



Australian Government
Climate Change Authority

PROSPERING IN A LOW-EMISSIONS WORLD: AN UPDATED CLIMATE POLICY TOOLKIT FOR AUSTRALIA

MARCH 2020



Published by the Climate Change Authority

www.climatechangeauthority.gov.au

© Commonwealth of Australia 2020

This work is licensed under the Creative Commons Attribution 3.0 Australia Licence. To view a copy of this license, visit <http://creativecommons.org/licenses/by/3.0/au>

The Climate Change Authority asserts the right to be recognised as author of the original material in the following manner:



© Commonwealth of Australia (Climate Change Authority) 2020.

IMPORTANT NOTICE – PLEASE READ

This document is produced for general information only and does not represent a statement of the policy of the Commonwealth of Australia. The Commonwealth of Australia and all persons acting for the Commonwealth preparing this report accept no liability for the accuracy of or inferences from the material contained in this publication, or for any action as a result of any person's or group's interpretations, deductions, conclusions or actions in relying on this material.

ACKNOWLEDGEMENTS

The Climate Change Authority would like to thank the many individuals and organisations who contributed time and expertise to this report, including those who provided submissions and participated in consultation. These contributions have improved the quality of the report and provided evidence to help inform the Authority's recommendations.

A number of government departments and public agencies provided technical expertise to the Authority in its preparation of this report. They include the Department of the Environment and Energy, the Department of Agriculture and Water Resources, the Clean Energy Regulator, the Commonwealth Science and Industrial Research Organisation, the Department of Foreign Affairs and Trade, the Department of Industry, Innovation and Science, the Department of Infrastructure, Cities and Regional Development, the Australian Energy Market Commission, the Reserve Bank of Australia and the Clean Energy Finance Corporation. The views expressed in this report are the Authority's own and should not be taken as the views or positions of any of the departments or agencies listed above.

CONTENTS

ACKNOWLEDGEMENTS.....	II
CHAIR'S FOREWORD	1
EXECUTIVE SUMMARY	3
LIST OF RECOMMENDATIONS.....	9
1. INTRODUCTION	15
1.1. The challenges and opportunities of transitioning to a low-emissions economy	15
1.2. The Climate Change Authority.....	15
1.3. This report	16
1.4. Structure of this report.....	17
2. CLIMATE CHANGE IN AUSTRALIA	18
2.1. What is the climate change problem?.....	18
2.2. Climate change is already happening in Australia.....	19
2.3. Every half degree matters.....	22
2.4. Economic, environmental and social costs of climate change	23
3. GLOBAL RESPONSE TO CLIMATE CHANGE	27
3.1. Global agreements.....	27
3.2. National responses	28
3.3. Responses by other entities.....	29
4. AUSTRALIAN CONTEXT.....	32
4.1. Australia's emissions profile.....	32
4.2. Australia's emissions targets	36
4.3. Climate action in Australia	39
5. THE POLICY RESPONSE	44
5.1. The case for government action	44
5.2. A policy toolkit	45
5.3. The need for an update.....	48
6. TRANSITIONING AUSTRALIA TO A LOW-EMISSIONS FUTURE.....	51
6.1. Looking beyond 2030.....	51
6.2. Advancing Australia's economic transition through a long-term strategy.....	52
6.3. Intergovernmental policy coordination and support.....	54
6.4. Opportunities for Australia in moving to a low-emissions economy	55
6.5. Helping regional communities transition to a low-emissions economy	57
6.6. Meeting Australia's 2030 target with new emissions reductions	60

6.7.	International collaboration	61
7.	PREPARING FOR A CHANGING CLIMATE	65
7.1.	Responsibilities of different levels of government	66
7.2.	Building resilience to climate change impacts	66
7.3.	Current policies	68
7.4.	Opportunities for enhancing our preparedness	71
8.	ELECTRICITY	74
8.1.	Current policies	75
8.2.	The Authority's previous advice	75
8.3.	Significant changes since 2016	75
8.4.	The outlook for low-emissions electricity	79
8.5.	Policies to support the transition	80
9.	INDUSTRY.....	89
9.1.	Current policies	90
9.2.	The Authority's previous advice	91
9.3.	Significant changes since 2016	92
9.4.	Opportunities for emission reductions	92
10.	TRANSPORT.....	98
10.1.	Achieving emissions reductions in the transport sector	99
10.2.	Current policies	100
10.3.	The Authority's previous advice	101
10.4.	Significant changes since 2016	101
10.5.	Opportunities for emission reductions	102
11.	AGRICULTURE AND LAND.....	111
11.1.	Emissions and removals of greenhouse gases	111
11.2.	Current policies	113
11.3.	The Authority's previous advice	113
11.4.	Significant changes since 2016	114
11.5.	The role of the Emissions Reduction Fund.....	116
11.6.	Markets for low-emissions and carbon neutral products	118
11.7.	Research, development and extension	119
11.8.	Innovative finance to unlock investment.....	120
11.9.	Enhancing preparedness for climate change impacts.....	121
11.10.	Land use regulations are important	122
11.11.	Supporting forestry and sustainable use of wood.....	123

12. WASTE	124
12.1. Strategies for emissions reductions through waste management.....	124
12.2. Current policies	124
12.3. The Authority's previous advice.....	125
12.4. Significant changes since 2016	125
12.5. Opportunities for emissions reductions.....	126
13. ENERGY EFFICIENCY	130
13.1. Barriers to improving energy efficiency.....	131
13.2. Current policies	132
13.3. The Authority's previous advice.....	135
13.4. Significant changes since 2016	135
13.5. Opportunities for improvements in energy efficiency.....	136
14. RESEARCH AND DEVELOPMENT, INNOVATION AND TECHNOLOGY.....	142
14.1. Identifying needs for research, development and deployment.....	143
14.2. Current policies	144
14.3. Significant changes since 2016	145
14.4. Opportunities for climate change RD&D	147
15. FINANCE AND INVESTMENT.....	150
15.1. The role of finance and investment in emissions reduction.....	150
15.2. Pricing climate-related financial risk	151
15.3. Supporting increased investment flows of green finance	157
APPENDIX A. PUBLIC CONSULTATION	160
APPENDIX B. OPERATION OF THE EMISSIONS REDUCTION FUND.....	163
APPENDIX C. GOVERNMENT ELECTRICITY MARKET INITIATIVES.....	167
APPENDIX D. COSTS AND BENEFITS OF RECOMMENDATIONS	170
GLOSSARY	187
TABLE OF ABBREVIATIONS AND ACRONYMS	189
REFERENCES	192

FIGURES

Figure 1.	Australia's average annual temperature relative to the 1861–1990 period	20
Figure 2.	Frequency of extreme heat events in Australia, 1910–2018.....	21
Figure 3.	Australia's emissions by sector, 2005–2019	33
Figure 4.	Share of global emissions by country, 2016	35
Figure 5.	Australia's historical and projected emissions by source, 2005–2030.....	36
Figure 6.	Australia's emissions targets and budgets	37
Figure 7.	Solar PV module prices, 1976–2019.....	49
Figure 8.	Emissions from industrial emitters, 1990–2017	90
Figure 9.	Transport emissions by subsector, 2017.....	99
Figure 10.	Emissions from agriculture, 2017	112
Figure 11.	Expenditure on research and development by sector, 2009–2018	146

TABLES

Table 1.	Current Nationally Determined Contributions and emissions data	29
Table 2.	Breakdown of Australia's emissions by source, 2019	33
Table 3.	Emissions in selected countries and regions, 2016	34
Table 4.	State and territory emission reduction targets (converted to a 2005 base year)	42
Table 5.	State and territory renewable energy targets up to 2030.....	78
Table 6.	New light vehicle emissions performance or standard.....	103
Table 7.	Previous Climate Change Authority policy recommendations for the agriculture and land sector and the Emissions Reduction Fund.....	114
Table 8.	Issues with Emissions Reduction Fund administration or methods.....	165
Table 9.	Analysing the recommendations' outcomes.....	170

BOXES

Box 1	How do emissions cause climate change?	19
Box 2	Changing bushfire seasons	22
Box 3	Non-linear impacts and tipping points	23
Box 4	Evolution of the long-term targets	28
Box 5	Budget approach to emissions targets	38
Box 6	The Safeguard Mechanism	40
Box 7	The Emissions Reduction Fund.....	41
Box 8	Communities transitioning from coal-fired power	59

Box 9	Preparing for a changing climate.....	68
Box 10	State and territory renewable energy targets	78
Box 11	Australian minerals to power electric vehicles	108
Box 12	CSIRO's Australian National Outlook 2019 and carbon sequestration.....	115
Box 13	Australian canola must be low-emissions to meet European Union market regulations...	119
Box 14	Building measurement and reporting capability	120
Box 15	State and territory energy efficiency schemes	135
Box 16	Climate scenario analysis in Australian agriculture.....	153
Box 17	Investor pressure to disclose climate-related risk and implement transition strategies....	156

CHAIR'S FOREWORD

The Climate Change Authority (the Authority) is proud to release this report outlining how Australia can reduce greenhouse gas emissions to meet its 2030 Paris Agreement target and subsequent, more ambitious targets; and prosper in a world transitioning to global net zero emissions.

In 2016, the Authority released the final report of its Special Review, *Towards a climate policy toolkit: Special Review on Australia's climate goals and policies*. That report looked at the policy action Australia should take to implement the outcomes flowing from the historic Paris Agreement. Since then important developments have occurred in Australia and around the world. For example, international scientific bodies have provided us with a better understanding of the existing and likely negative impacts that continued global warming will have on our natural environment, economic systems and way of life. And the costs of low-emissions technologies, particularly in the energy sector, continued to fall rapidly.

Australians are already experiencing the effects of a variable and changing climate. 2019 was Australia's warmest and driest year on record—a key factor driving the past summer's extreme bushfire season. Australian families and communities have lost loved ones, homes and livelihoods, and millions more endured hazardous air quality. Much wildlife and many natural ecosystems have been devastated. This crisis is occurring during a record severe and prolonged drought.

Among developed countries, Australia is one of the most vulnerable to the impacts of climate change. In order to protect our health and wellbeing, and sustain our economic productivity and the natural systems that support us, Australia needs to participate in strong global action to reduce emissions. We need to position our economy for the coming changes in global trade and investment markets and do more to ensure we are prepared for future climate impacts that are unavoidable.

The good news is that global action to reduce climate change presents many opportunities for Australia. Our abundance of clean energy provides Australia with a natural advantage in a low-emissions future. As global demand for energy increases and countries move to lower emissions, there will be a growing demand for Australia's clean energy resources and low-emissions products. A lower emissions world has the potential to open up new areas of jobs and growth in Australia in diverse economic sectors such as sustainable agriculture, new green-tech industries, environmental and financial services and climate-resilient infrastructure to name a few. Emerging technologies, such as clean hydrogen, have the potential to generate opportunities in other sectors.

In this report, the Authority updates its previous policy toolkit on economy-wide opportunities to reduce emissions for Australia to meet its Paris Agreement commitments. The report presents 35 recommendations to help transition Australia to a low emissions future, building on the Government's current policy settings to drive down emissions in the transport, industrial, electricity, agriculture and land, and waste sectors. It also extends the analysis to position Australia for the global acceleration in emissions reductions that will be necessary to avoid the worst impacts of climate change and to increase our resilience and preparedness for a changing climate.

CHAIR'S FOREWORD

The Authority is firmly of the view that strong measures to tackle and prepare for climate change will enhance Australia's economic prosperity. However, the climate is changing at an increasing rate and countries around the world are responding. Australia must act now or risk being left behind. The case for moving quickly to reduce climate change, adopt measures to build our resilience and seize the new low-carbon opportunities before us has never been stronger.



Wendy Craik AM

Chair, Climate Change Authority

12 March 2020

EXECUTIVE SUMMARY

The impacts of climate change are being felt in Australia and around the world and are projected to intensify. Global action to reduce greenhouse gas emissions will need to accelerate if we are to ensure the safety of our communities, secure our health and wellbeing, and achieve positive outcomes for economic productivity and the natural environment. Many countries are increasing their climate action ambition, adopting net-zero emission targets and deploying long-term climate change strategies.

The necessary global transition to low-carbon emissions and the need for Australia to enhance our preparedness for future climate impacts present challenges but also great opportunities. We are a resource-rich trading nation with abundant clean energy resources. Our prosperity depends on continued access to overseas markets, which will increasingly favour low- and zero-emissions products and services.

The Climate Change Authority (the Authority) views Australian leadership on emissions reduction and climate resilience to be of strategic national interest and therefore recommends that the Australian Government pursue a comprehensive suite of policies that:

- incorporates new strategies, including the Government's proposed Technology Investment Roadmap, to optimise the transition of the Australian economy in a world moving to global net-zero emissions, improve our resilience to climate change and make the most of the opportunities that a low-carbon world will present to our economy
- positions us to meet our 2030 Paris Agreement target using emissions reductions achieved between 2021 and 2030 and to meet the subsequent, more ambitious targets that will necessarily follow
- supports businesses, governments, communities and families to develop, access and understand the technologies and information they need to reduce their emissions and build their preparedness for a changing climate.

The challenges and opportunities of transitioning to a low-emissions economy

Urgent global action is needed if we are to properly manage the risks to human health, natural ecosystems and economic productivity posed by human-induced climate change. Global warming has already reached 1.1°C above the pre-industrial level (the baseline adopted in the Paris Agreement). Across Australia, we are experiencing higher temperatures and coastal sea levels, more frequent and severe heatwaves and bushfire weather conditions, a longer bushfire season, and drier conditions across southern Australia.

Climate change is a global problem requiring leadership and action from the international community. Through the Paris Agreement, 188 countries including Australia agreed to hold the increase in the global average temperature to well below 2°C above pre-industrial levels, to pursue efforts to limit the temperature increase to 1.5°C and to achieve global net-zero emissions in the second half of this century. In pursuit of those goals, countries are expected to progressively strengthen their emissions reduction ambition every five years. The agreement also outlines a commitment to improve preparations for the impacts of climate change.

While the projected impacts and economic costs of unmitigated climate change continue to mount, the costs of action to reduce emissions are declining. National governments around the world are setting long-term emissions reduction targets to guide policy making and investment decisions. Regional and local governments are also taking action driven by price signals, as technology costs decline, and by community

demands. Businesses have started to consider, disclose and manage climate risks, motivated by a desire to meet the expectations of customers, investors, regulators and, increasingly, the courts.

Australia stands to prosper in a world with lower emissions. Our sun-drenched, windswept land has the potential to generate renewable energy at a world-leading rate. Our scientific institutions and highly educated workforce have changed the world for the better, as demonstrated through innovations like Wi-Fi, cochlear implants and advanced solar photovoltaic technologies. We have a strong reputation for clean, green produce—our beef, wine and dairy are renowned—and we have strong trade relationships worldwide. Our robust and stable institutions already make us an attractive destination for investors.

Our abundance of clean energy will give Australia a natural advantage in the global low-emissions economy. We could export clean energy through sub-sea cables and as hydrogen. We could produce energy-intensive goods like low-emissions steel and aluminium. We could become a hub for low- and zero-emissions manufacturing and processing, and for ‘green’ financial services, and there is long-term potential to export carbon offsets from the land. The potential for new jobs and flow-on benefits to regional communities is substantial.

The Authority is firmly of the view that strong measures to tackle and prepare for climate change will enhance Australia’s economic prosperity—it is not a case of sacrificing one for the other.

We need new strategies and frameworks to underpin our prosperity

As a small, open economy, Australia will feel the full force of the global transition to net-zero emissions. If we do not embrace and prepare for the transition—for example, to make the most of our clean energy advantage—we risk our economy being left behind and our prosperity declining.

The challenges are readily apparent. We already face competition as other countries race to transition their energy systems and establish new industries such as hydrogen. There is presently an uncertain long-term future for some industries, regions and communities that have come to rely on emissions-intensive businesses. The uneven pace of actions to reduce emissions around the world will raise competitiveness concerns for our emissions-intensive, trade-exposed industries, and our exports generally, as we seek to accelerate our own emissions reductions.

Our future prosperity will be best served by planning for and managing the impacts of the global transition. Policy action is required to support the development of new industries and to navigate the bumps along the way. A lumpy transition, such as the one that has emerged in the electricity sector, can be disruptive and expensive. Through anticipation and planning, such as for changing global demand, technological innovations and changing consumer preferences, we can realise our opportunities and insulate ourselves from unexpected shocks. The National Hydrogen Strategy agreed to by the Council of Australian Governments (COAG) Energy Council in November 2019 is a good example.

The Australian Government, by delivering on its commitment to develop a long-term climate change strategy, can provide a clear, long-term signal to businesses, investors and communities on the transition of the Australian economy in a world moving to a net-zero emissions. The strategy can also establish frameworks for future decisions on Paris Agreement targets and climate change policies and provide a foundation for addressing the implications of the transition for regions, communities and the disadvantaged.

The Government has indicated its long-term climate strategy will be underpinned by the forthcoming technology investment roadmap, which will aim to provide guidance to the public and private sectors on priority low-emissions technologies for the future and pathways for their efficient deployment. The roadmap could support the above-mentioned strategies by identifying emerging clean technologies that are aligned with our competitive advantages and have the potential to generate new economic opportunities for Australia’s regions and communities.

To ensure we make the most of the opportunities and manage the challenges, the long-term climate change strategy should incorporate or be complemented with:

- a trade and investment strategy that identifies and leverages our new competitive advantages in a global net-zero emissions world
- strategies and pathways for supporting regions and communities to position themselves for new and alternative economic opportunities
- efforts to support the further development of a green finance market in Australia and position our traded goods and services sectors to participate fully in low-emissions markets.

We can do more to reduce emissions

The Australian Government's initial Paris Agreement target is to achieve a 26 to 28 per cent reduction in emissions by 2030 compared with 2005 levels.¹ As noted above, more ambitious targets will be required in Australia and around the world over time to meet the goals of the Paris Agreement. Consequently, emissions reduction policies implemented today should be sufficiently flexible and scalable to deliver emissions reductions beyond those required for the 2030 target. There are many opportunities for governments, industries and households to do more to reduce emissions.

The electricity sector is already delivering significant reductions in emissions. It is well positioned to play a vital role in leading the Australian economy to a low-emissions future, given declining clean energy technology costs, the need to replace an ageing coal-fired generation fleet and significant opportunities to improve our energy efficiency. This also creates opportunities for emissions reductions in other sectors, such as in industrial processes and transport, through electrification.

State and territory renewable energy targets are likely to provide the main policy incentives for clean electricity projects beyond 2020, building on progress made under the Government's Renewable Energy Target. The National Electricity Market states should work closely with the Australia Energy Market Operator to ensure that the projects they support align with the priorities it has identified for delivering reliable, secure and affordable electricity. The COAG Energy Council should prioritise reforms to facilitate the integration of large amounts of low- and zero-emissions generation, energy storage and other technologies to 'firm up' intermittent renewables and demand-side response into the electricity market. Natural gas can still play a transitional role as a relatively low-emissions source of dispatchable electricity in the short to medium term, if current supply and price pressures can be alleviated. The economic life of natural gas generators can be extended beyond the time that they might otherwise be phased out for emissions reasons by modifying them to operate with hydrogen blended into the natural gas stream. Hydrogen has the potential to make other contributions to the electricity system including seasonal storage and load balancing.

The COAG Energy Council should also give the National Energy Productivity Plan greater ambition and resources to accelerate measures that reduce emissions, lower business costs, reduce energy bills and improve health outcomes for households. There are opportunities to enhance current approaches to residential and commercial buildings (existing and new construction), consumer appliances and business equipment. A national energy savings scheme would harmonise and extend the schemes currently operating in some states and territories.

¹ In setting its 2030 emissions reduction target, the Government advised it would use a carbon budget approach to track progress against the target. See Chapter 4 for more details.

In the transport sector, reconsideration of a greenhouse gas emissions standard for light vehicles would be worthwhile. Such a standard would help reduce emissions, address the recent trend towards less efficient vehicles and provide technology-neutral support for low-emissions vehicles such as electric vehicles, hybrids and hydrogen fuel cell vehicles. There is also compelling evidence that it would save motorists money and improve air quality in our cities.

The expected continued decline in electric vehicle costs and increases in range are likely to result in strong growth in uptake of electric vehicles in Australia during the 2020s and beyond. Hydrogen vehicles may also gain prominence, although they appear to be on a slower track. With these new technologies affecting the market, the government can play a role by ensuring a smooth transition. Its forthcoming electric vehicle strategy should ensure that vehicle charging infrastructure becomes widely available and consider the implications for fuel excise revenue and electricity network pricing as the share of electric vehicles in the passenger motor vehicle fleet rises.

In the industrial sector, fugitive emissions have been one of the primary sources of emissions growth in Australia in recent years driven by the rapid expansion in liquefied natural gas (LNG) production for export. This presents us with a challenge, given the benefits that flow to the Australian economy from these exports. The Safeguard Mechanism constrains growth in industrial emissions to an extent, but it is not designed to reduce them. The Safeguard Mechanism should be enhanced to ensure the industry sector plays its part in helping to meet our targets. It should incorporate declining emissions baselines for the largest emitters; targeted and transitional assistance for emissions-intensive, trade-exposed industries; and the ability to trade under- and over-achievement.

To ensure they meet their declining baselines, liable entities under an enhanced Safeguard Mechanism could take action to reduce their emissions, acquire Australian Carbon Credit Units (ACCUs) or offset their emissions using over-achievement from another entity or period. In the longer term, it might also be possible to incorporate limited use of high-quality international credits.

This approach would foster a deeper and more certain market for ACCUs generated via the Emissions Reduction Fund (ERF), which should retain a focus on offsets from the land and agricultural sector. ERF purchasing would continue in the meantime. A new Land and Environment Investment Fund would improve outcomes in the sector by investing in low-emissions and climate-smart agriculture—for example, by providing longer dated finance terms than are typically available but which are necessary for projects with relatively long payoff periods.

The Clean Energy Finance Corporation (CEFC) has proven to be successful in overcoming barriers to the flow of private finance into cutting-edge renewable energy, low-emissions and energy efficiency projects. Relaxing restrictions on the scope of its activities, its portfolio mix and the financial instruments through which it can invest will enable the CEFC to provide greater support for the transition to net-zero emissions across the economy where barriers to finance exist.

We can empower people to act

Beyond direct policy interventions, there are a range of ways governments can empower businesses, households, communities, non-government organisations (NGOs) and others to take action to reduce emissions, as well as help them better prepare for the changes in our climate that are already locked in. Governments in Australia could identify and remove remaining impediments to low-emissions activities; boost support for the research and development that is required to solve the difficult abatement challenges that remain across our economy; and help arm businesses, communities and consumers with better information to enhance their decision making when it comes to reducing emissions and managing the risks of a changing climate.

In the electricity sector, providing greater certainty on the timing of the retirement of coal-fired electricity stations will raise the prospects for timely investment in replacement, lower emissions generation capacity. It will also enhance planning support for local workforces. Fast-tracking reforms to energy market rules to better facilitate the integration of large amounts of low- and zero-emissions generation will ensure the significant investor appetite for the sector is not held back.

Advances in technology will be critical to a successful global response to climate change. In Australia, further research, development and deployment will help to maximise our contribution to global emissions reductions and realise the potential opportunities that the shift to a net-zero emissions global economy offers. There are emissions problems for which science and engineering have not yet identified solutions or where potential solutions have been identified but are still some way from being implemented at scale on a commercial basis.

There are several ways in which the government can boost its support for innovation. The Government has said its technology investment roadmap will aim to stimulate research and development and the early deployment of emerging clean technologies and track the progress of these technologies for reaching commerciality. The Government can also allocate new funding to the Australian Renewable Energy Agency and consider expanding its scope beyond renewable energy to energy efficiency and low-emissions technologies more generally. New funding can be made available for research on low-emissions agriculture and carbon farming, including basic research and applied research (such as new ERF methods), and the development of reporting tools. Research and development support could also be prioritised for new areas of potential comparative advantage in a decarbonising global economy and sectors with well-defined low-emissions goals, targets and pathways. This includes support for industries and sectors that have embraced the challenge and are driving emissions reductions but that require assistance in specific areas that they cannot address on their own.

The primary focus of this report is on the task of reducing greenhouse gas emissions and the implications and opportunities for Australia of a decarbonising global economy. However, the Authority acknowledges the importance of enhancing Australia's resilience and preparedness for the expected changes in our climate. There is a view among many of the people consulted for this report that Australia should be doing more to prepare for the impacts of climate change that lie ahead. While there is a broad awareness of some of the likely current and future impacts, understanding of the risks and what can be done to better prepare for them can be improved.

Such matters are an integral part of climate change policy and increasingly of national economic significance as the frequency and severity of climate-related events increase.

The Australian Government has recently commenced two significant processes aimed at building Australia's resilience to future climate change impacts: the recent establishment of a National Royal Commission into the 2019-20 unprecedented bushfire season; and a forthcoming report by the CSIRO, in partnership with an expert advisory panel chaired by Australia's Chief Scientist, to provide practical options for Australian governments to support and improve climate and disaster resilience. The resulting information from these processes should go a long way towards addressing the Authority's recommendations on preparedness and resilience. In particular the Authority has proposed an update of the National Climate Resilience and Adaptation Strategy, both to better communicate the range of initiatives the Government already has underway and to identify future priority actions to enhance Australia's readiness for climate impacts.

The Authority considers there is a strategic leadership role for the Government to play in ensuring businesses, communities and environmental managers have the high-quality, locally relevant climate change information they need to better assess and manage current and projected climate risk and impacts. Initiatives such as the Government's Future Drought Fund provide opportunities to roll out such support.

All levels of government have differentiated yet complementary responsibilities in preparing Australia for the current and future impacts of climate change. Coordinated action on climate resilience across levels of government will be crucial to ensuring Australia can manage the risks of climate impacts effectively. The terms of reference of both the bushfire royal commission and the CSIRO report, seek to investigate ways to strengthen coordination across levels of government.

There is no time like the present

This update to the Authority's 2016 *Towards a climate policy toolkit* report sets out a suite of policies to increase resilience in Australia and to position Australia to meet its commitments under the Paris Agreement—its 2030 targets and beyond. The toolkit also provides options to create and seize major opportunities that will arise for Australia in the global transition to net-zero emissions. Recommendations on the above issues and more are described in further detail in this report.

The case for moving quickly on the recommended policy toolkit is strong. Additional flexible and scalable policies are required to ensure we meet our 2030 emissions reduction target but, even more importantly, to put us on a trajectory for the emissions reductions required to contribute to the long-term goals of the Paris Agreement and avoid the worst impacts of climate change. As the Authority has stated previously, a delay in action is likely to come at a cost.

Moreover, the climate is changing at an increasing rate and countries around the world are responding. We need to anticipate the likely consequences and prepare accordingly. This will help us to avoid sudden and unpalatable impacts on our economy. It will also help us to make the most of the opportunities that our strong institutions and natural endowments of clean energy and high-value mineral resources afford us. However, the world will not wait for us to do so. The work to be done in 2020 on the Government's long-term climate strategy presents an ideal vehicle for considering much of what the Authority has recommended in this report.

LIST OF RECOMMENDATIONS

CHAPTER 6. TRANSITIONING AUSTRALIA TO A LOW-EMISSIONS FUTURE

1. Develop a long-term climate change strategy that secures Australia's contribution to the achievement of the temperature goals of the Paris Agreement and ensures we make the most of the opportunities arising from the transition to a low-emissions global economy.
2. Include emission reductions and climate resilience as a standing item on the Council of Australian Governments (COAG) meeting agenda.
3. Develop a trade and investment strategy that identifies and leverages Australia's competitive advantages in a net-zero emissions world.
4. Governments should work together to support industries and communities facing an uncertain future to identify pathways for industries to evolve and remain competitive and to exploit new economic opportunities, including:
 - potential infrastructure requirements and supply chain logistics
 - assessment of vocational training needs for new low-emissions industries
 - exploration of opportunities for Indigenous communities
5. Aim to meet Australia's 2030 Paris Agreement target using emissions reductions achieved between 2021 and 2030.
6. Develop an international climate strategy to:
 - support a strong global response to climate change that minimises physical impacts on Australia and increases international demand for Australia's emerging low-emissions export industries
 - maximise the opportunities for Australia from international trade in emissions reductions, including by:
 - a. identifying potential carbon trade partners, prioritising developing countries in our region
 - b. supporting potential trade partners to build their capacity to deliver low-cost, high-integrity international units
 - c. defining the criteria for and identifying the international units considered to be 'high-integrity' and acceptable to Australia
 - d. establishing quotas on the import of international units to ensure Australia's domestic transition to a low-emissions economy continues
 - e. establishing a timeline for high-integrity international units to be permitted under the enhanced Safeguard Mechanism.

CHAPTER 7. PREPARING FOR A CHANGING CLIMATE

- 7 In consultation with state, territory and local governments, and drawing on the findings of the bushfire National Royal Commission and the forthcoming CSIRO report on climate resilience, review and update the 2015 National Climate Resilience and Adaptation Strategy to ensure a coordinated and integrated approach, with clear roles and accountabilities, to enhance Australia's climate resilience.
- 8 Fully integrate consideration of emissions and climate change risks in decision making about government programs, assets and services through frameworks such as the Climate Compass.
- 9 Implement the strategic actions in the National Climate Science Advisory Committee's *Climate science for Australia's future* report to get the most out of the Government's investment in climate science and ensure governments, businesses and communities have the information they need to respond to climate change risks.

CHAPTER 8. ELECTRICITY

- 10 To promote the reliable and secure supply of clean electricity at lowest cost for electricity consumers, National Electricity Market (NEM) jurisdictions should, in the design and implementation of their renewable energy policies:
 - emphasise renewable projects that align with the priorities identified by the Australian Energy Market Operator (AEMO) in its Electricity Statement of Opportunities and Integrated System Plan
 - consider supporting projects located outside of their respective jurisdictions where this will maximise benefits for their electricity consumers and the NEM generally
 - include electricity system security as a criterion in project selection processes, consult with AEMO for advice on security implications of proposed projects and consider supporting system strength remediation measures.
- 11 The COAG Energy Council should fast-track reforms to facilitate the integration of large amounts of low- and zero-emissions generation and related technologies into the electricity market, focusing on distributed energy resources, integration of storage and demand-side response and timely and efficient transmission and generation investment.
- 12 The Government's Underwriting New Generation Investments program and bilateral energy agreements with the states should further align with the priorities for generation and transmission identified in AEMOs Integrated System Plan and be supported by rigorous cost–benefit analysis to ensure efficient outcomes for electricity consumers.
- 13 Identify and implement measures for providing greater certainty on the timing of the retirement of ageing coal generators to facilitate timely investment in replacement capacity and storage and to enhance planning for measures to support local workforces and communities affected by closures.

CHAPTER 9. INDUSTRY

- 14 Enhance the Safeguard Mechanism to deliver emission reductions from large emitters in industry, with:
 - declining baselines with clear trajectories and the ability to trade under- and over-achievement once baselines have commenced declining and are binding

- targeted, transitional and transparent competitiveness assistance to emissions-intensive, trade-exposed industries captured by the enhanced Safeguard Mechanism where a demonstrated risk of carbon leakage exists.

15 Investigate how best to encourage smaller businesses to reduce emissions, including through assistance to participate in the Emissions Reduction Fund (ERF).

CHAPTER 10. TRANSPORT

16 Reconsider implementing a greenhouse gas emissions standard for light vehicles and undertake a cost-benefit analysis of an emissions standard for heavy vehicles.

17 The forthcoming electric vehicle strategy should aim to minimise barriers to electric vehicle uptake by:

- addressing standards for vehicles and charging infrastructure to ensure interoperability
- ensuring public electric vehicle infrastructure addresses barriers to uptake for those without access to private charging
- ensuring adequate infrastructure coverage on highways and in regional areas
- considering implications for electricity network tariff reform and fuel excise revenue
- incorporating information about electric vehicle ownership costs in the Green Vehicle Guide
- promoting the development of a used car market for electric vehicles, including through consideration of reduced import barriers for quality used electric vehicles
- setting targets for electric vehicle adoption in government fleets.

18 Investigate barriers to shifting freight transport from more emissions-intensive road to less emissions-intensive rail transport and how these can be overcome by Government.

CHAPTER 11. AGRICULTURE AND LAND

- 19 Land use and agriculture activities should continue to be covered by the ERF crediting mechanism, with credits continuing to be used as offsets for facilities covered by the Safeguard Mechanism and available for use in other (for example, voluntary) markets. The ERF purchasing mechanism should continue until an enhanced Safeguard Mechanism provides a source of demand for credits.
- 20 Undertake a review of green product standards and definitions being developed in export markets and engage with trade partners to ensure they do not unduly restrict market access for Australian agriculture.
- 21 Allocate additional funds for research on low-emissions agriculture and carbon farming, including possible new agricultural industries. This would include basic research, applied research (including on new ERF methods) and the development of tools to report on the emissions profile of agricultural activities.
- 22 Introduce a Land and Environment Investment Fund (that is, a Clean Energy Finance Corporation (CEFC) for the land) to invest in actions to support low-emissions and climate-smart agriculture and associated environmental services.
- 23 Investigate and implement the most effective incentives to encourage the use of emissions-reducing inputs in agricultural production systems.
- 24 Together with state and territory governments, continue to coordinate and integrate programs designed to increase mitigation, build resilience to drought and climate impacts, enhance biodiversity and provide benefits for Indigenous communities, including through interjurisdictional partnerships and program linkages.

CHAPTER 12. WASTE

- 25 Work with the states and territories to reduce landfill emissions by strengthening and harmonising regulations on methane emissions from landfill waste, diverting organic waste from landfill and fully implementing the National Food Waste Strategy.
- 26 Recognising the benefits of a circular economy approach for emissions reductions, ensure implementation of the National Waste Policy Action Plan considers industry development, the waste hierarchy, research and development needs, training requirements and barriers to adoption; and emphasises the creation of industries in regions undergoing transition.

CHAPTER 13. ENERGY EFFICIENCY

- 27 Working with the COAG Energy Council, reinvigorate the National Energy Productivity Plan, with enhanced ambition and additional resources, including by:

- implementing a National Energy Savings Scheme that builds on existing state and territory energy efficiency schemes
- accelerating implementation of the Independent Review of the Greenhouse and Energy Minimum Standards Act, strengthening existing performance standards and extending coverage to new categories of appliances and commercial equipment, such as hot water products and pumps, boilers and air compressors
- accelerating energy efficiency improvements for buildings in the National Construction Code via the Trajectory for Low Energy Buildings initiative

- developing a detailed action plan for improving the energy efficiency performance of existing commercial and residential buildings via the Addendum to the Trajectory for Low Energy Buildings initiative; and addressing energy efficiency improvements for vulnerable consumers.
- 28 In partnership with state and territory governments, design and deliver targeted programs to improve energy efficiency in priority groups, such as low-income households and small to medium businesses, through the provision of information, expertise and financial assistance (grants and tax incentives) where appropriate.
- 29 All governments should pursue energy efficiency improvements in government owned and leased buildings, undertake targeted retrofits and implement steadily rising minimum standards for public housing to improve the energy efficiency performance of the public housing stock.

CHAPTER 14. RESEARCH AND DEVELOPMENT, INNOVATION AND TECHNOLOGY

- 30 In developing and implementing the Technology Investment Roadmap:
- partner with industry and researchers to identify areas where research and development (R&D) support is needed to capitalise on areas of comparative advantage for Australia and to support strategic development of clean technology industries
 - continue to fund the Australian Renewable Energy Agency and consider expanding its remit into other sectors requiring R&D for low-emissions technology or practice
 - build on Australia's Mission Innovation commitment to double investment in clean technology over the five years to 2020 by undertaking to grow the level of investment further to 2030
 - support the development of negative emissions technologies, including R&D and methodology development for inclusion in the ERF
- 31 Target funding support for innovation in emissions reduction towards harder-to-abate and emissions-intensive, trade-exposed industries and towards industries with well-defined low-emissions goals, targets and pathways.
- 32 Expand the remit of the CEFC to allow it to invest in emissions reduction technologies in all sectors to help overcome barriers to finance. Restrictions on the scope of the CEFC's activities, its portfolio mix and the financial instruments it can use should be lifted. The Government should consider making further capital injections in the CEFC to fund this expansion.

CHAPTER 15. FINANCE AND INVESTMENT

33 Review the data that are necessary to enable industry, investors and business to understand and manage climate-related financial risk and develop and implement plans for addressing gaps and deficiencies in the data.

34 A joint taskforce of the Council of Financial Regulators should:

- develop standard reporting criteria to enhance the quality and usefulness of disclosures under the Taskforce on Climate-related Financial Disclosures framework. To support standardised reporting, the Government should develop standardised national climate scenarios aligned to the Paris Agreement temperature goals
- together with the major accounting bodies, examine the phasing-in and mandatory reporting of climate-related risks and mainstream climate-related disclosures in companies' audited financial statements

LIST OF RECOMMENDATIONS

- provide regulatory guidance to clarify the duties of institutional investors to consider climate-related risk.
- 35 To facilitate the development of Australia's green finance market and ensure Australian low-emissions industries, products and services are able to benefit from increased international green investment flows, the Australian Government should consider the recommendations of the Australian Sustainable Finance Initiative when the final report is published, and:
- participate in international initiatives developing global green economy rules and standards
 - collaborate with other jurisdictions to ensure alignment and convergence of emerging international classification systems for low-emissions technologies, assets and industries (low-emissions taxonomies) and to ensure Australia's low-emissions exports are defined and included
 - assist the finance and investment sector to develop standards and verification processes for green finance products and services, including through possible funding and endorsement.

1. INTRODUCTION

1.1. The challenges and opportunities of transitioning to a low-emissions economy

Climate change is a serious global challenge and poses major risks to the Australian community, economy and environment. Climate change impacts are already being observed in Australia and around the world. The faster the world acts to reduce emissions, and the better we manage the risks from climate change through adaptation measures, the less onerous the impacts of climate change will be.

Countries around the world are increasing their efforts to minimise greenhouse gas emissions associated with human activity. National governments have set their initial targets under the Paris Agreement and are implementing policies to reduce emissions. Investors, insurers, financial regulators, regional and local governments, businesses and consumers have begun to take account of climate risks and/or their contribution to the emissions problem. For example, increasingly, investors are directing capital toward sustainable investments, consumers are demanding products produced with minimal environmental impact, and businesses are seeking to meet the demands of investors and consumers by reducing their emissions footprint.

However, the transition to a low-emissions global economy is only just beginning. Global emissions are still increasing. Countries, including Australia, will need to do much more in this and coming decades if the goals of the Paris Agreement are to be met.

This presents risks and challenges for Australia, but these will be outweighed by the substantial opportunities on offer if we manage the transition well. A sustained, comprehensive policy response will ensure we make our contribution to reducing emissions and make the most of the opportunities that we can create or will come our way. Australia has the potential to be a leader in renewable energy production and exports, an exporter of sustainable products and knowledge and a hub for the growing sustainable finance market. These and other opportunities will support new industries and jobs in Australia while we take steps to manage impacts elsewhere in the economy.

The advice provided in this report is intended to help the Australian Government to manage this transition, fulfil its commitments under the Paris Agreement and position Australia to prosper in a low-emissions global economy.

1.2. The Climate Change Authority

The Climate Change Authority (the Authority) is an independent statutory agency established to provide expert advice to the Australian Government on climate change policy. The Authority does this by conducting statutory and specifically commissioned reviews and by undertaking independent research and analysis. The Authority is made up of a Chair, the Chief Scientist and up to seven other members. Further detail on the Climate Change Authority can be found at www.climatechangeauthority.gov.au.

The *Climate Change Authority Act 2011* (Cth) requires the Authority to have regard to the following principles when assessing the relative merits of emissions reduction policies:

- economic efficiency
- environmental effectiveness

- equity
- the public interest
- the impact on households, business, workers and communities
- support for the development of an effective global response to climate change
- consistency with Australia's foreign policy and trade objectives.

1.3. This report

This report updates the Authority's 2016 report, *Towards a climate policy toolkit: Special review on Australia's climate goals and policies* (the 2016 Special Review) on policies for meeting Australia's emissions reduction commitments under the Paris Agreement. Given developments in Australia and around the world in the economics and science of climate change, the Authority has undertaken independent research and analysis to review and update its earlier advice.

In developing this updated toolkit, the Authority has taken a long-term view to ensure policy options enable Australia to meet its 2030 targets and subsequent, more ambitious emissions reduction targets in line with the Paris Agreement. Importantly, the advice also takes account of the challenges and opportunities facing Australia as the world transitions to a low-emissions economy.

This report draws on previous internal research, further desktop research, analysis, and consultation with interested parties from industry, government and the non-profit sector. This includes three 'stocktake' reports released by the Authority in the first half of 2019 which examined:

- climate change policies at the Australian and state and territory government levels
- strategies other countries are using to achieve their emissions reduction goals
- actions being taken by industry to position for a carbon constrained future.

As was the case in 2016, in this report the Authority recommends a climate policy toolkit for Australia but does not give a complete blueprint for implementing each of the policies or provide detailed estimates of the abatement potential associated with each recommendation. The detailed policy design and implementation arrangements will need further work by government in consultation with stakeholders. This would include governance arrangements and appropriate legislative frameworks. These policy design elements will also fundamentally affect the abatement that each recommendation may lead to. The Authority is confident that its proposed measures, appropriately calibrated, would lead to emission reductions to more than meet current targets.

There are some matters which affect the delivery and outcomes of climate policy but are outside the scope of this review. These matters also warrant further consideration:

- support for vulnerable groups across Australia in the transition to a net-zero emissions economy, including those vulnerable to the impacts of climate change and to any climate policy induced price rises, those on low-incomes, Indigenous communities and regional communities
- planning permissions for large-scale, low-emissions project development—in particular, whether these create unnecessary barriers to approval
- consistency of current government policies with the policies recommended in the Authority's toolkit.

1.3.1. Public consultation

The Authority consulted widely as part of this research and thanks all individuals and organisations that took the time to share their expertise and knowledge.

In response to a consultation paper published in July 2019, the Authority received 67 written submissions (Appendix A). Submissions can be found at <http://climatechangeauthority.gov.au/submissions/submissions-received>.

The Authority also met with individuals from more than 50 organisations and heard from diverse groups including:

- industry organisations
- research bodies and non-government organisations
- Australian, state and territory and local government agencies
- businesses.

The Authority also considered submissions made in response to the stocktake reports on domestic and international mitigation action published earlier this year and other reviews completed since 2016.

1.4. Structure of this report

Chapters 2 to 5 of this report provide an update on climate change science and policy developments. They summarise the most recent, authoritative analysis of current and projected climate change impacts and progress on implementation of the Paris Agreement. They outline current emission levels and abatement that will be required to meet Australia's commitments made under the Paris Agreement. They also establish the purpose and objective of the advice in this report.

Chapter 6 explores how we can best position Australia to take advantage of the opportunities that will arise from the global shift to net-zero emissions, in the process managing the transitions risks that are likely to emerge from climate actions being pursued by governments, businesses and consumers around the world. Chapter 7 identifies how we can better prepare for the physical risks that climate change presents to our economy and communities.

Chapters 8 to 15 examine developments in each of the key sectors of the economy, including emissions and technology trends and current climate policies. They update the Authority's previous advice on opportunities for policy action to reduce emissions.

2. CLIMATE CHANGE IN AUSTRALIA

Australia is already experiencing increases in temperature and sea-level rise. Average surface air temperatures in Australia have warmed by approximately 1.4°C since 1910.

Climate change is also contributing to changing rainfall patterns, with a greater proportion of annual rainfall coming from heavy rain days and rainfall over parts of southern Australia having declined.

There is evidence that the lower the rise in global temperature, the lower the risks to humans and the natural environment. Strong action is necessary to limit emissions and increases in the Earth's temperature and prevent the impacts of climate change becoming increasingly severe. Warming of more than 2°C is modelled to lead to more frequent unprecedented high temperatures and greater risks to the way we live and to the natural world.

Australia needs to do two things to effectively address the risks posed by climate change. First, it needs to play a proactive role in coordinated international mitigation efforts; and, second, become better prepared for future climate impacts. Together, these will protect the resilience, health and wellbeing of Australians and sustain Australia's economic productivity and the natural systems that support us.

2.1. What is the climate change problem?

Climate change is the response of the Earth's climate system to human-induced emissions of carbon dioxide (CO₂) and other greenhouse gases, leading to higher concentrations of these gases in the atmosphere.

Human activities such as the burning of fossil fuels for energy, industrial processing, agricultural production and land clearing are causing climate change by increasing the concentrations of these greenhouse gases (UNEP and UNFCCC 2001).

In 2016 the CO₂ concentration in the atmosphere rose above 400 parts per million (ppm) and the concentrations of long-lived greenhouse gases reached 500 ppm carbon dioxide equivalent (CO₂-e) for the first time in at least 800,000 years (BoM and CSIRO 2018).² The rate of increase in CO₂ concentration since the year 2000 is about 10 times faster than any time in the past 800,000 years (IPCC 2018). These higher greenhouse gas concentrations are leading to higher temperatures and these in turn are driving further changes in the climate system (Box 1).

Globally, average temperature is over 1°C warmer than the period 1850 to 1900.³ Human-induced warming is responsible for essentially all of this change—with natural solar and volcanic contributions adding less than 0.1°C of either warming or cooling (IPCC 2018). Each decade since the 1960s has been warmer than the previous one and the last five years (2015–2019) have been the five warmest years on record (NASA 2020).

The increase in global temperature has already increased the frequency and/or severity of heatwaves, droughts, floods and some other extreme weather events, altered ecosystems and exacerbated biodiversity losses across the world (IPCC 2018, IPBES 2019).

Global sea levels have risen by over 20 centimetres since 1880 and the world's oceans are absorbing more CO₂, causing ocean acidification (BoM and CSIRO 2018).

² Pre-industrial concentrations of CO₂ in the atmosphere were around 280 ppm over the past 2,000 years and generally under 300 ppm for the previous 800,000 years (BoM and CSIRO 2018).

³ Average temperature refers to combined surface air and sea surface temperatures (IPCC 2018).

Box 1 How do emissions cause climate change?

The Earth is warmed by the sun and the atmosphere acts as a blanket, trapping some of the sun's energy and stopping it from being radiated back into space. This is the natural 'greenhouse effect'.

For centuries prior to industrialisation, incoming sunlight and outgoing radiation were in balance (BoM and CSIRO 2018). Since industrialisation, the increased levels of CO₂ and other greenhouse gases in the atmosphere have enhanced this greenhouse effect. The emitted gases trap more heat, causing the world to warm. This increased heat is also changing patterns of air and water movement in the atmosphere and oceans, leading to changes to rainfall and increasing the severity of heatwaves and some extreme weather events (Trenberth 2011; BoM and CSIRO 2018).

Because increased levels of CO₂ persist in the atmosphere for hundreds of years, even if all emissions resulting from human activity ceased today, the atmosphere and oceans will continue to warm until a new balance is reached. Further warming and sea-level rise is inevitable from the emissions already in the atmosphere, but past emissions alone are likely to contribute less than 0.5°C of additional warming (IPCC 2018; BoM and CSIRO 2018).

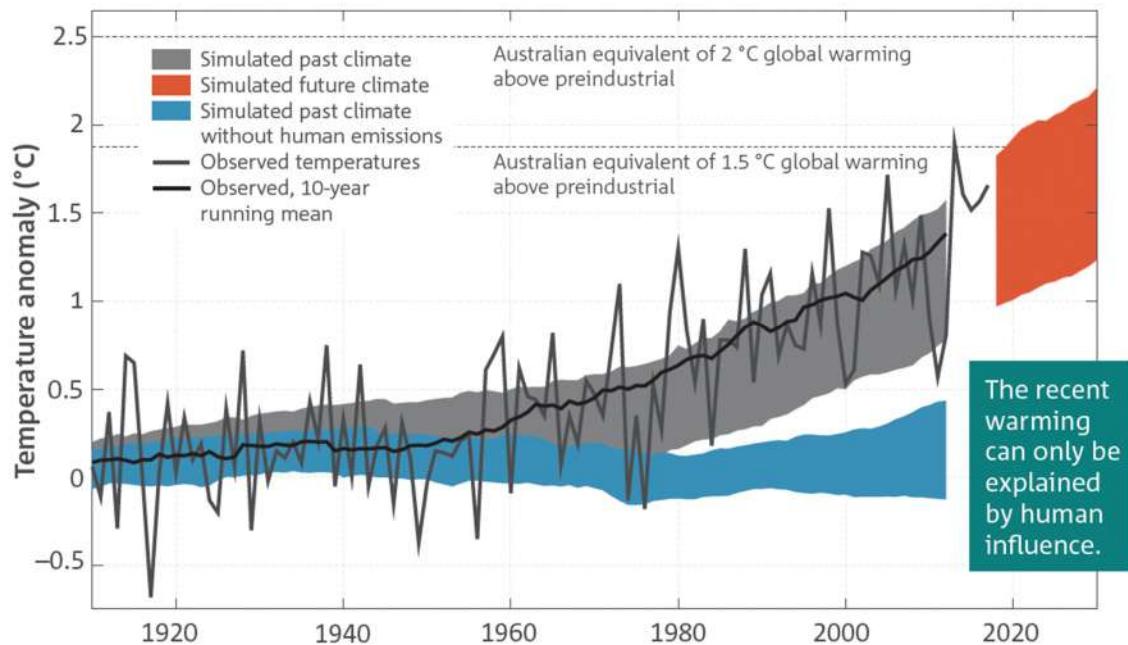
As more emissions enter the atmosphere, warming will continue to increase and will persist for hundreds of years unless action is taken to remove these emissions from the atmosphere. Currently, CO₂ removal processes and technologies are not possible at scale without significant costs, impacts and risks (Smith et al. 2016).

Limiting global temperature at any level requires reducing emissions to net-zero (IPCC 2018). Reducing global emissions sooner will prevent greater changes to the world's climate and will reduce associated risks to human and natural systems.

2.2. Climate change is already happening in Australia

Australia is experiencing increases in temperature and sea-level rise. Surface air temperatures in Australia have already warmed by approximately 1.4°C (BoM n.d.). Figure 1 shows observed and simulated temperature anomalies for Australia, with and without the effect of human activities. This illustrates the extent to which Australia's climate has been affected by human activities and the projected future change. Over the past half a century, the sea level around Australia has risen at an average rate of 2.1 millimetres per year (CoastAdapt 2018).

FIGURE 1. AUSTRALIA'S AVERAGE ANNUAL TEMPERATURE RELATIVE TO THE 1861–1990 PERIOD

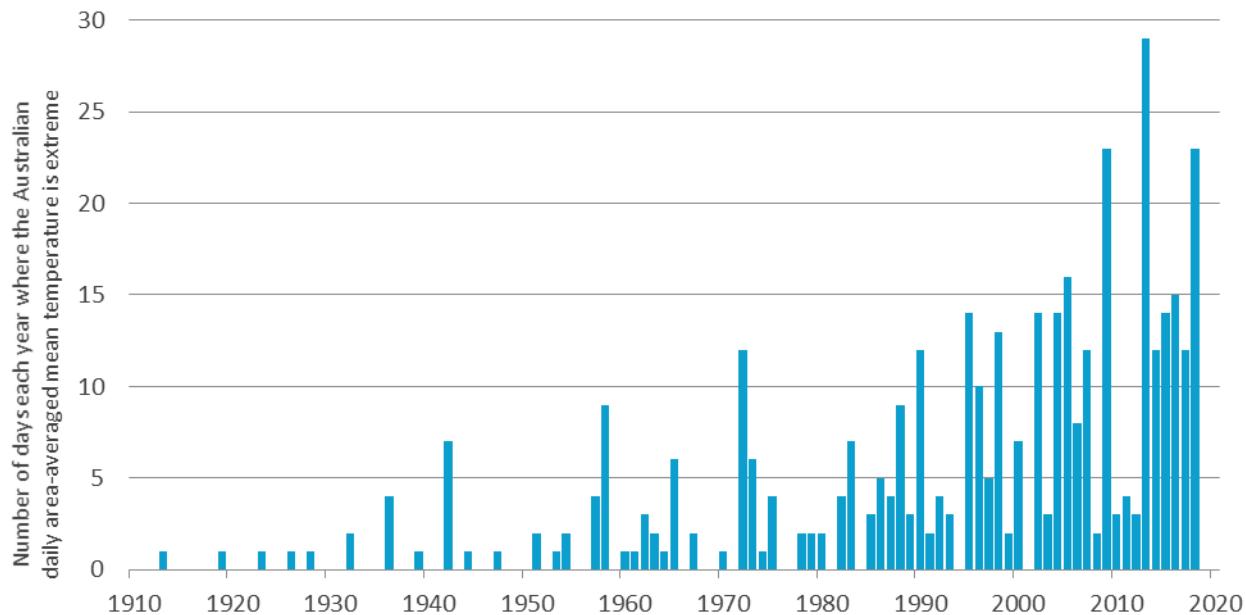


Source: Reproduced by permission of Bureau of Meteorology, © 2018 Commonwealth of Australia

Note: The grey shaded area in this chart shows the estimated impact of human emissions on Australia's temperature observations, whereas the blue shaded area projects the climate without human emissions. The projected future temperature increases in Australia are expected to be greater than the global average. This is illustrated by the two horizontal dotted lines in the chart. For global warming of 2°C, the expected warming in Australia is estimated to be 2.5°C.

In Australia, 2019 was the warmest and driest year on record (BoM 2020). These warm and dry conditions were a key factor driving extreme fire conditions observed in the 2019–20 spring and summer (BoM 2019d). Historically there has also been an increase in extreme heat events, with more days in each year in the top 1 per cent of temperatures experienced (Figure 2).

FIGURE 2. FREQUENCY OF EXTREME HEAT EVENTS IN AUSTRALIA, 1910–2018



Source: Bureau of Meteorology

Note: This shows the number of days each year where the Australian area-averaged daily mean temperature is extreme. Extreme days are those above the 99th percentile of each month from the years 1910–2017. These extreme daily events typically occur over a large area, with generally more than 40 per cent of Australia experiencing temperatures in the warmest 10 per cent for that month.

Climate change is contributing to changing rainfall patterns, with a greater proportion of annual rainfall coming from heavy rain days (BoM and CSIRO 2018). Reduced rainfall during April to October in the south of the country has affected winter crops in recent decades—this is consistent with climate change projections, but the trend so far is difficult to distinguish from year-to-year variability (BoM and CSIRO 2018). Warmer oceans off the coast of Queensland caused coral bleaching of the Great Barrier Reef in 2016 and 2017 (BoM and CSIRO 2018). Over the period 2016 to 2018 the Great Barrier Reef lost as much as 50 per cent of its shallow water corals (Hughes et al. 2017; IPCC 2018). Bleaching is a stress response of coral. With prolonged or severe thermal stress, coral can ultimately die (BoM and CSIRO 2018).

Box 2 Changing bushfire seasons

Australia's bushfire conditions have changed in recent decades. In southern and eastern Australia fire seasons have started earlier and more extreme conditions have been observed during summer. The Bureau of Meteorology has stated that these changes are at least partly attributable to climate change (BoM 2019a). Northern Australia has experienced an increase in monsoonal rainfall, which has increased fuel growth and hence fire risk (BoM 2019a).

The impact of climate change on the frequency and severity of bushfire conditions includes changes in weather patterns, temperature, environmental moisture and fuel conditions (BoM 2019a).

The spring and summer of 2019–20 brought widespread and damaging bushfires to eastern Australia. Readings from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Forest Fire Danger Index (a measure of fire weather conditions) observed in September 2019 in southern Queensland and northeast New South Wales (NSW) were beyond what had previously been observed since 1950 (BoM 2019b). In NSW and Victoria, it is estimated that over 5.3 million hectares had burned during the fire season by early January.

Fire seasons are changing in other countries, and there is an emerging overlap of fire seasons internationally that will probably limit the future availability of shared resources (IGEM 2018).

2.3. Every half degree matters

The lower the rise in global temperature, the lower the risks to human and natural systems. For example, analysis by the Intergovernmental Panel on Climate Change (IPCC) has demonstrated the benefits of pursuing efforts to limit warming to 1.5°C by comparing the difference between projected climate change impacts at 1.5°C and 2°C.⁴ It is worth noting that these increases in temperature are expressed as a global average and some areas will warm substantially more than this. By keeping global warming to 1.5°C, there is a lower risk of extreme hot weather, flooding and drought and a smaller expected rise in sea level. Minimising these impacts would reduce the risks of economic and social disruption by helping to protect coastal communities, agricultural production and natural ecosystems and to limit health risks. Globally, limiting warming to 1.5°C is projected to expose 420 million fewer people to extreme heatwaves and 10 million fewer people to risks associated with sea-level rise compared with warming of 2°C (IPCC 2018). In Australia, limiting global warming to 1.5°C is projected to reduce water stress and significantly reduce impacts on ecosystems and food production (IPCC 2018).

However, even at 1.5°C warming, there are likely to be significant impacts on some ecosystems. For example, there is a risk of losing 70 to 90 per cent of tropical coral reefs compared with 2018 levels (IPCC 2018). Small Island developing states and low-lying tropical nations will be particularly affected by climate change at 1.5°C warming from loss of corals and other impacts such as storm surges and increased temperatures (IPCC 2018).

If strong action is not taken to limit emissions, the impacts of climate change will become increasingly severe. Warming of more than 2°C is projected to lead to more frequent unprecedented high temperatures, disrupting human and natural systems (Power 2019; IPCC 2018). With more than 2°C warming, there are increasing risks that the climate system may respond with sudden and abrupt changes, particularly in water

⁴ The IPCC is the United Nations body responsible for assessing the science related to climate change.

availability and heat extremes, rather than incremental changes (Box 3). These sudden changes could have severe consequences for humans and natural systems due to the extent or speed of the change.

Meeting the Paris Agreement goal to keep the rise in global temperatures well below 2°C, and to pursue efforts to limit the temperature increase to 1.5°C, will limit this damage. The IPCC projects that, on current warming trends, human-induced global warming will reach 1.5°C around 2040 (IPCC 2018). Analysis of current commitments under the Paris Agreement indicates the world is tracking for at least 3°C of warming by 2100—well above the commitment to limit temperature increases to well below 2°C (UNEP 2018).

Box 3 Non-linear impacts and tipping points

The higher the concentration of greenhouse gases in the atmosphere, the greater the risk of non-linear changes to the climate, including passing ‘tipping points’ in climate systems. ‘Tipping points’ can lead to large changes in the state of the climate and ecosystems from which it could take tens of thousands of years to millions of years for the Earth to return. Some tipping points, such as species extinction, are irreversible.

For example, global warming may lead to large and irreversible sea-level rise from the loss of land-based ice sheets. The centre of the Greenland ice sheet has been stable for three million years (Bierman et al. 2014), but models indicate it could melt entirely, contributing one to two metres to sea-level rise over the next two hundred years and five to seven metres to sea-level rise over a thousand years or more (IPCC 2018; NASA 2019). The ice sheets might regrow with a cooling of the climate, but that would depend on many factors (IPCC 2018).

A faster rate of warming also increases the risk of species extinction, particularly as warming interacts with ice loss, ocean acidification and other stressors. Many species are at risk from climate change across terrestrial, freshwater and marine ecosystems (IPCC 2014a).

The IPCC states that overshooting a 1.5°C or 2°C temperature target before reducing global emissions to net-zero is a risky strategy for limiting dangerous climate change to human and natural systems. This is because the temperature at the peak of global warming is important in determining impacts. If the peak temperature is high, it increases the risk of large, irreversible impacts occurring (IPCC 2018).

2.4. Economic, environmental and social costs of climate change

Climate change has already imposed economic and environmental costs within Australia and globally. However, these current impacts are small compared with the impacts that are projected with future warming. Global efforts to reduce emissions will help to avoid or minimise these projected impacts.

2.4.1. Impacts in Australia

Among developed countries, Australia is one of the most vulnerable to the impacts of climate change (Kompas et al. 2018). Climate change poses significant risks to our economy, communities and the natural environment.

There have already been large costs associated with extreme weather events that are made more likely by climate change. Some recent extreme events include the 2009 Black Saturday fires in Victoria, fires in Gondwanan forests in Tasmania in 2016 and 2019, flooding in Queensland in 2011 and 2019, and the current prolonged drought in north-western NSW, where it is drier than during the Millennium Drought (ANU 2019). These events are consistent with the expected outcomes of a warming world and have large economic impacts which are borne across different sectors of the economy (Steffen et al. 2019).

Climate change is also affecting the natural environment, changing the distribution of species and ecosystem functions such as water and nutrient cycles (CSIRO 2012). For example, climate change is a significant threat to the large old trees in Mountain Ash forests (Lindenmayer 2016) and may already be posing a significant risk to the Australian pygmy possum that inhabits the alpine area due to a decline in its main food source, the Bogong moth (Gibson et al. 2018; Cox 2019). In the future, there are likely to be more widespread and significant ecological changes and loss of biodiversity from factors that include altered fire regimes and the impacts of invasive species (IPCC 2014a).

Climate change impacts are likely to affect community health and wellbeing—for example, increased temperatures will lead to higher rates of heat-related illnesses, the spread of mosquito-borne diseases, and increased exposure to natural disasters (Beggs et al. 2019). They will also be likely to affect recreational activities—for example, heat could limit the time of the day and year that some events can take place.

Estimated costs to agriculture

Australia can expect climate change impacts on the agricultural sector to arise both incrementally as temperatures rise over time; and through short-term shocks resulting from extreme weather-related events. One example of an incremental change is the stagnation in wheat yield improvements in Australia since 1990 due to unreliable rains and increasing temperatures compared with a long-term trend of increasing yield, which tripled between 1900 and 1990 (CSIRO 2017a). This trend can be seen in the cropping sector more broadly, with the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) estimating that climate conditions from 2000 to 2019 have reduced profits from cropping farms by 35 per cent on average compared with 1950 to 1999 (ABARES 2019).

In contrast, three weeks of heavy rainfalls and major flooding from the 2019 North and Far North Queensland monsoon trough is estimated to have caused A\$432 million worth of damages to agriculture and A\$5.68 billion in total social and economic damages (Deloitte 2019). While this event is not directly attributed to climate change, climate change increases the likelihood of heavy rainfall events in most locations in Australia (BoM 2019c). Extended drought has a widespread and significant impact. Previous severe droughts have reduced Australia's gross domestic product (GDP) growth by around 1 per cent (Treasury 2004). Irrigated agriculture is also likely to be affected, with climate change increasing production risks to the A\$8.6 billion value of irrigated agricultural production in the Murray-Darling Basin (ABS 2019a; MDBA 2019).

ABARES has estimated that profits from all broadacre farms are on average 22 per cent lower since 2000 due to climate variability (ABARES 2019). The Climate Council estimates that on current trends the cumulative loss in reduced agricultural and labour productivity due to climate change in Australia would be worth A\$19 billion by 2030, increasing to A\$211 billion by 2050 (Steffen et al. 2019).⁵

Estimated costs to infrastructure

Around Australia's coasts, over A\$226 billion in commercial, industrial, road and rail, and residential assets will potentially be exposed to inundation and erosion hazards by 2100 (DoCCEE 2011).⁶ Construction of protection works for threatened assets and public facilities, such as airports or sewage treatment plants, may be needed (McKinsey 2019).

⁵ These figures include some health impacts.

⁶ This is expressed as replacement value in 2008 dollars with 1.1 metre sea-level rise (high-end scenario for 2100).

The climate change risks faced by properties and infrastructure are increasingly a consideration for banks and insurance companies. The Australian Prudential Regulation Authority has said the ‘high and rising costs of natural disasters drive the high and rising general insurance premiums in northern Australia’ (APRA 2019a). Some homes, including homes in southern Australia, have become uninsurable for natural disasters following repeated recent exposure—for example, homes in Tasmania affected by repeated floods (Burgess 2019). Climate change risks are adding to the costs of living for everyday Australians, such as through increased insurance premiums and increased costs from higher energy use for cooling during heatwaves (Saman et al. 2013; De Ciana et al. 2019).

Costs across the whole economy

In the 2016 Special Review, the Authority noted the work of the Garnaut Climate Change Review (Garnaut 2008) which drew on a wide range of expertise and models and found that the measurable costs of climate change were considerably more than the cost of strong action to reduce emissions. Other studies since then have also reached this conclusion (IRENA 2019a; UNEP Finance Initiative 2019). A study by the University of Melbourne has estimated the costs of climate change across the whole Australian economy in the hundreds of billions of dollars in 2030 and at more than A\$5 trillion in cumulative damages by 2100, even excluding many costs of flood, fire and environmental losses (Kompas et al. 2019).⁷

2.4.2. Global impacts

Preliminary estimates suggest that, if the current trend towards 3°C warming by 2100 is sustained, this could cost the world US\$9.6 trillion (A\$13.8 trillion) every year by the end of the century compared with a scenario with no further warming from the base year of 2017. These are costs associated with sea-level rise, lost agricultural productivity and health impacts; and these impacts will differ across countries (Kompas et al. 2018).⁸ While these cost estimates are based on particular assumptions and are therefore open to debate, they provide an initial indication of the magnitude of potential costs. Furthermore, as the estimates exclude a number of expected types of impacts such as natural disasters, they are likely to be conservative (Kompas et al. 2018).

Climate change will disproportionately affect developing countries (IPCC 2018; World Bank 2018a). The physical impacts are likely to be greatest in these countries—for example, due to extreme temperatures in Africa and India and the more limited ability of their economies to respond to the impacts compared with developed countries (IPCC 2018).

There will also be large impacts in developed countries around the world. Insights into likely future impacts can be gained from recent events. For example, climate model-based attribution indicates the heatwave in the United Kingdom in 2018 was made 30 times more likely by human-induced climate change, and this magnitude of heatwave is likely to happen approximately every second year by 2050 regardless of global emissions levels (Met Office n.d.). The costliest insurance event of 2018 was the California Camp Fire wildfire, which destroyed over 18,000 structures and killed 86 people (Munich Re 2019; AON 2018). The total estimated economic loss from wildfires in California in 2018 was around US\$24 billion and the world’s largest reinsurance firm, Munich Re, attributed the severity of the wildfires to increasing hot, dry summers linked to climate change (Munich Re 2019).

⁷ These figures exclude the bulk of costs of floods and bushfires, pollution, damage to environmental assets and biodiversity losses.

⁸ A 4°C global warming scenario has a global US\$23.1 trillion estimated loss to GDP (Kompas et al. 2018).

Globally, 2019 was the second warmest year and the past five years are the warmest since records began in 1880 (NASA 2020). The years 2017 and 2018 were among the warmest and were also the costliest back-to-back years on record for both economic losses solely due to weather-related events and for insured losses (AON 2018).

There may be some limited regional benefits from climate change, such as an increase in the length of the growing season in high-latitude countries leading to higher agricultural productivity (IPCC 2014a). However, these benefits are likely to be more than offset by a reduction in agricultural productivity in tropical regions (IPCC 2014a; IPCC 2018).

A changing climate is considered to be a compounding factor of global instability (Pezzullo 2018). Globally, managing the relocation of people within countries and potentially across national boundaries may prove to be one of the greatest social impacts of climate change. Organisations such as the World Bank are assessing risks from mass migration, with a report finding that, without concerted action to curb greenhouse emissions, more than 140 million people in Sub-Saharan Africa, South Asia and Latin America could be forced to migrate within countries by 2050 (World Bank 2018a).

3. GLOBAL RESPONSE TO CLIMATE CHANGE

Through the 2015 Paris Agreement, 188 parties have agreed to hold the increase in the global average temperature to well below 2°C above pre-industrial levels, pursue efforts to limit the temperature increase to 1.5°C, and achieve net-zero emissions in the second half of this century.

In pursuit of those goals, countries are required to progressively strengthen their targets every five years. Currently, countries' pledged responses do not meet the level of ambition required to meet the goals of the Paris Agreement but instead might limit global warming to 3.2°C by 2100.

A growing number of countries have outlined plans to achieve net-zero emissions and over 100 nations are planning to enhance their ambition or actions in 2020.

Global firms are increasingly cognisant of the impact that climate change will have on their operations, their suppliers and customers, and many are responding directly to the Paris Agreement. Financial regulators are beginning to focus on management of climate-related risk and global investors are embracing 'green bonds' and other climate-friendly investment opportunities.

3.1. Global agreements

The IPCC's *Special report on global warming of 1.5°C* warns that 'rapid and far-reaching transitions' are needed across many economic sectors and industrial systems to limit global warming to 1.5°C (IPCC 2018). According to the report, limiting warming to 1.5°C will require global carbon dioxide (CO₂) emissions to reach net-zero by around 2050 and neutrality for all other greenhouse gases later in the century.

Climate change is a global problem and it is beyond the ability of any individual nation to deliver a solution. Although action by individual nations is required to mitigate climate change, global agreement and coordination is necessary to ensure that each is doing its fair share and the combined actions of individual nations will result in the achievement of long-term goals to limit global warming.

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992. The UNFCCC was the first global agreement on climate change:

[The UNFCCC's ultimate aim is to achieve] stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner (UNFCCC 1992).

The UNFCCC does not set binding emissions reduction targets but provides a framework for further agreements to reduce emissions—the Kyoto Protocol and the Paris Agreement. There are 197 parties to the UNFCCC, including all United Nations member states and the European Union (UNFCCC n.d.a).

3.1.1. The Paris Agreement

The Paris Agreement, signed by all 197 members of the UNFCCC, establishes long-term goals for climate action. Those goals are to:

- limit the increase in global average temperature to 'well below' 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C

- increase the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development
- make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

These long-term goals are supported by the Paris Agreement's aspiration to 'reach global peaking of greenhouse gas emissions as soon as possible' and to reach net-zero emissions 'in the second half of this century' (Paris Agreement 2015). Reaching net-zero emissions in the second half of the century is broadly consistent with limiting global warming to 2°C, although the IPCC has most recently suggested that net-zero would need to be achieved by around 2070 to have a chance of meeting this goal (IPCC 2018). To limit warming to 1.5°C, net-zero should be achieved by 2050 (IPCC 2018).

Under the Paris Agreement, nations set out their post-2020 climate action plans, including emissions reduction targets, through their Nationally Determined Contributions (NDCs). NDCs are to be reviewed and updated every five years, with the ambition of targets expected to increase over time to a level consistent with the agreement's goals (Box 4) (Paris Agreement 2015; UNFCCC n.d.d). In addition to NDCs, all signatories are expected to develop a long-term, low greenhouse gas emissions development strategy, and they are invited to communicate them to the international community by 2020 (Paris Agreement 2015; UNFCCC 2016a).

Box 4 Evolution of the long-term targets

The Paris Agreement's long-term temperature goal is to limit global warming to well below 2°C and to pursue efforts to limit warming to 1.5°C. Although the target of limiting warming to 2°C has been proposed for several decades, more recent research has suggested that the impacts of climate change at 2°C may be more serious than previously thought, both for human and natural systems. Increasingly, the realisation that climate change impacts are already occurring and are causing environmental, social and economic disruption has focused greater attention on how a 1.5°C target could be achieved. As of 2018, scientists considered that it was still possible to limit warming to 1.5°C, although urgent and significant cuts to greenhouse gas emissions are necessary to maintain this possibility (IPCC 2018).

3.2. National responses

Since the signing of the Paris Agreement, nations have outlined their intended responses to climate change through their NDCs. Collectively, the initial pledged responses did not meet the level of ambition required to meet the goals of the Paris Agreement. They are expected to limit global warming to 3.2°C by 2100 (UNEP 2018)—overshooting the long-term goals of the Paris Agreement. Increases in the ambition of NDC pledges will be required by 2030 to retain the possibility of limiting warming to 2°C (UNEP 2018). Many countries are not yet on track to meet their pledges (den Elzen et al. 2019; UNEP 2018) and will need to reduce their emission levels over the next decade. A summary of national pledges to 2030 is provided at Table 1. As at December 2019, 41 countries had stated an intention to update their NDC by 2020, with a further 80 nations planning to enhance their ambition or an action in their NDC in 2020 (ClimateWatch 2019).

Of the 161 NDCs analysed by the UNFCCC secretariat in 2016 (covering about 99 per cent of global emissions), 32 per cent contained an absolute emissions reduction target; 45 per cent pledged a reduction from business-as-usual levels; 4 per cent promised a reduction in emissions intensity; and 2 per cent promised a target year or time frame to peak emissions. Other forms of commitments were made in 21 per cent of NDCs, including pledges to implement policies and actions (UNFCCC 2016b). Subsequent to the submission of their NDCs, a growing list of countries, including the United Kingdom, New Zealand and

the European Union, have outlined plans to achieve net-zero emissions (Climate Action Tracker 2019; European Commission 2019c).

3.3. Responses by other entities

Unlike the preceding Kyoto Protocol, the Paris Agreement makes provision for and encourages actions of entities that are not national governments, including sub-national or local governments and private entities. These entities are proving to be an important part of the global response to the Paris Agreement in mobilising climate action, particularly where national commitment is wavering. For example, in the United States, 25 state governors have joined the United States Climate Alliance—a ‘bipartisan coalition of governors committed to reducing greenhouse gas emissions consistent with the goals of the Paris Agreement’ (United States Climate Alliance n.d.). Hawaii, California and New York have committed to becoming carbon neutral by 2050 (2045 for Hawaii) (United States Climate Alliance 2018; Roberts 2019). As of 6 December 2019, a total of 9,465 cities and 2,688 companies globally had declared actions to respond to climate change according to the United Nations’ Global Climate Action Portal (UNFCCC n.d.c).

TABLE 1. CURRENT NATIONALLY DETERMINED CONTRIBUTIONS AND EMISSIONS DATA

Country/ region	Paris Agreement commitments (all commitments are to 2030 unless otherwise indicated)	Paris target implied change in total emissions 2005–2030 (%)
China	Peak carbon dioxide emissions by around 2030, making best efforts to peak early; lower carbon intensity by 60 to 65 per cent compared with 2005	+76 to +101
United States	Reduce emissions by 26 to 28 per cent compared with 2005 levels by 2025	–35 to –39
European Union	Reduce emissions by 40 per cent compared with 1990	–34
India	Lower carbon intensity by 33 to 35 per cent compared with 2005 levels	+244 to +254
Indonesia	Reduce emissions by 29 per cent below BAU, or 41 per cent conditional on international support	+14
Russia	Reduce emissions by 25 to 30 per cent below 1990 levels	+29 to +39
Brazil	Reduce emissions by 37 per cent compared with 2005 levels by	–43

	2025; 43 per cent compared with 2005 levels by 2030	
Japan	Reduce emissions by 26 per cent compared with 2013 levels	-25
Canada	Reduce emissions by 30 per cent compared with 2005 levels	-30
Mexico	Reduce emissions by 22 per cent below BAU	0
Republic of Korea	Reduce emissions by 37 per cent below BAU	+6
Australia	Reduce emissions by 26 to 28 per cent compared with 2005 levels	-26 to -28
New Zealand	Reduce emissions by 30 per cent compared with 2005 levels	-30

Sources: Based on CCA 2016a. Updated calculations based on data from ClimateWatch 2019; OECD n.d.; UN DESA n.d.

Notes: BAU is business as usual. Carbon and emissions intensity is carbon dioxide and emissions intensity per unit of GDP. Some countries are likely to convert their point targets, which identify an emissions target and a target year, into carbon budgets that identify the total amount of emissions allowable over a period of time. As such, there is some uncertainty with regard to the total emissions associated with the point targets. Targets may also allow for the use of international units to meet shortfalls in domestic emissions reductions. Some countries have put forward two targets—one they will unconditionally meet regardless of other countries' actions and another they will meet if certain conditions are met. These conditions are usually based on stronger global action.

3.3.1. Corporate responses

Global firms are increasingly cognisant of the impacts climate change will have on their operations, suppliers and customers, and many are responding directly to the Paris Agreement. As of 10 December 2019, 732 companies had committed to setting emissions reduction targets, of which 312 had set targets consistent with 1.5° or 2°C pathways. Companies with certified targets included large multinational firms like AB InBev, Adobe, Colgate-Palmolive, Dell, Electrolux, Groupe Renault, Heidelberg Cement, IKEA, Mars, McDonalds, Nestle, Panasonic and Unilever. A number of Australian companies have also set targets, including Origin Energy, Investa, Frasers Property Australia, Dexus and Edge Environment Pty Ltd (Science Based Targets n.d.).

Global businesses have also been advocating for effective government responses to climate change. At its March 2019 Tokyo summit, the B20 forum of business leaders from G20 nations called on the G20 'to promote policies for the mitigation of and adaptation to climate change, and simultaneously to promote energy transitions, resource efficiency, and preservation of biodiversity in a concerted manner' (B20 2019).

Initiatives targeting businesses and financial markets, such as the Task Force on Climate-related Financial Disclosures (TCFD), are seeking to ensure that companies take climate change risks into account in their

business planning and operations. The TCFD aims to help companies and financial markets measure and respond to physical, transition and liability risks associated with climate change (TCFD n.d.).

3.3.2. Financial sector responses

The financial sector is taking a significant lead in the response to climate change at an international level. Financial institutions may seek to manage their exposure to climate risks, including that of their clients (RBA 2019b). This may have implications for the availability of capital and insurance for business.

The Network for Greening the Financial System is an international forum for central banks and financial supervisors (including the Reserve Bank of Australia) that contributes to the development of environment and climate-related risk management in the financial sector. The network notes that ‘climate change is one of many sources of structural change affecting the financial system’ and that climate-related risk is a source of financial risk. The network considers that climate-related risk is within the mandate of central banks and supervisors to ‘ensure the financial system is resilient to these risks’ (NGFS 2019a).

Global investors have also responded to the challenges posed in the Paris Agreement—specifically those relating to aligning finance flows with low greenhouse gas emissions and climate-resilient development. Climate financing channels in the private sector are gaining momentum. In particular, investors have embraced ‘green bonds’, which direct financing to climate-related business activities. Global issuance of green bonds exceeded US\$167 billion in 2018, with expectations of continued growth (Climate Bonds Initiative 2019c). Advanced economies have agreed to jointly mobilise US\$100 billion per year by 2020, from a variety of sources to address the pressing mitigation and adaptation needs of developing countries. The latest figures from 2017 estimate USD71 billion has been mobilised for developing countries. Further, pledges to the Green Climate Fund, part of the formal financing mechanism of the UNFCCC that aims to support developing countries to respond to climate change, amounted to around US\$10 billion following the Fund’s first replenishment round in 2019 (Green Climate Fund 2019).

Multilateral development banks have responded to the Paris Agreement by committing to increase the proportion of their funding devoted to climate finance, with the World Bank Group and the European Investment Bank hitting their respective targets for 2020 early (the targets were 28 and 35 per cent of operations devoted to climate finance) (Thwaites 2019).

3.3.3. Local government responses

Local governments have a strong interest in reducing the impacts of climate change. Their responsibilities mean they are often the first to encounter and respond to climate change impacts, and their local knowledge makes them see the need for adaptation on a local scale (Victorian Government DELWP n.d.). The Global Covenant of Mayors for Climate and Energy is a network of local governments that have committed to taking action on climate change. Commitments by local governments under the covenant include pledges to reduce greenhouse gas emissions by up to 1.4 billion tonnes of carbon dioxide equivalent annually by 2030. This would represent a per-capita reduction in emissions of 43 per cent in those municipalities between 2010 and 2030 (Global Covenant of Mayors 2018).

4. AUSTRALIAN CONTEXT

In the year to September 2019, Australia's emissions were 530.8 million tonnes (Mt) of carbon dioxide equivalent (CO₂-e). Australia's largest source of emissions is the generation of electricity, followed by other direct combustion emissions (for the generation of steam, heat or pressure) and transport.

Australia is the world's 14th largest emitter and we account for around 1 per cent of global emissions. Successful global action on climate change will require the many countries with similar or smaller contributions to global emissions to take action to reduce those emissions, in addition to action taken by the largest emitters.

Australia's emissions have fluctuated since 2005. In 2018–19, total emissions were 13 per cent lower than in 2005. Australia's emissions peaked at 627 Mt CO₂-e in 2007 but have increased slightly since 2016. Increasing emissions in most sectors, particularly industry and transport, have offset falling emissions in the electricity and agriculture and land sectors.

This means Australia's projected emissions need to be reduced by 392 Mt CO₂-e if the government's target of reaching –26 per cent to –28 per cent on 2005 levels by 2030 is to be met (before any application of Kyoto Protocol 'carryover'). That would require emissions to be on average 39 Mt CO₂-e (or around 7 per cent of total annual emissions) lower than otherwise projected for each year between 2021 and 2030.

There are a range of climate policies in place at the federal, state and territory and local government levels in Australia. These policies are yet to put Australia's emissions on a clear downward trajectory.

4.1. Australia's emissions profile

4.1.1. Current emissions

In the year to September 2019, Australia's emissions were 530.8 Mt of CO₂-e. Australia's largest source of emissions is the generation of electricity, followed by other direct combustion emissions (for the generation of steam, heat or pressure) and transport (Table 2). The land sector both generates emissions (for example, through land clearing) and stores carbon (for example, growth of forests and regrowth on cleared lands)—in 2018–19 the Australian land sector had a net effect of removing carbon dioxide from the atmosphere.

Australia's emissions have fluctuated since 2005, the base year for Australia's 2030 Paris Agreement emissions reduction target (Figure 3). In 2018–19, total emissions were 13 per cent lower than in 2005 (Figure 3). Australia's emissions peaked at 627 Mt CO₂-e in 2007 (DoEE 2019a). Emissions reductions realised since have mostly been due to lower emissions from the land sector. Between 2007 and 2016 there was a significant decline in land clearing, coupled with an increase in regrowth and forest plantations (DoEE 2019b).

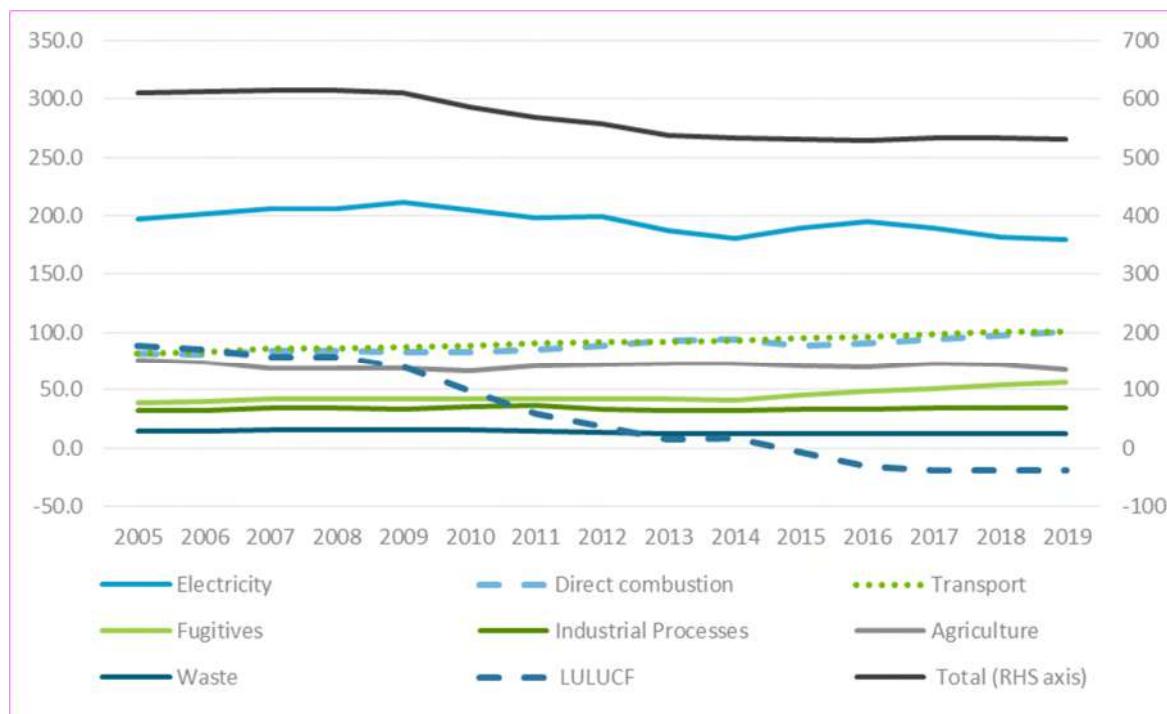
Since 2016, however, Australia's emissions have increased slightly. This can be attributed to increasing emissions in most sectors, particularly transport, direct combustion and fugitives. A decrease in emissions from electricity, achieved through increased uptake of renewables and reduced coal-fired generation, and the short-term effects of the drought on agriculture have offset some of this increase (DoEE 2019b).

TABLE 2. BREAKDOWN OF AUSTRALIA'S EMISSIONS BY SOURCE, 2019

Source	Emissions (Mt CO ₂ -e)	Share of emissions (%)
Electricity	178.1	34
Direct combustion	100.5	19
Transport	100.3	19
Agriculture	66.4	12
Fugitives	57.3	11
Industrial processes	34.7	7
Waste	11.8	2
Land use, land use change and forestry	-18.4	-4
Total	530.8	100

Source: DISER 2020

FIGURE 3. AUSTRALIA'S EMISSIONS BY SECTOR, 2005–2019



Source: DoEE 2019a

4.1.2. Australia's contribution to global emissions

Australia produces around 1 per cent of global emissions and is the world's 14th largest emitter in absolute terms. Compared with Australia's major trading partners and other major economies, considering our population and the size of our economy, Australia is relatively emissions-intensive (Table 3).

Figure 4 illustrates the make-up of global emissions by country. It shows the two biggest emitters, China and the United States, together produced over 35 per cent of global emissions. It also shows that over 50 per cent of total emissions came from countries that each accounted for less than 5 per cent of global emissions. There were 176 countries individually responsible for producing less emissions than Australia. Together they accounted for about 33 per cent of global emissions. The share of emissions from this group of countries was greater than any individual country, highlighting the importance of countries with relatively small emissions taking action in support of the Paris Agreement.

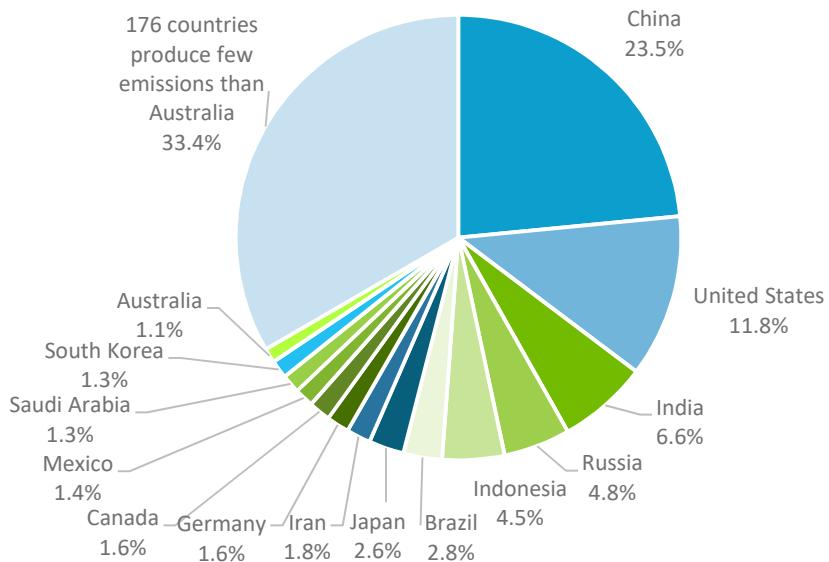
TABLE 3. EMISSIONS IN SELECTED COUNTRIES AND REGIONS, 2016

Country/ region	Share of global emissions (%)	Emissions per capita (t CO ₂ -e per person)	Emissions per unit of GDP (kg CO ₂ -e/US\$)
China	23.5	8.4	1.0
United States	11.8	18.1	0.3
European Union	7.3	7.1	0.2
India	6.6	2.4	1.4
Indonesia	4.5	8.5	2.4
Japan	2.6	10.0	0.3
Canada	1.6	21.6	0.5
Republic of Korea	1.3	12.8	0.5
Australia	1.1	21.5	0.4
New Zealand	0.1	13.5	0.3

Sources: Climate Change Authority analysis based on CAIT 2019; World Bank n.d.

Note: 2016 is the latest year where comparable data is available across all countries.

FIGURE 4. SHARE OF GLOBAL EMISSIONS BY COUNTRY, 2016



Source: CCA analysis based on CAIT 2019

Note: 2016 is the latest year where comparable data is available across all countries.

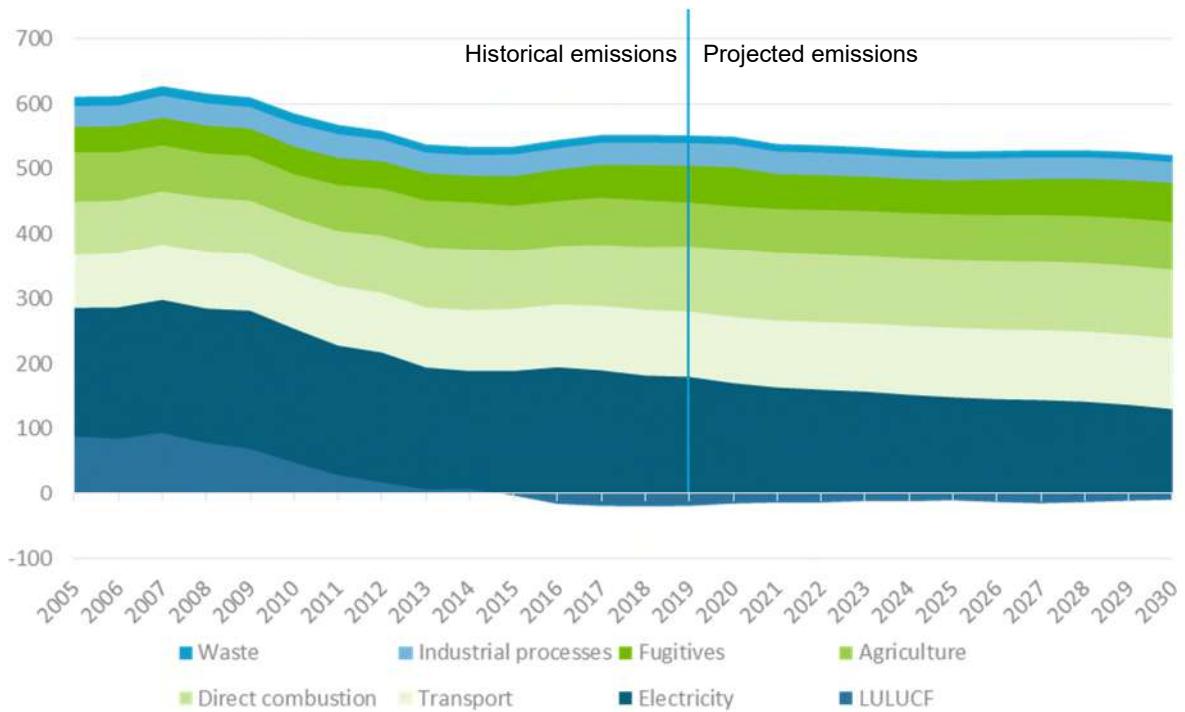
4.1.3. Projected emissions to 2030

The Australian Government's 2019 emissions projections show Australia's emissions falling to 511 Mt CO₂-e by 2030, which is 16 per cent below 2005 levels (DoEE 2019i). Emissions are expected to decrease in the electricity, industrial processes and waste categories and increase in other categories.

These projections are indicative only and are subject to change over time. They assume that current trends and existing policies continue. They do not account for the introduction of new emissions reductions policies and measures.

Australia's projected emissions are updated each year. In 2016, at the time the initial toolkit report was released, Australia's emissions were projected to be 724 Mt CO₂-e in 2030—29 per cent higher than current projections. This means the estimated abatement task is smaller now than it was in 2016. Revisions to the projections reflect emission reduction policies that have been implemented, as well as updated reported emissions levels and developments in economic activities. For example, the most recent emissions projections reflect the expected emission reductions from the Government's Climate Solutions Fund and other measures from the Climate Solutions Package announced in February 2019 (Australian Government 2019a). It also includes the effects of the 50 per cent renewable energy targets in Victoria, Queensland and the Northern Territory (DoEE 2019i).

FIGURE 5. AUSTRALIA'S HISTORICAL AND PROJECTED EMISSIONS BY SOURCE, 2005–2030



Source: DoEE 2019i

4.2. Australia's emissions targets

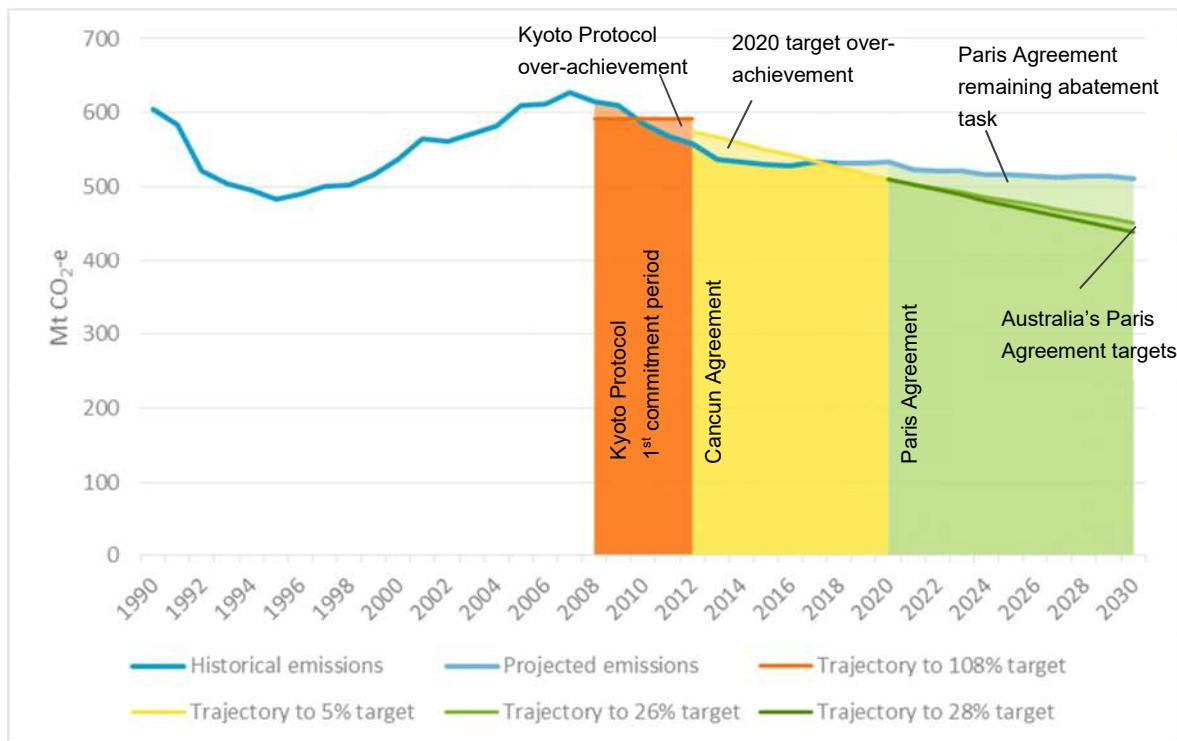
In 2015, the Australian Government made a commitment to reduce Australia's emissions by 26 to 28 per cent below 2005 levels by 2030 as part of the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) (Australian Government 2015d). As noted in Chapter 3, the Paris Agreement also has a number of other elements and includes a long-term commitment to reducing global emissions to net-zero in the second half of the century.

In setting its target (or Nationally Determined Contribution (NDC)), the Australian Government advised it would use a budget approach to track progress towards the targets (Box 5) (Australian Government 2015d). Using this approach, Australia's cumulative emissions over the period 2021 to 2030 need to be limited to 4,777 Mt CO₂-e for the 26 per cent target to be met (Figure 6).⁹ This is also known as the 'emissions budget' for the period.

In Figure 6, the blue line shows historical and projected annual emissions. The orange, yellow and green coloured lines show the trajectory used to determine the emissions budgets for each target period. The areas under these coloured lines show the emissions budgets to meet the targets under the Kyoto Protocol first commitment period, Australia's 2020 target under the Cancun Agreement and the 2030 Paris Agreement target. See Box 5 for an explanation of emissions budgets. The light-shaded areas illustrate over-achievement against corresponding targets and projected under-achievement against the Paris target (that is, the remaining abatement task).

⁹ This is an indicative number and is subject to change based on updates to Australia's national inventory.
36

FIGURE 6. AUSTRALIA'S EMISSIONS TARGETS AND BUDGETS



Source: Climate Change Authority based on DoEE 2019i

Box 5 Budget approach to emissions targets

Under the first commitment period of the Kyoto Protocol, emission reduction targets were expressed as a percentage of a base year. This percentage was then multiplied by the number of years in the commitment period to determine the country's total target emissions for the period. For example, Australia's emissions over the period 2008 to 2012 were limited to 108 per cent of 1990 emission levels multiplied by five. In Figure 6, this is illustrated by the horizontal orange line at 630 Mt CO₂-e, which is 108 per cent of Australia's emissions in 1990.

This is often referred to as a budget approach to emissions targets. Countries are considered to have met their target if their total emissions do not exceed their emissions budget for the period in question.

Using a budget approach:

- aligns with the objectives of the policy, as the driver of climate change is the total volume of emissions (for the most part, the timing of the emission is irrelevant)
- provides some flexibility for countries in how and when emissions occur
- imposes a commitment that needs to be considered over a number of years, not just a single year.

Australia's 2020 target of 5 per cent below 2000 levels was nominated under the Cancun Agreement and Australia has stated it will meet this target using a budget approach. The point target is converted to an emissions budget using an approach consistent with a technical paper issued by the UNFCCC (2011). The emissions budget for the period is calculated using a linear downward trajectory from a starting point in 2010 set at the first commitment period target level to the 2020 target level (yellow line in Figure 6). Adding together the emissions for the years 2013 to 2020 comprised the budget.

Australia also has a target under the second Kyoto Protocol commitment period (2013–2020). The target under the second commitment period is set the same way as the first commitment period—as a percentage of emissions in the base year (1990) multiplied by the number of years in the period (eight). Australia's target is 99.5 per cent of 1990 levels over the period 2013 to 2020. Australia's 2020 target under the Cancun Agreement was an input to the target-setting process for the second commitment period with the aim that the two targets were consistent with each other.

In Australia's NDC under the Paris Agreement, it stated its target is an '[a]bsolute economy-wide emissions reduction by 2030, to be developed into an emissions budget covering the period 2021–2030' (Australian Government 2015d). The approach for calculating the emissions budget has not been stated publicly. However, the Government's emissions projections document, which estimates the emissions reduction task, adopts an approach based on cumulative emissions assuming a straight line reduction between the 2020 and 2030 point target values (5 per cent below 2000 levels and 26 per cent below 2005 levels respectively).

In 2007 the Australian Government committed to limiting Australia's emissions to 8 per cent above 1990 levels between 2008 and 2012 for the first commitment period of the Kyoto Protocol (Kyoto Protocol 2008). This commitment was met and exceeded by 128 Mt CO₂-e, on the basis of a budget approach used under the Kyoto Protocol (Box 5) (DoEE 2019i) (light orange shaded area in Figure 6). Under the Kyoto Protocol, Australia is eligible to count its over-achievement toward the second Kyoto Protocol commitment period if required. This is referred to as 'carryover' (Kyoto Protocol 2008). Kyoto Protocol rules require that carryover is cancelled at the end of the subsequent commitment period if not used—it can only be carried forward once.

In 2010, the Australian Government committed to reducing Australia's emissions by 5 per cent below 2000 levels by 2020 under the UNFCCC (the Cancun Agreement) (DFAT n.d.a). Australia is expected to over-achieve this target by an estimated 283 Mt CO₂-e (without making use of carryover from the first commitment period) (DoEE 2019i). The 2020 target is consistent with Australia's target under the second commitment period of the Kyoto Protocol (which is specified as a reduction in emissions by 0.5 per cent from 1990 levels over the period 2013 to 2020).

4.2.1. The expected abatement task

Based on the Government's emissions projections, Australia's cumulative emissions between 2021 and 2030 are estimated to be 5,169 Mt CO₂-e. This means Australia's projected emissions need to be reduced by 392 Mt CO₂-e if the 26 per cent target is to be met. That would require emissions to be on average 39 Mt CO₂-e (or 7 per cent of total emissions) lower than otherwise projected for each year between 2021 and 2030. This is equivalent to total emissions from industrial processes and product use, or more than a third of current transport emissions. Analysis by the United Nations Environment Programme indicates Australia is currently not on track to meet its emissions reduction target of 26 to 28 per cent below 2005 levels by 2030 (UNEP 2019a).

The estimated emissions reduction task is based on a number of assumptions and is therefore likely to change over time. The Government's emissions projections indicate it will use Australia's over-achievement against previous targets toward meeting this abatement task if required. Based on current projections, if the full amount of carryover were used, Australia's 26 per cent target would be met (DoEE 2019i).

4.3. Climate action in Australia

Actions to reduce emissions and address climate change are occurring in Australia as all levels of government implement policies and programs to reduce emissions, industry prepares for a carbon-constrained future and households and individuals undertake voluntary action to reduce their carbon footprint. These actions are summarised below. The Authority's 2019 'stocktake' reports of climate change policies, and international and industry action, provide further details. The effectiveness of existing policies and current policy opportunities will be discussed in the policy sections of this report (Chapter 6 onwards).

4.3.1. Australia's national climate change policies

The Australian Government has implemented climate change policies across all sectors of the economy. Key policies are:

- the National Greenhouse and Energy Reporting Scheme, which requires companies to report their emissions and energy production and consumption to the Government
- the Safeguard Mechanism, which places limits on emissions from large facilities (Box 6)
- the Emissions Reduction Fund (ERF), which allows organisations and individuals to register projects to reduce their emissions and sell the carbon credits generated by the project to the Government or a third party (Box 7)
- the Climate Active Carbon Neutral Standard (formerly the National Carbon Offset Standard), which allows organisations to be certified for voluntarily measuring, reducing and offsetting their emissions
- the Renewable Energy Target, which places an obligation on electricity retailers to surrender a certain number of certificates created by renewable energy generators each year

- funding for low-emissions technologies through the Clean Energy Finance Corporation (CEFC) and the Australian Renewable Energy Agency (ARENA).

Box 6 The Safeguard Mechanism

The Safeguard Mechanism applies to Australia's largest emitters that have facilities whose direct emissions (scope 1) are more than 100,000 tonnes CO₂-e a year. Those facilities are subject to a baseline and required to manage their scope 1 emissions to ensure they do not exceed the baseline. From 2020–21 onwards, in general, baselines will be determined on the emissions intensity of production. Grid-connected electricity generation facilities are subject to a sector-wide baseline.

In 2017–18, the safeguard applied to 211 facilities and covered 138 Mt CO₂-e of emissions. These are predominantly facilities in the mining, oil and gas, manufacturing, transport and off-grid electricity sectors.

All facilities complied with their safeguard obligations, some through the use of compliance options:¹⁰

- 17 facilities had multi-year monitoring periods in place, which provide facilities with additional time to manage their average net emissions in line with their baselines
- two facilities received a temporary baseline variation as they exceeded their baseline but reduced their emissions intensity
- facilities surrendered almost 260,000 ACCUs, representing 0.26 Mt CO₂-e (CER 2019b).

¹⁰ See the Clean Energy Regulator website for details on individual facilities:

<http://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20odata/safeguard-facility-reported-emissions/safeguard-facility-emissions-2017-18>.

Box 7 The Emissions Reduction Fund

The ERF was established in 2014. The ERF credits reductions in greenhouse gas emissions that result from additional, project-level action and combines this with Government purchasing of credits to help meet Australia's 2030 target. The crediting aspect of the ERF had its foundations as the Carbon Farming Initiative—a voluntary offset scheme that operated between 2011 and 2014 to support compliance with the Carbon Pricing Scheme.

The Australian Government made A\$2.55 billion available to purchase credits, with purchases commencing in 2014. To date, the Clean Energy Regulator (CER), which administers the ERF, has used competitive auctions to purchase least-cost abatement.

As of October 2019, the CER had awarded 455 abatement contracts to purchase 192 million tonnes of abatement (CER 2019g). A total of 48 million ACCUs,¹¹ or 25 per cent of contracted abatement, have been sold under the purchasing mechanism of the ERF. Eighty-two per cent of contracted abatement is from the agriculture and land sector;¹² around 13 per cent is from landfill and waste; and 5 per cent is from the rest of the economy (CER 2019c).

In 2019, the Government announced it would allocate a further A\$2 billion to establish a Climate Solutions Fund to continue purchases of low-cost abatement currently underway through the ERF. The Government estimates this will provide over 100 million tonnes of abatement by 2030.

4.3.2. State and territory policies

The state and territory governments cooperate with the Australian Government on some climate change policies and implement their own policies in line with their constitutional responsibilities and to meet their own emissions reduction targets (summarised in Table 4). If met, these targets would see Australia's emissions approach net-zero by 2050. Some of these targets are aspirational and the policy mechanisms to reduce emissions are not yet developed. Many local governments also have climate change strategies or action plans for reducing emissions in areas under their control, including waste, street lighting and trees.

¹¹ Each carbon credit, or ACCU, represents one tonne of CO₂-e.

¹² This includes savanna-burning projects.

TABLE 4. STATE AND TERRITORY EMISSION REDUCTION TARGETS (CONVERTED TO A 2005 BASE YEAR)

	2020	2030	2050
Queensland		30 per cent below 2005 levels <i>Announced in 2017</i>	Net-zero Announced in 2017
New South Wales			Net-zero Announced in 2016
Victoria	15–20 per cent below 2005 levels <i>Announced in 2017</i>		Net-zero Committed in 2016
South Australia			<i>60 per cent below 2005 levels^{b,c}</i> Committed in 2007
Australian Capital Territory^a	<i>40 per cent below 2005 levels</i> Committed in 2010 ^d	<i>65–75 per cent below 2005 levels^e</i> Committed in 2018	Net-zero by 2045 Committed in 2018
Tasmania			<i>64 per cent below 2005 levels^f</i> Committed in 2008 Net-zero Announced in 2017
Western Australia			Net-zero Announced in 2019
Northern Territory			Net-zero Announced in 2019

Sources: CCA 2019b; Government of Western Australia 2019c; Northern Territory Government 2019

Notes: Legislated targets are italicised.

^a The Australian Capital Territory also has a 2025 target of 50–60 per cent below 2005 levels and a 2040 target of 90–95 per cent below 2005 levels (Climate Change and Greenhouse Gas Reduction (Interim Targets) Determination 2018 (ACT)).

^b The previous South Australian Government announced a target of net-zero emissions by 2050 in 2015.

^c The South Australian Government's legislated 2050 target is expressed as 60 per cent below 1990 levels.

^d The Australian Capital Territory's 2020 target is expressed as 40 per cent below 1990 levels.

^e The Australian Capital Territory's 2030 target is expressed as 65 to 75 per cent below 1990 levels.

^f Tasmania's legislated 2050 target is expressed as 60 per cent below 1990 levels.

The majority of state and territory policies are concentrated in the energy sector. Apart from NSW and Western Australia, all states and territories have implemented renewable energy targets and mechanisms to achieve them (CCA 2019b).

All state and territory governments apart from the Northern Territory have also implemented policies to reduce emissions from transport. These include biofuel mandates, registration and tax discounts for low-emissions vehicles, support for electric vehicle infrastructure and consumer education (CCA 2019b).

4.3.3. Industry action on climate change

Industry is taking action on climate change in response to a number of drivers, including to reduce operating costs, respond to shifting consumer preferences and attract investment finance (CCA 2019a). Industry action on climate change takes various forms including setting emissions reduction targets, investing in low-emissions technology and renewable energy, and improving operational efficiency. The Authority's stocktake of industry actions found that many companies are taking actions to address climate change and ASX listed companies are beginning to incorporate risk into their governance frameworks. The actions being taken illustrate the options available to reduce emissions without negatively affecting economic activity.

For example:

- As at November 2019, over 80 companies across Australia have carbon neutral certifications under the Climate Active Carbon Neutral Standard (formerly the National Carbon Offset Standard).¹³
- In 2017 there were 46,000 businesses with solar photovoltaic (PV) installations and 3,100 megawatts of new investments in renewable energy capacity has been delivered through Power Purchase Agreements since 2016.
- Emissions intensity of aluminium, cement and steel production is lower than in 2005 due to improvements to industrial plants and re-use of products, such as cement kiln dust.
- Agricultural enterprises, such as dairies and piggeries, are lowering emissions intensity through improved productivity, using improved herd management practices and manure management.
- Some fugitive emissions from coal mines and oil and gas production are being mitigated through flaring.
- Some road transport companies are lowering emissions intensity by improving logistics planning, changing driver behaviour and updating their fleets, including to electric vehicles (CCA 2019a).

These actions by industry are yet to result in a decline in Australia's net greenhouse gas emissions. In some cases, it is still very early days or in some sectors action may not be widespread or may not significantly reduce emissions. Continued efforts will be needed to put Australia on a path to a low-emissions economy.

Technological advances have been a key enabler of emissions reductions, and new and emerging technologies will continue to play an important role in transitioning the economy to a low-emissions future. For example, engineered wood products can be used instead of some steel and concrete to reduce the emissions embodied in buildings. It is expected that in the future industrial heat may be able to be generated by renewable sources rather than fossil fuels. The Government has announced that it is developing a Technology Investment Roadmap to establish an enduring, strategic approach to Australia's low-emissions technology investment (Taylor 2019a).

¹³ See the Climate Active website for a list of certified companies: <https://www.climateactive.org.au/buy-climate-active/certified-brands>.

5. THE POLICY RESPONSE

The updated policy toolkit recommended in this report builds on Australia's current policies to ensure we make our contribution to the global task of reducing emissions in both the short- and long-term and position Australia to take advantage of the opportunities of a global low-emissions economy.

The Authority considers a range of criteria when evaluating potential policies, including economic efficiency, environmental effectiveness and equity.

There have been a number of significant developments in the climate science and policy landscape since the Authority's 2016 climate policy toolkit report. Scientific understanding of the current and future impacts of climate change has improved, as has understanding of the global task to limit climate change in line with the 2°C temperature goal—the current level of countries' ambition needs to roughly triple. The costs of low-emissions technologies, including solar photovoltaic (PV), wind, lithium-ion batteries and electric vehicles, have fallen and technological progress continues to accelerate. A number of major economies are enhancing their ambition and implementing policies to lift progress towards reducing emissions.

5.1. The case for government action

Addressing climate change is a global challenge. As outlined in Chapter 2, various human activities release greenhouse gases into the atmosphere, causing climate change. The physical, social and economic costs of unmitigated climate change are significant (IPCC 2018; Krogstrup et al. 2019). However, in the absence of government policy measures, the price that producers and consumers pay for greenhouse gas emitting products and services does not reflect these costs. This pollution or damage not considered in decision making by the polluter is a clear example of what economists refer to as an 'externality'. The consequence is an over-reliance on, and over production of, high greenhouse gas emitting products such as fossil fuels. There is also no price incentive for individual producers and consumers to curtail greenhouse gas emissions by shifting to alternative technologies or products.

To address climate change and reduce the various current and future costs, governments around the world are increasingly implementing policies to reduce emissions and enable low-emission activities. The benefit of collective government action is reduced physical impacts of climate change by holding temperatures below 2°C. However, this action will involve some risks and up-front costs in the short term. On the other hand, delaying further action is predicted to lead to at least 3°C or more warming with damaging consequences (WMO et al. 2019).

Scientists acknowledge there are uncertainties regarding the specific impacts of climate change, so they present a range of possible outcomes for future temperature increases with different likelihoods of occurring. It is possible that temperatures could go beyond current estimates or reach an irreversible tipping point (Box 3). The non-negligible probability that the costs of climate change could be catastrophic is a material risk (Krogstrup et al. 2019). In its submission, Engineers Australia highlighted the risk that comes with this uncertainty, stating:

Our view is that the calculations used to define the carbon budget to meet the Paris objective are too optimistic ... For confidence levels in the order of 90%, the carbon budget to keep temperature rises below 2 degrees Celsius is already exhausted. At 90% this is a 1 in 10 chance of failure, three orders of magnitude greater than normal engineering design (Engineers Australia submission, p. 4).

The precautionary principle dictates that, if there is a probable risk that an action can cause serious harm or irreversible loss to the public, precautionary measures should be taken to avoid that risk (Heal 2017; Kundreuther et al. 2014; Wagner et al. 2015). The Paris Agreement aims to apply the precautionary principle by limiting global temperature warming (Farber 2015; Ekardt et al. 2018).

It is becoming increasingly clear that there is building global momentum to address climate change, driven by investors, businesses, consumers and governments across the world. Australia will be part of the global transition. The costs of the transition are likely to be lower if action is taken earlier to manage adjustments rather than delaying action and being subjected to disruptive change. Taking action to ensure an orderly transition also creates multiple co-benefits in the short term, including for human health and the environment, and presents new economic opportunities and untapped markets (UNECE 2016).

Intergenerational and international aspects of climate change make addressing the problem particularly challenging. The many costs associated with unmitigated climate change are predicted to affect future generations the most (Schuppert 2011; Rudebusch 2019). This issue was noted in submissions to this review by the Australian Competition and Consumer Commission and the WA Local Government Association. Without further action to reduce emissions, children who are born today will be likely to experience temperature increases in their lifetime that exceed the Paris Agreement goals, with potentially devastating impacts on their way of life (IPCC 2018). Intergenerational equality requires current policies to ensure all resources, including the climate, are used efficiently within and between generations to avoid the irreversible future impacts of unmitigated climate change (Heal 2017; Harrison 2010; Markulev et al. 2013). The Australian Religious Response to Climate Change stated in its submission:

Australia needs to be much more disciplined in reducing its emissions ... [O]therwise we are burdening today's younger generations with the imperative to live more restrained lifestyles than we ourselves have been prepared to accept. This is intergenerational injustice. (p. 1)

Furthermore, climate change is global in both its causes and consequences, creating a unique collective problem. As no single actor or jurisdiction has the capacity to fully capture the benefits of reducing their individual emissions, all have an incentive to 'free-ride' and benefit from the actions of others. While there is a risk that some countries will not comply with their Paris Agreement commitments, effective climate change mitigation can only occur if there is collective compliance and cooperation (Clancy 1998; Cole 2007; Sekeris 2015). As a member of the global community, and signatory to the Paris Agreement, Australia has a responsibility to do its part in reducing emissions.

5.2. A policy toolkit

The Authority last provided comprehensive, economy-wide advice to government on the policy toolkit to meet Australia's 2030 greenhouse gas emissions reduction target in 2016. The Authority has also published a number of subsequent reviews and reports. These include legislative reviews of the National Greenhouse and Energy Reporting Scheme and Safeguard Mechanism (2018) and Emissions Reduction Fund (2017); and reports on reducing emissions on the land (*Reaping the rewards*, 2018) and the electricity sector (*Towards the next generation*, 2017).

In providing its advice in 2016, the Authority decided a sectoral approach that builds on existing policies was the most appropriate way forward. The Authority also noted aspects of the 2016 toolkit would need to be recalibrated over time in response to developments in science and technology and domestic and global circumstances, including the progress Australia and other countries are making towards meeting their Paris Agreement obligations (CCA 2016a).

As well as the principles outlined in Chapter 1, the Authority has further identified the following desirable characteristics of emissions reduction policies for use in evaluating policy options:

- Credibility—this will provide an incentive for businesses to invest and innovate and to ensure emissions reductions are real.
- Durability and simplicity—this will reduce the costs to government associated with implementing policies and the costs to businesses of adjusting to new policies.
- Scalability—this will enable Australia to adjust its emissions reduction commitment over time as Australia transitions to a low-emissions economy in response to changes in technology, the economy and the action of international competitors.
- Coherency with other policies—the policy toolkit should have broad coverage to reduce the overall costs of emissions reductions and maximise opportunities to achieve co-benefits.
- Flexibility—a range of compliance options should be included to reduce the cost of emissions reductions, such as allowing access to international units subject to quantitative and qualitative limits.
- Certainty—consistent policy should be linked to Australia's low-emissions transition, providing durable signals for business to be able to invest with confidence.
- Avoid lock-in—policies developed for the short term should not make future emissions reductions more difficult or costly.
- Adaptation—policies should be robust in a changing climate and complement, rather than hinder, climate adaptation responses.

It is important for Australia to meet its 2030 target and commence the shift towards a low-emissions economy in the short term to enable meaningful emission reductions in the long term. Given this, and noting Australia's history of uncertainty around climate policy, the updated toolkit seeks to build on and further develop Australia's existing policies.

5.2.1. Economic efficiency

The Authority evaluates the economic efficiency of policies by considering whether they help Australia to achieve its emissions reduction goals at least cost, taking into account the costs and benefits to the Australian economy in the short, medium and long term. The Authority also seeks to identify policy areas where there is an opportunity to achieve co-benefits.

There is still broad consensus among economists, policy makers and analysts that the most cost-effective and efficient way to address climate change is through a broad, market-based policy approach (Krogstrup et al. 2019; Narassimhan et al. 2018). Many stakeholders have expressed support for such an approach (Carbon Markets Institute, Australian Petroleum Production and Exploration Association, Australian Industry Greenhouse Gas Network, Australian Marine Conservation Society, Australian Religious Response to Climate Change, Victorian Greenhouse Alliances, Australian Local Government Association, The Chamber of Minerals and Energy of Western Australia).

Market-based policy instruments create a financial incentive for firms to reduce greenhouse gas emissions. These include price-based instruments like a tax on greenhouse gas emissions; or quantity-based instruments like a cap and trade scheme, where the price results from restricting the quantity of allowable greenhouse gas emissions and allowing users to trade among themselves. They make high greenhouse gas emitting activities more costly, creating an incentive for industry and consumers to find ways to reduce

greenhouse gas emissions and avoid the costs associated with emissions (CCA 2016a; GCEC 2014; Markulev et al. 2013).

Examples of several market policy mechanisms, including emissions trading schemes and carbon taxes, were provided as part of the Authority's advice to government on the policy toolkit in 2016 (Report Two of the Special Review) (CCA 2015). In 2018, 45 national and 25 subnational jurisdictions around the world had implemented or intended to implement an emissions pricing mechanism (World Bank 2018b). Because the political and economic context is unique for each country, the design of these pricing mechanisms varies across jurisdictions—for example, in relation to quantity caps for emissions trading schemes and sectoral coverage (Narassimhan et al. 2018).

The Authority recognises there can be significant political and social challenges in implementing a broad-based market mechanism for pricing greenhouse gas emissions. These challenges are caused in part by complexity, lack of transparency and perceptions about the welfare and price impacts of policies (Krogstrup et al. 2019; Hammar et al. 2013). The level of political and social concern surrounding a policy can be affected by the approach taken by decision makers to address these sources of concern and also the specific design settings of the policies.

5.2.2. Environmental effectiveness

The Authority analyses the environmental effectiveness of policies based on their ability to achieve real emissions reductions at the national and global level.

Different pathways to reducing emissions to a given level can have different effects on total cumulative emissions. Long lead times can help generate support for a policy and give participants more time to plan for changes but can also lead to missed opportunities for early emission reductions. Initially higher emissions could necessitate greater emission reductions in the future to meet cumulative emission targets.

Also reflected in the Authority's analysis is the precautionary principle. The Authority's advice errs on the side of taking action early in line with the Paris Agreement rather than delaying action to reduce the chances of extreme, irreversible damage from climate change.

5.2.3. Equity

When assessing equity, the Authority considers whether policies take account of, and support, an equitable distribution of impacts and risks across households, businesses and communities.

Low socio-economic households and communities are likely to be affected disproportionately by climate change given the relatively limited resources they have with which to respond. These groups and the broader community also stand to benefit from action to mitigate climate change, including the health benefits of cleaner air and new job opportunities. Policies will be needed to support vulnerable groups to identify risks and opportunities to adapt and to ensure an equitable distribution of costs and benefits across the economy.

Policies designed to manage the transition to a low-emissions economy can also disproportionately affect certain industries, communities or regions. There may be opportunities to align low-emissions activities, like hydrogen production and mining for battery minerals, to affected regions. This can create win-win situations, particularly where workforces and infrastructure are already in place, but requires forward planning and communication to ensure the skill sets are available in a timely fashion.

Equity considerations for vulnerable groups, assistance for communities transitioning to a low-emissions economy and the importance of a long-term signal are discussed further in Chapter 6.

5.3. The need for an update

Since 2016, there have been significant developments in the scientific understanding of climate change, the technology to address climate change, and climate-related policies in Australia.

5.3.1. Climate science developments

There have been advances in climate science and a greater understanding of the likely impacts of climate change. Scientists have observed increasing global temperatures—between 2015 and 2019 average global temperatures are estimated to be 1.1°C above pre-industrial levels (1850–1900), which is 0.2°C warmer than the preceding five years (WMO et al. 2019).

The estimated level of cumulative emissions to keep global warming to below 1.5°C has also become clearer. Using changes in global mean surface air temperature, the Intergovernmental Panel on Climate Change (IPCC) now estimates the remaining global carbon budget is 420 to 580 billion tonnes CO₂ for a 66 to 50 per cent probability of limiting warming to 1.5°C relative to pre-industrial levels during and beyond this century (IPCC 2018).¹⁴

Based on the remaining global carbon budget, implementing current unconditional Nationally Determined Contributions (NDCs) would lead to a global mean temperature rise of 3.2°C by the end of the century relative to pre-industrial levels and a continued rise thereafter (UNEP 2018). The current level of NDC ambition needs to roughly triple for emissions reduction to be in line with the 2°C temperature goal and increase fivefold for the 1.5°C goal (WMO et al. 2019).

Major reports released by the IPCC and other international scientific bodies since 2016 detail observed changes to the Earth's land, ocean and cryosphere (the frozen part of the Earth system) and the impacts of 1.5°C and 2°C warming (IPCC 2018, 2019a, 2019b). There is also a better understanding of the existing and likely negative impacts climate change will have on biodiversity and other natural resources, sea-level rise and medium- to long-term economic stability (IPBES 2019; IPCC 2018, 2019a, 2019b). These are described in Chapter 2.

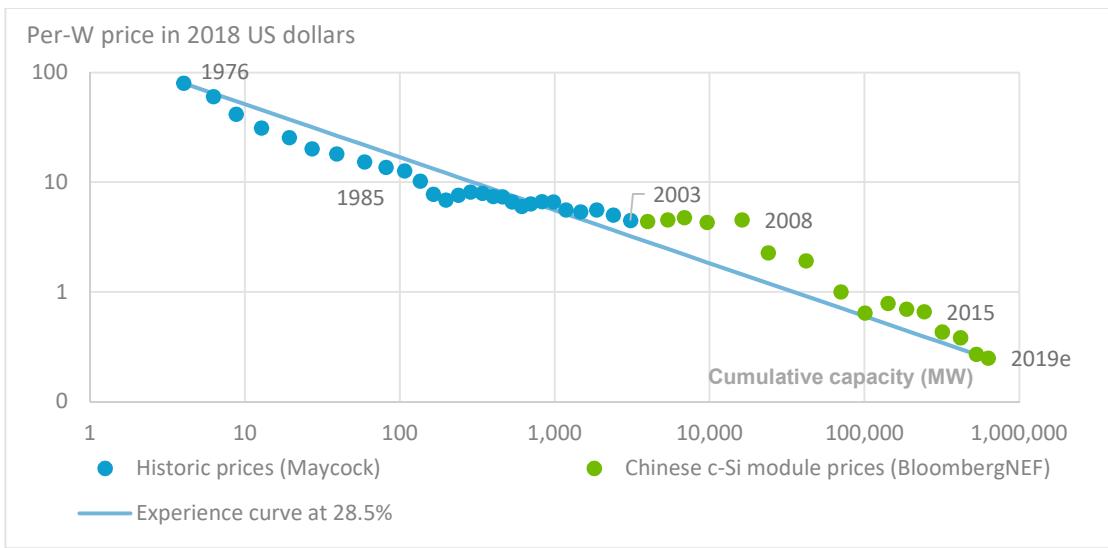
5.3.2. Technology advances

The costs of low-emissions technologies, including solar photovoltaic (PV), wind, lithium-ion batteries and electric vehicles, continue to fall and technological progress continues to accelerate (BloombergNEF 2019a, 2019b; IRENA n.d.). The rate at which the price of renewable energy technology has fallen for each doubling of production volume (the experience curve) has been exponential. For solar PV systems, the average selling price of solar modules fell by almost 29 per cent for each doubling of production volume (Figure 7). Wind technology has experienced an 8 per cent price reduction for each doubling of production volume. Although the experience curve for wind is flatter than for solar PV, wind has experienced a much higher rate of technology optimisation over the same period through improvements to the efficiency of generating units (Bloomberg NEF 2019a).

Declining costs of current technologies provide viable, cost-competitive pathways for low-emissions transitions in the energy, road transport and building sectors. Emerging technologies, like renewable hydrogen, will have the potential to generate future opportunities in other sectors (Energy Transitions Commission 2018; Bloomberg NEF 2019a).

¹⁴ This estimate excludes potential additional carbon release from future permafrost thawing and methane release from wetlands.

FIGURE 7. SOLAR PV MODULE PRICES, 1976–2019



Source: BloombergNEF 2019a

5.3.3. Accelerating global action

Global commitment to implement the Paris Agreement is strong. A number of major economies are enhancing their ambition and progress toward reducing emissions. As discussed in Chapter 6, the United Kingdom recently became the first major economy to legislate its commitment to become carbon neutral by 2050. Together with six¹⁵ other G20 countries, it has submitted a long-term strategy under the Paris Agreement, bringing the total number of long-term strategies submitted to 13 as of October 2019. All the G20 long-term strategies set out significant greenhouse gas emissions reduction commitments by mid-century. An estimated 86 per cent of global greenhouse gas emissions will soon be covered under long-term strategies (Gov.UK 2019; UNFCCC n.d.b; UNFCCC and UNDP 2019).

As detailed in Chapter 15, the finance and investment sector and private corporations are responding to climate change. The TCFD is developing the first global prudential regulatory framework that seeks to address crucial information barriers of climate-related risks. There is evidence the framework is already mobilising investors and shifting business reporting and behaviour (Summerhayes 2019). Investor demand for low-emissions investment opportunities has grown exponentially over the past decade particularly in the areas of green infrastructure, and clean energy and transport (CCA 2019a).

5.3.4. Climate policy developments in Australia

Since 2016 there have been several new climate policies introduced in Australia. Some state and territory governments have introduced new emission reduction and renewable energy targets. The Australian Government undertook a review of climate policies in 2017; announced the Climate Solutions Package of measures in early 2019; and has initiated the development of strategies and measures in areas such as

¹⁵ This includes the United States, which submitted a long-term strategy in 2016 prior to announcing its intention to withdraw from the Paris Agreement.

technology investment, hydrogen, electric vehicles and energy efficiency. These policies and changes are outlined in Chapter 4 and Chapter 6 onwards.

6. TRANSITIONING AUSTRALIA TO A LOW-EMISSIONS FUTURE

Strong global action to reduce emissions will protect us from the worst impacts of a changing climate. As a resource-rich trading nation whose prosperity depends on continued access to overseas markets, it will also present opportunities to grow our economy, increase jobs and reduce our living expenses. Our sun-drenched, windswept land offers enormous potential to produce and export clean energy; to become a low- and zero-emissions manufacturing and processing hub; and to store carbon in trees and soil.

The global transition is underway. In keeping with the Paris Agreement, countries are increasing their ambition, some are adopting net-zero emission targets and deploying long-term climate change strategies. Regional and local governments are also taking action in response to falling technology costs and changing community demands. Businesses have started to consider, disclose and manage climate risks, motivated by a desire to meet the expectations of customers, investors, regulators and, increasingly, the courts. This means Australia will need to respond to changing global circumstances, irrespective of our own targets, or risk getting left behind.

By delivering on its commitment to developing a long-term climate change strategy, the Australian Government has an opportunity to set out its vision for a prosperous, sustainable Australian economy while we make our contribution to achieving the temperature goals of the Paris Agreement. It could provide businesses, investors, governments, communities and workers with information that will help them prepare for the future and take steps like investing in technology, capital, education and training and economic diversification. Clear direction at the national level will enable Australia to better manage climate risks and make the most of the opportunities the global transition offers.

6.1. Looking beyond 2030

The emissions reduction challenge does not end with the 2030 target. The Paris Agreement is designed to ratchet up ambition over time, accelerating the pace of emissions reduction in order to avoid, or at least reduce, dangerous impacts of climate change (see Chapter 3). The world and Australian economies will need to adjust to meet future, more ambitious emission reduction targets and to respond to changing environmental and economic circumstances.

As countries increasingly take action, and investor and consumer preferences change, demand for our exports of goods and services will also change. New estimates prepared by the Government show that greenhouse gas emissions released in Australia in producing our exports for 2018–19 were 199 Mt CO₂-e—67 million tonnes Mt CO₂-e, or 50 per cent, more than for 2004–05—exhibiting a steady upward trend across this period (DoEE 2019a). While the Australian economy has benefited, and continues to benefit, considerably from these exports (for example, of coal and liquid natural gas), one interpretation of this data is that the increase in emissions associated with the production of our exports means we are becoming increasingly vulnerable to potential shifts in attitudes towards emissions-intensive goods. The immediate outlook is that demand for Australia’s coal and gas is likely to remain strong, although there are uncertainties for coal export demand, particularly thermal coal, in the longer term as countries transition away from coal-powered electricity generation (RBA 2019a). The benefits of these exports to the Australia economy add to the challenges we face in achieving long-term emissions reductions.

Australia’s future prosperity will be best served by planning for and managing the transition risks associated with global climate change action (see also Chapter 15).

6.2. Advancing Australia's economic transition through a long-term strategy

The Government committed to developing a long-term greenhouse gas emissions reduction strategy by the end of 2020 in its *2017 Review of Climate Change Policies*, through its 2019 *Climate Solutions Package* (Australian Government 2019a, 2017) and through its response to the *2017 Independent Review into the Future Security of the National Market* (Finkel review). The Climate Solutions Package stated that the Government's long-term strategy will explore 'how Australia can benefit from new opportunities that arise from continued advances in technology as we, along with all other countries, transition our economy in the decades ahead' (Australian Government 2019a). More recently the Government has stated that its forthcoming technology investment roadmap will be the corner stone of Australia's long-term climate strategy (Taylor 2020). The roadmap will aim to evaluate, prioritise and progress clean technologies to full commerciality and deployment as quickly as possible through government support and private-sector investment (Taylor 2020).

The Government's 2017 *Foreign Policy White Paper* also highlighted the importance of including climate change in long-term planning and investment decisions. The white paper highlighted the opportunities that Australia has to capitalise on renewable energy resources and capture the benefits of the global transition (DFAT 2017).

A long-term strategy can serve as a strategic document that integrates economic development planning with emissions reduction and climate resilience policies (Vener et al. 2019). The goal is to take advantage of the opportunities, and adequately mitigate the risks, associated with the global transition to a low-emissions economy. A well-crafted long-term strategy could identify the challenges facing Australia and assist decision makers across the economy to identify long-lasting technologies, investments and land uses that are compatible with the desired transition. It could also help avoid near-term decisions that would lock in high-emissions activities and lead to stranded assets, given the need to achieve deeper cuts in emissions over time. A long-term strategy can also inform short- and medium-term emissions reduction target setting under the Paris Agreement's 'review, refine and ratchet' mechanism for NDCs (Vener et al. 2019).

A long-term strategy could provide an informed basis for policy makers and communities to be able to plan for an equitable transition, particularly for workers in emissions-intensive industries. It would provide an opportunity to assess and anticipate social and employment impacts of the transition to a low-emissions economy and identify new opportunities for emerging industries and job creation (Vener et al. 2019; European Commission 2018).

Strategies can also set out long-term infrastructure investment plans such as low-emissions electricity transmission systems and urban infrastructure and transport systems. In order to remain dynamic and relevant, country-level long-term strategies should have periodic delivery and review mechanisms (Stern 2018). The Finkel review, in recommending that the Australian Government develop a whole-of-economy emissions reduction strategy for 2050, noted that such a strategy 'will set expectations and help to guide investment decisions in the electricity sector by providing an anchor point for Australia's long-term emissions trajectory' (Finkel et al. 2017).

As at October 2019, 13 countries, including six G20 countries (Japan, Germany, the United Kingdom, France, the United States and Canada), had submitted long-term emissions reduction strategies. A notable feature of all the G20 country long-term strategies is the focus on opportunities to drive economic growth (UNFCCC n.d.). Common identified pathways across countries' long-term strategies include a planned shift to low-emissions energy systems, enhanced resource efficiency through the adoption of circular economy principles, implementation of energy efficiency measures and implementation of carbon sequestration activities in the land sector (Germany 2016; HM Government 2017; United States 2016). According to the United Nations, 86 per cent of global greenhouse gas emissions will soon be covered under long-term strategies, with 53 countries currently preparing or planning strategies (UNFCCC and UNDP 2019).

More than 70 countries have signalled they are working to achieve net-zero emissions by 2050 and over 200 non-state actors have committed to net-zero emissions by 2050 or earlier (IISD, UNFCCC and UNDP 2019). This is consistent with the findings of the IPCC that global emissions would need to fall to net-zero by 2050 to limit warming to 1.5°C (Section 3.1.1). The United Kingdom became the first advanced economy to legislate to bring the nation's emissions reduction target to net-zero by 2050. The Victorian Government's *Climate Change Act 2017* also establishes a long-term target of net-zero greenhouse gas emissions by 2050. A long-term target creates certainty that enables the private sector to plan long-term investment decisions and take appropriate action to meet the specified target (Victorian Government 2017).

Business, governments and community groups said in their submissions that a clear, long-term signal like a mid-century target is important for investment and ensuring a smooth transition to a low-emissions economy (for example, CPA Australia and Chartered Accountants ANZ joint submission, CMI, ARRCC, Victorian Government, WALGA). The Business Council for Sustainable Development (BCSD) Australia stated that meeting the goals of the Paris Agreement 'requires clear policies with long-term market signals' and called for Australia to develop a comprehensive 'blueprint for action' (p. 3). The Business Council of Australia has also recently signalled its support for Australia legislating a net-zero emissions target by 2050 (BCA n.d.).

The Government is committed to the Paris Agreement aim of limiting global emissions to net-zero in the second half of the century. It has not indicated whether its long-term strategy will include a long-term emissions reduction target or goal.

Most state and territory governments have adopted the ambition of reaching net-zero emissions by 2050 or earlier (Table 4 in Chapter 4). Some states and territories are backing up their commitments with visions and strategies for the economic transition needed to achieve net-zero emissions. Most recently, the NSW Government has announced the first stage of its plan for achieving net zero emissions, which focuses on supporting uptake of proven emissions reduction technologies, empowering consumers and businesses to make informed choices to lower their emissions footprint through enhanced information provision, supporting development and commercialisation of new low emissions technologies and improving the resource efficiency of government operations (NSW Government Department of Planning, Industry and Environment 2020). (For other examples see, Victorian Government DEWLP 2016; Queensland Government 2017b; Australian Capital Territory Government 2019). In addition, the Australian Government and the Queensland, NSW, Victorian, South Australian and Australian Capital Territory governments have each established independent bodies that provide advice on setting or meeting their emissions reduction targets (CCA 2019b). A number of cities and regions are also making long-term commitments—for example, the City of Sydney local government has a target for 70 per cent reduction in emissions below 2006 levels by 2030 and net-zero by 2050 (City of Sydney 2018).

Some stakeholders (Woodside Energy, Minerals Council of Australia) pointed out that non-alignment between state and national settings risks increasing the cost of reducing emissions. A national long-term strategy would help align and coordinate the various state commitments, create certainty and economic efficiencies, manage any gaps and provide a national vision with a clear pathway for an orderly economic transition to a low-emissions economy. As Australia's state and territory governments move ahead with pathways to meet their 2050 ambition, there is an increasing need for this coordination.

- 1 Develop a long-term climate change strategy that secures Australia's contribution to the achievement of the temperature goals of the Paris Agreement and ensures we make the most of the opportunities arising from the transition to a low emissions global economy.**

6.3. Intergovernmental policy coordination and support

Reducing emissions and preparing for a changing climate are whole-of-economy and whole-of-society issues that cut across federal, state and territory, and local government responsibilities. Many of the Authority's recommendations in this report explicitly identify a role for, or would benefit from consultation across, multiple levels of government. This is likely to lead to more effective, integrated policy responses, avoid unnecessary duplication and regulation, and lower costs for businesses and households.

Given the strategic and national significance of responding to climate change, the Authority considers the COAG, as the peak intergovernmental forum in Australia, to be the natural home for coordinated government action on emissions reduction and climate resilience. Some relevant policy matters are already being progressed through the COAG council structure or in separate ministerial fora. Examples of recent positive outcomes include:

- the COAG Energy Council reaching agreement on a National Hydrogen Strategy in November 2019 (COAG Energy Council 2019a)
- the Agricultural Ministers' Forum endorsement in October 2019 of a coordinated national approach to supporting the agriculture sector to adapt to climate change and manage emissions (DoA 2019b).

However, the COAG meeting has not considered emissions reduction and economy-wide climate resilience issues in recent times. Arguably, this has contributed to an ad hoc and fragmented approach. In the Authority's view, reducing emissions across the Australian economy, ensuring we prosper as a nation as the world economy transitions to low emissions and maximising our preparedness for the impacts of climate change all call for integrated and coordinated policy responses.

In keeping with this view, the Authority considers emissions reduction and climate resilience should be a standing item on the COAG agenda at least once a year. This would provide the appropriate forum at which government leaders could:

- oversee and discuss the development of Australia's long-term climate change strategy and the related work programs recommended by the Authority
- monitor progress of the various COAG councils and other ministerial meetings on emissions reduction and climate resilience issues (for example, in the Energy Council, Transport and Infrastructure Council, Agriculture Ministers' Forum and Meeting of Environment Ministers) to ensure timely delivery of outcomes and that cross-sectoral linkages are identified and acted on
- ensure that federal and state policies are complementary rather than conflicting, best practice is pursued and policies are harmonised across jurisdictions where possible and appropriate.

Elevating these issues to standing item status should also lead to improved dialogue between and across jurisdictions at officials and departmental levels. The Prime Minister has already signalled his intention to discuss resilience measures with the states and territories at a March 2020 meeting of COAG, including to ensure that the newly established National Bushfire Recovery Agency invests in assets that are built to survive longer, hotter and drier summers in the future (Morrison S 2020a).

A number of submissions made to the Authority noted the importance of all levels of government taking a coordinated approach to addressing climate change, from developing the overarching long-term strategy to implementing individual measures in particular sectors (WALGA, Victorian Government, Cement Industry Federation, ASBEC, CAANZ and CPA, NFF, CME WA and Woodside Energy). The WA Local Government Association called on the Australian Government to 'develop a formalised coordinated approach, such as in

the form of a Commonwealth/State/Local Government partnership agreement or Intergovernmental Agreement'.

One early action COAG could take is to commission a review of regulatory barriers to emissions reduction activities. Such a review would ensure there are no unnecessary obstacles to businesses and households taking action on emissions. The results could inform the development of a new National Partnership Agreement. National Partnerships support the delivery of specific projects, facilitate reforms or reward those jurisdictions that deliver on nationally significant reforms. Actions by the states and territories to reduce emissions will help the Australian Government to meet its international targets. Actions to help prepare for climate change will have benefits for the whole economy and reduce risks for the Australian Government related to assuming the role of insurer of last resort in response to climate impacts.

2 Include emission reductions and climate resilience as a standing item on the Council of Australian Governments (COAG) meeting agenda.

6.4. Opportunities for Australia in moving to a low-emissions economy

Discussion of the impacts of policies to reduce emissions often focuses on the economic costs of these government interventions. Modelling exercises that examine scenarios where Australia and the rest of the world are taking action in response to climate change (for example, Fisher 2019; Liu et al. 2019) do show there are costs involved, and it is important that we understand them. However, it is also important to note that these modelling exercises:

- demonstrate that the Australian economy continues to experience robust growth
- show that most of the costs imposed on the Australian economy result from the impacts of the policies implemented by our trading partners rather than domestic climate change policies
- do not consider the benefits of avoiding or minimising the impacts of dangerous climate change (that is, the *avoided* costs of climate change impacts)
- do not consider the dynamic benefits and opportunities that global decarbonisation present to Australia—for example, the emergence of new industries and potential shifts in comparative advantage associated with low-emissions energy resources.

These last two points explain why the typical modelling exercises almost certainly underestimate the benefits to Australia of taking strong action on climate change. Embracing and planning for the opportunities arising from the global transition are vital for maximising our economic prosperity.

For example, there are now many voices spreading the vision of Australia being a world low-emissions energy hub. Australia has plentiful solar and wind and is capable of producing up to 200 per cent renewable energy, or more, in order to meet domestic requirements and service a sizable export industry (Garnaut 2019a; Australian–German Energy Transition Hub 2019; ANU Energy Change Institute n.d.).

South Korea and Japan are potential buyers of hydrogen over coming decades (Commonwealth of Australia 2018b). There are already plans from investors to convert renewable energy to hydrogen and ammonia for export to Asia and for the direct transfer of electricity via an undersea cable to take renewable energy directly from Tennant Creek to Singapore (Government of Western Australia DPIRD 2019a; SunCable 2019).

Our future low-emissions energy sector could also support other industries. Australia could produce energy-intensive commodities, such as green steel (see The Next Economy submission) and, given our proximity to Asian markets, host data centres powered by clean energy (Northern Territory Government 2019). An

emerging clean hydrogen industry could be worth A\$1.7 billion annually and create up to 2,800 jobs by 2030 with the right settings (ACIL Allen 2018). There is potentially a global market for hydrogen of nearly A\$2 trillion by 2050 if the price of producing hydrogen can be reduced to substantially lower than A\$2 per kilogram (Finkel 2020).

Submissions to this review highlighted the opportunities in moving to a low-emissions economy and large costs in not doing so (*The Next Economy*). BCSD Australia has said:

Transforming the decarbonisation of Australia's economy represents a major opportunity for a large number of companies and numerous jobs and new skills can be created. (p. 13)

Australia's low-emissions industries are already making a contribution to the Australian economy and have the potential to become burgeoning export markets and attract strong investment. Australia has:

- existing and emerging green-tech industries, such as the production of zero-emissions hydrogen, and windmill blade and battery production
- reserves of rare minerals needed for battery technologies, which play an increasingly important role in the provision of clean energy
- the land available to contribute significant emissions offsets through land revegetation and regeneration
- low-emissions, climate-resilient infrastructure frameworks and knowhow
- a strong financial services and investment sector with growing climate finance capacity.

(COAG Energy Council 2019a; DIIS and ATIC 2019; CSIRO 2019a; Barrett and Skarbek 2019; Australian Trade Commission n.d.)

Investment in low-emissions activities is growing exponentially. Eighty-three per cent of the forecast US\$13.3 trillion global investment in energy out to 2050 is projected to be directed towards low-emissions solutions (BloombergNEF 2019a). The increase in available capital coupled with the current macroeconomic environment of sustained low interest rates has lowered the cost of emissions reduction policies and investments. This provides the private sector and governments with a unique opportunity to invest in low-emissions technologies that will open up new areas of economic opportunity and create long-term growth (OECD 2017). Several stakeholders highlighted this opportunity during consultations.

Australia should capitalise on its competitive advantages and favourable market conditions. Several countries around the world, including Australia's key trading partners, have already carried out analyses of the size and performance of their low-emissions economies as part of their trade and investment strategies (HM Government 2015; Analytica Advisors 2017; New Zealand Productivity Commission 2018). However, the contribution of Australia's low-emissions industries to the economy is currently not well understood.

Investor stakeholders highlighted the need to define and classify Australia's low-emissions economy in order to encourage global investment that is currently looking for low-emissions opportunities (Responsible Investment Association Australasia submission, p. 5). This is discussed further in Chapter 15. Research that provides a comprehensive analysis of Australia's low-emissions industry sectors, including size, performance and contribution to the overall economy, will help investors to identify and respond to opportunities and assist policy makers to determine the barriers and pathways to growth. The forthcoming technology investment roadmap is intended to help identify emerging low-emissions technologies and pathways to efficient deployment and commercialisation (Taylor 2020).

3 Develop a trade and investment strategy that identifies and leverages Australia's competitive advantages in a net-zero emissions world.

6.5. Helping regional communities transition to a low-emissions economy

The move to a low-emissions economy will create opportunities for new industries and pose challenges for emissions-intensive industries. In regions that are dominated by emissions-intensive industry, there is a risk of higher unemployment and regional decline if the transition is not well managed.

The need for communities to adapt and respond to significant changes in economic circumstances is not new and will continue. The transition to a low-emissions global economy is not unique in requiring us to think about how we can respond to remain prosperous. Over time, industries rise to prominence and can also fade in response to a myriad of global and local factors. The Productivity Commission has noted that:

Despite significant and systemic changes across Australia's regions, most have continued to grow and prosper. History shows, however, that the factors underpinning regional activity do change and that some regions will inevitably decline. Good policy needs to recognise this reality in supporting regions to adapt to changing circumstances. (Productivity Commission 2017)

Examples of governments assisting communities through industry adjustment in Australia include the closure of BHP's steelmaking facilities in Newcastle in 1999 and closure of car manufacturing in Victoria and South Australia in 2016 and 2017. In these cases, regional communities were assisted in the transition by coordination of initiatives by governments of all levels and industry, as well as sufficient notice in the lead-up to closures (Jones et al. 2017; DoE 2019).

Many submissions raised the importance of managing an orderly transition and providing assistance for communities to mitigate the negative impacts, especially for those affected by coal power plant closures (Shire of Augusta Margaret River, BCSDA, Australian Marine Conservation, CMI, Friends of the Earth). As discussed in the Chapter 8, a substantial proportion of Australia's coal-fired power station fleet is approaching end of life in the next two decades. The need for all levels of government to be part of the transition, along with businesses and communities, was also highlighted (Energy Australia, Chartered Accountants Australia New Zealand and CPA Australia submissions).

International experience from closures of coal-fired power plants and coal mines, and experience from other transitions in Australia, shows the need to diversify and build resilience in affected communities. This requires identifying a region's strengths and assets and prioritising new investment in an industry of competitive advantage (Productivity Commission 2017; Investor Group on Climate Change 2017; Agora Energiewende et al. 2019). When this process happens well in advance of industry closures, the community and workforce are able to prepare ahead of time (Jotzo et al. 2018; Agora Energiewende et al. 2019). It is important too that the process is regionally driven and the community is involved. Germany's Coal Commission is held up as an international example of an organisation with a long-term transition plan that has gained agreement through the collaboration of all key stakeholders (Agora Energiewende et al. 2019).

A smooth and orderly transition will require consideration of the potential barriers to change. To help communities take advantage of new opportunities for investment, whether they be in reducing the emissions intensity of existing activities or in exploiting new economic opportunities, it is important to remove unnecessary planning and other regulations that can present obstacles (Productivity Commission 2017). Other arrangements can also potentially affect the transition of a region. The Port of Newcastle—Australia's largest coal exporting port—has developed a strategy to diversify its business, including through building a container terminal for non-coal freight business (Port of Newcastle 2018). However, a potential barrier to this change is the penalty the Port of Newcastle would pay to the NSW Government for handling non-coal

container freight. Identifying various types of barriers could be a part of the long-term strategies being developed by states and territories to meet their long-term emissions reduction goals.

Another crucial part of the low-emissions transition is supporting new industries with an appropriately skilled workforce and providing meaningful new employment for workers affected by facility closures. Submissions to this review said that skills are needed to support new industries, such as carbon markets, and to support the economic transition of the electricity sector (CMI, City of Sydney). The BCSD Australia considered that:

Anticipating these changes by Government is crucial so that companies and communities in adversely affected regions and sectors are assured that the level of employment, qualifications and skills is improved. (p. 15)

For affected communities, providing people with retraining and job services systems is part of an effective response to economic disruption in a region (Productivity Commission 2017).

A number of sectors in Australia are likely to experience significant change. The transition away from emissions-intensive electricity generation and towards low-emissions electricity generation has already started, driven by supportive policies and the lower costs and emissions of renewables. The CFMEU Mining and Energy Division submission states that ‘With around 33% of Australia’s emissions coming from power generation—coal and gas—it is abundantly clear that the industry will undergo major transformation and that such transformation has already commenced’ (p. 2). The Hazelwood power plant closed in 2017 and by the mid-2030s around two-thirds of Australia’s coal capacity will have reached technical end of life. New technologies and market pressure will provide challenging circumstances for investors wanting to replace these power plants with new coal plants (Investor Group on Climate Change 2017). Significant investment in renewable and other low-emissions electricity generation and storage is expected (Chapter 8). Box 8 provides three examples of regions with jobs provided by coal-fired power plants that are actively engaged in diversifying their economies to create new skilled jobs.

Box 8 Communities transitioning from coal-fired power**Latrobe Valley, Victoria**

The Latrobe Valley Authority, supported by A\$266 million from the Victorian Government, was developed to support the communities, workers and businesses affected by the closure of the Hazelwood power plant and mine in 2017 (LVA 2016, n.d.). The Latrobe Valley Authority is collaborating with the community to deliver new jobs by building infrastructure that meets community needs and creates jobs. The Latrobe Valley Authority is also coordinating with government to facilitate investment through policies such as additional renewable energy investment incentives, investment tax incentives and the prioritised construction of new infrastructure. While the Latrobe Valley Authority has been held up as an example of good practice, it was created only five months ahead of the closure, which was the notice period given by Engie, leading to a sharper transition (Jotzo et al. 2018).

Hunter Valley, New South Wales

In the Hunter Valley, the Hunter Energy Transition Alliance,¹⁶ in consultation with stakeholders, has produced a blueprint to manage the closure of both Liddell and Bayswater power plants, in 2023 and 2035 respectively, and diversify the region (HETA 2016). AGL, which owns both power plants, has developed a detailed transition plan for the closure of Liddell seven years in advance, including new investment in renewable generation and storage and a new gas peaking plant (AGL 2017). It also committed to no forced redundancies when Liddell closes and to providing retraining for workers (AGL 2019).

Collie region, Western Australia

In Western Australia, the state government Collie Futures Fund is a five-year initiative to diversify and develop the Collie region, although it does still allow funding to support optimising the use of the area's coal resources (SWDC 2019, n.d.). Funding of A\$20 million is currently available, with a further A\$42 million announced (Government of Western Australia 2019a; SWDC n.d.)

A transition to a low-emissions economy will occur alongside other impacts on communities, such as global markets influencing Australia's economy as demand for our goods and services change, as well as the direct impacts of climate change (Chapter 2). Examples of community change being approached in an integrated way is the A\$1.5 million Communities in Transition pilot program, supported by the Queensland Government (Clean Growth Choices n.d.). The pilot is working with six communities in regional Queensland to deliver roadmaps and business cases addressing economic, social and environmental prosperity to help the communities shift towards a more resilient future. In addition, the Australian Government recently announced funding for the Cooperative Research Centre for Transformations in Mining Economies. This initiative is intended to provide the tools for towns and regions to take advantage of opportunities for new jobs and development that will enable them to continue to prosper, including where they are highly dependent on individual mining projects (Andrews, Pitt 2020).

¹⁶ The Hunter Energy Transition Alliance is a partnership between AGL and the NSW Energy and Resources Hub.

- 4 Governments should work together to support industries and communities facing an uncertain future to identify pathways for industries to evolve and remain competitive and to exploit new economic opportunities, including:**
- potential infrastructure requirements and supply chain logistics
 - assessment of vocational training needs for new low-emissions industries
 - exploration of opportunities for Indigenous communities.

6.6. Meeting Australia's 2030 target with new emissions reductions

Australia's 2030 target under the Paris Agreement is to reduce emissions by 26 to 28 per cent on 2005 levels by 2030. The Australian Government has said it will use an emissions budget over the period 2021 to 2030 to assess progress to the target, and its official emissions projections indicate it will use up to 411 million tonnes of emissions reductions carried over from over-achievement of earlier targets (Chapter 4).¹⁷ More recent statements by the government indicate it will seek to 'meet and beat' its 2030 target without the use of carryover if possible (Morrison 2020a).

The Kyoto Protocol, which preceded the Paris Agreement, allows a country to help meet its emissions target using carried-over emissions reductions ('carryover') from the over-achievement of a previous target (CCA 2014a). Under the Kyoto Protocol, carryover may only be used for the next target and cannot be rolled over again for successive targets.¹⁸ Using the 128 million tonnes of carryover from 2008–2012 to meet a 2030 target would not be allowed under the Kyoto Protocol rules; however, the Paris Agreement rules apply to 2030 targets. The Paris Agreement rules are currently silent as to how carryover would apply, although countries were encouraged to cancel Kyoto units as part of the decision adopting the agreement.¹⁹

There is a short-term benefit to Australia in using its carryover surplus in that it makes it easier to meet its 2030 target. However, the reduced task lowers the level of ambition represented by Australia's 2030 target to about a 14 per cent reduction on 2005 levels instead of a 26 to 28 per cent reduction. Relying on carryover credits to meet Australia's 2030 target will essentially defer Australia's transition and require accelerated emissions abatement in future years.

Australia's emission reduction efforts will be better recognised by many in the international community if targets are met without the use of carryover credits. At the UNFCCC Conference in December 2019, Australia faced harsh criticism for its position on the use of carryover credits (Carbon Brief 2019). To date, Australia is the only country to have indicated it may use carryover to meet its commitment under the Paris Agreement. New Zealand has declared it will not use any carryover units to meet its Paris commitments

¹⁷ Australia has 128 million tonnes of surplus from its first Kyoto target to limit emissions to 108 per cent of 1990 levels over 2008–2012 and is projected to over-achieve its 2013–2020 target to limit emissions to 5 per cent below 2000 levels by 283 million tonnes (DoEE 2019i).

¹⁸ Decision 3/CMP.11 of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol: <https://unfccc.int/resource/docs/2015/cmp11/eng/08a01.pdf>.

¹⁹ Decision 1/CP.21 of the Conference of the Parties to the UNFCCC: <https://unfccc.int/process-and-meetings/conferences/past-conferences/paris-climate-change-conference-november-2015/cop-21/cop-21-decisions>.

(Hannam 2018). The United Kingdom, Germany, Sweden, Denmark and the Netherlands cancelled over 600 million surplus units from the first Kyoto period and several member states committed to cancelling significant additional amounts of over-achievement in the second commitment period to send a ‘strong positive signal of support for an ambitious global climate agreement’ (Regeringskansliet 2015). Globally, in the order of several billion surplus units were created from the first Kyoto period (Climate Analytics 2012). Widespread use of these surplus units towards countries’ Paris Agreement targets would undermine achievement of the goals of the agreement.²⁰

If Australia meets its target through emission reductions from within the target period (2021–2030), future, more ambitious targets under the Paris Agreement will be easier and less costly to meet compared with delayed action with the use of carryover credits. New industries expected to arise in a low-emissions economy will also benefit from an earlier transition, as they have the opportunity to get established ahead of counterparts in competitor countries. This concern with the use of carryover was echoed in some submissions (Business Council for Sustainable Development Australia, Carbon Market Institute).

Stakeholders who addressed the issue of carryover expressed a range of views on its use. The Australian Industry Greenhouse Network considers that the use of carryover should be possible. The National Farmers’ Federation submission ‘supports the use of carryover from earlier commitments to meet emissions reduction targets’ (p. 20). A number of stakeholders are against the use of carryover on the basis this weakens action to mitigate climate change (for example, Chartered Accountants Australia New Zealand and CPA Australia, Business Council for Sustainable Development Australia, Carbon Market Institute, WA Local Government Association, and some community groups and individuals).

It is the Authority’s view that the Government should aim to meet the 2030 target using emissions reductions achieved during this time period (2021–2030) and apply carryover only as a last resort.

5 Aim to meet Australia’s 2030 Paris Agreement target using emissions reductions achieved between 2021 and 2030.

6.7. International collaboration

6.7.1. Supporting strong global action

As discussed in Chapter 5, addressing climate change is a global challenge requiring actions by all nations. Furthermore, as discussed in Chapter 2, a strong global effort to reduce greenhouse gas emissions and avert the worst impacts of climate change is very much in Australia’s interests, as we are one of the developed countries most vulnerable to climate change. Australia will benefit in other ways as well:

- There will be increased international demand for our existing and emerging low-emissions energy resources, technologies, industries and services.
- Strong action in other countries will enable Australia to address the challenge of reducing emissions in emissions-intensive, trade-exposed industries with fewer concerns about the international competitiveness of those industries and the risk of businesses (and emissions) moving offshore (see Chapter 9).

²⁰ Globally, in the order of several billion surplus units were created from the first Kyoto period (Climate Analytics 2012).

There is an opportunity for the Government, within its long-term climate strategy, to develop a strategic approach to promoting and supporting a stronger global response to climate change. As described below, Australia is already participating in, and in some cases leading, a range of international initiatives and forums that sit alongside the Paris Agreement to facilitate cooperation on climate action. An international climate strategy could ensure these efforts sit within an overarching framework, with clear objectives, and are integrated and prioritised appropriately for maximum effectiveness. The strategy could also incorporate efforts to make the most of the opportunities offered by international trade in emissions reductions (discussed in Section 6.7.2) and link with efforts to develop and promote emerging and potential new export industries (Recommendation 3). Effective communication of a robust international climate strategy would underscore Australia's commitment to climate action and potentially lessen our exposure to transitional risks, such as the inclusion of climate-related measures in countries' trade regulations and agreements.

Australia is supporting global action by assisting other countries to respond to climate change. The Government has allocated A\$500 million of aid funding from 2020 to 2025 to building Pacific climate change and disaster resilience through its development assistance program. Details are set out in the *Climate Change Action Strategy*, published by the Department of Foreign Affairs and Trade (DFAT 2019). This builds on the Government's previous commitment in 2015 to allocate A\$1 billion over the five years to 2020, which included A\$300 million to address climate change and disaster resilience in Pacific island countries (DFAT 2019). Other initiatives supported by the Australian Government through this funding include:

- a contribution of A\$200 million between 2015 and 2018 to the Green Climate Fund—a global fund established under the UNFCCC to help developing countries reduce their emissions and adapt to climate change (DFAT n.d.b)
- Australia's contributions to the Asian Development Bank, World Bank, Global Green Growth Institute and United Nations Agencies, which provide climate change assistance to developing countries through their programs (DFAT 2017)
- a contribution of A\$93 million to the Global Environment Facility between 2014 and 2018 to support the reduction of emissions and building resilience in the Pacific region (DFAT n.d.b).

The Australian Government is also collaborating with countries to help them build technical capacity to track greenhouse gas emissions. For example, Australia is working directly with Indonesia and Kenya to build systems to measure and report on the carbon stored in land, vegetation and soils and with Thailand to develop its national emissions inventory information system. Through the Global Forest Observations Initiative, Australia is partnering with governments (Norway, United States, United Kingdom and Germany) and multilateral organisations (FAO and World Bank Group) to build forest monitoring capacity in developing countries in South America, Africa and Asia. This capacity-building work lays the foundations for effective emissions reduction action.

The Government is participating in a range of international initiatives seeking to accelerate research and development (R&D) and innovation on emissions reduction technologies. For example, Australia participates in the Mission Innovation initiative, which is working to accelerate clean energy innovation—Australia co-leads the renewable and clean hydrogen work stream (which exists primarily due to Australia's efforts) and the business and investor engagement subgroup. At the UNFCCC Conference of the Parties meeting in Madrid in December 2019, the Government announced that it is joining the Leadership Group for Industry Transition. The group's goal is to support the transition of heavy industry to net-zero carbon emissions by 2050.

Australia coordinates the International Partnership for Blue Carbon—an initiative that seeks to protect and conserve coastal blue carbon ecosystems (mangroves, tidal marshes and seagrasses) for both climate

change mitigation and resilience benefits (International Partnership for Blue Carbon n.d.). Australia is also a member of the 14-country High Level Panel for a Sustainable Ocean Economy, which is developing a roadmap for rapidly transitioning to a sustainable ocean economy. The panel has examined both the expected impacts of climate change on the ocean economy (for example, marine fisheries, aquaculture and tourism) and how ocean-based solutions can contribute to climate change mitigation efforts (Hoegh-Guldberg et al. 2019; Gaines et al. 2019).

6.7.2. International trade in emissions reductions

In its 2016 climate policy toolkit report, the Authority set out the case for using credible, high-quality international emissions reductions in the form of tradable units (credits from offsets projects or permits from emissions trading schemes) to complement Australia's domestic climate action. International carbon markets provide countries with the flexibility to outsource some of their abatement to other countries and allow selling countries to benefit financially when they over-achieve on their targets.

A global carbon market would allow countries to access the cheapest abatement in the world and reduce the overall cost of meeting the global targets. The World Bank estimates that international carbon trading could reduce global mitigation costs by around 54 per cent, or almost US\$4 trillion, in 2050 (World Bank 2016).

There are 27 emissions trading initiatives underway or scheduled for implementation in jurisdictions worldwide. However, most of these do not extend beyond national boundaries (World Bank 2019). Carbon trading has been part of the UNFCCC architecture since the Kyoto Protocol was negotiated in 1997. The Paris Agreement also provides for countries using international emissions trading to assist in meeting their emissions reduction targets. This can take the form of either:

- direct trading of emissions between countries, referred to as 'cooperative approaches'
- participation in a centralised 'mechanism for sustainable development and mitigation' to be developed under the Paris Agreement (Paris Agreement 2015, Art. 6).

Although the Paris Agreement rules for international carbon trading are still under negotiation, around half of the parties to the agreement have expressed their intention to use international carbon trading and are engaged in discussions with trading partners. Many low-income countries are seeking to sell emission units to generate income. There are fewer countries that have indicated an intention to purchase abatement, but they include Japan, Norway, Switzerland and Turkey (Brandi 2017).

The Authority noted in 2016 that using credible international units could lower the cost of meeting Australia's emissions reduction goals and may also reduce international competitiveness concerns for Australian businesses by providing access to a wider range of low-cost emissions reductions opportunities. Chapter 9 discusses the potential role for international units under the Authority's proposed enhanced Safeguard Mechanism, noting the strong support from business stakeholders who are keen to ensure that abatement is sourced at lowest cost from around the world.

The principles for the use of international units that the Authority outlined in 2016 remain relevant:

- Our transition to a lower emissions economy must not be delayed by the use of these permits and credits. This risk can be managed through limiting the volume of international permits and credits that can be used to meet emissions reduction obligations in Australia.
- There are many different types of international units, and their environmental integrity varies, which means our confidence that they genuinely represent abatement and avoid adverse impacts (for example, on biodiversity or communities) varies. To preserve the environmental integrity of

Australia's climate policies, we should only link with robust sources of international permits and credits and set strict eligibility criteria for permits and credits based on their environmental integrity.

Australia has particular strengths in carbon markets. Our land sector offset scheme (the ERF) is well established and highly regarded, and we have expertise and an industry involved in carbon markets, including measuring, reporting and verifying abatement. Australia already exports some of these skills and supports other countries in our region through capacity-building programs such as those described above. As well as supporting partner countries to meet their targets, these programs build the foundations of carbon markets and, together with other fora, provide an avenue for influencing the development of standards for offsets schemes in our region. This will benefit Australian businesses and help ensure international standards align with our existing schemes.

The Australian Government supports in principle the use of international units but does not currently allow the use of international units in the Safeguard Mechanism, nor can ACCUs be exported. The Government has committed to considering the use of international units in 2020 as part of the 2020 review of the Safeguard Mechanism and development of its long-term climate change strategy (Australian Government 2017). These reviews present an opportunity for developing a strategy for Australia's approach to trading emissions reductions to ensure we take advantage of low-cost abatement opportunities overseas and realise the potential benefits of exporting abatement from Australia when the circumstances are right.

To maximise the likelihood of a future successful carbon offsets export industry, we need to ensure our emissions reduction ambition is regarded as adequate, our units are known to be high integrity, and we can over-achieve on our targets. Extensive land resources and expertise in land-sector abatement positions Australia well to export land-based carbon offsets. We therefore need to continue to develop land-based offsets and other negative emissions technologies (NETS) such as bioenergy carbon capture and storage (BECCS) (see Chapter 14). Offsets from NETs projects will become increasingly important as countries approach their net-zero goals.

6 Develop an international climate strategy to:

- **support a strong global response to climate change that minimises physical impacts on Australia and increases international demand for Australia's emerging low-emissions export industries**
- **maximise the opportunities for Australia from international trade in emissions reductions, including by:**
 - a. **identifying potential carbon trade partners, prioritising developing countries in our region**
 - b. **supporting potential trade partners to build their capacity to deliver low-cost, high-integrity international units**
 - c. **defining the criteria for and identifying the international units considered to be 'high-integrity' and acceptable to Australia**
 - d. **establishing quotas on the import of international units to ensure Australia's domestic transition to a low-emissions economy continues**
 - e. **establishing a timeline for high-integrity international units to be permitted under the enhanced Safeguard Mechanism.**

7. PREPARING FOR A CHANGING CLIMATE

Enhancing our preparedness for future climate impacts will protect the resilience, health and wellbeing of Australians and sustain Australia's economic productivity and the natural systems that support us.

All levels of government have differentiated yet complementary responsibilities in preparing Australia for a changing climate. The Australian Government has a leading role to play in strengthening Australia's climate resilience. This stems from the nationally significant economic and social consequences of major climate-related events, the key roles played by such agencies as the Bureau of Meteorology and CSIRO, the significant funding contributions that the Government makes in areas such as health and transport infrastructure, and the 'insurer of last resort' function it frequently performs in relation to national disaster recovery. State and territory and local governments also have crucial roles in relation to delivery of services and infrastructure and land-use planning.

Information about the impacts of climate change and options to manage future changes supports effective decision making, is vital for the preparations Australians need to make and informs mitigation efforts. There is a role for the Australian Government and its science agencies to lead and coordinate the production and communication of Australia-specific climate change information.

As discussed in Chapter 2, the impacts of climate change are already being felt around the world and in Australia. Some further global warming is inevitable even if the Paris Agreement is successful. The Bureau of Meteorology and CSIRO project Australia to experience:

- further increases in sea and air temperatures, with more hot days and marine heatwaves, and fewer cool extremes
- further sea-level rise and ocean acidification
- decreases in rainfall across southern Australia with more time in drought, but an increase in intense heavy rainfall throughout Australia (BoM and CSIRO 2018).

Human and natural systems are, to varying degrees, resilient and adaptable to climate change and climate variability. However, given the projected pace and extent of climate change impacts, we will also need planned and proactive efforts to sustain Australia's future economic productivity and the natural systems that support us. Alongside goals to limit global warming, the Paris Agreement (Art. 2) recognises increasing the ability to adapt to the adverse impacts of climate change and fostering climate-resilient and low-emissions development as equally important objectives.

Recent extreme weather events in Australia, including the current severe drought and associated 2019–20 bushfire season, have raised awareness of the importance of enhancing our preparedness for climate change impacts. The issues are recognised as a priority for the agriculture industry, the health sector, emergency services and many regional communities (Australian Farm Institute 2019; Doctors for the Environment Australia 2019; Emergency Leaders for Climate Action 2019). There is also growing awareness from regulators and the finance sector of the macroeconomic effects and insurance risks of the physical impacts of climate change (Chapter 15).

There are benefits in well-planned actions to build our resilience to the physical impacts of climate change that include maintaining business productivity, reducing health impacts of extreme weather and minimising upward pressure on insurance premiums (CBA 2019; Beggs et al. 2019; APRA 2019a).

As noted in the Australian Government's 2015 National Climate Resilience and Adaptation Strategy (Australian Government 2015a), climate-resilient pathways for development and growth will depend on what

the world accomplishes with greenhouse gas emissions reduction. Successful global action to reduce emissions will reduce the rate and magnitude of warming, increasing the time available to prepare for a given level of climate change and reducing the chances of dangerous climate change that could exceed our capacity to respond effectively.

7.1. Responsibilities of different levels of government

Governments are responsible for creating the conditions and incentives to enable communities and the private sector to manage climate change risks and impacts and to build resilience. In Australia, these responsibilities are split between the federal, state and local governments who all have differentiated yet complementary roles.

The Australian Government has overall responsibility for the national economy and Australia's national interests and should therefore play a leading role in positioning Australia to adapt to climate change, as it affects the nation's prosperity and security. In particular, the Government is in a position to lead on the provision and coordination of national and regional science and information so that communities and businesses can plan for and mitigate their risk. This includes funding, managing and coordinating climate change science and national adaptation research. The Australian Government is also best placed to lead on certain national adaptation reforms that are likely to impact the national economy and national security and affect natural systems of national significance—for example, water management and electricity generation (NCCARF 2012).

State and territory governments deliver a broad range of services and are primarily responsible for service delivery and infrastructure, such as emergency management, transport infrastructure, land-use planning, health and education services and public housing. Local governments have an important role to play through local planning and regulations and managing the risks and impacts of climate change on local service delivery (NCCARF 2012).

Coordinated allocation of climate adaptation and resilience tasks across levels of government will be crucial to ensuring Australia can manage the risks and impacts of climate change. In doing so, local capacity and knowledge will need to be balanced with considerations of national significance, the benefits of national coordination and the existing allocation of government responsibilities and accountabilities (NCCARF 2012).

The terms of reference of the recently established National Royal Commission into the 2019-20 bushfire season address, among other issues, the responsibilities of, and coordination between, Australia's levels of government in relation to preparedness, response, and recovery from natural disasters. The inquiry will look at resource sharing arrangements, Australia's legal framework for the designation of government responsibilities and whether nationally consistent accountability and reporting frameworks and standards are required (Morrison 2020c). The findings of the Royal Commission will likely inform future coordination efforts of climate resilience tasks between levels of governments.

7.2. Building resilience to climate change impacts

The Garnaut Climate Change Review found that an effective adaptive response to climate change needs both well-functioning markets and appropriate information on impacts (Garnaut 2011). The information should be in a form that is useful to businesses, governments and communities to help them assess and manage climate risks and respond to the impacts. It should be supported by research and include appropriate tools and technologies.

Improving our resilience to the changing climate will involve important, long-term decisions about land-use planning and major infrastructure development. Adaptation responses are likely to be most effective if integrated with mitigation and other mainstream policies, including health, regional development and

biosecurity (IPCC 2018). As climate changes continue, there will also increasingly be a need to consider systemic and transformational approaches in decision making, rather than just incremental changes (Rickards and Howden 2012).

Some parts of the Australian economy need a greater focus on adaptation, as they are more exposed to the physical risks of climate change (for example, long-lived infrastructure, coastal environments and agriculture) or because they need to respond to the impacts of climate change (for example, health systems and disaster response). Building greater resilience within our social, economic and environmental systems is integral to enhancing our preparedness for climate change. Examples include building housing and transport infrastructure to better withstand weather extremes and improved community preparedness for a natural disaster event.

The tools used to adapt to climate change will typically be different across the country—for instance, the adaptive responses to the increased variability of rainfall will be different in interior Australia (where prolonged drought may affect the viability of primary industry) compared with coastal Australia (where desalination of seawater may be an option). Increased recycling of water may be viable in a range of areas. Local adaptive capacity will vary depending on available resources, requiring adaptation to take account of local circumstances responses (Productivity Commission 2012; Stafford Smith and Ash 2011; Doran 2011). In addition to planning for adaptation, responses need to be continuously monitored and evaluated to ensure adaptation initiatives are actually reducing vulnerability to risk and to enable knowledge sharing of what interventions are working, how they are working and in what contexts (Scott 2019).

Information about the impacts of climate change supports effective decision making, as well as informing efforts to prepare for and mitigate climate change (Productivity Commission 2012; Australian Government 2015a). This includes information on how the climate may change in the future, what the likely impacts might be and how to prepare to minimise the impacts and to take advantage of any opportunities. Global research on climate change examines the Earth system as a whole and provides more limited information at a local scale. The process of making the outputs of global models relevant to local scales is known as downscaling (DoEE n.d.g). Downscaled climate information is typically of greater use to governments, businesses and communities than broad-scale global trends and can be used in conjunction with other environmental, economic and social information to inform decision making. Downscaled information also needs to be translated into practical and usable formats so that the information can help diverse decision makers such as agricultural and resource managers, insurers, directors, investors, health professionals, households and governments to reduce their particular risks and adapt accordingly (NCSAC 2019).

As the Australian continent and adjacent oceans have many unique ecosystems, it is important that Australia retains the ability to generate knowledge about uniquely Australian environments through basic and applied research. It is likely that climate change will affect Australian conditions in different ways from those experienced overseas, meaning that international science will have a limited ability to inform Australia's response to climate change (Australian Academy of Science 2017). Ready access to local expertise on climate change also facilitates the development of more widespread and more effective climate change adaptation strategies.

Box 9 Preparing for a changing climate

Actions for preparing and responding to a changing climate include:

- managing climate risks to natural assets that provide critical ecosystem services and recreation opportunities and those that support business
- enhancing emergency management strategies, arrangements and responses
- increasing community understanding of climate risks to build capacity in the community to respond to the changing climate
- advancing climate science and providing regionally specific information and tools
- driving innovation and changes in products, services and markets to create more sustainable practices
- embedding climate change considerations into policy, regulation and decision making
- reducing health risks and considering climate in health service planning
- continuing to participate in strong global action to reduce emissions, minimising the impacts of climate change
- facilitating the implementation of priority adaptation actions across industry and community sectors
- managing risks to the built environment, facilitating coastal hazard adaptation planning and embedding adaptation in land-use planning
- improving access to information products, resources and tools to support adaptation decisions by businesses and households.

Sources: Australian Government 2015a; Victorian Government 2017; Queensland Government 2017a

The scale and complexity of climate modelling and projections means that forming useful information is an activity beyond the capability of individuals and all but the largest of businesses. Locally relevant information on climate change impacts is required to allow people and organisations to adequately prepare for and optimally adapt to climate change impacts. Relevant information includes not only anticipated changes to weather and climate but also how other local biophysical systems (including plants and animals) will respond to the changed climate. Initially, this is of particular importance to those most exposed to climate change impacts, such as primary industries and local government. However, as the impacts of climate change become more severe and are felt by more people and organisations, the need for relevant, high-quality information to prepare for climate change will become more widespread (Stafford Smith and Ash 2011; IPCC 2018; Productivity Commission 2012).

7.3. Current policies

The role for government leadership in enhancing our preparedness for the changing climate is recognised by the Australian and state and territory governments (for example, COAG 2007; Australian Government 2015a; Victorian Government 2017; Queensland Government 2017a). It includes all levels of government being involved in:

- building adaptive capacity through the provision of information and tools and investing in climate science
- integrating climate change into policies and strategies and managing risks to government assets
- maintaining essential services to deal with the impacts of climate change.

The Australian and state and territory governments all have strategies for adapting to the physical impacts of climate change or have broader planning and resource management legislation and policy to address climate risks (CCA 2019b). Some of these strategies provide detailed forward action plans (Victorian Government 2017; Queensland Government 2017a).

The Australian Government's *2015 National Climate Resilience and Adaptation Strategy* is principles based and reiterates the need for climate risks to be integrated into decision making (Australian Government 2015a). The strategy identifies eight priority sectors for adaptation: coasts, cities and the built environment, agriculture, fisheries and forestry, water resources, natural ecosystems, health and wellbeing, disaster risk management, and a secure and resilient region.

The Government is working to integrate climate and disaster risks in its policies, programs and assets. The Australian Government Disaster and Climate Resilience Reference Group is a coordinating group of senior government officials that considers the risks and opportunities from climate change and natural disasters. As part of the reference group work plan, CSIRO and the Department of the Environment and Energy developed a climate risk management framework for Commonwealth agencies called Climate Compass (DoEE 2018c). Climate Compass provides guidance to Australian public servants on identifying and managing climate risks from the strategic through to operational level. This approach is starting to be incorporated in the Government's programs—for example, the Department of Agriculture is committed to integrating climate risk management across its portfolio (DoA 2019a).

Agriculture ministers have also agreed to a program of work to assist the agriculture sector to adapt to climate change and manage emissions (Chapter 11). The Government's Future Drought Fund and Natural Disaster Resilience Funding will provide significant financial support for building resilience to the impacts of extreme climate events. The government-supported rural research and development corporations also deliver the Managing Climate Variability program, which provides climate information for primary industries (MLA n.d.).

The National Disaster Risk Reduction Framework emphasises proactive risk-reduction measures, including factoring in climate risk, to minimise the loss and suffering caused by disasters (Commonwealth of Australia 2018a). COAG endorsed the Framework in March 2020 and asked Emergency Management Ministers to develop a National Action Plan for its implementation, which will be supported by a new A\$261 million Commonwealth-State partnership agreement. Additionally, Infrastructure Australia has highlighted the importance of considering climate resilience in the construction of major projects (Infrastructure Australia 2019).

The success of a resilience approach can be seen in the Queensland Betterment Fund—a joint initiative of the Australian and Queensland governments that allows local governments to restore or rebuild public assets to a more disaster-resilient standard following damage from a natural disaster. Following Tropical Cyclone Oswald in 2013, A\$27 million was spent restoring or rebuilding assets to an improved standard. These same assets were left only superficially damaged following Tropical Cyclone Marcia in 2015 due to the higher standards used in the rebuilding (Queensland Government 2017a).

7.3.1. Climate research and information

Australian Government agencies lead the development and distribution of climate change information for Australia, principally through the Bureau of Meteorology and CSIRO. With partners, the Government also supports further climate change research through the National Environmental Science Program, particularly the Earth Systems and Climate Change Hub, and higher education research institutions (DoEE n.d.l). These agencies participate in the global climate science effort and develop tools and knowledge to assist in development of climate information relevant for Australia. Other agencies also support Australia's contribution to the global climate science effort, including the Australian Antarctic Division, the Australian Institute of Marine Science, the Australian Nuclear Science and Technology Organisation and Geoscience Australia. There are also organised academic efforts through the Australian Research Council Centre of Excellence for Climate Extremes. Universities also contribute to building the knowledge base.

Examples of Australian Government funded climate change information resources are the Climate Change in Australia website, which includes a 'Regional Climate Change Explorer' that provides a summary of climate change projections for Australia based on national resource management regions; and CoastAdapt—an online support tool for managing climate risks in Australia's coastal zone (Australian Government n.d.; NCCARF n.d.). Developed by the National Climate Change Adaptation Research Facility, CoastAdapt provides specific information on local sea-level rise under a range of global climate change scenarios. This enables individuals and organisations to make better-informed decisions when undertaking economic activity near the ocean. In the financial sector, company reporting under the guidance of the international TCFD is intended to inform markets about climate risks (see Chapter 15).

The Australian Government is also providing A\$6.1 million over three years, beginning 2018–19, to improve climate and extreme weather information for the electricity sector (DoEE n.d.f). This project will make existing climate change data and research more accessible and useful for decision makers and improve long-term operational and strategic planning for electricity infrastructure. The work is being undertaken by the CSIRO and the Bureau of Meteorology in collaboration with the Australian Energy Market Operator.

State and territory governments have also invested in developing granular climate change information resources for their jurisdictions. For example, the Queensland Government's Future Climate Dashboard provides locally relevant information across a wide range of climate variables (Queensland Government n.d.). Previously, state governments have also been leading partners in climate research initiatives that delivered climate change understanding—for example, the Indian Ocean Climate Initiative and the South Eastern Australian Climate Initiative (IOCI 2011; SEACI 2012). While there are exceptions (the Victorian Department of Environment, Land, Water and Planning's Victorian Water and Climate Initiative), funding and effort for these initiatives have now largely ceased. Given the recent advances in the understanding of climate change and the emergence of a new generation of climate models, new insights are now available and some of the information developed by these programs in the earlier part of the decade may now be outdated.

Research on impacts and adaptation strategies, and the effective communication of information and advice produced, is vital for improving our resilience to and preparedness for climate change. Without further research and innovation, the future impact of climate change on the health and wellbeing of Australians, the Australian economy and the Australian environment will be greater than it would otherwise be. Research is recognised as a priority under the *2015 National Climate Resilience and Adaptation Strategy*, although the Government's investments have been sporadic. The main government-funded research initiatives have included:

- development of a world-leading capability in the provision of Earth system and climate information by the Earth Systems and Climate Change Hub of the National Environmental Science Program (A\$23.9 million for the period 2015–2021)
- creation of a decadal climate science and modelling capability by CSIRO (A\$37 million over 10 years commencing in 2016)
- Antarctic ice core research to improve understanding of the Earth’s climate system (A\$45 million for the period 2016–2025)
- research and engagement to help the Great Barrier Reef to resist, recover from and adapt to a changing environment (A\$100 million, announced in 2018–19 Federal Budget)
- a four-year study administered by the Murray-Darling Basin Authority to examine how climate change and hydrology affect the environment and the livelihoods of people in Basin communities, to help inform water and environmental management decisions in the catchment (A\$20 million, announced in September 2019).

Funding for the National Climate Change Adaptation Research Facility ceased in 2017.

7.4. Opportunities for enhancing our preparedness

The Australian Government has a significant leadership role to play in improving Australia’s preparedness for climate change impacts. This derives from a range of factors, including:

- the policy leadership role it plays in areas such as agriculture, water, energy, national disaster risk management and biosecurity
- the significant levels of funding it provides to the states and territories for spending on hospitals, transport infrastructure and natural disaster recovery
- the Government’s own programs, including defence and communications
- the scientific expertise in agencies such as the Bureau of Meteorology and CSIRO, which are already playing a vital role in disseminating information on current and future climate impacts.

Notwithstanding the range of government initiatives currently underway, several submissions (for example, AFPA, RMA, GBRMPA, WALGA, EDO, MCA, APPEA and Shire of Augusta Margaret River) raised the need for governments to address climate change adaptation and to provide information on climate impacts. In April 2019, fire and emergency services leaders called for an inquiry into whether Australian emergency services are adequately resourced to cope with the increasing natural disaster risks (Emergency Leaders for Climate Action 2019). There remain concerns that there is not an adequate integration of climate change risks across the Australian Government. For example, the 2018 Senate inquiry into the implications of climate change for Australia’s national security made 10 recommendations for improvement, including the development of a government climate security white paper to guide a coordinated whole-of-government response to climate change risks (Commonwealth of Australia 2018c).

The Prime Minister has recently commissioned a report by the CSIRO to provide practical options for Australian governments to support and improve climate and disaster resilience (CSIRO 2020). The report is to be prepared in close partnership with an expert advisory panel chaired by Australia’s Chief Scientist Dr Alan Finkel. A final report with ‘implementable recommendations’ is due to be delivered to the Prime Minister mid-2020 to underpin discussions in COAG on future actions. The terms of the report include investigating

both short- and long-term measures for all levels of government as well as business, NGOs and the community. Areas to be considered include:

- integrating climate and disaster resilience consideration into land use and infrastructure planning, zoning and development approvals, construction, environment management and agricultural practices
- the capability of governments and emergency services to target threat warnings and public safety communications
- strengthening hazard modelling and weather satellite data through improved prediction models and data collection
- protecting Australia's unique natural assets
- a strategic, scientific approach to hazard reduction burning and vegetation management incorporating traditional indigenous knowledge and management
- improved use of science and technology, including for early detection and management, and situation reporting
- the work of Commonwealth Ministers in delivering the Commonwealth's climate resilience initiatives
- likely global emissions scenarios under existing international emissions reductions frameworks.

The report is to have regard to current and completed work on climate and disaster resilience and adaptation including existing state and territory initiatives (CSIRO 2020).

The Authority considers that now is an opportune time for the Government to update its *National Climate Resilience and Adaptation Strategy*. The resulting information from the CSIRO report could underpin the update, which would also reflect the improved understanding of how climate change is affecting Australia, including through the experiences of the 2019 North Queensland flood event, the ongoing drought conditions in the Murray-Darling Basin and the forthcoming findings of the Royal Commission into the 2019–20 bushfire season. An updated national strategy would place recent and future policy developments within an integrated framework. The CSIRO report could provide information to help evolve the 2015 Strategy from a principles based document to include more clearly defined actions for enhancing Australia's preparedness for climate impacts and roles, accountabilities and timeframes for delivering those actions.

As noted above, Australian Government departments are integrating climate change risk management into decision making about government policies, programs and assets—evident in areas such as agriculture, water and national disaster risk reduction policy. However, the work is just beginning, with only four government departments having completed an initial scan of climate risks (DoEE 2019e). It should be a priority for all Australian Government portfolios.

There remains a clear role for the Australian Government's scientific agencies (particularly the Bureau of Meteorology and CSIRO) to coordinate the production and distribution of enhanced, locally relevant climate change information. Partnerships with other organisations like state, territory and local government, natural resource managers and specialist research institutes can enhance the quality of information through information sharing and local networks and knowledge.

Previous initiatives in this area, such as the 2015 *Climate change in Australia—projections for Australia's natural resource management regions: Technical report*, completed by CSIRO and the Bureau of Meteorology, helped to inform planning of natural resource management boards (CSIRO and BoM 2015). The information is used routinely as part of ongoing climate services provided by the Bureau of Meteorology

and CSIRO to help meet broader needs. The information is based on the last generation of global climate models (Taylor et al. 2012). A new generation of global climate models is now emerging (Eyring et al. 2016).

The need for relevant, granular climate information has been raised repeatedly by a range of stakeholders in the Authority's consultation. As firms are increasingly looking to manage their climate risks and local communities experience the impacts of climate change, the requirements for high-quality information will increase. To effectively guide mitigation and adaptation efforts, Australia will need to retain an expert capacity to model climate change impacts at local levels and develop capability in customising information for the needs of communities and organisations (Australian Academy of Science 2017).

In 2019, the National Climate Science Advisory Committee finalised a report on the development of a strategy for climate science in Australia (NCSAC 2019). The report identifies 10 strategic actions with a view to ensuring Australia is prepared for the impacts of climate change and variability in the decades ahead, informed by robust climate science and projections that are integrated into decision making across all sectors of society and the economy. Intended outcomes of these actions include:

- an enhanced national weather and climate model platform
- next-generation climate projections for Australia
- a national climate service capability that provides decision makers with climate risk information tailored to their organisations and sectors
- improved coordination and prioritisation of Australia's climate science and research effort.

The Authority welcomes the committee's report, which the Government has accepted, and recommends the Government endorse implementation of the identified strategic actions as a priority for the relevant government agencies, including ensuring that sufficient resourcing is available to them for this purpose.

There will be opportunities for private sector consultants to assist larger organisations to best develop appropriate information, but high-quality modelled climate projections for Australia will be most effectively generated by science agencies with existing resources and expertise. A systematic and ongoing approach to the production and delivery of climate change information is needed. Knowledge transfer or brokering between agencies and the wider community will require development and scale to ensure appropriate information is provided to those who require it to support decision making.

- 7 In consultation with state, territory and local governments, and drawing on the findings of the bushfire National Royal Commission and the forthcoming CSIRO report on climate resilience, review and update the 2015 National Climate Resilience and Adaptation Strategy to ensure a coordinated and integrated approach, with clear roles and accountabilities, to enhance Australia's climate resilience.**
- 8 Fully integrate consideration of emissions and climate change risks in decision making about government programs, assets and services through frameworks such as the Climate Compass.**
- 9 Implement the strategic actions in the National Climate Science Advisory Committee's *Climate science for Australia's future* report to get the most out of the Government's investment in climate science and ensure governments, businesses and communities have the information they need to respond to climate change risks.**

8. ELECTRICITY

Australia's electricity sector is undergoing a transformation. Abundant renewable energy resources, government support for renewable energy, the emergence of new clean energy technologies, declining technology costs and the need to replace an ageing coal-fired generation fleet are all playing a part. The sector has already been a major contributor to emissions reductions and it is well placed to lead Australia's transition to a low-carbon economy.

This can be achieved both through the direct contribution of low- and zero-emissions electricity generation and through 'electrification' in sectors such as transport and industry. In a decarbonising global economy, our clean energy could also underpin significant new export opportunities such as hydrogen and low-emissions manufacturing. As the costs of the technology to generate electricity from renewables continue to fall, the advantage that stems from the zero cost of renewable fuel (wind and solar energy) will continue to grow.

While the transformation to cleaner electricity has begun, policy actions are required to ensure the ongoing transition is a smooth one and electricity prices are kept as low as possible. This would be best achieved through technology neutral policies that allow the optimal mix of low- and zero-emissions generation technologies to emerge.

The current outlook is for state renewable policies to provide the main policy impetus for investment in large-scale, low-emissions generation. To support a reliable, secure and affordable energy system, the National Electricity Market (NEM) jurisdictions and bilateral energy deals between the Australian Government and the states should align supported renewable and transmission projects with the priorities identified by the Australian Energy Market Operator (AEMO).

The COAG Energy Council and energy market bodies should fast-track reforms to accelerate and smooth out the transition to low- and eventually net-zero emissions electricity. These include measures to better integrate large amounts of low- and zero-emissions generation, storage and other technologies to firm intermittent renewables, and demand-side response into the market. Measures that provide greater certainty on the timing of the exit of coal-fired power stations and ensure timely investment in efficient transmission and generation are also important.

The right mix of policies will send the much needed signals for private investment and deliver substantial emissions reductions, while ensuring a reliable, secure supply of electricity at the lowest cost possible for households and for businesses, including those seeking out new export opportunities.

The electricity sector accounts for 34 per cent of Australia's greenhouse gas emissions (178 million tonnes in the year to September 2019) (DISER 2020). Around 83 per cent of electricity emissions are from the NEM. Other emissions are associated with electricity generation in other grids, such as the South West Interconnected System and North West Interconnected System in Western Australia and the Darwin Katherine Interconnected System in the Northern Territory. Emissions from off-grid electricity generation (such as onsite generation at mines) are also included in the sector.

Emissions from electricity generation fell 2 per cent in the year to September 2019 and are now 16 per cent below 2005 levels (DISER 2020). This reflects a decline in emissions in the NEM to 15 per cent below 2005 levels, which has outweighed the impacts of a 44 per cent increase in emissions in the remainder of the electricity sector (DoEE 2019i).

Renewable sources accounted for 19 per cent of Australia's overall electricity generation in 2018, with the largest source being hydro generation (DoEE 2019g). The share of renewable generation varies by state.

Tasmania has particularly high renewables penetration at 91 per cent, predominantly from hydro generation. In South Australia, 47 per cent of generation is from renewables, almost all from wind and solar generation. Renewable penetration is lowest in Queensland (7 per cent) and in the non-NEM states of Western Australia (8 per cent) and the Northern Territory (4 per cent) (DoEE 2019c).

8.1. Current policies

At the federal level, emissions in the electricity sector have primarily been addressed through the Large-scale Renewable Energy Target (LRET) and Small-scale Renewable Energy Scheme (SRES). The LRET is set at 33,000 gigawatt hours (GWh) of electricity in 2020, and that volume is to remain the same until the scheme ends in 2030 (CER 2018a). The SRES helps to lower the up-front cost of small-scale renewable energy systems for individuals and businesses. The SRES is phasing out over the period to 2030 (CER 2018b).

In addition, the Safeguard Mechanism applies to grid-connected electricity generators using a sectoral baseline. These facilities only have an obligation under the mechanism if emissions from the entire sector exceed the baseline (set at the high point of Australia's electricity emissions between 2009–10 and 2013–14) (DoEE 2016b). The sectoral baseline is not expected to be exceeded (CCA 2018b).

In the past five years, additional policies have been introduced by both the Australian and state and territory governments. These are discussed in Section 8.3.

8.2. The Authority's previous advice

The Authority has previously recommended that the electricity sector be subject to a comprehensive market-based policy approach such as an emissions intensity scheme (CCA 2016a, 2017b). The Authority's analysis found that market instruments have a greater capacity to deliver cost-effective emissions reductions while remaining robust to different possible future conditions (for example, changes in the demand for electricity) compared with other policy types, but the Government has opted for alternative approaches.

In 2016, the Authority also recommended that, to promote price stability and investor certainty, the existing LRET should be unchanged, noting it plateaus from 2020 before ceasing in 2030 (CCA 2016a). The Authority's analysis showed that alternative policies would be more cost-effective in meeting post-2020 emission reduction targets (CCA 2016b). In previous advice, the Authority stated that support for small-scale technologies through the SRES should also continue and phase out as planned by 2030 (CCA 2016a).

The Authority has made a number of other recommendations for the electricity sector to facilitate the transition to a low-emissions generation market (see CCA 2017b). For example, the Authority recommended that the Government implement reforms arising from Australian Energy Market Commission (AEMC) and AEMO work on future system security services to increase system strength, including inertia and fast frequency response emergency control schemes. These have now been implemented. It also recommended that the Government work with COAG energy ministers to maintain their commitment to cost-reflective network pricing and to pursue tariff arrangements that allow NEM consumers to readily exercise the 'power of choice' (CCA 2017b).

The Authority also recommended in 2017 that the Government continue efforts to work with the states and territories to remove restrictions on gas exploration and development and to improve the transparency of gas price and offer contract outcomes on a market-based trading platform (CCA 2017b).

8.3. Significant changes since 2016

The electricity sector is undergoing a significant transformation. Historically, the bulk of Australia's electricity has been supplied by large fossil-fuel power stations located adjacent to fuel sources, particularly coal, and delivered via network infrastructure to customers. Increasingly, our electricity is being supplied by a much

larger number of more geographically dispersed renewable (wind and solar) generators, as well as households' own rooftop solar systems. Electricity now flows 'two-way' over local distribution networks, rather than 'one-way'. New battery storage technologies at both grid and household scale and additional pumped hydro storage are being deployed to support variable renewable energy generation.

Several factors have contributed to these trends:

- Ongoing and large declines in technology costs and government policy support have fuelled an investment boom in large-scale renewable power stations. From 2015 to 2018, electricity generated from renewable sources increased by 37 per cent (DoEE 2019g, Appendix C):
 - The global weighted average levelised cost of electricity declined 7 per cent between 2016 and 2018 for onshore wind and 25 per cent for solar photovoltaic (PV) (IRENA 2019c).
 - In 2015, legislative changes resolved uncertainty over the future of the large-scale Renewable Energy Target. This resulted in a significant increase in the number of power stations accredited under the scheme from 2016 onwards (CER 2019e, 2018c). The ARENA and the CEFC also played a key role in supporting initial investments in large-scale solar farms.
- Distributed renewable generation has also grown strongly in recent years. The SRES, state and territory incentives and rapidly declining costs have seen a dramatic increase in the installation of domestic rooftop solar PV systems. Approximately 1.1 gigawatts (GW) of rooftop solar capacity was installed in 2017 and a further 1.6GW in 2018 (Clean Energy Council 2019a).
- Most of Australia's states and territories have implemented their own renewable energy targets, further increasing the incentives for investment in renewable energy generation. Currently all states and territories, except for NSW and Western Australia, have some sort of renewable energy target (Table 5).
- There have been closures of ageing fossil fuel power plants. Between 2010 and 2017, 12 coal-fired power stations closed (Burke, Best and Jotzo 2018). The largest station to close was the brown coal fuelled Hazelwood power station in 2017.

Increasing renewable energy investment has led to the development of a substantial industry. There were over 17,000 direct full-time equivalent jobs in renewable energy activities in 2017–18, including both construction and operational roles (ABS 2019b). Investment in large-scale renewable energy projects was A\$10 billion in 2017 and A\$20 billion in 2018 (Clean Energy Council 2019a).

In 2016, the government commissioned the Finkel review to develop a national reform blueprint for the NEM. This recognised the trends discussed above, the challenges they were beginning to pose for the reliability and security of electricity supply, and the need to reduce emissions in accordance with the Government's commitment to the Paris Agreement. The Finkel review made 50 recommendations for maintaining the security and reliability of the NEM while also reducing emissions (Finkel et al. 2017). The COAG Energy Council accepted 49 of these recommendations (COAG Energy Council 2017).

The Government decided not to pursue the Finkel review's recommendation for a clean energy target to reduce emissions from electricity generation. Instead, working with the newly founded Energy Security Board and the COAG Energy Council, it developed the National Energy Guarantee (the Guarantee) to address both emissions and reliability in the NEM.

- The Retailer Reliability Obligation (RRO) came into effect in the NEM on 1 July 2019. If AEMO forecasts a reliability gap three years and three months from the identified gap, it must request the Australian Energy Regulator (AER) to trigger the RRO.²¹ If the AER triggers the RRO, energy retailers and potentially some large energy users are required to hold contracts, or invest directly in generation or demand response, to support reliability in the NEM (COAG Energy Council 2019d).
- The emissions component of the Guarantee would have required wholesale market customers (for example, electricity retailers and large electricity users) in the NEM to ensure the average emissions intensity of their electricity load is at or below the prescribed emissions intensity target (Schott et al. 2018). Ultimately, the Australian Government decided not to proceed with the emissions component.

The Australian Government has indicated its intention to enter into bilateral agreements to support generation and transmission investments in the states and territories (Taylor 2019b). The Prime Minister and the Premier of NSW announced the first such agreement in January 2020 (Morrison 2020b). It includes commitments to support timely network upgrades; development of a renewable energy zone; identification of options to maintain reliability as ageing coal-fired power stations retire; increasing the supply of gas; and emissions reduction in non-electricity sectors (Energy NSW 2020).

Appendix C outlines other key government policies and initiatives that have emerged in the past three years, including in response to the Finkel review.

²¹ In addition, the South Australian Energy Minister can trigger the RRO in South Australia.

Box 10 State and territory renewable energy targets

State and territory renewable energy targets range from 50 to 100 per cent by 2030. If realised, and assuming the same distribution of electricity generation between states in 2030 as in 2018, over 35 per cent of Australia's electricity generation can be expected from renewable energy sources by 2030.

The states can use a variety of methods to deliver the targeted renewable electricity; however, the main approach used is a reverse auction along with contracts for difference.

Although NSW has not adopted a renewable energy target, as part of its Electricity Strategy the NSW Government announced it will establish three Renewable Energy Zones, commencing with the Central-West region pilot, which is expected to deliver 3,000 megawatts of new generation by the mid-2020s (Energy NSW 2019).

TABLE 5. STATE AND TERRITORY RENEWABLE ENERGY TARGETS UP TO 2030

	Renewable energy target	Policy measure(s)
Queensland (large-scale)	50% by 2030 Announced in 2015	Reverse auction to fund renewable energy generation projects (550 MW) and successful bidders enter into contracts for difference to supply electricity.
Victoria	25% by 2020, 40% by 2025 Committed in 2017	Reverse auction to fund renewable energy generation projects (>900 MW in total) and successful bidders enter into contracts for difference to supply electricity.
	50% by 2030 Committed in 2019	
South Australia	33% by 2020 Announced in 2009 50% by 2025 Announced in 2014	No market mechanism. A range of complementary measures, including government funding for renewables and storage.
Northern Territory	50% by 2030 Announced in 2017	In January 2019, the Northern Territory Government entered into power purchase agreements to buy electricity from two new solar farms.
Australian Capital Territory	100% by 2020 Committed in 2016	Reverse auction to fund renewable energy generation projects (650 MW in total) and successful bidders enter into contracts for difference to supply electricity.
Tasmania	100% by 2022 Announced in 2017	No market mechanism. A range of complementary measures, including government investment in existing hydro-power assets.

Source: CCA 2019b; Victorian Government 2019a

Notes: Legislated targets are italicised. Power purchase agreements are long-term contracts under which an entity agrees to purchase electricity directly from an energy generator. NSW and Western Australia do not have renewable energy targets.

8.4. The outlook for low-emissions electricity

Chapter 6 of this report discusses the medium- to long-term opportunities that Australia's world-class clean energy resources present our economy given the coming global transition to net-zero emissions. Lu et al. (2009) found that Australia had the second greatest potential for onshore wind generation after Russia and could generate 86,000 terawatt hours of wind energy per year. In 2017, however, Australia produced 1.1 per cent of global wind energy, ranked 16th in the world (IRENA 2019b). Australia's potential for solar power is also significant. Australia produced 1.8 per cent of world solar energy in 2017, ranked 10th (IRENA 2019b). Australia has the highest solar radiation per square metre of any continent (Geoscience Australia n.d.).

In terms of the future electricity generation mix, modelling conducted by AEMO indicates that:

the least-cost and [least]-regret transition of the NEM is from a centralised coal-fired generation system to a highly diverse portfolio dominated by distributed energy resources, variable renewable energy, supported by dispatchable resources and enhanced grid and service capabilities to ensure the power system can reliably meet demand at all times. (AEMO 2019a)

AEMO suggests that the dispatchable resources required to firm up inherently variable wind and solar will take the form initially of investments in pumped hydro and battery storage, with new flexible gas generators playing a role if gas prices materially reduce. The mix of technologies could diversify further as new technologies, such as hydrogen, emerge and mature. Nuclear energy is not considered by AEMO given the legislative prohibitions in place. Coal-fired power stations with carbon capture and storage (CCS) could also contribute to a low-emissions electricity system. However, AEMO notes that currently no such technologies are in operation and there is not the data available for it to model the generation, capture, transmission and storage of emissions using dedicated pipeline infrastructure to new CO₂ storage facilities (AEMO 2019d).

Many expect the electricity sector to make a meaningful contribution to meeting Australia's abatement targets (for example, Energetics 2016; Woodside submission to this review), with the potential for the sector to contribute greater than a proportional share of the national emission reduction target. For example, Origin Energy stated 'the electricity sector should contribute more than its proportional share of any 2030 target as it has viable options at scale and can help unlock abatement in other sectors' (submission to this review). Other respondents to this review called for 100 per cent renewable electricity in Australia (for example, Australian Marine Conservation Society).

With the current combination of government policies and market forces, the sector is projected to see significant emission reductions to 2030. The Government's projections of emissions for the electricity sector show that emissions in the NEM are projected to be 41 per cent lower in 2030 than 2005 and emissions from the electricity sector as a whole are projected to be 34 per cent lower than in 2005. Similarly, AEMO scenario modelling projects NEM emissions to be 39 per cent lower in 2030 compared with 2005 (AEMO 2019a).

These results reflect both continuing strong growth in rooftop solar PV and the projected cost competitiveness of large-scale renewables. For example, the CSIRO recently found that the levelised cost of energy of new solar or wind, including costs associated with back-up storage, is lower than the cost of new fossil fuel alternatives (CSIRO 2019c).

Yet, as seen in Chapter 4 of this report, the outlook for the electricity sector is not sufficient to overcome trends in other sectors and ensure that Australia's 2030 emissions reduction target is met without relying on the substantial use of carryover credits or additional policies. There is also some uncertainty around the levels of large-scale renewable investment that will eventuate in coming years, as their deployment increasingly faces challenges relating to network constraints and system security requirements.

AEMO has reported that, while over 30 GW of new variable renewable energy may be required by 2040, the existing network has an estimated connection capacity for only 13 GW in areas with favourable renewable

resources (AEMO 2019a). For example, AEMO has identified the West Murray region²² as an area where low system strength and network constraints in the NEM are impacting on several generators, who are being required to curtail their output, and where many proposed renewable projects will not be able to connect to the grid or generate at full output ahead of major new network infrastructure investment (AEMO 2019e). Strong growth in the connection of renewable generators, typically at the edges of the network, has also led to significant revisions to ‘marginal loss factors’ in some regions, with negative impacts on revenues and potentially the commercial viability of existing generators and dampening of the investment outlook for new projects.²³ This had led to calls for revisions to the current framework for the treatment of electricity losses in the NEM.²⁴

If Australia is to become a major producer and exporter of hydrogen, develop industrial and manufacturing industries based on clean energy and quickly adopt electric vehicles then we will require amounts of low- and zero-emissions electricity orders of magnitude above what would be needed to simply achieve net-zero emissions in the sector based on ‘business as usual’ demand growth. The cost of electricity should be no higher than absolutely necessary to support investment requirements of the sector. This will be aided by efficient, flexible and far-sighted policy choices that allow for the optimal mix of low- and zero-emissions technologies to emerge and by ensuring we use our energy as efficiently as possible (see Chapter 13).

All of the above suggests there remains a strong role for policies that promote and smooth the transition to cleaner electricity. In submissions received for this report several stakeholders were supportive of implementing a broad, market-based approach (National Farmers’ Federation, AIGN, Engineers Australia, Origin Energy, ALGA and Business Council for Sustainable Development Australia), or full implementation of the National Energy Guarantee (EnergyAustralia), to support low-emissions generation. The Authority recognises that introducing such measures in the electricity sector has been politically difficult and the Australian Government has ruled out such approaches. However, there remain several other significant opportunities for promoting and supporting the ongoing transition of the electricity sector.

8.5. Policies to support the transition

8.5.1. State and territory renewable energy targets

With the 2020 LRET now met with existing and committed renewable generation, state and territory renewable energy targets represent the main policy drivers for new large-scale renewable generation investment. There is a risk that, in the absence of some degree of coordination, disparate state policy approaches could lead to less than ideal outcomes across the NEM, given the interdependencies that exist between state NEM regions. This coordination could be achieved with some involvement of AEMO.

To inform decisions by electricity market participants, investors and policy makers, AEMO releases:

²² The area of the Victorian and NSW power system bounded by Ballarat, Dederang and Darling Point.

²³ As electricity flows through networks towards end customers, a portion of that electricity is ‘lost’ due to physical factors such as electrical resistance. These losses increase as more generation connects in locations that are distant from load centres. Marginal loss factors reflect the impact of electricity losses along the network and are applied to market settlements in the NEM and so affect generator revenues (AEMC 2019b). See also AEMO, *Indicative marginal loss factors: FY 2020–21* (AEMO 2019f).

²⁴ The AEMC made a determination in February 2020 that gives AEMO more flexibility around the way it calculates marginal loss factors. The AEMC is also working to give investors more information about the market. In October 2019 it changed the rules to increase transparency in relation to new generation projects.

- an Electricity Statement of Opportunities report each year which forecasts electricity supply reliability in the NEM over a 10-year period and identifies where additional generation capacity will be required to address potential electricity supply reliability gaps
- an updated Integrated System Plan every two years which provides a whole-of-system roadmap for the development of the NEM, including potential generation and transmission investment requirements under different scenarios, with a planning horizon of at least 20 years.

These reports are supported by more frequent publication of information on system and energy adequacy and by the pre-dispatch processes run by AEMO.

To support optimal operation of the NEM, the abovementioned reports should weigh heavily in decisions that NEM states make about the location and timing of renewable projects supported under their renewable energy targets.

In keeping with the above, the states could also consider adopting a geographically neutral approach, at least in part, to the selection of large-scale renewable generation projects. State governments will be naturally inclined to support projects within their own jurisdictions. However, from the point of view of an efficient NEM, the ‘next’ most valuable large-scale renewable power station may be one located in a different jurisdiction. Such projects may still offer benefits to the supporting state in terms of reliability and security of supply while avoiding costs associated with less efficiently located generation projects.²⁵

The addition of large amounts of intermittent, non-dispatchable wind and solar generation capacity raises challenges for power system security—that is, the ability of the system to operate safely and securely within defined technical limits (AEMC 2017). This issue takes on more significance as renewables approach and exceed a majority share of the generation mix (AEMO 2019c). The experience in South Australia, where the share of renewables routinely exceeds 45 per cent and reaches as high as 79 per cent (DoEE 2019c), demonstrates that the system can operate reliably and securely with large amounts of renewables. However, this requires careful planning and active involvement of AEMO. The Energy Security Board, AEMO and the AEMC have a significant system security work program underway to address these issues and make it easier for the NEM to transition to a low emissions future.

Consequently, impacts on power system security should be an evaluation criterion in state renewable energy project selection processes and AEMO advice should be sought. The states could also consider financially supporting system strength remediation measures (e.g. investment in synchronous condensers) in the short-term where, as part of an overall package, this delivers the best outcome for NEM consumers.

²⁵ In support of its renewable energy targets, the ACT Government has contracted via auctions with renewable energy projects located outside its borders but included requirements relating to local industry support and engagement.

- 10 To promote the reliable and secure supply of clean electricity at lowest cost for electricity consumers, National Electricity Market (NEM) jurisdictions should, in the design and implementation of their renewable energy policies:**
- emphasise renewable projects that align with the priorities identified by the Australian Energy Market Operator (AEMO) in its Electricity Statement of Opportunities and Integrated System Plan
 - consider supporting projects located outside of their respective jurisdictions where this will maximise benefits for their electricity consumers and the NEM generally
 - include electricity system security as a criterion in project selection processes, consult with AEMO for advice on security implications of proposed projects and consider supporting system strength remediation measures.

8.5.2. Integrating a growing share of renewables into Australia's electricity supply

The design of the NEM requires some adjustments to support the transition to increasing low-emissions generation (Energy Security Board 2019). The Authority is confident that the NEM market authorities are taking action to maintain the affordability, reliability and security of the electricity supply. For example:

- AEMO is preparing the next update of its Integrated System Plan and is undertaking a Renewable Integration Study to quantify the capacity of the power system to absorb renewables for a projected generation mix and network configuration in 2025 and provide a roadmap of priority actions required to support increasing levels of renewable generation in the NEM (AEMO n.d.a).
- The AEMC's strategic priorities, and hence its program of rule changes and other work, emphasise the implications of the transition to a lower emission power sector over time for ensuring customers can access safe, secure and reliable energy at the lowest possible cost (AEMC submission).

The Energy Security Board's Post-2025 Market Design review will provide advice on a long-term, fit-for-purpose market framework to support reliability, considering the needs of diverse sources of non-dispatchable generation and potential roles for demand-side response, storage and distributed energy.

The significance of the Energy Security Board's Post-2025 Market Design Review is growing as the commitment of NEM jurisdictions to an agreed set of rules for the operation of the NEM is unwinding. South Australia has implemented and invoked its own procedures in relation to the RRO, while NSW and Victoria have announced their intention to augment and/or derogate from NEM rules to achieve reliability and renewables goals within their jurisdictions (Energy NSW 2019; Victorian Government 2020). To the extent that such measures are justifiable, this reinforces the need for a review of the current NEM frameworks to ensure they are fit for purpose. However, the propensity for jurisdictions to deviate from established NEM rules also raises some risks in terms of the achievement of the broader goals of the NEM which the rules are intended to support.

The electricity market reform agenda is wide in scope. The Authority considers the electricity market bodies should be supported to accelerate and implement the reforms required to facilitate a smooth transition to low emissions and distributed energy resources. Priority areas for focus, which hold considerable promise for enhancing the efficiency of Australia's electricity markets and maximising benefits for electricity consumers, are discussed below.

Distributed energy resources

'Distributed energy resources' refers to small-scale generating units and related technologies that are located on the customer's side of the electricity meter (AEMC n.d.). The most common example is rooftop solar PV systems, but it can also include battery storage, batteries in electric vehicles, wind generating units and other technologies. Distributed energy resources are very likely to play a key role in Australia's future electricity system. The recent very strong growth in household rooftop solar PV in Australia, and the expectation this will continue, was noted earlier in this chapter. Take-up of household battery storage is accelerating, supported by government programs, and growth in the electric vehicle market is projected to rise over this decade (see Chapter 10).

The AEMC has highlighted that distributed energy resources hold out the prospect of substantial benefits for all electricity customers, whether they are users of such resources or not (AEMC n.d.). Potential benefits include reductions in prices consumers pay for electricity and improved reliability outcomes; avoidance of costs associated with power system augmentation—for example, through the use of 'virtual power plants' helping to reduce the overall cost of electricity supply; and reductions in the emissions intensity of the electricity supply by displacing more emissions-intensive generation.

However, the clean energy industry and electricity market bodies have identified the need for the development of a supportive regulatory framework to ensure distributed energy resources deliver benefits for electricity system users rather than increased costs (AEMC 2019c; Clean Energy Council 2019b). For example, the AEMC has noted that, in the absence of appropriate regulatory and market frameworks, electric vehicles could add to peak demand instead of smoothing it, zero marginal cost rooftop solar generation could be inefficiently constrained, prices could become more volatile instead of less, and the benefits of distributed energy resources could be appropriated by others in the electricity supply chain rather than flowing through to consumers.

Demand-side response

Demand-side response (or participation) describes the process by which electricity consumers actively manage their electricity consumption and expenditure (and, in some cases, output from their own behind-the-meter generating equipment) to reduce their energy costs. It can refer to the direct actions of large industrial users of electricity as well as household actions aggregated by electricity retailers, network service providers or other businesses.

Demand-side response offers consumers the prospect of avoiding high electricity prices at times of peak demand and can lower overall system costs by alleviating peak demand pressures and, in the longer term, reduce the need for costly power system augmentation. However, demand-side response has only played a small role in the NEM to date (Wood et al. 2019). The AEMC is currently considering a rule change for the NEM that would introduce a mechanism for wholesale demand response (AEMC 2019d). The change would enable new businesses to work with consumers to sell their demand reductions into the wholesale market in a similar way to scheduled generation and be settled in the market at the price available at that time.

Large-scale dispatchable storage

AEMO has highlighted the potential for utility-scale pumped hydro and battery storage to feature prominently in the future operation of the NEM, providing dispatchable energy resources to firm up wind and solar. The Australian Government has made a strong commitment to pumped hydro, including through its investment in the Snowy 2.0 project and support for assessment of the Tasmanian 'Battery of the Nation' proposal.

The Hornsdale Power Reserve battery installation in South Australia has demonstrated the potential of large-scale battery storage. In a 2018 report on the early operation of Hornsdale, AEMO found that it can provide a range of valuable power system services, including rapid, accurate frequency response and control and

support for power system reliability and network load control. AEMO suggested that current market arrangements for frequency control services could be modified to recognise, or reward, the more rapid response capabilities of batteries (AEMO 2018).

This points to a broader opportunity to review NEM rules to ensure that barriers to new technologies participating in the provision of network services are identified and addressed and to incentivise such technologies by ensuring they are appropriately rewarded for the full amount of value that they deliver to the market.

Promoting timely and efficient network augmentation and generation investment

AEMO's draft 2020 Integrated System Plan sets out a roadmap for priority, near-term and longer-term transmission network investments projects that AEMO identifies as necessary for meeting the needs of the NEM as it transitions over the next 20 years. Concerns exist that the current regulatory process for the approval of transmission investment proposals—the regulatory investment test for transmission (RIT-T)—while seeking to promote efficient outcomes, is impeding the timely development of projects needed to support the optimal operation of the electricity grid. These concerns have been recognised in some state government decisions, noted above, to fast-track transmission projects outside of NEM rules; and in an AEMC determination that seeks to expedite the regulatory approval processes for upgrades to the Queensland –NSW Interconnector, the Victoria –NSW Interconnector and the proposed new interconnector between South Australia and NSW by allowing aspects of those process to occur simultaneously (AEMO 2019e).

The AEMC's determination did not address the general concern of whether the RIT-T is fit for purpose given the rapid transformation taking place in the NEM. The Energy Security Board is currently progressing work to address this issue and recently consulted on draft NEM rule changes that are intended to streamline the regulatory processes for key projects identified in the Integrated System Plan, while also retaining a rigorous cost–benefit assessment (COAG Energy Council 2019f). At the same time, the AEMC is developing proposals that will facilitate better coordination between generation and transmission investment by improving the market signals for generation and storage investments (AEMC 2019f). The AEMC has identified several benefits of these proposals:

- Generators and storage can gain greater certainty over the operation and revenue of their assets and will have greater incentives to locate in areas most beneficial for the power system.
- Consumers will benefit from lower transmission costs, with generators sharing some of the costs of transmission.
- AEMO and networks will have better information for planning and investment decision-making processes.

Promoting timely, efficient investment decisions in both generation and transmission is vital for ensuring that electricity prices are as low as possible for electricity consumers and that the ongoing transition in the sector is a smooth one. In addition to its general role as Chair of the COAG Energy Council, the Australian Government has an important role play in securing these outcomes given its decisions to support dispatchable generation technologies through its Underwriting New Generation Investments program and to pursue bilateral energy agreements with the states. The Government should ensure that these initiatives align with AEMO's Integrated System Plan and respect the price signals in the NEM, which should improve as the various reform process outlined above come to fruition.

- 11 The COAG Energy Council should fast-track reforms to facilitate the integration of large amounts of low- and zero-emissions generation and related technologies into the electricity market, focusing on distributed energy resources, integration of storage and demand-side response and timely and efficient transmission and generation investment.**
- 12 The Government's Underwriting New Generation Investments program and bilateral energy agreements with the states should further align with the priorities for generation and transmission identified in AEMO's Integrated System Plan and be supported by rigorous cost-benefit analysis to ensure efficient outcomes for electricity consumers.**

8.5.3. Coal generator closures

Australia's coal-fired power stations are ageing, and over 60 per cent of coal capacity is expected to reach end of life in the next two decades (AEMO 2019). Most owners of coal-fired power plants have stated they will close and not replace their plants (CCA 2019a).

The closure of coal-fired power stations is expected to lead to transitional challenges for communities and management of the electricity grid. Managing these challenges is all the more difficult when the timing of exit is uncertain. Greater certainty would allow the transition to be managed in an orderly manner, helping to minimise anxiety and disruption within communities and helping the market and regulators plan appropriately so that the electricity market continues to supply the right amount of electricity reliably and securely.

The Finkel review examined the issue of orderly closure of coal-fired power plants. It recommended that generators provide three years' notice of their intention to close and that the AEMO publish a non-binding register of expected closures. These recommendations have since been implemented. However, through consultation, the Authority heard that this approach may not be sufficient to ensure a smooth transition away from coal-fired generation. The Grattan Institute has stated that the three-year notice rule 'lacks teeth', with small penalties for non-compliance, and allows generators to game the system by delaying closures (Dundas 2019). AEMO, in its Electricity Statement of Opportunities, has also noted challenges around certainty of closure remain despite the three-year notice rule (AEMO 2019b). The statement says the three-year notice rule may not be sufficient to protect consumers from high prices and load-shedding risks; or it may not give sufficient time to implement cost-effective replacement generation options. AEMO notes that, as generators approach decommissioning, there are increased risks of a major outage, and economic considerations may lead to early exit.

The challenge of arranging an orderly transition away from coal-fired power stations has been addressed in other countries. For example, in 2017 the United Kingdom Government, after consultation, regulated for the closure of all coal-fired power generation units by 2025. Analysis identified the benefits associated with closures as including reduced air pollution, emission reductions and certainty in the electricity market around the need for new capacity (HM Government BEIS 2018). The cessation of coal-fired power in Britain will be implemented by regulation of an emissions intensity limit on generation that will prohibit coal-fired generation without carbon capture and storage. Closure dates are signalled to the market through capacity market auctions held up to four years prior to delivery. The share of coal in the United Kingdom electricity market has declined from 40 per cent in 2012 to 2 per cent in 2019 (Nationalgrid 2020).

In Germany, the government is planning the phase-out of coal fired power stations by 2038²⁶ and is proposing a combination of auctions and negotiations to provide compensation payments to closing power stations. Reports have suggested the compensation payments may amount to €1 billion to close 5 GW of capacity (Jennen et al. 2019).

The Authority recommends that the Government continue to consider mechanisms that will aid in managing the inevitable transition of the electricity sector away from coal-fired power plants (see also Chapter 6).

13 Identify and implement measures for providing greater certainty on the timing of the retirement of ageing coal generators to facilitate timely investment in replacement capacity and storage and to enhance planning for measures to support local workforces and communities affected by closures.

8.5.4. The role of gas

The domestic gas market has undergone significant transformation, particularly in eastern Australia, with the development of Queensland's liquid natural gas (LNG) industry and export terminals. Exports from Queensland commenced in 2015 and, by 2018, around 61 per cent of eastern Australian gas was being exported (AER 2018). Domestic gas prices now follow prices on international markets. This saw east coast domestic gas prices rise substantially following the start of LNG exports, although they have since come down from their peak in 2017. Higher gas prices also impact in the NEM market, where gas-fired power stations play an important role as 'peaking' plant, exerting upward pressure on wholesale electricity prices. Both the increase in price and the availability of gas are concerns for eastern Australian commercial and industrial gas users (ACCC 2019).

Gas-powered generation can play a role in the mix of large-scale dispatchable energy resources required to firm up the increasing share of variable wind and solar generation in the electricity system. AEMO notes that the ultimate mix will depend on the relative cost and availability of different energy storage technologies compared with future gas prices—as noted earlier in the chapter, new flexible gas generators could play a greater role if gas prices materially reduce (AEMO 2019a). The economic life of natural gas generators could be extended beyond the time that they might otherwise be phased out for emissions reasons by modifying them to operate with hydrogen blended into the natural gas stream.

To ease pressure on domestic prices, the Authority continues to encourage the Government to work with the states and territories to remove restrictions on gas exploration and development with a view to increasing supply. This should be done along with consideration of the long-term implications for domestic greenhouse gas emissions, likely trends in international demand for LNG and prospects for the emergence of hydrogen. The Authority supports the COAG Energy Council's gas market reform agenda and welcomes the council's recent decision to approve further work on market transparency measures.

Some submissions to this review identified the potential contribution that decarbonising the supply of gas in Australia can make to long-term emissions reduction goals. Both Energy Networks Australia and Gas Energy Australia point to benefits associated with continuing to utilise existing gas network infrastructure—for

²⁶ Germany still relies on coal-fired power for around 38 per cent of its electricity needs. Coal-fired generation has declined more slowly than coal mining, leading to an increasing reliance on coal imports. However, since 2017 energy imports have steadily fallen as the share of renewables in Germany's electricity production increases. In 2019, renewables overtook coal-fired power generation as the largest single source of electricity production (40 per cent) (IEA 2020, Deutsche Bank 2019).

example, with hydrogen—to meet energy demand for the purposes of heating and in some forms of transport. Energy Networks Australia also noted the roles that hydrogen could play in the electricity sector—in addition to on-demand generation of electricity via turbines or fuel cells, hydrogen production processes offer a manageable load that can assist electricity market operators to respond to sudden changes in the demand or supply of electricity.

These issues have been examined in the course of the development of the National Hydrogen Strategy, which was agreed to by the COAG Energy Council in November 2019. The strategy aims to establish Australia's hydrogen industry as a major global player by 2030. The Authority welcomes the announcement of the strategy, which looks at our clean hydrogen potential and how we can make the most of this opportunity—through both export opportunities and increased domestic use. It includes a set of nationally coordinated actions involving governments, industry and the community (COAG Energy Council 2019a). The National Hydrogen Strategy and government support for the development of hydrogen technologies are discussed further in Chapter 14.

8.5.5. Concerns about electricity prices and government policy interventions

The Authority has received some submissions (for example, from EnergyAustralia, Origin Energy and AEMC) suggesting that a lack of clear long-term policy for the sector has created uncertainty and has affected investment in electricity generation, storage and transmission infrastructure. Origin Energy highlighted the negative impact of ad hoc government interventions on electricity market investments. It stated that it is considering a range of projects to reduce emissions and provide firming for intermittent renewables but that it remains cautious in deploying capital in the current uncertain policy environment.

It is entirely appropriate for governments to respond to concerns about high electricity prices and the reliability of electricity supplies, particularly during a period of significant transition in the industry. However, it is also important to recognise that, as discussed earlier in this chapter, high wholesale electricity prices are the market's natural signal of the need for more investment in generation. Government interventions need to be carefully considered and appropriately targeted to addressing problems either inherent in the design of the market or that the market cannot otherwise address.

The Authority notes that the AEMC's most recent annual report on residential electricity prices shows a falling price outlook over the next three years (AEMC 2019a). This primarily reflects new generation capacity entering the market and, to a lesser extent, lower regulated network prices. Looking further ahead, AEMO's Integrated System Plan modelling indicates that retiring coal plants can be most economically replaced with a portfolio of utility-scale renewable generation, storage, distributed energy resources, flexible thermal capacity and transmission.

The Authority considers that its recommendations for:

- fast-tracking measures to facilitate the integration of a rising share of renewables, and related technologies, into the electricity market
- a coordinated and efficient approach to the implementation of state and territory renewable energy targets
- greater certainty over coal-fired power station exits
- improving energy efficiency (Chapter 13)
- the development of a long-term climate strategy (Chapter 6)

together represent a package that can smooth out the necessary transformation of the electricity sector and minimise upward pressure on electricity prices. This approach leaves room for, and can send the right

signals to, private sector participants to invest with confidence in new generation to deliver that transformation.

9. INDUSTRY

Trends in industrial emissions have been dominated by the mining, oil and gas sector, with steady growth in emissions since 1990s and rapid growth in recent years as a result of the rapid expansion in liquefied natural gas (LNG) production for export.

The primary policy for managing industry emissions is the Australian Government's Safeguard Mechanism. While it is working as intended, the Safeguard Mechanism is not designed to reduce emissions or cap them in absolute terms.

The Authority's view remains that an enhanced Safeguard Mechanism should be deployed with declining baselines to reduce direct combustion, industrial process and fugitive emissions, and ensure these sectors contribute towards the 2030 and subsequent Paris Agreement targets.

With declining and binding baselines in place, the enhanced Safeguard Mechanism should also incorporate:

- trading of under- and over-achievement against baselines
- the ability for liable entities to use high-quality domestic and international offsets, the latter subject to quantitative restrictions to ensure an incentive to reduce emissions locally remains in place
- targeted, transitional and transparent competitiveness assistance to emissions-intensive, trade-exposed (EITE) industries.

There is considerable potential for the emergence of new low-emissions industries in Australia, if we are able to capitalise on our substantial mineral and renewable energy resources, to meet emerging global demand for low- and zero-emissions products (see also Chapters 6 and 14).

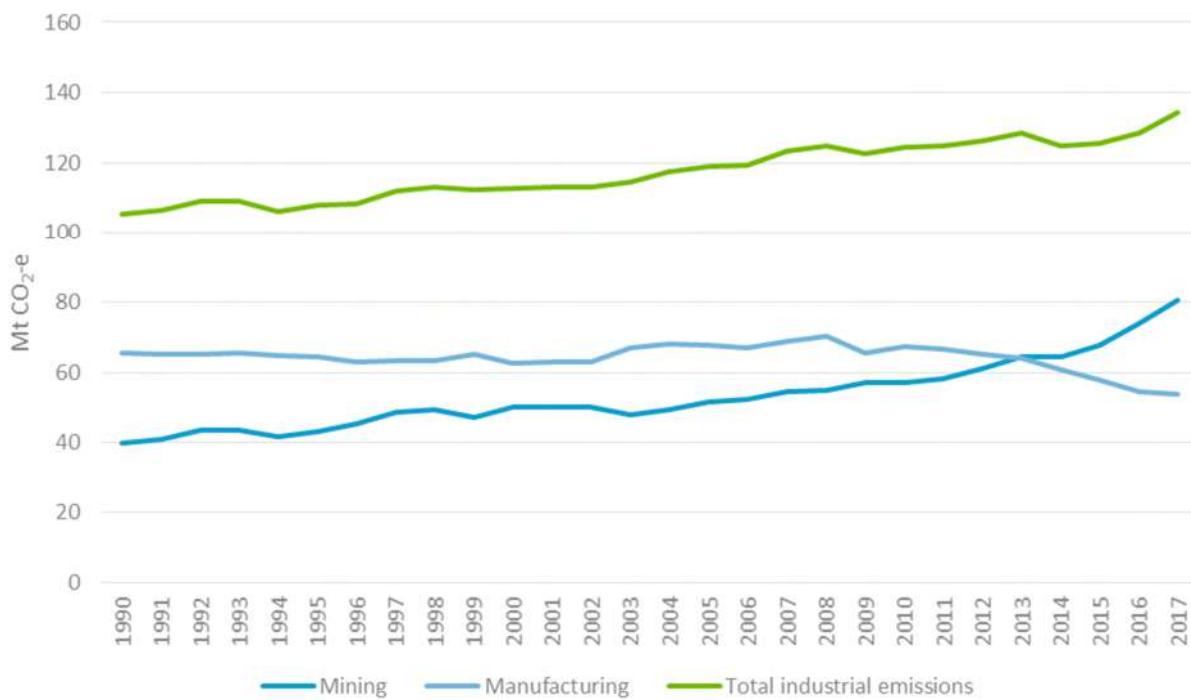
The industry sector incorporates the mining, oil and gas, manufacturing and industrial processing sectors. It generates emissions from the direct combustion of fossil fuels to generate heat, steam or pressure; fugitive emissions associated with the extraction and distribution of fossil fuels; and non-energy related industrial processes, including emissions from hydrofluorocarbons. This chapter deals with emissions from larger industrial emitters rather than emitters in the commercial and services sectors.

In 2016–17, direct emissions from the Australian and New Zealand Standard Industrial Classification (ANZSIC) sectors of mining and manufacturing were 134 Mt CO₂-e—25 per cent of Australia's emissions (DoEE n.d.b).²⁷ In addition, these sectors were responsible for 67.7 Mt CO₂-e of scope 2 emissions, which is 36 per cent of Australia's emissions from electricity (DoEE n.d.d). Direct emissions from industrial emitters have risen steadily since 1990, although this is made up predominantly of increased emissions from mining (including oil and gas), as manufacturing emissions have declined since 2008 (Figure 8). This is reflective of structural trends in the economy—mining's contribution to GDP has increased from 5 per cent in 1989 to 7.8 per cent in 2018, whereas manufacturing has declined from 11.7 per cent to 5.7 per cent of GDP over the

²⁷ There are several ways of interpreting Australia's greenhouse gas inventory to isolate 'industrial emissions'. A broad interpretation could include all emissions from industrial processes, stationary energy and fugitive emissions. However, this would also include combustion of fuels (such as natural gas) in residential and small business, agricultural and commercial services settings. In this chapter, using the inventory of emissions from the ANZSIC sectors of mining and manufacturing most closely represents emissions from large industrial emitters. Emissions data by ANZSIC sector is only available up to 2016–17.

same period (ABS 2019c). In recent years, the main driver of emissions growth has been the rapid expansion in LNG production for export markets (DoEE 2018a).

FIGURE 8. EMISSIONS FROM INDUSTRIAL EMITTERS, 1990–2017



Source: DoEE n.d.b

Note: 2017 is the latest year with data available at the sub-sector level. Mining refers to ANZSIC Division B and Manufacturing is ANZSIC Division C.

Australia's latest emissions projections estimate that emissions from industrial processes and fugitive emissions will decline slightly between 2020 and 2030; however, a small increase in direct combustion of fossil fuels will partly offset this (DoEE 2019i).

9.1. Current policies

Current Australian Government policies to constrain and reduce industrial emissions include the Safeguard Mechanism and the ERF. State and territory governments can manage industrial emissions in some cases by incorporating emissions management measures into development approvals for new projects.

9.1.1. The Safeguard Mechanism

The primary policy for managing industry emissions is the Australian Government's Safeguard Mechanism, which places limits on greenhouse gas emissions from large facilities (Box 6). The Safeguard Mechanism is intended to constrain growth in emissions to ensure that emissions reductions purchased by the ERF 'are not displaced by significant increases in emissions above business-as-usual levels elsewhere in the economy' (DoEE 2016a). In 2017–18, the safeguard applied to 211 facilities, including approximately 190 facilities in the mining, oil and gas, and manufacturing sectors. Of the 138 Mt CO₂-e of emissions covered by the

safeguard, approximately 90 per cent are from facilities in the mining, oil and gas, and manufacturing sectors.

Between 2016–17 and 2017–18, total emissions by industry facilities covered by the safeguard increased by 6 per cent (CER 2018c, 2019b). This is due to a number of factors, including baselines originally being set above actual emissions; the options under the mechanism that allow baselines to increase under certain circumstances; and an increase in the number of facilities covered by the policy in 2017–18 (CER 2018c, 2019b, 2019h). In 2018, the Authority found that the Safeguard Mechanism was working as it was designed (CCA 2018b); however, the Safeguard Mechanism was not designed to reduce emissions.

9.1.2. The Emissions Reduction Fund

There are 58 projects registered under the Australian Government's ERF to reduce emissions in the industry sector. These include industrial energy efficiency projects and collecting and combusting methane released from coal mines (CER 2019a). Approximately 5.2 million tonnes of emissions reductions—2.9 per cent of all contracted abatement—are contracted to be delivered to the Government from industry sector projects (CER 2019d).

The low take-up of ERF methods by industrial emitters (and projects outside the land and waste sectors more generally) reflects a number of barriers which were identified in the Authority's 2017 review of the ERF. Reasons for low uptake include requirements of specific methods, auction prices lower than the cost of abatement, administrative and audit costs and the lengths of contracts and crediting periods. Low uptake suggests that the ERF has not been an effective policy to reduce emissions from industrial emitters (CCA 2017a).

9.1.3. State and territory measures

State and territory governments can also use development approval as a tool to manage greenhouse gas emissions. For example, the Western Australian Government requires Chevron's Gorgon LNG development on Barrow Island to sequester 80 per cent of carbon dioxide removed from the gas stream during processing through underground injection as a condition of its project approval (Faragher 2009).

9.2. The Authority's previous advice

In its 2016 *Special Review* and 2018 *Review of the National Greenhouse and Energy Reporting Legislation*, the Authority found the Safeguard Mechanism could be designed to effectively and efficiently reduce emissions in the industry sector (CCA 2016a, 2017a). The Authority recommended other policies be introduced to reduce emissions in the electricity and transport sectors, which are covered to some extent by the Safeguard Mechanism as it currently operates.

The Authority recommended that the Safeguard Mechanism should be enhanced by removing access to further baseline increases, expanding its coverage to facilities with lower emissions, and allowing additional flexibility for entities to achieve compliance. The Authority also recommended that Safeguard Mechanism baselines decline linearly from 2018 in line with Australia's economy-wide emissions reduction commitments under the Paris Agreement (CCA 2016a). In its 2017 *Review of Climate Change Policies*, the Government stated that it will consider the role of the Safeguard Mechanism in a review in 2020 and in the context of progress towards the 2030 Paris target, including consideration of any updates to rules and regulations (Australian Government 2017).

9.3. Significant changes since 2016

Since 2016, emissions in the industrial sector have continued to rise, despite the introduction of the Safeguard Mechanism. Although mitigation technologies (such as carbon capture and storage) have continued in development, significant deployment of these technologies is yet to occur.

Expansion of emissions in the industrial sector has primarily been driven by expansion of Australia's LNG industry (DoEE 2018a). LNG production has expanded from 23 million tonnes in 2013–14 to 75 million tonnes in 2018–19 and is expected to peak at approximately 81 million tonnes per annum in 2019–20. Significant expansion of LNG export capacity beyond 2019–20 levels is not predicted in the short term (DIIS 2019c).

9.3.1. Amendments to the Safeguard Mechanism

In 2019, changes were made to the rules that underpin the Safeguard Mechanism. Under these amendments, all covered facilities will move from baselines derived from historical reported emissions to production-adjusted baselines. In the majority of cases, facility baselines will be calculated by multiplying their annual production by the applicable emissions intensity for that production. The baseline emissions intensity will either be site-specific for existing facilities or use an industry-average default emissions intensity prescribed in the rules (DoEE 2018b).

This means that, in almost all cases, the Safeguard Mechanism will use a production-adjusted emissions intensity baseline.

9.4. Opportunities for emission reductions

Current policy settings will be insufficient to drive emissions reduction in industrial sectors. Although other sectors (such as the electricity, transport and land sectors) may be able to provide early mitigation outcomes that will help Australia to meet its 2030 commitment under the Paris Agreement, the further goals of the Paris Agreement will necessitate significant emissions reduction across the economy beyond 2030. This will need to include reducing emissions by large industrial emitters. In some sectors, emissions may be difficult to abate with current technology, sensitivity to international competitiveness concerns, or both. Therefore, policies need to send a strong signal to reduce emissions across the economy, while being flexible enough to accommodate the differing abatement pathways that different industries may need to follow.

Industry groups have been broadly supportive of well-designed policies to reduce emissions:

APPEA supports a national climate change policy that delivers greenhouse gas emissions reductions at least cost and facilitates broad-based investment decisions consistent with an international price on carbon ... Australia's climate change policy response should seek to deliver lowest cost greenhouse gas emissions abatement through an appropriately designed mechanism that provides an economy-wide transparent price signal to shape business and consumer plans and investments. The mechanism should be efficient, have low compliance costs, and support international trade that recognises different national circumstances.

(Australian Petroleum Production and Exploration Association submission, p. 12)

AFPA supports a policy environment that delivers least-cost, environmentally effective and reliable outcomes for Australia. The policy framework needs to be stable, predictable and avoid complexity to help minimise investment uncertainty, and not expose Australian export and

import competing industries to costs not faced by their competitors in other countries.
(Australian Forestry Products Association submission, p. 4)

9.4.1. An enhanced Safeguard Mechanism

As the Authority has previously found, the Safeguard Mechanism is a policy that could be adapted to reduce emissions in the industrial sector. It builds on the architecture of the National Greenhouse and Energy Reporting Scheme, which has been in existence for over a decade. This means there is relatively high engagement and experience with the system, making it easier to enhance the Safeguard Mechanism than to implement a completely new policy:

The MCA considers the current domestic policy approach has elements that can provide a clear way to meet Australia's 2030 emissions reduction target. The Emission Reduction Fund and the Safeguard Mechanism provide a scalable approach to ensure that the 2030 Paris target can be met. (Minerals Council of Australia submission, p. 4)

The Safeguard Mechanism should be enhanced to transform it into a policy with the ability to reduce emissions. The design of an enhanced Safeguard Mechanism should incorporate the features and considerations described below.

Declining baselines

Each facility subject to the Safeguard Mechanism has an emissions baseline that must not be exceeded. Since the commencement of the safeguard, these baselines have changed from being based on historical emissions to calculated baselines reflecting the emissions intensity of recent production. Although the safeguard should prevent large increases in business-as-usual emissions, it is unlikely to result in long-term reductions in industrial emissions. For this reason, facility baselines should begin to be reduced on an emissions-intensity production basis.

Initially, baselines could decline at a rate consistent with Australia's 2030 emissions reduction target—26 to 28 per cent below 2005 levels by 2030. Safeguard entities currently account for 138 Mt CO₂-e of emissions. If safeguard baselines are made to decline to achieve a 26 per cent reduction in emissions relative to 2005 levels, the annual emission reduction expected is approximately 55 Mt CO₂-e in 2030 (compared with projected emission levels).²⁸

Baselines should commence declining as soon as possible. Predictably declining baselines will send a strong signal to industrial emitters to allow them to invest in lower emissions technology with confidence. For some groups, declining baselines are seen as a logical step in emissions reduction:

Enhancement of the safeguard mechanism by declining safeguard baselines ... remains essential for the mechanism to contribute to achievement of Australia's commitments under the Paris Agreement. Further delay in setting declining baselines implies steeper declines in future. (Business Council for Sustainable Development Australia submission, p. 9)

Others, such as the Australian Industry Greenhouse Network and Cement Industry Federation, noted the need for careful design and flexibility options to address competitiveness concerns.

²⁸ This assumes safeguard entities continue to account for 65 per cent of total emissions from direct combustion, industrial processes and fugitive sources.

Flexible compliance options

Individual facilities should be provided with options for meeting their baselines in ways that still allow the aggregate emissions reduction target to be met. Flexibility could be provided by allowing:

- (continued) use of high-quality domestic offsets to meet obligations
- trading of under- and over-performance of meeting baselines
- use of high-quality international credits or permits.

Allowing flexible compliance options provides businesses with the ability to reduce emissions at least cost, assuming flexibility options do not compromise environmental integrity. Business stakeholders have emphasised the importance of access to international units in complying with emissions reduction targets, which allow them to source abatement at lowest cost from around the world (Australian Industry Greenhouse Network submission; Australian Chamber of Commerce and Industry submission; Chamber of Minerals and Energy of Western Australia submission).

International units should meet credible quality standards and quantitative restrictions on permit use should be considered to ensure that an incentive to reduce emissions domestically remains in place (see Chapter 6).

Declining baselines, in combination with flexibility measures, could create a new source of demand for ACCUs to help transition the ERF from government to private sector purchasing.

Allow crediting and trading of over-achievement

When the Authority previously considered enhancing the Safeguard Mechanism to reduce emissions, some facilities had baselines based on historical levels of production that proved to be much higher than subsequent actual emissions levels. This posed a risk that, if facilities were granted credits for over-achievement (coming in under their baselines), they would receive windfall gains without reducing emissions, undermining the integrity of the scheme. For example, 2016–17 baselines for industrial facilities totalled 164.7 Mt CO₂-e, while actual reported emissions came to 117.9 Mt CO₂-e (CER 2018c, 2019b). There was also concern that crediting over-achievement would penalise early movers who consequently had a lower starting baseline. Hence, at the time, the Authority recommended that issuing credits for emissions lower than baselines should only be possible where additionality requirements were met. This could be achieved by requiring the emission reduction activities to be projects approved under ERF methods (CCA 2016a).

Facility baselines are now calculated based on actual production and emissions intensity rather than historical data, and facilities have the option to choose a default emissions intensity (DoEE 2018b). These two changes largely address the Authority's 2016 concerns. There is reduced risk of facilities receiving windfall gains from having historically high baselines. Where baselines are production-adjusted, it is far more likely that emissions reductions below baselines are inherently additional.

The Authority, therefore, now considers crediting and trading of over-achievement to be a preferred policy setting. Allowing for crediting of over-achievement of facility baselines provides an immediate incentive to reduce emissions for those facilities that are able to do so economically.

Once crediting is in place, access to the ERF for safeguard facilities' scope 1 emissions should be removed to simplify reporting under the Safeguard Mechanism scheme and remove any possibility of double-counting emissions reduction. Safeguard-liable facilities should retain access to industrial energy efficiency ERF methods in respect of scope 2 emissions, which are not covered by the Safeguard Mechanism. Industry has suggested that these changes could help encourage emissions reductions in the sector:

The [Safeguard Mechanism]’s regulatory objective could do more to incentivise least cost abatement, by providing an incentive for a facility to reduce its emissions below its baseline ... To do this, facilities should be issued with Australian Carbon Credit Units (ACCUs) where their emissions are below their baseline. (Woodside Limited submission, p. 8)

The [Safeguard Mechanism] scheme currently operates to drive emissions down to the baseline but does not offer any incentive ... for abatement achieved to further reduce emissions below the baseline. It is probable that efficient, low cost abatement options exist within industry that could be incentivised if the Safeguard Mechanism was transitioned more towards a baseline and credit scheme. (The Chamber of Minerals and Energy of Western Australia submission, p. 3)

Crediting of over-achievement against safeguard baselines should be recognised through a new form of tradeable unit that is distinguishable from ACCUs. The higher overall integrity of ACCUs which have been subject to ERF additionality criteria should be recognised and preserved. Safeguard over-achievement units, like ACCUs, should be eligible for use as offsets against safeguard liabilities—as long as Safeguard Mechanism baselines are met or exceeded, the absence of additionality requirements for over-achievement units does not matter. However, the distinction between the two types of unit is important for maintaining the reputation and value of ACCUs in other carbon markets (for example, international, voluntary).

Set new entrants’ baselines at best-practice levels

Under a system of declining emissions intensity baselines, new entrants should be assigned an appropriate emissions intensity baseline. The 2019 amendments to the Safeguard Mechanism describe how benchmark emissions baselines will be calculated (DoEE 2018b). Benchmark baselines should be set at best-practice levels to ensure that investors receive strong signals to deploy efficient low-emissions technology. Consideration will need to be given to ensuring that benchmark emissions intensities keep pace with technology and that they are not overtaken by declining baselines of existing facilities.

Sequencing and implementation

Implementation of a system of declining baselines with crediting and trading will benefit from considered sequencing of reforms.

The Authority considers that crediting and trading over-achievement should commence only once baselines have begun to decline and the Clean Energy Regulator is satisfied that baselines reflect current production emissions intensities. At that point, crediting of over-achievement should be automatic. If the Government were inclined to adopt crediting before the introduction of declining and binding baselines, the risk of windfall gains could be addressed by using best-practice industry baselines, rather than existing compliance baselines, for determining over-achievement.

The full design of a scheme of declining baselines could learn from successful Australian analogues, such as the NSW Greenhouse Gas Abatement Scheme. Measures for assisting EITE industries to meet safeguard obligations should be considered separately, based on need, feasible opportunities for abatement and potential for carbon leakage.

Implementation of an enhanced Safeguard Mechanism, with declining baseline trajectories established well in advance, should promote transparency, clarity and confidence so that firms are able to make long-term decisions based on well-understood policy signals. This approach will promote efficient and environmentally effective outcomes under the enhanced safeguard.

9.4.2. Competitiveness measures

The industrial sector includes several EITE industries. It has been the practice of successive governments to extend assistance or exemptions to ameliorate the competitiveness impacts of climate change policies on these industries. This is based on the premise that, if compliance with climate change policies increases costs for trade-exposed businesses, those business and their emissions may simply shift offshore to countries without similar policies. Such a scenario would see Australia losing industry and employment with no net gain for the environment (CCA 2016a; Productivity Commission 2011).

There remains a tension between providing assistance to these industries to reduce the burden of compliance with policy and progressing the transition to a lower emissions economy. Indefinitely providing relief to EITE industries delays action to reduce emissions and is not sustainable. The provision of competitiveness assistance also raises issues of equity. Relief or assistance provided to a specific industry or company can mean the burden of compliance falls more heavily on other non-trade-exposed businesses (as with the renewable energy target). If the relief or assistance is funded from the Budget, the burden falls on taxpayers more generally, who may or may not benefit from the EITE activity.

Competitiveness measures applied to an enhanced Safeguard Mechanism could include less restricted access to international permits or for Government to purchase abatement on behalf of EITE industries. Competitiveness measures should only be applied where a significant risk of carbon leakage can be demonstrated. Competitiveness assistance should be targeted, transitional and transparent.

14 Enhance the Safeguard Mechanism to deliver emission reductions from large emitters in industry, with:

- **declining baselines with clear trajectories and the ability to trade under- and over-achievement once baselines have commenced declining and are binding**
- **targeted, transitional and transparent competitiveness assistance to emissions-intensive, trade-exposed industries captured by the enhanced Safeguard Mechanism where a demonstrated risk of carbon leakage exists.**

9.4.3. Non-safeguard emitters in the industry sector

Mining and manufacturing enterprises that are not subject to the Safeguard Mechanism because they are below the threshold account for up to 40 Mt CO₂-e per year. Further policies will be required to reduce these emissions. Given the range of sizes of mining and manufacturing enterprises not covered by the Safeguard Mechanism, there should be a range of different policies to effectively target these firms. Small manufacturing enterprises could be effectively covered by policies that target retail electricity and gas customers, such as a national energy efficiency scheme. In some cases, the provision of resources (funding, expertise or facilitation) to small and medium enterprises directly to assist them to reduce emissions could be effective. For larger non-safeguard entities, policies aimed at reducing barriers to participation in the ERF may assist in achieving emissions reduction at scale. In all cases, policies would need to be carefully designed to ensure they are complementary to the ERF.

15 Investigate how best to encourage smaller businesses to reduce emissions, including through assistance to participate in the Emissions Reduction Fund (ERF).

9.4.4. Opportunities for low-emissions industry

Opportunities exist for Australia to capitalise on its substantial mineral and renewable energy resources, given sufficient ambition and innovation. If renewable energy infrastructure can be deployed at sufficiently large scale, it could allow for energy-intensive manufacturing industries to be established in Australia. For example, the co-location of Australia's substantial iron ore or bauxite resources with high levels of low-cost, zero emissions energy could allow for production of low-emissions steel or aluminium.

Researchers and businesses have already identified pathways for the use of renewable energy (heat or electricity) to reduce emissions in processes like production of cement, steel and alumina (Nathan et al. 2019; Pooler 2019). Further research and development is expected to create technical pathways for substitution of other currently emissions-intensive manufacturing processes (Energy Transitions Commission 2018). Some academics have speculated that lower employment due to reduced global demand for coal could be more than replaced by establishing an integrated mineral processing industry in Australia. Processing of just a fraction of the current volume of unprocessed exported ores would be sufficient to offset coal employment declines (Garnaut 2019b).

Although the development of low-emissions manufacturing industries may be possible in Australia given the availability of mineral and energy resources and technical viability, these conditions are not sufficient for the development of new, clean manufacturing industries. The highly competitive and trade-exposed nature of Australia's current commodity-based industries can make the necessary sustained investment in research and development and new plant difficult. Further barriers can include the relatively high cost of labour in Australia and a lack of strong policy signals to encourage low-emissions industry. As discussed in Chapter 14, public support for research, development and innovation for harder-to-abate industries is essential to capitalise on the opportunities that Australia's resources present. The development of industry road maps is likely to help in identifying strategic research directions and remaining barriers to realising emission reductions—for example, any regulatory or other barriers to technology adoption.

10. TRANSPORT

The transport sector is the second largest source of emissions in Australia and transport emissions have sustained a clear upward trend over the past decade.

Road transport emissions account for more than 80 per cent of transport emissions and offer considerable opportunity for abatement, given the continued development of the global electric vehicle market, falling cost of battery technology and prospects for continued emissions reductions in electricity generation.

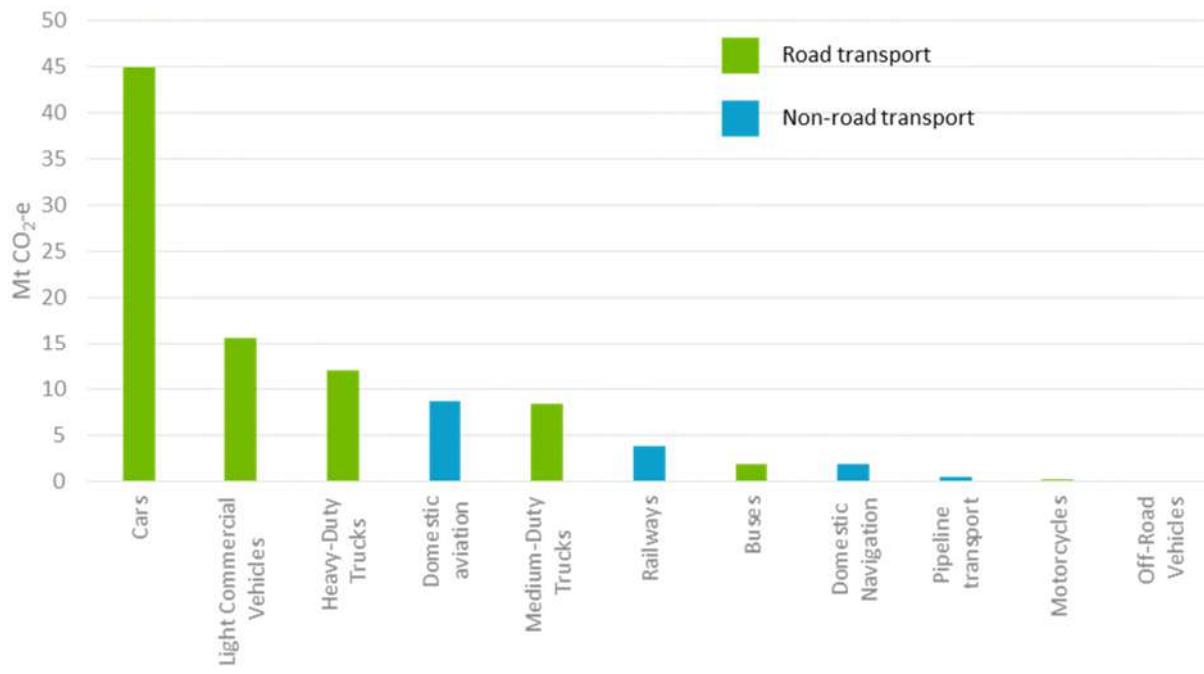
Although the Government has not supported this approach, there remains a strong case for the implementation in Australia of a greenhouse gas emissions standard for light vehicles, which would deliver reduced emissions and savings for motor vehicle users.

The Government's forthcoming electric vehicle strategy offers an excellent opportunity for ensuring that potential barriers to the uptake of electric vehicles are addressed.

Further work should be done by the Government to identify and pursue opportunities to shift more of Australia's freight task onto less emissions-intensive forms of transport.

Domestic transport makes up 18.6 per cent (or 98.7 Mt CO₂-e) of Australia's greenhouse gas emissions. In 2017, it was the second-largest source of emissions after electricity generation and has been growing since 1990 by 1.4 Mt CO₂-e per annum on average. As shown in Figure 9, emissions from transport principally come from road transport, with domestic aviation, rail and shipping emissions accounting for a comparatively small share (DoEE n.d.a). The source of these emissions is fossil fuel combustion in internal combustion engines. International aviation and shipping are not counted in Australia's emissions inventory (DoEE 2019b).

FIGURE 9. TRANSPORT EMISSIONS BY SUBSECTOR, 2017



Source: DoEE n.d.a

Note: 2017 is the latest year with data available at the sub-sector level.

10.1. Achieving emissions reductions in the transport sector

There are four general options for reducing emissions from transport activities (CCA 2016a):

- Reduce, avoid or substitute the need for transport activity.
- Improve efficiency of vehicles and equipment or optimise transport routes, loading and timing.
- Mode-switch to a less greenhouse gas emissions intensive mode of transport.
- Fuel-switch to a less greenhouse gas emissions intensive fuel—electrification of transport activity is a special case of fuel switching.

Electrification of transport activity can be particularly beneficial in reducing emissions, as electrification combines the ability of transport to be powered by low-emissions electricity sources and the much higher energy efficiency afforded by electric motors (IEA 2019a).²⁹ Not all methods of reducing emissions are suitable for every transport task for technical or economic reasons.

²⁹ For example, electric cars have ‘tank-to-wheel’ energy efficiency approximately three to five times that of internal combustion engine cars (IEA 2019a).

10.2. Current policies

10.2.1. Australian Government policies

There are a number of Australian Government policies that cover transport as part of their operation. However, there are no transport-specific emissions reduction policies.

- Under the ERF, transport enterprises can use either the Aviation Transport method or the Land and Sea Transport method to earn carbon credits for reducing the emissions intensity of their transport operations. As of January 2020, only one transport project has accrued carbon credits (CER 2019a).
- The Safeguard Mechanism can constrain the emissions of very large emitters. Fourteen transport enterprises are covered by the Safeguard Mechanism, including major road freight transport operators, rail freight operators, the major domestic airlines, public transport operators and passenger and freight shipping operators (CER 2019b).
- ARENA is providing funding for research on low-emissions transport technologies, including biofuels, batteries, electric vehicles and hydrogen; the construction of an ultrafast charging network on Australia's major highways; and overcoming barriers to the adoption of electric vehicles (ARENA n.d.).
- The CEFC has provided financing for the purchase of electric vehicles and has also invested in innovative firms in the electric vehicle supply chain (CEFC 2018a).

There are some policies which can reduce emissions as a co-benefit. For example, the Australian Rail Track Corporation is completing the Inland Rail freight link between Melbourne and Brisbane, which is forecast to reduce greenhouse gas emissions by approximately 750,000 tonnes CO₂-e per year (ARTC 2019).

10.2.2. State and territory governments

Several policies exist at the state and territory level that could reduce greenhouse gas emissions from transport, at least as a co-benefit of the policy. These include biofuel mandates in NSW and Queensland and general support for low-emissions vehicles, including registration incentives, support for electric vehicle charging infrastructure and government procurement initiatives (CCA 2019b).

The Victorian Government has committed funding to encourage the shift of containerised freight from road to rail. It is also developing a Port Rail Shuttle to reduce road truck movements between freight hubs and the Port of Melbourne, with significant co-funding from the Australian Government (Victorian Government Department of Transport 2019). Additionally, several state governments are making substantial investments in urban passenger public transport—for example, the Melbourne and Sydney metro rail projects—as well as heavy and light rail projects in Perth, Canberra, Adelaide, Newcastle and south-east Queensland.

10.2.3. Coverage of policies

Although Australia's main emissions reduction policies nominally include transport, the extent that they affect the sector is limited. The Safeguard Mechanism only includes large corporate emitters that account for around 10 Mt CO₂-e, or 11 per cent of transport emissions (CER 2019b). As at January 2020, there were six transport projects registered under the ERF and those projects with associated contracts to deliver emissions reductions for the government amount to 1.2 Mt CO₂-e (CER 2019c). Emissions from road transport have been difficult to cover with effective policies (beyond fuel taxation), as road transport emissions primarily come from a large number of individuals or smaller enterprises (NTC 2016). At the Australian Government

level, no policies currently exist that reduce emissions from privately operated transport at significant scale, beyond providing fuel consumption information to consumers at the point of new car sale (Green Vehicle Guide n.d.a).

10.2.4. Efficacy of policies

Only a limited amount of ACCUs have been issued under the transport-specific methods of the ERF (CER 2019a). On the two years' worth of available data, it is not yet possible to determine if the Safeguard Mechanism has effectively constrained the emissions from the largest transport enterprises. Of the 14 transport facilities covered by the Safeguard Mechanism in 2017–18, two facilities applied for multi-year monitoring periods and one facility exceeded its baseline. These facilities either surrendered ACCUs or took other action to comply with the Safeguard Mechanism. The balance of the facilities have some 'headroom' between their reported emissions and their baseline—ranging from 3 per cent of their baseline to 61 per cent (CER 2019b).

The continued rise in transport emissions suggests that current policies are not effective at significantly reducing greenhouse gas emissions associated with transport. Investments in innovation through ARENA and the CEFC have not yet achieved deployment of low-emissions transport technology at significant scale, and policies designed to encourage the uptake of low-emissions vehicles at state and territory level have not been rewarded by large-scale deployment. This indicates that there is room for further policies to reduce greenhouse gas emissions from transport.

10.3. The Authority's previous advice

In 2016, the Authority recommended that a light vehicle CO₂ emissions standard be implemented (CCA 2016a). The Authority has previously investigated light vehicle emissions standards and found them to be an effective way to reduce emissions from light vehicle use (CCA 2014b). In 2016, the Ministerial Forum on Vehicle Emissions commissioned a regulatory impact assessment on light vehicle emissions standards, which found that the implementation of such standards would provide significant savings to consumers (DIIRD 2016). However, the Government has indicated it does not support the implementation of a standard (ABC News 2019). The Authority also recommended that a cost-benefit analysis for heavy vehicle emissions standards be undertaken (CCA 2016a), and this has not occurred.

The Authority also made recommendations that the government consider including transport emissions in a market-based mechanism for reducing emissions, eventually replacing crediting transport activities under the ERF.

10.4. Significant changes since 2016

There have been several important policy developments since the Authority last provided its advice. The Australian Government has committed to developing a national electric vehicle strategy and the COAG Energy Council released Australia's National Hydrogen Strategy in 2019 (DoEE n.d.j, DIIS 2019b). State and territory governments have introduced some measures to encourage lower emissions forms of transport. The COAG Transport and Infrastructure Council is also developing a program of work to address the barriers and challenges impeding the uptake of low- and zero-emissions vehicles. This is due early in 2020. The program of work will consider both the National Hydrogen Strategy and the future development of a national electric vehicles strategy (Transport and Infrastructure Council 2019).

The transport technology landscape has changed significantly in recent years. The uptake of electric vehicles has gained momentum globally as their performance and cost narrow the gap with internal combustion engine vehicles. In 2018, two million new electric cars were sold globally, bringing the size of the world's

electric car fleet to 5.1 million (IEA 2019a).³⁰ The substantial increase in the electric vehicle fleet largely reflects growth in China, where policy (such as the New Energy Vehicle mandate) has driven uptake (IEA 2019a). Continued growth is expected, as many countries intend to phase out the use of internal combustion engines for small passenger vehicles. Eleven countries, including China and India, have announced a phase-out of the sale of petrol or diesel cars, with most coming into force in 2030 (Senecal and Leach 2019).

Improvements in lithium battery production have driven decreased prices and increased range for electric vehicles. Between 2010 and 2018, the cost of lithium-ion batteries decreased by 85 per cent (BloombergNEF 2019c). This has led to the introduction of longer range electric vehicles at more affordable prices, including in Australia. Both light passenger vehicles and light commercial vehicles are available in Australia (AEVA n.d.). Electric passenger buses are also in use globally, and they are in limited use in Australia (IEA 2019a; ClimateWorks 2018).

10.5. Opportunities for emission reductions

Current technology points to opportunities for reducing transport emissions arising from electrification where possible, starting with short-distance urban transport. Overall, stakeholders have noted that electrification seems to underpin emissions reduction potential in transport:

The mobility decisions of people will increasingly be affected by technology advances in the transport sector, especially the development of electric vehicles. This momentum suggests the lines between public and private transportation will become more permeable as the result of lower prices, better information and increased vehicle autonomy. We are clearly not at this point but need to enable the emergence of integrated mobility platforms that are low-carbon by design. The catalyst for this is the shift to, and adoption of, electric vehicles. (Engineers Australia submission, p. 6)

The introduction of a light vehicle CO₂ emissions standard has been demonstrated to have benefits for both consumers and society (DIIRD 2016). Additionally, shifting freight transport from road to rail could also significantly reduce emissions where viable, and continuing to improve efficiency in transport generally remains important.

10.5.1. Improving vehicle efficiency

Australia is one of only a few advanced economies that have not implemented a mandatory fuel efficiency or greenhouse gas emissions standard for light vehicles (IEA 2019b).

In 2018, average greenhouse gas emissions from new light vehicles sold in Australia were 180.9 grams (g) of CO₂-e per kilometre (km) overall. New passenger cars emitted an average of 169.8 g CO₂-e/km and light commercial vehicles emitted on average 221.5 g CO₂-e/km (NTC 2019). In recent years, improvements in efficiency have stagnated, and new research suggests that overall efficiency is declining as the gap between test and real-world performance increases (Smit 2019). Although it can be difficult to compare vehicle performance across countries, Australia's vehicle efficiency clearly lags behind international peers such as the United States, China, Europe, Canada and Japan (Table 6).

There has also been public debate regarding the role that Australia's fuel quality plays in the efficiency of vehicles. Australia is the last OECD nation to allow unleaded petrol that contains more than 10 parts per

³⁰ This includes both pure battery electric vehicles and plug-in hybrid electric vehicles that combine a small battery that can be charged from the grid with an internal combustion engine.

million of sulfur, and our fuel quality standards allow a number of other fuel quality parameters that are higher than other developed nations (DoEE 2018d). After consideration of proposals to improve fuel quality standards in line with other developed countries, the Government has decided to extend the current fuel quality standards through to 2027 without improvement to sulfur levels (DoEE n.d.e). The Authority has previously discussed the assertion that lax fuel quality standards prevent manufacturers from bringing efficient cars to the Australian market (CCA 2014b). Although these standards may present a barrier to the most advanced combustion and monitoring technology being added to cars, there remain a number of other technologies that can improve vehicle fuel efficiency (and lower greenhouse gas emissions) that are not reliant on higher fuel quality to improve efficiency (DIRD 2016). Consequently, improvements in fuel quality standards are not required for an immediate improvement in fuel efficiency.

TABLE 6. NEW LIGHT VEHICLE EMISSIONS PERFORMANCE OR STANDARD

Country	Year	Passenger car (g CO ₂ /km)	Light commercial vehicle (g CO ₂ /km)
Australia	2018	169.8	221.5
Canada	2018	136.2*	193.9*
China	2018	135.4	166.2 (2020)*
European Union	2018	120.4	158.1
Japan	2017	114.6	154.7 (2015)*
United States	2017	145.8	208.2

Source: NTC 2019; ICCT 2019

Note: * Indicates standards rather than observed performance. Values are normalised to New European Drive Cycle test standards.

The 2016 regulatory impact assessment on the introduction of light vehicle emissions standards found that a standard implemented by 2025 would save between A\$10.8 and A\$27.5 billion in fuel by 2040. It also found that an emissions standard of 1.05g CO₂ per km would lead to cumulative abatement of 65 Mt CO₂-e between 2020 and 2030 (DIRD 2016). Recent analysis has indicated that Australian light vehicle CO₂ emissions are getting worse (Smit 2019). A light vehicle CO₂ emissions standard could support demand for more efficient vehicles, which are not always made available in Australia (CCA 2014b).³¹ It could also help to support the uptake of zero tailpipe emissions vehicles, such as battery electric and plug-in hybrid electric vehicles, as well as lower emissions internal combustion engines.

The Authority is of the view the Government should reconsider its position on the introduction of a light vehicle emissions standard. Further delays in implementation of these standards will reduce the contribution this policy could make to achieving Australia's 2030 emissions reduction target. The Authority first recommended a standard in 2014, based on the state of technology at that time. As technology has

³¹ There are a number of reasons that vehicles may not be made available in Australia. These include normal commercial judgements on the suitability of the vehicle for the market but also include other factors such as the cost of certifying the vehicle against Australia-specific regulatory requirements. There also remains a contested assertion that Australia's fuel quality standards allow too much sulfur to allow importation of some highly efficient vehicles (CCA 2014b).

improved since that time, consideration should be given to increasing the level of ambition of light vehicle standards when implemented.

A light vehicle emissions standard should also take account of baseline uptake of zero-emissions vehicles in its ambition. Should electric vehicle technology improvements or cost declines be faster than anticipated, and if manufacturers are able to meet the standard through sales of electric or other zero-emissions vehicles, the objective of the standard could be enhanced at very little cost to the community.

Heavy road transport in Australia is also a candidate for emissions reduction. However, the industry is characterised by high levels of independent owner operators, with 70 per cent of operators owning only one truck (National Transport Insurance 2016). While fleet operators may have access to capital and expertise to improve the efficiency of their operations driven by normal business practice (or the ERF), these opportunities may not be available or viable for small owner–operators. Similar to light vehicles, an effective policy option could be to introduce efficiency standards for heavy vehicles, although the costs and benefits of this option have not yet been established. Any heavy vehicle emission standard would need to consider variations in vehicle configuration and usage patterns.

16 Reconsider implementing a greenhouse gas emissions standard for light vehicles and undertake a cost-benefit analysis of an emissions standard for heavy vehicles.

10.5.2. Encouraging uptake of electric vehicles

Electric vehicles are expected to play a significant role in reducing emissions from transport. More than 60 per cent of transport emissions come from cars and light commercial vehicles, which are relatively well suited to electrification (DoEE n.d.a). Increased use of electric vehicles will also reduce air and noise pollution in cities, bringing health benefits (EEA 2018). Electric vehicles charged from the electricity grid are responsible for indirect emissions, although in general these emissions are less than petrol emissions for an equivalent internal combustion engine vehicle (CCA 2014b; Green Vehicle Guide n.d.b).³² However, vehicles charged using renewable energy would give rise to no operational emissions:

As the electricity sector progressively decarbonises, it will increase the abatement potential of EVs. Further, with an already high penetration of residential solar PV systems, growth in large scale solar and the emergence of home battery technologies, there is an exciting opportunity for Australia to be a market leader in EVs powered by zero emissions renewable energy sources. (Origin Energy submission, p. 5)

Several barriers to consumer acceptance of battery electric vehicles (particularly vehicle cost, model availability and range between recharging) are reducing (ClimateWorks 2018; Energeia 2018). In 2019, the Hyundai Kona and Tesla Model 3 vehicles were introduced to Australia. They offer a range of at least 400 kilometres and are available for less than A\$75,000. Several shorter range vehicles have also been released

³² The only vehicle currently available in both internal combustion engine and battery electric vehicle form in Australia is the Hyundai Kona. In electric vehicle format, it is responsible for an average of 118 g CO₂-e/km. As an internal combustion engine vehicle, it has tail-pipe emissions of 153 g CO₂-e/km, or fuel lifecycle emissions of 179 g CO₂-e/km (Green Vehicle Guide n.d.b). (Fuel lifecycle emissions take into account that production and distribution of liquid fuel also produce greenhouse gas emissions. This is a better measure to use when comparing internal combustion engine cars with grid-charged electric cars).

in Australia (such as the Hyundai Ioniq, the updated Nissan Leaf and Renault Zoe). They offer around 250 kilometres of range and are priced around A\$50,000 (AEVA n.d.).

Improvements in range and reductions in price will need to continue to allow battery electric vehicles to have up-front cost and range parity with internal combustion engine vehicles. In some cases, the total cost of ownership of currently available electric vehicles may be close to parity with internal combustion engine vehicles (Schmidt 2019; ClimateWorks 2019b). Electric vehicles can have higher up-front capital costs but lower operational costs compared with an internal combustion engine vehicle, making total cost of ownership comparisons challenging for car buyers. The provision of information and guidance in this area could be important in reducing barriers to uptake and could be included in the Australian Government's Green Vehicle Guide (ClimateWorks 2019b).

Despite the current disparity in up-front cost between internal combustion engine vehicles and electric vehicles, a number of countries have already announced plans to phase out sales of petrol- or diesel-powered vehicles in coming decades. Norway, which already has the world's highest penetration of electric vehicles, has announced that it will phase out new petrol and diesel car sales by 2025 (SLoCAT 2019; IEA 2019a).

The rollout of electric vehicle infrastructure is also beginning to develop momentum. Open-access public electric vehicle chargers are being deployed by several networks, including the NRMA, Chargefox and Evie, complementing the proprietary Tesla network (ARENA 2019a, 2019d; Energeia 2018). State and territory governments are also making investments in electric vehicle charging networks (CCA 2019b).

If electric vehicles are deployed at scale, there will be changes in how the electricity grid is used (such as increased electrical demand overnight for home charging and significant peak loads in areas with a high concentration of rapid chargers). There is also potential for two-way interaction between the electricity grid and vehicles (where stored electricity in a vehicle battery can be sent to the grid or home). Only one electric vehicle available in Australia currently possesses a vehicle-to-grid or home capability (Evenergi 2019).

Barriers to the uptake of electric vehicles are gradually being reduced, but road vehicle electrification is still in its infancy and could benefit from policy support:

Successful EV markets overseas all initially suffered from the same 'barstool' problem that currently faces Australia. The market requires sufficient charging infrastructure, model availability, and consumer demand. If any of those three legs are missing, the other two also fall over. Foreign governments have shown that strong policy action is able to get over this initial problem and jumpstart nations' EV markets. (Electric Vehicle Council submission, p. 7)

Although price, range and availability of infrastructure for electric vehicles are improving, electric vehicles still have relatively limited uptake in Australia (ClimateWorks 2018). There is currently a window of opportunity to undertake enabling work that will facilitate efficient electric vehicle deployment. Although price remains a significant barrier to the uptake of electric vehicles, there are other issues which may affect the attractiveness of electric vehicles to consumers. These include:

- **Access to private charging:** electric vehicle owners who would normally garage their vehicle in communal garages (such as in apartment buildings or multi-tenant commercial premises) may not be able to install home charging equipment or be able to access electricity at all in private parking locations. Electric vehicle owners in older parts of cities where dwellings do not commonly include garages may need to rely on third-party 'destination' or transit charging infrastructure (IEA 2019a; ClimateWorks 2018; Energeia 2018).

- *Access to public charging:* 783 public charging locations were recorded as being available in 2018 (ClimateWorks 2018). The vast majority of these were slower, alternating current charging facilities (which were in many cases simply a power point provided for the use of electric vehicles). As at December 2019, fewer than 150 fast, direct-current chargers were reported as being available in Australia, some of which are Tesla superchargers that cannot charge non-Tesla electric vehicles (Plugshare n.d.). The major charging network projects recently funded by ARENA, the National Ultrafast EV Charging Infrastructure Network and Chargefox Electric Vehicle Charging Network will significantly add to the number of fast, direct-current charging stations over the next few years. These new fast charging stations will allow all electric vehicle models currently available for sale in Australia to charge along major driving routes (ARENA 2019a, 2019d). In addition, there are several different networks of commercial charging station operators that maintain different charging and payment systems, some requiring pre-registration and the issuance of a radio frequency identification (RFID) card to access chargers (Energeia 2018).
- *Incompatible charging standards:* there are currently five different charging plugs fitted to electric vehicles and chargers in Australia (not including proprietary Tesla superchargers), and they have limited interoperability. This reflects the reality that cars in Australia are imported from a variety of overseas markets. This may present an issue for electric vehicle owners who will rely on destination charging or mid-journey transit charging, as charging stations typically only cater for a few different plug types (Pearson 2017; Plugshare n.d.). In 2017 members of the Federal Chamber of Automotive Industries agreed that by 2020 all new models of vehicles and electric vehicle supply equipment would be capable of operating within a specified list of standards (FCAI 2017).

While these challenges currently present barriers to the uptake of electric vehicles, they are able to be solved at relatively low cost through early, coordinated action. Standards for new electric vehicle charging stations could be implemented, and funding could be made available to retrofit existing charging stations to maximise compatibility.

The Australian Government is developing a national electric vehicle strategy which could resolve these matters and remove barriers to electric vehicle uptake (DoEE n.d.j). State and territory governments should be cautious of pursuing independent strategies to avoid creating a modern analogue of Australia's historical railway gauge problems.

Hydrogen-fuelled electric vehicles, also considered a possibility for low-emissions transport, have not yet achieved any scale of deployment in Australia beyond very limited state and territory government trials (Palaszuk, Dick and de Brenni 2019; Dowling 2019).³³ Despite this, there may be future opportunities for hydrogen to fuel transport, particularly longer distance road and rail transport. Electric vehicle strategies could highlight opportunities to coordinate research and development in this area in tandem with the implementation of the National Hydrogen Strategy.

Significant uptake of electric vehicles will also mean a decline in fuel excise revenue. Excise duty on petrol and diesel amounted to A\$17.6 billion in taxation revenue in 2018–19 (Commonwealth of Australia 2019a). Policy development aimed at encouraging the uptake of electric vehicles will also need to consider if, and how, this revenue should be replaced.

³³ The emissions intensity of hydrogen production is highly dependent on the production method but has the potential to be low or zero emissions.

Although it is likely that price barriers will eventually be addressed through technology improvements and market competition, new electric vehicles may remain unaffordable for some private purchasers for the foreseeable future (BITRE 2019). The uptake of electric vehicles may be assisted by the development of a liquid and well-functioning used electric vehicle market. Well-functioning used vehicle markets overcome two potential barriers to electric vehicle uptake. First, they permit used vehicle purchasers to choose an electric vehicle if one is suitable. Second, they allow for new vehicle purchasers (particularly fleet buyers) to predictably depreciate vehicles, which is more difficult if the used car market is illiquid.

Corporate and government fleet cars make up approximately half of new car sales, meaning that they are an important source of used cars. Research by ClimateWorks shows the total cost of ownership for electric vehicles is already cost-competitive to internal combustion vehicles for local government fleets (Schmidt 2019; ClimateWorks 2019b). Targets for electric vehicle procurement in government fleets have been raised as a straightforward way for governments to encourage the uptake of electric vehicles, with modest (or no) additional cost:

Fleet buyers ... are likely to recognise the lifecycle benefits available through EVs earlier than the broader consumer market. Additionally, the recycling of vehicles into the resale market at the end of fleet leasing arrangements provides a lower cost entry point for the broader consumer market. (Origin Energy submission, p. 5)

Information provision to allow fleet managers to properly evaluate electric vehicles is seen as important. This may also be important for private buyers as well:

Consumer surveys have shown a strong correlation between knowledge of EVs and willingness to purchase. Providing consumers and businesses with clear information about the benefits of EVs is a cheap and effective way to increase uptake and reduce emissions. This can be both in the form of an online resource as well as through public demonstrations of the technology.
(Electric Vehicle Council submission, p. 10)

Other submitters have also suggested temporary exemptions from Fringe Benefits Tax for electric vehicles to encourage uptake in corporate fleets (Electric Vehicle Council submission). Improving the liquidity of the used vehicle market could also be achieved by liberalising used vehicle import restrictions, which could lead greater availability of electric vehicles at more affordable price and improve market penetration, similar to the experience in New Zealand (Energeia 2018). Although there is progress underway in improving the ability of electric (and other lower emissions) vehicles to be imported with the introduction of the *Road Vehicle Standards Act 2018* (Cth), importation of used vehicles is still difficult to achieve at scale.³⁴ This presents regulatory barriers for Australian consumers who wish to access a wider range of or more affordable electric vehicles.

³⁴ For example, a used vehicle must be imported through a Registered Automotive Workshop. Registered Automotive Workshops are limited to processing 100 vehicles per year each (DITCRD 2019). This prevents importation at scale. This is in comparison to New Zealand, which allows substantial importation of used vehicles provided they meet biosecurity and limited age and technical restrictions (New Zealand Customs Service 2018).

Box 11 Australian minerals to power electric vehicles

The development of a global electric vehicle industry will require substantial amounts of lithium and other minerals for use in batteries and motors. Australia is well positioned to capitalise on these requirements, thanks to an endowment of resources in lithium, nickel, cobalt and rare earth minerals that are used in battery manufacture. Australia also has a mature and expert resources industry with a well-developed regulatory regime that can assure an ethical supply chain. The Western Australian Government has developed a Future Battery Industry Strategy that seeks to capitalise on increased global demand for batteries in electric vehicles by attracting investment, increasing research and development and facilitating adoption (Government of Western Australia 2019b). Australia is currently the world's largest producer of lithium and captures approximately A\$800 million in export revenue (DIIS and ATIC 2019). Globally, most analysts expect demand for lithium to more than double by 2025, representing a significant opportunity for Australia (Austrade 2018).

17 The forthcoming electric vehicle strategy should aim to minimise barriers to electric vehicle uptake by:

- addressing standards for vehicles and charging infrastructure to ensure interoperability
- ensuring public electric vehicle infrastructure addresses barriers to uptake for those without access to private charging
- ensuring adequate infrastructure coverage on highways and in regional areas
- considering implications for electricity network tariff reform and fuel excise revenue
- incorporating information about electric vehicle ownership costs in the Green Vehicle Guide
- promoting the development of a used car market for electric vehicles, including through consideration of reduced import barriers for quality used electric vehicles
- setting targets for electric vehicle adoption in government fleets.

10.5.3. Encouraging a shift to less emissions-intensive forms of freight transport

In Australia, rail transport accounts for around half of Australia's freight transport, yet is responsible for only 4 per cent of transport emissions (NTC 2016; DoEE n.d.a). Increasing the share of freight carried by rail could reduce greenhouse gas emissions from transport where opportunities exist to do so. In some instances, moving freight from road to rail can achieve co-benefits, including reduction in air pollution and reduced congestion on suburban streets (BITRE 2016).

Despite this, shifting to less emissions-intensive forms of transport (mode-shifting) is difficult to incentivise using existing policies. The ERF Land and Sea Transport method does not permit mode-shifting, and a proposal for a mode-shifting method was rejected by the Emissions Reduction Assurance Committee in 2017. The committee was concerned that additionality would be difficult to determine for mode-shifting methods (ERAC 2017). Despite this, mode-shifting remains an effective opportunity to reduce emissions from transport, and governments should consider how mode-shifting could be effectively incentivised. It is important to recognise that emissions reduction might be only one reason for encouraging mode-shifting to rail, with other economic and community factors being important in decision making around rail. Additionally, mode-shifting will not always reduce emissions, so careful analysis is needed to ensure that encouragement is carefully targeted at genuine emissions reduction opportunities.

18 Investigate barriers to shifting freight transport from more emissions-intensive road to less emissions-intensive rail transport and how these can be overcome by Government.

10.5.4. Air and sea transport

Together, domestic aviation and marine transport account for 10.7 Mt CO₂-e—around 2 per cent of Australia's overall greenhouse emissions (DoEE n.d.a). International transport emissions are not counted in national greenhouse gas inventories or the Paris Agreement. They are instead covered through separate agreements of the International Civil Aviation Organisation (Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)) and the International Maritime Organization (IMO) 'strategy on the reduction of greenhouse gas emissions from ships'. Under the CORSIA strategy, the international aviation industry aims for carbon-neutral growth from 2020 (that is, international aviation emissions should remain at a 2020 baseline level). The IMO has set a target of reducing emissions from international shipping by 50 per cent by 2050 compared with 2008 levels (ICAO 2019a; IMO 2018). Australia is also a member of the High Level Panel for a Sustainable Ocean Economy, which in September 2019 released a Call to Action to address climate change. One of the identified actions was the decarbonisation of ocean industries, including shipping and marine transport, port infrastructure and operations, fisheries, aquaculture and tourism (High Level Panel for a Sustainable Ocean Economy 2019).

Emissions reduction from shipping and aviation remain challenging for technical and economic reasons. Shipping faces challenges in replacing the current dominant fuel—very heavy oil—at scale primarily due to its very low cost. Lower emission alternatives include currently available but higher cost fuels like liquefied natural gas (LNG) or potential alternatives such as hydrogen. The IMO's current efforts focus on improving ship design and efficiency (IMO 2018; Energy Transitions Commission 2018).

Aviation faces more difficult technical challenges. The International Civil Aviation Organisation's (ICAO) strategy for aviation relies on efficiency improvements of current technology and using emissions offsets to achieve carbon-neutral growth rather than a plan for substantial emission reductions (ICAO 2019b). Beyond these activities, the most promising candidate for aviation abatement is the introduction of biofuels or low-emissions synthetic jet fuels. These candidates are well-understood technologies; however, they face technical and economic challenges to deployment at sufficient scale. Although progress has been made in

the development of electric aircraft, electrification of aviation appears to remain a difficult proposition for all but the smallest of aircraft, due to the low energy density of batteries.³⁵ Other options to reduce emissions from aviation could include substitution of some of the aviation task with high-speed rail. However, Australia does not currently have plans to develop a high-speed rail network (IEA 2019a; Energy Transitions Commission 2018; ICAO 2019a).

The efforts of the ICAO and IMO to reduce international aviation and shipping emissions should have flow-through impacts for domestic aviation and marine transport emissions. In part, these agreements should lead to the availability of more efficient aircraft and ships, which could be incorporated into Australian domestic operations. The Australian Government is supporting these international agreements and should continue working within these frameworks to reduce aviation and shipping emissions (DIRD 2017).

³⁵ Currently, jet fuel has an energy density (energy per unit of mass or volume) about 50–100 times greater than the best performing batteries (Clean Energy Institute 2019). Even with the continual improvements in batteries and the greater efficiency of electric motors, electric-powered aircraft appear unlikely to be a practical option for most of the air transport task for the foreseeable future.

11. AGRICULTURE AND LAND

The agriculture and land sector includes emissions from the management of agricultural lands and forests. Australian farmers and land managers manage not only agricultural activity but also water, biodiversity and soil health among other factors. There is significant potential for the land sector to contribute to achieving Australia's long-term emission reduction goals through holistic management approaches, including by reforesting and regenerating the land.

The ERF has provided opportunities for some agricultural producers and land managers to generate ACCUs for emissions reductions. However, a range of barriers have prevented others from participating.

As the ambition of Australia's emission reduction targets increases over time, the crediting mechanism of the ERF will provide a strong foundation for an offsets scheme to complement an enhanced Safeguard Mechanism.

In the agriculture sector, producers are looking for opportunities to demonstrate their environmental credentials to meet emerging demand from domestic and export markets. For our agricultural products to retain market access, we need to ensure international standards and 'carbon footprint' labelling schemes take account of Australia's circumstances. Research, development and financial support are needed to help transition agriculture to a low-emissions future. An enhanced plantation forestry and wood products industry should also be part of the economic transition.

Climate change represents a significant risk to the outlook for the agriculture sector. Development of appropriate adaptation measures, supported by information and government policies, is needed.

11.1. Emissions and removals of greenhouse gases

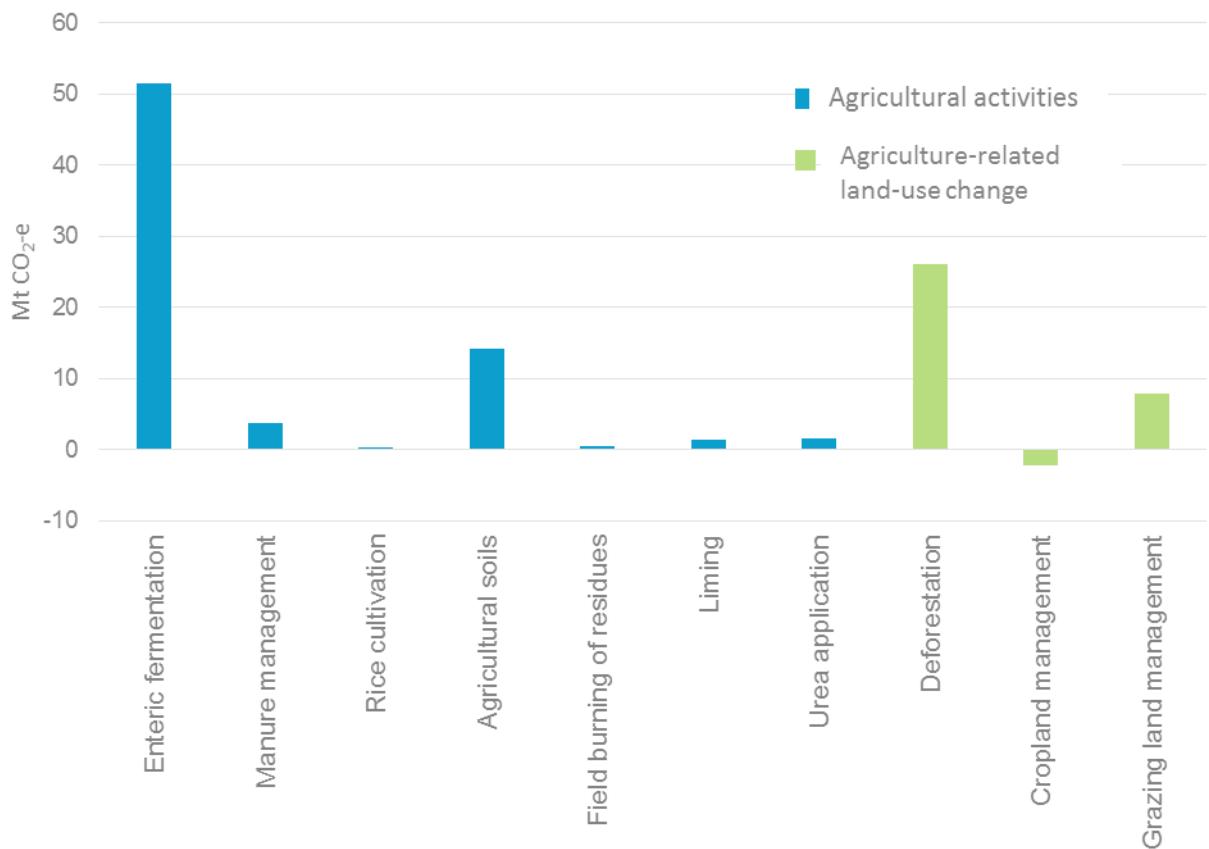
Farmers and other landholders manage around 378 million hectares—nearly 50 per cent of the Australian landmass (ABS 2019d). Management of agricultural lands can both generate greenhouse gas emissions and store carbon in vegetation and soils.

The agriculture sector is responsible for 13 per cent of Australia's greenhouse gas emissions. In 2017, 105.7 Mt CO₂-e were attributed to the net emissions from agriculture and agriculture-related land-use change.³⁶ Most agriculture emissions were from livestock³⁷ (55.2 Mt CO₂ e), followed by land clearing (net emissions from deforestation) (26.1 Mt CO₂-e) and agricultural soils (14.2 Mt CO₂-e) (Figure 10, DoEE n.d.a).

³⁶ 2017 data is used here, as it is the latest available data broken down into sub-sectors.

³⁷ Includes emissions from enteric fermentation and manure management.

FIGURE 10. EMISSIONS FROM AGRICULTURE, 2017



Source: DoEE n.d.a

Note: 2017 is the latest year with data available at the sub-sector level. Figure 10 uses Kyoto Protocol classifications. It includes emissions of methane and nitrous oxide from agriculture sources; carbon dioxide emissions from liming and urea application; and net emissions from deforestation, grazing land management and cropland management. Revegetation which does not meet the definition of 'forest' is a sink of 9.9 kilotonnes CO₂-e and is too small to represent on this graph. Environmental plantings on agricultural land that do meet the definition of 'forest' are included in the forestry sector and excluded from this graph.

Australia has 134 million hectares of forest, of which 28.1 million hectares are available and suitable for commercial wood production (Australian Government 2018). The forestry sector stores more greenhouse gases than it releases, as trees remove carbon dioxide from the air as they grow and store it as wood and other biomass. Forestry contributed a net sink of 52.6 Mt CO₂-e in 2017 (DoEE n.d.b).

There has been a 78 per cent decline in emissions from the agriculture and forestry economic sectors combined since 1990 due to declining emissions from land clearing and forest harvesting, and an increase in carbon stored in regrowing forests as well as more recent impacts of drought (DoEE 2019h).

Actions that can reduce emissions or sequester carbon in agriculture and forestry include:

- improving the production efficiency of agriculture, for example through improving: breeding practices; the quality of livestock feed and supplements; and the efficiency of fertiliser use in cropping
- reducing land clearing, increasing revegetation and increasing forestry plantations
- improving soil management to increase plant biomass in the soil and reduce soil disturbance

- managing savanna burning for cooler early-season burns.

11.2. Current policies

The ERF is currently the primary Australian Government policy incentive for emissions reduction in the sector (see Chapter 4). It provides ACCUs to projects that undertake activities to reduce emissions or enhance carbon storage. Government purchasing of ACCUs is being used to help meet Australia's 2030 target and, as of January 2020, A\$2.3 billion had been spent or committed on contracts to purchase 192 million tonnes of abatement across all sectors for which there are project methods (CER 2019c). Most projects (56 per cent) and most contracted abatement (65 per cent) are for enhancing carbon storage in vegetation.

There are a number of Australian Government, state or territory and local government natural resource management policies that are helping to lower emissions or enhance carbon storage. Most of these are not directly aimed at reducing emissions but achieve this as a co-benefit. They include the National Landcare Program and state and territory land stewardship programs. State and territory governments also manage or prevent clearing of vegetation and conserve biodiversity through specific legislation.

Research and development corporations are the main way the Australian Government and primary producers co-invest in research and development for industry and public benefit. The corporations are responsible for planning, investing in and overseeing the research, some of which is aimed at reducing emissions from agricultural production and adapting to climate change.

In 2018, the Australian Government adopted a National Forest Industries Plan, *Growing a Better Australia—A Billion Trees for Jobs and Growth* to support new plantations through research and development, education, infrastructure investment and removing regulatory barriers. State governments also provide support for plantation forestry and there are state-owned forest businesses (for example, VicForests n.d.; Forestry Corporation n.d.).

11.3. The Authority's previous advice

The Authority has provided 46 recommendations from 2016 onwards in relation to the agriculture and land sector and the ERF, summarised in Table 7.

In particular, the Authority recommended the ERF transition to an offsets scheme to provide ACCUs to entities with commitments under the Safeguard Mechanism rather than be a standalone economy-wide scheme.

The Authority has also made a number of recommendations for mobilising action in the land sector through the recognition of multiple benefits and innovative financing arrangements.

TABLE 7. PREVIOUS CLIMATE CHANGE AUTHORITY POLICY RECOMMENDATIONS FOR THE AGRICULTURE AND LAND SECTOR AND THE EMISSIONS REDUCTION FUND

Review	Summary of policy recommendations
2016 Special Review	<p>The Australian Government should continue to purchase ERF credits until other policies to reduce emissions are put in place and increased ambition under the Safeguard Mechanism creates private demand for offsets to help safeguard entities meet their obligations and to supply the voluntary market.</p> <p>ERF crediting for the land sector, and projects covered by the Safeguard Mechanism, should continue and the resulting credits could be used as offsets for facilities with obligations under the Safeguard Mechanism.</p>
2017 Review of the Emissions Reduction Fund	<p>The Government and the Clean Energy Regulator should pursue opportunities to improve the administration of the scheme in order to enhance its environmental integrity, strengthen investment in ERF projects and enhance contract delivery.</p>
2018 Reaping the Rewards	<p>Governments should do more to assist landholders to take action to reduce emissions and conserve natural capital while improving farm profitability, including by improving data availability, better coordinating land-sector policies and creating new markets and financing solutions for multiple benefits.</p>
2019 Review of the National Greenhouse and Energy Reporting scheme	<p>Extend voluntary reporting of emissions to the agriculture sector.</p> <p>Make refinements to the provisions relating to safeguard entities undertaking ERF projects to increase incentives and maintain environmental integrity.</p>

11.4. Significant changes since 2016

Since the 2016 Special Review, there has been increasing recognition that agriculture and land use both contribute to climate change and are part of the solution (IPCC 2019b). In particular, the land sector, globally, can be a source of offsets to transition economies to net-zero emissions (IPCC 2019b). Compared with other capture and storage technologies, the technologies required to restore the land and capture carbon are reasonably well developed. Australia has significant carbon sequestration potential through reforestation and afforestation (CSIRO 2019a). In the right circumstances, in coming decades the land sector could contribute carbon offsets into international markets (see Box 12).

In 2019, the government announced an extra A\$2 billion for the Climate Solutions Fund to continue investment in practical climate solutions and low-cost abatement currently underway through the ERF (Australian Government 2019a). With this new funding available, the Clean Energy Regulator (CER) has said it will be working with industry to help unlock more abatement after recent auctions have purchased increasingly small amounts (CER 2019c). The bilateral deal between the Commonwealth and New South Wales on energy reliability announced in January 2020 includes a commitment on the part of the Commonwealth to contribute A\$450 million of the Climate Solutions Fund to NSW-based projects that

support businesses, farms and land managers to take practical, low cost abatement actions (Energy NSW 2020).

Box 12 CSIRO's Australian National Outlook 2019 and carbon sequestration

The significant potential of the land sector in Australia to contribute to achieving long-term emissions reduction goals is highlighted in the CSIRO's Australian National Outlook 2019.

The CSIRO identified investing in agriculture productivity, restoring ecosystem health and capitalising on emerging markets as three key levers for supporting healthy and productive landscapes.

In relation to the latter, the CSIRO found that, in a world where there is effective global action on climate change to limit global average temperatures rises to 2°C by 2100, an optimal mix of carbon and environmental plantings could sequester up to 260 Mt CO₂-e in 2050 (CSIRO 2019a)—equivalent to almost half of Australia's entire greenhouse gas emissions in 2019. With more effective global action on climate change (and hence higher demand and prices for carbon offsets), the figure could be between 400 and 700 Mt CO₂-e in 2060, with up to half of this sequestration being sold to other countries. The CSIRO noted that the scale of the shift in land use that this implies would necessitate careful planning, consultation and engagement with the community, particularly regional communities.

In addition to effective global action on climate change, the CSIRO identified two further prerequisites for realising the land sector's carbon sequestration potential: continued research and development, investment and development of infrastructure to support carbon plantations; and realisation of benefits for rural communities and the natural environment.

There is growing recognition of the desirability of pursuing integrated actions on the land that together address the multiple objectives of reducing emissions, improving productivity, adapting to climate change and conserving natural capital (Productivity Commission 2005a; RIRDC 2015; Australian Government 2015c; CCA 2017a, 2018a). Interest has been increasing in carbon projects with environmental, social and cultural co-benefits, and progress in the ability to identify such projects is being made, although the market is still emerging (CMI 2017; Reef Credit n.d.; Aboriginal Carbon Foundation n.d.; Accounting for Nature n.d.).

Climate change is also affecting the land sector's ability to meet these multiple objectives, as discussed in Chapter 2, and these impacts will become increasingly severe. Through the Agriculture Ministers' Forum, ministers with responsibility for primary industries have agreed on a coordinated national approach and proposed work program to support the sector adapt to climate change as well as manage emissions (AGMIN 2019). Banks are considering their exposure to climate risk in their agricultural loan portfolios and seeking to manage this (Box 16).

There are emerging drivers in agriculture markets for sustainable, low-emissions products and practices, driven by consumers and sustainability agendas in export countries (IPCC 2019b). Awareness of how the market is changing is increasing the focus of the agriculture industry on managing emissions. For example:

- In 2018, the National Farmers' Federation released its *2030 Roadmap*, which envisages Australian agriculture trending towards carbon neutrality by 2030 and 50 per cent of farm energy sources being renewable by 2030 (NFF 2018a). As part of this vision, 5 per cent of farm revenue would come from environmental services (NFF 2018a).
- The Carbon Market Institute's *Carbon Farming Industry Roadmap* estimates the benefits of the carbon farming industry to be between A\$4.1 and A\$10.4 billion in revenue and between 7,875 and 15,750 jobs by 2030 if Australia meets its target without carryover (CMI 2017).

- In 2018, the Australian Forest Products Association launched its initiative *18 by 2030—Forest Industries help tackle Australia's climate change challenge*, setting out its proposal for how forest industries can remove up to 18 million tonnes of CO₂-e per year in 2030 (Australian Forest Products Association n.d.)³⁸
- In 2017, the Australian red meat industry adopted the target of being carbon neutral by 2030 (MLA 2017), with the industry noting this 'sends a clear message to our global consumers that the Australian red meat industry is serious about addressing greenhouse gas emissions' (Australian Beef Sustainability Framework n.d.).

11.5. The role of the Emissions Reduction Fund

The Authority found in its 2017 review that the ERF was generally operating well. This was due in no small part to the robust mechanisms for ensuring the environmental integrity of ACCUs issued under the ERF. The Authority reiterates the importance of maintaining scheme integrity going forward to ensure that the ERF credits genuine, additional abatement, and we welcome the government's actions in this regard since the 2017 ERF review.

In previous reviews, the Authority found that land-based offsets are likely to be needed as part of Australia's emissions reduction toolkit to help lower the cost of reducing emissions from other sectors (CCA 2016a). Overall, the Authority remains of the view that the crediting aspects of the ERF architecture are fit for use as an offsets scheme, incentivising least-cost project-level abatement in sectors that do not have requirements to comply with emission reduction policies.

Some issues regarding operational aspects of the ERF have been raised in submissions to this report. These are discussed in Appendix A. The concerns go to reducing the costs of participation, increasing opportunities for participation, and achieving multiple benefits from land-based projects. Specific matters raised were related to the complexity of ERF compliance, the need for new abatement methods and better consideration of co-benefits. Many of these concerns have been raised previously with the Authority and we recommended supporting the development of new methods, the development of online tools to reduce the cost of reporting, and the coordination of programs that seek other environmental benefits with the ERF (discussed in Chapter 10 and Appendix A). The Authority has a legislated requirement to review the operation of the ERF in 2020 and will examine operational aspects in more detail as part of that review.

11.5.1. Government and private sector demand

Current government policy is that the Australian Government is the primary purchaser of abatement under the ERF. Notwithstanding the allocation of significant additional funding to continue the ERF in the form of the Climate Solutions Fund, the Authority remains of the view that the scheme would operate best as an offsets scheme that creates credits ACCUs to be used by private entities with emissions obligations. Under an enhanced Safeguard Mechanism, declining safeguard baselines should support economy-wide emissions reductions and allow for Government purchasing of ACCUs to be phased out and replaced by the private sector demand (see also Chapter 9).³⁹ This demand, along with demand for ACCUs in other markets, should support a deep and growing offsets market.

³⁸ Plantations start to be planted in 2020 under this scenario (BAEconomics 2018).

³⁹ The voluntary market would continue to have access to the ERF and ACCUs, as is currently the case.

This approach was supported by a number of submissions (BCSDA, CMI, ALGA, Greening Australia, Outback Carbon). The AIGN supported a phased approach to declining baselines, cautioning that the ERF may not provide a large supply of units. In conjunction with this shift to declining baselines, the Authority supports research on new, well-targeted methods to increase the supply of units (see Appendix A) and eventually incorporating other unit types (see Chapter 9).

Where Government purchasing underpins the ERF market, the potential levels of abatement and the price received are capped by the amount of taxpayer funds made available. Some stakeholders have said that the price paid for emissions reductions under the ERF will need to increase to unlock significant new abatement based on current methods. This would affect the amount of abatement that the Government will be able to purchase towards its 2030 target. In the future, budget constraints may limit the extent to which ERF purchasing can contribute to the achievement of higher post-2030 Paris Agreement targets.

Increasing demand for Australia's land-based offsets has the potential to drive the growth of a significant economic sector. The Carbon Markets Institute estimates that with increased emission reduction ambitions, and access to international markets, Australia's carbon farming sector would provide 21,000 jobs by 2030 (CMI 2017). The revenues, jobs and other benefits would largely accrue to regional communities. Australia has already developed significant knowledge, expertise and institutional arrangements in land-based industries which could be harnessed to help develop the carbon farming sector (Garnaut 2019a).

- 19 Land use and agriculture activities should continue to be covered by the ERF crediting mechanism, with credits continuing to be used as offsets for facilities covered by the Safeguard Mechanism and available for use in other (for example, voluntary) markets. The ERF purchasing mechanism should continue until an enhanced Safeguard Mechanism provides a source of demand for credits.**

11.5.2. Uptake of vegetation and agriculture methods

Some agriculture producers and landholders have benefited from participating in the ERF. ERF projects have been particularly attractive for large piggeries, landholders that are able to protect land from clearing and encourage revegetation, and groups managing savanna burning. Projects that reduce methane emissions from piggeries provide producers with revenue from ACCUs, and potentially also reduced energy costs from using the captured methane to generate electricity. For example, Blantyre Farms has a project that has earned over 79,000 ACCUs and reduced energy costs by over A\$20,000 a month (Noon 2018; CER 2019a). In addition to generating ACCUs, savanna-burning projects have provided multiple environmental, social and economic benefits to landholders and Indigenous communities (CCA 2018a). Anecdotally, low opportunity cost revegetation projects (which make up half of all contracted abatement) and avoided deforestation projects are providing income diversification that is allowing farmers to invest in their properties (DoEE 2016c) and in some cases helping them to manage their business through the current drought.

Experience with the ERF to date shows that larger producers and landholders are able to benefit from the scheme but that the financial incentives of the ERF are not sufficient for most smaller producers to overcome barriers to participation (CCA 2017a). The National Farmers' Federation stated that 'further reform ... is needed to improve farmer participation in the carbon market' (NFF submission, p. 6).

There are a range of reasons given for the low uptake of some agriculture and vegetation methods (four agriculture methods have no registered projects) (CER 2019a). These include the higher up-front capital costs of some projects, the large scale of projects required to meet the minimum bid size for government auctions of 2,000 ACCUs, and the difficulty in implementing projects for mixed enterprise businesses (CCA 2017a). Again, reducing participation costs and increasing opportunities for projects can help to address this (Appendix A).

While the ERF has a role in the agriculture and land sectors, the Environmental Defenders Office noted that the agriculture sector is unlikely to sufficiently transition to low-emissions production on the basis of government purchasing alone (Environmental Defenders Office submission). Other climate-related opportunities and challenges are arguably driving greater change. These include emerging markets for low-emissions agricultural commodities, innovative forestry products and environmental services, opportunities for integrating renewable energy production and managing climate risks (see sections below).

11.6. Markets for low-emissions and carbon neutral products

Stakeholders have told the Authority that an emerging issue for agriculture is demonstrating the environmental credentials of agricultural products both for export markets and to meet domestic and overseas consumer preferences.

In particular, the European Union is developing a number of frameworks to identify and preference sustainable production that may affect Australian producers. The European Union is developing a set of criteria for sustainable finance, referred to as a 'green taxonomy' (Chapter 15). The proposed green taxonomy includes agricultural and forestry products and specifies criteria for both emissions abatement and climate adaptation that the products need to meet to be considered 'green' (European Commission 2019a). In addition, the European Union has a framework for a circular economy that aims to close the loop on product life cycles by sustainably using resources and minimising waste. This framework includes separate reporting on the environmental footprint of products (European Commission 2019b). A commitment to the Paris Agreement is part of the European Union's free trade agreements with both Canada and Japan, and the European Union has indicated it is seeking similar provisions with Australia (Chapter 15; Darby 2018). Beyond the European Union, China has green finance guidance in place, Canada and Japan are developing frameworks and New Zealand is also progressing a green finance agenda (Chapter 15; The Aotearoa Circle 2019; Government of Canada 2019).

While meeting environmental standards is currently only mandatory in limited circumstances, such as for Australian canola exported to the European Union biofuel market (Box 13), developments in this area have the potential to affect Australian agricultural exports. The CSIRO has reflected that demonstration of these environmental credentials is becoming increasingly important to maintain market access (CSIRO 2019b).

As market benchmarks become more common, Australia's agriculture industry will need to be able to demonstrate that it meets market requirements. Australia's agriculture production systems are very different from those in the northern hemisphere. To maintain access to Australia's export markets, it will be important for Australia to ensure that the metrics being proposed by the European Union and other countries suit Australian systems. It will also be important that we have the evidence base needed to demonstrate our credentials.

- 20 Undertake a review of green product standards and definitions being developed in export markets and engage with trade partners to ensure they do not unduly restrict market access for Australian agriculture.**

Box 13 Australian canola must be low-emissions to meet European Union market regulations

The European Union has regulations in place requiring canola imported for use in biofuels to be produced using low-emissions practices (GRDC 2018). This is an important market for Australia—it represents 91 per cent of exported canola and was worth around A\$1 billion in 2016–17 (CSIRO 2017b; GRDC 2018).

Australia retained access to this market as a result of CSIRO research which demonstrated that the life cycle emissions from Australian canola met the European Union’s strict requirements. This research was important, because Australian production systems differ from those in Europe. For the life cycle assessment to be accepted, it needed to be based on strong evidence.

11.7. Research, development and extension

The Authority found in its 2016 Special Review that research and development on abatement opportunities for agriculture and land sectors is a priority area and should be part of a policy toolkit to help Australia to meet its Paris Agreement targets.

As part of this review, stakeholders have told us that more basic research is needed to support the transition pathway towards net-zero emissions agriculture and that this research needs to be accompanied by better adoption of existing research and data (RMAC, NFF).

The Australian Government and primary producers co-invest in research and development for the agriculture industry through the rural research and development corporations. The Authority’s 2017 ERF review and 2018 *Reaping the rewards* report recommended that rural research and development corporations consider and prioritise objectives for both emissions reductions and natural resource management as well as on-farm profitability in their work programs.

Given the transition task ahead, the Authority considers that additional funding should be made available for targeted research with the specific goal of identifying and/or delivering benefits to emissions reductions. This would focus on research that is not able to immediately be commercialised but with good potential. In determining the best governance for this additional funding, the Government should take into account the outcomes from the review of the rural research and development corporations and consider synergies with the work program on climate change under the Agriculture Ministers’ Forum. The Red Meat Advisory Council has suggested this research funding needs to be guaranteed for a period of 10 years to have impact in the agriculture sector (RMAC submission).

Transition pathways for each agriculture industry should be developed to inform where best to invest, with governments and industry working together. This would build on the work already done by agriculture industries, including the overarching National Farmers’ Federation 2030 Roadmap and sector-specific frameworks and plans (NFF 2018a; AgriFutures Australia 2019a).

Stakeholders have told us that the transition pathways could include:

- new technologies and practices to reduce methane emissions from livestock, reduce emissions from fertiliser, including from fertiliser production, and improve regenerative agriculture practices (RMAC, Greening Australia, The Next Economy submissions; CCA 2019a)
- developing measurement standards, targeted online tools and platforms to assist farmers to report on voluntary industry emissions targets, international green standards and product labelling, and ERF methods (Box 14; CMI 2017; CCA 2018a).

ARENA’s development of a bioenergy road map for Australia will further help support the sector and is welcomed by the Authority. The IPCC recognises a place for sustainably managed bioenergy in a low-

emissions economy and the Australian Forest Products Association has called for an expanded renewable bioenergy industry in Australia (IPCC 2019b; AFPA submission).

Box 14 Building measurement and reporting capability

The Australian red meat industry is positioning itself to be carbon neutral by 2030 (Australian Beef Sustainability Framework n.d.; RMAC submission) and the Climate Active Carbon Neutral Standard (formerly the National Carbon Offset Standard) certified its first carbon neutral beef product in mid-2019 (Five Founders n.d.).

To support these initiatives, the industry will need to build its capability to measure and report on its emissions.

The Authority recommended in 2018 that agriculture companies be included in the National Greenhouse and Energy Reporting Scheme in a voluntary capacity to develop a national standard for measuring emissions, build industry capability and begin to harmonise agriculture emissions reporting with other sectors (CCA 2018b).

Stakeholders and industry reports suggest more work is needed to adopt existing low-emissions agriculture technologies and practices through extension, outreach and pilots (NFF, The Next Economy submissions; ACIL Allen 2019; Australian Farm Institute 2019). The Authority reiterates its recommendation from the *Reaping the rewards* report (2018) that rural research and development corporations should build on their existing extension programs to improve adoption rates.

21 Allocate additional funds for research on low-emissions agriculture and carbon farming, including possible new agricultural industries. This would include basic research, applied research (including on new ERF methods), and the development of tools to report on the emissions profile of agricultural activities.

11.8. Innovative finance to unlock investment

In 2018, the Authority recommended that the government establish a Land and Environment Investment Fund to facilitate greater investment in projects that reduce emissions and have other public good benefits in the agriculture and land sector (CCA 2018a). This fund would function in a similar way to the CEFC for low-emissions energy projects, which has reduced the commercial risk of investing in such projects.

Stakeholders have continued to support this recommendation (ClimateWorks 2019a; The Next Economy, RMAC submissions). The Red Meat Advisory Council, in its submission to this review, added that, to suit the land sector, the fund would need to:

- extend beyond emissions reductions to also invest in ecosystem service opportunities
- support ‘investment cycles of up to 10 years’ to align with the industry (p3).

Other stakeholders discussed the importance of developing the frameworks for investing in natural capital, together with carbon offsets, and working with banks to build their capacity for investing (ClimateWorks 2019a). Some noted that, with greater information and capacity building, there is potential for banks to financially reward farmers for practices that reduce risks to productivity.

The CEFC has invested more than A\$260 million in the agriculture sector over the last five years to increase the use of clean energy by the sector (CEFC 2019a). This investment has led to clear benefits, including the 120

development of industry guidance on energy efficiency and clean energy investments (NFF submission; CEFC 2019a). In November 2019, it announced a further A\$8 million contribution in the form of a cornerstone investment in a specialist agrifood tech investment fund, which invests in companies helping the agriculture sector lower emissions while becoming more climate resilient (CEFC 2019b). Given the CEFC's knowledge of working with the agriculture sector, one possibility is for the Land and Environment Investment Fund to be incorporated within the CEFC institutional structure.

The Land and Environment Investment Fund should work with the rural research and development corporations and other organisations undertaking research on emissions reductions to support commercialisation of new research in a similar format to the CEFC working with ARENA on clean energy technologies.

22 Introduce a Land and Environment Investment Fund (that is, a Clean Energy Finance Corporation (CEFC) for the land) to invest in actions to support low-emissions and climate-smart agriculture and associated environmental services.

In its submission to this review, the Red Meat Advisory Council recommended incentivising the uptake of new technologies through tax deductions for supplements to reduce livestock methane. The Authority considers that there is merit in assisting in the uptake of low-emissions agriculture inputs, such as nitrate-based lick-blocks for cattle to reduce methane emissions and high-efficiency fertilisers to reduce nitrous oxide emissions from soils (CCA 2019a; NFF 2017). The Authority recommends that the Government consider the best way to encourage agricultural producers to use low-emissions inputs and practices.

23 Investigate and implement the most effective incentives to encourage the use of emissions-reducing inputs in agricultural production systems.

11.9. Enhancing preparedness for climate change impacts

Climate change is one of the most significant risks facing the future of the Australian agriculture industry and is expected to cause productivity declines (Chapter 2). Agriculture industries (for example, the grains and red meat industries) have highlighted this risk in their strategies and have called for more information on both future climate risks and opportunities and research on adaptation to help prepare farmers for the future (Australian Farm Institute 2019; AgriFutures Australia 2019b; NFF 2018a; KPMG 2019; RMAC submission). Banks are also now using information on climate impacts to understand their own investment risk in the agriculture industry (CBA 2019).

Agriculture groups and stakeholder submissions to this review called for a national strategy for the agriculture industry on both climate change mitigation and adaptation (RMAC, NFF, EDO). Since then, on 25 October 2019, agriculture ministers from the Australian and state and territory governments committed to a coordinated national approach and a work program to support the agriculture sector to adapt to climate change and manage emissions (AGMIN 2019). The work program intends to focus on information delivery to support decision making and risk management, research and innovation for adaptation and mitigation in the sector, building resilience in agriculture businesses through strengthening market opportunities and managing increased risks from pests in a changing climate. The National Farmers' Federation responded positively to the announced work program with the expectation that it will provide a critical framework to pursue action for the sector (Australian Farmers 2019). The Authority also welcomes this commitment and notes the importance of creating linkages between it and the Authority's recommended long-term climate change policy strategy to guide the low-emissions transition for the economy as a whole (Chapter 6, Recommendation 1).

The Australian Government is separately making a significant investment in improving the resilience of Australian agriculture to climate change through the Future Drought Fund. The Future Drought Fund is a long-term investment fund that will provide a sustainable source of funding to support Australian farmers and communities to become more prepared for, and resilient to, the impacts of drought. From July 2020, A\$100 million will be available each year to invest in drought resilience projects, research, extension and adoption of technology and improved natural resource management. The draft funding plan specifically mentions the need to link with other policies and programs to address the agriculture sector's multiple challenges and opportunities (DoA 2019c).

The need for coordination between land sector policies was discussed in the Authority's 2018 *Reaping the rewards* research report. The Authority recommended better coordination of policies on emissions reductions, enhanced natural resource management outcomes and on-farm profitability, starting with the development of best-practice guidance and followed by the establishment of a community of practice. The Queensland Government's A\$500 million Land Restoration Fund is a good example of a program integrating carbon farming and co-benefits while supporting research (Queensland Government 2019). The objective of the fund is to facilitate projects that deliver verified environmental, social or Indigenous co-benefits at the same time as increasing carbon storage in vegetation and soils through an ERF method. The need for this type of coordination of programs and information provision continues to grow and is being sought by stakeholders (ClimateWorks 2019a; AgriFutures Australia 2019a).

The Authority has also heard from stakeholders that climate risk and adaptation should be considered together with mitigation for outcomes to be most effective. This was a focus of the IPCC's report on climate and the land (Greening Australia, AFPA submissions; Australian Farm Institute 2019; IPCC 2019b).

- 24 Together with state and territory governments, continue to coordinate and integrate programs designed to increase mitigation, build resilience to drought and climate impacts, enhance biodiversity and provide benefits for Indigenous communities, including through interjurisdictional partnerships and program linkages.**

11.10. Land use regulations are important

Emissions from agriculture-related land clearing have reduced significantly since 1990, and a major reason for this reduction was the state regulations on land clearing introduced in the 1990s (CCA 2014a). Since then, land use emissions have reduced to less than 1 per cent of the national total (DoEE n.d.c). However, NSW, Queensland and Western Australia relaxed their land clearing regulations in 2013 and there is evidence this may have led to some increases in clearing (Queensland Government 2018; New South Wales Government 2019). In the case of Queensland, around 60 to 80 per cent of clearing between 2015 and 2018 was of regrowth (non-remnant vegetation) (Queensland Government 2018). Clearing of regrowth has a lower carbon impact on a per-hectare basis than clearing of mature vegetation due to the lower biomass of younger regrowth forests (DoEE 2019b).

In NSW, new legislation came into force in 2017 and the Audit Office of NSW recently found that 'the processes supporting the regulatory framework are weak and there is no evidence-based assurance that clearing of native vegetation is carried out in accordance with approvals' (Audit Office 2019). According to NSW Government data, rates of land clearing varied from 5,400 to 9,700 hectares a year from 2009–10 to 2014–15 and this increased to 27,100 hectares of woody vegetation cleared in 2018–19 (New South Wales Government 2019).

In 2018, Queensland introduced new regulations designed to better manage land use, and the impact of this new legislation is not yet known.

Concern with the current rates of land clearing, tighter land clearing regulations and the development of new reserves were raised in some submissions. The National Farmers' Federation called for farmers to be compensated for productivity losses from any changes to regulations.

Given the desire for agriculture to move to carbon neutral by 2030, and the importance of natural capital to buffer agriculture land from climate impacts, it will be important for state governments to properly monitor and enforce compliance with their land clearing regulations.

11.11. Supporting forestry and sustainable use of wood

The forestry industry has estimated that it could contribute up to 18 million tonnes of abatement (CO₂-e) in 2030. Around 13 Mt CO₂-e of this would be through 400,000 hectares of planned new plantations, and the remaining 5 Mt CO₂-e would be from initiatives to improve forest management and replacing carbon-intensive concrete and fuel with wood and biofuels (Australian Forest Products Association n.d.; BAEconomics 2018).

The Australian Government's forestry plan, published in 2018, helps to support this vision. As part of the Government's plan, it announced funding to support the commercialisation of farm forestry; drive further innovation, research and development for new products and value-adding in forest industries; and pilot a regional forestry hub (DoA 2018). This plan aims to create and maintain regional jobs and the increase to farm forestry has the support of the National Farmers' Federation. The Authority considers that, where appropriate, farm forestry projects should have access to its proposed Land and Environment Investment Fund (Recommendation 22).

12.WASTE

Enhancing and harmonising current state and territory regulatory approaches to reducing emissions from waste, especially landfill gas, combined with the implementation of the National Waste Policy Action Plan, together present the best way forward for reducing waste sector emissions.

The waste sector makes up around 2 per cent of Australia's total emissions (11.8 million tonnes in the year to September 2019) (DISER 2020). The majority of waste emissions (around 70 per cent) come from landfills, when organic matter decomposes in the absence of oxygen, producing methane. The remaining emissions come from the release of gases during the treatment of wastewater (around 27 per cent), waste incineration and biological treatment of solid waste (DoEE 2019b).

12.1. Strategies for emissions reductions through waste management

Landfills present the main opportunity for emissions reductions in the waste sector. Options for reducing emissions include capturing methane at landfills, reducing the volume of waste generated, recycling, and diverting materials from landfill. Studies have shown that an efficient landfill gas collection system can capture about 90 percent of the emissions produced at a landfill site.

Emissions from wastewater treatment can be reduced by capturing methane. Emissions from waste incineration and biological treatment of solid waste (windrow composting and anaerobic digestion) can be reduced by controlling fugitive emissions (Victorian Government DELWP 2017).

12.2. Current policies

Current policies to reduce emissions from the waste sector include landfill gas regulation, measures to incentivise landfill gas capture beyond regulatory requirements and diversion of waste from landfill.

Landfill gas management is mandatory in most states and territories, requiring landfill operators to meet safety and odour standards and to limit greenhouse gas emissions. However, there is significant variation between jurisdictions in the level of emissions allowed from landfills. Regulation also takes the form of site-specific licence conditions, which means landfill gas management requirements can vary between sites within the same jurisdiction (ERAC 2018).

As coverage of landfill gas regulation varies, larger landfills are more likely to capture landfill gas than smaller landfills. Analysis undertaken by the Emissions Reduction Assurance Committee (ERAC) found that around 50 per cent of small to medium landfills capture methane, compared with 90 per cent of large landfills. In 2017 approximately 45 per cent of total methane generated by landfills was collected for either flaring or energy generation (DoEE 2019b).

The Safeguard Mechanism can also constrain the emissions of large landfills. To date, 14 landfills have been issued baselines under the Safeguard Mechanism (ERAC 2018).

Projects that capture landfill gas beyond regulatory requirements or divert waste from landfill can earn ACCUs under the ERF. There are over 100 registered landfill gas projects under the ERF, representing around 15 per cent of operating landfills in Australia (CER 2019a; ERAC 2018). As of January 2020, there are only 30 projects registered under the ERF which divert waste from landfill using the source separated organic waste and alternative waste treatment methods (CER 2019a).

Landfill and waste projects under the ERF have been successful in reducing emissions in the waste sector, representing over 25 million tonnes of abatement since 2012 (CER 2019c). In its 2018 review of the Landfill Gas Method, the Electrical Regulatory Authorities Council (ERAC) found that 'flaring only' landfill gas

projects under the ERF have been particularly successful in achieving abatement beyond the ordinary course of business (ERAC 2018).

Under the Renewable Energy Target, projects which capture and combust landfill gas to generate electricity are also eligible to earn saleable Large-scale Generation Certificates. There are 57 power stations accredited under the Renewable Energy Target fuelled by landfill gas (CER 2019e).

12.3. The Authority's previous advice

In 2016 the Authority recommended that regulations that set limits on methane emissions from landfill waste should be harmonised across Australia and that consideration be given to how best to cover small and regional landfills. In its 2017 review of the ERF, the Authority reaffirmed its view that the best approach to reducing emissions from landfills would be for the COAG to agree to nationally harmonised regulation (CCA 2017a).

The Authority also recommended emissions reductions projects from landfill waste should be eligible for ERF purchasing and crediting until enhanced regulation is put in place for these sectors (CCA 2016a).

12.4. Significant changes since 2016

Since 2016 the most significant changes in the waste and resource recovery sector have been the update of Australia's National Waste Policy and a commitment by COAG to ban the export of recyclable waste.

The Australian Government has recently released an updated National Waste Policy and supporting Action Plan which commit to ambitious recycling targets and adopt a circular economy approach to waste (DoEE 2018e, 2019d). A circular economy approach reduces waste by improving the design of materials, products and business models and by keeping products and materials in use for as long as possible (Ellen Macarthur Foundation 2019). The National Waste Policy outlines actions that business, individuals and governments can take to transition to a circular economy, including designing products to last, improving the quality of recycled materials and building markets for recycled products (DoEE 2018e). The updated policy reflects a global movement toward applying circular economy principles, such as in the European Union, Canada and Australia's major trading partners, including China (DoEE 2018e). State governments are also developing and implementing their own circular economy policies and action plans (Victorian Government DEWLP 2019a; NSW EPA 2019; Green Industries SA 2017; Government of Western Australia DWER 2020). The adoption of a circular economy approach to waste by Australian governments reduces greenhouse gas emissions by reducing waste and recirculating materials. This avoids emissions associated with new virgin material production and from end-of-life treatment, such as landfill and incineration (Ellen Macarthur Foundation 2019).

COAG has recently committed to banning the export of recyclable waste (COAG 2019). Every year since 2012, Australia has exported over four million tonnes of recyclable materials, including scrap metals, paper and cardboard and plastics (Blue Environment 2018). Following China's introduction of import restrictions on recyclable materials in 2018, export markets for Australia's recyclable waste have been progressively shrinking, with countries such as Malaysia and Thailand looking to implement similar restrictions in the near future (Blue Environment 2019). In August 2019 COAG agreed to ban exports of waste plastic, paper, glass and tyres, commencing on 1 July 2020 with a phased approach. (DoEE 2019f). About 1.4 million tonnes of these waste materials are currently exported every year (Blue Environment 2019).

To support implementation of the waste export ban and more ambitious recycling targets, the Australian Government has announced a A\$100 million Australian Recycling Investment Fund (Cormann et al. 2019). Managed by the CEFC, the fund supports projects and technologies that will boost Australia's recycling capacity, with a particular focus on supporting the recycling of plastics, paper, glass and tyres, to help contribute to COAG's waste export ban (CEFC 2019d). State governments have also made similar

investment pledges to develop Australia's recycling industry in the wake of China's import restrictions (NSW EPA 2018; Victorian Government 2019b; Queensland Government DSDMIP 2019b; Green Industries SA n.d.).

While landfill gas projects under the ERF have been effective at driving emissions reductions in the waste sector, the crediting period for most projects will expire in 2021. ERAC's 2018 review of the landfill gas method found electricity generating landfill gas projects were unlikely to be additional; therefore, crediting periods should not be extended. However, limited extensions will be granted to 'flaring only' projects, representing around half of all registered landfill gas projects. Waste emissions are projected to fall by just 1 Mt CO₂-e between 2020 and 2030 to 11 Mt CO₂-e (DoEE 2019i).

The opportunity remains to harmonise and strengthen emissions regulations across Australia as recommended by the Authority in 2016. A number of stakeholders continue to support this recommendation (BCSD, ALGA and WMRRRAA submissions):

Once landfill gas flaring projects under the Emissions Reduction Fund (ERF) come to an end, there will generally be no incentive in many cases for continued flaring and it is likely that this will lead to instances of abandoned gas collection equipment and uncontrolled methane emissions. The Commonwealth should coordinate all State and Territory EPAs and/or relevant Departments and develop a nationally consistent set of regulations requiring landfill flaring wherever feasible. (Waste Management & Resource Recovery Association Australia submission, p. 1)

12.5. Opportunities for emissions reductions

12.5.1. Landfill gas capture

With limited extensions to crediting periods available under the Landfill Gas Method, the need for improved regulations as previously recommend by the Authority takes on some urgency. Strengthened and harmonised regulations should be put into place by 2021 in order to maintain the current rate of landfill gas abatement and to encourage additional landfill gas capture.

Harmonising and strengthening regulation of emissions from landfill is an environmentally effective and straightforward way to maintain and further reduce emissions from the waste sector. Regulations should offer flexibility for landfill operators to meet set emissions levels rather than adopt a particular technology so that any new technologies discovered can also be used to meet regulations.

Consideration should be given to how best to deal with smaller regional landfills that emit lower volumes of greenhouse gases, as some abatement options may not be feasible. It will also be important to avoid creating perverse outcomes like waste being transported from one region to another to avoid the impact of regulation.

Adequate monitoring and enforcement by state and territory regulatory bodies will be needed to ensure that regulations deliver the potential emissions reductions.

12.5.2. Reducing organic waste

Organic material (including food, garden and timber waste) creates particular problems in landfill because it releases methane, produces liquid leachate that can pollute groundwater, creates odour and attracts vermin (Blue Environment 2018).

The Australian Government has committed to a national goal of halving the amount of organic waste sent to landfill for disposal by 2030 (DoEE 2019d). Organic waste is a valuable resource that can be harnessed and returned to productive use (DoEE 2019d). For instance, a food manufacturing plant could use organic waste in an anaerobic digestion plant to generate biogas that could be used in place of either gas or electricity from the grid (Victorian Government DELWP 2017). Composting facilities are also able to turn organic waste into various grades of compost which provide further benefits, such as reducing the need for frequent watering, improving soil structure and reducing soil degradation (Sustainability Victoria 2015). Actions that can be taken to divert more organic waste from landfill include better separation and recovery of organic wastes in households and businesses, increasing the capacity of organics processing facilities and creating sustainable end markets for recycled organic products (Sustainability Victoria 2015).

Food waste is a key focus area for the Australian Government given the high quantity and cost to householders and businesses. Food waste is estimated to cost the Australian economy around A\$20 billion every year (DOEE 2017a). The Australian Government has committed to a national goal of halving food waste by 2030, and it developed the National Food Waste Strategy to meet this goal. Actions to reduce food waste include increasing community and business awareness of food waste, promoting food waste avoidance and supporting food rescue organisations (DoEE 2017a).

The Authority recommends that the Government continue to work towards the national goals of halving food waste and the amount of organic waste sent to landfill by 2030 and that all levels of government consider opportunities to strengthen this level of ambition.

25 Work with the states and territories to reduce landfill emissions by strengthening and harmonising regulations on methane emissions from landfill waste, diverting organic waste from landfill and fully implementing the National Food Waste Strategy.

12.5.3. Circular economy

Transitioning to a circular economy presents opportunities for significant emissions reductions in the waste sector. A circular economy displaces landfill gas emissions by reducing waste and avoiding landfill disposal. A circular economy also enables broader emissions reductions in other sectors such as transport and manufacturing. These reductions are achieved by recirculating key production inputs such as steel, aluminium and plastics, which reduces raw material extraction and requires less energy in processing, as well as by reducing waste in the production process by improving materials efficiency (Energy Transitions Commission 2018; Material Economics 2018). For instance, recycling 1 tonne of plastics can reduce emissions between 1.1 and 3.0 tonnes of CO₂-e compared with producing the same tonne of plastics from virgin fossil feedstock (Ellen Macarthur Foundation 2019).

Some waste streams, such as solar panels and batteries, will rapidly increase as Australia transitions toward a low-emissions economy. For instance, Australian researchers have estimated that the amount of waste from retired solar panels will be over 1.5 million tonnes by 2050 (Salim et al. 2019). Keeping these materials out of landfill prevents environmental and human health problems and recovers valuable resources for reuse. CSIRO and the Australian Council of Learned Academies have both highlighted recycling of lithium-ion batteries as a significant opportunity for Australia, estimating that 1 tonne of lithium-ion battery waste has potential recoverable value of between A\$4,550 and A\$17,252 (CSIRO 2018). Currently, Australia has little capacity to recycle lithium-ion batteries, with only 2 per cent of Australia's annual 3,300 tonnes of lithium-ion battery waste recycled (CSIRO 2018). To ensure solar panels and battery waste are safely managed, and to recover valuable resources, a strong commitment is needed from governments and industry to adopt a circular economy approach. The Victorian and Queensland governments are currently leading work on product stewardship schemes for batteries and photovoltaic (PV) systems with the support of industry, the

Australian and other state and territory governments (DoEE n.d.k). ARENA has also recently announced up to A\$15 million in funding to support research that aims to address end-of-life issues for solar PV panels (ARENA 2019e).

Adopting a circular economy approach in the mining industry through the stewardship of mineral and metal materials can also reduce emissions and add value. Material stewardship practices include better resource utilisation through recovering and recycling critical minerals and re-purposing by-product materials generated from the extraction and production processes, for example the production of cobalt as a by-product of copper and nickel (Australian Government 2006, DISS n.d.b).

The benefits of a circular economy extend beyond reducing emissions. Circular principles, such as improving management of plastic waste, will help prevent significant biodiversity loss and protect human health (Victorian Government DELWP 2019a). Transitioning to a circular economy can also create jobs and contribute to economic growth (OECD 2018). Opportunities for new business models and services emerge in a circular economy, such as repair and product leasing businesses (OECD 2018). There is also potential for significant growth in the waste and resource recovery sector. Modelling undertaken by Access Economics suggests 9.2 full-time jobs are created for every 10,000 tonnes of material recycled compared with 2.8 jobs per 10,000 tonnes sent to landfill (Access Economics 2009).

While there are many benefits to a circular economy approach, there are also many barriers to achieving it. These barriers are complex in nature and require coordinated action across different sectors of the economy and along the supply chain of any given product. For instance, many plastic products are designed in ways that make recycling difficult or impossible because product manufacturers lack incentives to enable high-value recycling. When plastics products are recycled, contamination of recycling streams can often result in production of low-quality recycled plastics at relatively high cost (Material Economics 2018). These barriers can be overcome by a range of measures such as reducing unnecessary plastic packaging, using product design standards for recyclability and improving the quality of collection and processing of plastics for recycling (OECD 2018):

*Government support for innovation in low-carbon technology is key to positioning the Australian waste and resource recovery sector as leaders in circular economy principles.
(WMRRAA submission, p. 2)*

The Authority welcomes the Australian Government's adoption of a circular economy approach for waste in Australia. In particular, the Authority commends the identified actions in the National Waste Policy Action Plan, which will help to identify key barriers to a circular economy and coordinate efforts across different sectors of the economy (DoEE 2019d). Implementation of the Action Plan will help Australia transition to a low-emissions economy by achieving greenhouse gas reductions and by identifying emerging opportunities for communities undergoing transition. There is a potential opportunity for Australia to be a world leader in circular economy practices, for example for materials that enable a net zero emissions future such as lithium and manganese.

However, it is not always desirable to recycle some types of materials. In some cases, recycling could result in a net increase in greenhouse gas emissions compared with landfill disposal (WMRRAA submission, p. 2). According to the waste hierarchy, waste-to-energy⁴⁰ is preferable to landfill disposal and can help reduce greenhouse gas emissions from landfill (Victorian Government DELWP 2017). ARENA has provided funding for the development of two large-scale waste-to-energy facilities in Western Australia. The combined effort of

⁴⁰ 'Waste-to-energy' is a term commonly used to describe the process of generating energy such as electricity, heat or fuels from waste.

these two facilities will divert up to 700,000 tonnes of waste per year from landfill and recover enough energy to power 90,000 homes (ARENA 2018b, 2020). There remains an opportunity for the Australian Government to clarify the role of waste-to-energy in Australia's transition to a circular economy and to help identify opportunities and barriers to generating energy from waste that is unsuitable for recycling.

26 Recognising the benefits of a circular economy approach for emissions reductions, ensure implementation of the National Waste Policy Action Plan considers industry development, the waste hierarchy, research and development needs, training requirements and barriers to adoption; and emphasises the creation of industries in regions undergoing transition.

13. ENERGY EFFICIENCY

Energy efficiency can reduce emissions in all sectors of the economy, including in transport, industry and the built environment.

Improving energy efficiency can deliver substantial economic benefits, including financial savings to businesses and households and lower cost of transition to a low-emissions economy by reducing energy demand.

Energy efficiency offers some of the cheapest ways to reduce emissions. However, persistent barriers have continued to prevent increased uptake of energy efficiency improvements. Government intervention through effective regulation and information programs can unlock significant cost-effective emissions reductions.

Energy efficiency measures reduce the amount of energy used to undertake a given activity, which results in lower overall energy use, or allow increased production of goods or services for the same amount of energy. Reducing energy use reduces the amount of greenhouse gas emissions that result from the use of energy (Productivity Commission 2005b; IEA 2014, 2019c). This is particularly important for emissions reduction in Australia, as the use and production of fossil fuels for energy is responsible for 82 per cent of Australia's emissions (DoEE n.d.a). Energy efficiency can reduce emissions in all sectors of the economy, including households, industry, transport and services (ClimateWorks 2014).

Energy efficiency improvements have multiple benefits that accrue to both the energy user (such as improved productivity or lower costs) and the community (such as job creation, health and environmental benefits) (IEA 2014). In the context of climate change mitigation, energy efficiency has two principal benefits—reduction of energy use, leading directly to lower greenhouse gas emissions from energy; and lowering of the cost of transition to a low-emissions economy by reducing the amount of low-emissions energy infrastructure that must be built to replace high-emissions infrastructure (Productivity Commission 2005b; IEA 2014).

Despite the benefits that can be derived from improving energy efficiency, Australia's performance on energy efficiency is poor compared with other developed nations. An international scorecard ranked Australia's energy efficiency as 18th of the top 25 energy using countries—down from 10th in 2014 and well behind comparable developed economies, such as Japan, Germany, France and the United Kingdom. Industrial energy efficiency in Australia scores particularly poorly (ACEEE 2018).

To date, most efforts to improve energy efficiency have focused on the buildings sector.⁴¹ The buildings sector includes the design, construction and management of commercial and residential buildings. Buildings account for 18 per cent of Australia's greenhouse gas emissions, around 20 per cent of Australia's energy use and over 50 per cent of Australia's electricity use (COAG Energy Council 2018; Low Carbon Living CRC 2017). Emissions from the buildings sector are divided almost equally between residential and non-residential buildings. Grid-supplied electricity consumption by buildings is responsible for 86 per cent of the sector's emissions. The remainder is from direct fuel combustion, such as gas or wood for heating, hot water systems and cooking (ASBEC 2016).

⁴¹ For example, several energy efficiency schemes have focused on energy efficiency upgrades in residences through replacement of incandescent light bulbs and provision of other energy savings technology.

13.1. Barriers to improving energy efficiency

Little recent information is available about the specific Australian drivers of, and barriers to, energy efficiency. Possible barriers include:

- market failures, including imperfect information, split incentives and externalities
- behavioural, cultural and organisational barriers
- opportunity costs of investment in energy efficiency
- policy uncertainty (Productivity Commission 2005b; IEA 2011; Energy Efficiency Council 2016).

There is limited information about Australia's progress in improving energy efficiency. Although some high-level data is available to track the energy intensity of the economy and of selected industrial sectors (ABS 2019e; DoEE 2019g), these indicators provide little information about meaningful energy efficiency activity in smaller economic segments. A more detailed understanding of this activity would highlight where barriers exist and help in the development of policy to overcome them.

However, substantial work has been undertaken in the building sector to identify the specific, persistent barriers that prevent wider uptake of energy efficiency improvements. These include:

- information gaps, which arise because there is no obligation on the seller/lessor to disclose a building's energy performance to potential buyers/lessees at point of sale or lease. Homeowners, tenants and businesses also lack appropriate data, information and skills to understand their energy use and improve their energy efficiency
- split-incentives, which arise when the costs of actions to improve energy efficiency are borne by one party (typically the owner) but the benefits accrue to others, such as tenants.
- price barriers, which arise from high up-front costs and long payback periods. Low-income households and small to medium enterprises may experience difficulty in financing energy efficiency improvements (ClimateWorks and ASBEC 2018; CIE 2019).

Compared with Organisation for Economic Co-operation and Development (OECD) peers, Australia has historically enjoyed low energy prices and developed an economy with high energy intensity, indicating that energy efficiency improvements may have assumed a low priority for firms and consumers. In turn, historical inaction on energy efficiency can contribute to information, organisational and cultural barriers to improving energy efficiency, such as a lack of developed expertise and resources available to consumers and firms (Productivity Commission 2005b).

Even though there can be barriers to improving energy efficiency, it is a highly scalable strategy for reducing greenhouse gas emissions. Actions can be taken at a variety of levels, which can lead to energy savings and emissions reduction, for example:

- individuals can purchase energy-efficient appliances and vehicles, use energy-saving heating and cooling settings, switch off unused appliances and follow energy-efficient practices such as waiting until they have a full load before using a washing machine
- householders can upgrade lighting to energy-efficient LED varieties, seal gaps around doorways and windows and use curtains and blinds to reduce heat loss. Homeowners who are able to make changes to their dwellings could insulate wall and roof cavities, upgrade water heaters to solar or other efficient varieties, upgrade pool equipment to efficient varieties and use external shading to reduce cooling needs in summer

- small and medium business can upgrade equipment to energy efficient varieties, ensure all equipment is maintained and running efficiently, optimise business lighting, heating and cooling and make changes to practices and processes to most efficiently use energy and resources
- transport enterprises can upgrade vehicles and equipment or use smart optimisation of routes, loads and schedules to save fuel
- agricultural enterprises can use energy-efficient equipment for production, processing and storage of agricultural products, as well as smart technology to optimise operations
- large industrial enterprises can implement changes to processes or upgrade equipment to save energy in production processes. In energy-intensive processes, even small changes can lead to thousands of dollars' worth of savings. Fuel-switching to more flexible fuels (such as electricity or gas) can also lead to energy savings (CCA 2019a; ClimateWorks 2014, 2015; YourHome 2013; Energy Efficiency Council 2016).

While these may seem to be straightforward actions, anecdotal evidence provided through consultation suggests that consumers and firms lack the information and resources necessary to make efficient use of energy. Even though energy prices have increased significantly faster than inflation over the past decade, progress in energy efficiency appears to be modest. This is despite the fact that marginal abatement cost data consistently shows that energy efficiency should deliver overall savings to consumers and firms (ABS 2019e, 2019f; ClimateWorks 2010; RepuTex 2015). Overall, it appears that barriers to implementing energy efficiency are not overcome by current policies.

13.2. Current policies

13.2.1. Strategic national energy efficiency policy

Australia has had a national strategic policy on energy efficiency since 2004. The current policy is the National Energy Productivity Plan, agreed by the COAG Energy Council in 2015. The plan aims to improve energy productivity by 40 per cent between 2015 and 2030 (COAG Energy Council 2015).⁴² It includes 34 measures for improving energy productivity, split between strategies to improve energy affordability and energy market reform; and strategies that could improve energy efficiency. Some stakeholders have criticised the low ambition of the plan, as well as a seeming lack of progress on many of its measures (A2EP 2018). In isolation, improving energy affordability may not be complementary to energy efficiency, as improving affordability can allow for the continuance of inefficient, energy-intensive practices.

Over the past two decades, national strategic energy policy has prioritised the introduction of competition into previously vertically integrated electricity and gas systems. While some measures designed to introduce and improve competition (such as cost-reflective tariffs and advanced/smart metering infrastructure that can increase consumer awareness of electricity use and costs) have the potential to encourage consumer energy efficiency, the benefits promised through implementation of these measures do not seem to have been realised by consumers or the community (Victorian Auditor General 2015; Chandrashekeran et al. 2018).

⁴² Energy productivity is defined as the amount of gross domestic product (GDP) that is produced per unit of energy used. It is the inverse of economic energy intensity, which measures energy used per unit of GDP.

13.2.2. Energy efficiency improvement policies

Policies and programs exist at both the Australian and state and territory government levels to improve energy efficiency. Agreements at COAG level have underpinned many national initiatives, as states and territories have historically been responsible for energy services.

Energy efficiency standards and labelling

Among the most effective national energy efficiency measures are standards and labelling for appliances under the *Greenhouse and Energy Minimum Standards Act 2012* (Cth) and its precursors, which continue to deliver energy savings to consumers. Products subject to the standards must meet a Minimum Energy Performance Standard and in some cases display an Energy Rating Label before being offered for sale in Australia. The standards apply to most household appliances, including air conditioners, washing machines, computers, TVs and lighting. They also apply to commercial appliances such as commercial refrigeration, distribution transformers and electric motors (energyrating.gov.au n.d.).

A recent review found that the costs of the scheme to consumers were ‘significantly outweighed’ by energy bill savings returned to consumers. Between 2014 and 2020, energy labelling and minimum performance standards are cumulatively expected to save between 69,000 and 80,000 GWh of energy over the life of the appliance, avoiding greenhouse gas emissions of between 60 and 70 million tonnes CO₂-e (Databuild 2015). Under its Climate Solutions Package, the Australian Government has committed to expanding the coverage of energy rating labels to additional heating appliance types, as well as providing information about improving energy efficiency to households and businesses (Australian Government 2019a).

Buildings

The National Construction Code (NCC), implemented by all states and territories, also plays an important role in energy efficiency. The NCC sets minimum requirements for all new buildings and major renovations in Australia and includes requirements for energy efficiency. The 2019 revision of the code has increased energy efficiency requirements for commercial buildings and is expected to reduce commercial building energy consumption by up to 35 per cent (ABCB 2018). Regular updates to the NCC, aligned with the trajectory to zero energy (and carbon) ready buildings that has been adopted by the COAG Energy Council in its Trajectory for Low Energy Buildings, will further improve the energy efficiency of new residential and commercial buildings (COAG Energy Council 2018).

While the NCC mandates minimum energy efficiency requirements for all new buildings, there is no mechanism to address the retrofitting of existing buildings. The recently adopted Addendum to the Trajectory for Low Energy Buildings outlines a suite of policies for improving the energy efficiency of existing residential and commercial building (COAG Energy Council 2019e). For existing residential buildings this includes targeted policies, such as minimum rental requirements, energy efficiency requirements for renovations and a national framework for energy efficiency disclosure, as well as other measures, including financial incentives and support for vulnerable households. For commercial buildings this includes expanding existing policies—the Commercial Building Disclosure (CBD) program and the Energy Efficiency in Government Operations (EEGO) policy—and other measures, such as extending coverage of National Australian Built Environment Rating System (NABERS) energy ratings to all major building types and improving heating, ventilation, and air-conditioning (HVAC) systems in existing buildings (COAG Energy Council 2019e).

The CBD program requires mandatory disclosure of energy efficiency information to be provided in most cases when commercial office space of 1,000 square metres (m^2) or more is offered for sale or lease.⁴³ There is evidence to suggest that the CBD program has resulted in substantial improvements in building performance over time (ACIL Allen 2015; Ernst & Young 2015). The program has been particularly successful in achieving rapid improvements in less energy-efficient buildings, with average star ratings improving by over two stars and energy use falling, on average, by 160MJ per m^2 of floor space (CIE 2019).

The Australian Government's EEGO policy sets out minimum energy efficiency targets for government buildings. This includes a base 4.5 star NABERS rating for government-owned buildings and green leases for tenanted spaces. The EEGO policy only applies to large government office buildings ($\geq 2,000 \text{ m}^2$) that are new or have undergone major refurbishment and are leased for over two years (AGO 2006).

Other policies

Some state and territory jurisdictions operate energy efficiency schemes ('white certificate' schemes) that require energy retailers to assist consumers to improve energy efficiency. Although their targets and methods vary, evaluations of these schemes have found them to be a cost-effective method of improving energy efficiency and reducing emissions (Box 15). In 2017, the Australian Capital Territory's (ACT) scheme is estimated to have saved energy equal to 2.9 per cent of the ACT's electricity and gas use (Point Advisory 2018).

In 2019, the Australian Government announced a Business Energy Advice Program to assist small businesses to manage and reduce their energy costs. As a part of the program, advisory services are available to help small businesses understand their energy saving opportunities through energy efficiency improvements and by switching energy plans and retailers (Australian Government 2019b).

The ERF also provides a mechanism to incentivise energy efficiency, but take-up under the scheme has been low. Of the 192 million tonnes of abatement contracted to the ERF, only 5.2 million tonnes is from energy efficiency projects (CER 2019c). The Safeguard Mechanism does not provide a strong signal to liable entities to improve efficiency, although it can discourage reductions in efficiency.

⁴³ The CBD program requires provision of information in a Building Energy Efficiency Certificate (BEEC) about the lighting efficiency of the tenanted area through a Tenancy Lighting Assessment (TLA) and a NABERS star rating, which provides information on energy use; GHG emissions; and a benchmark of how energy use compares with similar buildings in similar climatic locations (CIE 2019).

Box 15 State and territory energy efficiency schemes

NSW, Victoria, South Australia and the ACT have established separate schemes to encourage energy efficiency (CCA 2019b). Under these schemes, activities are incentivised by the creation of energy savings certificates that energy retailers (usually electricity retailers) are obliged to purchase and surrender. Typical activities have included replacing incandescent lighting with energy-efficient LEDs or compact fluorescent globes or assisting businesses to save energy in their operations (New South Wales Government DTI 2015; Point Advisory 2018; South Australian Government DMITRE 2013; Bown 2011). In the last decade, the NSW Energy Savings Scheme has supported projects that will save more than 21,000 GWh of electricity over their lifetime (New South Wales Government DPIE 2019).

In evaluations, these schemes have been shown to be:

- successful at overcoming barriers to energy efficiency, particularly information and expertise barriers
- cost-effective (schemes return benefits typically three to four times more than their costs)
- successful in reducing greenhouse gas emissions as a result of energy use savings
- successful in promoting awareness of energy efficiency
- providing both public and private benefits (although the largest benefits accrue to consumers that participate in the schemes)
- able to be targeted to priority groups, such as low-income households (New South Wales Government DTI 2015; Point Advisory 2018; South Australian Government DMITRE 2013; Bown 2011).

13.3. The Authority's previous advice

The Authority's 2016 advice noted that energy efficiency offers some of the cheapest ways to reduce emissions. The Authority concluded that market-based energy efficiency schemes can help drive energy efficiency and recommended that existing state and territory schemes be harmonised and extended to all jurisdictions (CCA 2016a). In 2017 the Authority recommended that a National Energy Savings Scheme be implemented (CCA 2017b).

In the buildings sector, the Authority's climate policy toolkit noted that updates to the NCC and energy efficiency standards for appliances can unlock energy efficiency improvements that provide individual benefits to consumers, as well as reducing emissions. The Authority also recommended that the Australian Government should investigate best-practice domestic and international approaches to improving the energy efficiency of low-income homes, including innovative models for financing the up-front costs of retrofits (CCA 2016a).

13.4. Significant changes since 2016

Since the Authority's last report in 2016, the most significant change to policy settings in energy efficiency has been the adoption of the Trajectory for Low Energy Buildings—a national plan that sets a trajectory

towards zero energy (and carbon)⁴⁴ ready buildings for Australia. Adopted by the COAG Energy Council in 2019, the trajectory will inform future updates to the NCC and further buildings policy measures (COAG Energy Council 2018, 2019e). Direct combustion emissions from buildings (mostly from the consumption of gas) are projected to decline by 4 per cent between 2020 and 2030 due to energy efficiency improvements that are expected to more than offset the projected increase in the number of dwellings (DoEE 2019i).

The NCC 2019 update was the first significant update to energy efficiency requirements since 2010. It focused on increasing energy efficiency requirements for new commercial buildings. The next update to the NCC in 2022 will focus on enhanced energy efficiency provisions for residential buildings (ABCB 2019).

In other areas of energy efficiency, little has changed since the Authority's previous advice to government. The Australian Government has committed to expanding existing energy efficiency policies through the Climate Solutions Package, and these policies can be expected to deliver some improvements in energy efficiency (Australian Government 2019a). However, opportunities remain for stronger action:

Energy efficiency uptake is largely guided by a series of small-scale regulatory decisions which shape the operating environment, especially for the construction of new buildings and energy efficiency decision making in existing buildings. The National Energy Productivity Plan provides a strong platform for shaping this operating environment but requires much stronger resourcing and political attention to achieve its ambitions. (Engineers Australia submission, p. 6)

13.5. Opportunities for improvements in energy efficiency

Australia's poor performance in achieving energy efficiency improvements relative to other countries could indicate there are plenty of opportunities to reduce energy use and associated emissions. In comparable economies, improvements in energy efficiency have offset new growth in energy use, either partially or completely. In some cases, efficiency has outpaced growth, leading to a reduction in overall energy consumption. This is not the case for Australia, where energy use continues to grow (DoEE 2019g; IEA 2017).

The International Energy Agency has conducted analysis on OECD and other economies to determine the contribution to changes in energy use from demand growth, structural effects and efficiency effects. Unlike most other economies, Australia showed a 0.7 per cent decline in the 'efficiency effect' between 2008 and 2016, after modest gains in the preceding eight years (IEA 2017). This appears to suggest that observed improvements to energy productivity in the Australian economy could be more closely related to structural change (such as the continued shift from manufacturing to services) than to improvements in efficiency (RBA 2010; IEA 2017).

The COAG Energy Council could introduce new measures to reinvigorate and enhance the National Energy Productivity Plan with additional resources. Well designed and implemented energy efficiency measures could lead to significant financial and energy savings and ease the transition in the electricity sector.

⁴⁴ Zero energy (and carbon) ready homes have an energy efficient thermal shell and major fixed appliances, have sufficiently low energy use and have the relevant set-up, so they are 'ready' to achieve net-zero energy (and carbon) use annually if they are combined with renewable or decarbonised energy systems either onsite or offsite.

13.5.1. Overcoming information deficits for policy development

Policies to improve energy efficiency could either seek to create an economy-wide framework that encourages energy efficiency (such as a price signal or broad regulation) or seek to overcome specific barriers to improving energy efficiency. Effective policy design should be based on comprehensive information about the drivers and barriers to energy efficiency relevant to Australian consumers and businesses. This information is not readily available.

A priority for improvement in energy efficiency should be the development of a comprehensive knowledge base on barriers and opportunities for Australia, as well as an audit of current activities. This information should be used to identify targeted areas for policy reform, as well as new programs to increase activity in energy efficiency. The analysis should identify opportunities at all levels of government. This work could support achievement of the National Energy Productivity Plan.

13.5.2. Continue and enhance white certificate schemes

In the absence of economy-wide frameworks that encourage energy efficiency, state and territory white certificate schemes have proven to be effective mechanisms to encourage investment in improving energy efficiency. The Carbon Market Institute notes that these schemes also support large corporate and industrial companies (who are generally not included in the scheme activities) by establishing an accessible expertise and knowledge base for managing energy productivity, appliance and building standards and related emissions reductions (CMI submission).

Several jurisdictions still lack schemes and should consider implementing an efficiency scheme as a priority. A nationally consistent scheme would provide economies of scale and reduce transaction costs for companies operating across state borders (CCA 2017b). The COAG Energy Council should consider how existing schemes might be transitioned to a national energy savings scheme or white certificate scheme. However, the varying methods and ambition of existing schemes means that harmonisation or transition to a national scheme could take some time, and priority should be given to ensuring that transition or harmonisation enhances, rather than interrupts, activity under current schemes. Ultimately, harmonisation could result in significant efficiencies for a scheme and could have co-benefits for its efficacy:

The persistence of differing approaches across each state adds operational complexity that wastes the resources of national participants and works against customers getting the best possible assistance at the lowest cost. Each scheme requires separate configuration in participant administration technology systems, as well as separate approaches to reporting and audit. Further, we suggest that a coherent national framework would improve outcomes through sharing of best practice and demonstrating a national commitment to the objective of reducing usage. (EnergyAustralia submission, p. 4)

13.5.3. Continue and expand effective regulation

The *Greenhouse and Energy Minimum Standards Act 2012* creates regulatory regimes to set nationally consistent energy efficiency labelling and minimum energy efficiency performance standards for certain appliances that use electricity or gas. The Independent Review of the Greenhouse and Energy Minimum Standards (GEMS) Act 2012 concluded that the Act provided ‘a streamlined nationally-consistent approach to appliance energy efficiency while effectively reducing energy use, power bills and greenhouse gas emissions’ (Collyer 2019). These schemes overcome some barriers to the deployment of energy-efficient appliances in residential settings through the provision of information and the prevention of sale of inefficient appliances.

The Government has announced an intention to expand the energy efficiency labelling scheme to additional heating appliances, which was a recommendation of the independent review (Australian Government 2019a). This approach should be continued and enhanced.

13.5.4. Delivering a zero carbon ready building code

Improving the energy performance of buildings is an environmentally and cost-effective way to reduce emissions. Proven technologies which are commercially available today can deliver substantial reductions. Improving the energy performance of buildings also has many co-benefits, including improved comfort levels and health outcomes, lower energy bills for households and improved resilience to extreme weather and reduced electricity peak demand (ClimateWorks and ASBEC 2018):

As energy costs rise and increased demand places ever growing pressures on our energy infrastructure, buildings can provide some of the fastest and most affordable solutions to our energy problems. At the same time, more efficient buildings have the potential to keep costs manageable for households and businesses. (Australian Sustainable Built Environment Council submission, p. 1)

Buildings are long-lived assets, with more than half of the building stock in 2050 expected to have been built or refurbished after 2019 (ClimateWorks and ASBEC 2018). This means that any delays in improving energy performance can lock in higher emissions for decades into the future.

Improving the energy efficiency of new buildings can be driven through a single regulatory instrument—the NCC. Regular reviews of and adjustments to the NCC allow for low-cost abatement, as it is more practical and cheaper to design and build-in higher energy efficiency for new buildings compared with retrofitting existing ones (Energy Action 2018). Regular NCC updates also enable energy performance requirements to remain aligned with emerging energy prices and technology improvements over time (ClimateWorks and ASBEC 2018).

The Trajectory for Low Energy Buildings seeks to inform future updates to the NCC, reducing the regulatory uncertainty and burden associated with ad hoc updates. By enabling greater predictability of future NCC energy performance requirements, the trajectory provides certainty for planning and investment (Energy Action 2018). In delivering the trajectory, the COAG Energy Council should accelerate building energy efficiency improvements in the NCC. A joint study by ClimateWorks and ASBEC projected that stronger energy standards for new buildings in the NCC could deliver 78 million tonnes of cumulative emissions savings by 2050 (ClimateWorks and ASBEC 2018). To ensure the trajectory is aligned with the long-term goal of a net-zero emissions economy, it should be extended from 2030 out to 2050 and include interim targets and a process for regular review (Property Council of Australia and GBCA 2019).

While updates to energy efficiency provisions in the NCC provide opportunities for substantial emissions reductions, there is often a gap between the expected and actual energy performance of buildings (IPEEC 2019). Effective compliance with, and enforcement of, the NCC can help to address this gap (Property Council of Australia and GBCA 2019). In July 2019, Australian building ministers committed to developing a national framework to address issues relating to compliance and enforcement identified in the report by Shergold and Weir, *Building confidence: Improving the effectiveness of compliance and enforcement systems for the building and construction industry across Australia* (BMF 2019). However, there are a range of factors contributing to the gap between the expected and actual energy performance of buildings which need further investigation (SBEEnrc 2019).

13.5.5. Investigate energy performance improvements for existing buildings

Existing buildings that were built prior to building standards offer the greatest potential for energy efficiency improvements (COAG Energy Council 2018). However, there are multiple barriers to uptake, including information gaps, split incentives and affordability. A suite of policies, including financial incentives, regulation and information programs, may be needed to overcome these barriers.

In 2016 the Authority noted that disclosure is effective in improving the energy performance of existing buildings by helping prospective buyers and tenants to compare the energy efficiency of buildings, providing an incentive for owners and landlords to make improvements. Modelling has shown that expansion of the CBD program to other building types, and disclosure of residential building energy efficiency information, could deliver significant emissions reductions (Energy Action and EnergyConsult 2018; COAG Energy Council 2019b).

However, disclosure is unlikely to be as effective in rental markets with low vacancy rates where tenants have little market power to choose between properties of differing quality. As a result, rents tend not to reflect differences in energy efficiency performance, so there is no price signal to encourage owners to invest in upgrades (Environment Victoria 2017). Tenants typically lack the financial capacity to make changes that would improve efficiency or may be denied permission to do so. Furthermore, when owners invest in upgrades, they are more likely to prioritise measures to improve asset value, such as installing ducted heating, over less visible measures that would deliver higher benefits to tenants, such as draught proofing. There may be a case to introduce minimum efficiency standards for existing buildings, particularly for residential rental properties and office tenancies, to address this market failure (Environment Victoria 2017; GBCA 2015). The New Zealand Government introduced minimum insulation requirements in rental properties in 2019 (Tenancy Services 2019):

Many rental homes are energy-inefficient and therefore produce unnecessary emissions, but tenants face systemic barriers to improving them, and landlords generally lack an incentive to do so. Mandating minimum energy efficiency standards is the most realistic way to improve these homes and to realise the associated emissions reductions. (Brotherhood of St Laurence submission, p. 1)

Financial incentives can drive accelerated uptake of energy efficiency in existing buildings by helping to overcome the up-front costs associated with upgrades. Priority should be placed on supporting low-income households and small to medium enterprises that have limited access to finance to make energy efficiency upgrades. Financial incentives could include low-interest loans, grant programs and tax incentives (COAG Energy Council 2019b, 2019c; Property Council of Australia and GBCA 2019).

While financial incentives can encourage many cost-effective energy efficiency opportunities to be taken up, better provision of information via rating tools helps support improved energy efficiency decision making. Energy rating tools, such as NABERS and the Nationwide House Energy Rating Scheme (NatHERS),⁴⁵ help to simplify complex energy efficiency information for households and businesses and provide useful

⁴⁵ The Nationwide House Energy Rating Scheme (NatHERS) is a star rating system (out of 10) that rates the energy efficiency of a home based on its design. Its scope is limited to thermal performance of the building structure and is intended to indicate the heating and cooling requirements. It excludes other home energy use such as hot water, lighting and appliances (COAG Energy Council 2019b).

information on how to make cost-effective improvements. There are significant opportunities for expansion of these tools to facilitate increased take-up of energy efficiency improvements and disclosure of energy performance. For instance, expansion of NatHERS into a whole-of-home⁴⁶ rating tool will enable households to make informed decisions on energy efficiency upgrades (COAG Energy Council 2019b). Similarly, NABERS, the benchmarking tool for Australia's Commercial Building Disclosure Scheme, is only available in six sectors of the built environment. Work is being undertaken to expand the tool into new sectors such as schools, industrial buildings and retail stores, which will enable the expansion of mandatory energy performance disclosure (NABERS 2019).

The Addendum to the Trajectory for Low Energy Buildings outlines a suite of policies for improving existing buildings, both commercial and residential (COAG Energy Council 2019e). Modelling indicates that implementing proposed policies for improving the energy efficiency of existing houses in 2025 in all jurisdictions could deliver a net present value of A\$3.4 billion and reduce greenhouse gas emissions by 40.3 Mt CO₂-e by 2050 (COAG Energy Council 2019b). For commercial buildings, policies could deliver a net present value of over A\$8.4 billion and reduce greenhouse gas emissions by 87.5 Mt CO₂-e by 2050 (COAG Energy Council 2019c).

27 Working with the COAG Energy Council, reinvigorate the National Energy Productivity Plan with enhanced ambition and additional resources, including by:

- **implementing a National Energy Savings Scheme that builds on existing state and territory energy efficiency schemes**
- **accelerating implementation of the Independent Review of the Greenhouse and Energy Minimum Standards Act, strengthening existing performance standards and extending coverage to new categories of appliances and commercial equipment, such as hot water products and pumps, boilers and air compressors**
- **accelerating energy efficiency improvements for buildings in the National Construction Code via the Trajectory for Low Energy Buildings initiative**
- **developing a detailed action plan for improving the energy efficiency performance of existing commercial and residential buildings via the Addendum to the Trajectory for Low Energy Buildings initiative; and addressing energy efficiency improvements for vulnerable consumers.**

In the Authority's view, governments are well placed to overcome barriers in energy efficiency improvements through the provision of information, expertise and funding. While existing programs to improve energy efficiency (such as state and territory white certificate schemes and the Australian Government's Business Energy Advice Program) are making some progress, there is an opportunity to better target activity to those with the greatest barriers to energy efficiency (such as low-income households). The Independent Review into the Future Security of the National Electricity Market (Recommendation 6.6) called for the government to address low-income household access to energy efficient appliances and distributed energy resources (Finkel et al. 2017). Policy development could build on existing programs and identify under-served segments of the community and the most appropriate strategies to assist them. Policies that increase energy

⁴⁶ 'Whole-of-home' is taken to include thermal performance, space conditioning, water heating, cooking, lighting, pool pumps and onsite renewable generation.

efficiency could also help overcome cultural barriers to energy efficiency improvement through familiarity and the demonstration effect; and solve split-incentive barriers.

28 In partnership with state and territory governments, design and deliver targeted programs to improve energy efficiency in priority groups, such as low-income households and small to medium businesses, through the provision of information, expertise and financial assistance (grants and tax incentives) where appropriate.

There is a significant opportunity to increase the energy efficiency of existing buildings owned or leased by governments. This includes institutional buildings such as hospitals, universities, galleries and government office buildings (COAG Energy Council 2019c). As a major presence in the buildings sector, governments can leverage their market power to drive energy efficiency and normalise best practice. This will reduce emissions, deliver significant financial savings for the public sector and build skills and capability in the market (Property Council of Australia and GBCA 2019).

Australian governments control a substantial portion of low-income housing stock through public and community housing. Low-income householders are particularly vulnerable to energy prices, spending up to five times more of their disposable income on electricity than high-income earners (ACCC 2017). Low-income householders are also more likely to live in inefficient homes and have less efficient appliances, leading to poorer health and wellbeing as well as energy affordability stress (ACOSS 2013).

Improving the energy efficiency of public housing will reduce emissions, improve health and wellbeing and reduce energy costs for those most disadvantaged in the community. Australian governments should improve the energy efficiency of public housing by undertaking targeted retrofits and implementing steadily rising minimum standards for public housing. High priority should be given to upgrading the worst performing public housing stock and could include insulation, shading, draught proofing and more efficient fixed appliances (Property Council of Australia and GBCA 2019).

29 All governments should pursue energy efficiency improvements in government owned and leased buildings, undertake targeted retrofits and implement steadily rising minimum standards for public housing to improve the energy efficiency performance of the public housing stock.

14. RESEARCH AND DEVELOPMENT, INNOVATION AND TECHNOLOGY

Research and development (R&D) and innovation are critical to Australia's response to climate change.

Effective mitigation of climate change and decarbonisation in the long term is heavily reliant on the development and deployment of new knowledge, technology and practices. This is particularly the case of harder to abate, emissions-intensive industries.

Australia has a strong research and development capability, but gaps exist—particularly in the development and scale-up of basic research into mature products and services. Development of new opportunities in low-emissions industries will rely on a well-functioning innovation system. The Government has said its forthcoming Technology Investment Roadmap will aim to stimulate research and development and the early deployment of emerging clean technologies and will track the progress of these technologies for reaching commerciality.

Government programs, including the CEFC and ARENA, have been successful in aiding the development and deployment of new technologies and practices. The development of technology pathways also allows for a systematic approach to addressing the R&D task.

Research, development and deployment (RD&D) are a critical part of Australia's, and the global, response to climate change and essential to achieving the goals of the Paris Agreement. Together, they:

- provide information on the extent and impacts of climate change
- generate new knowledge and technologies to help prepare for and mitigate climate change
- allow development of optimal adaptive responses to climate change impacts.

Without advances delivered by science, research and innovation, achieving global net-zero emissions in the second half of the century would be a difficult and costly task. RD&D addresses multiple barriers to responding to climate change, including information, price and technology barriers (Garnaut 2008; Stern 2006).

RD&D is undertaken by different actors in the economy. In Australia, basic or discovery research that seeks to uncover new knowledge or develop emergent technology is undertaken by universities, science agencies (such as CSIRO) and research institutions, usually with high levels of public funding.

As technologies become more mature (and research turns to development), RD&D shifts away from laboratory settings to prototypes, pilots and trials—often with a lesser degree of public funding. Deployment (product commercialisation)—implementation of a new or significantly improved technology or practice—is often undertaken by firms in commercial settings. Non-commercial deployment, such as the implementation of practices or technologies that support public benefits that are usually not captured by the innovator, are often supported or encouraged by the public sector. Examples of non-commercial deployment include public health initiatives, improvements in educational practice, environmental conservation and natural resource management. As the full benefits of mitigating or adapting to climate change are captured by the wider community rather than individuals or firms, there is a generally high level of government involvement and public funding in climate change related RD&D (Bell et al. 2014; Innovation and Science Australia 2017; OECD 2011; Garnaut 2008).

Deployment also includes the provision of climate services to communicate relevant, useful and useable information. This includes information on how the climate may change in the future, what the likely impacts might be and how to prepare to minimise the impacts and to take advantage of any opportunities. Federal agencies, including the Bureau of Meteorology and CSIRO, provide relevant services that help to meet some but not all of the growing demand for such information.

14.1. Identifying needs for research, development and deployment

Effective mitigation of climate change and achieving long-term decarbonisation relies heavily on the development and deployment of new knowledge, technology and practices (IPCC 2014b). Achieving the goals of the Paris Agreement over the long term through achieving net-zero emissions in the second half of the century is likely to require the deployment of technologies that are not yet well developed (IPCC 2018; Stern 2006). This is particularly the case for industries like concrete manufacturing or long-distance air travel that are currently considered ‘harder to abate’ (Energy Transitions Commission 2018).⁴⁷

RD&D also lowers the cost of responding to climate change, as development of new technologies provides society with choices on the best ways to reduce emissions. Deployment of a range of emissions reduction technologies, selected from a variety of candidate technologies, can deliver optimal utilisation of resources and expertise taking local circumstances into consideration.⁴⁸ The IPCC (2014) highlights that using a ‘full’ technology portfolio reduces costs of mitigation compared with using ‘constrained’ technology portfolios that exclude certain technologies.

Although Australia is a small economy and will inevitably capitalise on overseas technological advances, Australia’s R&D effort forms a significant part of the global response to climate change (Australian Academy of Science 2017). Australia has made important contributions to the development of mitigation technology, including substantial improvements in solar panel efficiency and the ongoing development of knowledge in carbon capture and storage (CCS) (Cook 2017; CCA 2016a).

Deployment is a critical phase for mitigation technology. Although many candidate technologies have shown promise in laboratory settings, the ability to scale up and deploy technologies is the defining factor in their ability to mitigate climate change. In recent years, significant government attention has focused on the development of innovation within the wider economy, particularly in bringing early-stage discoveries to deployment (Australian Government 2015b; DIIS n.d.a). Despite these efforts, successful deployment for climate mitigation can be challenging, particularly where the mitigation benefits of a technology are not coupled to strong economic benefits for the innovator. In these circumstances, policy support can be important to accelerate the deployment of low-emissions technology (OECD 2011).

⁴⁷ In these activities, a practical alternative to current practice has not been identified that would allow replacement of the current greenhouse gas intensive activity at acceptable scale or cost. There may be candidate technologies for replacement (such as synthetic or biologically derived fuels for long-distance aviation), but the current state of technology has not allowed cost or scale barriers to be overcome.

⁴⁸ For example, R&D has provided a range of low-emissions electricity technologies. Deployment of a mix of these, relevant to Australian conditions (solar, wind and hydro), helps decarbonise Australia’s electricity supply at low cost. If only a very small number of technologies were available—if Australia had to rely solely on hydropower or geothermal energy—the cost of decarbonisation using only these technologies could be high, considering the relatively limited hydro and geothermal resources available in Australia.

14.2. Current policies

Over the past two decades, the Australian Government has provided funding to low-emissions technology development through a range of different initiatives, with particular emphasis on renewable energy and CCS technologies.

ARENA provides funding for early-stage research and development. Under the *Australian Renewable Energy Agency Act 2011* (Cth), ARENA is able to provide financial assistance for the research, development, deployment or commercialisation of renewable energy technologies and to collect and share information about renewable energy technologies. It has primarily provided funding for R&D through grants and has a strong focus on developing knowledge and information about renewable energy, as well as the development of technology. In recent years, it has also been involved in equity funding as a joint manager of the Clean Energy Innovation Fund (ARENA 2019b). On 30 September 2019 ARENA advised that its remaining funding would be fully committed in the coming 12 to 18 months, which means that it will not be able to provide further grant funding without a new allocation of funds from the government (ARENA 2019c).

The CEFC makes commercial investments in renewables, energy efficiency and low-emissions technology on behalf of the Australian Government. It has the ability to invest up to A\$10 billion of government funds and had committed A\$6.2 billion by June 2019 (CEFC 2019c). The CEFC provides funding through debt, equity or other financial instruments and attempts to facilitate additional private finance. On average, for each dollar invested by the CEFC in 2018–19, an additional three dollars were invested by the private sector (CEFC 2019c). The CEFC targets innovation and deployment, rather than R&D, and invests in more mature technology than ARENA. Its investments are constrained to energy efficiency, low-emissions technologies and renewable energy technologies. Under the *Clean Energy Finance Corporation Act 2012* (Cth), the CEFC cannot invest in nuclear or carbon capture and storage technology. The Government announced in October 2019 that the CEFC will administer a new A\$1 billion Grid Reliability Fund, which will support new energy generation, storage and transmission infrastructure (Morrison 2019).

The Carbon Capture and Storage Flagships program has provided funding for a small number of CCS demonstration projects, as well as R&D projects in CCS. CCS has also been supported by the Low Emissions Technology Development Fund (formerly the Low Emissions Technology Demonstration Fund), which provided funding to the Gorgon CO₂ Injection Project located on Barrow Island⁴⁹ (DIIS 2019a, 2019d).

The Australian Government and state and territory governments have committed to a National Hydrogen Strategy (see below) and announced funding for the development of hydrogen technology. For example, the Australian and Victorian governments have each committed A\$50 million to developing a lignite-to-hydrogen trial in the Latrobe Valley in Victoria (Turnbull et al. 2018). Additionally, ARENA has awarded A\$22.1 million in funding to 16 renewable hydrogen projects (ARENA 2018a). Both Queensland and Western Australian governments have also opened funds for hydrogen industry development (Government of Western Australia DPIRD 2019b; Queensland Government DSDMIP 2019a).

The Australian Government has announced it is developing a Technology Investment Roadmap. This will aim to identify, evaluate, prioritise and progress new clean technologies to full commerciality and deployment as quickly as possible (Taylor 2020). The Government has said it will establish a Technology Investment Roadmap Ministerial Reference Group, to be chaired by Australia's Chief Scientist Dr Alan Finkel and which

⁴⁹ More recently private companies have signed a memorandum of understanding to investigate an investment in carbon capture and storage at the Moomba gas processing plant in South Australia. The project proposes to capture the 1.7 million tonnes of carbon dioxide currently separated from natural gas at the plant each year and to permanently store it in geological formations of the Cooper Basin (Santos 2020).

will comprise industry, investment, Government and research leaders, to advise on pathways for the efficient development of new technologies. An annual Clean Technology Statement will be issued to provide an update on global technology developments and allow the Government to prioritise its technology investments. Progress will be measured by tracking economic goals that assess whether technologies are able to become commercially competitive, and the ability to attract private-sector investment (Taylor 2020).

Beyond specific projects, RD&D conducted through the general innovation system (universities, science agencies, business) are contributing to the development of mitigation technology. General policies that support RD&D include the National Competitive Grants Program and research block grants, appropriations to CSIRO and other science agencies, the Research and Development Tax Incentive and federal, state and territory innovation programs (Innovation and Science Australia 2017).

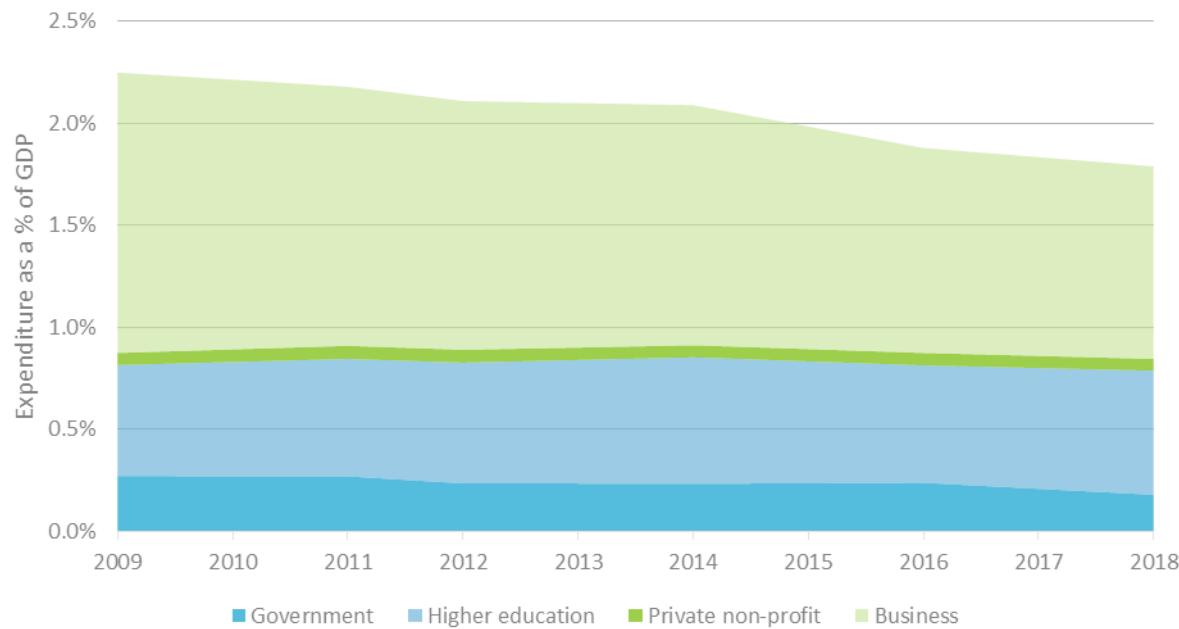
14.3. Significant changes since 2016

The state of climate change R&D is changing rapidly. In some areas, technological advancement continues to dramatically outpace expectations (such as the development of solar panel and battery storage technology), while breakthroughs have been elusive in other fields (IPCC 2018; Energy Transitions Commission 2018). Further advances in understanding of the physical science basis of climate change have created greater impetus for low-emissions innovation, as firms are beginning to align their business models with a carbon-constrained future economy (see Chapter 15).

14.3.1. Commercial innovation and investment

A challenge for Australia's response to climate change is a slowdown of capital investment by Australian firms in the non-mining sector over the past decade—a phenomenon common to many advanced economies (RBA 2019c). The transition to a low-emissions economy will require investment in low-emissions capital stock to replace high-emissions stock, and deployment of new technology requires capital investment. The lack of investment has also extended to low investment in R&D by the business sector—it has fallen from 1.37 per cent of gross domestic product in 2008–09 to 0.94 per cent in 2017–18 (Figure 11; ABS 2019g). Although public sector R&D (the combination of government and higher education) has remained relatively stable over that period, the decline in business R&D is a challenge for the deployment of mitigation technology, as the scale-up and deployment of technology is typically an activity carried out through private sector innovation (DIIS 2017).

FIGURE 11. EXPENDITURE ON RESEARCH AND DEVELOPMENT BY SECTOR, 2009–2018



Source: ABS 2019g

Note: These are financial years—for example, 2009 represents the financial year 2008–09.

14.3.2. New technological developments and opportunities

Since the Authority's 2016 report, there have been significant technological developments. In Australia, a particular emphasis has been placed on the development of a clean hydrogen industry through the development of a National Hydrogen Strategy. Hydrogen can be used as an energy carrier that can be made from a variety of energy sources, with potential for its production to be near zero emissions. This could either be from gas or coal coupled to CCS or through electrolysis of water using renewable electricity (COAG Energy Council 2019a). Governments and businesses have identified the potential to establish a successful hydrogen export industry in Australia (Victorian Government submission, p. 6; The Chamber of Minerals and Energy of Western Australia submission, p. 2).

The potential for a low-emissions Australian hydrogen export industry relies on Australia's substantial renewable energy resources and potential sites for CCS. Several of Australia's trading partners have declared interest in importing low-emissions hydrogen, suggesting that a market could be developed. However, development of an Australian hydrogen industry will require substantial efforts in R&D from the public and private sector to develop low-emissions hydrogen production at acceptable cost and scale (COAG Energy Council 2019a). The COAG Energy Council, as well as the Victorian, Queensland, Tasmanian and Western Australian governments, have developed strategies for the development of hydrogen industries (COAG Energy Council 2019a; Victorian Government DELWP 2019b; Queensland Government DSDMIP 2019a; Government of Western Australia DPIRD 2019a; Tasmanian Government DSG 2019).

With these opportunities in mind, the Government has recently announced the establishment of a Future Energy Exports Cooperative Research Centre. This will bring together national and international partners with expertise in LNG, hydrogen, digital technologies and sector development from industry, government, and research organisations. It is intended to develop technologies to improve the efficiency of existing LNG

production process, to lower costs and carbon emissions, as well as contribute to the development of new exports such as hydrogen (Andrews, Pitt 2020).

Changing drivers for renewable energy development

Australia is a member of the Mission Innovation initiative that seeks to make clean energy affordable, with an initial goal to double investment in government-directed clean energy research, development and demonstration between 2015 and 2020. Australia's progress towards its own commitment under Mission Innovation is currently on track (Mission Innovation 2019). However, it is not clear that additional investment in renewable energy RD&D is set to continue.

In 2019, the CER announced that sufficient capacity has been accredited to meet the Large-scale Renewable Energy Target (LRET) (CER 2019f). This means that the LRET will decline in importance as a 'demand-pull' mechanism to further deploy large-scale renewable electricity in Australia. The challenges of decarbonising the electricity supply and integrating additional low-emissions energy into the grid remain and require substantial innovation, such as development of storage and other integration technologies. Further work is needed to ensure that strong policy signals encourage innovation in grid decarbonisation (see Chapter 8).

In a positive step in this direction, the Government has announced funding for the Reliable Affordable Clean Energy for 2030 (RACE for 2030) Cooperative Research Centre. RACE for 2030 will lead collaborative research and innovation to grow Australian energy technology businesses and improve clean energy uptake, while addressing the grid stability challenges facing new energy technologies (Andrews, Taylor 2020).

14.4. Opportunities for climate change RD&D

14.4.1. Research, development and deployment as a climate change response

The development of locally appropriate mitigation and adaptive responses requires a locally expert RD&D capability. Australia has a generally strong R&D capability in the public sector, particularly in basic research through the universities and science agencies. However, capability gaps exist, particularly in the development and scale-up of basic research into mature products (Innovation and Science Australia 2017). There is a need for coordination to ensure that opportunities presented by climate change led transition are supported by appropriate development capabilities.

Numerous stakeholders have highlighted the potential for Australia to move to a new, low-emissions export economy based on access to abundant renewable energy resources. The development of a hydrogen industry is one example of this, but opportunities have also been identified in mining (such as lithium and critical mineral production), manufacturing and transport (such as the potential to innovate in low-emissions long distance transport) and agriculture (National Farmers' Federation submission, The Chamber of Minerals and Energy WA submission, Woodside submission). The continuing development of zero-emissions energy sources to improve affordability and practicality is an enabling step, and the work of ARENA has been important in this area.

The IPCC has highlighted the probability that large-scale deployment of negative emissions technologies (NETS)—systems that remove greenhouse gases from the atmosphere—will be necessary to achieve the temperature limitation goals of the Paris Agreement. These technologies are currently largely conceptual, and significant research and development is required to bring them to deployment (IPCC 2018).

30 In developing and implementing the Technology Investment Roadmap:

- partner with industry and researchers to identify areas where research and development (R&D) support is needed to capitalise on areas of comparative advantage for Australia and to support strategic development of clean technology industries.
- continue to fund the Australian Renewable Energy Agency and consider expanding its remit into other sectors requiring R&D for low-emissions technology or practice.
- build on Australia's Mission Innovation commitment to double investment in clean technology over the five years to 2020 by undertaking to grow the level of investment further to 2030.
- support the development of negative emissions technologies, including R&D and methodology development for inclusion in the ERF.

Development of new opportunities in these low-emissions industries relies on a well-functioning innovation system and markets that send strong signals to encourage investment in low-emissions production. Researchers must have adequate resources to pursue promising technologies; innovators and technology deployers must be able to reliably identify market opportunities for new technology or knowledge; and investors must have confidence that their commercial decisions will not be subject to unacceptable levels of risk.

In particular, development of mitigation solutions for harder to abate, emissions-intensive, trade-exposed industries face a challenging RD&D path. There are multiple technological and competitive barriers to decarbonising these industries, yet their eventual decarbonisation will be required to achieve the goals of the Paris Agreement (Energy Transitions Commission 2018).

In these circumstances, government innovation programs can assist by providing patient capital or other types of facilitation. Well-targeted partnerships between industry and the public sector could lead to good outcomes, although care must be taken to ensure that government action accelerates low-emissions technology without inhibiting the potential of other innovators to emerge.

The need to tackle emissions in hard-to-abate areas of heavy industry has been recognised internationally with the establishment of the Leadership Group for Industry Transition. The group was launched by Sweden and India at the United Nations Climate Action Summit in New York in September 2018. Its aim is to enable the transition of heavy industry towards net-zero carbon emissions by 2050. The Australian Government has since announced it will join this initiative (Taylor 2019a).

14.4.2. Technology pathways and partnerships

Increasingly, industry is recognising the need to plan for a low-emissions future. In areas that are harder to abate, the development of technology pathways allows for a systematic approach to the R&D task that underpins progress towards a goal. For example, the Red Meat Advisory Council has developed a strategic plan based on a technology roadmap developed by Meat and Livestock Australia that would see the red meat industry becoming carbon neutral by 2030 through a combination of R&D and offset activities (RMAC submission, p. 2; Red Meat Advisory Council 2019; MLA2018). Although the development of technology pathways cannot necessarily predict the speed and direction of technological development, they provide a tool for businesses and governments to determine where R&D investment is most usefully directed.

The development of mitigation technology pathways also provides strong signals to markets about the required or anticipated technological developments in a sector and allows innovators and investors to identify

opportunities for development in the industry. Additionally, pathways enable partnerships to be developed, providing opportunities for governments to facilitate industry action towards decarbonisation.

Stakeholders have strongly emphasised the role for RD&D in Australia's response to climate change and highlighted the success of efforts to date. In particular, the success of the CEFC and ARENA has been widely noted, with several proposals to replicate or expand their activities in other sectors of the economy. These agencies are well suited to assist as partners in the development and implementation of decarbonisation pathways through complementary functions—ARENA as a facilitator and funder of R&D and the CEFC as a financier of innovation and deployment.

The 2018 statutory review of the CEFC confirmed that it has facilitated the flow of finance into the clean energy sector, enabling projects that otherwise would not have proceeded (Deloitte 2018). There are other sectors in which the CEFC's role as a de-risker of investments could accelerate additional private investment to facilitate innovation—such as in the agricultural and land sectors, where private finance is unable to adequately assess and price climate risk. In keeping with the findings of the statutory review, and supported by the CEFC's own submission (CEFC 2018b), the CEFC's ability to undertake such a role is likely to be enhanced if it is permitted to use a wider range of financial products and the requirement relating to the share of renewable projects in its portfolio is relaxed. The Government could also consider injecting further capital into the CEFC.

- 31 Target funding support for innovation in emissions reduction towards harder-to-abate and emissions-intensive, trade-exposed industries and towards industries with well-defined low-emissions goals, targets and pathways.**
- 32 Expand the remit of the CEFC to allow it to invest in emissions reduction technologies in all sectors to help overcome barriers to finance. Restrictions on the scope of the CEFC's activities, its portfolio mix and the financial instruments it can use should be lifted. The government should consider making further capital injections into the CEFC to fund this expansion.**

15. FINANCE AND INVESTMENT

Transitioning to a low-emissions economy will require a reorientation of public and private investment away from high-emitting activities towards existing, emerging and new low-emissions industries.

Australia's large and highly sophisticated funds management industry and growing climate finance capacity mean we are well placed to become a major investor in low-emissions opportunities and a green finance hub for the region.

Currently, markets tend not to adequately recognise and price climate-related risk because of a lack of information and short-termism in investment decision making. However, this is changing quickly as relevant tools become available and financial regulators divert more attention to the issue.

The Australian Government has several avenues available for taking action to ensure and support appropriate reporting of climate-related risks in Australia; promote the development of Australia's green finance market; and ensure Australian low-emissions industries, products and services are able to benefit from increased international green investment flows.

The finance and investment sector comprises firms and institutions that provide financial services to commercial and retail customers and the Australian community at large in the form of borrowing, investment and insurance. The sector extends to auxiliary services including accounting, financial technology and assurance (credit rating) services. These services enable modern economies to function. Insurers price and underwrite risk, banks and other lenders deploy capital to finance economic activity and investors direct new investment, which drives productivity and growth. The efficient and effective allocation and use of capital helps to support the needs of the Australian community and grow the economy (ASFI 2019).

The financial services sector is one of the largest contributors to the Australian economy, contributing around A\$160 billion gross value added and employing about 440,000 people in 2018 (ABS 2018a, 2018b). The superannuation industry has almost A\$2.9 trillion in investment assets (Association of Superannuation Funds of Australia 2019).

15.1. The role of finance and investment in emissions reduction

Appropriate regulatory settings and information provision for the finance and investment sector will help the efficient allocation of capital flows towards low-emissions opportunities, facilitating the economic transition to a net-zero emissions economy.

This transition requires a reorientation of public and private investment away from high-emitting activities towards existing and emerging low-emissions industries. The Paris Agreement explicitly addresses the role of the finance sector in climate change mitigation. Article 2.1(c) states that the global response to the threat of climate change should include 'making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development'.

Although investment in low-emissions activities is growing at a rapid rate, much more is needed. Low-emissions energy sources need to attract more than double current investment flows by 2030⁵⁰ if the world is to meet the Paris Agreement temperature goals, according to the International Energy Agency (IEA 2019d). Sufficient capital is available to meet the Paris Agreement goals, but systemic market failures, including the

⁵⁰ The estimation is based on a sustainable development scenario aligned with the Paris Agreement's goal of holding the increase in the global average temperature to well below 2°C.

underpricing of climate-related risk, prevent markets from adequately shifting available capital towards low-emissions opportunities (Krogstrup et al. 2019; New Zealand Productivity Commission 2018).

In its submission, the Responsible Investment Association of Australia (RIAA) stated:

The finance sector has the means to do the heavy lifting to help Australia meet its 2030 emissions target and put the economy on a path to net-zero emissions. However, to do this efficiently and within a meaningful timeframe, it needs long, loud and legal signals. These signals would include ... enabling support through the financial sector to discourage flows away from unsustainable investments and unlock financial flows towards lower carbon assets and companies (p. 2).

Considering Australia's large and highly sophisticated funds management industry and growing climate finance capacity, it is well placed to become a major investor in low-emissions opportunities and a green finance hub for the region.

The Authority's previous advice to Government on the policy toolkit to meet Australia's 2030 greenhouse gas emissions reduction target in 2016 did not address the prudential regulation of climate-related risk or the role of government in helping to facilitate increased flows of green finance covered in this chapter. This chapter will examine the financial policy tools that could:

- redress the underpricing of climate-related risks in financial markets and accelerate investment in low-emissions opportunities
- enable the Australian financial services sector to capture the domestic and international commercial opportunities in the burgeoning global green finance market, including climate-related data and analytics and green financial products and services.

15.2. Pricing climate-related financial risk

In its latest world energy investment report, the International Energy Agency (2019d) found market and policy signals are not incentivising the necessary reallocation of capital to low-emissions energy technology. The report highlighted that markets lack information and do not understand the evolution of risks, causing a reluctance to shift investment to uncertain investment opportunities in low-emissions activities.

The reason markets fail to adequately recognise and price climate-related risk is a lack of information on the nature of the risk and short-termism in investment decision making. In a landmark speech in 2015, Mark Carney, Governor of the Bank of England, explained that, because the worst impacts of climate change will be felt beyond the traditional investment horizons of most investors, financiers and businesses, they are disincentivised to act. This will create a 'tragedy beyond the horizon ... with potential "catastrophic" consequences for financial stability' (Carney 2015). Although the impacts of climate change are becoming more prevalent, material risks posed by climate change are typically beyond the business and credit cycle, which has a time span of between seven and 10 years. It is also beyond the traditional horizon of macroeconomic authorities like central banks, whose mandate has traditionally been the targeting of short-term inflation and macroeconomic stability (Carney 2015). There is an inherent misalignment between long-term investment horizons, particularly for superannuation investments, and the short-term timeframes over which investment performance is measured (ASFI 2019).

Currently, most financial risks are priced based on historical outcomes. However, this approach will not capture climate-related risks because no historical precedents exist. The widespread incorporation of climate change considerations in the pricing of risk requires new information disclosures.

In 2016 the international finance community, through the Financial Services Board (FSB), began to explore how to avoid climate change risk becoming a major threat to the sustainability of the global financial system. The FSB Taskforce on Climate-related Financial Disclosures (TCFD) presented a report and recommendations to the 2017 G20 Leaders' Summit (Carney 2015; TCFD 2017).

The TCFD recommendations outline a comprehensive framework for companies to voluntarily disclose climate-related financial risks and undertake future scenario analysis and long-term planning. The disclosure framework aims to help inform lenders, investors, insurers and other stakeholders of the material risks of climate change. This information will enable companies and investors to take strategic decisions to diversify away from that risk into new low-emissions opportunities. Scenario analysis and planning provides a counterbalance to the disproportionate focus on short-term price and profit performance, particularly in listed equity and bond markets (EU High-Level Expert Group on Sustainable Finance 2018; Summerhayes 2019; TCFD 2017).

The identified risks under the TCFD framework include both risks associated with physical climate damages and transitional risks associated with moving to a low-emissions economy (TCFD 2017).

15.2.1. Recognising physical risks

Physical risks capture chronic weather patterns resulting from increased global temperatures, such as lower rainfall, permanent sea-level rises and increased frequency of natural disasters like flooding and wildfires (see Chapter 2). These risks cause physical damage to assets and increase insurance liabilities (AON 2018; Insurance Journal 2019).

In Australia, the physical effects of climate change are already affecting Australia's insurance industry. Inflation-adjusted insurance claims for natural disasters this decade have more than doubled those from the decade before. In northern Australia, insurance premiums have risen by 130 per cent in real terms over the past 10 years, compared with 50 per cent in the rest of Australia (RBA 2019b; ACCC 2018). Unaffordable insurance will lead to communities and businesses being unable to recover financially from physical losses. Lack of insurance will also make it harder to gain access to credit (APRA 2019b).

Banks and other lenders are similarly exposed to the physical risks of climate change. For example, in the agricultural industry, climate change threatens a long-term decline in farm income as droughts become more severe and long-term average rainfall declines. The predicted result is a steady decrease in farm productivity over time and the decline in value of collateral that banks are lending against (RBA 2019b; CBA 2019) (Box 16).

Box 16 Climate scenario analysis in Australian agriculture

In 2019, the Commonwealth Bank of Australia (CBA) conducted scenario analysis on the physical risks of climate change on its agribusiness lending portfolio. The CBA's agriculture exposure was A\$22.4 billion at 31 December 2018. The scenario analysis sought to understand how acute and chronic shifts in temperature, humidity and rainfall would affect agriculture (CBA 2019).

The scenario analysis found that, based on predicted rainfall changes, current grain-growing regions face the risk of a decrease in farm profitability of up to 50 per cent below 2018 baseline levels by 2060 if adaptive measures are not taken. Some regions will become significantly less viable for crop production in the long term. Livestock and dairy farmers not taking proactive adaptive measures face similar predicted declines in profitability. For dairy regions a key risk is the predicted incidences of consecutive days of significant heat stress.

CBA used the findings to analyse the credit risk of existing farm customers and has said it will use the information to inform future management of its agriculture portfolio, including better tools to monitor and manage risks (CBA 2019).

15.2.2. Identifying transition risks

Transition risks are those resulting from domestic and international policy changes, reputational impacts, technology developments and shifting legal norms as the world transitions away from carbon-intensive activities to keep warming below 2°C. For example, a company could face financial losses because of changes in regulation or pricing introduced to mitigate emissions. If the risk of financial loss was reasonably foreseeable and the company did not respond adequately to mitigate the risk, the company could also be liable for compensation and face reputational damage (TCFD 2017; RBA 2019b).

Australia is an export-orientated economy and is therefore exposed to the evolving emissions reduction policies of our trading partners. Increasingly, trade-related policies are being used as a tool to support the Paris Agreement and embed mitigation actions. The European Union – Japan trade deal, which will create the world's largest open trade zone, commits both parties to upholding the Paris Agreement and striving to facilitate trade in low-emissions solutions (Mathiesen 2018). The European Union is also considering imposing a border carbon adjustment tax on goods and services entering the European Union (von der Leyen 2019). New Zealand has initiated a set of multi-party trade rules with Costa Rica, Fiji, Iceland and Norway that aim to promote low emissions by eliminating tariffs on environmental goods, including new commitments on environmental services, and developing guidelines for voluntary eco-labelling programs (New Zealand Foreign Affairs and Trade n.d.). The emergence of such trade policies has the potential to pose risks for Australian businesses.

Other transition risks include:

- consumers and businesses switching to new technology which is displacing established business practices and assets (leading to stranded assets)
- shifts in consumer preferences towards green products and services
- reputational damage if companies are perceived as contributing to climate change
- the legal enforcement of a duty of care on company directors to adequately consider, disclose and manage climate risks (Barker 2018; Matikainen 2018; RBA 2019b).

To adequately report on climate related financial risks and take meaningful steps to manage those risks, new data that relies on the science of climate change is required. Arguably, the data available to manage these

risks is not granular enough to be useful and is complex and fragmented. The RBA has recognised that ‘significant data gaps compound the difficulties financial institutions and investors face’ in assessing and managing climate risks and have highlighted the need for granular information on the location and physical risks of individual banks and insurers to enable them to manage their own direct exposure (RBA 2019b). There is a role for government to support the creation of a function within Australia’s key data agencies to collect, validate, organise and disseminate climate-relevant data (Summerhayes 2019; Krogstrup et al. 2019).

33 Review the data that are necessary to enable industry, investors and business to understand and manage climate-related financial risk and develop and implement plans for addressing gaps and deficiencies in the data.

15.2.3. Prudential regulation of climate-related risk

Central banks around the world have begun to acknowledge that monetary policy needs to consider the effects of climate change on output, prices, inflation and asset values and the implications for financial stability of the economy (Debelle 2019; NGFS 2019b). The Reserve Bank of Australia (RBA) has assessed that, while climate change is not yet a significant threat to Australia’s financial stability, it is becoming increasingly important for the finance sector to take account of and manage (RBA 2019b).

Stakeholders have also noted the importance of prudential regulation for climate-related risks. For example, in their joint submission to the Authority, CPA Australia and the Chartered Accountants ANZ stated that:

Prudential regulation and the overarching role of central banks play a critical part in ensuring the timely and accurate pricing of climate-related risks in domestic and international financial markets, and so minimising the risk of large-scale build-up of stranded assets (p. 4).

The Australian Securities and Investments Commission (ASIC) and the Australian Prudential Regulatory Authority (APRA) are the two primary regulators of the finance and investment sector in Australia. Governance and regulation is complemented by the Australian Stock Exchange (ASX) governance rules for all ASX listed companies and the Australian Accounting Standards Board.

Both ASIC and APRA, together with the RBA, have recognised the TCFD framework as best practice (APRA 2019c; Debelle 2019; ASIC 2019a, 2019b). These bodies, together with the Australian Treasury, make up the Council of Financial Regulators—a coordinating body for Australia’s main financial regulatory agencies that promotes stability of Australia’s financial system. The body has a working group on climate risk. In 2020 APRA announced climate change financial risk would be an area of focus for its activities. The Regulator is intending to publish a prudential practice guide with climate change stress tests to assist banks, insurers and investors develop frameworks to assess and monitor climate-related risks (APRA 2020).

The Corporate Governance Council of the ASX has recommended all listed companies identify climate risks and consider making risk disclosures in line with the TCFD framework. If listed companies do not follow the ASX recommendations, they are required to set out reasons for not doing so, creating a strong incentive for compliance (ASX Corporate Governance Council 2019). The Australian Accounting Standards Board has also recommended the framework as best practice (Australian Accounting Standards Board 2018; Li et al. 2019).

However, the TCFD framework does not specify how risks should be reported or the level of detail required. A recent TCFD status review of disclosure practices found the quality and content of TCFD reporting highly variable, with many companies failing to provide useful climate-related financial information. The TCFD emphasised the need for more ‘consistent, comparable, reliable and clear disclosures’ (TCFD 2019).

Currently, climate risk is mostly reported as a non-financial risk and included in Environmental, Sustainability and Governance reporting rather than in companies' audited financial statements (Li et al. 2019).

Additionally, adoption by the ASX means requirements apply only to publicly listed companies.

Australia's major accounting bodies recently stated that entities can no longer treat climate-related risks as a matter of corporate social responsibility. They have called for consideration of climate-related risk to be fully integrated into mainstream financial considerations as part of company financial statements (Li et al. 2019). The Authority is of the view that mandatory, standardised disclosure that is streamlined in mainstream financial reporting could provide a major incentive for improved pricing of climate risk, help streamline information, reduce transaction costs and improve efficiencies for the finance sector.

Globally, countries are considering how to integrate the TCFD framework into their financial regulatory environments to manage climate-related risks. France has encoded these disclosures into law, China has implemented mandatory disclosure of environmental information and the European Union is seeking to legislate a range of new regulations that complement and encourage risk disclosure, including new fiduciary and disclosure requirements for investors (Barrett and Skarbek 2019; University of Cambridge 2018). The New Zealand Government has also agreed in principle to make climate-related financial disclosures mandatory (on a comply-or-explain basis) (New Zealand Government 2019).

The Bank of England, recognising that reporting under the TCFD framework lacks a systematic approach to scenario analysis, is developing a consistent approach to climate-focused scenario analysis (BoE PRA 2019). Once fully developed, there may be an opportunity for Australia to build on this work to inform scenario analysis for Australian firms.

15.2.4. Private sector responses to climate-related risk reporting

Increased awareness of climate-related financial risk is starting to influence the risk profile of high-emitting activities. Over a two-year period to August 2017, the credit rating agency S&P Global changed the rating or outlook of 106 cases due to event-driven and longer-term climate-related risk factors. The majority of these rating downgrades were in the oil refining, regulated utilities and unregulated power and gas sectors (Williams 2017).

Further indicating that credit rating agencies are viewing climate-related risk as a material consideration, Moody's recently acquired a majority stake in a leading provider of economic climate modelling that assesses physical risks associated with climate-related processes for governments, cities and companies (Tigue 2019).

Banks, investors and other financial institutions are increasingly including climate-related risk considerations in decisions and rules regarding their investment and loan portfolios. They are putting pressure on companies they invest in to disclose information on climate-related risks and put in place mitigation strategies to manage these risks (Box 17).

Box 17 Investor pressure to disclose climate-related risk and implement transition strategies

Climate Action 100+, an organisation comprising more than 370 investors with over US\$35 trillion in assets under management, is using its financial influence to drive climate-related risk reporting and actions to reduce emissions in some of the world's largest companies. The group has targeted 161 companies that are collectively responsible for over two-thirds of global industrial greenhouse gas emissions.

The group's investor engagement has led to some major companies agreeing to disclose climate risk in accordance with the TCFD framework and put in place strategic long-term plans to start aligning their businesses with a low-emissions future. In its first assessment report, Climate Action 100+ emphasised the need for a smooth and orderly transition to a decarbonised global economy. It committed to pushing for a more ambitious response by the targeted companies to ensure the transition is realised within the scientifically recognised timeframe (Climate Action 100+ 2019).

Many finance and insurance institutions have committed to divesting from, or ceasing to underwrite, high-emitting activities over the coming decade. A recent global study traced over 1,110 institutions with more than US\$11 trillion in assets under management that have already committed to divesting from fossil fuels (Cardan et al. 2019). Examples of divestment actions in Australia and globally are set out in the Authority's recently published stocktake on industry action on climate change mitigation in Australia (CCA 2019a).

As a matter of Australian law, company directors can, and in some cases should be, considering the impact on their business of climate-related risks. To the extent that climate-related risks represent a foreseeable risk for Australian businesses, directors have a duty of care to mitigate that risk. The elevation of the importance of climate-related risk by Australian regulators has probably strengthened the standard of care expected of company directors (Hutley and Hartford Davis 2019).

The duties of institutional investors and trustees are governed by a range of laws, including the *Superannuation Industry (Supervision) Act 1993* (Cth) (SIS Act), as well as the common law on trusts. The SIS Act provides for superannuation trustees to act in the best interest of beneficiaries. However, it is unclear to what extent this permits or requires trustees to consider climate-related risk. In the absence of such clarity, litigation by beneficiaries is more likely. In its submission, the Responsible Investment Association of Australasia recommended that APRA clarify investor duties relating to climate-related risk (RIAA submission).

34 A joint taskforce of the Council of Financial Regulators should:

- **develop standard reporting criteria to enhance the quality and usefulness of disclosures under the Task Force on Climate-related Financial Disclosures framework. To support standardised reporting, the Government should develop standardised national climate scenarios aligned to the Paris Agreement temperature goals**
- **together with the major accounting bodies, examine the phasing-in and mandatory reporting of climate-related risks and mainstream climate-related disclosures in companies' audited financial statements**
- **provide regulatory guidance to clarify the duties of institutional investors to consider climate-related risk.**

15.3. Supporting increased investment flows of green finance

15.3.1. Global shift to sustainable finance systems

Country-level sustainable finance plans now exist in several countries. These plans are setting out systematic changes to countries' financial services sectors to enable shifts in finance and investment flows towards low-emissions activities and sustainable development (UNEP 2019b; Barrett and Skarbek 2019). For example, the European Union has introduced legislation that will require institutional investors and asset managers to integrate sustainability considerations in their investment decision-making processes. In many cases, national governments led the development of the sustainable finance plans. Key strategic-partner countries for Australia that have developed sustainable finance plans include China, the United Kingdom and Indonesia, as well as the European Union (Barrett and Skarbek 2019).

The private finance and investment sector in Australia, together with academia, civil society and peak finance bodies, launched the Australian Sustainable Finance Initiative (ASFI) in early 2019. The sector recognises the systematic shifts in finance sector governance that are happening around the world and the need for Australia to evolve in line with global trends (ASFI submission).

The objective of the ASFI is to create a sustainable finance road map for Australia, including pathways, policy signals and frameworks that will help mobilise capital to deliver on Australia's climate and sustainable development goals. The road map to be delivered by the ASFI Steering Committee in mid-2020 will make recommendations to assist the finance and investment sector to:

- mobilise capital to deliver on national and global sustainable development and climate goals
- enhance the sustainability, resilience and stability of the financial system by embedding climate and other considerations into financial markets and products
- ensure better informed financial decision making by enhancing disclosures and transparency on environmental risks and opportunities
- deliver a financial system that meets community expectations around sustainability (ASFI submission).

The ASFI has identified several areas of focus for the finance and investment sector. These include the alignment of frameworks to manage financial and non-financial risks to ensure long-term financial stability; the availability of quality data to help the sector identify emerging risks and opportunities; the alignment of globally agreed 'green' definitions, labels and standards; and regulator guidance and supervision to reinforce the factors for sustainable finance (ASFI 2019).

The Authority views the ASFI as an opportunity for government to collaborate with the Australian finance and investment sector to identify and deliver key finance policy tools to ensure long-term finance sector stability, including by assisting the Australian financial services sector to capitalise on the global growth in green finance.

15.3.2. Growing Australia's green finance sector

There is a large pool of capital managed by investors looking for sustainable or green investment opportunities. This demand for sustainable investment options has grown exponentially in the past decade, particularly since the Paris Agreement in 2015.

In Australia, the green bond market grew from around A\$750 million in 2014, when the first green bond was issued, to around A\$15.6 billion in 2019 (Gilbert and Tobin 2019; Climate Bonds Initiative 2019b). In 2019

the global annual issuance of green bonds exceeded US\$200 billion for the first time (Climate Bonds Initiative 2019a). There is an opportunity for Australian funds, banks and other financial services to become world leaders in the development of green finance products and services and for Australia's low-emissions industries to become recipients of green foreign investment.

Notwithstanding the above, green bonds currently still only make up around 1 per cent of the global bond market (Chasan 2019; Petkov 2018). The trade in green finance products globally and in Australia is still hampered by lack of definition, information, transparency, standardisation and certification (Edwards et al. 2019).

In order to mobilise capital at scale for low-emissions activities, a technically robust classification system of low-emissions activities is needed—a ‘low-emissions taxonomy’. A low-emissions taxonomy will classify activities and assets that deliver on key climate and sustainability goals. This will reduce transaction costs and minimise ‘greenwashing’ by clearly distinguishing low-emitting activities from moderate and high-emitting assets and activities, ensuring maximum investment in genuine low-emissions assets. A robust classification system will also support effective disclosure by companies in line with the TCFD reporting framework by enabling companies to demonstrate actions and investments clearly defined as low-emissions activities (EU High-level Expert Group on Sustainable Finance 2019).

Green investment standards will further facilitate investment flows by helping to reduce transaction costs and increase confidence in the market. Whereas a low-emissions taxonomy sets out the eligibility criteria for the inclusion of activities in green investment instruments, standards provide issuers of investment instruments such as green bonds with standardised methodologies for disclosure, monitoring, verification and reporting. Green standards enable investors to create homogeneous financial instruments and compare performance when allocating investment portfolios. These standards can also assist credit rating agencies to compare and rate different green finance products (KPMG 2016; ASFI 2019).

China, the European Union and the United Kingdom are all establishing low-emissions taxonomies and considering ways to assist their finance and investment sectors to develop new green financial products and services, including the development of green standards with certification and verification services (Krogstrup et al. 2019; HM Government 2019; European Union High-level Expert Group on Sustainable Finance 2019).

There is also a global push to harmonise rules around green finance. A recently established initiative between the European Union, China, India and others, called the International Platform in Sustainable Finance, will seek to coordinate rules including green classification systems and standards for private and public green investment (European Commission 2019d).

Australia risks falling behind other jurisdictions as a provider of green financial services and as a recipient of green foreign direct investment. The adoption of a regulated taxonomy for Australia's low-emissions economy and support for setting green finance standards—for example, an Australian green bond standard—has emerged as an important issue for some stakeholders (RIAA). The Authority supports the development of these information products to enable greater investment in Australia's low-emissions industries, products and services.

- 35 To facilitate the development of Australia's green finance market and ensure Australian low-emissions industries, products and services are able to benefit from increased international green investment flows, the Australian Government should consider the recommendations of the Australian Sustainable Finance Initiative when the final report is published, and:
- participate in international initiatives developing global green economy rules and standards
 - collaborate with other jurisdictions to ensure alignment and convergence of emerging international classification systems for low-emissions technologies, assets and industries (low-emissions taxonomies) and to ensure Australia's low-carbon exports are defined and included
 - assist the finance and investment sector to develop standards and verification processes for green finance products and services, including through possible funding and endorsement.

APPENDIX A. PUBLIC CONSULTATION

The Climate Change Authority (the Authority) conducts public consultations for all of its reviews and reports.

On 11 July 2019, the Authority released a paper to facilitate consultation for this report. The Authority received 67 stakeholder submissions. The Authority also met with 40 organisations in Melbourne, Sydney and Canberra and conducted over 16 teleconferences. The Authority met with and received submissions from:

- industry organisations
- research bodies and non-government organisations
- Australian, state and territory and local government agencies
- businesses.

Non-confidential submissions are available on the Authority's website at <http://climatechangeauthority.gov.au/submissions/submissions-received>.

The Authority also drew from the three stocktakes it released earlier this year:

- Australia's climate change and energy policies at the Commonwealth and state and territory level,
- the current state of global climate change mitigation action
- actions being taken by industry in Australia to position for a carbon constrained future, including the role of low-emissions technologies.

The stocktakes are available on the Authority's website at <http://climatechangeauthority.gov.au/authority-releases-its-stocktakes-australian-and-international-climate-change-policies>.

The Authority thanks all those that provided submissions or engaged with the Authority for this work.

Individuals and organisations that made non-confidential submissions on this report are:

- Angela Michaelis
- Australian Petroleum Production and Exploration Association
- Australian Chamber of Commerce and Industry
- Australian Energy Market Commission
- Australian Forest Products Association
- Australian Industry Greenhouse Network
- Australian Local Government Association
- Australian Marine Conservation Society
- Australian Religious Response to Climate Change
- Australian Sustainable Built Environment Council

- Australian Sustainable Finance Initiative
- Brotherhood of St Laurence
- Business Council for Sustainable Development Australia
- Carbon Market Institute
- Clean Energy Finance Corporation
- Cement Industry Federation Submission
- Construction Forestry Mining and Energy Union—Mining and Energy Division
- Chartered Accountants Australia and New Zealand and CPA Australia
- City of Sydney
- Climate Action Moreland
- Climate Analytics
- Climate Change Balmain-Rozelle Inc.
- Climate Council
- Climate Friendly and PEW Charitable Trusts
- CSIRO
- Darryl Fallow
- Dr Lindsay Simpson
- Environmental Defenders Offices of Australia
- Electric Vehicle Council
- Energy Networks Australia
- Energy Saving Industry Association
- EnergyAustralia Pty Ltd
- Engineers Australia
- Friends of the Earth Australia
- Gas Energy Australia
- Great Barrier Reef Marine Park Authority
- Greening Australia
- ICLEI Oceania
- International Women's Development Agency
- Local Government Association of Queensland

- Madeline Combe
- Minerals Council of Australia
- National Trust, Far South Coast (NSW) Branch
- National Farmers' Federation
- Origin Energy
- Outback Carbon
- Peter Van de Graaff
- Professor Andrew Blakers
- Red Meat Advisory Council
- Responsible Investment Association Australasia
- Shire of Augusta Margaret River
- The Chamber of Minerals and Energy of Western Australia
- The Next Economy
- United Nations Association of Australia
- Victorian Government
- Victorian Greenhouse Alliances
- Waste Management and Resource Recovery Association of Australia
- Western Australian Local Government Association
- Woodside Energy
- Zenith Australia Group Pty Ltd

APPENDIX B. OPERATION OF THE EMISSIONS REDUCTION FUND

As part of the consultation on this review on Updating Advice, the following themes were raised that go to the operation or administration of the fund. The Climate Change Authority (the Authority) is aware that the Government and the Clean Energy Regulator (CER) are actively working on options to address some of these issues. The Authority will consider the issues below as part of its 2020 statutory review of the Emissions Reduction Fund (ERF) where the Government is not already giving them consideration.

Streamlining operations

There is a balance to be struck between streamlining the rules for the ERF and maintaining environmental integrity by ensuring the abatement delivered by projects is genuine and additional. In its 2017 ERF review, the Authority found that the mechanisms for ensuring the environmental integrity of the credits issued were a crucial part of the scheme and generally working well (CCA 2017a). The Authority recommended actions to enhance environmental integrity and the Government has since accepted most of them, including reviewing and updating several methods (Australian Government 2019c; DoEE n.d.h).

The CER announced in August 2019 that it wants to work with industry to help unlock more abatement through market innovation, development and outreach, including through recognising projects with multiple benefits (CER 2019i).

A number of submissions made specific recommendations for changes to streamline or increase flexibility in the ERF (Table 8). For example, requiring a project to be a new activity at the time of project registration was considered to be a barrier to innovation and early implementation of an abatement activity ahead of a method being in place (PEW Charitable Trusts and Climate Friendly).

Expanding coverage with new methods

The Authority previously recommended funding the Department of the Environment and Energy to work with research organisations on new ERF methods. A number of submissions made specific recommendations for new methods or variations to current methods (Table 8).

Through the Climate Solutions Fund, extra funding has been made available and the department is working on new methods, including some that stakeholders drew to the Authority's attention in 2017, such as a blue carbon (mangroves) method (Commonwealth of Australia 2019b; DoEE n.d.i). The department and the Emissions Reduction Assurance Committee (ERAC) are also both considering current methods with a view to improving ease of use and making them more generally applicable (DoEE n.d.h).

There were calls for greater support to develop new methods, including increasing investment in research and development (CMI, Woodside, AIGN, PEW Charitable Trust and Climate Friendly). The Authority considers that more research funding would allow for the development of innovative new methods.

Purchasing principles and co-benefits

Some stakeholders said that the government should be able to do more than purchase least-cost abatement (RMAC, AFPA, Greening Australia submissions). Others said that keeping least-cost purchasing is important to maximise abatement (CMI, BCSDA submissions). The Red Meat Advisory Council and Greening Australia recommended banding by technology or practice change or region to broaden uptake across different sectors of the economy and country.

The CER has signalled that, going forward, it would like to identify projects with environmental, social and cultural benefits co-benefits. The CER considers that co-benefits would be supported by the private sector or other government initiatives while the fund continues with least-cost purchasing. This is in keeping with the Authority's previous recommendations of no change to the purchasing principles of least-cost abatement. Greening Australia considered that the ERF should pay a premium for projects that deliver co-benefits to improve the overall outcomes from ERF projects (Greening Australia).

The ERF is providing participating landholders with a diversified income source and, anecdotally, the income diversification offered by some ERF projects is helping some farmers manage through the current drought. Some stakeholders said that this role could be enhanced through projects that better integrate co-benefits. Greening Australia said that 'Carbon-centred co-benefit investment is likely to build resilient regions and provide critical farmer support through contributing to farm productivity and mental health in the bush' (Greening Australia submission, p. 2). The Red Meat Advisory Council sees a need for 'planning the resilience of carbon offset plantings to withstand and survive the coming changes in climate and conditions' (RMAC submission, p. 7).

The Government has provided significant additional funding through the Climate Solutions Fund and contracted projects continue to be heavily concentrated in the land sector.⁵¹ There may be a case to consider how the ERF could further enhance the achievement of other benefits such as biodiversity and resilience in addition to abatement.

Some stakeholders also raised the geographical concentration of contracted projects as a risk to the delivery and permanence of abatement, with close to half of all contracted abatement coming from revegetation projects in western NSW and south-western Queensland (Western Local Land Services 2018; ERAC 2019). For example, there are concerns about the impact of the current severe drought on the forecast carbon storage from revegetation projects in NSW (NFF 2018b) and about risks from re-clearing and climate change impacts once the projects are completed (ERAC 2019; Western Local Land Services 2018). Delivery of abatement is currently on track compared with contract schedules, and updates are publicly reported by CER (CER 2019a). This issue can continue to be monitored as delivery ramps up considerably in 2019–20 and remains high over the next seven years.

Improving the secondary market

Stakeholders have noted that the carbon market remains immature and some asked for secondary products to develop to a mature market. The Red Meat Advisory Council and Greening Australia both suggest the Government develop a futures and options carbon market.

⁵¹ As at the July 2019 auction, 82 per cent of contracted abatement is from vegetation, agriculture and savanna-burning projects (CER 2019c).

TABLE 8. ISSUES WITH EMISSIONS REDUCTION FUND ADMINISTRATION OR METHODS

Issue	Stakeholder submission
Reduce transaction costs and complexity	Australian Forest Products Association National Farmers' Federation
Change least-cost purchasing to target multiple benefits and emissions reductions across sectors	Australian Forest Products Association Red Meat Advisory Council Greening Australia
Provide greater support for new method development	National Farmers' Federation PEW Charitable Trusts and Climate Friendly Carbon Market Institute AIGN Woodside Greening Australia
New methods proposed, including: <ul style="list-style-type: none">• productive forests and plantations• woodlands• rangelands• Caring for Country Indigenous practices• holistic vegetation and fire management• land management practices appropriate to southern states• regenerative agriculture practices• wetlands.	Australian Forest Products Association PEW Charitable Trusts and Climate Friendly The Next Economy Greening Australia Victorian Government
Amend current methods, including: <ul style="list-style-type: none">• human-induced regeneration of native vegetation• measured soil carbon method• forestry methods.	Outback Carbon Zenith Australia Group Pty Ltd National Farmers' Federation
Amend definition of newness	PEW Charitable Trusts and Climate Friendly
Remove negative list water provision	Australian Forest Products Association

Allow change from 25-year to 100-year permanence obligations

PEW Charitable Trusts and Climate Friendly

Note: Further information on these issues can be found in the submissions listed. The submissions can be found on the Authority's website.

APPENDIX C. GOVERNMENT ELECTRICITY MARKET INITIATIVES

Measure	Description	Responsible body	Timing
Establishment of the Energy Security Board	Established to coordinate the implementation of the Finkel review recommendations.	COAG Energy Council	Established in August 2017.
Equity support for Snowy 2.0	Equity funding for the development of a large pumped hydro facility.	Australian Government	Funding approved in February 2019; project expected to be operational in 2024–25.
Underwriting New Generation Investments (UNGI) program	A mechanism to support targeted investment in reliable electricity generation in response to Recommendation 4 of the ACCC Retail Electricity Pricing Inquiry. In March 2019, 12 projects were shortlisted under the program.	Australian Government	A multi-phased program open between 2019 and 2023.
Legislative changes to enable penalties or forced divestiture for electricity companies found guilty of misconduct	The Treasury Laws Amendment (Prohibiting Energy Market Misconduct) Bill 2018 proposes new prohibitions and remedies in response to prohibited conduct in retail, contract and wholesale electricity markets. Remedies extend to applying for a divestiture order from the Federal Court.	Australian Government	Legislation passed November 2019.
Post-2025 Market Design Review	The Energy Security Board is to advise on a long-term, fit-for-purpose market framework to support reliability in the NEM with non-dispatchable generation, demand-side response, storage and distributed energy systems.	Energy Security Board, requested by the COAG Energy Council	Recommendations to be provided by end of 2020. Interim advice on preserving reliability and system security in the transition to the post-2025 market design to

			be provided for COAG Energy Council consideration in March 2020.
Integrated System Plan (ISP)	A whole-of-system plan that provides an integrated roadmap for the efficient development of the NEM over the next 20 years, focusing on transmission infrastructure requirements.	AEMO	First prepared in 2018, and updated every two years. 2020 ISP to be released in June 2020.
Priority Transmission Taskforce	The taskforce will support timely delivery of the Australian Energy Market Operator's recommended projects from its ISP.	Australian Government	Announced April 2019.
Regional and Remote Communities Reliability Fund	A\$50.4 million over five years for feasibility studies looking at microgrid technologies to replace, upgrade or supplement existing electricity supply arrangements in off-grid and fringe-of-grid communities in regional and remote areas.	Australian Government	2019–20 to 2023–24.
Marinus Link	A proposed second interconnector providing 1,200 megawatts of capacity between Tasmania and the mainland. The Government committed A\$10 million through ARENA for the feasibility assessment and will commit an additional A\$56 million in partnership with the Tasmanian Government to progress to a final investment decision in 2021–22.	Australian Government, with ARENA and Tasmanian Government	Announced February 2019.
Grid Reliability Fund	A\$1 billion provided to CEFC for investments in energy storage, transmission and distribution infrastructure, grid-stabilising technologies and eligible projects short-listed under the UNGI program.	Australian Government funding of CEFC	Announced October 2019.
Supporting Reliable Energy Infrastructure	A A\$10 million program to improve energy reliability and affordability in central and northern Queensland, including identifying opportunities for	Australian Government	2018–19 to 2020–21.

targeted government support. In addition, the Government is supporting early works to facilitate the proposed Copperstring 2.0 transmission line which would link Mt Isa and the north-west minerals province with the NEM at Townsville.

Qld–NSW interconnector (QNI)	Joint A\$102 million commitment between the Australian and NSW governments to underwrite the QNI interconnector upgrade ahead of final approval by the AER.	Australian and NSW governments	Announced October 2019.
-------------------------------------	---	--------------------------------	-------------------------

APPENDIX D. COSTS AND BENEFITS OF RECOMMENDATIONS

The Authority is required to have regard to the principles set out in the *Climate Change Authority Act 2011* (Cth) when performing its functions. Table 9 presents a summary of the recommendations' outcomes against these criteria. Further analyses of the costs and benefits of the recommendations are made throughout the report.

Where the Authority has recommended further analysis or the development of a strategy, *italicised text* indicates the outcome of the recommendation if the change is made or strategy implemented.

TABLE 9. ANALYSING THE RECOMMENDATIONS' OUTCOMES

RECOMMENDATION	ECONOMIC EFFICIENCY		ENVIRONMENTAL EFFECTIVENESS	EQUITY	BODY RESPONSIBLE FOR IMPLEMENTATION
	COSTS	BENEFITS			
Chapter 6: Transitioning Australia to a low-emissions future					
1	Develop a long-term climate change strategy that secures Australia's contribution to the achievement of the temperature goals of the Paris Agreement and ensures we make the most of the opportunities arising from the transition to a low-emissions global economy.	General policy development.	<i>Increased certainty to businesses, investors and policy makers.</i> <i>New opportunities for emerging industries and job creation.</i>	<i>Enhanced abatement through improved investment in low-emissions activities.</i>	<i>Provides an informed basis for policy makers to identify pathways for industries to evolve and remain competitive and to exploit new economic opportunities.</i>
2	Include emission reductions and climate resilience as a standing item on the Council of Australian		<i>Increased coordination and reduced duplication of policy efforts.</i>	<i>Enhanced abatement through improved coordination.</i>	<i>Potential for greater consistency and</i> <i>Australian, state and territory and local governments</i>

	Governments (COAG) meeting agenda.			<i>coordination between states.</i>	
3	Develop a trade and investment strategy that identifies and leverages Australia's competitive advantages in a net-zero emissions world.	General policy development.	<i>Increased economic opportunity and long-term growth.</i> <i>Decreased opportunity costs.</i>	<i>Enhanced abatement through improved investment in low-emissions activities.</i>	<i>Provides opportunities to align low-emissions activities to regions affected by the low-emissions transition.</i>
4	Governments should work together to support industries and communities facing an uncertain future to identify pathways for industries to evolve and remain competitive and to exploit new economic opportunities, including:	General policy development.	<i>Increased private sector understanding and certainty.</i> <i>New opportunities for emerging industries and job creation.</i> <i>Reduced impacts of job losses.</i> <i>New training opportunities.</i>	<i>Indirect abatement through facilitating transition of economy.</i>	Enhanced equity through reduced job losses, improved job readiness and enhanced job creation in affected communities.
5	Aim to meet Australia's 2030 Paris Agreement target using emissions reductions achieved between 2021 and 2030.	Resource costs associated with higher level of abatement in the period (as opposed to applying Kyoto Protocol carryover).	Economy is better prepared for transition to lower emissions post-2030. Stronger signal sent to international community on Australia's ambition and level of commitment to the Paris Agreement.	Enhanced abatement.	May have domestic equity implications from short-term cost of more abatement if this is not taken into account.

6	<p>Develop an international climate strategy to:</p> <ul style="list-style-type: none"> • support a strong global response to climate change that minimises physical impacts on Australia and increases international demand for Australia's emerging low-emissions export industries • maximise the opportunities for Australia from international trade in emissions reductions, including by: <ol style="list-style-type: none"> a. identifying potential carbon trade partners, prioritising developing countries in our region b. supporting potential trade partners to build their capacity to deliver low-cost, 	<p>General policy development.</p> <p><i>Potential for higher prices for domestic offsets.</i></p>	<p><i>New opportunities for emerging low-emission industries and job creation.</i></p> <p><i>Potential access to lower cost international offset units.</i></p> <p><i>Enhanced trade in emission reductions lowers the overall cost of abatement.</i></p>	<p><i>Enhanced abatement through trading.</i></p> <p><i>Promoting and supporting the use of 'high-integrity' international units.</i></p>	<p><i>Improved equity outcomes through allowing abatement to be sourced from low-cost sources.</i></p>	Australian Government
----------	--	--	---	---	--	-----------------------

- high-integrity international units
- c. defining the criteria for and identifying the international units considered to be 'high-integrity' and acceptable to Australia
- d. establishing quotas on the import of international units to ensure Australia's domestic transition to a low-emissions economy continues
- e. establishing a timeline for high-integrity international units to be permitted under the enhanced Safeguard Mechanism.

COSTS AND BENEFITS OF RECOMMENDATIONS

7	In consultation with state, territory and local governments, and drawing on the findings of the bushfire National Royal Commission and the forthcoming CSIRO report on climate resilience, review and update the 2015 National Climate Resilience and Adaptation Strategy to ensure a coordinated and integrated approach, with clear roles and accountabilities, to enhance Australia's climate resilience.	General policy development.	<i>Improved management of physical climate risk.</i> <i>Lower costs associated with natural disasters.</i> <i>Improved economic activity due to less disturbance from climate impacts.</i>	NA.	<i>May improve equity through managing physical climate risks.</i>	Australian Government
8	Fully integrate consideration of emissions and climate change risks in decision making about government programs, assets and services through frameworks such as the Climate Compass.	General business planning.	<i>Improved management of physical climate risk for Government assets and services.</i>	NA.	<i>May improve equity through managing physical climate risks to Government services.</i>	Australian Government
9	Implement the strategic actions in the National Climate Science Advisory Committee's <i>Climate science for Australia's future</i> report to get the most out of the Government's investment in climate science and ensure governments, businesses and communities have the information they need to respond to climate change risks.	General policy development.	Reduced information barriers allowing more efficient planning of climate change response.	NA.	Enhances equity, as allows enhanced planning for climate change for the wider community.	Australian Government

Chapter 8: Electricity

10	<p>To promote the reliable and secure supply of clean electricity at lowest cost for electricity consumers, National Electricity Market (NEM) jurisdictions should, in the design and implementation of their renewable energy policies:</p> <ul style="list-style-type: none"> • emphasise renewable projects that align with the priorities identified by the Australian Energy Market Operator (AEMO) in its Electricity Statement of Opportunities and Integrated System Plan • consider supporting projects located outside of their respective jurisdictions where this will maximise benefits for their electricity consumers and the NEM generally • include electricity system security as a criterion in project selection processes, consult with AEMO for advice on security implications of proposed projects and consider supporting system strength remediation measures. 	General policy development.	<p>Minimise costs for electricity network upgrades. Lower electricity costs for consumers.</p>	<p>May enhance uptake of renewable energy projects, reducing emissions.</p>	<p>Minimises adverse network impacts of poor electricity investment decisions.</p>	<p>Australian, state and territory and local governments</p>
11	<p>The COAG Energy Council should fast-track reforms to facilitate the integration of large amounts of low- and zero-emissions generation and related technologies into the electricity market, focusing on distributed energy resources,</p>	General policy development.	<p>Lower costs of integrating renewable electricity generation.</p>	<p>Greater uptake of renewables will enhance abatement.</p>	COAG Energy Council	

COSTS AND BENEFITS OF RECOMMENDATIONS

	integration of storage and demand-side response and timely and efficient transmission and generation investment.				
12	The Government's Underwriting New Generation Investments program and bilateral energy agreements with the states should further align with the priorities for generation and transmission identified in AEMO's Integrated System Plan and be supported by rigorous cost–benefit analysis to ensure efficient outcomes for electricity consumers.				
13	Identify and implement measures for providing greater certainty on the timing of the retirement of ageing coal generators to facilitate timely investment in replacement capacity and storage and to enhance planning for measures to support local workforces and communities affected by closures.	General policy development.	Greater certainty for electricity sector and communities.	No change.	Improve equity through managed transitions. Australian Government, COAG Energy Council and electricity market bodies
Chapter 9: Industry					
14	Enhance the Safeguard Mechanism to deliver emission reductions from large emitters in industry, with: <ul style="list-style-type: none"> • declining baselines with clear trajectories and the ability to 	General policy development. Additional compliance costs for industry.	The sector contributes to achievement of whole-of-economy emissions reduction target.	Significantly enhanced abatement, depending on ambition of baseline decline. May enhance abatement through easing	Burden of compliance falls on emitters. Risks to equity for workers if industry elects to close rather than comply. Australian Government, industry

	trade under- and over-achievement once baselines have commenced declining and are binding	Program costs, or transfer from non-EITE industry depending on design of assistance.	Increased policy predictability / certainty for private sector. Trading allows more efficient emissions reduction. Continued employment and tax revenue from EITE industries.	implementation of declining baselines. Poorly designed EITE assistance can detract from environmental effectiveness.	EITE assistance transfers burden of compliance away from emitters to taxpayers or non-EITE industry. However, equity may be enhanced for EITE workers and communities who would otherwise bear disproportionate burden of transition.	
15	Investigate how best to encourage smaller businesses to reduce emissions, including through assistance to participate in the Emissions Reduction Fund (ERF).	General policy development. <i>Possible program costs.</i>	<i>Lowering of administrative costs to businesses; lowering of energy costs; reduction of energy waste; lowering cost of energy system transition.</i>	<i>May enhance abatement through actions of businesses not otherwise reducing emissions.</i>	<i>Taxpayers paying for business abatement; however, community may also capture medium- and long-term benefits.</i>	<i>Australian Government</i>
Chapter 10: Transport						
16	Reconsider implementing a greenhouse gas emissions standard for light vehicles and undertake a cost–benefit analysis of an emissions standard for heavy vehicles.	Higher up-front purchase price to consumers. Lower fuel excise tax revenue. Compliance costs to vehicle importers.	Lowering overall cost of vehicle use to consumers.	Enhanced abatement due to reduced combustion of petrol and diesel.	Benefits will accrue to consumers who are also responsible for paying costs of measure.	Australian Government, car importers
17	The forthcoming electric vehicle strategy should aim to minimise barriers to electric vehicle uptake by: • addressing standards for vehicles and charging infrastructure to ensure interoperability	General policy development. <i>Possible compliance costs.</i>	<i>Possible lowering of overall cost of electric vehicle adoption.</i> <i>Possible overall savings for consumers (through lower vehicle costs) and government</i>	<i>Could enhance abatement through accelerated uptake of electric vehicles.</i>	<i>No specific equity concerns, unless strategy imposes significant requirements on businesses or electric vehicle users.</i> <i>Equity is a concern if fuel excise remains the only</i>	<i>Australian Government</i>

COSTS AND BENEFITS OF RECOMMENDATIONS

- ensuring public electric vehicle infrastructure addresses barriers to uptake for those without access to private charging
 - ensuring adequate infrastructure coverage on highways and in regional areas
 - considering implications for electricity network tariff reform and fuel excise revenue
 - incorporating information about electric vehicle ownership costs in the Green Vehicle Guide
 - promoting the development of a used car market for electric vehicles, including through consideration of reduced import barriers for quality used electric vehicles
 - setting targets for electric vehicle adoption in government fleets.
- (through lower total cost of ownership of electric vehicles).*
- form of road-user charging, as electric vehicles will not pay, meaning burden falls only on fossil fuel vehicles.*
- Could improve ability of consumers to access electric vehicles at lower cost.*

18	Investigate barriers to shifting freight transport from more emissions-intensive road to less emissions-intensive rail transport and how these can be overcome by government.	<i>General policy development. Possible program cost.</i>	<i>Possible benefits/savings to business if barriers to mode shifting can be overcome.</i>	<i>Could enhance abatement through use of less emissions-intensive transport.</i>	<i>Taxpayers may subsidise commercial rail freight. Could enhance equity vs. road transport, which relies on infrastructure largely paid for by taxpayers.</i>	Australian Government
----	---	---	--	---	--	-----------------------

Chapter 11: Agriculture and land

19 (Part 1)	Land use and agriculture activities should continue to be covered by the ERF crediting mechanism, with credits continuing to be used as offsets for facilities covered by the Safeguard Mechanism and available for use in other (for example, voluntary) markets.	Reduced overall costs to safeguard entities from option to purchase Australian Carbon Credit Units to meet obligations.	Significantly reduced government program costs from not purchasing abatement.	Declining safeguard baselines set abatement (Rec.14).	Improved equity as safeguard entities rather than taxpayers directly pay for Australian Carbon Credit Units. More funds are available for other government programs.	Australian Government
(Part 2)	The ERF purchasing mechanism should continue until an enhanced Safeguard Mechanism provides a source of demand for credits.	No change.	No change.	No change.	No change.	Australian Government
20	Undertake a review of green product standards and definitions being developed in export markets and engage with trade partners to ensure they do not unduly restrict market access for Australian agriculture.	<i>General policy development.</i>	<i>Increased awareness of any risks to market access and investment from new low-emissions taxonomies and standards.</i> <i>Increase or maintain market access and green investment through standards that are fit for use in Australia.</i>	<i>Indirect abatement when businesses improve to meet standards that are fit for use in Australia.</i>	<i>Helps to avoid adverse impacts through seeking to maintain or improve access to export markets for Australian products.</i>	Australian Government
21	Allocate additional funds for research on low-emissions agriculture and carbon farming, including possible new agricultural industries. This would include basic research, applied research (including on new ERF methods), and the development of tools to report on the emissions profile of agricultural activities.	Program costs.	Increases investment and jobs in research.	In the longer term, research creates new technologies and practices allowing for decarbonisation of economy and potential export.	Provides opportunities for agriculture industries.	Australian Government

COSTS AND BENEFITS OF RECOMMENDATIONS

22	Introduce a Land and Environment Investment Fund (i.e. a Clean Energy Finance Corporation (CEFC) for the land) to invest in actions to support low-emissions and climate-smart agriculture and associated environmental services.	Increased short-term borrowing costs to government.	Increased investment in agriculture and land sector industries. Returns on investments.	Enhanced abatement.	Provides opportunities for agriculture industries.	Australian Government
23	Investigate and implement the most effective incentives to encourage the use of emissions-reducing inputs in agricultural production systems.	Additional administrative cost. <i>Potential increased cost to government depending on approach.</i>	<i>Decreased costs to agriculture businesses.</i>	<i>Enhanced abatement.</i>	<i>May have equity implications if there are less funds available for other government programs.</i>	<i>Australian Government</i>
24	Together with state and territory governments, continue to coordinate and integrate programs designed to increase mitigation, build resilience to drought and climate impacts, enhance biodiversity and provide benefits for Indigenous communities, including through interjurisdictional partnerships and program linkages.	General policy development.	<i>Increased private sector understanding and certainty.</i> <i>Decreased opportunity costs through enabling better investment.</i>	<i>Indirect abatement through facilitating transition of agriculture sector.</i>	<i>May improve equity by managing risks to both large and small agriculture enterprises.</i>	Australian and state and territory governments
Chapter 12: Waste						
25	Work with the states and territories to reduce landfill emissions by strengthening and harmonising regulations on methane emissions from landfill waste, diverting organic waste from landfill and fully	May increase transaction costs for some regulatory bodies.	Could lead to lower cost abatement opportunities.	May increase abatement.	Consideration should be given as to how best to deal with smaller regional landfills given that they tend to emit lower volumes of greenhouse gases and some	COAG State and territory regulatory bodies

	implementing the National Food Waste Strategy.			abatement options may not be feasible.		
26	Recognising the benefits of a circular economy approach for emissions reductions, ensure implementation of the National Waste Policy Action Plan considers industry development, the waste hierarchy, research and development needs, training requirements and barriers to adoption; and emphasises the creation of industries in regions undergoing transition.	General policy development.	Support the development of Australia's circular economy and ensure Australian industries are able to benefit from emerging opportunities.	Enable Australia to move toward a low-emissions economy through a circular economy approach.	Provides opportunities for industries in regional areas. Australian Government	
Chapter 13: Energy efficiency						
27	Working with the COAG Energy Council, reinvigorate the National Energy Productivity Plan with enhanced ambition and additional resources, including by: <ul style="list-style-type: none"> • implementing a National Energy Savings Scheme (NESS) that builds on existing state and territory energy efficiency schemes • accelerating implementation of the Independent Review of the Greenhouse and Energy Minimum Standards Act, strengthening existing performance standards and extending coverage to new categories of appliances and commercial equipment, such 	General policy development. Compliance costs to business. Higher up-front purchase price of more efficient appliances.	Participants in the NESS likely to save money, and benefits also delivered to other energy system users through lower infrastructure needs.	May increase abatement. Reduced information barriers to purchasing energy-efficient equipment. Could lead to lower cost abatement opportunities. Reduced energy costs.	Some equity concerns for the NESS as white certificates are a cross-transfer between energy system users, but benefits accrue to both participants and other energy system users. Benefits generally accrue to consumers, who also pay the cost of the measure.	Australian Government, COAG Energy Council, state and territory governments

COSTS AND BENEFITS OF RECOMMENDATIONS

- as hot water products and pumps, boilers and air compressors
- accelerating energy efficiency improvements for buildings in the National Construction Code via the Trajectory for Low Energy Buildings initiative
- developing a detailed action plan for improving the energy efficiency performance of existing commercial and residential buildings via the addendum to the Trajectory for Low Energy Buildings initiative; and addressing energy efficiency improvements for vulnerable consumers.

28	In partnership with state and territory governments, design and deliver targeted programs to improve energy efficiency in priority groups such as low-income households and small to medium businesses through the provision of information, expertise and financial assistance (grants and tax incentives) where appropriate.	General policy development.	Benefits to participants through energy savings. Benefits to community through enhanced energy efficiency activity (lowers cost of infrastructure, lowers organisational and cultural barriers to energy efficiency).	Well-designed programs should increase abatement.	Equity improved for low-income households. Taxpayers paying for small business abatement, but could provide wider community benefits.
29	All governments should pursue energy efficiency improvements in government owned and leased buildings, undertake targeted retrofits and implement steadily	Possible additional cost to government.	Reduced costs to government through improved energy performance.	May increase abatement.	Improved equity by reducing energy costs for low-income public housing tenants.

rising minimum standards for public housing to improve the energy efficiency performance of the public housing stock.

Reduced energy costs for public housing tenants.

Chapter 14: Research and development, innovation and technology

30	<p>Partner with industry and researchers to identify areas where research and development (R&D) support is needed to capitalise on areas of comparative advantage for Australia and to support strategic development of clean technology industries.</p> <p>Continue to fund the Australian Renewable Energy Agency and consider expanding its remit into other sectors requiring R&D for low-emissions technology or practice.</p> <p>Build on Australia's Mission Innovation commitment to double investment in clean technology over the five years to 2020 by undertaking to grow the level of investment further to 2030.</p> <p>Support the development of negative emissions technologies, including R&D and methodology development for inclusion in the ERF.</p>	<p>Program costs. General policy development.</p>	<p><i>Reduces cost and technology barriers to mitigation.</i> Enables least-cost mitigation and lowers technology barriers to mitigation.</p>	<p>New technology development can enhance mitigation.</p>	<p>Could enhance equity by encouraging new industries and employment opportunities.</p>	<p>Australian Government</p>
-----------	---	---	--	---	---	------------------------------

COSTS AND BENEFITS OF RECOMMENDATIONS

31	Target funding support for innovation in emissions reduction towards harder-to-abate and emissions-intensive, trade-exposed industries and towards industries with well-defined low-emissions goals, targets and pathways.	Program costs.	Enables least-cost mitigation and lowers technology barriers to mitigation.	New technology development can enhance mitigation.	Could enhance equity by encouraging new industries and employment opportunities. Taxpayers paying for private innovation.	Australian Government
32	Expand the remit of the CEFC to allow it to invest in emissions reduction technologies in all sectors to help overcome barriers to finance. Restrictions on the scope of the CEFC's activities, its portfolio mix and the financial instruments it can use should be lifted. The Government should consider making further capital injections into the CEFC to fund this expansion.	General policy development. <i>Increased short-term borrowing costs (if further capital injections made).</i>	Enhanced financial flows for low-emissions technology. <i>Additional investment returns to government (if further capital injections made).</i>	Deployment of low-emissions technology can enhance mitigation.	Could enhance equity by encouraging new industries and employment opportunities.	Australian Government
Chapter 15: Finance and investment						
33	Review the data that are necessary to enable industry, investors and business to understand and manage climate-related financial risk and develop and implement plans for addressing gaps and deficiencies in the data.	General policy development.	<i>Help decision makers across the economy to understand and manage climate-related financial risk.</i>	<i>Assist industry, investors and business to mitigate climate-related risk, including through investment in low-emissions activities.</i>	<i>Improved information and transparency.</i>	Australian Government
34	A joint taskforce of the Council of Financial Regulators should:	General policy development.	<i>Mandatory, standardised and streamlined disclosure could provide incentives for</i>	<i>Assist industry, investors and business to mitigate climate-related risk, including through</i>	<i>Improved information and transparency.</i>	Australian Government and Australian financial regulators

	<ul style="list-style-type: none"> develop standard reporting criteria to enhance the quality and usefulness of disclosures under the Task Force on Climate-related Financial Disclosures framework. To support standardised reporting, the Government should develop standardised national climate scenarios aligned to the Paris Agreement temperature goals together with the major accounting bodies, examine the phasing-in and mandatory reporting of climate-related risks and mainstream climate-related disclosures in companies' audited financial statements provide regulatory guidance to clarify the duties of institutional investors to consider climate-related risk. 	<p><i>improved pricing of climate risk, reduce transaction costs and improve efficiencies for the finance sector.</i></p> <p><i>Clarifying investor and trustee duties could provide certainty and avoid needless litigation.</i></p>	<p><i>investment in low-emissions activities.</i></p>		
35	To facilitate the development of Australia's green finance market and ensure Australian low-emissions industries, products and services are able to benefit from increased international green investment flows, the Australian Government should consider the recommendations of the Australian Sustainable Finance Initiative when the final report is published, and:	General policy development.	<p><i>Opportunity for government to collaborate with the Australian finance and investment sector to identify and deliver key finance policy tools to ensure long-term finance sector stability.</i></p> <p><i>Support the development of Australia's green finance market and ensure Australian low-emissions industries, products and services are able</i></p>	<p><i>Enable Australia to move more readily toward a low-emissions economy through the enhanced flow of capital into low-emissions activities.</i></p> <p><i>Improved information and transparency. Increased investment and economic opportunity.</i></p>	Australian Government and Australian financial regulators

COSTS AND BENEFITS OF RECOMMENDATIONS

- participate in international initiatives developing global green economy rules and standards
 - collaborate with other jurisdictions to ensure alignment and convergence of emerging international classification systems for low-emissions technologies, assets and industries (low-emissions taxonomies) and to ensure Australia's low-emissions exports are defined and included
 - assist the finance and investment sector to develop standards and verification processes for green finance products and services, including through possible funding and endorsement.
- to benefit from increased international green investment flows.*

GLOSSARY

business as usual (BAU) emissions	Emissions that would occur without any additional policy intervention.
Cancun Agreements	Reached on December 11 in Cancun, Mexico, at the 2010 United Nations Climate Change Conference, the Cancun Agreements established a goal for reducing human-generated greenhouse gas emissions to keep the global average temperature rise below 2°C and major economies committed to submitting emissions reduction commitments.
carbon dioxide removal	A process that removes greenhouse gases from the atmosphere—for example, reforestation, soil enhancement to increase soil carbon, or biomass energy with carbon capture and storage (where biomass is burned to generate energy and the carbon dioxide emissions are captured and stored underground).
carbon farming	The process of changing agricultural practices or land use to increase the amount of carbon stored in the soil and vegetation (sequestration) and to reduce greenhouse gas emissions from livestock, soil or vegetation (avoidance).
circular economy	A circular economy aims to redesign economic activity so that waste and pollution are no longer by-products of economic activity, products and materials remain in use and natural systems are regenerated.
co-benefits	Benefits that arise from the introduction of a policy in addition to its main purpose. An example is health benefits from emissions standards for power plants.
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.
fugitive emissions	Emissions that occur during production, processing, transmission and distribution of fossil fuels. The major sources of fugitive emissions are the intentional release or combustion of waste gases and unintended leakage.
global warming	A warming of global average temperatures caused by increased atmospheric concentrations of greenhouse gases. This warming results in changes to the climate system.
greenhouse gas	Any gas (natural or produced by human activities) that absorbs infrared radiation in the atmosphere. Key greenhouse gases include carbon dioxide, water vapour, nitrous oxide, methane and ozone.

Kyoto Protocol	An international agreement adopted under the United Nations Framework Convention on Climate Change in 1997. It includes binding national targets for developed countries and flexible mechanisms including the Clean Development Mechanism (CDM).
land use (land use, land-use change and forestry) emissions and removals	Emissions and emissions removals associated with human-induced changes in land use, such as deforestation and afforestation, and those arising from management of forests, crop lands and rangelands and savanna burning.
net-zero emissions	When greenhouse gas emissions released are balanced by an equivalent quantity removed from the atmosphere or offset.
Nationally Determined Contributions (NDCs)	Under the Paris Agreement, countries have put forward NDCs, which outline efforts by each country to reduce national emissions, including emissions reduction targets, and adapt to the impacts of climate change.
offset	A verified emissions reduction in comparison to a baseline. That reduction could be used to balance ('offset') other emissions.
Paris Agreement	An international agreement adopted under the United Nations Framework Convention on Climate Change in 2015. Under the Paris Agreement, the global temperature goal is to keep warming to 'well below' 2°C Celsius compared with pre-industrial levels, and to 'pursue efforts to limit the temperature rise to 1.5°C'.
scope 1 emissions	Emissions released to the atmosphere as a direct result of an activity or series of activities at a facility level—for example, emissions produced from manufacturing processes such as the manufacture of cement.
scope 2 emissions	Emissions released to the atmosphere from the indirect consumption of energy—for example, emissions that come from the use of electricity produced by the burning of coal in another facility.
temperature goal	A goal set by the Parties to the United Nations Framework Convention on Climate Change to limit global warming with the aim of avoiding dangerous climate change.
renewable energy target	A type of technology pull policy that creates a market for additional renewable electricity that supports investment in new renewable capacity.

TABLE OF ABBREVIATIONS AND ACRONYMS

Australian Bureau of Agricultural and Resource Economics (ABARES)	A research arm of the Australian Government department responsible for agriculture, tasked with providing independent data, research, analysis and advice that informs public and private decisions affecting Australian agriculture, fisheries and forestry.
Australian Carbon Credit Unit (ACCU)	A unit issued by the Australian Clean Energy Regulator and recorded in the electronic Australian National Registry of Emissions Units. Each ACCU issued represents one tonne of carbon dioxide equivalent (t CO ₂ -e) stored or avoided by a particular action or project.
Australian Energy Market Commission (AEMC)	The commission is tasked with making and revising Australia's national electricity rules, national gas rules and national energy retail rules.
Australian Energy Market Operator (AEMO)	The operator manages the National Electricity Market, the Wholesale Electricity Market and the Victorian gas transmission network and performs an array of gas and electricity market, operational, development and planning functions.
Australian Renewable Energy Agency (ARENA)	Australian Government agency established to improve the competitiveness of renewable energy technologies and increase the supply of renewable energy in Australia through the provision of financial assistance for the research, development, deployment or commercialisation of renewable energy technologies and to collect and share information about renewable energy technologies.
Business 20 (B20)	The private sector's voice at the G20 community. It addresses global challenges and priorities defined by the G20 countries.
Carbon capture and storage (CCS)	A technology that can capture a portion of the carbon dioxide emissions produced from the use of fossil fuels in electricity generation and industrial processes, preventing the carbon dioxide from entering the atmosphere.
Carbon dioxide-equivalent (CO₂-e)	A measure that quantifies different greenhouse gases in terms of the amount of carbon dioxide that would deliver the same global warming.
Clean Energy Finance Corporation (CEFC)	An Australian Government owned Green Bank that was established to facilitate increased flows of finance into the clean energy sector.
Clean Energy Regulator (CER)	An Australian independent statutory authority responsible for administering legislation to reduce carbon emissions and increase the use of clean energy.
Council of Australian Governments (COAG)	The peak intergovernmental forum in Australia. Comprising the federal government, the governments of the six states and two mainland territories

TABLE OF ABBREVIATIONS AND ACRONYMS

	and the Australian Local Government Association, it manages governmental relations within Australia's federal system.
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	An independent Australian federal government agency responsible for scientific research. Its chief role is to improve the economic and social performance of industry for the benefit of the community.
Emissions Reduction Assurance Committee (ERAC)	An independent, expert committee that assesses whether methodology determinations (methods) under the Emission Reduction Fund meet the requirements of the fund and helps ensure the ongoing integrity of methods under the fund.
Emissions Reduction Fund (ERF)	A voluntary scheme that aims to provide incentives for a range of organisations and individuals to adopt new practices and technologies to reduce their emissions. A number of activities are eligible under the scheme and participants can earn ACCUs for emissions reductions.
Group of Twenty (G20)	An international forum for global economic cooperation. The G20 members account for 85 per cent of the world economy, 75 per cent of global trade and two-thirds of the world's population.
Intergovernmental Panel on Climate Change (IPCC)	The intergovernmental scientific body that produces reports that support the United Nations Framework Convention on Climate Change, which is the main international treaty on climate change.
Nationally Determined Contributions (NDCs)	Intended reductions in greenhouse gas emissions committed by countries under the United Nations Framework Convention on Climate Change Paris Agreement.
National Electricity Market (NEM)	A wholesale market through which generators and retailers trade electricity in Australia. It interconnects the six eastern and southern states and territories and delivers around 80 per cent of all electricity consumption in Australia. Western Australia and the Northern Territory are not connected to the NEM. They have their own electricity systems and separate regulatory arrangements.
non-government organisations (NGOs)	Organisations independent of any government. They are usually non-profit.
Organisation for Economic Co-operation and Development (OECD)	An international organisation that shares policy information, data and ideas on a range of social, economic and environmental issues. There are currently 36 member organisations, of which Australia is one.
Financial Stability Board Task Force on Climate-related Financial Disclosures (TCFD)	A market-driven initiative set up to develop a set of recommendations for voluntary and consistent climate-related financial risk disclosures in mainstream corporate filings.

United Nations Framework Convention on Climate Change (UNFCCC)	An international convention that commits signatory countries (known as Parties) to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human-induced interference with the climate system.
---	--

REFERENCES

ABC News 2019, *Coalition says it's not anti-electric cars, but doesn't want to tell people what to drive*, viewed 12 March 2020, <https://www.abc.net.au/news/2019-04-18/coalition-says-it-is-not-anti-electric-cars/11029222>.

Aboriginal Carbon Foundation n.d., *Environmental, social & cultural core benefits*, viewed October 2019, <https://www.aboriginalcarbonfoundation.net/core-benefits-standard>.

ACIL Allen 2019, *Supporting agriculture to adapt to climate change. Stream 2: Opportunities and risks*, viewed 21 November 2019, <https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/ag-food/drought/stream-2-report.pdf>.

ACIL Allen 2018, *Opportunities for Australia from hydrogen exports, a report prepared for ARENA*, viewed 26 November 2019,
https://acilan.com.au/uploads/files/projects/227/ACILAllen_OpportunitiesHydrogenExports_2018pdf-1534907204.pdf.

ACIL Allen 2015, *Commercial building disclosure: Program review*, viewed 29 July 2019,
https://www.acilan.com.au/uploads/files/projects/171/ACILAllen_CommercialBuilding_2015.pdf.

Access Economics 2009, *Employment in waste management and recycling*, viewed 3 December 2019,
<https://www.environment.gov.au/system/files/resources/5cc6a848-a93e-4b3f-abf7-fc8891d21405/files/waste-and-recycling-employment.pdf>.

Accounting for Nature n.d., *Accounting for nature*, viewed 19 November 2019,
<https://www.accountingfornature.org/>.

AGL 2019, *Annual report 2019, business value driver: Communities & relationships*, viewed 26 November 2019, <https://www.2019annualreport.agl.com.au/business-value-drivers/communities-relationships>.

AGL 2017, *NSW generation plan*, viewed 26 November 2019, <https://www.agl.com.au/-/media/agl/about-agl/documents/media-center/asx-and-media-releases/2017/171209nswgenerationplandecember2017.pdf?la=en&hash=BB2DAB602AE1D1AECD85D4F2881EA665>.

Agora Energiewende and Aurora Energy Research (Agora Energiewende) 2019, *The German Coal Commission. A roadmap for a just transition from coal to renewables*, viewed 17 January 2020,
https://www.agora-energiewende.de/fileadmin2/Projekte/2019/Kohlekommission_Ergebnisse/168_Kohlekommission_EN.pdf.

Agriculture Ministers' Forum (AGMIN) 2019, *Agriculture Ministers' Forum 25 October 2019*, viewed 19 November 2019, <https://www.agriculture.gov.au/about/media-centre/communiques/ag-ministers-forum-october-2019>.

AgriFutures Australia 2019a, *Integrating NRM with industry-led sustainability*, viewed 25 November 2019,
<https://www.agrifutures.com.au/product/integrating-nrm-with-industry-led-sustainability/>.

AgriFutures Australia 2019b, *Agriculture—a \$100b sector by 2030?*, viewed 25 November 2019,
<https://www.agrifutures.com.au/product/agriculture-a-100b-sector-by-2030/>.

American Council for an Energy-Efficient Economy (ACEEE) 2018, *2018 International Energy Efficiency Scorecard*, viewed 8 May 2019, <https://aceee.org/sites/default/files/publications/researchreports/i1801.pdf>.

- Analytica Advisors 2017**, *Canadian clean technology industry report*, viewed 6 December 2019, <http://analytica-advisors.com/sites/default/files/2017%20Canadian%20Clean%20Technology%20Industry%20Report%20Synopsis%20FINAL.pdf>.
- Andrews K, Pitt K 2020**, *Investing in Australia's mining and energy future*, viewed 16 March 2020, <https://www.minister.industry.gov.au/ministers/karenandrews/media-releases/investing-australias-mining-and-energy-future>
- Andrews K, Taylor A 2020**, *Supporting affordable clean energy*, viewed 16 March 2020, <https://www.minister.industry.gov.au/ministers/karenandrews/media-releases/supporting-affordable-clean-energy>
- AON 2018**, *Weather, climate and catastrophe insight: 2018 annual report*, viewed 3 July 2019, <http://thoughtleadership.aonbenfield.com/Documents/20190122-ab-if-annual-weather-climate-report-2018.pdf>.
- Association of Superannuation Funds of Australia 2019**, *Superannuation statistics*, viewed 13 December 2019, <https://www.superannuation asn.au/resources/superannuation-statistics>.
- Audit Office of New South Wales (Audit Office) 2019**, *Managing native vegetation*, viewed 25 November 2019, <https://www.audit.nsw.gov.au/our-work/reports/managing-native-vegetation>.
- Australian–German Energy Transition Hub 2019**, *Australia's power advantage: Energy transition and hydrogen export scenarios, Insights from the Australian–German Energy Transition Hub*, viewed 1 September 2019, https://www.energy-transition-hub.org/files/resource/attachment/australia_power_advantage_0.pdf.
- Australian Academy of Science 2017**, *Australian climate science capability review*, viewed 6 November 2019, <https://www.science.org.au/files/userfiles/support/reports-and-plans/2017/climate-science-capability-review-2017.pdf>.
- Australian Accounting Standards Board 2018**, *Climate-related and other emerging risks disclosures: Assessing financial statement materiality using AASB Practice Statement 2*, viewed 24 April 2019, <https://www.aasb.gov.au/admin/file/content102/c3/AASB AUASB Joint Bulletin 13122018 final.pdf>.
- Australian Alliance for Energy Productivity (A2EP) 2018**, *National Energy Productivity Plan A2EP review of progress—year 2*, viewed 13 May 2019, https://www.2xep.org.au/files/A2EP_review_of_NEPP_2018.pdf.
- Australian Beef Sustainability Framework n.d.**, *Managing climate change risk*, viewed 19 November 2019, <https://www.sustainableaustralianbeef.com.au/managing-climate-change-risk>.
- Australian Building Codes Board (ABCB) 2019**, *Energy efficiency: NCC 2022 and beyond*, viewed 8 August 2019, https://consultation.abcb.gov.au/engagement/energy-efficiency-scoping-study-2019/supporting_documents/Scoping%20studyEnergy%20efficiency%20NCC%202022%20and%20beyond.pdf.
- ABCB 2018**, *What to expect from NCC 2019*, viewed 29 July 2019, <https://abcb.gov.au/News/2018/12/02/What-to-expect-from-NCC-2019>.
- Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2019**, *The effects of drought and climate variability on Australian farms*, viewed 19 December 2019, https://www.agriculture.gov.au/sites/default/files/documents/EffectsOfDroughtAndClimateVariabilityOnAustralianFarms_v1.0.0.pdf.
- Australian Bureau of Statistics (ABS) 2019a**, *Gross value of irrigated agricultural production*, viewed 9 October 2019, <https://www.abs.gov.au/ausstats/abs@.nsf/mf/4610.0.55.008>.

REFERENCES

- ABS 2019b**, *Employment in renewable energy activities, Australia, 2017–18*, cat. no. 4631, viewed 6 December 2019, <https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4631.02017-18?OpenDocument>.
- ABS 2019c**, *Australian national accounts: national income, expenditure and product, Mar 2019*, cat. no. 5206.0, viewed 17 January 2020, https://www.abs.gov.au/ausstats/meisubs.nsf/log?openagent&5206006_industry_gva.xls&5206.0&Time%20Series%20Spreadsheet&15740D8C8E5627D1CA25840F00187F6F&0&Mar%202019&05.06.2019&Latest.
- ABS 2019d**, *Agricultural commodities, Australia, 2015–16*, cat. no. 7121.0, viewed 19 November 2019, <https://www.abs.gov.au/AUSSTATS/abs@.nsf/allprimarymainfeatures/97B95C93A7FD9B75CA2573FE00162CAF?opendocument>.
- ABS 2019e**, *Energy account, Australia, 2016–17*, cat. no. 4604, viewed 8 May 2019, <https://www.abs.gov.au/ausstats/abs@.nsf/mf/4604.0>.
- ABS 2019f**, *Consumer Price Index, Australia, March 2019*, cat. no. 6401.0, viewed 9 May 2019, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/6401.0>.
- ABS 2019g**, *Research and experimental development—business, Australia, 2017–18*, cat. no. 8104.0, viewed 7 November 2019, <https://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/8104.0Main%20Features22017-18?opendocument&tabname=Summary&prodno=8104.0&issue=2017-18&num=&view=>.
- ABS 2018a**, *Australian national accounts: National income and expenditure and product*, viewed 28 November 2019, <https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5206.0Jun%202019?OpenDocument>.
- ABS 2018b**, *Labour force, Australia detailed quarterly, Feb 2019*, viewed 28 November 2019, <https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6291.0.55.003Feb%202019?OpenDocument>.
- Australian Capital Territory Government 2019**, *ACT Climate Change Strategy 2019–25 summary*, viewed 25 November 2019, [https://www.environment.act.gov.au/_data/assets/pdf_file/0003/1414641/ACT-Climate-Change-Strategy-2019-2025.pdf/ recache](https://www.environment.act.gov.au/_data/assets/pdf_file/0003/1414641/ACT-Climate-Change-Strategy-2019-2025.pdf/).
- Australian Competition and Consumer Commission (ACCC) 2019**, *Gas Inquiry 2017–2020 interim report July 2019*, viewed 24 January 2020, <https://www.accc.gov.au/system/files/Gas%20inquiry%20July%202019%20interim%20report.pdf>.
- ACCC 2018**, *Northern Australia insurance inquiry. First interim report 18 December 2018*, viewed 17 January 2020, <https://www.accc.gov.au/focus-areas/inquiries-ongoing/northern-australia-insurance-inquiry/first-interim-report>.
- ACCC 2017**, *Retail Electricity Pricing Inquiry: Preliminary report*, viewed 27 August 2019, <https://www.accc.gov.au/system/files/Retail%20Electricity%20Inquiry%20-%20Preliminary%20report%20-%202013%20November%202017.pdf>.
- Australian Council of Social Service (ACOSS) 2013**, *Energy efficiency & people on low incomes: Improving affordability*, viewed 27 August 2019, https://www.acoss.org.au/images/uploads/ACOSS_ENERGY EFFICIENCY PAPER FINAL.pdf.
- Australian Electric Vehicle Association (AEVA) n.d.**, *New BEVs and PHEVs currently available in Australia*, viewed 4 December 2019, <https://www.aeva.asn.au/sites/default/files/public/u552/Aust%20BEVs%20PHEVs%201.8.19%20V0.1.pdf>.

Australian Energy Market Commission (AEMC) 2019a, Residential electricity price trends 2019, final report, viewed 17 January 2020, <https://www.aemc.gov.au/sites/default/files/2019-12/2019%20Residential%20Electricity%20Price%20Trends%20final%20report%20FINAL.pdf>.

AEMC 2019b, Fact sheet—marginal loss factors, viewed 18 February 2020, <https://www.aemc.gov.au/sites/default/files/2019-03/Fact%20sheet%20marginal%20loss%20factors.pdf>.

AEMC 2019c, Economic Regulatory Framework Review: Integrating distributed energy resources for the grid of the future, viewed 20 February 2020, <https://www.aemc.gov.au/sites/default/files/2019-09/Final%20report%20-%20ENERFR%202019%20-%20EPR0068.PDF>.

AEMC 2019d, Draft Rule Determination: National Electricity Amendment (Wholesale Demand Response Mechanism) Rule 2019, viewed 20 February 2020, <https://www.aemc.gov.au/sites/default/files/2019-07/Draft%20determination%20-%20ERC0247%20-%20Wholesale%20demand%20response%20mechanism.pdf>.

AEMC 2019e, National Electricity Amendment (Early Implementation of ISP Priority projects) Rule 2019, viewed 20 February 2020, <https://www.aemc.gov.au/sites/default/files/2019-04/Final%20determination.pdf>.

AEMC 2019f, Update paper: Coordination of generation and transmission investment, viewed 20 February 2020, https://www.aemc.gov.au/sites/default/files/documents/cogati_update_paper_final_1.pdf.

AEMC 2017, System Security Market Frameworks Review, final report, viewed 17 January 2020, <https://www.aemc.gov.au/sites/default/files/content/f510069a-791b-4e4d-8bc0-9e6a216be7a2/System-Security-Market-Frameworks-Review-Final-Report.pdf>.

AEMC n.d., Distributed energy resources, viewed 20 February 2020, <https://www.aemc.gov.au/energy-system/electricity/electricity-system/distributed-energy-resources>.

Australian Energy Market Operator (AEMO) 2019a, Draft 2020 integrated system plan, viewed 14 January 2020, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/ISP/2019/Draft-2020-Integrated-System-Plan.

AEMO 2019b, 2019 Electricity Statement of Opportunities, viewed 17 January 2020, https://aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2019/2019-Electricity-Statement-of-Opportunities.pdf.

AEMO 2019c, Maintaining power system security with high penetrations of wind and solar generation, international insights for Australia, viewed 17 January 2020, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Future-Energy-Systems/2019/AEMO-RIS-International-Review-Oct-19.pdf.

AEMO 2019d, 2019 forecasting and planning scenarios, inputs, and assumptions, viewed 18 February 2020, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/2019-to-2020-forecasting-and-planning-scenarios-inputs-and-assumptions-report.pdf?la=en.

AEMO 2019e, Power system limitations in north western Victoria and south western New South Wales, viewed 18 February 2020, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Power-System-Limitations-December.pdf.

AEMO 2019f, Indicative marginal loss factors: FY 2020–21, viewed 18 February 2020, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Loss_Factors_and_Regional_Boundaries/2019/Indicative-Marginal-Loss-Factors-2020-21-Financial-Year.pdf.

REFERENCES

- AEMO 2018**, *Initial operation of Hornsdale power reserve battery energy storage system*, viewed 20 February 2020, https://www.aemo.com.au/-/media/Media_Centre/2018/Initial-operation-of-the-Hornsdale-Power-Reserve.pdf.
- AEMO n.d.a**, *Renewable integration study*, viewed 17 January 2020, <https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Future-Energy-Systems/Renewable-Integration-Study>.
- AEMO n.d.b**, *Integrated system plan*, viewed 28 January 2020, <https://www.aemo.com.au/energy-systems/major-publications/integrated-system-plan-ispl>.
- Australian Energy Regulator (AER) 2019**, *AER issues default market offer decision*, viewed 28 January 2020, <https://www.aer.gov.au/news-release/aer-issues-default-market-offer-decision>.
- AER 2018**, *State of the energy market 2018*, viewed 14 January 2020, https://www.aer.gov.au/system/files/State%20of%20the%20Energy%20Market%202018%20-%20Full%20report%20A4_2.pdf.
- Australian Farm Institute 2019**, *Change in the air: Defining the need for an Australian agricultural climate change strategy*, viewed 21 November 2019, [file:///upvirtclus01fs/Users\\$/A22788/Profile/Downloads/FCA_layout_inside_20190717_web.pdf](file:///upvirtclus01fs/Users$/A22788/Profile/Downloads/FCA_layout_inside_20190717_web.pdf).
- Australian Farmers 2019**, *Ministers agree on climate adaptation plan for agriculture*, viewed 17 December 2019, <https://farmers.org.au/news/ministers-agree-on-climate-adaptation-plan-for-agriculture/>.
- Australian Forest Products Association n.d.**, *18 Megatonnes of CO2 equivalent by 2030*, viewed 25 March 2019, https://d3n8a8pro7vhmx.cloudfront.net/afpa/pages/169/attachments/original/1529295400/AFPA_18_BY_2030_test.pdf?1529295400.
- Australian Government 2019a**, *Climate solutions package*, viewed 16 July 2019, <https://www.environment.gov.au/system/files/resources/bb29bc9f-8b96-4b10-84a0-46b7d36d5b8e/files/climate-solutions-package.pdf>.
- Australian Government 2019b**, *Business Energy Advice Program*, viewed 7 November 2019, <https://www.energy.gov.au/government-priorities/energy-programs/business-energy-advice-program>.
- Australian Government 2019c**, *Australian Government response to the Climate Change Authority's Review of the Emissions Reduction Fund*, viewed 25 November 2019, <https://www.environment.gov.au/system/files/resources/73b550d8-f879-45e7-bb11-3ced98078319/files/government-response-cca-review-erf.pdf>.
- Australian Government 2019d**, *Regional and Remote Communities Reliability Fund*, viewed 28 January 2020, <https://www.energy.gov.au/government-priorities/energy-programs/regional-and-remote-communities-reliability-fund>.
- Australian Government 2019e**, *Battery of the nation and Marinus Link Interconnector*, viewed 28 January 2020, https://www.energy.gov.au/sites/default/files/battery_of_the_nation_and_marinus_link.pdf.
- Australian Government 2018**, *Australia's state of the forests report 2018*, viewed 22 January 2020, https://www.agriculture.gov.au/sites/default/files/abares/forestsaustralia/documents/sofr_2018/web%20accessible%20pdfs/SOFR_2018_web.pdf.
- Australian Government 2017**, *2017 Review of climate change policies*, viewed 7 November 2019, <https://www.environment.gov.au/system/files/resources/18690271-59ac-43c8-aee1-92d930141f54/files/2017-review-of-climate-change-policies.pdf>.

Australian Government 2015a, *National Climate Resilience and Adaptation Strategy*, viewed 23 January 2020, <https://www.environment.gov.au/system/files/resources/3b44e21e-2a78-4809-87c7-a1386e350c29/files/national-climate-resilience-and-adaptation-strategy-summary.pdf>.

Australian Government 2015b, *National innovation and science agenda*, viewed 7 November 2019, https://www.industry.gov.au/sites/default/files/July%202018/document/pdf/national-innovation-and-science-agenda-report.pdf?acsf_files_redirect.

Australian Government 2015c, *Agricultural competitiveness white paper: Stronger farmers, stronger economy*, viewed 24 January 2020, <https://agwhitepaper.agriculture.gov.au/sites/default/files/SiteCollectionDocuments/ag-competitiveness-white-paper.pdf>.

Australian Government 2015d, *Australia's intended nationally determined contribution to a new climate change agreement August 2005*, viewed 24 January 2020, <https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/Australia/1/Australias%20Intended%20Nationally%20Determined%20Contribution%20to%20a%20new%20Climate%20Change%20Agreement%20-%20August%202015.pdf>.

Australian Government 2006, *Stewardship: Leading practice sustainable development program for the mining industry*, viewed 17 February 2020, <https://www.industry.gov.au/sites/default/files/2019-04/lpsdp-stewardship-handbook-english.pdf>.

Australian Government n.d., *Climate change in Australia*, viewed 30 October 2019, <https://www.climatechangeaustralia.gov.au/en/>.

Australian Greenhouse Office (AGO) 2006, *Energy Efficiency in Government Operations (EEGO) Policy*, viewed 22 August 2019, https://www.energy.gov.au/sites/default/files/energy-efficiency-in-government-operations-policy-2007_0.pdf.

Australian National University (ANU) 2019, *New satellites show worrying view of droughts and ice loss*, viewed 17 January 2020, <https://www.anu.edu.au/news/all-news/new-satellites-show-worrying-view-of-droughts-and-ice-loss>.

ANU Energy Change Institute n.d., *Zero-carbon energy for the Asia Pacific Region*, viewed 24 January 2020, <https://www.anu.edu.au/research/research-initiatives/zero-carbon-energy-for-the-asia-pacific>.

Australian Prudential Regulation Authority (APRA) 2020, *Information paper: APRA's policy priorities*, viewed 24 January 2020, <https://www.apra.gov.au/sites/default/files/2020-01/APRA%202020%20Policy%20Priorities.pdf>.

APRA 2019a, *Submission to the Australian Competition and Consumer Commission—Northern Australia Insurance Inquiry second update report*, viewed 15 October 2019, https://www.apra.gov.au/sites/default/files/submission_northern_australia_insurance_inquiry_second_update_report_september_2019.pdf.

APRA 2019b, *APRA urges greater investment in mitigation to improve insurance affordability in Northern Australia (24 September)*, viewed 18 October 2019, <https://www.apra.gov.au/news-and-publications/apra-urges-greater-investment-mitigation-to-improve-insurance-affordability>.

APRA 2019c, *Information paper: Climate change: Awareness to action (20 March)*, viewed 28 November 2019, https://www.apra.gov.au/sites/default/files/climate_change_awareness_to_action_march_2019.pdf.

Australian Rail Track Corporation (ARTC) 2019, *Inland rail—benefits*, viewed 1 November 2019, <https://inlandrail.artc.com.au/benefits#>.

REFERENCES

- Australian Renewable Energy Agency (ARENA) 2020**, *Second waste-to-energy plant gets green light*, viewed 28 January 2020, <https://arena.gov.au/blog/second-waste-to-energy-plant-gets-green-light/>.
- ARENA 2019a**, *Ultra fast highway charging network for electric vehicles*, viewed 1 November 2019, <https://arena.gov.au/news/ultra-fast-highway-charging-network-for-electric-vehicles/>.
- ARENA 2019b**, *Annual report 2018–19*, viewed 7 December 2019, <https://arena.gov.au/assets/2019/10/arena-annual-report-2018-19.pdf>.
- ARENA 2019c**, *Funding*, viewed 7 November 2019, <https://arena.gov.au/funding/>.
- ARENA 2019d**, *Chargefox Electric Vehicle Charging Network Project*, viewed 24 January 2020, <https://arena.gov.au/projects/chargefox-electric-vehicle-charging-network-project/>.
- ARENA 2019e**, *Addressing solar PV end-of-life issues and lowering solar PV cost*, viewed 28 January 2020, <https://arena.gov.au/funding/addressing-solar-pv-end-of-life-issues-and-lowering-solar-pv-cost/>.
- ARENA 2018a**, *Boosting research into exporting renewable hydrogen*, viewed 17 January 2020, <https://arena.gov.au/news/boosting-research-into-exporting-renewable-hydrogen/>.
- ARENA 2018b**, *Australia's first energy-from-waste plant to be built in WA*, media release, 18 October 2018, viewed 28 January 2020, <https://arena.gov.au/news/australias-first-energy-from-waste-plant-to-be-built-in-wa/>.
- ARENA n.d.**, *Projects*, viewed 1 July 2019, <https://arena.gov.au/projects/>.
- Australian Securities Exchange (ASX) Corporate Governance Council 2019**, *Corporate governance principles and recommendations*, 4th edition, viewed 24 April 2019, <https://www.asx.com.au/documents/asx-compliance/cgc-principles-and-recommendations-fourth-edn.pdf>.
- Australian Securities and Investments Commission (ASIC) 2019a**, *RG 247 effective disclosure in an operating and financial review*, viewed 29 November 2019, <https://www ASIC.gov.au/regulatory-resources/find-a-document/regulatory-guides/rg-247-effective-disclosure-in-an-operating-and-financial-review/>.
- ASIC 2019b**, *RG 228 Prospectuses: Effective disclosure for retail investors*, viewed 29 November 2019, <https://asic.gov.au/regulatory-resources/find-a-document/regulatory-guides/rg-228-prospectuses-effective-disclosure-for-retail-investors/>.
- Australian Sustainable Built Environment Council (ASBEC) 2016**, *Low carbon, high performance*, viewed 29 July 2019, <https://www.asbec.asn.au/wordpress/wp-content/uploads/2016/05/160509-ASBEC-Low-Carbon-High-Performance-Full-Report.pdf>.
- Australian Sustainable Finance Initiative (ASFI) 2019**, *Developing an Australian sustainable finance roadmap: Progress report*, viewed 12 December 2019, <https://static1.squarespace.com/static/5c982bfaa5682794a1f08aa3/t/5def2c72f9cab8076810145e/1575955580290/ASFI+Progress+Report+%28Final%29+-+Embargoed.pdf>.
- Australian Trade and Investment Commission (Austrade) 2018**, *The lithium-ion battery value chain*, viewed 4 November 2019, <https://www.austrade.gov.au/ArticleDocuments/5572/Lithium-Ion%20Battery%20Value%20Chain%20report.pdf.aspx>.
- Australian Trade Commission n.d.**, *Australian green building industry showcase*, viewed 6 December 2019, <https://www.austrade.gov.au/MultiMediaFiles/Australian-Green-Building-Industry-Showcase/>.
- B20 2019**, *B20 Tokyo Summit joint recommendations—‘Society 5.0 for SDGs’*, viewed 26 June 2019, http://www.b20tokyo.org/documents/pdf/Joint_Recommendations_eng.pdf.

BAEconomics 2018, *Carbon sequestration potential of plantation forestry expansion in Australia*, viewed 25 November 2019, <http://www.baeconomics.com.au/wp-content/uploads/2018/06/Plantation-forestry-sequestration-13June18.pdf>.

Bank of England Prudential Regulation Authority (BoE PRA) 2019, *Life insurance stress test 2019 scenario specification, guidelines and instructions FINAL* 18 June 2019, viewed 5 December 2019, <https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/letter/2019/life-insurance-stress-test-2019-scenario-specification-guidelines-and-instructions.pdf>.

Barker S 2018, *Directors' liability and climate risk: Australia—country paper*. Commonwealth Climate and Law Initiative (April 2018), viewed 18 October 2019, <https://ccli.ouce.ox.ac.uk/wp-content/uploads/2018/04/CCLI-Australia-Paper-Final.pdf>.

Barrett C and Skarbek A 2019, *Climate risk and the financial system*. Melbourne: Monash Sustainable Development Institute, viewed 1 May 2019,

https://www.monash.edu/_data/assets/pdf_file/0009/1748745/Climate-Risk-and-the-Financial-System.pdf.

Beggs P et al. 2019, *The 2019 report of the MJA—Lancet countdown on health and climate change: A turbulent year with mixed progress*, viewed 17 January 2020, <https://doi.org/10.5694/mja2.50405>.

Bell J, Frater B, Butterfield L, Cunningham S, Dodgson M, Fox K, Spurling T and Webster E 2014, *The role of science, research and technology in lifting Australian productivity*, Australian Council of Learned Academies, viewed 6 November 2019, <https://acola.org/wp-content/uploads/2018/08/saf04-lifting-australian-productivity-report.pdf>.

Bierman P, Corbett L, Graly J, Neumann T, Lini A, Crosby B and Rood D 2014, 'Preservation of a preglacial landscape under the centre of the Greenland ice sheet', *Science*, Vol. 344, issue 6182, pp 402–405, viewed 17 January 2020, <https://doi.org/10.1126/science.1249047>.

Bloomberg New Energy Finance (BloombergNEF) 2019a, *Bloomberg new energy outlook 2019*, viewed 28 August 2019, <https://about.bnef.com/new-energy-outlook/>.

BloombergNEF 2019b, *Battery power's latest plunge in costs threatens coal, gas*, viewed 18 July 2019, <https://about.bnef.com/blog/battery-powers-latest-plunge-costs-threatens-coal-gas/>.

BloombergNEF 2019c, *Electric vehicle outlook 2019*, viewed 4 July 2019, <https://about.bnef.com/electric-vehicle-outlook/>.

Blue Environment 2019, *Data on exports of Australian wastes 2018–19*, viewed 3 December 2019, <http://www.environment.gov.au/system/files/resources/23acbf02-2178-4139-81b0-58adcac4f5cd/files/data-exports-australian-wastes-2018-19.pdf>.

Blue Environment 2018, *National waste report 2018*, viewed 15 July 2019, <https://www.environment.gov.au/system/files/resources/7381c1de-31d0-429b-912c-91a6dbc83af7/files/national-waste-report-2018.pdf>.

Bown G 2011, *Victorian Energy Efficiency Target Act Independent Review final report*, viewed 14 May 2019, https://www.energy.vic.gov.au/_data/assets/pdf_file/0025/75760/2011-Victorian-Energy-Efficiency-Target-Independent-Review-report.pdf.

Brandi C 2017, *Trade elements in countries' climate contributions under the Paris Agreement*, ICTSD, viewed 19 January 2020, https://www.icts.org/sites/default/files/research/trade_elements_in_countries_climate_contributions.pdf.

Brisbane City Council n.d., *Reducing Brisbane's emissions*, viewed 17 January 2020, <https://www.brisbane.qld.gov.au/about-council/governance-and-strategy/vision-and-strategy/reducing-brisbanes-emissions>.

REFERENCES

- Building Ministers' Forum (BMF) 2019**, *Building Ministers' Forum Communiqué—18 July 2019*, viewed 29 January 2020, <https://www.industry.gov.au/sites/default/files/2019-07/bmf-communique-18-july-2019.pdf>.
- Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2019**, *Electric vehicle uptake: Modelling a global phenomenon*, viewed 4 December 2019, <https://www.bitre.gov.au/publications/2019/files/bitre-report-151.pdf>.
- BITRE 2016**, *Why short-haul intermodal rail services succeed*, viewed 4 November 2019, https://www.bitre.gov.au/publications/2016/files/rr_139.pdf.
- Burke, P J, Best R, and Jotzo F 2018**, 'Closures of coal-fired power stations in Australia: Local unemployment effects', *Australian Journal of Agricultural and Resource Economics* 63(1): 142–65, viewed 18 February 2020, <https://doi.org/10.1111/1467-8489.12289>.
- Bureau of Meteorology (BOM) n.d.** *Climate change – trends and extremes*, viewed 19 March 2020, http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=timeseries&tQ=graph%3Dmean%26area%3Daus%26season%3D0112%26ave_yr%3DT
- BoM 2020**, *Annual climate statement 2019*, viewed 10 January 2020, <http://www.bom.gov.au/climate/current/annual/aus/>.
- BoM 2019a**, *Bushfire weather*, viewed 28 November 2019, <http://www.bom.gov.au/weather-services/fire-weather-centre/bushfire-weather/index.shtml>.
- BoM 2019b**, Special climate statement 71—severe fire weather conditions in southeast Queensland and northeast New South Wales in September 2019, viewed 6 December 2019, <http://www.bom.gov.au/climate/current/statements/scs71.pdf>.
- BoM 2019c**, *Special climate statement 69—an extended period of heavy rainfall and flooding in tropical Queensland*, viewed 23 January 2020, <http://www.bom.gov.au/climate/current/statements/scs69.pdf>.
- BoM and Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2018**, *State of the climate 2018*, viewed 17 January 2020, <http://www.bom.gov.au/state-of-the-climate/>.
- Burgess G 2019**, *Tasmanian councils grapple with effects and price tag of climate change*, viewed 1 July 2019, <https://www.abc.net.au/news/2019-06-05/this-is-what-climate-change-looks-like-in-tasmania/11176182>.
- Burke P, Rohan B and Frank J 2018**, 'Closures of coal-fired power stations in Australia: Local unemployment effects', *Australian Journal of Agricultural and Resource Economics* 63(1): 142–65, viewed 20 January 2020, <https://doi.org/10.1111/1467-8489.12289>.
- Business Council of Australia (BCA) n.d.** *We support strong action on climate change*, viewed 28 February 2020, https://www.bca.com.au/energy_and_climate.
- CAIT Climate Data Explorer (CAIT) 2019**, *Country greenhouse gas emissions*, Washington, DC: World Resources Institute, viewed 20 January 2020, <http://cait.wri.org>.
- Carbon Brief 2019**, *COP25: Key outcomes agreed at the UN climate talks in Madrid*, viewed 7 January 2020, <https://www.carbonbrief.org/cop25-key-outcomes-agreed-at-the-un-climate-talks-in-madrid>.
- Carbon Market Institute (CMI) 2017**, *Carbon farming industry roadmap*, viewed 5 December 2019, <http://carbonmarketinstitute.org/wp-content/uploads/2017/11/Carbon-Farming-Industry-Roadmap.pdf>.

- Cardan Y, Mokgopo A and Vondrich C 2019, \$11 trillion and counting**, viewed 21 October 2019,
https://financingthefuture.platform350.org/wp-content/uploads/sites/60/2019/09/FF_11Trillion-WEB.pdf.
- Carney M 2015, Breaking the tragedy of the horizon—climate change and financial stability**, viewed 17 October 2019, <https://www.bis.org/review/r151009a.pdf>.
- Centre for International Economics (CIE) 2019, Independent review of the Commercial Building Disclosure Program**, viewed 18 February 2020,
<http://cbd.gov.au/files/CBD%20Review%20CIE%20report%20draft.pdf>.
- Chandrashekeran S, Gill M and Dufty G 2018, Smart electricity meters are here, but more is needed to make them useful to customers**, viewed 20 January 2020, <https://theconversation.com/smart-electricity-meters-are-here-but-more-is-needed-to-make-them-useful-to-customers-92029>.
- Chasan E 2019, Bonds to save the planet**, viewed 29 November 2019,
<https://www.bloomberg.com/news/articles/2019-04-23/bonds-to-save-the-planet>.
- Climate Action 100+ 2019, Climate Action 100+ 2019 progress report**, viewed 21 October 2019,
<https://climateaction100.files.wordpress.com/2019/10/progressreport2019.pdf>.
- De Ciana E, Pavanello F, Randazzo T, Mistry M and Davide M 2019, Households' adaptation in a warming climate. Air conditioning and thermal insulation choices**, viewed 20 January 2020,
<https://doi.org/10.1016/j.envsci.2019.06.015>.
- City of Sydney 2018, Sustainable Sydney 2030—Community Strategic Plan 2017–2021**, viewed 20 January 2020, https://www.cityofsydney.nsw.gov.au/_data/assets/pdf_file/0011/288173/Adopted-Sustainable-Sydney-2030_Accessible-Version.pdf.
- Clancy E 1998, 'The tragedy of the global commons'**, *Indiana Journal of Global legal Studies*, Vol. 5, issue 2, pp 601–619, viewed 16 July 2019,
<https://www.repository.law.indiana.edu/cgi/viewcontent.cgi?article=1136&context=ijgl>.
- Clean Energy Council 2019a, Clean Energy Australia report 2019**, viewed 20 January 2020,
<https://www.cleanenergycouncil.org.au/resources/resources-hub/clean-energy-australia-report>.
- Clean Energy Council 2019b, The distributed energy resources revolution: A roadmap for Australia's enormous rooftop solar and battery potential**, viewed 20 February 2020,
<https://assets.cleanenergycouncil.org.au/documents/advocacy-initiatives/the-distributed-energy-resources-revolution-paper.pdf>.
- Clean Energy Finance Corporation (CEFC) 2019a, Transforming Australian agriculture with clean energy**, viewed 19 November 2019,
https://www.cefc.com.au/media/402212/cefc_transform_aust_agriculture_w_clean_energy.pdf.
- CEFC 2019b, CEFC finance sows seeds of innovation with agrifood tech VC fund**, viewed 25 November 2019, <https://www.cefc.com.au/media/files/cefc-finance-sows-seeds-of-innovation-with-agrifood-tech-vc-fund/>.
- CEFC 2019c, Annual report 2018–19**, viewed 7 November 2019,
https://annualreport2019.cefc.com.au/media/1428/cefc_annual_report_2018-19.pdf.
- CEFC 2019d, Australian Recycling Investment Fund**, viewed 28 January 2020,
<https://www.cefc.com.au/where-we-invest/accessing-our-finance/investment-programs/australian-recycling-investment-fund/>.
- CEFC 2018a, Annual report 2017–18**, viewed 1 July 2019,
<https://annualreport2018.cefc.com.au/media/1154/cefc-annual-report-2017-18.pdf>.

REFERENCES

- CEFC 2018b**, *Statutory Review of the Clean Energy Finance Corporation: CEFC submission*, viewed 22 January 2020, <https://www.environment.gov.au/climate-change/publications/cefc-statutory-review>.
- Clean Energy Institute 2019**, *Lithium-ion battery*, viewed 4 December 2019, <https://www.cei.washington.edu/education/science-of-solar/battery-technology/>.
- Clean Energy Regulator (CER) 2019a**, *Emissions reduction fund project register*, viewed 20 January 2020, <http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register>.
- CER 2019b**, *Safeguard facility reported emissions 2017–18*, viewed 30 July 2019, <http://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/safeguard-facility-reported-emissions/safeguard-facility-emissions-2017-18>.
- CER 2019c**, *Auction July 2019*, viewed 3 December 2019, <http://www.cleanenergyregulator.gov.au/ERF/Auctions-results/july-2019>.
- CER 2019d**, *Carbon abatement contract register*, viewed 30 July 2019, <http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/carbon-abatement-contract-register>.
- CER 2019e**, *Register of accredited power stations*, viewed 5 December 2019, <https://www.rec-registry.gov.au/rec-registry/app/public/power-station-register>.
- CER 2019f**, *2020 Large-scale Renewable Energy Target capacity achieved*, viewed 7 November 2019, <http://www.cleanenergyregulator.gov.au/About/Pages/News%20and%20updates/NewsItem.aspx?ListId=19b4efbb-6f5d-4637-94c4-121c1f96fcfe&ItemId=683>.
- CER 2019g**, *Emissions position as at October 2019*, viewed 20 January 2020, <http://www.cleanenergyregulator.gov.au/Infohub/Media-Centre/Pages/Resources/ERF%20media%20resources/Emissions-Position-as-at-October-2019.aspx>.
- CER 2019h**, *Safeguard facility reported emissions for 2017–18 now available*, viewed 30 July 2019, <http://www.cleanenergyregulator.gov.au/NGER/Pages/News%20and%20updates/NewsItem.aspx?ListId=19b4efbb-6f5d-4637-94c4-121c1f96fcfe&ItemId=625>.
- CER 2019i**, *Climate Solutions Fund—Implementing emissions reduction projects*, viewed 18 December 2019, <http://www.cleanenergyregulator.gov.au/csf/Pages/Home.html>.
- CER 2018a**, *Large-scale Renewable Energy Target*, viewed 6 December 2019, <http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Large-scale-Renewable-Energy-Target>.
- CER 2018b**, *Small-scale Renewable Energy Scheme*, viewed 6 December 2019, <http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Small-scale-Renewable-Energy-Scheme>.
- CER 2018c**, *Safeguard facility reported emissions 2016–17*, viewed 30 July 2019, <http://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/safeguard-facility-reported-emissions/safeguard-facility-emissions-2016-17>.
- Clean Growth Choices n.d.**, *Communities in transition for Queensland communities*, viewed 27 November 2019, <https://www.cleangrowthchoices.org/>.
- Climate Action Tracker 2019**, *Climate crisis demands more government action as emissions rise—June 2019 update*, viewed 24 June 2019, https://climateactiontracker.org/documents/537/CAT_2019-06-19_SB50_CAT_Update.pdf.

Climate Analytics 2012, Hot topic: AAU surplus. Political implications of the long-term effect of surplus from the first and second Kyoto period, viewed 27 November 2019,
<https://climateanalytics.org/publications/2012/hot-topic-aau-surplus-political-implications-of-the-long-term-effect-of-surplus-from-the-first-and-second-kyoto-period/>.

Climate Bonds Initiative 2019a, Green bond issuance tops \$200 bn milestone—New global record in green finance: latest Climate Bonds data, viewed 25 October 2019, <https://www.climatebonds.net/2019/10/green-bond-issuance-tops-200bn-milestone-new-global-record-green-finance-latest-climate>.

Climate Bonds Initiative 2019b, Australia: Green finance state of the market 2019, viewed 21 October 2019, <https://www.climatebonds.net/resources/reports/australia-green-finance-state-market-2019>.

Climate Bonds Initiative 2019c, Green bonds—the state of the market 2018, viewed 26 June 2019,
https://www.climatebonds.net/system/tdf/reports/cbi_gbm_final_032019_web.pdf.

Climate Change Authority (CCA) 2019a, Industry action on climate change mitigation and low-emissions technologies, viewed 21 October 2019,
<http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/Industry%20paper.pdf>.

CCA 2019b, Australia's climate change policies at the Australian and state and territory government levels: A stocktake, viewed 1 November 2019,
<http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/Australian%20climate%20change%20policies%20-%20stocktake.pdf>.

CCA 2018a, Reaping the rewards: Improving farm profitability, reducing emissions and conserving natural capital. Final report, viewed 19 November 2019, <http://climatechangeauthority.gov.au/reaping-rewards-research-report>.

CCA 2018b, Review of the national greenhouse and energy reporting legislation, viewed 20 January 2020,
<https://prod-climatechangeauthority.energy.slicedtech.com.au/sites/prod.climatechangeauthority.gov.au/files/NGERS%20Final%20report%20PDF.pdf>.

CCA 2017a, Review of the Emissions Reduction Fund, viewed 20 January 2020,
<http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/CFI%202017%20December/ERF%20Review%20Report.pdf>.

CCA 2017b, Towards the next generation: Delivering affordable, secure and lower emissions power, viewed 8 December 2019,
<http://www.climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/170616%20CCA%20AEMC%20elec%20report%20FINAL.pdf>.

CCA 2016a, Towards a climate policy toolkit: Special review on Australia's climate goals and policies, viewed 20 January 2020,
<http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/Special%20review%20Report%203/Climate%20Change%20Authority%20Special%20Review%20Report%20Three.pdf>.

CCA 2016b, Special review electricity research report, viewed 20 January 2020,
<http://climatechangeauthority.gov.au/reviews/special-review/special-review-electricity-research-report>.

CCA 2015, Special review second draft report: Australia's climate policy options, viewed 2 July 2019,
<http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/SpecialReport2/Options%20paper%20Final.pdf>.

REFERENCES

- CCA 2014a**, *Reducing Australia's greenhouse gas emissions—Targets and progress review*, viewed 25 October 2019, <http://www.climatechangeauthority.gov.au/files/files/Target-Progress-Review/Targets%20and%20Progress%20Review%20Final%20Report.pdf>.
- CCA 2014b**, *Light vehicle emissions standards for Australia*, viewed 3 December 2019, <http://www.climatechangeauthority.gov.au/files/files/Light%20Vehicle%20Report/Lightvehiclesreport.pdf>.
- ClimateWatch 2019**, *2020 NDC tracker*, viewed 17 December 2019, <https://www.climatewatchdata.org/2020-ndc-tracker>.
- ClimateWorks 2019a**, *Natural capital roadmap*, viewed 22 November 2019, <http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/methods/review-human-induced-regeneration>.
- ClimateWorks 2019b**, *Electric vehicle ready local government fleets*, viewed 4 November 2019, https://www.climateworksaustralia.org/wp-content/uploads/2019/10/ev_ready_local_government_fleets_report.pdf.
- ClimateWorks 2018**, *The state of electric vehicles in Australia*, viewed 1 July 2019, https://www.climateworksaustralia.org/sites/default/files/documents/publications/climateworks_australia_state_of_electric_vehicles2_june_2018.pdf.
- ClimateWorks 2015**, *Australia's energy productivity potential*, viewed 8 December 2019, https://www.climateworksaustralia.org/sites/default/files/documents/publications/climateworks_energy_productivity_report_20150310_0.pdf.
- ClimateWorks 2014**, *Pathways to deep decarbonisation in 2050: How Australia can prosper in a low carbon world—technical report*, viewed 8 December 2019, https://www.climateworksaustralia.org/sites/default/files/documents/publications/climateworks_pdd2050_technicalreport_20140923.pdf.
- ClimateWorks 2010**, *Low carbon growth plan for Australia*, viewed 9 May 2019, https://www.climateworksaustralia.org/sites/default/files/documents/publications/climateworks_lcpa_australia_summary_mar2010.pdf.
- ClimateWorks and Australian Sustainable Built Environment Council (ASBEC) 2018**, *Built to perform*, viewed 30 July 2019, https://www.climateworksaustralia.org/sites/default/files/documents/publications/built_2_perform.pdf.
- CoastAdapt 2018**, *Climate change and sea-level rise in the Australian region*, viewed 18 January 2020, <https://coastadapt.com.au/climate-change-and-sea-level-rise-australian-region>.
- Cole D 2007**, *Climate change and collective action*. SSRN. 12 December, viewed 3 July 2019, <https://dx.doi.org/10.2139/ssrn.1069906>.
- Collyer A 2019**, *Independent review of the Greenhouse and Energy Minimum Standards (GEMS) Act 2012*, Australian Government, viewed 5 November 2019, https://www.energy.gov.au/sites/default/files/gems_review - final_report-accessible.pdf.
- Commonwealth Bank of Australia (CBA) 2019**, *Annual report on risk management*, viewed 18 October 2019, <https://www.commbank.com.au/content/dam/commbank-assets/about-us/2019-08/CBA-2019-Annual-Report-Risk-management.pdf>.
- Commonwealth of Australia 2019a**, *Final budget outcome 2018–19*, viewed 28 October 2019, https://archive.budget.gov.au/2018-19/fbo/FBO_2018-19_web.pdf.

Commonwealth of Australia 2019b, Budget documents, viewed 10 December 2019,
<https://budget.gov.au/2019-20/content/documents.htm>.

Commonwealth of Australia 2018a, National Disaster Risk Reduction Framework, viewed 21 January 2020, <https://www.homeaffairs.gov.au/emergency/files/national-disaster-risk-reduction-framework.pdf>.

Commonwealth of Australia 2018b, Hydrogen for Australia's future, viewed 26 November 2019,
https://www.chiefcientist.gov.au/sites/default/files/HydrogenCOAGWhitePaper_WEB.pdf.

Commonwealth of Australia 2018c, Final report: Implications of climate change for Australia's national security, The Senate Foreign Affairs, Defence and Trade References Committee, May 2018, viewed 6 November 2018,
https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Foreign_Affairs_Defence_and_Trade/Nationalsecurity/Final_Report.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2020, CSIRO report on climate and disaster resilience, viewed 10 March 2020,
<https://www.csiro.au/en/Research/Environment/Extreme-Events/Bushfire/frontline-support/report-climate-disaste-resilience>.

CSIRO 2019a, Australian National Outlook 2019, viewed 19 November 2019,
<https://www.csiro.au/en>Showcase/ANO>.

CSIRO 2019b, Life cycle assessments, viewed 24 October 2019,
<https://www.csiro.au/en/Research/AF/Areas/Sustainable-farming-systems/Life-cycle-assessments>.

CSIRO 2019c, GenCost 2019–20: preliminary results for stakeholder review, viewed 14 January 2020,
https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/CSIRO-GenCost2019-20_DraftforReview.pdf.

CSIRO 2018, Lithium battery recycling in Australia, viewed 9 October 2019,
<https://www.csiro.au/en/Research/EF/Areas/Grids-and-storage/Energy-storage/Battery-recycling>.

CSIRO 2017a, Australia's wheat yields stalled, viewed 1 July 2019, <https://www.csiro.au/en/News/News-releases/2017/Australias-wheat-yields-stalled>.

CSIRO 2017b, Australia secures \$1.0 billion EU canola export market, viewed 29 April 2019,
[https://www.csiro.au/en/News/News-releases/2017/Australia-secures-\\$1-billion-EU-canola-export-market](https://www.csiro.au/en/News/News-releases/2017/Australia-secures-$1-billion-EU-canola-export-market).

CSIRO 2012, The implications of climate change for biodiversity, conservation and the National Reserve system: Final synthesis, viewed 1 July 2019,
<https://publications.csiro.au/rpr/pub?list=SEA&pid=csiro:EP105380>.

CSIRO and BOM 2015, Climate change in Australia—projections for Australia's NRM regions—technical report, viewed 7 December 2019,
https://www.climatechangeaustralia.gov.au/media/ccia/2.1.6/cms_page_media/168/CCIA_2015_NRM_TechnicalReport_WEB.pdf.

Cook P 2017, 'CCS research development and deployment in a clean energy future: lessons from Australia over the past two decades', *Engineering*, Vol. 3(4) pp 477–484, viewed 7 December 2019,
<https://www.sciencedirect.com/science/article/pii/S2095809917306070>.

Cormann M, Taylor A, Ley S and Evans T 2019, Joint media release: Backing Australia's recycling industry, Sunday 15 December 2019, viewed 18 January 2020, <https://www.financeminister.gov.au/media-release/2019/12/15/backing-australias-recycling-industry>.

REFERENCES

- Council of Australian Governments (COAG) 2019, COAG meeting communiqué, 9 August 2019**, viewed 9 October 2019, <https://www.coag.gov.au/meeting-outcomes/coag-meeting-communique-09-august-2019>.
- COAG 2007, National Climate Change Adaptation Framework**, viewed 27 November 2019, <https://www.nccarf.edu.au/sites/default/files/Australian-Government-2007a.pdf>.
- COAG Energy Council 2019a, Australia's national hydrogen strategy**, viewed 7 December 2019, <https://www.industry.gov.au/sites/default/files/2019-11/australias-national-hydrogen-strategy.pdf>.
- COAG Energy Council 2019b, Report for achieving low energy existing homes**, viewed 9 December 2019, http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Trajectory%20Addendum%20-%20Report%20for%20Achieving%20Low%20Energy%20Existing%20Homes_1.pdf.
- COAG Energy Council 2019c, Achieving low energy existing commercial buildings in Australia**, viewed 9 December 2019, <http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Trajectory%20Addendum%20-%20EY-Achieving%20Low%20Energy%20Existing%20Commercial%20Buildings%20in%20Australia.pdf>.
- COAG Energy Council 2019d, RRO bulletin—20190701**, viewed 21 January 2020, <http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/RRO%20Bulletin%20-%2020190701.pdf>.
- COAG Energy Council 2019e, Addendum to the Trajectory for Low Energy Buildings—Existing buildings**, viewed 9 December 2019, http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Trajectory%20Addendum%20-%20ADDENDUM%20TRAJECTORY%20FOR%20LOW%20ENERGY%20BUILDINGS_0.pdf.
- COAG Energy Council 2019f, Energy Security Board: Converting the Integrated System Plan into action**, viewed 20 February 2020, http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Actionable%20ISP%20-%20Consultation%20on%20Draft%20ISP%20Rules_0.pdf.
- COAG Energy Council 2018, Trajectory for Low Energy Buildings**, viewed 29 July 2019, <http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Trajectory%20for%20Low%20Energy%20Buildings.pdf>.
- COAG Energy Council 2017, Report to leaders signed 2017**, viewed 21 January 2020, <http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Report%20to%20Leaders%20signed.pdf>.
- COAG Energy Council 2015, National Energy Productivity Plan**, viewed 13 May 2019, http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/National%20Energy%20Productivity%20Plan%20release%20version%20FINAL_0.pdf.
- Cox L 2019, Bogong moth tracker launched in face of ‘unprecedented’ collapse in numbers**, viewed 30 October 2019, <https://www.theguardian.com/environment/2019/sep/17/bogong-moth-tracker-launched-in-face-of-unprecedented-collapse-in-numbers>.
- Darby M 2018, Canada and EU add climate clause to trade pact**, viewed 7 December 2019, <https://www.climatechannews.com/2018/09/27/canada-eu-add-climate-clause-trade-pact/>.
- Databuild 2015, GEMS review—final report**, viewed 9 May 2019, http://energyrating.gov.au/sites/new.energyrating/files/documents/GEMS_Review_2015_Final_Report_0.pdf.
- Debelle G 2019, Climate change and the economy (March 12)**, viewed 24 April 2019, <https://www.rba.gov.au/speeches/2019/sp-dg-2019-03-12.html>.

- Deloitte 2019, *The social and economic cost of the North and Far North Queensland Monsoon Trough*** (2019) Queensland Reconstruction Authority June 2019, viewed 21 January 2020,
<https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-dae-monsoon-trough-social-economic-cost-report-160719.pdf>.
- Deloitte 2018, *Statutory review of the Clean Energy Finance Corporation: Final report***, prepared for Department of the Environment and Energy, viewed 22 January 2020,
<https://www.environment.gov.au/climate-change/publications/cefc-statutory-review>.
- Department of Agriculture (DoA) 2019a, *Annual report 2018–19***, viewed 24 January 2020,
<https://www.agriculture.gov.au/about/reporting/annualreport>.
- DoA 2019b, *Agriculture Ministers' Forum***, viewed 20 December 2019,
<https://www.agriculture.gov.au/about/media-centre/communiques/ag-ministers-forum-october-2019>.
- DoA 2019c, *Drought resilience funding plan 2020 to 2024, Future Drought Fund***, viewed 25 November 2019,
<https://haveyoursay.agriculture.gov.au/future-drought-fund>.
- DoA 2018, *Growing a better Australia. A billion trees for jobs and growth***, viewed 25 November 2019,
<https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/forestry/national-forest-industries-plan.pdf>.
- Department of Climate Change and Energy Efficiency (DoCCEE) 2011, *Climate change risks to coastal buildings and infrastructure—a supplement to the first pass national assessment***, viewed 24 January 2020,
<https://environment.gov.au/climate-change/adaptation/publications/climate-change-risks-coastal-buildings>.
- Department of Employment, Skills, Small and Family Business (DoE) 2019, *The transition of the Australian car manufacturing sector—outcomes and best practice summary report***, viewed 8 November 2019, https://docs.employment.gov.au/system/files/doc/other/summary_report_-transition_of_the_australian_car_manufacturing_sector_final_0.pdf.
- Department of the Environment and Energy (DoEE) 2019a, *Quarterly update of Australia's National Greenhouse Gas Inventory: June 2019***, viewed 3 December 2019,
<https://www.environment.gov.au/system/files/resources/8d47dec2-cd70-4a67-a7ab-85d67f3d53be/files/nggi-quarterly-update-jun-2019.pdf>.
- DoEE 2019b, *National inventory report 2017***, viewed 3 December 2019,
<http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-inventory-report-2017>.
- DoEE 2019c, *Australian energy statistics, Table O Electricity generation by fuel type 2017–18 and 2018***, Text. 8 March 2019, viewed 24 January 2020, <https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2017-18-and-2018>.
- DoEE 2019d, *National Waste Policy action plan 2019***, viewed 4 December 2019,
<https://www.environment.gov.au/system/files/resources/5b86c9f8-074e-4d66-ab11-08bbc69da240/files/national-waste-policy-action-plan-2019.pdf>.
- DoEE 2019e, *Annual report 2018–19***, viewed 23 January 2020,
<http://www.environment.gov.au/system/files/resources/1c417884-f855-4411-943b-c284450cf1b/files/annual-report-2018-19-full.pdf>.
- DoEE 2019f, *Ninth meeting of environment ministers—agreed statement***, viewed 3 December 2019,
<https://www.environment.gov.au/system/files/pages/4f59b654-53aa-43df-b9d1-b21f9caa500c/files/mem-9-agreed-statement.pdf>.

REFERENCES

- DoEE 2019g**, *Australian energy update 2019*, viewed 8 November 2019,
https://www.energy.gov.au/sites/default/files/australian_energy_statistics_2019_energy_update_report_september.pdf.
- DoEE 2019h**, *National inventory by economic sector 2017*, viewed 19 November 2019
<http://www.environment.gov.au/system/files/resources/f60946ae-37d8-4823-8b3b-dc1181314b44/files/national-inventory-economic-sector-2017.pdf>.
- DoEE 2019i**, *Australia's emissions projections 2019*, viewed 18 January 2020,
<https://www.environment.gov.au/system/files/resources/4aa038fc-b9ee-4694-99d0-c5346afb5fb/files/australias-emissions-projections-2019-report.pdf>.
- DoEE 2019j**, *Portfolio budget statements 2019–20*, viewed 28 January 2020,
<https://www.environment.gov.au/system/files/resources/c47f29fd-f85e-4789-af69-6b26630b8f4d/files/2019-20-pbs.pdf>.
- DoEE 2018a**, *Australia's emissions projections 2018*, viewed 22 July 2019,
<https://www.environment.gov.au/system/files/resources/128ae060-ac07-4874-857e-dced2ca22347/files/australias-emissions-projections-2018.pdf>.
- DoEE 2018b**, *Explanatory document—exposure draft amendments to the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*, viewed 22 October 2019,
<http://www.environment.gov.au/system/files/consultations/56b64cc6-6455-4aa1-9b72-d00b7e09bfb3/files/safeguard-mechanism-rule-amendment-explanatory-document.pdf>.
- DoEE 2018c**, *Climate Compass—a climate risk management framework for Commonwealth agencies*, viewed 27 November 2019, <https://www.environment.gov.au/climate-change/adaptation/publications/climate-compass-climate-risk-management-framework>.
- DoEE 2018d**, *Better fuel for cleaner air regulation impact statement*, viewed 19 December 2019,
<http://www.environment.gov.au/system/files/resources/0a047a41-f521-4f4f-8122-a114e2fb394d/files/better-fuel-cleaner-air-ris.pdf>.
- DoEE 2018e**, *National Waste Policy: Less waste, more resources*, viewed 15 July 2019,
<https://www.environment.gov.au/protection/waste-resource-recovery/publications/national-waste-policy-2018>.
- DoEE 2017a**, *National Food Waste Strategy: Halving Australia's food waste by 2030*, viewed 10 September 2019, <https://www.environment.gov.au/system/files/resources/4683826b-5d9f-4e65-9344-a900060915b1/files/national-food-waste-strategy.pdf>.
- DoEE 2017b**, *Portfolio budget statements 2017–18*, viewed 7 December 2019,
<https://www.environment.gov.au/system/files/resources/e9f767ee-0b12-463c-a6d4-f5f612a6fd97/files/2017-18-pbs.pdf>.
- DoEE 2016a**, *The safeguard mechanism: Overview*, viewed 30 July 2019,
<https://www.environment.gov.au/system/files/resources/8fb34942-eb71-420a-b87a-3221c40b2d21/files/factsheet-safeguard-mechanism.pdf>.
- DoEE 2016b**, *The safeguard mechanism—electricity sector*, viewed 6 December 2019,
<http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/publications/factsheet-safeguard-mechanism-electricity-sector>.
- DoEE 2016c**, *Emissions Reduction Fund—case study. Avoided deforestation: Protecting trees to fund property improvements*, viewed 19 November 2019,
<http://www.environment.gov.au/system/files/resources/0c3ea455-3d02-4f98-876b-9ca97a712527/files/case-study-deforestation.pdf>.

DoEE n.d.a, *National Greenhouse Gas Inventory Kyoto Protocol classifications*, viewed 1 July 2019, <http://ageis.climatechange.gov.au/NGGI.aspx>.

DoEE n.d.b, *National inventory by economic sector*, viewed 29 July 2019, <http://ageis.climatechange.gov.au/ANZSIC.aspx>.

DoEE n.d.c, *UNFCCC inventory*, viewed 25 November 2019, <http://ageis.climatechange.gov.au/UNFCCC.aspx>.

DoEE n.d.d, *Scope 2 emissions—indirect emissions from purchased electricity*, viewed 29 July 2019, <http://ageis.climatechange.gov.au/Electricity.aspx>.

DoEE n.d.e, *Fuel quality standards*, viewed 19 December 2019, <https://www.environment.gov.au/protection/fuel-quality/standards>.

DoEE n.d.f, *Adapting to climate change*, viewed 7 November 2019, <https://www.environment.gov.au/climate-change/adaptation>.

DoEE n.d.g, *Downscaling*, viewed 7 December 2019, <https://www.climatechangeaustralia.gov.au/en/climate-campus/modelling-and-projections/climate-models/downscaling/>.

DoEE n.d.h, *Method reviews*, viewed 25 November 2019, <https://www.environment.gov.au/climate-change/government/emissions-reduction-fund/methods/review>.

DoEE n.d.i, *Emissions Reduction Fund methods*, viewed 10 December 2019, <https://www.environment.gov.au/climate-change/government/emissions-reduction-fund/methods/method-development>.

DoEE n.d.j, *A national strategy for electric vehicles*, viewed 3 December 2019, <https://www.environment.gov.au/climate-change/government/national-vehicle-strategy>.

DoEE n.d.k, *2017–18 product list*, viewed 8 January 2020, <https://www.environment.gov.au/protection/waste-resource-recovery/product-stewardship/legislation/product-list-2017-18>.

DoEE n.d.l, *Australian climate change research*, viewed 7 November 2019, <https://www.environment.gov.au/climate-change/climate-science-data/climate-science/australian-climate-change-science>.

Department of Foreign Affairs and Trade (DFAT) 2019, *Climate Change Action Strategy*, viewed 7 January 2020, <https://dfat.gov.au/about-us/publications/Documents/climate-change-action-strategy.pdf>.

DFAT 2017, *Foreign policy white paper*, viewed 29 November 2019, <https://www.fpwhitepaper.gov.au/foreign-policy-white-paper>.

DFAT n.d.a, *International cooperation on climate change*, viewed 22 January 2020, <https://dfat.gov.au/international-relations/themes/climate-change/Pages/international-cooperation-on-climate-change.aspx>.

DFAT n.d.b, *Health, education and environment funds*, viewed 23 January 2020, <https://dfat.gov.au/aid/who-we-work-with/multilateral-organisations/Pages/health-education-and-environment-funds.aspx>.

Department of Industry, Innovation and Science (DIIS) 2019a, *Low emissions technology development fund*, viewed 7 November 2019, <https://www.industry.gov.au/funding-and-incentives/low-emissions-technology-development-fund>.

DIIS 2019b, *Australia's national hydrogen strategy*, viewed 3 December 2019, <https://www.industry.gov.au/data-and-publications/australias-national-hydrogen-strategy>.

REFERENCES

- DIIS 2019c**, *Resources and energy quarterly September 2019*, viewed 22 October 2019,
<https://publications.industry.gov.au/publications/resourcesandenergyquarterlyseptember2019/documents/Resources-and-Energy-Quarterly-September-2019.pdf>.
- DIIS 2019d**, *Carbon capture and storage flagships*, viewed 7 November 2019,
<https://www.industry.gov.au/funding-and-incentives/carbon-capture-storage-flagships>.
- DIIS 2017**, *Australian innovation system report 2017*, viewed 7 December 2019,
<https://publications.industry.gov.au/publications/australianinnovationsystemreport2017/documents/australian-innovation-system-report-2017.pdf>.
- DIIS n.d.a**, *Boosting innovation and science*, viewed 7 November 2019,
<https://www.industry.gov.au/strategies-for-the-future/boosting-innovation-and-science>.
- DIIS n.d.b** *Making opportunities for critical minerals*, viewed 18 February 2019,
<https://www.industry.gov.au/data-and-publications/australias-critical-minerals-strategy/market-opportunities-for-critical-minerals>.
- DIIS and Australian Trade and Investment Commission (ATIC) 2019**, *Australia's Critical Minerals Strategy*, viewed 6 December 2019, <https://www.industry.gov.au/sites/default/files/2019-03/australias-critical-minerals-strategy-2019.pdf>.
- Department of Infrastructure and Regional Development (DIRD) 2016**, *Improving the efficiency of new light vehicles—draft Regulation Impact Statement*, viewed 3 July 2019,
https://www.infrastructure.gov.au/vehicles/environment/forum/files/Vehicle_Fuel_Efficiency_RIS.pdf.
- DIRD 2017**, *Managing the carbon footprint of Australian aviation*, viewed 7 November 2019,
<https://www.infrastructure.gov.au/aviation/environmental/emissions/files/Managing-the-Carbon-Footprint-of-Australian-Aviation.pdf>.
- Department of Industry, Science, Energy and Resources (DISER) 2020**, *Quarterly Update of Australia's National Greenhouse Gas Inventory: September 2019*, viewed 28 February 2020,
<https://www.industry.gov.au/sites/default/files/2020-02/nggi-quarterly-update-sep-2019.pdf>.
- Department of Infrastructure, Transport, Cities and Regional Development (DITCRD) 2019**, *Registered automotive workshop scheme*, viewed 4 December 2019, <https://www.infrastructure.gov.au/vehicles/raws/>.
- Deutsche Bank 2019**, *German energy imports decline—but only slightly*, viewed 28 February 2020,
https://www.dbresearch.com/servlet/reweb2.ReWEB?rwsite=RPS_EN-PROD&rwoj=ReDisplay.Start.class&document=PROD0000000000501813.
- Doctors for the Environment Australia 2019**, *MJA–Lancet report prompts doctors to call for urgent action on climate change*, media release 13 November 2019, viewed 27 November 2019,
<https://www.dea.org.au/media-release-new-report-prompts-doctors-to-call-for-urgent-action-on-climate-change-nbspnbsp/>.
- Doran C 2011**, *Climate change adaptation—a review of Australian local governments' barriers and priorities*, viewed 7 December 2019,
https://www.nccarf.edu.au/localgov/sites/nccarf.edu.au.localgov/files/resources/pdf/climate_change_adaptation - a review of australian local governments barriers and priorities 23 july 2011.pdf.
- Dowling J 2019**, *Hyundai Nexo: First hydrogen car certified for Australia, now for the refuelling stations*, viewed 4 December 2019, <https://www.caradvice.com.au/805257/hyundai-nexo-certified-australia/>.
- Dundas G 2019**, *No more Hazelwoods: A proposal to ensure coal plants close in an orderly way*, Grattan Institute, viewed 21 January 2020, <https://grattan.edu.au/news/no-more-hazelwoods-a-proposal-to-ensure-coal-plants-close-in-an-orderly-way/>.

Edwards M, Kelly S, Klettner A and Brown P 2019, *Unlocking Australia's sustainable finance potential*, University of Technology Sydney, viewed 29 November 2019, <https://www.uts.edu.au/sites/default/files/2019-06/Unlocking%20Sustainable%20Finance.pdf>.

Ekardt F, Wieding J and Zorn A 2018, 'Paris Agreement, precautionary principle and human rights: Zero emissions in two decades?', *Sustainability*, Vol. 10, p. 2812, viewed 29 November 2019, [file:///pvac01file02/user\\$/A24811/Profile/Downloads/sustainability-10-02812-v2.pdf](file:///pvac01file02/user$/A24811/Profile/Downloads/sustainability-10-02812-v2.pdf).

Ellen Macarthur Foundation 2019, *Completing the picture: How the circular economy tackles climate change*, viewed 9 October 2019,

https://www.ellenmacarthurfoundation.org/assets/downloads/Completing_The_Picture_How_The_Circular_Economy- Tackles_Climate_Change_V3_26_September.pdf.

den Elzen M, Kuramochi T, Höhne N, Cantzler J, Esmeijer K, Fekete H, Fransen T, Keramidas K, Roelfsema M, Sha F, van Soest H and Vandyck T 2019, 'Are the G20 economies making enough progress to meet their NDC targets?', *Energy Policy*, Vol. 26, pp 238–250, viewed 24 June 2019, <https://www.sciencedirect.com/science/article/pii/S030142151830750X>.

Emergency Leaders for Climate Action 2019, *Australia unprepared for worsening extreme weather*, viewed 27 November 2019, https://emergencyleadersforclimateaction.org.au/wp-content/uploads/2019/04/CC_MVSA0184-Fighting-and-Emergency-Services-Statement-A4-Version_V4-FA.pdf.

Emissions Reduction Assurance Committee (ERAC) 2019, *Review of the human-induced regeneration and native forest from managed regrowth methods: Final report March 2019*, viewed 5 November 2019, <https://www.environment.gov.au/system/files/consultations/78b935ed-7dae-4333-87b9-bcf8ffd7724a/files/erac-hir-nfmr-final-report.pdf>.

Energy NSW 2020, *Memorandum of Understanding—NSW Energy Package*, viewed 18 February 2020, <https://energy.nsw.gov.au/media/2001/download>.

Energy NSW 2019, *NSW Energy Strategy*, viewed 18 February 2020, <https://energy.nsw.gov.au/media/1921/download>.

Energieia 2018, *Australian electric vehicle market study*, viewed 23 October 2019, <https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf>.

Energetics 2016, *Modelling and analysis: Australia's 2030 abatement opportunities 2016*, viewed 21 January 2020, <https://www.environment.gov.au/system/files/resources/b8540c8a-8a31-4aba-a8b5-63cc46466e33/files/modelling-and-analysis-australias-2030-abatement-opportunities.pdf>.

Energy Action 2018, *Achieving low energy commercial buildings in Australia*, viewed 29 July 2019, http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Achieving%20Low%20Energy%20Commercial%20Buildings%20in%20Australia_0.pdf.

Energy Action and EnergyConsult 2018, *CBD expansion: Feasibility study*, viewed 29 July 2019, <http://cbd.gov.au/files/Energy%20Consult%20and%20Energy%20Action%20-%20CBD%20Expansion%20Feasibility%20Study%20-%20May%202018.pdf>.

Energy Efficiency Council 2016, *Australian energy efficiency policy handbook*, viewed 10 May 2019, <http://www.eec.org.au/uploads/Documents/Platofrm%20Documents/Australian%20Energy%20Efficiency%20Policy%20Handbook%20E2%80%93%20July%202016.pdf>.

Energyrating.gov.au n.d., *Legislation*, viewed 5 December 2019, <http://www.energyrating.gov.au/suppliers/legislation>.

- Energy Security Board 2019**, *Post 2025 market design: Issues paper*, viewed 24 January 2020, http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/EC%20-%20Post%202025%20Market%20Design%20Issues%20Paper%20-%2020190902_0.pdf.
- Energy Transitions Commission 2018**, *Mission possible—reaching net-zero carbon emissions from harder-to-abate sectors by mid-century*, viewed 6 November 2019, http://www.energy-transitions.org/sites/default/files/ETC_MissionPossible_FullReport.pdf.
- Environment Victoria 2017**, *Bringing rental homes up to scratch: Efficiency standards to cut energy bills, reduce pollution and create jobs*, viewed 21 August 2019, <http://environmentvictoria.org.au/wp-content/uploads/2017/09/Bringing-rental-homes-up-to-scratch-Sept-2017-online.pdf>.
- ERAC 2018**, *Landfill gas method crediting period review report*, viewed 17 July 2019, <http://www.environment.gov.au/system/files/consultations/53d880e3-2ee1-4853-9a9d-ee48f749fc47/files/erac-landfill-gas-review-report.pdf>.
- ERAC 2017**, *Notice of advice to the Minister for the Environment under subsection 123A(2) of the Carbon Credits (Carbon Farming Initiative) Act 2011 (the Act)—Draft new Carbon Credits (Carbon Farming Initiative—Land and Sea Transport) Methodology Determination 2017 (draft Determination)*, viewed 4 December 2019, <https://www.environment.gov.au/system/files/pages/426fa633-9a63-4bb9-bb1f-d52bbff0a0dd/files/erac-advice-land-sea-transport-2017.pdf>.
- Ernst & Young 2015**, *Mid-tier commercial office buildings in Australia: Research into improving energy productivity*, viewed 19 August 2019, https://www.gbc.org.au/uploads/97/36449/Mid-tier%20Commercial%20Office%20Buildings%20Sector%20Report_FINAL.pdf.
- European Commission 2019a**, *TEG report on EU taxonomy*, 18 June 2019, viewed on 19 November 2019, https://ec.europa.eu/info/files/190618-sustainable-finance-teg-report-taxonomy_en.
- European Commission 2019b**, *Sustainable products in a circular economy—towards an EU product policy framework contributing to the circular economy (Chapter 6)*, Commission Staff Working Document, SWD(2019) 91 final, Brussels, viewed 19 November 2019, https://ec.europa.eu/environment/circular-economy/pdf/sustainable_products_circular_economy.pdf.
- European Commission 2019c**, *The European Green Deal sets out how to make Europe the first climate-neutral continent by 2050, boosting the economy, improving people's health and quality of life, caring for nature, and leaving no one behind*, viewed 17 December 2019, https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6691.
- European Commission 2019d**, *FAQ: International Platform on Sustainable Finance (18 October)*, viewed 28 November 2019, https://ec.europa.eu/commission/presscorner/detail/en/QANDA_19_6116.
- European Commission 2018**, *A clean planet for all: A European strategic vision for a prosperous, modern, competitive and climate neutral economy*, COM (2018) 773 Final. 28 November, Brussels, viewed 19 June 2019, <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN>.
- European Environment Agency (EEA) 2018**, *Electric vehicles from life cycle and circular economy perspectives TERM 2018: Transport and Environment Reporting Mechanism (TERM) report*, viewed 5 December 2019, <https://www.eea.europa.eu/publications/electric-vehicles-from-life-cycle>.
- EU High-Level Expert Group on Sustainable Finance 2018**, *Financing a sustainable European economy*, viewed 27 May 2019, https://ec.europa.eu/info/sites/info/files/180131-sustainable-finance-final-report_en.pdf.
- Evenerti 2019**, *Managing the impact of renewably powered electric vehicles on electricity distribution networks*, viewed 4 November 2019, <https://arena.gov.au/assets/2019/03/managing-the-impacts-of-renewably-powered-electric-vehicles-on-distribution-networks.pdf>.

Eyring V, Bony S, Meehl G, Senior C, Stevens B, Stouffer R and Taylor K 2016, Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, geoscientific model development, Vol. 9, pp 1937–1958, viewed 20 December 2019, <https://www.geosci-model-dev.net/9/1937/2016/>.

Faragher D 2009, Statement that a proposal may be implemented—Gorgon gas development revised and expanded proposal, Government of Western Australia, viewed 29 July 2019, https://australia.chevron.com-/media/australia/our-businesses/documents/min_statement_no_800_epa_rep_1221-1323_10aug09.pdf.

Farber D A, 2015, 'Coping with uncertainty: Cost–benefit analysis, the precautionary principle, and climate change', *Washington Law Review*, Vol. 90, pp 1659–1726, viewed 3 December 2019, <https://scholarship.law.berkeley.edu/cgi/viewcontent.cgi?article=3563&context=facpubs>.

Federal Chamber of Automotive Industries (FCAI) 2017, FCAI technical statement on EV charging standards for public recharging infrastructure, viewed 29 January 2019, <https://www.fcai.com.au/news/codes-of-practice/view/publication/99>.

Finkel A 2020, The orderly transition to the electric planet, National Press Club Address, 12 February 2020, viewed 13 March 2020, https://www.chiefscientist.gov.au/news-and-media/national-press-club-address-orderly-transition-electric-planet#_edn19

Finkel A, Moses K, Munro C, Effeney T and O’Kane M 2017, Independent review into the future security of the National Electricity Market, viewed 8 December 2019, <https://www.energy.gov.au/sites/default/files/independent-review-future-nem-blueprint-for-the-future-2017.pdf>.

Fisher B 2019, Economic consequences of Labor’s Climate Change Action Plan, viewed 29 November 2019, <http://www.baeconomics.com.au/wp-content/uploads/2019/05/Economic-Consequences-of-Labors-Climate-Change-Action-Plan-1May19.pdf>.

Five Founders n.d., Our difference, viewed 20 November 2019, <https://fivefounders.com.au/our-difference/>.

Forestry Corporation n.d., Welcome to Forestry Corporation of NSW, viewed 19 November 2019, <https://www.forestrycorporation.com.au/>.

Gaines S, Cabral R, Free C, Golbuu Y et al. 2019, The expected impacts of climate change on the ocean economy, Washington, DC, World Resources Institute, viewed 19 January 2020, www.oceanpanel.org/_expected-impacts-climate-change-ocean-economy.

Garnaut R 2019a, Superpower: Australia’s low-carbon opportunity, La Trobe University Press, 2019.

Garnaut R 2019b, Australia could fall apart under climate change. But there’s a way to avoid it, viewed 7 November 2019, <http://theconversation.com/australia-could-fall-apart-under-climate-change-but-theres-a-way-to-avoid-it-126341>.

Garnaut R 2011, The Garnaut review 2011. Australia in the global response to climate change, viewed 5 December 2019, <https://cpb-ap-se2.wpmucdn.com/blogs.unimelb.edu.au/dist/a/142/files/2016/01/Garnaut-Review-Update-2011-t7k4e9.pdf>.

Garnaut R 2008, ‘The innovation challenge’, in *The Garnaut climate change review*, viewed 6 November 2019, https://webarchive.nla.gov.au/awa/20190509080859/http://www.garnautreview.org.au/pdf/Garnaut_Chapter18.pdf.

Geoscience Australia n.d., Solar energy, viewed 4 December 2019, <https://www.ga.gov.au/scientific-topics/energy/resources/other-renewable-energy-resources/solar-energy>.

REFERENCES

- Germany 2016**, *Climate Action Plan 2050—principles and goals of the German government’s climate policy*, viewed 19 June 2019, https://unfccc.int/sites/default/files/resource/Klimaschutzplan_2050_eng_bf.pdf.
- Gibson R, Broome L and Hutchinson M 2018**, ‘Susceptibility to climate change via effects on food resources: The feeding ecology of the endangered mountain pygmy-possum (*Burramys parvus*)’, *Wildlife Research*, Vol. 45(6), pp 539–550, viewed 21 January 2020, <https://doi.org/10.1071/WR17186>.
- Gilbert and Tobin 2019**, *Green bond market in Australia and overseas*, viewed 21 October 2019, <https://www.gtlaw.com.au/insights/green-bond-market-australia-overseas>.
- Global Commission on the Economy and Climate (GCEC) 2014**, *Better growth, better climate: The new climate economy report*, viewed 5 July 2019, <https://newclimateeconomy.report/2014/>.
- Global Covenant of Mayors 2018**, *Implementing climate ambition—Global Covenant of Mayors 2018 global aggregation report*, viewed 20 June 2019, https://www.globalcovenantofmayors.org/wp-content/uploads/2018/09/2018_GCOM_report_web.pdf.
- Government of Canada 2019**, *Final report of the expert panel on sustainable finance: Mobilising finance for sustainable growth*, viewed 7 December 2019, http://publications.gc.ca/collections/collection_2019/eccc/En4-350-2-2019-eng.pdf.
- Government of Western Australia 2019a**, *Collie’s investment potential highlighted*, media statement 28 June 2019, viewed 26 November 2019, <https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/06/Collies-investment-potential-highlighted.aspx>.
- Government of Western Australia 2019b**, *Future battery industry strategy*, viewed 23 October 2019, https://www.jtsi.wa.gov.au/docs/default-source/default-document-library/future-battery-industry-strategy-wa-0119.pdf?sfvrsn=ccc7731c_6.
- Government of Western Australia 2019c**, *State government details emissions policy for major projects*, viewed 21 January 2020, <https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/08/State-Government-details-emissions-policy-for-major-projects.aspx>.
- Government of Western Australia Department of Primary Industries and Regional Development (DPIRD) 2019a**, *Western Australian Renewable Hydrogen Strategy*, viewed 21 January 2020, http://www.drd.wa.gov.au/Publications/Documents/wa_renewable_hydrogen_strategy.pdf.
- Government of Western Australia DPIRD 2019b**, *Renewable hydrogen industry*, viewed 11 November 2019, <http://www.drd.wa.gov.au/projects/EnergyFutures/Pages/Renewable-Hydrogen-Industry.aspx>.
- Government of Western Australia Department of Water and Environmental Regulation (DWER) 2020**, *Closing the Loop: waste reforms for a circular economy*, viewed 28 February 2020, https://consult.dwer.wa.gov.au/waste-policy/consultation-dashboard-closing-the-loop/user_uploads/closing-the-loop---waste-reforms-for-a-circular-economy---1.pdf.
- Gov.UK 2019**, *UK becomes first major economy to pass net-zero emissions law*, 27 June, viewed 18 July 2019, [https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-netzero-emissions-law](https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law).
- Grain Research and Development Corporation (GRDC) 2018**, *Understanding the European biofuel market for Australian Canola*, viewed 1 May 2019, www.australianoilseeds.com/_data/assets/pdf_file/0010/11431/EU_Canola_Certification_-GRDC_Fact_Sheet.pdf.

Green Building Council Australia (GBCA) 2015, *Mid-tier commercial office buildings in Australia*, viewed 12 August 2019, <https://www.gbc.org.au/uploads/97/36449/Mid-Tier%20Commercial%20Office%20Buildings%20Pathway%20report.pdf>.

Green Climate Fund 2019, *Resource mobilization*, viewed 30 October 2019, <https://www.greenclimate.fund/how-we-work/resource-mobilization>.

Green Industries SA 2017, *Potential benefits of a circular economy in South Australia*, viewed 22 July 2019, <https://www.greenindustries.sa.gov.au/circular-economy>.

Green Industries SA n.d., *China's new waste and recycling policy*, viewed 28 January 2020, <https://www.greenindustries.sa.gov.au/chinas-new-policy-on-waste-and-recycling>.

Green Vehicle Guide n.d.a, *Fuel consumption label*, viewed 3 December 2019, <https://www.greenvehicleguide.gov.au/pages/Information/FuelConsumptionLabel>.

Green Vehicle Guide n.d.b, *Vehicle search*, viewed 3 December 2019, <https://www.greenvehicleguide.gov.au/>.

Hammar H, Sterner T and Akerfeldt S 2013, 'Sweden's CO₂ tax and taxation reform experiences', *Reducing inequalities: A sustainable development challenge*, viewed 10 October 2019, <https://voxeu.org/sites/default/files/file/sterner%20and%20kohlin.pdf>.

Hannam P 2018, *New Zealand rules out using 'Kyoto credits' for Paris, Australia shuns*, viewed 21 January 2020, <https://www.smh.com.au/environment/climate-change/new-zealand-rules-out-using-kyoto-credits-for-paris-australia-shuns-20181211-p50llv.html>.

Harrison M 2010, *Valuing the future: The social discount rate in cost–benefit analysis*, Visiting research paper, Productivity Commission, viewed 15 July 2019, <https://www.pc.gov.au/research/supporting/cost-benefit-discount/cost-benefit-discount.pdf>.

Heal G 2017, 'The economics of the climate', *Journal of Economic Literature*, Vol. 55(3), pp 1046–1063, viewed 2 July 2019, <https://pubs.aeaweb.org/doi/pdfplus/10.1257/jel.20151335>.

Her Majesty's (HM) Government 2019, *Green Finance Strategy: Transforming finance for a greener future*, viewed 17 October 2019, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820284/190716_BEIS_Green_Finance_Strategy_Accessible_Final.pdf.

HM Government 2017, *The Clean Growth Strategy: Leading the way to a low carbon future*, viewed 19 June 2019, <https://unfccc.int/sites/default/files/resource/clean-growth-strategy-amended-april-2018.pdf>.

HM Government 2015, *The size and performance of the UK low carbon economy*, viewed 28 November 2019, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/416240/bis-15-206-size-and-performance-of-uk-low-carbon-economy.pdf.

HM Government Department for Business, Energy and Industrial Strategy (BEIS) 2018, *Implementing the end of unabated coal by 2025*, viewed 22 January 2020, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/672137/Government_Response_to_unabated_coal_consultation_and_statement_of_policy.pdf.

High Level Panel for a Sustainable Ocean Economy 2019, *Call to ocean-based climate action*, viewed 10 January 2020, <http://live-oceanpanel.pantheonsite.io/sites/default/files/2019-10/HLP%20FINAL%20Call%20to%20Ocean%20Based%20Climate%20Action.pdf>.

REFERENCES

- Hoegh-Guldberg O et al. 2019**, *The ocean as a solution to climate change: Five opportunities for action*, Report, Washington, DC, World Resources Institute, viewed 19 January 2020, http://oceanpanel.org/sites/default/files/2019-10/HLP_Report_Ocean_Solution_Climate_Change_final.pdf.
- Hughes T, Kerry J, Alvarez-Noriega M et al. 2017**, 'Global warming and recurrent mass bleaching of corals', *Nature*, Vol. 543(7645), pp 373–377, viewed 21 January 2020, [doi:10.1038/nature21707](https://doi.org/10.1038/nature21707).
- Hunter Energy Transition Alliance (HETA) 2016**, *Blueprint report*, viewed 22 October 2019, <https://www.energyinnovation.net.au/uploads/files/Final-blueprint.pdf>.
- Hutley N and Hartford Davis S 2019**, *Climate change and directors' duties*, viewed 24 April 2019, <https://cpd.org.au/2019/03/directors-duties-2019/>.
- Indian Ocean Climate Initiative (IOCI) 2011**, *About IOCI*, viewed 7 November 2019, <http://www.ioci.org.au/about-ioci.html>.
- Infrastructure Australia 2019**, *Asset management for critical infrastructure*, viewed 7 November 2019, <https://www.infrastructureaustralia.gov.au/listing/speech/asset-management-critical-infrastructure>.
- Innovation and Science Australia 2017**, *Australia 2030: Prosperity through innovation*, Australian Government, Canberra, viewed 6 November 2019, <https://www.industry.gov.au/sites/g/files/net3906/f/May%202018/document/pdf/australia-2030-prosperity-through-innovation-full-report.pdf>.
- Insurance Journal 2019**, *Climate change and the (Re)insurance implications*, viewed 29 November 2019, <https://www.insurancejournal.com/research/app/uploads/2019/06/a3198871-63e5-4e03-8f83-6cade27d08a8-1.pdf>.
- Intergovernmental Panel on Climate Change (IPCC) 2019a**, *IPCC special report on the ocean and cryosphere. Summary for policymakers*, viewed 29 November 2019, https://report.ipcc.ch/srocc/pdf/SROCC_SPM_Approved.pdf.
- IPCC 2019b**, *Climate change and land*, viewed 19 November 2019, <https://www.ipcc.ch/report/srcl/>.
- IPCC 2018**, *Global warming of 1.5°C*, viewed 7 November 2019, https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf.
- IPCC 2014a**, *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects*, viewed 21 January 2020, https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf.
- IPCC 2014b**, *Climate change 2014: Mitigation of climate change*, viewed 6 November 2019, https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf.
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) 2019**, *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, viewed 5 July 2019, https://www.ipbes.net/sites/default/files/downloads/spm_unedited_advance_for_posting_htn.pdf.
- International Civil Aviation Organisation (ICAO) 2019a**, *What is CORSIA and how does it work?*, viewed 7 November 2019, https://www.icao.int/environmental-protection/Pages/A39_CORSIA_FAQ2.aspx.
- ICAO 2019b**, *Introduction to the ICAO basket of measures to mitigate climate change*, viewed 4 December 2019, https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2019/ENVReport2019_pg111-115.pdf.
- International Council on Clean Transportation (ICCT) 2019**, *Passenger vehicle fuel economy data*, viewed 19 December 2019, https://theicct.org/sites/default/files/Global_PV_figure-data-20190730.xlsx.

International Energy Agency (IEA) 2020, *Global CO₂ emissions 2019*, viewed 28 February 2020, <https://www.iea.org/articles/global-co2-emissions-in-2019>.

IEA 2019a, *Global electric vehicle outlook 2019*, viewed 3 July 2019, <https://webstore.iea.org/global-ev-outlook-2019>.

IEA 2019b, *Fuel economy in major car markets*, viewed 5 July 2019, <https://www.iea.org/topics/transport/gfei/>.

IEA 2019c, *Multiple benefits of energy efficiency—emissions savings*, viewed 8 December 2019, <https://www.iea.org/reports/multiple-benefits-of-energy-efficiency/emissions-savings#abstract>.

IEA 2019d, *World energy investment 2019*, viewed 17 October 2019, <https://webstore.iea.org/world-energy-investment-2019>.

IEA 2017, *Energy efficiency 2017*, viewed 8 May 2019, https://www.iea.org/publications/freepublications/publication/Energy_Efficiency_2017.pdf.

IEA 2014, *Capturing the multiple benefits of energy efficiency*, viewed 8 May 2019, https://www.iea.org/publications/freepublications/publication/Multiple_Benefits_of_Energy_Efficiency.pdf.

IEA 2011, *25 energy efficiency policy recommendations*, viewed 10 May 2019, https://www.iea.org/publications/freepublications/publication/25recom_2011.pdf.

International Institute for Sustainable Development (IISD) 2019, *73 countries commit to net zero CO₂ by 2030*, viewed 28 February 2020, [https://sdg.iisd.org/news/73-countries-commit-to-netzero-co2-emissions-by-2050/](https://sdg.iisd.org/news/73-countries-commit-to-net-zero-co2-emissions-by-2050/).

International Maritime Organisation (IMO) 2018, *UN body adopts climate change strategy for shipping*, viewed 7 November 2019, <http://www.imo.org/en/MediaCentre/PressBriefings/Pages/06GHGinitialstrategy.aspx>.

International Partnership for Blue Carbon n.d., *Our objective*, viewed 10 January 2020, <https://bluecarbonpartnership.org/>.

International Partnership for Energy Efficiency Cooperation (IPEEC) 2019, *Building energy performance gap issues: An international review*, IPEEC Building Energy Efficiency Taskgroup, viewed 29 January 2020, https://ipeec.org/upload/publication_related_language/pdf/1626.pdf.

International Renewable Energy Agency (IRENA) 2019a, *Global energy transformation: A roadmap to 2050 (2019 edition)*, viewed 1 July 2019, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Apr/IRENA_Global_Energy_Transformation_2019.pdf.

IRENA 2019b, *Renewable electricity capacity and generation statistics July 2019*, viewed 4 December 2019, <https://www.irena.org/statistics>.

IRENA 2019c, *Renewable power generation costs in 2018*, viewed 20 January 2020, <https://www.irena.org/publications/2019/May/Renewable-power-generation-costs-in-2018>.

IRENA n.d., *Costs*, viewed 18 July 2019, <https://www.irena.org/costs>.

Investor Group on Climate Change 2017, *Coal, carbon and the community: Investing in a just transition*, viewed 27 November 2019, <https://igcc.org.au/wp-content/uploads/2016/04/Coal-Carbon-and-Community.pdf>.

Jennen B, Parkin B and Wilkes W 2019, *Germany likely to offer utilities less cash to close coal plants—Bloomberg*, viewed 21 January 2020, <https://www.bloomberg.com/news/articles/2019-10-02/germany-likely-to-offer/utilities-less-cash-to-close-coal-plants>.

REFERENCES

- Jones S and Tee C 2017**, *Experiences of structural change*, Australian Treasury, viewed 8 November 2019, <https://treasury.gov.au/publication/p2017-t213722b>.
- Jotzo F, Mazouz S and Wiseman J 2018**, *Coal transition in Australia. Preparing for the looming domestic coal phase-out and falling export demand*, viewed 22 October 2019, https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Idri/Rapport/20180609_ReportCoalAustralia.pdf.
- Kompas T, Witte E and Keegan M 2019**, *Australia's clean energy future: Costs and benefits*, MSSI Issues Paper 12, Melbourne Sustainable Society Institute, The University of Melbourne, viewed 21 January 2020, https://sustainable.unimelb.edu.au/_data/assets/pdf_file/0012/3087786/Australias_Clean_Economy_MSSI_Issues_Paper12.pdf.
- Kompas T, Pham V and Che T 2018**, 'The effects of climate change on GDP by country and the global economic gains from complying with the Paris Climate Accord', *Earth's Future*, Vol. 6, pp 1153–1173, viewed 21 January 2020, <https://doi.org/10.1029/2018EF000922>.
- KPMG 2019**, *Behind the grain*, viewed 24 October 2019, <https://behindaustraliangrain.com.au/wordpress/wp-content/uploads/2019/09/Behind-Australian-Grain-insights-report-2019.pdf>.
- KPMG 2016**, *Mainstreaming the green bond market: Pathways towards common standards*, viewed 4 November 2019, <https://home.kpmg/content/dam/kpmg/lu/pdf/mainstreaming-the-green-bond-market-kpmg-wwf-2016.pdf>.
- Krogstrup S and Oman W 2019**, *Macroeconomic and financial policies for climate change mitigation: A review of the literature*, International Monetary Fund (IMF) Working Paper WP/19/185, viewed 1 October 2019, [file:///pvac01file02/user\\$/A24811/Profile/Downloads/wpiea2019185-print-pdf.pdf](file:///pvac01file02/user$/A24811/Profile/Downloads/wpiea2019185-print-pdf.pdf).
- Kundreuther H, Sgupta, V Bosetti, R Cooke, V Dutt, M Ha-Duong, H Held, J Llanes-Regueiro, A Patt, E Shittu and E Weber 2014**, *2014: Integrated risk and uncertainty assessment of climate change response policies, climate change 2014: Mitigation of climate change contribution of working group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, viewed 5 July 2019, https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter2.pdf.
- Kyoto Protocol 2008**, *Kyoto Protocol to the United Nation Framework Convention on Climate Change*, viewed 23 January 2020, <http://www.austlii.edu.au/au/other/dfat/treaties/2008/2.html>.
- Latrobe Valley Authority (LVA) 2016**, *Working together towards a bright future for the greater Latrobe Valley*, media release, viewed 27 November 2019, <https://lva.vic.gov.au/news/working-together-towards-a-bright-future-for-the-greater-latrobe-valley>.
- LVA n.d.**, *Latrobe Valley Authority*, viewed 27 November 2019, <https://lva.vic.gov.au/>.
- von der Leyen, Ursula 2019**, *Mission letter to Paolo Gentiloni—Commissioner-designate for the Economy (10 September 2019)*, viewed 28 October 2019, https://ec.europa.eu/commission/sites/beta-political/files/mission-letter-paolo-gentiloni_en.pdf.
- Li A, Michaelides M, Rose M and Garg M 2019**, 'Climate-related risk and financial statements: Implications for regulators, preparers, auditors and user', *Australian Accounting Review* Vol. 29, No. 90, issue 3, viewed 18 February 2020, <https://onlinelibrary.wiley.com/doi/full/10.1111/auar.12296>.
- Liberal 2019**, *Ensuring the future of reliable electricity supply for NSW*, viewed 28 January 2020, <https://www.liberal.org.au/latest-news/2019/10/28/ensuring-future-reliable-electricity-supply-nsw>.
- Lindenmayer 2016**, 'The importance of managing and conserving large old trees: A case study from Victorian mountain ash forests', *The Royal Society of Victoria*, Vol. 128, pp 64–70, viewed 21 January 2020, <https://www.publish.csiro.au/rs/pdf/RS16006>.

Liu W, McKibbin W, Morris A and Wilcoxen P 2019, *Global economic and environmental outcomes of the Paris Agreement*, viewed 29 November 2019, <https://www.brookings.edu/research/global-economic-and-environmental-outcomes-of-the-paris-agreement/>.

Low Carbon Living CRC 2017, *Best practice policy and regulation for low carbon outcomes in the built environment*, viewed 8 November 2019,
http://www.lowcarbonlivingcrc.com.au/sites/all/files/publications_file_attachments/best_practice_policy_and_regulation_14_march_2017_crclcl.pdf.

Lu X, McElroy M and Kiviluoma J 2009, ‘Global potential for wind-generated electricity’, *Proceedings of the National Academy of Sciences*, June 2009, viewed 6 December 2019, DOI: 10.1073/pnas.0904101106.

Markulev A and Long A 2013, ‘On sustainability: An economic approach’, Staff Research Note, Productivity Commission, viewed 15 July 2019,
<https://www.pc.gov.au/research/supporting/sustainability/sustainability.pdf>.

Material Economics 2018, *The circular economy: A powerful force for climate mitigation*, viewed 16 July 2019, <https://materialeconomics.com/publications/the-circular-economy-a-powerful-force-for-climate-mitigation-1>.

Mathiesen K 2018, *EU–Japan trade deal first to carry Paris climate clause*, viewed 29 November 2019, <https://www.euractiv.com/section/climate-environment/news/eu-japan-trade-deal-first-to-carry-paris-climate-clause/>.

Matikainen S 2018, *What are stranded assets?*, viewed 27 May 2019,
<http://www.lse.ac.uk/GranthamInstitute/faqs/what-are-stranded-assets/>.

Meat and Livestock Australia (MLA) 2018, *Greenhouse gas mitigation potential of the Australian red meat production and processing sectors*, viewed 7 December 2019,
<https://www.mla.com.au/download/finalreports?itemId=3871>.

MLA 2017, *Red meat industry can be carbon neutral by 2030*, viewed 19 November 2019,
<https://www.mla.com.au/news-and-events/industry-news/archived/2017/red-meat-industry-can-be-carbon-neutral-by-2030/>.

MLA n.d., *Managing climate variability R&D program*, viewed 7 December 2019,
<http://www.climatekelpie.com.au/index.php/mcvproject/>.

Met Office n.d., *Heatwave*, viewed 28 October 2019, <https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/temperature/heatwave>.

McKinsey 2019, *Climate resilience: Asset owners need to get involved now*, viewed 23 January 2020,
<https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/climate-resilience-asset-owners-need-to-get-involved-now>.

Mission Innovation 2019, *Australia*, viewed 7 November 2019, <http://mission-innovation.net/our-members/australia/>.

Morrison S 2020a, *Prime Minister of Australia, National Press Club Address*, 29 January 2020, viewed 18 February 2020, <https://www.pm.gov.au/media/address-national-press-club>.

Morrison S 2020b, *NSW energy deal to reduce power prices and emissions*, media release 31 January 2020, viewed 18 February 2020, <https://www.pm.gov.au/media/nsw-energy-deal-reduce-power-prices-and-emissions>.

REFERENCES

- Morrison S 2020c**, *National royal commission into black summer bushfires established – terms of reference*, viewed 10 March 2020, <https://www.pm.gov.au/media/national-royal-commission-black-summer-bushfires-established>.
- Morrison S 2019**, *\$1 billion boost for power reliability*, media release 30 October 2019, viewed 11 November 2019, <https://www.pm.gov.au/media/1-billion-boost-power-reliability>.
- Mullins G 2019**, *Greg Mullins climate councillor and former NSW Fire and Rescue Commissioner talking to 10's The Project on how climate change is impacting hazard reduction burns*, viewed 27 November 2019, <https://www.climatecouncil.org.au/not-normal-climate-change-bushfire-web/>.
- Munich Re 2019**, *Extreme storms, wildfires and droughts cause heavy nat cat losses in 2018*, viewed 3 July 2019, <https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2019/2019-01-08-extreme-storms-wildfires-and-droughts-cause-heavy-nat-cat-losses-in-2018.html>.
- Murray-Darling Basin Authority (MDBA) 2019**, *Climate change and the Murray-Darling Basin Plan*, viewed 10 January 2020, <https://www.mdba.gov.au/sites/default/files/pubs/Climate-change-discussion-paper-Feb-19.pdf>.
- Narassimhan E, Gallagher K, Koester S and Alejo J 2018**, ‘Carbon pricing in practice: A review of existing emissions trading systems’, *Climate Policy*, Vol. 18(8), pp 967–991, viewed 3 December 2019, <https://www.tandfonline.com/doi/pdf/10.1080/14693062.2018.1467827?needAccess=true>.
- NABERS 2019**, *NABERS: Our five-year strategy 2019–2023*, viewed 7 November 2019, <https://www.nabers.gov.au/publications/strategic-plan>.
- Nathan G et al. 2019**, *HiTeMP outlook 2018: Transforming high temperature minerals processing*, viewed 7 November 2019, <http://www.adelaide.edu.au/hitemp/system/files/media/documents/2019-04/HiTeMP-Outlook-2019.pdf>.
- National Aeronautics and Space Administration (NASA) 2020**, *NASA, NOAA analyses reveal 2019 second warmest year on record*, viewed 18 January 2020, <https://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-2019-second-warmest-year-on-record>.
- NASA 2019**, *Study predicts more long-term sea level rise from Greenland ice*, viewed 1 July 2019, <https://climate.nasa.gov/news/2883/study-predicts-more-long-term-sea-level-rise-from-greenland-ice/>.
- Nationalgrid 2020**, *Britain hits historic clean energy milestone as zero carbon electricity outstrips fossil fuels in 2019*, viewed 18 February 2020, <https://www.nationalgrid.com/britain-hits-historic-clean-energy-milestone-zero-carbon-electricity-outstrips-fossil-fuels-2019>.
- National Climate Change Adaptation Research Facility (NCCARF) 2012**, *Roles and responsibilities for climate change adaptation in Australia*, viewed 17 February 2020, <https://www.nccarf.edu.au/sites/default/files/18-dccee-2012.pdf>.
- NCCARF n.d.**, *Coastadapt*, viewed 6 November 2019, <https://www.nccarf.edu.au/content/coastal-tool-overview>.
- National Climate Science Advisory Committee (NCSAC) 2019**, *Climate science for Australia’s future*, viewed 21 January 2020, <https://www.industry.gov.au/sites/default/files/2019-12/climate-science-for-australias-future-2019.pdf>.
- National Farmers’ Federation (NFF) 2018a**, *2030 Roadmap*, viewed 19 November 2019, <https://farmers.org.au/roadmap/>.

NFF 2018b, *Submission to ERAC method review*, viewed 22 November 2019,
<https://www.environment.gov.au/submissions/emissions-reduction/methods/method-reviews/national-farmers-federation.pdf>.

NFF 2017, *Submission in response to the 2017 Review of climate change policies discussion paper*, viewed 23 January 2020, <https://www.environment.gov.au/submissions/climate-change/review-climate-change-policies-2017/national-farmers-federation.pdf>.

National Transport Commission (NTC) 2019, *Carbon dioxide emissions intensity for new Australian light vehicles*, viewed 19 December 2019,
<https://www.ntc.gov.au/sites/default/files/assets/files/Carbon%20dioxide%20emissions%20intensity%20for%20new%20Australian%20light%20vehicles%202018.pdf>.

NTC 2016, *Who moves what where—freight and passenger transport in Australia*, viewed 8 July 2019,
<https://www.ntc.gov.au/sites/default/files/assets/files/Whomoveswhatwherereport.pdf>.

National Transport Insurance 2016, *NTI's guide to the trucking industry 2016*, viewed 1 November 2019,
<http://www.thewordshop.com.au/wp-content/uploads/2011/06/NTI-eBook-Editing.pdf>.

Network for Greening the Financial System (NGFS) 2019a, *A call for action—climate change as a source of financial risk*, viewed 25 June 2019, https://www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs_first_comprehensive_report - 17042019_0.pdf.

NGFS 2019b, *Central Banks and Supervisors Network for Greening the Financial System*, viewed 1 November 2019, <https://www.mainstreamingclimate.org/ngfs/>.

New South Wales Environment Protection Authority (NSW EPA) 2019, *NSW circular economy policy statement: Too good to waste*, viewed 19 July 2019, <https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/recycling/19p1379-circular-economy-policy-final.pdf?la=en&hash=F80151EA9C2C3E27BA889D15D18041CDF7A4D25A>.

NSW EPA 2018, *\$47 million to support recycling in NSW*, viewed 28 January 2020,
[https://www.epa.nsw.gov.au/news/media-releases/2018/epamedia180320-\\$47-million-to-support-recycling-in-nsw](https://www.epa.nsw.gov.au/news/media-releases/2018/epamedia180320-$47-million-to-support-recycling-in-nsw).

New South Wales Government 2019, *NSW woody vegetation change 2017–18 spreadsheet*, viewed 25 November 2019, <https://www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/reports-and-resources/reports>.

New South Wales Government Department of Planning, Industry and Environment (DPIE) 2019, *NSW Energy Savings Scheme*, viewed 14 May 2019, <https://energy.nsw.gov.au/government-and-regulation/energy-savings-scheme>.

New South Wales Government Department of Trade and Investment (DTI) 2015, *Review of the NSW Energy Savings Scheme—overview*, viewed 14 May 2019,
<http://www.resourcesandenergy.nsw.gov.au/energy-consumers/sustainable-energy/efficiency/scheme?a=558863>.

New Zealand Customs Service 2018, *Advice on private motor vehicle imports*, factsheet, viewed 23 January 2020, <https://www.customs.govt.nz/globalassets/documents/fact-sheets/fact-sheet-29-advice-on-private-motor-vehicle-imports.pdf>.

New Zealand Foreign Affairs and Trade n.d., *Agreement on climate change, trade and sustainability (ACCTS)*, viewed 9 October 2019, <https://www.mfat.govt.nz/en/trade/free-trade-agreements/climate/agreement-on-climate-change-trade-and-sustainability-accts-negotiations/>.

REFERENCES

- New Zealand Government 2019**, *Transitioning to a low-emissions future—the government response to the Productivity Commission’s Low Emissions Economy Project*, viewed 18 October 2019, <https://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/transitioning-to-a-low-emissions-future.pdf>.
- New Zealand Productivity Commission 2018**, *Low-emissions economy*, viewed 17 October 2019, <https://www.productivity.govt.nz/inquiries/lowemissions/>.
- Noon S 2018**, *The power of pig poo*, viewed 19 November 2019, https://www.nswfarmers.org.au/NSWFA/Posts/The_Farmer/Environment/The_power_of_pig_poo.aspx.
- Northern Territory Government 2019**, *Climate change response*, viewed 25 November 2019, <https://haveyoursay.nt.gov.au/49504/documents/116898>.
- Office of the Inspector-General Emergency Management (IGEM) 2018**, *The 2018 Queensland bushfires review report 2: 2018–2019*, viewed 29 November 2019, <https://www.igem.qld.gov.au/reports-and-publications/reports/Documents/IGEM%20Queensland%20Bushfire%20REVIEW%202019.pdf>.
- Organisation for Economic Co-operation and Development (OECD) 2018**, *The macroeconomics of the circular economy transition: A critical review of modelling approaches*, viewed 10 September 2019, https://www.oecd-ilibrary.org/environment/the-macroeconomics-of-the-circular-economy-transition_af983f9a-en.
- OECD 2017**, *Investing in climate, investing in growth*, viewed 19 June 2019, <https://www.oecd-ilibrary.org/docserver/9789264273528-en.pdf?expires=1560919841&id=id&accname=guest&checksum=015FAD1731511C14317AB95F5BA69FC1>
- OECD 2011**, *Promoting technological innovation to address climate change*, viewed 6 November 2019, <http://www.oecd.org/env/cc/49076220.pdf>.
- OECD n.d.**, *OECD.Stat*, viewed 23 January 2020, <https://stats.oecd.org/>.
- Palaszuk A, Dick C and de Brenni M 2019**, *Hydrogen cars to extend Queensland’s renewable energy lead*, viewed 4 December 2019, <http://statements.qld.gov.au/Statement/2019/8/27/hydrogen-cars-to-extend-queenslands-renewable-energy-lead>.
- Paris Agreement 2015**, done at Paris 12 December 2015, (entered into force for Australia 9 December 2016), viewed 7 June 2019, <http://www.austlii.edu.au/au/other/dfat/treaties/ATS/2016/24.pdf>.
- Partnership on Sustainable Low Carbon Mobility (SLoCAT) 2019**, *E-mobility trends and targets*, viewed 7 November 2019, http://www.slocat.net/sites/default/files/e-mobility_overview.pdf.
- Pearson C 2017**, *EV chargers: which one do I use?*, viewed 4 November 2019, https://rac.com.au/carmotoring/info/ev-our-future_ev-charging-cheat-sheet.
- Petkov M 2018**, *A look at banks’ green bond issuance through the lens of our green evaluation tool*, viewed 29 November 2019, <https://www.spglobal.com/en/research-insights/articles/a-look-at-banks-green-bond-issuance-through-the-lens-of-our-green-evaluation-tool>.
- Pezzullo M 2018**, *Michael Pezzullo’s seven gathering storms: National security in the 2020s*, viewed 23 January 2020, <https://www.themandarin.com.au/105494-michael-pezzullos-seven-gathering-storms-national-security-in-the-2020s/>.
- Plugshare n.d.**, viewed 18 February 2020, <https://www.pluginshare.com/>.
- Point Advisory 2018**, *Review of the Energy Efficiency Improvement Scheme*, viewed 14 May 2019, https://www.environment.act.gov.au/_data/assets/pdf_file/0020/1221527/EEIS-Review-Part-1-Executive-Summary-ACCESSIBLE.pdf.

Pooler M 2019, 'Gupta steel empire aims to be carbon neutral by 2030', *Financial Times*, 29 October 2019, viewed 7 November 2019, <https://www.ft.com/content/b87bda52-f9a5-11e9-98fd-4d6c20050229>.

Port of Newcastle 2018, *Port Master Plan 2040*, viewed 26 November 2019, <https://www.portofnewcastle.com.au/wp-content/uploads/2019/10/Port-Master-Plan-2040-for-web.pdf>.

Power S and Delage FPD 2019, 'Setting and smashing extreme temperature records over the coming century', *Nature Climate Change*, volume 9, pp. 529–534, viewed 28 February 2020, <https://www.nature.com/nclimate/>.

Productivity Commission 2017, *Transitioning regional economies*, viewed 23 January 2020, <https://www.pc.gov.au/inquiries/completed/transitioning-regions/report>.

Productivity Commission 2012, *Barriers to effective climate change adaptation*, viewed 6 November 2019, <https://www.pc.gov.au/inquiries/completed/climate-change-adaptation/report/climate-change-adaptation.pdf>.

Productivity Commission 2011, *Carbon emission policies in key economies*, viewed 2 December 2019, <https://www.pc.gov.au/inquiries/completed/carbon-prices/report/carbon-prices.pdf>.

Productivity Commission 2005a, *Trends in Australian agriculture*, viewed 23 January 2020, <https://www.pc.gov.au/research/completed/agriculture>.

Productivity Commission 2005b, *The private cost effectiveness of improving energy efficiency*, viewed 10 May 2019, <https://www.pc.gov.au/inquiries/completed/energy-efficiency/report/energy.pdf>.

Property Council of Australia and GBCA 2019, *Every building counts*, viewed 9 December 2019, <https://www.everybuildingcounts.com.au>.

Queensland Government 2019, *About land restoration fund*, viewed 22 November 2019, <https://www.qld.gov.au/environment/climate-change/land-restoration-fund/about>.

Queensland Government 2018, *Land cover change in Queensland. Statewide landcover and trees study summary report: 2016–17 and 2017–18*, viewed 25 November 2019, https://www.qld.gov.au/_data/assets/pdf_file/0031/91876/landcover-change-in-queensland-2016-17-and-2017-18.pdf.

Queensland Government 2017a, *Pathways to a climate resilient Queensland: Queensland Climate Adaptation Strategy 2017–2030*, viewed 27 November 2019, https://www.qld.gov.au/_data/assets/pdf_file/0017/67301/qld-climate-adaptation-strategy.pdf.

Queensland Government 2017b, *Pathways to a clean growth economy: Queensland Climate Transition Strategy*, viewed 25 November 2019, https://www.qld.gov.au/_data/assets/pdf_file/0026/67283/qld-climate-transition-strategy.pdf.

Queensland Government n.d., *Queensland future climate dashboard*, viewed 7 November 2019, <https://app.longpaddock.qld.gov.au/dashboard/#responseTab1>.

Queensland Government Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP) 2019a, *Hydrogen industry development*, viewed 11 November 2019, <https://www.dsdmip.qld.gov.au/industry/priority-industries/advanced-manufacturing/hydrogen-industry-development.html>.

Queensland Government DSDMIP 2019b, *Queensland resource recovery industries: 10-year roadmap and action plan*, viewed 28 January 2020, <http://www.dsdmip.qld.gov.au/resources/plan/resource-recovery-roadmap.pdf>.

Red Meat Advisory Council 2019, *Red meat 2030*, viewed 7 December 2019, <http://rmac.com.au/misp2030-staging/wp-content/uploads/2019/10/RedMeat2030.pdf>.

REFERENCES

- Reef Credit n.d., Reef credit**, viewed 5 November 2019, <https://www.reefcredit.org/>.
- Regeringskansliet 2015**, *Five EU member states decide to cancel surplus of Kyoto Protocol units*, viewed 27 November 2019, <https://www.regeringen.se/artiklar/2015/12/five-eu-member-states-decide-to-cancel-surplus-of-kyoto-protocol-units/>.
- RepuTex 2015**, *A marginal abatement cost (MAC) curve for Australia to 2020 and 2030*, viewed 9 May 2019, <https://www.slideshare.net/RepuTex/reputex-market-briefing-a-marginal-abatement-cost-curve-briefing-the-lost-yearsaustralian-mac-for-2020-and-2030-0115>.
- Reserve Bank of Australia (RBA) 2019a**, *The Changing Global Market for Australian Coal*, Bulletin – September 2019, viewed 2 March 2020,
- Reserve Bank of Australia (RBA) 2019b**, *Financial stability review*, viewed 18 October 2019, <https://www.rba.gov.au/publications/fsr/2019/oct/box-c-financial-stability-risks-from-climate-change.html>.
- RBA 2019c**, *Can structural change account for the low level of non-mining investment?*, viewed 7 November 2019, <https://www.rba.gov.au/publications/bulletin/2019/jun/can-structural-change-account-for-the-low-level-of-non-mining-investment.html>.
- RBA 2010**, *Structural change in the Australian economy*, viewed 8 December 2019, <https://www.rba.gov.au/publications/bulletin/2010/sep/1.html>.
- Rickards and Howden 2012**, ‘Transformational adaptation: Agriculture and climate change’, *Crop and Pasture Science*, Vol. 63(3), pp 240–250, viewed 23 January 2020, <https://doi.org/10.1071/CP11172>.
- Roberts D 2019**, *New York just passed the most ambitious climate target in the country*, viewed 21 October 2019, <https://www.vox.com/energy-and-environment/2019/6/20/18691058/new-york-green-new-deal-climate-change-cuomo>.
- Rudebusch G 2019**, *Climate change and the Federal Reserve*, viewed 2 July 2019, https://www.frbsf.org/economic-research/publications/economic-letter/2019/march/climate-change-and-federal-reserve/?utm_source=frbsf-home-economic-letter-title&utm_medium=frbsf&utm_campaign=economic-letter.
- Rural Industries Research and Development Corporation (RIRDC) 2015**, *Rural industry futures: Megatrends impacting Australian agriculture over the coming twenty years*, viewed 23 January 2020, <https://www.agrifutures.com.au/product/rural-industry-futures-megatrends-impacting-australian-agriculture-over-the-coming-twenty-years/>.
- Salim H et al. 2019**, ‘There’s a looming waste crisis from Australia’s solar energy boom’, *The Conversation*, 2 August 2019, viewed 18 February 2020, <https://www.pri.org/stories/2019-08-02/theres-looming-waste-crisis-australias-solar-energy-boom>.
- Saman W, Boland J, Pullen S, de Dear R, Soebarto V, Miller W, Pocock B, Belusko M, Bruno F, Whaley D, Pockett J, Bennetts H, Ridley B, Palmer J, Zuo J, Ma T, Chileshe N, Skinner N, Chapman J, Vujinovic N, Walsh M, Candido C and Deuble M 2013**, *A framework for adaptation of Australian households to heat waves*, viewed 23 January 2020, https://www.nccarf.edu.au/sites/default/files/attached_files_publications/Saman_2013_Adapting_households_to_heat_waves.pdf.
- Santos 2020**, *Santos and BHP enter into non-binding agreement on Moomba carbon capture and storage projects*, viewed 5 March 2020, <https://www.santos.com/news/santos-and-bp-enter-non-binding-agreement-on-moomba-carbon-capture-and-storage-project/>
- Schmidt B 2019**, *Electric vehicles are already cheaper than petrol cars for fleet owners*, viewed 23 October 2019, <https://thedriven.io/2019/08/26/electric-vehicles-are-already-cheaper-than-petrol-cars-for-fleet-owners/>.

Schott K 2019, ‘Costly efforts to keep coal plants going are ill advised’, *Australian Financial Review*, 8 October 2019, viewed 18 February 2020, <https://www.afr.com/policy/energy-and-climate/costly-efforts-to-keep-coal-plants-going-are-ill-advised-20191008-p52ykl>.

Schott K, Savage C, Conboy P, Pierce J and Zibelman A 2018, *Energy Security Board—final detailed design of the National Energy Guarantee*, viewed 23 January 2020, <http://coagenergycouncil.gov.au/publications/energy-security-board-%E2%80%93-final-detailed-design-national-energy-guarantee>.

Schuppert F 2011, ‘Climate change mitigation and intergenerational justice’, *Environmental Politics*, Vol. 20(3), pp 303–321, viewed 23 January 2020, <https://doi.org/10.1080/09644016.2011.573351>.

Science Based Targets n.d., *Companies taking action*, viewed 26 June 2019, <https://sciencebasedtargets.org/companies-taking-action/>.

Scott H 2019, *Monitoring and evaluation of climate change adaptation by local government: The state of play in Australia*, viewed 17 February 2020, file:///prod.protected.ind/user/user09/ny8802/Downloads/Scott_2018_MonitoringandEvaluationofClimateChangeAdaption_NCCARF2018.pdf.

Sekeris P 2015, *How to encourage collective action on climate change*, World Economic Forum, 18 June, viewed 3 July 2019, <https://www.weforum.org/agenda/2015/06/how-to-encourage-collective-action-on-climate-change/>.

Senecal P and Leach F 2019, ‘Diversity in transportation: Why a mix of propulsion technologies is the way forward for the future fleet’, *Results in Engineering*, Vol. 4, December, viewed 5 December 2019, <https://www.sciencedirect.com/science/article/pii/S259012301930060X>.

Smit R 2019, ‘Real-world CO2 emissions performance of the Australian new passenger vehicle fleet 2008–2018—impacts of trends in vehicle/engine design’, *Transport Energy Research*, viewed 3 December 2019, https://docs.wixstatic.com/ugd/d0bd25_9527cdcb01a84440a53308b3b5624320.pdf.

Smith et al. 2016, ‘Biophysical and economic limits to negative CO2 emissions’, *Nature Climate Change*, Vol. 6, pp 42–50, viewed 23 January 2020, <https://doi.org/10.1038/nclimate2870>.

South Australian Government Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) 2013, *Review report of the Residential Energy Efficiency Scheme*, viewed 14 May 2019, http://www.energymining.sa.gov.au/_data/assets/pdf_file/0014/315500/REES-review-report.pdf.pdf.

South Eastern Australian Climate Initiative (SEACI) 2012, *The South Eastern Australian Climate Initiative*, viewed 7 November 2019, <http://www.seaci.org/>.

South West Development Commission (SWDC) 2019, *Collie futures: Collie investment prospectus*, viewed 26 November 2019, [http://www.swdc.wa.gov.au/media/367322/collie%20investment%20prospectus%20\(june%202019\).pdf](http://www.swdc.wa.gov.au/media/367322/collie%20investment%20prospectus%20(june%202019).pdf).

SWDC n.d., *Collie Futures Fund*, viewed 26 November 2019, <http://www.swdc.wa.gov.au/funding/collie-futures-fund.aspx>.

Stafford Smith M and Ash A 2011, ‘Adaptation: Reducing risk, gaining opportunity’, *Climate change—science and solutions for Australia*, CSIRO, viewed 6 November 2019, <http://www.publish.csiro.au/ebook/download/pdf/6558>.

Steffen W, Mallon K, Kompass T, Dean A and Rice M 2019, *Compound costs: How climate change is damaging Australia’s economy*, viewed 23 January 2020, <https://www.climatecouncil.org.au/wp-content/uploads/2019/05/costs-of-climate-change-report-v3.pdf>.

REFERENCES

- Stern N 2018**, 'Core principles and foundations for building a long-term country strategy for tackling climate change', *Long-term climate strategies: Climate action with tomorrow in mind. Expert perspectives on long-term climate and development strategies*, Vol. 1, viewed 18 June 2019, https://wriorg.s3.amazonaws.com/s3fs-public/Expert-Perspective-book.pdf?_ga=2.210180949.1738924517.1560905675-1363756041.1560905675.
- Stern N 2006**, 'Accelerating technological innovation', *Stern review: The economics of climate change*, viewed 6 November 2019, https://webarchive.nationalarchives.gov.uk/20100407172811/http://www.hm-treasury.gov.uk/d/Chapter_16_Accelerating_Technological_Innovation.pdf.
- Summerhayes G 2019**, *Financial exposure: The role of disclosure in addressing the climate data deficit*, viewed 24 April 2019, <https://www.cisl.cam.ac.uk/news/news-pdfs-or-prs/financial-exposure-geoff-summerhayes.pdf>.
- SunCable 2019**, *Project overview*, viewed 26 November 2019, <https://www.suncable.sg/>.
- Sustainability Victoria 2015**, *Victorian Organics Resource Recovery Strategy*, viewed 31 October 2019, <https://www.sustainability.vic.gov.au/About-us/What-we-do/Strategy-and-planning/Victorian-organics-resource-recovery-strategy>.
- Sustainable Built Environment National Research Centre (SBEEnrc) 2019**, *Closing the gap between design and reality of building energy performance, final industry report, SBEEnrc ARC Hub Project*, viewed 29 January 2020, https://sbenrc.com.au/app/uploads/2019/12/P1.43H_IndustryReport-WEB.pdf.
- Taskforce on Climate-related Financial Disclosure (TCFD) 2019**, *2019 status report*, viewed 21 January 2020, <https://www.fsb-tcfd.org/wp-content/uploads/2019/06/2019-TCFD-Status-Report-FINAL-053119.pdf>.
- TCFD 2017**, *Recommendations of the Task Force on Climate-related Financial Disclosures: final report*, viewed 1 May 2019, <https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-2017-TCFD-Report-11052018.pdf>.
- TCFD n.d.**, *About the Task Force*, viewed 25 June 2019, <https://www.fsb-tcfd.org/about/>.
- Tasmanian Government Department of State Growth (DSG) 2019**, *Tasmanian hydrogen action plan*, viewed 7 December 2019, https://www.stategrowth.tas.gov.au/_data/assets/pdf_file/0003/207705/Draft_Tasmanian_Hydrogen_Action_Plan - November 2019.pdf.
- Taylor 2020**, *Future direction in energy technologies*, Keynote address at CEDA, 28 February 2020, viewed 3 March 2020, <https://www.minister.industry.gov.au/ministers/taylor/speeches/keynote-address-ceda-future-direction-energy-technologies-event-sydney>.
- Taylor A 2019a**, *National statement COP25, Madrid: Transcript 10 December 2019*, viewed 9 January 2020, <https://minister.environment.gov.au/taylor/news/2019/national-statement-cop25-madrid>.
- Taylor A 2019b**, *Keynote address at the UBS Annual Australasian Conference Sydney: Transcript 18 November 2019*, viewed 13 January 2020, <https://minister.environment.gov.au/taylor/news/2019/keynote-address-ubs-annual-australasian-conference-sydney>.
- Taylor K, Stouffer R and Meehl G 2012**, 'An overview of CMIP5 and the experiment design', *Bulletin of the American Meteorological Society*, Vol. 93, pp 485–498, viewed 20 December 2019, <https://journals.ametsoc.org/doi/10.1175/BAMS-D-11-00094.1?mobileUi=0>.
- Tenancy Services 2019**, *Current insulation regulations*, viewed 21 January 2020, <https://www.tenancy.govt.nz/maintenance-and-inspections/insulation/compulsory-insulation/>.

The Aotearoa Circle 2019, Sustainable Finance Forum interim report, viewed 23 January 2020,
https://static1.squarespace.com/static/5bb6cb19c2ff61422a0d7b17/t/5db95acd1b54db1101b158b7/1572428509136/1013241_Sustainable+Finance+Report_FINAL.pdf.

Thwaites J 2019, Multilateral Development Bank climate finance in 2018: The good, the bad and the urgent, viewed 26 June 2019, <https://www.wri.org/blog/2019/06/multilateral-development-bank-climate-finance-2018-good-bad-and-urgent>.

Tigue K 2019, Climate change becomes an issue for rating agencies, viewed 20 October 2019,
<https://insideclimateneWS.org/news/04082019/climate-change-ratings-agencies-financial-risk-cities-companies>.

Transport and Infrastructure Council 2019, National policy framework for land transport technology: Action plan 2020–2023, viewed 24 January 2020,
https://www.transportinfrastructurecouncil.gov.au/sites/default/files/documents/National_Policy_Framework_Land_Transport_Technology_and_Action_Plan_2020-2023.pdf.

The Treasury 2004, The impact of the 2002 drought on the economy and agricultural employment, viewed 1 July 2019, <https://treasury.gov.au/publication/economic-roundup-autumn-2004/the-impact-of-the-2002-drought-on-the-economy-and-agricultural-employment>.

Treasury Laws Amendment (Prohibiting Energy Market Misconduct) Bill 2018 (Cth)

Trenberth 2011, ‘Changes in precipitation with climate change’, *Climate Research*, Vol. 47(1–2), pp 123–138, viewed 3 December 2019, https://www.int-res.com/articles/cr_oa/c047p123.pdf.

Turnbull M, Cash M and Frydenburg J 2018, Local jobs and a new energy industry for the Latrobe Valley, media release, 12 April 2018, viewed 7 November 2019,
<https://www.minister.industry.gov.au/ministers/cash/media-releases/local-jobs-and-new-energy-industry-latrobe-valley>.

UN DESA n.d., World population prospects 2017, viewed 23 January 2020, <https://population.un.org/wpp/>.

United Nations Economic Commission for Europe (UNECE) 2016, The co-benefits of climate change mitigation: Sustainable development brief No. 2, viewed 29 November 2019,
http://www.unece.org/fileadmin/DAM/Sustainable_Development_No._2_Final_Draft_OK_2.pdf.

United Nations Environment Programme (UNEP) 2019a, Emissions gap report 2019, viewed 22 January 2020, <https://www.unenvironment.org/resources/emissions-gap-report-2019>.

UNEP 2019b, Sustainable finance progress report, viewed 21 October 2019, http://unepinquiry.org/wp-content/uploads/2019/03/Sustainable_Finance_Progress_Report_2018.pdf.

UNEP 2018, The emissions gap report 2018, viewed 20 June 2019,
http://wedocs.unep.org/bitstream/handle/20.500.11822/26895/EGR2018_FullReport_EN.pdf?sequence=1&isAllowed=y.

UNEP Finance Initiative 2019, Changing course, a comprehensive investor guide to scenario-based methods for climate risk assessment, in response to the TCFD, viewed 15 October 2019,
<https://www.unepfi.org/wordpress/wp-content/uploads/2019/05/TCFD-Changing-Course-Oct-19.pdf>.

UNEP and United Nations Framework Convention on Climate Change (UNFCCC) 2001, Climate change information kit, viewed 3 December 2019, <https://unfccc.int/resource/iuckit/cckit2001en.pdf>.

UNFCCC 2016a, Decisions adopted by the Conference of the Parties 1/CP.21, viewed 23 January 2020,
<https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf>.

REFERENCES

- UNFCCC 2016b**, *Aggregate effect of the intended nationally determined contributions: An update*, viewed 24 June 2019, <https://unfccc.int/sites/default/files/resource/docs/2016/cop22/eng/02.pdf>.
- UNFCCC 2011**, *Issues relating to the transformation of pledges for emission reductions into quantified emission limitation and reduction objectives: Methodology and examples, Revised technical paper FCCC/TP/2010/3/Rev.1*, viewed 18 January 2020, <https://unfccc.int/resource/docs/2010/tp/03r01.pdf>.
- UNFCCC 1992**, done at New York 9 May 1992 (entered into force for Australia 21 March 1994), viewed 7 June 2019, [http://www.austlii.edu.au/other/dfat/treaties/1994/2.html](http://www.austlii.edu.au/au/other/dfat/treaties/1994/2.html).
- UNFCCC n.d.a**, *List of parties*, UNFCCC, Bonn, viewed 7 June 2019, <https://unfccc.int/process/parties-non-party-stakeholders/parties-convention-and-observer-states?>.
- UNFCCC n.d.b**, *Communication of long-term strategies*, viewed 19 June 2019, <https://unfccc.int/process/the-paris-agreement/long-term-strategies>.
- UNFCCC n.d.c**, *Total actions*, viewed 20 June 2019, <https://climateaction.unfccc.int/views/total-actions.html>.
- UNFCCC n.d.d**, *Nationally determined contributions (NDCs)*, viewed 6 December 2019, <https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs>.
- UNFCCC and the United Nations Development Programme (UNDP) 2019**, *Taking stock of global climate ambition*, viewed 9 October 2019, <https://unfccc.int/sites/default/files/resource/NDC%20Outlook.pdf>.
- United States 2016**, *United States mid-century strategy for deep decarbonisation*, viewed 19 June 2019, https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report_final_red.pdf.
- United States Climate Alliance 2018**, *2018 annual report*, viewed 25 June 2019, https://www.usclimatealliance.org/s/USCA_2018-Annual-Report_20180911-FINAL.pdf.
- United States Climate Alliance n.d.**, *About us*, viewed 20 June 2019, <https://www.usclimatealliance.org/alliance-principles>.
- University of Cambridge Institute for Sustainability Leadership (University of Cambridge) 2018**, *Sailing from different harbours*, viewed 28 November 2019, <https://www.cisl.cam.ac.uk/resources/publication-pdfs/cisl-tcfcd-report-2018.pdf>.
- Vener J et al. 2019**, ‘Scaling up ambition: Leveraging nationally determined contributions and long-term strategies to achieve the Paris Agreement goals’, Working paper, World Resources Institute, viewed 19 June 2019, <https://wriorg.s3.amazonaws.com/s3fs-public/scaling-up-ambition.pdf>.
- VicForests n.d.**, *VicForests*, viewed 19 November 2019, <http://www.vicforests.com.au/>.
- Victorian Auditor General 2015**, *Realising the benefits of smart meters*, viewed 13 May 2019, <https://www.audit.vic.gov.au/sites/default/files/20150916-Smart-Meters.pdf>.
- Victorian Government 2020**, *Victoria acts to secure a more reliable energy system*, media release 18 February 2020, viewed 20 February 2020, <https://www.premier.vic.gov.au/victoria-acts-to-secure-a-more-reliable-energy-system/>.
- Victorian Government 2019a**, *Victoria's renewable energy targets*, viewed 6 December 2019, <https://www.energy.vic.gov.au/renewable-energy/victorias-renewable-energy-targets>.
- Victorian Government 2019b**, *Strengthening Victoria's recycling industry*, media release, 2 June 2019, viewed 28 January 2020, <https://www.premier.vic.gov.au/strengthening-victorias-recycling-industry/>.

Victorian Government 2017, *Victoria's Climate Change Adaptation Plan 2017–2020*, viewed 27 November 2019, https://www.climatechange.vic.gov.au/_data/assets/pdf_file/0024/60729/Victorias-Climate-Change-Adaptation-Plan-2017-2020.pdf.

Victorian Government Department of Environment, Land, Water and Planning (DELWP) 2019a, *A circular economy for Victoria*, viewed 15 July 2019, https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.vic-engage.files/5115/6324/2021/A_circular_economy_for_Victoria_Issues_Paper_July2019.pdf.

Victorian Government DELWP 2019b, *Victorian Hydrogen Investment Program*, viewed 11 November 2019, <https://www.energy.vic.gov.au/renewable-energy/victorian-hydrogen-investment-program>.

Victorian Government DELWP 2017, *Turning waste into energy*, viewed 20 September 2019, https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.vic-engage.files/9415/0897/9363/Turning_waste_into_energy - Final.pdf.

Victorian Government DEWLP 2016, *Victoria's climate change framework*, viewed 25 November 2019, https://www.climatechange.vic.gov.au/_data/assets/pdf_file/0021/55254/DELWPClimateChange_Framework.pdf.

Victorian Government DELWP n.d., *Working with local government*, viewed 26 June 2019, <https://www.climatechange.vic.gov.au/local-government/working-with-local-government>.

Victorian Government Department of Transport 2019, *Port rail shuttle*, viewed 1 November 2019, <https://transport.vic.gov.au/our-transport-future/our-projects/port-rail-shuttle>.

Wagner G and Weitzman M 2015, *Climate shock: The economic consequences of a hotter planet*, Princeton University Press, 2015.

Western Local Land Services 2018, *Submission to ERAC method review*, viewed 10 December 2019, <http://www.environment.gov.au/submissions/emissions-reduction/method-reviews/western-lls.pdf>.

Williams J 2017, *How environmental and climate risks and opportunities factor into global corporate ratings—an update*, viewed 21 October 2019, <https://www.spglobal.com/en/research-insights/articles/environmental-and-climate-risks-factor-into-ratings#>.

Wood T, Dundas G and Percival L 2019, *Keep calm and carry on—managing electricity reliability*, Grattan Institute, viewed 20 February 2020, <https://grattan.edu.au/wp-content/uploads/2019/02/914-Keep-calm-and-carry-on.pdf>.

World Bank 2019, *States and trends of carbon pricing 2019*, viewed 14 January 2020, <https://openknowledge.worldbank.org/handle/10986/31755>.

World Bank 2018a, *Groundswell: Preparing for internal climate migration*, viewed 23 January 2020, <https://www.worldbank.org/en/news/infographic/2018/03/19/groundswell---preparing-for-internal-climate-migration>.

World Bank 2018b, *State and trends of carbon pricing 2018*, viewed 24 October 2019, <https://openknowledge.worldbank.org/bitstream/handle/10986/29687/9781464812927.pdf?sequence=5&isAllowed=y>.

World Bank 2016, *States and trends of carbon pricing*, viewed 14 January 2020, <https://openknowledge.worldbank.org/bitstream/handle/10986/25160/9781464810015.pdf?sequence=7&isAllowed=y>.

World Bank n.d., *DataBank World Development Indicator*, viewed 25 January 2020, <https://databank.worldbank.org/reports.aspx?source=2&series=SP.POP.TOTL,SP.POP.0014.TO.ZS,SP.PO>

REFERENCES

P.1564.TO.ZS,SP.POP.65UP.TO.ZS,SP.POP.DPND.YG,SP.POP.DPND.OL,SP.DYN.CDRT.IN,SP.DYN.CB
RT.IN#.

World Meteorological Organization (WMO), UNEP, Global Carbon Project, IPCC, Future Earth, Earth League and Global Framework for Climate Services 2019, United in science, viewed 24 October 2019,
https://ane4bf-datap1.s3-eu-west-1.amazonaws.com/wmocms/s3fs-public/ckeditor/files/United_in_Science_ReportFINAL_0.pdf?XqiG0yszsU_sx2vOehOWpCOKm9RdC_gN.

YourHome 2013, Energy, viewed 8 December 2019, <https://www.yourhome.gov.au/energy>.