Source: Climate Change Authority based on Jacobs 2016c.

Generator profits

Gross profits are the difference between total revenue and all operating costs. Gross profits for incumbent coal generators are projected to be lower than the reference case in all policies under the 2 degree emissions budget except in the absolute baselines scenario (Figure 29). Incumbent coal generators can have higher profits relative to the reference case in this scenario because:

- there are no additional costs to generation from the policy
- the wholesale price of electricity is relatively high (Figure 26).

Figure 29 Difference in NPV of gross profits for incumbent coal generators, relative to reference, 2 degrees, 2020–2050



Note: NPV of gross profits calculated with seven per cent discount rate and discounted to 2020 levels. Gross profit is a concept related to costs, and for a generator is the difference between total revenue, which consists of pool revenue, contract revenue and certificate revenue (where applicable), less all operating costs, including fuel costs, fixed and variable operating costs and emissions costs. Gross profits for reference case are adjusted for new entrants using a generation to capacity ratio. The regulated closures policy breaches the common cumulative emissions budget, so the change in profits may not be directly comparable with other policies. The reference case assumes strong global action to reduce emissions, and no additional climate policies in the Australian electricity sector. Revenue raised under the cap and trade scheme is not redistributed in the modelling. For further information on interpreting gross profits measures, see Appendix C.3.3 of Jacobs' modelling report (Jacobs 2016c)

Source: Climate Change Authority based on Jacobs 2016c.

The closure of coal generators creates opportunities for investment in new low-emissions generators (Figure 17 in Section 4.1.2), which could be taken up by new or existing businesses. Overall, between 2020 and 2050 the NPV of cumulative gross profits in the sector increases by around 10 to 110 per cent relative to the reference case, depending on the policy.

Incumbent hydro generators generally increase gross profits under all policies. Hydro generators benefit the most under market mechanisms and regulatory scenarios from the increased wholesale price, and under the emissions intensity scheme through revenue earned from permits. In the

technology pull policies, hydro generators receive lower wholesale prices, but benefit from price spikes resulting from higher penetration of intermittent generation. Incumbent gas generators benefit in a similar way to incumbent hydro generators, particularly in the 2020s before other non-intermittent generators are assumed to become available.

Further information on gross profits is in Appendix C.3.3 of Jacobs' modelling report (Jacobs 2016c).

Resource cost and cost of abatement

The resource costs presented in Jacobs' modelling represent the direct net cost of the policy to society as a whole, before accounting for indirect costs, and before considering the benefit of emissions reductions achieved by the policy. Resource costs comprise:

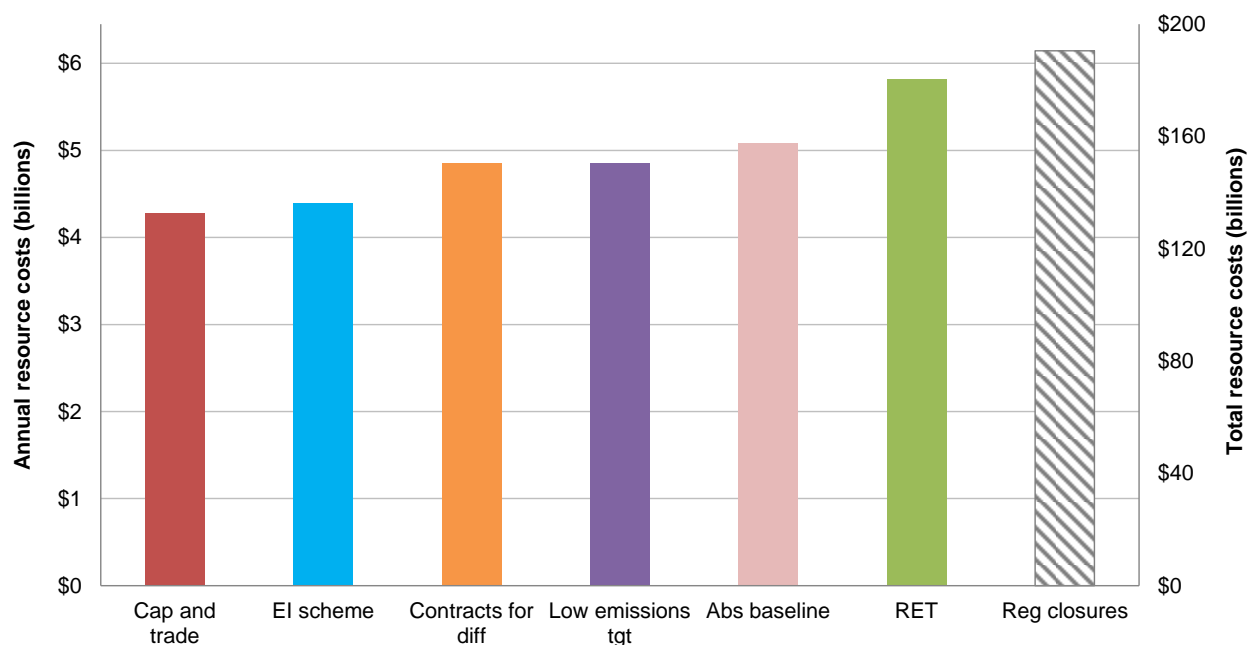
- fuel costs including any delivery (transmission or transport) costs
- variable operating and maintenance costs
- fixed operating and maintenance costs
- capital costs for new plant (both large-scale and distributed generation), large- and small-scale battery storage and interconnector upgrades
- decommissioning costs
- an adjustment to costs to account for changes in demand.

Further information on resource costs is in Appendix B.3 of Jacobs' modelling report (Jacobs 2016c).

The modelling projects that market mechanisms are the lowest cost (Figure 30). This is because market mechanisms create an incentive for generators and households to find the lowest cost ways to reduce emissions rather than prescribing particular emissions reduction activities.

The technology pull and the regulatory policies were all higher cost than the market mechanisms modelled. The technology pull policies have relatively high resource costs because they largely provide direct incentives for one type of emissions reduction activity in the electricity sector—building new zero- or low-emissions plants. This means that other and potentially cheaper emissions reductions are not directly targeted. Similarly, the regulatory policies are focussed on one type of emissions reduction activity—reducing output from high-emissions generators—and are less effective in targeting other emissions reduction opportunities in the sector.

Figure 30 Resource costs relative to the reference scenario, 2 degrees, 2020–2050



Note: Each bar represents the net present value of the change in resource costs relative to the reference case, adjusted for the reduction in demand due to the increase in electricity prices. This is equivalent to the present value of the welfare costs of the policy relative to the reference case before emissions reduction benefits are considered, discounted at the social discount rate of seven per cent. Annual resource cost (left axis) calculated by dividing the total resource cost (right axis) by the number of years. The regulated closures policy breaches the emissions budget by about 200 Mt CO₂-e or 15 per cent.

Source: Jacobs 2016c.

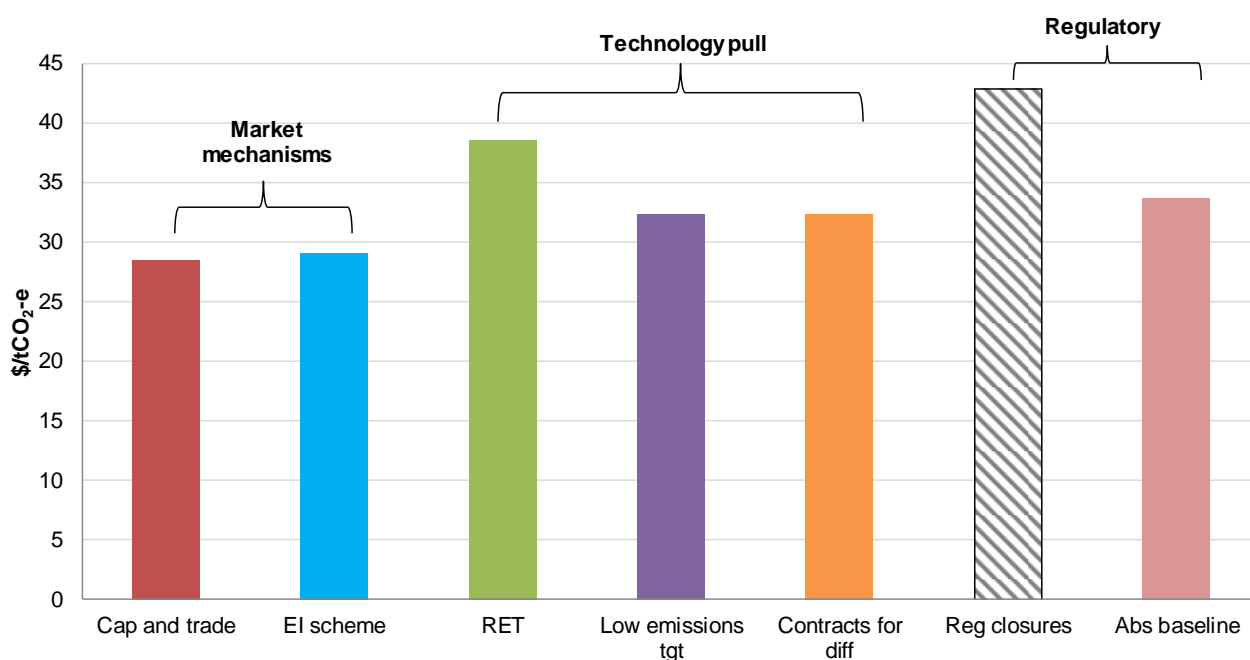
The average cost of abatement measures the cost effectiveness of a policy. It is calculated by dividing the present value of resource costs relative to the reference scenario by the emissions reductions achieved by the policy. Policies with a lower cost of abatement are more economically efficient. All policy scenarios—except regulated closures—achieved similar levels of cumulative emissions, so rankings by average cost of abatement are similar to rankings by resource costs (Figure 31). There are three points to note about the average cost of abatement calculations shown here:

- While experts take different views on whether future emissions reductions should be discounted or not, the Authority’s approach is not to discount the emissions reductions. The rationale for this approach is that, within the emissions budget and over the timeframes and volumes of emissions reductions considered, a tonne of emissions reductions in the future is as valuable as a tonne now. The approach to calculating the average cost of abatement was examined as part of an independent peer review of the modelling conducted for the Authority by HoustonKemp (Appendix C.2), which found the approach was appropriate (HoustonKemp 2016, p. 13).
- The estimates cover costs in the electricity sector only; the economy-wide modelling (Appendix C.3) investigates total economic costs for three scenarios examining different market mechanisms. It is not possible to calculate a cost of abatement in the economy-wide modelling as all scenarios have the same level of emissions; by contrast, abatement in the electricity sector modelling can be measured by comparing the reference case with the other scenarios.
- The average cost of abatement is not the same as the level of a carbon tax or the price of permits in a cap and trade or emissions intensity scheme. While all are measured in dollars per tonne of emissions, the rate of a carbon tax or price of permits is the price liable entities pay for emissions under these particular policies. If liable businesses can reduce emissions at a lower cost per tonne

by changing their processes or practices than by paying the carbon tax or permit price, they can do so. This means that the tax or permit price measures the *marginal* cost of abatement: the cost of the last (and most expensive) unit of emissions reductions required to meet the policy. The average cost of abatement considers the average cost per tonne of emissions reductions, taken across all of the emissions reductions achieved under the policy over a given time period. For example, it includes the changes businesses make by finding ways of reducing emissions rather than paying the tax or permit price.

Further explanation of the cost of abatement methodology is in Appendix B.3.3 of Jacobs' modelling report (Jacobs 2016c).

Figure 31 Average cost of abatement by policy, 2 degrees, 2020–2050



Note: Average cost of abatement over 2020–2050 using a seven per cent discount rate for resource costs. Emissions not discounted. Accounts for the reduction in welfare from a fall in electricity demand resulting from increased retail electricity prices. The regulated closures policy breaches the common cumulative emissions budget by about 200 Mt CO₂-e or 15 per cent, so the cost of abatement here is not directly comparable with other policies.

Source: Climate Change Authority based on Jacobs 2016c.

Appendix C.2 Peer review of modelling

To test the robustness of Jacobs' modelling, the Authority commissioned an independent peer review by HoustonKemp. The scope of the peer review was to:

- assess the implementation of the emissions reduction policies in Jacobs' modelling, providing an opinion on whether the instructions provided to Jacobs, or their translation into the modelling, may have resulted in some policies being more or less advantaged relative to others
- review the sources and approach used to determine the main input assumptions for the electricity modelling.

HoustonKemp's review of the modelling was informed by materials provided by the Authority, including a draft of Jacobs' modelling report and detailed modelling results. Overall, HoustonKemp found that:

Based on our consideration of these materials, in our opinion the approach to comparing emissions reduction policies is sound, and the input assumptions used in Jacobs' modelling are generally appropriate. Our overall view is that the modelling has been conducted to a high

standard of rigour and that the critical policy comparisons drawn by the report are robust
(HoustonKemp 2016, p. 1).

HoustonKemp suggested several minor areas for improving the modelling exercise. Where feasible, Jacobs updated the modelling results and modelling report; these changes are outlined in Jacobs' response to the peer review. Detailed findings and recommendations of the peer review are outlined in the HoustonKemp report, which is available along with Jacobs' response at www.climatechangeauthority.gov.au.

Appendix C.3 Economy-wide modelling

Modelling approach

This section provides an overview of the economy-wide computable general equilibrium (CGE) modelling performed by Victoria University for the Authority, with input from Jacobs for the electricity sector.

As with the electricity sector modelling described in Appendix C.1, this modelling helped to inform the Authority's policy recommendations in the Special Review. The Authority recognises that electricity sector policies will have effects on the broader economy that are not captured by electricity sector modelling. These 'indirect' effects include 'tax interaction effects' that arise when emissions reduction policies cause less labour or capital to be used in the economy, and effects arising from how revenue raised by policies is returned to the economy. The economy-wide modelling builds on and extends the Authority's electricity sector modelling to assess whether these indirect effects could change the relative ranking of the market mechanisms examined in the electricity market modelling. These policies were chosen because differences in indirect effects could significantly affect their relative cost effectiveness.

The focus of this modelling is to examine the relative cost effectiveness of different policy options. It is not intended to examine the total economic cost of Australia adopting an emissions reduction policy relative to it not doing so, which was an important element of several past modelling exercises.

To ensure that differences in modelled cost between different scenarios are due to differences in policy design, each policy is compared on a like-for-like basis. To achieve this, the modelling:

- uses common input assumptions across scenarios, varying only a few key policy parameters to simulate the effect of different policies
- ensures each scenario achieves the same level of net national emissions and therefore a common emissions budget. This means that Australia's economy-wide emissions, net of purchases of international permits or credits, is the same in each year. This is slightly different to how the electricity sector modelling was undertaken, which used a common emissions budget within the Australian electricity sector for all policies modelled.

To isolate the economy-wide effects of electricity sector policies from impacts arising in other emitting sectors, the economy-wide modelling applies the same emissions reduction policy (a cap and trade scheme with lump sum revenue recycling) in other emitting sectors in all scenarios (Table 4 in Chapter 3).

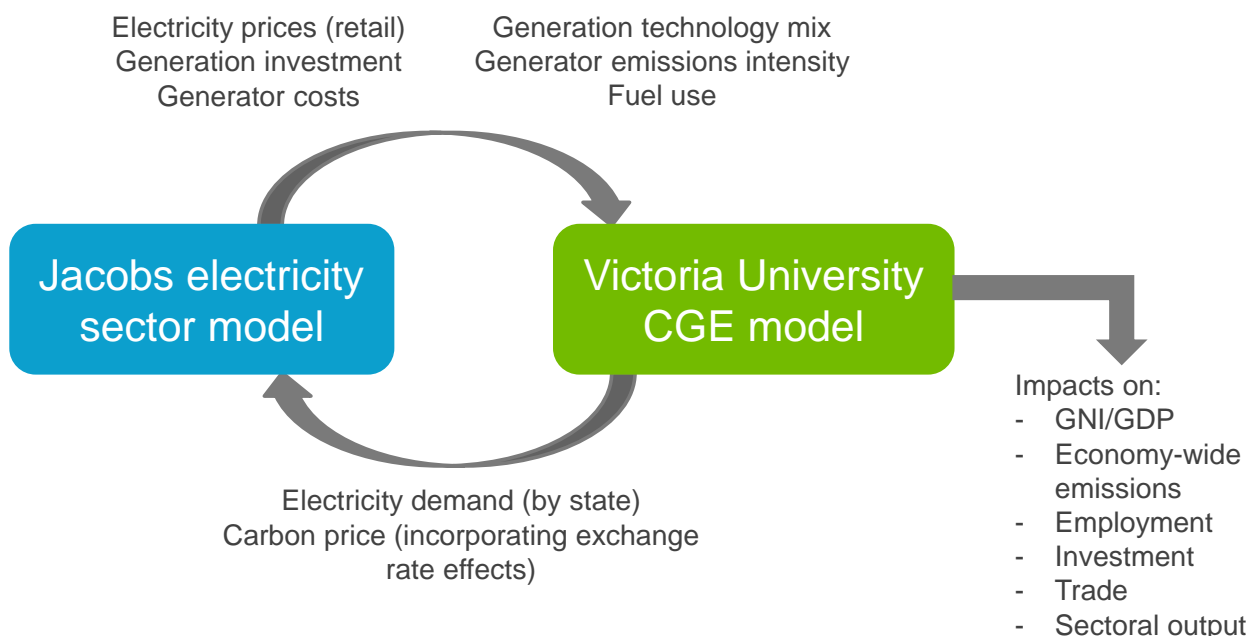
As with the Authority's electricity sector only modelling, the economy-wide modelling does not aim to predict future outcomes; rather it is intended to provide high-level insights to inform policy choice. The modelling makes a range of assumptions and simplifications in order to represent the entire Australian economy. All assumptions suffer from some degree of uncertainty, but by holding them constant across

all scenarios their effect on comparisons of cost effectiveness between policies will generally be negligible. In some cases simplifications could have a material impact on the Authority’s assessment of cost effectiveness; in particular the simplified representation of the tax system and how workers respond to changes in real wages could affect the relative ranking of different policies. Nevertheless, the modelled scenarios give credible indications of how policy choice may be affected by considering indirect costs and benefits alongside direct costs. Importantly, the modelling provides limited insight into distributional effects for households, and so its insights into the cost effectiveness of different policies should be considered alongside potential equity impacts.

Victoria University’s economy-wide modelling also required Jacobs to undertake new electricity sector modelling, as the detailed electricity sector effects of different policies could only be picked up with sectoral modelling. Jacobs’ modelling generally used the same methodology as that described in Appendix C.1. The two models were iterated to ensure that both models described a consistent picture of the economy, particularly through the interaction between electricity prices and electricity demand. As shown in Figure 32, the Jacobs model provided electricity price series for the Victoria University model, which in turn provided estimates of electricity demand to the Jacobs model. This iterative process was continued until the degree of change in those variables was small, indicating consistency across the two models.

More detail on the modelling approach is provided in modelling reports by Jacobs and Victoria University, available on the Authority’s website at www.climatechangeauthority.gov.au.

Figure 32 Iterative modelling using CGE and electricity sector models



Source: Climate Change Authority.

Scenarios

Victoria University modelled three scenarios:

- a cap and trade scheme with lump sum revenue recycling ('cap and trade (lump sum)')
- a cap and trade scheme with revenue recycling through tax cuts ('cap and trade (tax cuts)') and
- an emissions intensity scheme.

These scenarios were chosen to illuminate two indirect effects of particular interest:

- The change from the cap and trade (lump sum) to cap and trade (tax cuts) scenario illustrates the indirect economic benefit of recycling revenue through tax cuts rather than through lump sum payments to households.
- The change from the cap and trade (lump sum) to emissions intensity scheme scenario illustrates that the indirect cost of the tax interaction effect can be reduced by using an emissions intensity scheme to keep electricity prices lower than would prevail under a cap and trade scheme.

As the focus of the modelling was to examine the relative cost effectiveness of different policy options, rather than the total economic cost of Australia adopting an emissions reduction policy relative to not doing so, one of the three policy scenarios served as the reference case. The cap and trade (lump sum) scenario was chosen because the other two scenarios were expected to perform better. Table 4 in Chapter 3 provides an overview of the scenarios.

Key inputs and assumptions

Carbon price

Each of the three scenarios involves a market mechanism where emitters can purchase emissions permits from the government, other emitters, or other countries at the same prevailing international carbon price. As discussed above, emitters outside the electricity sector also face this carbon price.

In all three scenarios, the Authority adopted a common international carbon price, expressed in United States dollars consistent with global efforts with a likely chance of limiting temperature increases to 2 degrees. The international carbon price converted to slightly different Australian dollar carbon price series in each scenario within the Victoria University CGE model. This was a very similar carbon price series to the series used derive the emissions budget in the electricity sector only modelling.

The use of a common carbon price across both the cap and trade and emissions intensity scenarios varies from the approach in the electricity sector only Jacobs modelling. In that modelling the carbon price in the cap and trade scenario was lower than the certificate price in the emissions intensity scenario. The alternative approach was adopted because, in a world of strong action to reduce emissions, Australia would be likely to face the same effective global carbon price irrespective of whether it adopted a cap and trade scheme or an emissions intensity scheme.

Net national emissions budget

Adopting the same carbon price means that emissions from Australia's electricity generation sector, and other sectors, may vary between the CGE modelling scenarios. This differs from the electricity sector only modelling, where each policy was designed to achieve a fixed emissions budget within the Australian electricity generation sector.

In order to allow a like-for-like policy comparison, scenarios must be set up so that differences in costs are due to differences in policy design rather than in their level of emissions reductions. This is achieved by assuming Australia can purchase international permits or credits at the prevailing carbon price to achieve a common net national emissions budget, that is, a common level of national emissions net of purchases of international permits or credits.

Australia's net national emissions budget was established based on Australia's total domestic emissions in the cap and trade (tax cuts) scenario. Accordingly, trade in international permits or credits was very low in this scenario and higher in other scenarios. This emissions budget does not reflect any

Authority view of Australia's 'fair share' of a global emissions budget, but was adopted to simplify comparisons between scenarios.

Macroeconomic assumptions

Table 10 summarises key macroeconomic assumptions made by Victoria University for its economy-wide modelling. Further detail on these assumptions and on the Victoria University Regional Model (VURM) is provided in the accompanying modelling report (Adams 2016, available at www.climatechangeauthority.gov.au).

Table 10 Overview of macroeconomic assumptions, economy-wide modelling

Model element	Description and relevant assumptions
Regional structure	Australia's eight states and territories are modelled as economies in their own right, with linkages through trade and movements of labour and capital
Sectoral representation	The primary VURM database incorporates 84 separate economic sectors, which are aggregated to 72 in this modelling. Interrelationships between sectors are calibrated based on the 2009–10 ABS input-output tables.
Demographic assumptions	Based on the Australian Government's March 2015 Intergenerational Report (Treasury 2015).
Total factor technological progress (total factor productivity)	In the cap and trade (tax cuts) scenario, total factor productivity improvement is uniform across all industries necessary to achieve a targeted real GDP growth rate. This total factor productivity improvement rate is then held constant across all other scenarios.
Labour market assumptions	In the cap and trade (tax cuts) scenario, real wages are determined by the balance between labour supply, which is determined by demographic assumptions, and labour demand. In all other scenarios the real after-tax wage is 'sticky' in the short-term but flexible in the long-run. This means that short-run changes will primarily affect employment levels, and long-run changes will primarily affect wages. The exception to this are changes to labour tax rates, which affect before-tax and after-tax wages differently, and can therefore cause long-run differences in employment levels between scenarios. Labour is assumed to be mobile between states and territories to maintain constant regional differences in unemployment rates.
Budget balance	In each scenario the fiscal balance to GDP ratio is fixed at 2014 levels for all jurisdictions. The balancing variable is a lump sum payment to or from the representative household in each region.
Trade with the rest of the world	The rest of the world buys Australian exports based on a downward sloping demand schedule. The foreign demand schedule is calibrated in the cap and trade (tax cuts) scenario to achieve the terms of trade assumption in that scenario (see below), and are held constant in other scenarios. Australia sells imports at fixed foreign currency prices which are constant across all scenarios and consistent with the terms of trade assumption in the cap and trade (tax cuts) scenario.
Terms of trade	In the cap and trade (tax cuts) scenario, Australia's terms of trade is calibrated to a historically normal level, allowing for fixed fuel price assumptions (see below). The terms of trade can then vary from that level if changes to Australian exports result in changes to global commodity prices.
Fuel prices	US dollar prices for internationally traded crude oil, steam coal and natural gas are based on Climate Change Authority analysis of the IEA's 2014 World Energy Outlook.

Source: Climate Change Authority based on Adams 2016.

Electricity modelling inputs to economy-wide modelling

Retail electricity prices are a key output of Jacobs' electricity sector modelling. An important difference between the emissions intensity scenario and the two cap and trade scenarios is that the former has lower wholesale and retail electricity prices. This is because the allocation of permits to electricity generators effectively subsidises their output, lowering wholesale and retail electricity prices. This

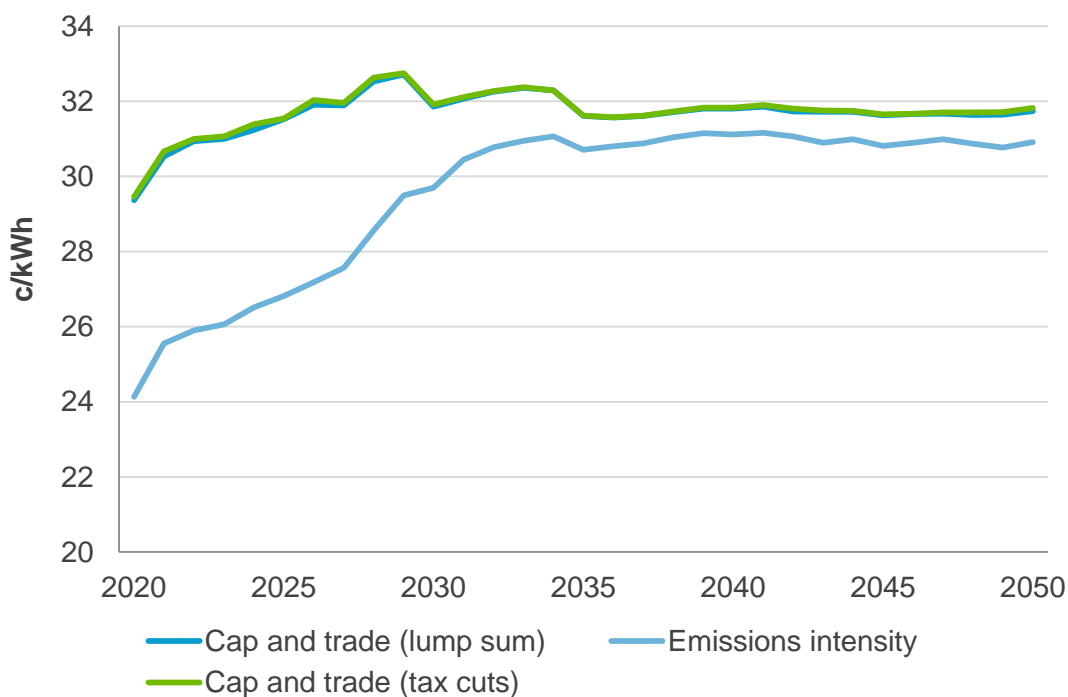
results in changes in the level of output in a range of economic sectors; in particular sectors that use large amounts of electricity would tend to have higher output under an emissions intensity scheme than a cap and trade scheme.

Jacobs' electricity modelling produces three retail electricity price series for three different types of energy users:

- residential
- small and medium enterprises (SME) and
- industrial.

Jacobs produced price series for each user type in each region.²² Victoria University matched these price series to the different industry sectors in each region within VURM, as outlined in its report. Figure 33 shows average residential electricity prices for each scenario; electricity prices for SME and industrial users are detailed in Jacobs' modelling report.

Figure 33 Average residential electricity prices by scenario, economy-wide modelling, 2020–2050



Note: Prices are a load-weighted average of prices in the NEM and WEM.

Source: Jacobs 2016d.

Jacobs also modelled a range of details about how the share of different generation technologies changes in response to emissions reduction policies. Differences in the generation technology share flow through to a range of impacts in VURM, such as investment, employment and profits for different generation types in different regions. Table 11 shows that technology shares are remarkably similar across the three scenarios. This in turn indicates that the differences between the scenarios will

²² Energy users in the Australian Capital Territory are assumed to have the same electricity prices as those in New South Wales. Jacobs did not model the Northern Territory (NT) explicitly; the NT electricity sector was modelled within VURM. Victoria University assumed that all Western Australian users face the electricity prices modelled by Jacobs for the WEM, which in practice only covers the south-western portion of the state.

primarily stem from differences in electricity prices and the use of carbon revenue, rather than from differences in the composition of the electricity generation sector.

Table 11 Share of generation by technology type by scenario, economy-wide modelling, 2030 and 2050

Scenario	2030				2050			
	Coal	Gas	Renewable	Other low emission	Coal	Gas	Renewable	Other low emission
Cap and trade (lump sum)	4%	37%	47%	12%	0%	8%	69%	24%
Cap and trade (tax cuts)	4%	38%	46%	13%	0%	8%	69%	23%
Emissions intensity scheme	3%	38%	47%	13%	0%	8%	68%	24%

Note: Rows may not sum up to 100 due to rounding. 'Other low emission' is gas CCS and nuclear (coal CCS was available but not deployed in any scenario).

Source: Jacobs 2016d.

Economy-wide modelling results

Electricity demand

Electricity demand is higher in the emissions intensity scenario than the two cap and trade scenarios (Figure 34). This is because electricity prices are lower in the emissions intensity scenario, particularly in the early years of the scheme when the emissions intensity target is higher. Electricity demand is slightly higher in the cap and trade (tax cuts) scenario than the cap and trade (lump sum) scenario because tax cuts stimulate economic activity, and therefore increase electricity demand. Other policies to promote energy efficiency could be put in place to realise the demand-side emissions reductions.

Figure 34 Change in electricity demand, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050



Source: Adams 2016.

Emissions

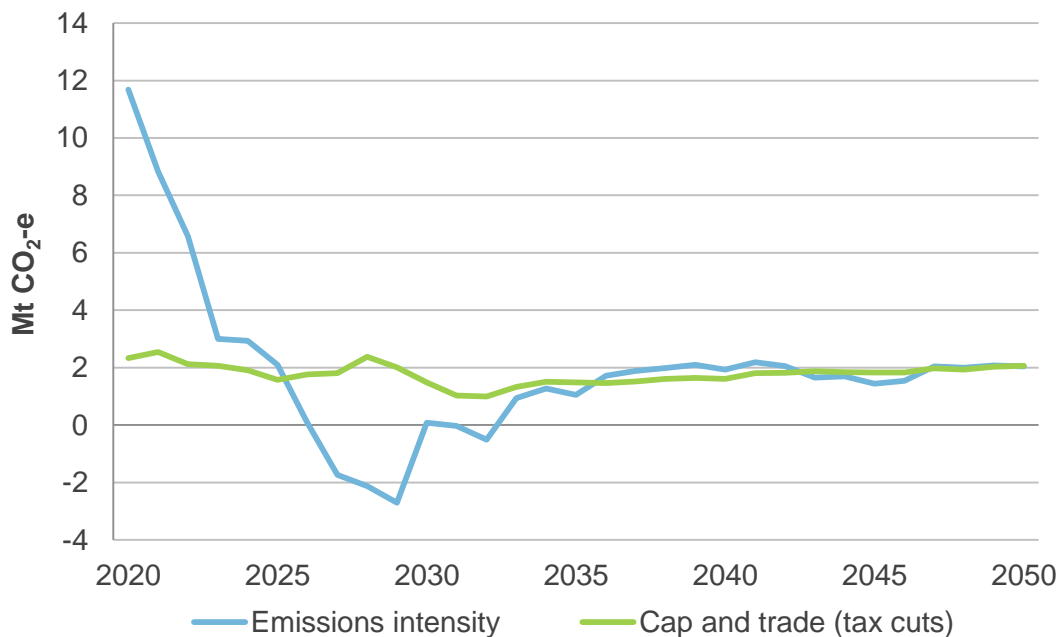
Higher electricity demand results in generally higher Australian emissions in the emissions intensity and the cap and trade (tax cuts) scenarios than in the cap and trade (lump sum) scenario (Figure 35).

Emissions grow both due to higher electricity demand and due to increased output in a range of energy and emissions-intensive sectors. Emissions under the emissions intensity scenario briefly fall below the cap and trade (lump sum) scenario as the higher electricity demand in that scenario brings forward investment in new low-emissions generators, but this effect is only temporary. As is discussed above, differences in domestic emissions between scenarios are offset by changes in purchases of international permits or credits to achieve a common net national emissions budget across all three scenarios.

Personal and company income tax rates

Personal and company income tax rates in the emissions intensity and cap and trade (lump sum) scenarios are held constant from 2020 to 2050. The cap and trade (tax cuts) scenario uses all revenue raised by selling permits to electricity generators to apply equivalent percentage cuts to both personal and company income taxes (Figure 36).

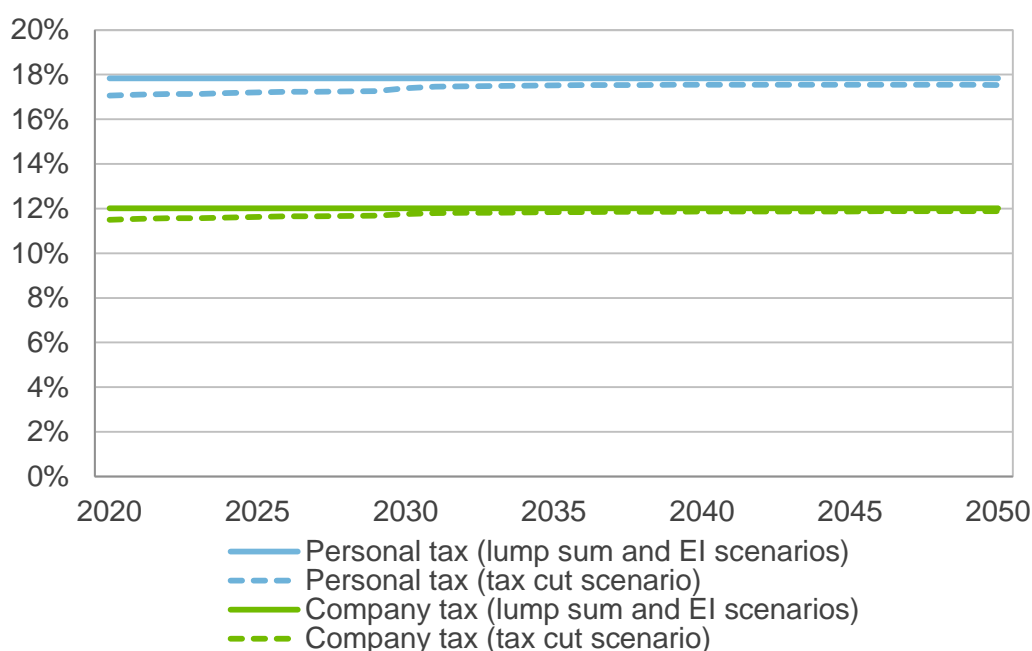
Figure 35 Change in Australian domestic emissions, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050



Note: Net national emissions are constant between scenarios. Therefore this chart could also be interpreted as showing differences in purchases of international permits or credits relative to the cap and trade (lump sum) scenario.

Source: Adams 2016.

Figure 36 Personal and company income tax rates by scenario, economy-wide modelling



Note: Personal income tax is represented in the modelling as a single flat rate, as shown, rather than as a tiered system as occurs in practice. The company tax rates shown are effective rates on the total capital base, and differs from the statutory company tax rate due to differences between the taxable and the actual capital base (for example, due to depreciation or other deductions).

Source: Adams 2016.

Economy-wide effects

The Authority has primarily used gross national income (GNI) to assess the cost effectiveness of different policy options, as GNI is a better (albeit imperfect) measure of Australia’s economic welfare than gross domestic product (GDP). Unlike GDP, GNI excludes income accruing to foreign residents, and takes into account changes in Australians’ purchasing power due to changes in the terms of trade, and so better depicts the potential living standard of Australians.

Table 12 summarises the overall cost effectiveness of three policy options modelled. These results show that:

- The relative performance of cap and trade and emissions intensity schemes depends on how revenue from the cap and trade scheme is recycled. A cap and trade scheme with all revenue recycled through tax cuts is likely to be somewhat more cost-effective than an emissions intensity scheme, while a cap and trade scheme with lump sum revenue recycling is likely to be the least cost-effective of the three.
- An emissions intensity scheme reduces tax interaction effects relative to a cap and trade scheme. Compared to the cap and trade (lump sum) scenario, an emissions intensity scheme can increase GNI by around 0.15 per cent over 2020–2050 by muting the impact on electricity prices relative to a cap and trade scheme, which in turn stimulates investment and activity in a range of electricity-using sectors.

- Recycling revenue through tax cuts delivers benefits, as is illustrated by comparing the two cap and trade scenarios. Recycling revenue through tax cuts can increase GNI by around 0.33 per cent over 2020–2050 relative to doing so through lump sum payments. This occurs because tax cuts can increase economic output by increasing investment and employment, whereas lump sum payments do not.
- While large in absolute terms, the differences between the scenarios are small in the context of the overall economy.

Table 12 Projections of gross national income, economy-wide modelling, relative to cap and trade (lump sum), 2020–2050

Scenario	Unit	GNI in 2030	GNI in 2050	Cumulative discounted GNI, 2020–2030	Cumulative discounted GNI, 2020–2050
Emissions intensity scheme, absolute change	\$bn	\$3	\$7	\$20	\$45
Emissions intensity scheme, percentage change	%	0.13%	0.18%	0.14%	0.15%
Cap and trade (tax cuts), absolute change	\$bn	\$5	\$13	\$51	\$97
Cap and trade (tax cuts), percentage change	%	0.25%	0.36%	0.35%	0.33%

Note: Cumulative discounted gross national income is calculated using a seven per cent discount rate.

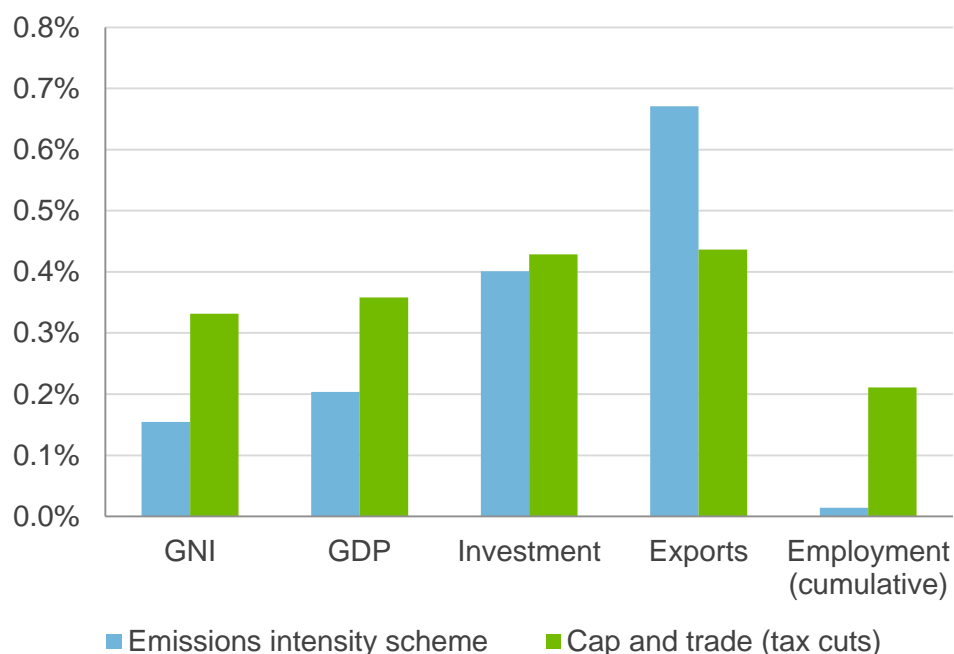
Source: Climate Change Authority based on Adams 2016 and Jacobs 2016d.

Figure 37 compares the three scenarios on a range of economic metrics. This figure shows that both an emissions intensity scheme and a cap and trade scheme that recycles revenue through tax cuts will increase economic output (as measured by GNI or GDP), investment, exports and employment relative to a cap and trade scheme with lump sum recycling. While using carbon revenue to cut taxes improves economic output and employment more than an emissions intensity scheme, investment outcomes are broadly similar and an emissions intensity scheme has a greater effect on exports.

GNI and GDP are higher under the cap and trade (tax cuts) scenario than the emissions intensity scenario. The difference in GNI results between these two scenarios is slightly larger than the difference in the GDP results. This is for two main reasons:

- Higher domestic emissions under the emissions intensity scenario mean more international permits or credits are required to meet the same net national emissions target. These purchases are netted out of GNI but not GDP. This effect reduces GNI under the emissions intensity scenario but has a negligible effect under the cap and trade (tax cuts) scenario.
- Australia’s terms of trade (the ratio of export to import prices) is generally slightly lower under the emissions intensity scenario than the cap and trade (tax cuts) scenario. This is because Australia exports more under the emissions intensity scenario. Australia’s increased export volume increases supply of electricity intensive goods in the international market, marginally reducing their price and therefore the terms of trade.

Figure 37 Percentage change in various economic metrics, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050



Note: GNI, GDP, investment and exports are calculated as a present value over the period 2020 to 2050, using a seven per cent discount rate. Employment is a cumulative undiscounted figure over the period 2020 to 2050.

Source: Climate Change Authority based on Adams 2016 and Jacobs 2016d.

Sectoral effects

An emissions intensity scheme and recycling cap and trade revenue through tax cuts represent two different ways of increasing economic output relative to a cap and trade scheme with lump sum recycling. An emissions intensity scheme increases economic output by reducing electricity prices, which increases production of a range of goods and services, particularly electricity-intensive goods and services. Alternatively, using carbon revenue to cut taxes on labour and capital makes it cheaper to employ these factors of production, and so stimulates economic output.

These differing approaches have different effects on sectoral output. This can be seen by comparing the change in sectoral gross value added (GVA) in each economic sector modelled in VURM under these two scenarios relative to the cap and trade (lump sum) scenario (Table 13). This comparison illustrates that 22 out of the 70 sectors depicted contract relative to the cap and trade (lump sum) scenario in the emissions intensity scenario, compared to only four under the cap and trade (tax cuts) scenario.²³ This result reflects the fact that capital and labour are used in more similar proportions across economic sectors than electricity, and so cutting labour and company taxes gives a more evenly distributed stimulus than does reducing electricity prices.

²³ Seventy-two economic sectors are modelled in VURM. In this analysis the uranium processing and nuclear waste sectors are ignored because they are extremely small.

Table 13 Change in sectoral gross value added, economy-wide modelling, relative to cap and trade (lump sum) scenario, 2020–2050

VURM Sector	Share of total sectoral GVA (cap and trade (lump sum) scenario)	Change in GVA – emissions intensity scenario	Change in GVA – cap and trade (tax cuts) scenario
1 SheepCattle	0.4%	0.06%	0.21%
2 DairyCattle	0.1%	0.06%	0.21%
3 OtherAnimals	0.2%	0.05%	0.21%
4 Crops	0.3%	-0.07%	0.17%
5 OtherAg	0.8%	-0.01%	0.20%
6 FishHuntTrap	0.1%	0.00%	0.27%
7 ForestryLogs	0.2%	0.00%	0.08%
8 AgSrv	0.2%	0.04%	0.22%
9 Coal	0.5%	1.69%	0.27%
10 Oil	0.5%	-0.01%	0.04%
11 GasLNG	0.6%	0.19%	0.17%
12 IronOre	2.2%	0.39%	0.35%
13 NonFeOres	1.8%	1.35%	0.38%
14 NonMetMins	0.2%	0.49%	0.37%
15 MiningSrv	0.5%	0.92%	0.33%
16 MeatProds	0.4%	0.12%	0.23%
17 DairyProds	0.2%	0.08%	0.22%
18 OtherFood	0.9%	0.10%	0.25%
19 Beverages	0.6%	0.00%	0.31%
20 TCF	0.3%	0.02%	0.33%
21 WoodProds	0.3%	0.37%	0.36%
22 PulpPaper	0.3%	0.18%	0.30%
23 Printing	0.3%	0.03%	0.23%
24 RefineProd	0.3%	-0.02%	0.04%
25 Chemicals	0.9%	0.22%	0.32%
26 PlasticRub	0.5%	0.33%	0.33%
27 NonMetalMin	0.2%	0.20%	0.35%
28 CementLime	0.1%	0.23%	0.33%
29 IronSteel	0.3%	0.46%	0.19%
30 Aluminium	0.3%	0.75%	0.07%
31 OtherNonFeMt	0.6%	2.45%	0.33%
32 MetalProds	0.7%	0.35%	0.33%
33 MVPOtherTran	0.3%	0.77%	0.32%
34 OtherEquip	1.2%	0.99%	0.30%
35 OtherMan	0.3%	1.59%	0.33%
36 ElecCoal	0.0%	0.39%	0.33%
37 ElecGas	0.1%	2.30%	0.81%
38 ElecHydro	0.0%	-0.44%	0.18%
39 ElecOther	0.1%	-6.03%	-0.23%
40 ElecNuclear	0.0%	-17.60%	-1.27%
41 ElecSupply	0.4%	2.56%	0.17%
42 GasSupply	0.1%	0.06%	0.03%
43 WaterDrains	0.6%	0.01%	0.19%

VURM Sector	Share of total sectoral GVA (cap and trade (lump sum) scenario)	Change in GVA – emissions intensity scenario	Change in GVA – cap and trade (tax cuts) scenario
44 ResidCons	1.2%	-0.26%	0.53%
45 NonResidCons	2.6%	0.65%	0.19%
46 ConsSrv	3.1%	0.14%	0.31%
47 WholeTrade	5.5%	0.18%	0.28%
48 RetailTrade	3.6%	0.03%	0.25%
49 AccomFood	2.3%	-0.13%	0.40%
50 RoadFreight	1.4%	0.25%	0.25%
51 RoadPass	0.3%	0.12%	0.19%
52 RailFreight	0.3%	0.72%	0.30%
53 RailPass	0.2%	0.00%	0.17%
54 Pipeline	0.1%	0.15%	0.09%
55 WaterTrans	0.2%	0.52%	0.22%
56 AirTrans	3.0%	0.08%	0.24%
57 Commun	3.4%	0.01%	0.21%
58 Banking	5.4%	-0.12%	0.37%
59 Finance	4.1%	-0.09%	0.27%
60 Dwellings	8.6%	-0.19%	0.38%
61 BusinessSrv	14.6%	0.05%	0.27%
62 PubAdminReg	4.4%	-0.02%	-0.04%
63 Defence	0.8%	-0.01%	-0.09%
64 Education	5.0%	-0.22%	0.09%
65 HealthSrv	3.9%	-0.12%	0.07%
66 ResidCare	2.6%	-0.16%	0.09%
67 ArtsRecreate	1.4%	-0.17%	0.32%
68 Repairs	1.7%	0.09%	0.24%
69 OtherSrv	1.3%	-0.29%	0.41%
70 UranMining	0.0%	-0.11%	0.37%

Note: Sectoral gross value added (GVA) is calculated as a present value over the period 2020 to 2050, using a seven per cent discount rate. Seventy-two economic sectors are modelled in VURM. In this analysis the uranium processing and nuclear waste sectors are ignored because they are extremely small.

Source: Climate Change Authority based on Adams 2016.

GLOSSARY OF TERMS

Term	Acronym/ abbreviation	Explanation
as generated		Electricity demand that includes generator 'auxiliary loads' (the electricity required to generate electricity)
Australian Energy Market Commission	AEMC	The Australian Energy Market Commission is the statutory rule maker for energy markets and is the expert adviser for Commonwealth, and state and territory governments.
Australian Energy Market Operator	AEMO	The Australian Energy Market Operator was established in 2009 and is responsible for the planning for and operation of the National Electricity Market. In 2015 AEMO started to take over operation in the Western Australian Wholesale Electricity Market.
bagasse		The fibrous pulp material left over when sugar is squeezed for its juice. It can be used as a fuel for generation of electricity and heat.
baseload generator		A plant that generally operates when able, due to low variable operating costs. Baseload power may be non-intermittent (e.g. coal) or intermittent (e.g. wind).
capacity		A measure of power or demand at a point in time, typically measured in gigawatts (GW) or megawatts (MW). For an individual generator it measures the maximum amount of electricity that can be produced under nominated conditions.
carbon capture and storage	CCS	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	CO ₂ -e	A measure that quantifies different greenhouse gases in terms of the amount of carbon dioxide that would deliver the same global warming.
Climate Change Authority	the Authority	Established on 1 July 2012, the Climate Change Authority provides independent expert advice on Australian Government climate change mitigation initiatives.
contracts for difference	CFD	A type of technology pull policy for encouraging new zero- or low-emissions generation. Government sets a required quantity of new low- or zero-emissions generation. Low-emission generators bid for long-term 'contracts for difference' with the government which partially or fully specify the price per MWh received by generators.
combined-cycle gas turbine	CCGT	A type of gas-fired power plant. Combined-cycle technology uses both gas and steam turbine cycles in a single plant to produce electricity with high conversion efficiencies and low emissions. Combined-cycle gas turbines have higher capital costs than open-cycle gas turbines but are more efficient so have lower fuel costs.
computable general equilibrium	CGE	A form of economic modelling that captures how economic changes flow through an entire economy, given interlinkages between economic sectors and regions. These models seek a 'general equilibrium' where supply and demand are in balance in each economic sector at the prevailing price.
cost of abatement		The cost per unit of emissions reduced. The cost of abatement is a measure of the overall cost effectiveness of a policy in reducing emissions. It is calculated by dividing the costs of meeting the policy by the emissions reductions achieved by the policy.

Term	Acronym/ abbreviation	Explanation
direct costs		The additional costs in the sector above those that would have occurred in the absence of the policy, such as the added cost of investing in a low-emissions electricity generation plant rather than a high-emissions one. In this report these are measured by the 'resource cost' of the policy in the electricity sector, before considering its emissions reductions.
direct emissions		Greenhouse gas emissions arising directly from an activity rather than associated activities such as the production of inputs. For example, the direct emissions from electricity generation are those from the generation itself rather than (say) the transport of fuel to power stations.
discount rate		The rate at which future costs and benefits are discounted. For example, an annual discount rate of seven per cent means that a cost or benefit in one year will be valued seven per cent higher than the same cost or benefit incurred a year later.
discounting (see also 'present value')		Discounting is a standard method for adjusting the value of a cost or benefit in the future to a 'present value' that reflects how far into the future that cost or benefit will occur. Discounting reflects 'time preference' which is the general preference of people for benefits to be received earlier rather than later, and for costs to be incurred later rather than earlier.
distributed generator		A generating unit, such as rooftop PV, within the premises of a distribution network customer. Often used interchangeably with 'embedded generator' in general usage.
embedded generator		A generating unit connected to the distribution network, or connected to a distribution network customer.
emissions intensity		A measure of the amount of emissions associated with a unit of output; for example, emissions per unit of gross domestic product or electricity production.
fixed operating and maintenance costs		Business operating costs that are independent of the level of output produced.
generation		The amount of electrical energy produced or used over a period of time, typically measured in gigawatt hours (GWh) or megawatt hours (MWh).
gigawatt hours	GWh	A measure of electricity generation or use over a period of time (or energy). One GWh is equivalent to 1,000,000 kWh.
gross domestic product	GDP	A measure of total activity in an economy, such as a country or region. It reflects the total market value of all final goods and services produced in that economy.
gross national income (see also 'terms of trade')	GNI	An economic measure of total income earned by residents of an economy that reflects gross domestic product, the terms of trade and international income transfers.
gross profits		For a business, the difference between revenue and operating costs.
gross value added	GVA	A measure of the economic value created by an economic sector or region. It is equal to the gross value of the sector or region's output, minus the value of goods and services produced by other sectors that it uses as inputs (intermediate consumption).
Independent Market Operator	IMO	The entity that manages dispatch and planning in the South-West Interconnected System. In 2015 the IMO functions were taken over by AEMO.

Term	Acronym/ abbreviation	Explanation
indirect costs (see also 'tax interaction effect')		In addition to their direct costs, emissions reduction policies often involve indirect costs, including those due to interactions with the tax system ('tax interaction effects'). In some cases indirect costs can be reduced through recycling revenue raised by emissions reduction policies in way that improve economic efficiency.
indirect emissions		Greenhouse gas emissions arising from associated activities rather than the activity itself. For example, in the electricity sector indirect emissions from electricity supply would include those from transporting fuel to a power station.
Intergovernmental Panel on Climate Change	IPCC	Scientific intergovernmental body that produces reports that support the United Nations Framework Convention on Climate Change, which is the main international treaty on climate change.
intermittent generation		A generator whose output is not readily predictable within periods relevant for the market operator. Examples are solar generators, wave generators, wind turbine generators and hydro generators without any material storage capability. A non-intermittent generator is any generator that is not intermittent.
kilowatt hour	kWh	A measure of electricity generation or use over a period of time (or energy).
large-scale generator		A generating facility such as a coal-fired power plant or a wind generator, generally either directly settled in the electricity wholesale market and/or is centrally dispatched or monitored by the market operator. In this report this term is used as a general one for generators that are not distributed. In practice, some small generating facilities are dispatched by the market operator, and some large generators are distributed. However, giving a precise definition would unnecessarily complicate the term for the purposes of this report.
Large-scale Renewable Energy Target	LRET	Commonwealth policy that creates a financial incentive for the establishment or expansion of renewable energy power stations, such as wind and solar farms or hydroelectric power stations.
low emissions target	LET	A type of technology pull policy that creates a market for additional zero or low-emissions electricity that supports investment in new zero- or low-emissions capacity. Eligible generators get certificates to sell (scaled in line with their emissions intensity), which electricity retailers buy to meet their target obligations. Trade in certificates determines their price, which subsidises new low-emissions generation.
lump sum		Lump sum payments are government payments such as pensions. While they return government revenue to households, resulting in an increase in consumption, they have a minimal effect on economic efficiency.
market mechanisms		In this report, 'market mechanisms' refers to policies which use markets to change the relative price of goods and services in proportion to their emissions intensity. Examples include cap and trade schemes, emissions intensity schemes and carbon taxes.
megawatt	MW	A measure of power (or demand).
megawatt hour	MWh	A measure of electricity generation/use over a period of time (or energy). One MWh is equivalent to 1,000 kWh.
National Electricity Market	NEM	The National Electricity Market interconnects five regional market jurisdictions (Queensland, New South Wales, Victoria, South Australia and Tasmania). Western Australia and the Northern Territory are not connected to the National Electricity Market.
net national emissions		National greenhouse gas emissions net of purchases or sales of international permits or credits.
net present value (see also 'discounting' and 'present value')	NPV	Net present value is a standard method for using the time value of money, or 'discounting', to compare the present value of future costs and future benefits.

Term	Acronym/ abbreviation	Explanation
open-cycle gas turbines	OCGT	A type of gas-fired power plant. Open-cycle technology uses gas turbine cycles in a single plant to produce electricity. Open-cycle gas turbines have lower capital costs than combined-cycle gas turbines and are very quick to start but have lower efficiency, so these generators typically operate in a peaking role.
operational demand		All electricity demanded by residential, commercial and industrial consumers, from the electricity grid, including distribution and transmission losses and 'auxiliary loads' (the electricity required to generate electricity).
peak demand		The maximum level of demand in a period of time.
peaking generator		A generator whose marginal or opportunity costs are higher than baseload generators and is therefore dispatched infrequently. In Australia, open-cycle gas turbines and limited-storage hydro generators typically operate in a peaking role.
present value (see also 'discounting', and 'net present value')		Present value is a standard method for using the time value of money, or 'discounting', to estimate future costs or future benefits. It adjusts the value of a cost or benefit in the future to a 'present value' that reflects how far into the future that cost or benefit will occur.
regulatory policies		General term for the regulated closures and absolute baselines policy scenarios.
reliability		The power system's ability to continue supplying sufficient power to satisfy customer demand.
renewable energy target	RET	A type of technology pull policy that creates a market for additional renewable electricity that supports investment in new renewable capacity. Eligible generators get certificates to sell, which electricity retailers buy to meet their target obligations. Trade in certificates determines their price, which subsidises new renewable generation. The current Commonwealth RET is specific example of this general policy type. It operates in two parts—the Small-scale Renewable Energy Scheme and the Large-scale Renewable Energy Target.
resource costs		The resource cost of a policy is a measure of its direct cost to society as a whole. It is generally measured relative to the situation without the policy. That is, it measures the net additional costs above those that would have occurred in the absence of a policy, before accounting for indirect costs, and before considering the benefit of emissions reductions achieved by the policy. In the electricity sector, resource costs of a policy include the present value relative to the situation without the policy of: fuel costs, operational expenditure, capital expenditure and retirement costs, adjusted for any reductions in electricity demand due to the policy.
retail price		The price of electricity that consumers pay. The retail price includes the cost of electricity generation, networks and retail businesses.
revenue recycling		Refers to how governments use any revenue raised by emissions reduction policies.
security of supply		The power system's ability to continue operating within defined technical limits even if a major power system element, such as a generator or interconnector, fails.
Small-scale Renewable Energy Scheme	SRES	Commonwealth policy that supports the installation of small-scale systems, including solar photovoltaic systems, solar water heaters, and small generation units.
solar photovoltaic	PV	A method of generating electricity by converting the sun's energy into electricity.
South-West Interconnected System	SWIS	The main Western Australian electricity grid, supplying the majority of electricity for the south-west region. It covers the region between Albany in the south, Kalbarri in the north and Kalgoorlie in the east.

Term	Acronym/ abbreviation	Explanation
tax interaction effect		The magnification of lost economic value due to emissions reduction policies being imposed as well as existing taxes.
technology pull policies		General name for policies such as renewable energy targets, low emissions targets and contracts for difference that encourage the deployment of additional renewable and/or low-emissions generation.
terms of trade		The ratio of the price of a country's exports to the price of its imports. It is typically expressed as an index.
total factor productivity		The efficiency with which labour and capital are used within an economy.
underlying demand		All electricity demanded by residential, commercial and industrial consumers whether or not from the electricity grid. Includes demand met by distributed generation including rooftop PV.
variable operating and maintenance costs		Costs incurred in the day-to-day operations and maintenance of business that are determined by the level of output produced. For example, for a fossil-fuel generator, fuel costs are a variable operating cost.
volume weighted prices		Prices weighted by the volume of electricity generation. In this report, the volume weighted price is the average NEM and WEM price derived by weighting each regional price by the ratio of each regions energy demand to total demand.
weighted average cost of capital	WACC	The average rate a business pays to finance its assets.
Western Australian wholesale electricity market	WEM	The WEM is the wholesale electricity market that supplies electricity to the South-West Interconnected System covering south-western Western Australia.
wholesale price		The price of electricity in the wholesale market.

ABBREVIATIONS AND ACRONYMS

ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
APGT	Australian Power Generation Technology report
ASX	Australian Stock Exchange
CO₂	carbon dioxide, a greenhouse gas
CO₂-e	carbon dioxide equivalent
CCA	Climate Change Authority
CCGT	combined-cycle gas turbines
CCS	carbon capture and storage
CGE	computable general equilibrium
COAG	Council of Australian Governments
CPRS	Carbon Pollution Reduction Scheme
CSIRO	Commonwealth Scientific Industrial and Research Organisation
DEDJTR	Department of Economic Development, Jobs, Transport and Resources
DIIS	Department of Industry, Innovation and Science
DIS	Department of Industry and Science
DoE	Department of the Environment
DRET	Department of Resources, Energy and Tourism
EI	emissions intensity
EITE	emissions-intensive trade-exposed

EITEI	emissions-intensive trade-exposed industries
ENA	Energy Networks Association
ERF	Emissions Reduction Fund
ETS	emissions trading scheme
EU	European Union
EY	Ernst & Young
GDP	gross domestic product
GNI	gross national income
GWh	gigawatt hours
IEA	International Energy Agency
IMO	Independent Market Operator
IPCC	Intergovernmental Panel on Climate Change
LET	low emissions target
LRET	Large-scale Renewable Energy Target
MWh	megawatt hours
NEM	National Electricity Market
NPV	net present value
NSW	New South Wales
OCGT	open-cycle gas turbines
OECD	Organisation for Economic Cooperation and Development
PV	photovoltaic
RET	Renewable Energy Target
SME	small and medium enterprise
SRES	Small-scale Renewable Energy Scheme
SWIS	South-West Interconnected System
TCI	The Climate Institute

UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
VURM	Victoria University Regional Model
WACC	Weighted average cost of capital
WEM	Wholesale Electricity Market

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