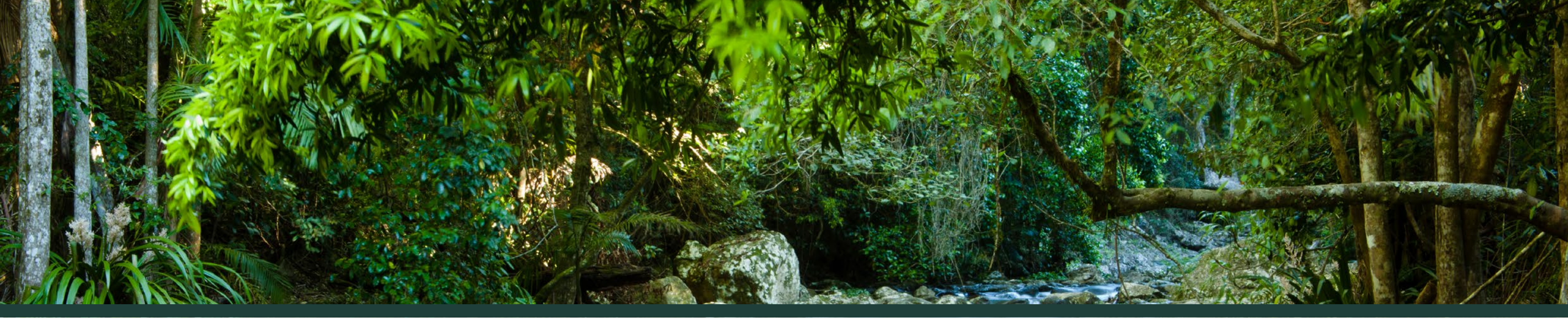
Australia's 8th National Communication on Climate Change

A report under the United Nations Framework Convention on Climate Change

December 2022



Minister’s foreword

In presenting the eighth National Communication on Climate Change for Australia, I would like to acknowledge Australia’s First Nations people, and celebrate their elders past, present and emerging. Traditional Owners have loved, cared for and listened to Country for thousands of generations. I would like to thank them for their continuing custodianship of the lands, waters and communities that we live and work within.

Since Australia submitted its seventh National Communication on Climate Change to the United Nations Framework Convention on Climate Change (UNFCCC) in 2019, a change of government has seen our climate change ambition significantly increase.

As a result, in May, Australia submitted an updated Nationally Determined Contribution with increased emission reduction targets of 2030 to 43 per cent below 2005 levels, a 15 per cent increase on its previous 2030 target, and net zero by 2050. Following the passage of the Climate Change Act 2022, these targets are now enshrined in legislation.

In support of these goals, the Australian Government is committed to implementing a substantial and rigorous suite of new policies across the economy to become a renewable energy superpower and achieve net zero by 2050. The policies under the Powering Australia plan are designed to maximise economic benefits, regional job opportunities, emissions reduction and provide industry with investment certainty. With an abundance of natural resources integral to the transition to clean energy worldwide, the Government is committed to being a trusted partner in the global transition.

Australia is also stepping up its international engagement. At COP27, we took a leadership position in negotiations on climate finance, and loss and damage. Australia has also signed up to new international pledges including the Global Methane Pledge, the Mangrove Alliance for Climate, Net Zero Government Initiative, and the Forests and Climate Leaders Partnership, amongst others.

We have also announced that we are working with our Pacific family in bidding for COP31. In hosting, Australia and Pacific countries would highlight the impact of climate change in the region, accelerate global action and harness the economic opportunities of the transition.

The Australian Government is also increasing its ambition on adaptation. Building on existing strategies including the National Climate Resilience and Adaptation Strategy 2021-25, the Australian Government has committed a further $948.3 million to adaptation and resilience initiatives in its 2022-23 budget. This includes establishing the Disaster Ready Fund, which will provide $200 million every year for disaster preparation and resilience projects.

Australia is committed to doing its part to meet the UNFCCC's climate finance goals to increase climate change resilience, mitigation and adaptation. Australia has been providing climate finance for more than 25 years. In October 2022, the Australian Government increased the official development assistance budget by $1.4 billion over the next four years (FY 2022-26). This will support new spending on climate action. Australia will also continue to support UNFCCC climate finance work, including through representation on the Standing Committee on Finance.

Australia is proud to present its eighth National Communication on Climate Change, which summarises the progress we have made as a nation to meet our obligations under the UNFCCC. Our country is rich in renewable energy and mineral resources, and as the world decarbonises, there is great potential for growth in Australian industries and jobs. We will continue to refine our policy responses and review our progress towards targets, in accordance with Australia's commitments under the UNFCCC and Paris Agreement.

The Hon Chris Bowen MP
Minister for Climate Change and Energy

Contents

Abbreviations and acronyms

AAD	Australian Antarctic Division
AAPP	Australian Antarctic Program Partnership
AASP	Australian Antarctic Science Program
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ACCESS	Australian Community Climate and Earth System Simulator
ACCU	Australian Carbon Credit Unit
ACEAS	Australian Centre for Excellence in Antarctic Science
ACT	Australian Capital Territory
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AGEIS	Australian Greenhouse Emissions Information System
AIDR	Australian Institute of Disaster Resilience
AIMS	Australian Institute of Marine Science
ANAO	Australian National Audit Office
ANREU	Australian National Registry of Emissions Units
APS	Australian Public Service
ARC	Australian Research Council
ARENA	Australian Renewable Energy Agency
ASEAN	Association of Southeast Asian Nations
BITRE	Bureau of Infrastructure and Transport Research Economics
Bureau	Bureau of Meteorology
CCA	Climate Change Authority
CCF	Climate Change Fund
CCUS	Carbon Capture, Utilisation and Storage
CEFC	Clean Energy Finance Corporation
CEIF	Clean Energy Innovation Fund
CEMP	Coastal Estuarine Mitigation Program
CER	Clean Energy Regulator
CESC	Clean Energy Solutions Centre
CH_4	methane
CHAS	Coastal Hazard Adaptation Strategies
CHRMAP	Coastal Hazard Risk Management and Adaptation Plans

CLEX	ARC Centre of Excellence for Climate Extremes
CMIP	Coupled Model Intercomparison Project
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
COAG	Council of Australian Governments
Convention	United Nations Framework Convention on Climate Change
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTI	Clean Technology Innovation
DAC	Development Assistance Committee
DCAP	Drought and Climate Adaptation Program
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DKIS	Darwin–Katherine Interconnected System
EAP	Emissions Avoidance Partnership
ECA	Energy Consumers Australia
EMM	Energy Ministers' Meeting
ENCRC	Energy National Cabinet Reform Committee
ENSO	El Niño–Southern Oscillation
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ERAC	Emissions Reduction Assurance Committee
ERF	Emissions Reduction Fund
EV	electric vehicle
FFDI	Forest Fire Danger Index
FullCAM	Full Carbon Accounting Model
GCM	general circulation model
GCOS	Global Climate Observing System
GDP	gross domestic product
GEF	Global Environment Facility
GEMS	Greenhouse and Energy Minimum Standards
GSP	gross state product
GVA	gross value-added
GW	gigawatt
GWh	gigawatt-hour
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
ICAO	International Civil Aviation Organization
ICIN	Indigenous Carbon Industry Network

IDA	International Development Association
IGCC	Investor Group on Climate Change
IMO	International Maritime Organization
IMOS	Integrated Marine Observing System
IOD	Indian Ocean Dipole
IPA	Indigenous Protected Areas
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
IRP	Indigenous Ranger Program
JPRM	Joint Policy Reform Matrix
kg	kilogram
km	kilometre
kt	kiloton
kWh	kilowatt-hour
lidar	light detection and ranging
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LRF	Land Restoration Fund
LTAG	long-term aspirational goal
LULUCF	land use, land-use change and forestry
MERiL	Methane Emissions Reductions in Livestock
ML	megalitre
Mt	megatonne (10^6 tonne)
MW	megawatt
MWh	megawatt-hour
N_2O	nitrogen dioxide
NABERS	National Australian Built Environment Rating System
NARCliM	NSW and Australian Regional Climate Modelling
NatHERS	Nationwide House Energy Rating Scheme
NCC	National Construction Code
NCI	National Computational Infrastructure
NCRIS	National Collaborative Research Infrastructure Strategy
NDC	Nationally Determined Contribution
NDRR	National Disaster Risk Reduction
NEM	National Electricity Market
NESP	National Environmental Science Program
NF_3	nitrogen trifluoride

NGER	National Greenhouse and Energy Reporting
NGHGI	National Greenhouse Gas Inventory
NHRA	Natural Hazards Research Australia
NIR	National Inventory Report
NPA	National Partnership Agreement
NPCP	National Partnership for Climate Projections
NRF	National Reconstruction Fund
NSW	New South Wales
NT	Northern Territory
NWIS	North West Interconnected System
OCE	Office of the Chief Economist
ODA	official development assistance
OECD	Organisation for Economic Co-operation and Development
PFC	perfluorochemical
PHN	Primary Health Network
PJ	petajoule (10^{15} joules)
PNG	Papua New Guinea
PV	photovoltaic
QCRC	Queensland Climate Resilient Councils
RCM	regional climate model
REZ	Renewable Energy Zone
RIS	Regulatory Impact Statement
SA	South Australia
SAEF	Securing Antarctica's Environmental Future
SAM	Southern Annular Mode
SEED	Sharing and Enabling Environmental Data
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
SWIS	South West Interconnected System
TERN	Terrestrial Ecosystem Research Network
UNFCCC	United Nations Framework Convention on Climate Change
WA	Western Australia
WELS	Water Efficiency Labelling and Standards
WEM	Wholesale Electricity Market
WMO	World Meteorological Organization
ZEV	zero emissions vehicles

Glossary

Abatement	Emissions reductions as a result of an action – for example, the adoption of a policy or measure.
Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm, or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.
Adaptive capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.
Australian Carbon Credit Units	Units issued by the Clean Energy Regulator representing 1 tonne of carbon dioxide equivalent (tCO_2-e) stored or avoided by projects under Australia's carbon crediting scheme.
Australian Community Climate and Earth System Simulator (ACCESS)	A weather and climate modelling system that provides short-term and seasonal forecasts and climate projections. Developed in Australia by the Bureau of Meteorology, CSIRO and universities, it builds on other forecast models, including the United Kingdom Met Office Unified Model.
Black Summer bushfires	A severe bushfire event over the 2019–20 Australian summer, with fires burning simultaneously across multiple Australian states and territories. The Black Summer bushfires burned more than 24 million hectares, destroyed more than 3,000 buildings and killed 33 people.
Broadacre cropping	Used in Australia to describe farms or industries engaged in the production of grains, oilseeds and other crops (especially wheat, barley, peas, sorghum, maize, hemp, safflower and sunflower) on a large scale.
Carbon capture and storage	A process in which a relatively pure stream of carbon dioxide (CO_2) from industrial and energy-related sources is separated (captured), conditioned, compressed and transported to a storage location for long-term isolation from the atmosphere.
Carbon Capture Utilisation and Storage (CCUS)	CCUS involves the capture of CO_2 from large point sources, such as power generation or industrial facilities that use either fossil fuels or biomass as fuel. The CO_2 can also be captured directly from the atmosphere. If not being used on-site, the captured CO_2 is compressed and transported by pipeline, ship, rail or truck to be used in a range of applications, or injected into deep geological formations (including depleted oil and gas reservoirs or saline aquifers), which can trap the CO_2 for permanent storage.
Carbon dioxide equivalent (CO_2-e)	A standard measure to take account of the different global warming potentials of different greenhouse gases and express the cumulative effect using a common unit.
Carbon neutral	Reducing emissions where possible and then investing in carbon offset projects to achieve zero overall emissions.
Carbon sink	Natural or manufactured systems that absorb and store CO_2 from the atmosphere, including trees, plants and the oceans.
Centennial Observing Station	Weather stations recognised by the World Meteorological Organization as providing a high-quality, 100-year record of at least one climate variable.

Clean Energy Regulator	The independent statutory authority responsible for administering schemes legislated by the Australian Government for measuring, managing, reducing or offsetting Australia's carbon emissions. This includes Australia's carbon crediting scheme, National Greenhouse and Energy Reporting System, Australian National Registry of Emissions Units, Safeguard Mechanism and Renewable Energy Target.
Climate Change Act 2022	Australian Government legislation that provides a framework for Australia's national climate ambition and incorporates Australia's nationally determined contributions into Australian law.
Climate Change Authority	An independent statutory agency established by the *Climate Change Authority Act 2011*. The Climate Change Authority provides independent expert advice to the Australian Government on climate change policy.
Climate change risks	The physical risks from the changing climate and the transition risks associated with developments that may (or may not) occur in the process of adjusting towards a lower-carbon economy.
Climate finance	Climate finance refers to local, national or transnational financing—drawn from public, private and alternative sources of financing—that seeks to support mitigation and adaptation actions that will address climate change.
Climate models	A numerical representation of the climate system based on the physical, chemical and biological properties of its components, and their interactions and feedback processes, accounting for all or some of its known properties.
COAG (Council of Australian Governments)	Formerly the peak intergovernmental decision-making forum in Australia, including the Prime Minister, state and territory governments' First Ministers, and the President of the Australian Local Government Association.
Country	The Indigenous concept of everything within a cultural landscape, including the land or sea itself; the plants and animals within it; the history, culture and traditions associated with it; and the connections between people and the landscape. Country is a distinct geographic, cultural and ecological space that is common to a specific Indigenous people, group of peoples or local community, and to which they are connected. Country contains complex ideas about law, place, custom, language, spiritual belief, cultural practice, material sustenance, family and identity.
Demand management	The modification of consumer demand for energy through various methods such as load reduction, load shifting and use of onsite generation, particularly during extreme peak electricity demand or emergencies.
Downscaling	The process by which coarser-resolution global climate model outputs are translated into finer-resolution climate information to better account for regional climatic influences, such as local topography.
El Niño and La Niña	Climate patterns affecting Australia's weather. El Niño refers to the extensive warming of the surface of the central and eastern tropical Pacific Ocean, which leads to a major shift in weather patterns across the Pacific. El Niño conditions are associated with drier conditions in eastern Australia. The La Niña phase is characterised by cooler-than-average sea surface temperatures in the central and eastern tropical Pacific Ocean. La Niña conditions are associated with higher-than-average winter, spring and early summer rainfall over much of Australia.
Energy and Climate Change Ministerial Council	The ministerial forum for the Australian, and state and territory governments to work together in the pursuit of national energy and climate reforms.
Energy security	The uninterrupted availability of energy.

Enteric fermentation	The process in animals by which gases, including methane, are produced as a by-product of the microbial fermentation associated with digestion of feed.
Extreme weather event	A weather event that is rare at a particular place and time of year. 'Rare' can be defined as being in the 10th or 90th percentile of the probability observed in past trends.
Fire weather conditions	Climatic conditions that increase or reduce the likelihood of bushfires. High temperatures, low rainfall and humidity, and high winds increase the likelihood of fire.
First Nations	A generic term for Indigenous peoples of any country. In Australia, the term refers to Aboriginal and Torres Strait Islander people; however, the term is not limited to Indigenous peoples of Australia and can be used to describe Indigenous peoples from other countries (e.g. Canada).
Forest degradation	A direct, human-induced activity that leads to a long-term reduction in forest carbon stocks.
Forest Fire Danger Index	Used to forecast the influence of weather on fire behaviour in forests. The index is related to the chances of a fire starting, its rate of spread, and its intensity and difficulty of suppression, according to various combinations of air temperature, relative humidity, wind speed, and long- and short-term drought effects.
Fugitive emissions	Fugitive emissions involve the release of non-combustion, greenhouse gases arising from the production and delivery of fossil fuels. Fugitive emissions from solid fuels arise from the production, transport and handling of coal, and emissions from decommissioned mines and coal mine waste gas flaring. Fugitive emissions from oil and gas extraction, production and transport involve venting, flaring, leakage, evaporation and storage losses. Fugitive emissions from carbon dioxide transport and storage arise from the transport, injection and storage of carbon dioxide associated with carbon capture and storage activities.
Full Carbon Accounting Model (FullCAM)	A calculation tool for modelling Australia's greenhouse gas emissions from the land sector. FullCAM is used in Australia's National Greenhouse Accounts for the land use, land-use change and forestry sectors.
Indian Ocean Dipole (IOD)	The seesawing nature of sea surface temperatures in the eastern and western Indian Ocean. The IOD is a major contributor to the variability of rainfall over Australia. A positive phase of the IOD is associated with drier conditions in the Australian region and a negative phase with increased rainfall.
Indigenous rangers	Indigenous Australians who combine traditional knowledge with conservation training to protect and manage their land, sea and culture, and maintain an enduring connection to Country. Many rangers are employed in Indigenous Protected Areas, which are areas of land and sea Country managed by Indigenous groups in accordance with Traditional Owners' objectives that contribute to the protection of the nation's biodiversity and cultural heritage. Indigenous ranger projects were introduced by the Australian Government in 2007 as part of the Working on Country program.
Intergovernmental Panel on Climate Change (IPCC)	The United Nations body for assessing the science related to climate change. The IPCC prepares comprehensive reports about the state of scientific, technical and socio-economic knowledge on climate change, its impacts and future risks, and options for reducing the rate at which climate change is taking place. It also produces methodology reports to provide guidelines for the preparation of greenhouse gas inventories.

Kyoto Protocol	The Kyoto Protocol was developed through the United Nations Framework Convention on Climate Change (UNFCCC) negotiating process, and adopted in Kyoto, Japan, in 1997. It is a multilateral treaty designed to limit global greenhouse gas emissions. The Protocol sets binding greenhouse gas emissions targets for developed country parties that ratified the Protocol. The first commitment period of the Kyoto Protocol ran from 2008 to 2012. In 2012, Parties to the Kyoto Protocol agreed to the Doha Amendment, establishing a second commitment period to run from 2013 to 2020.
Land use, land-use change and forestry (LULUCF)	The greenhouse gas inventory sector covering emissions and removals from land and forests caused by human activities. This sector does not include emissions from the agriculture sector, such as emissions from livestock or fertilisers applied to croplands.
Marine heatwave	A period of abnormally high water temperatures relative to the average seasonal temperature in a particular region of a sea or ocean.
Measures	Past, current or committed Australian, state or territory, or local government policy actions to reduce greenhouse gas emissions.
Megatonne (Mt)	One million tonnes. The unit commonly used to express Australia's national greenhouse gas emissions.
Mitigation	A human intervention to reduce the sources of, or enhance the sinks for, greenhouse gases.
Montreal Protocol	The Protocol on Substances that Deplete the Ozone Layer, adopted in 1987. It controls the consumption and production of chemicals, such as chlorofluorocarbons, that destroy stratospheric ozone and are also potent greenhouse gases. The Protocol was amended in 2016 to control and phase down consumption and production of hydrofluorocarbons (HFCs) which are one of the gases included in the Paris Agreement.
Murray–Darling Basin	A large area of south-eastern Australia where water flows through a system of interconnected rivers and lakes. The Basin includes 6 of Australia's 7 longest rivers and is one of the country's most significant agricultural areas, providing one-third of Australia's food supply.
National Cabinet	A forum for the Prime Minister, premiers and chief ministers to meet and work collaboratively on issues of national significance. The Australian Government, and state and territory governments individually remain responsible for implementation in their jurisdictions of decisions arising from National Cabinet.
National Electricity Market	The wholesale market through which generators sell electricity in eastern and southern Australia. The main customers are energy retailers, which bundle electricity with network services for sale to residential, commercial and industrial energy users.
National Inventory Report	An inventory of Australia's national greenhouse gas emissions estimates, prepared in accordance with UNFCCC and Kyoto Protocol rules and guidance, including Intergovernmental Panel on Climate Change emission estimation guidelines, to fulfil Australia's international emissions reporting obligations under those treaties. The report also forms a part of Australia's National Greenhouse Accounts.
Nationally Determined Contributions	Under the Paris Agreement, Parties are required to submit Nationally Determined Contributions every five years. NDCs are the vehicle for parties' mitigation commitments. Developed countries are required to submit economy-wide emissions reduction commitments, with developing countries to move towards these over time.

National Reconstruction Fund	Australian Government financing vehicle that will support, diversify and transform Australia's industry and economy to secure future prosperity and drive sustainable economic growth. The fund covers various sectors, including renewables and low-emissions technologies; transport; and the agriculture, forestry and fisheries sectors.
Paleoclimate	The climate during periods before the development of measuring instruments, including historical and geological time, for which only proxy climate records (for example, tree rings and ice cores) are available.
Paris Agreement	A legally binding international treaty on climate change adopted at the twenty-first Conference of the Parties to the United Nations Framework Convention on Climate Change in Paris in 2015. Under the agreement, all Parties must submit emissions reduction commitments known as Nationally Determined Contributions.
Safeguard Mechanism	The requirement for Australia's largest greenhouse gas emitters to keep their net emissions below an emissions limit (a baseline). The aim of the mechanism is to ensure that emissions reductions purchased through Australia's carbon crediting scheme are not displaced by significant increases in emissions elsewhere in the economy.
Statutory authority	A body created by Australian Government legislation that is a separate legal entity from the government and has the power to hold money on its own account.

1. Executive summary

This National Communication on Climate Change details Australia's progress towards meeting its commitments under the United Nations Framework Convention on Climate Change (UNFCCC). The fifth Biennial Report (Annex A) provides information on Australia's greenhouse gas emissions and trends, projections against our 2030 target, and financial assistance provided to developing countries that are party to the Convention.

The challenge we face

The Australian climate has changed. We have experienced higher temperatures, increased frequency and intensity of extreme events, and an increase in drought and high-fire-risk weather conditions since the middle of the 20th century. Our environment is under extreme pressure and deteriorating as a result of climate change, habitat loss, invasive species and pollution.

Strong and decisive action on emissions reduction, research and adaptation is necessary to protect Australia's environment, society, infrastructure and economy from our changing climate.

Our mitigation targets and efforts

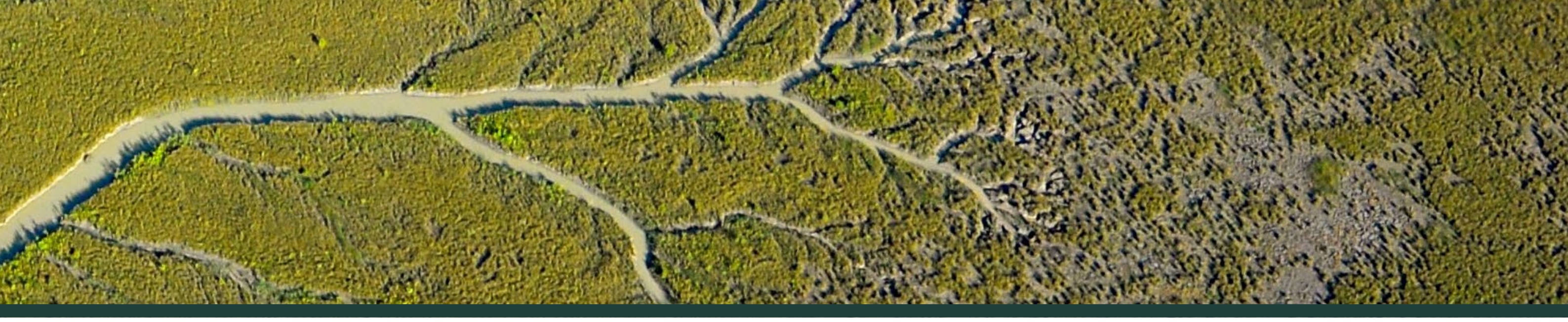
Since the seventh National Communication, Australia has stepped up its commitment and strengthened measures to reduce emissions, and adapt and respond to climate change impacts – both domestically and globally. With the passage of the *Climate Change Act 2022* (Cth), the Australian Government has legislated an ambitious target to reduce emissions by 43% compared with 2005 levels by 2030 and committed to achieve net zero emissions by 2050. Our new target will make a responsible contribution to global efforts to keep 1.5°C of warming within reach.

Furthermore, the new targets represent a floor in Australia's emissions reduction ambition, not a ceiling. The government's aspiration is that the commitments of industry, states and territories, and the Australian people will achieve even greater emissions reductions in the coming decade. At least once every 5 years, the independent Climate Change Authority will be asked to provide advice on Australia's emissions reduction targets to inform updates to Australia's nationally determined contribution.

Australia is supporting its increased ambition through new policies and funding, including:

- investing $*20 billion to upgrade Australia's electricity grid, increase reliability, put downward pressure on power prices, unlock greater use of renewable energy and accelerate decarbonisation of the grid
- reforming the Safeguard Mechanism to reduce emissions baselines predictably and gradually over time to support international competitiveness and economic growth
- training 10,000 new energy apprentices in jobs for the future and investing $9.6 million for the New Energy Skills Program to tailor skills training to the specific needs of new energy industries
- developing a new national strategy to accelerate the uptake of electric vehicles and cut car pollution, including by doubling Australian Government investment in charging and refuelling infrastructure to $500 million
- installing 400 community batteries and co-investing in 85 solar banks across Australia, to spread the benefits of the energy transition and ensure that more households can benefit from rooftop solar and cheaper electricity.

*All currency referred to in this report is AUD unless otherwise specified.



These key initiatives are complemented by policies across the energy, industrial, agricultural and waste sectors, driving economy-wide emissions reduction efforts.

Australia is also committed to continuously improving its national greenhouse gas inventory. Since the seventh National Communication, we have implemented several land sector model improvements, as well as improvements in the subsectors of oil and gas, coal mine fugitives, and product uses as substitutes for ozone-depleting substances. We have continued to implement aspects of the Intergovernmental Panel on Climate Change (IPCC) 2013 Wetlands Supplement into the national inventory; and improved the national inventory system by strengthening planning, documentation and quality control systems. Estimates are subject to extensive quality assurance and quality control processes to ensure that they meet the UNFCCC quality criteria of transparency, time-series consistency, accuracy, completeness and comparability.

The *Climate Change Act 2022* (Cth) further strengthens transparency and accountability by mandating that the responsible minister prepares an annual climate change statement to parliament. The first Annual Climate Change Statement was delivered on 1 December 2022, informed by independent advice from the Climate Change Authority, as required by the Act.

Our adaptation efforts

Australia is scaling up its adaptation efforts. All Australian governments have invested in further projection and assessment work, and in building knowledge about climate impacts specific to their communities. Australia is also incorporating First Nations people's knowledge and experience into adaptation action. For example, Australia's *State of the Environment 2021* report included Indigenous authors, an entire Indigenous-led chapter, and Indigenous-specific case studies throughout the report.

At a national level, the Australian Government has built on the inaugural National Climate Resilience and Adaptation Strategy 2015 by releasing the National Climate Resilience and Adaptation Strategy 2021–2025 before the UNFCCC 26th Conference of the Parties, alongside Australia's first Adaptation Communication.

The 2021–2025 strategy is designed to help governments, communities and businesses to better adapt. Complementing the strategy, the Australian Government has strengthened institutional arrangements for adaptation and resilience by establishing the:

- Department of Climate Change, Energy, the Environment and Water so that interconnected issues such as climate mitigation and adaptation, as well as the climate and biodiversity crises, can be addressed holistically
- National Adaptation Policy Office to oversee implementation of the strategy, coordinate work on climate resilience and adaptation, work in partnership to drive investment and action, and report on Australia's adaptation progress
- National Emergency Management Agency to adapt and drive long-term resilience to, and preparedness for, more intense and frequent disasters resulting from our changing climate.

Current adaptation efforts include:

- investing up to $200 million per year to strengthen disaster preparedness and resilience
- supporting private investment in nature capital and nature-based solutions for climate adaptation, addressing biodiversity loss and supporting livelihoods in partnership with Indigenous peoples

- doubling the number of Indigenous rangers, and boosting funding for Indigenous Protected Areas, as a recognition of the importance of Indigenous people's knowledge and experience in environmental management
- investing in the health and resilience of our ocean ecosystems, including by expanding our Marine Protected Area networks from 37% to 45% of our waters.

We also continue to invest in research into adaptation, and climate change impacts, risk and vulnerability assessments.

Improving climate understanding

Australia has made substantial progress in climate science research since the seventh National Communication.

Research efforts continue to increase our understanding of the El Niño–Southern Oscillation and Indian Ocean Dipole, especially their influence on extreme weather events. These climate processes are major influences on Australia's rainfall and seasonal weather patterns. Australia also continues to be a leader in climate research in the Southern Ocean and Antarctica. This research improves understanding of the Southern Ocean's role in moderating Earth's average surface climate, and how heat and carbon dioxide are absorbed by the ocean.

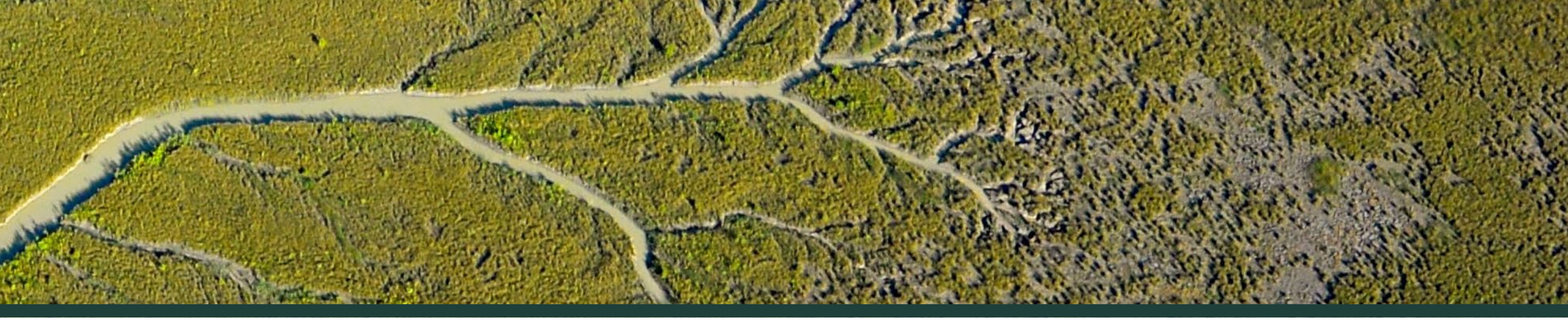
The Australian Climate Service (ACS) was established in 2021 to integrate the Australian Government's extensive climate and natural hazard information into a single national view. The ACS's purpose is to provide authoritative data, intelligence, models and tools to inform short- and long-term national responses to natural hazards in a changing climate.

Regionally, Australia plays an important role in systematic observations that contribute to global advances in climate science. For example, Australia has 6 Centennial Observing Stations, which the World Meteorological Organization recognises as providing a high-quality, 100-year record of at least one climate variable.

Australian scientists also continue to make valuable contributions to global understanding of climate change. Australians have contributed as authors or editors to the IPCC reports, including the Sixth Assessment Report and special reports on oceans and land. Australia used its national climate model (ACCESS) to simulate past climate, and provide climate projections for future greenhouse gas and aerosol concentration scenarios. These projections contributed to international modelling for the World Climate Research Programme Coupled Model Intercomparison Project Phase 6, which underpinned components of the IPCC's Sixth Assessment Report.

Over the past 5 years, the Australian Government has continued to publish resources and data to help decision-makers and communities understand and respond to the impacts of climate change. These include information on our climate and environment, such as in the *State of the climate* and *State of the environment* reports, and information to help with planning and decision-making, as published on public websites such as energy.gov.au (updated in 2020) and Your Home (updated in 2021).

The Australian Government supports awareness and climate change education through the Australian Curriculum, implemented through state and territory governments, and non-government education institutions. Cross-curriculum links for the sustainability theme were strengthened following a review in 2020–2022, providing greater early learning opportunities for Australian children.



Working together

All Australians must play their part to meet the global challenge of climate change. All states and territories have a net zero emissions target of 2050 or earlier, supported by strategies to achieve these targets. At the local level, Australian councils are also working together to reduce their climate risks and prepare their communities.

On 12 August 2022, energy ministers agreed to establish a new National Energy Transformation Partnership. The partnership is a framework for national alignment and cooperative action by the Australian, state and territory governments to support the smooth transformation of Australia's energy sector. Through the partnership, governments will identify and work together on specific actions to support the energy sector's transformation to help meet Australia's commitment to net zero emissions by 2050.

Respectful use of Indigenous knowledge, recognition of Indigenous knowledge rights, and Indigenous and non-Indigenous knowledge systems working together will also lead to positive change. Our *State of the Environment 2021* report states that renewed focus on landscape, and greater recognition and empowerment of Indigenous land management practices, where possible, across large parts of Australia is critical to helping us heal Country and find new ways to gain a broad range of benefits.

The Australian Government's increased ambition on climate extends throughout the region. Australia's climate finance focus is the Indo-Pacific region, and engagement is based on partnerships and respect. Priorities are set by national governments, and ongoing collaboration and dialogue ensure that Australia continues to be a responsive and effective development partner. In 2022, the Australian Government increased the official development assistance (ODA) budget by $1.4 billion over the next four years (FY 2022-26). This will support new spending on climate action. In 2021, Australia also doubled our 2015–2020 climate finance target to $2 billion over 2020–25.

State, territory and local governments continue to develop and update climate adaptation, risk and vulnerability plans and strategies, and consider and respond to sectoral and regional impacts. Non-government organisations, including industry peak bodies, are also leveraging industry-specific expertise and networks for tailored climate change adaptation support in the building, engineering, agriculture and investment sectors.

The path forward

Climate change action involves shared responsibility, and sustained and ongoing action. Australian governments at all levels are working together with industries, researchers and communities to develop new policies and actions to help Australia meet its international emissions reduction commitments and the challenges of climate change.

2 National circumstances relevant to greenhouse gas emissions and removals

Key developments

Since the seventh National Communication, Australia has faced increased temperatures and extreme weather events. Recent flooding across eastern states illustrates the impact of more frequent devastating weather events.

Floods and general wet weather will affect both exports and investments over coming quarters. The initial negative impact on economic activity from such events will be largely offset by increased spending and investment to replace and rebuild damaged housing, infrastructure and household goods over the next few years; however, the scale and timing of this are uncertain.

Australia is also exposed to the economic challenges posed by the COVID-19 pandemic and uncertain global economic outlook. In 2022, significant pressure has been put on global inflation by rising gas and energy prices, persistent supply chain pressures, extraordinary stimulus in response to the pandemic, adverse weather events and interruptions to food exports. Australia has not been immune to these impacts.

Despite these challenges, the Australian Government is working with state and territory governments to act on climate change. In 2022, the government consolidated its climate leadership by combining climate change, energy, environment and water policy responsibility under a single federal agency.

In 2022, the Australian Government updated its Nationally Determined Contribution under the Paris Agreement to reduce greenhouse gas emissions by 43% below 2005 levels by 2030 and reach net zero emissions by 2050, and enshrined these targets in legislation.

The government is transforming the economy by establishing a modern energy grid. The government aims to drive innovation and open up new energy industries to deliver cleaner, cheaper energy. With abundant solar and wind resources along with world-leading science, Australia is well placed in the global push towards low-emissions technologies.

2.1 Government structure

Australia has a federal system of government with 3 levels: federal (the Australian Government), state and territory (Australian Capital Territory, New South Wales, Northern Territory, Queensland, South Australia, Tasmania, Victoria, Western Australia) and local. Local government bodies are created by state and territory law. There are 566 local government areas across the country. Australia's written constitution sets out the responsibilities of the Australian Government, including foreign affairs and trade, defence, and immigration. States and territories are responsible for matters not assigned to the Australian Government, such as health and education, although in practice the 2 levels of government cooperate in many areas.

During the COVID-19 pandemic, National Cabinet was established as a forum for the Prime Minister, premiers and chief ministers to meet and work collaboratively and quickly on the response and other issues of national significance. The Australian, state and territory governments individually remain responsible for implementing decisions arising from National Cabinet in their jurisdictions.

Australian Government, state and territory ministers also often work collaboratively on issues specific to their portfolio areas through ministerial councils, which meet on a regular and ongoing basis, and provide ministers with a formal channel to resolve key priorities. The Energy and Climate Change Ministerial Council is the primary ministerial-level council for intergovernmental consideration of energy and climate portfolio issues, including the National Energy Transformation Partnership (see also section 4.1.1.1).

The Administrative Arrangements Order sets out policy responsibilities for Australian Government departments. In 2022, the Australian Government combined climate change, energy, environment and water policy responsibility under a single agency, the Department of Climate Change, Energy, the Environment and Water (see also section 4.1.1.3).

2.2 Population profile

As at 31 March 2022, Australia's population was 25.9 million people. Most people live in urban areas along the eastern and western coastal regions. More than 87% of Australians live within 50 km of the coast, and around 67% of Australians live in a capital city. New South Wales has the largest population (8,130,100), followed by Victoria (6,593,300), Queensland (5,296,100), Western Australia (2,773,400), South Australia (1,815,500), Tasmania (571,200), the Australian Capital Territory (445,900) and the Northern Territory (250,400).

Population growth is a strong driver of emissions growth, and an important element of Australia's national circumstances. From 2010 to 2020, Australia's population increased by almost 15%, or approximately 3.8 million people, compared with an Organisation for Economic Co-operation and Development (OECD) average of around 11%. All Australian states and territories experienced population growth over the year ending March 2022.

The closure of international borders due to the COVID-19 pandemic caused a temporary pause in Australia's migration intake, reducing population growth to below 1% during 2020 and 2021. Despite the easing of international and domestic restrictions, significant uncertainty remains around likely future migration patterns.

2.3 Economic profile

Australia's economy has more than doubled over the past 30 years. Between 1996 and 2021, Australia's average annual economic growth was 3.0%, compared with an OECD average of 2.1%. For 2021–22, Australia's real GDP grew by 3.6%, and real GDP per capita was approximately $83,678, an increase of 3.1% from the previous year. Australia's strong economic growth has boosted living standards and household consumption.

Australia is an open economy, highly integrated with the global economy. In this integrated global market, Australia has specialised in areas where it enjoys a comparative trade advantage. These include resources and energy, which account for around 60% of Australia's exports by value, and agriculture, which accounts for around 15% of exports by value.

However, Australia is not immune to the global challenges driving higher global inflation and slower global growth – including the Russian invasion of Ukraine that has significantly driven up global energy costs and exacerbated the impact of poor weather on global food prices. Food prices have been further exacerbated by recent floods. Inflation is now forecast to be more persistent, stemming from higher electricity and gas prices. Electricity and gas prices are expected to rise sharply over the next 2 years, as the cost of energy market disruptions are passed on to households.

2.4 Geographical profile

Australia is the sixth largest country in the world, with a land area of 7.7 million square kilometres.

Australia's marine jurisdiction is the third largest in the world, with an exclusive economic zone covering 10 million square kilometres. Australia is the driest inhabited continent; 70% of the land is either arid (average rainfall of 250 mm or less) or semi-arid (average rainfall of between 250 and 350 mm). Rainfall and temperature also vary considerably both across the country and from year to year.

2.5 Climate profile

The Australian continent covers a large range of climate zones, from the tropics in the north to the arid interior and temperate regions in the south. Across a backdrop of Australia's highly variable climate, climate change is affecting all regions (see also section 6.1).

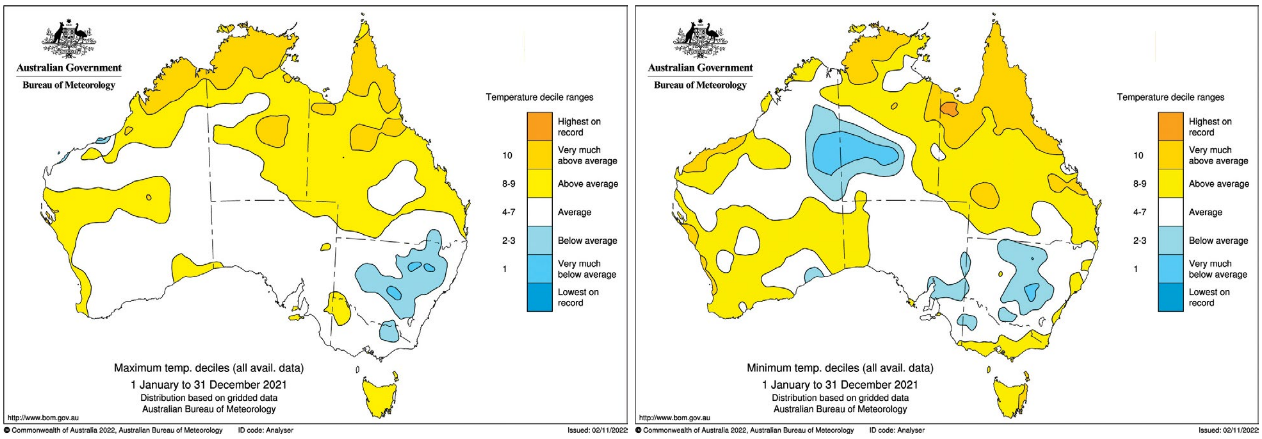
2.5.1 Temperature

Daily temperatures vary widely across the country (Figure 2.1). The summer of 2021–22 saw the equal highest temperature on record for Australia, 50.7 °C on 13 January 2022 at Onslow in Western Australia. On the same day, further south in Tasmania, Kunanyi (Mount Wellington pinnacle) observed a maximum of only 9.9 °C. Minimum temperatures over summer ranged from 34.6 °C at Marble Bar in Western Australia to –3.7 °C at Perisher Valley in New South Wales.

The year 2021 was Australia's 19th warmest year on record, at 0.56 °C above the 1961–1990 average, and the coolest year since 2012, as temperatures tend to be lower during La Niña years (Figure 2.2). However, 2021 was one of the warmest La Niña years on record for Australia. Annual mean temperatures for 2021 were above average for most of northern Australia; Tasmania; and, in Western Australia, along the coast, the interior and the south-east of the state. They were in the highest 1% of historical observations for most of the northern tropics. West of the ranges, much of central New South Wales had mean temperatures that were cooler than average.

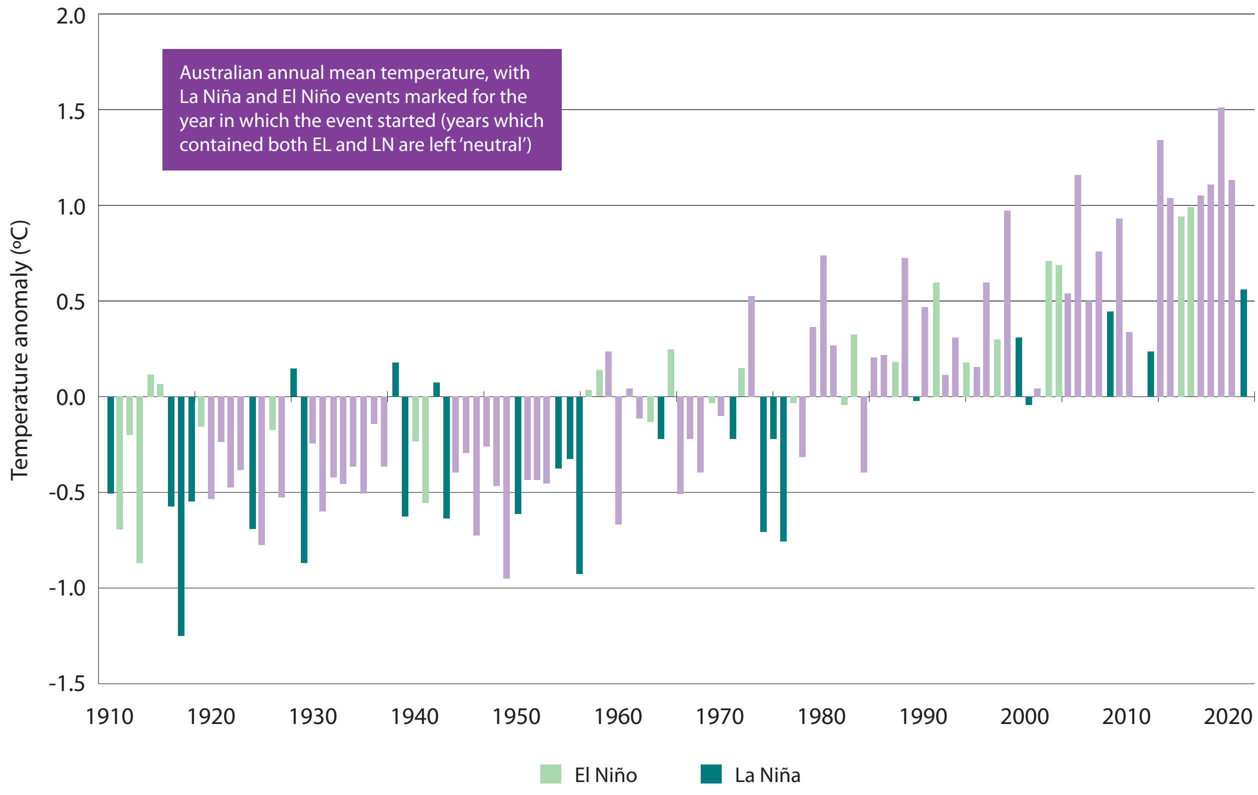
The annual average temperature in Australia has increased by more than 1.4 °C since 1910, with most warming occurring since 1950. Australia's warmest year on record was 2019. The 8 years from 2013 to 2020 all rank in the 10 warmest years on record; 2021 was the first year since 2013 that was not among the 10 warmest years on record for Australia. The mean temperature for the 10 years from 2012 to 2021 was the highest on record, at 0.99 °C above the 1961–1990 average. The long-term warming trend means that most years are now warmer than almost any observed during the 20th century.

Figure 2.1: Australia's maximum and minimum temperature deciles, 2021



Source: Bureau of Meteorology

Figure 2.2: Australian annual mean temperature, with years coded by the phase of the El Niño–Southern Oscillation



Years in which La Niña began are dark green, light green is El Niño, and years that were neutral or contained both El Niño and La Niña are purple.

Source: Bureau of Meteorology

2.5.2 Rainfall

Australian rainfall varies greatly from one year to the next and from one decade to the next. Rainfall variation from year to year is strongly influenced by regional climate patterns such as El Niño, La Niña, and the Indian Ocean Dipole.

Despite large natural variability, underlying longer-term trends are evident in some regions. These include a shift towards drier conditions across the south-west and south-east, and more frequent years of below-average rainfall. Conversely, rainfall has increased across parts of northern Australia since the 1970s, especially in the north-west during the northern wet season (October to April).

In recent decades, there has been significant drying across southern Australia, especially across the cool April to October growing season (Figure 2.3). For the south-east of the continent, rainfall since the late 1990s for the April to October period has decreased by around 10% since national rainfall records began in 1900. The Millennium Drought saw very low annual rainfall totals across the region from 1997 to 2010. Drought also affected many parts of eastern Australia from early 2017 to early 2020. The most extreme rainfall deficiencies occurred in the northern Murray–Darling Basin and in Gippsland, with numerous records for low rainfall set in both regions.

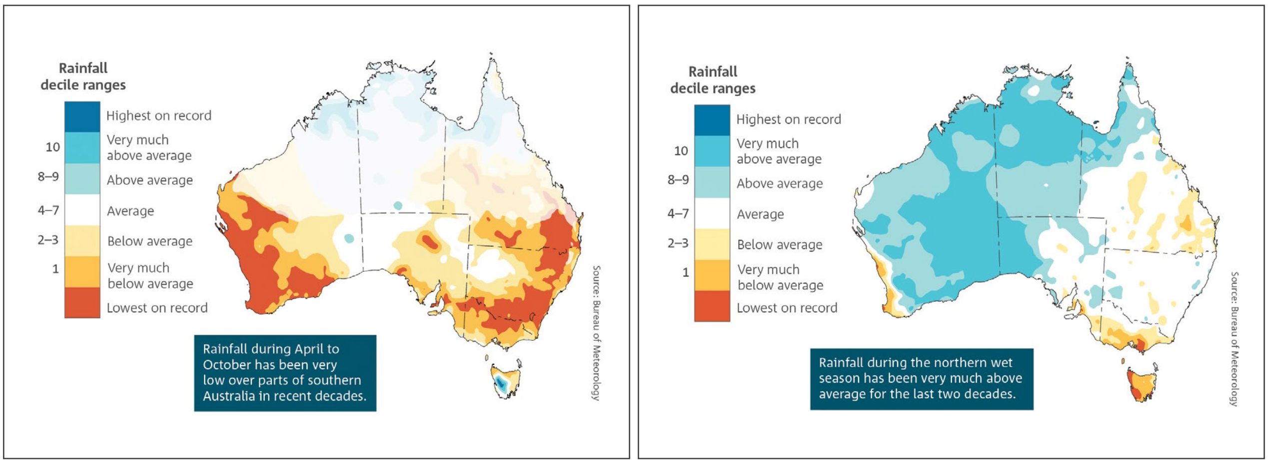
The drying trend across southern Australia is particularly strong between May and July over south-west Western Australia, with rainfall since 1970 around 19% less than the long-term average from 1900 to 1969. Since 2000, this decline has increased to around 27% when compared with the period from 1900 to 1999 despite relatively high cool-season rainfall during 2021.

However, rainfall variability remains high. Extreme examples of rainfall variability across Australia, including drought and flooding, have occurred from 2017 to 2022. In recent decades, the intensity of short-duration (hourly) extreme rainfall events increased by around 10% or more in some regions.

The year 2022 has been notably wet in much of eastern Australia, with extensive flooding across large areas. Numerous rainfall records have been set for daily totals, monthly totals and year to date. Most of New South Wales and northern Victoria received at least 150% of their average annual rainfall by mid-November, with some parts of New South Wales receiving more than double. With the end of the 2017–2019 drought, Australia shifted into a wetter climate pattern. This was driven by warm ocean temperatures around the continent; successive La Niña events in the tropical Pacific in 2020–21, 2021–22 and 2022–23; and negative Indian Ocean Dipole events in the Indian Ocean in 2021 and 2022. Australia's eastern landscape has progressively become wetter than it has been at any time since at least 2016 (a negative Indian Ocean Dipole year), and in many places since the strong La Niña event of 2010–11.

Rainfall was especially significant in south-east Queensland and coastal New South Wales in February and March, around Sydney in July, and in much of Victoria and inland New South Wales from August onwards, with major flooding occurring in all these periods. Spring 2022 was the wettest on record averaged over New South Wales, Victoria and the Murray–Darling Basin, and October 2022 was the wettest month on record for Victoria.

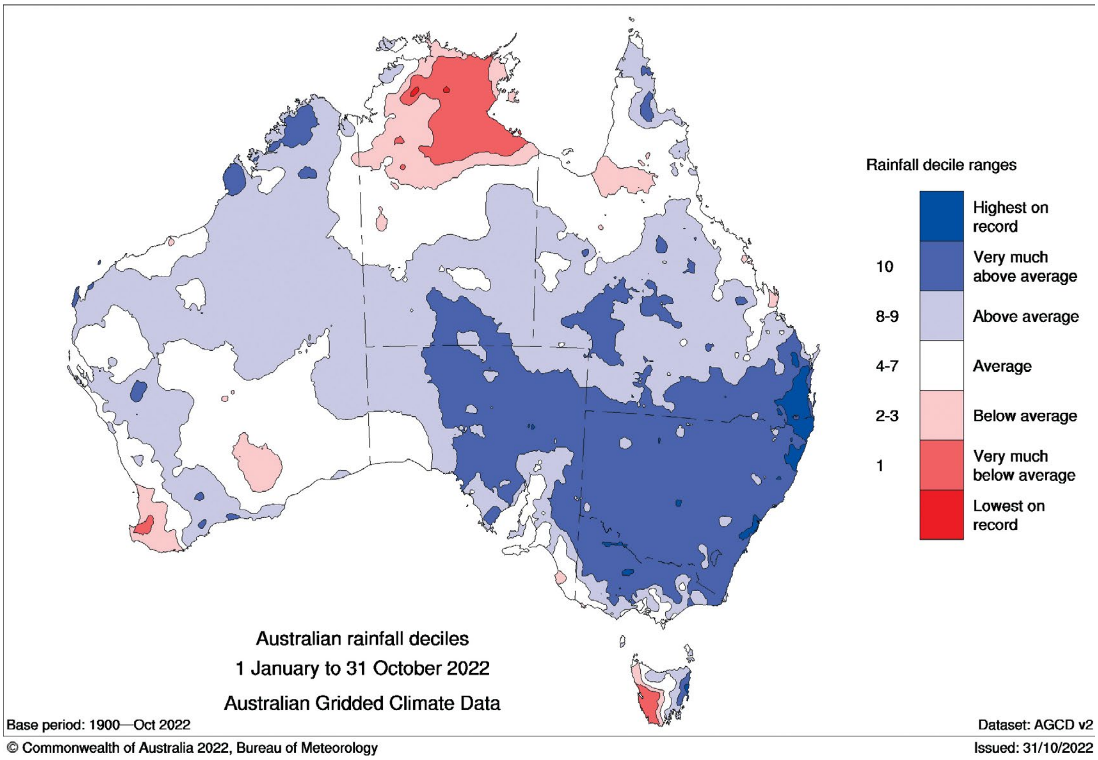
Figure 2.3: Rainfall deciles for the last 22 years, April to October 2000 to 2021 (left) and October to April 2000–01 to 2021–22 (right)



A decile map shows where rainfall is above average, average or below average for the recent period, in comparison with the entire rainfall record from 1900. Areas across northern and central Australia that receive less than 40% of their annual rainfall during April to October are faded.

Source: Bureau of Meteorology

Figure 2.4: Australian rainfall deciles



Source: Bureau of Meteorology

2.5.3 Extreme events

Australia regularly experiences extreme weather events, including droughts, floods, tropical cyclones, storms, heatwaves and bushfires. However, long-term records show that Australia is experiencing changes in both frequency and intensity of extreme weather events.

The most obvious change is an increase in the occurrence of record-breaking heat (Figure 2.5). Extreme and extensive heatwaves occurred in many parts of Australia in the 2018–19 and 2019–20 summers, exceeding historical records. The heatwaves were particularly notable for the large areas that were covered, which led to unprecedented average daily temperatures across Australia. The enhanced greenhouse effect will continue to increase the frequency and intensity of heat events, with longer heatwaves, more frequent extremely hot days, fewer extreme cold days and temperatures above the historical record for many regions.

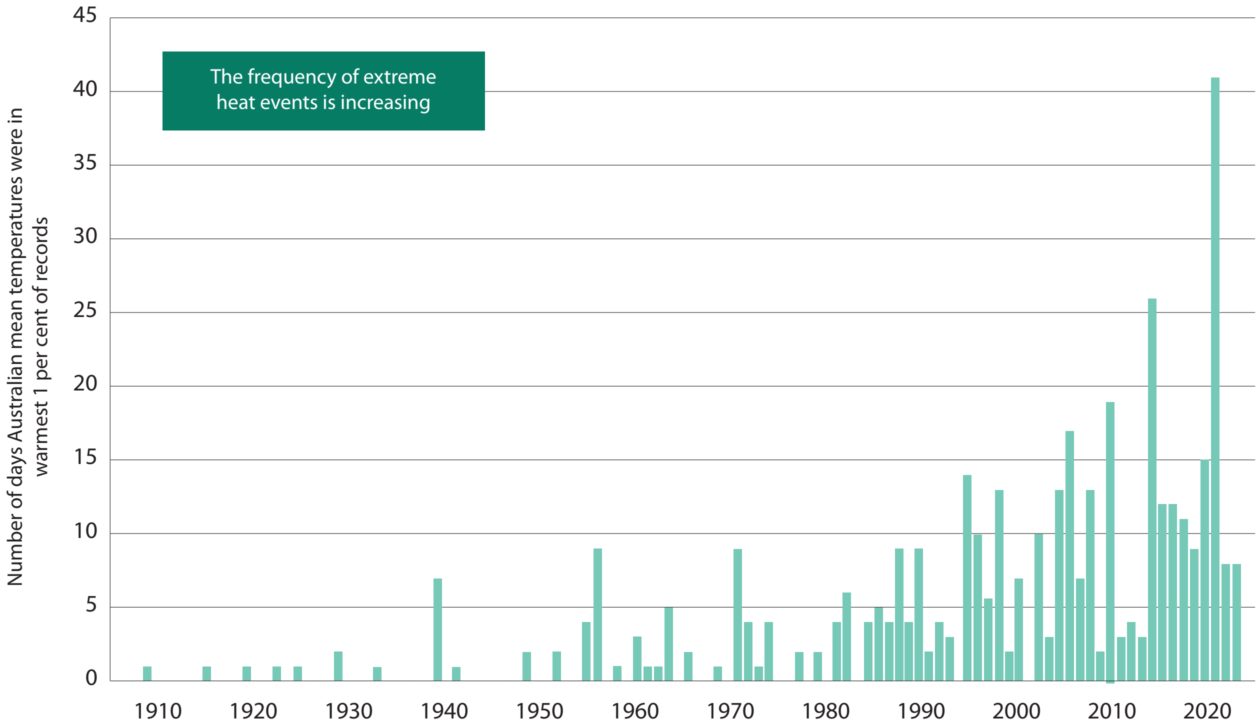
Ocean warming has contributed to recent record-breaking marine heatwaves. The global annual number of marine heatwave days has risen by 54% over the past century, with 8 of the 10 most extreme marine heatwaves ever recorded occurring after 2010. Marine heatwaves were recorded on the Great Barrier Reef in 2015–16, 2016–17, 2019–20 and 2021–22. The 2015–16 northern Australia marine heatwave was the longest on record in the south-east tropical Indian Ocean.

There is an observed trend in recent decades towards more dangerous fire weather conditions. Observed changes clearly show a lengthening fire season, particularly in parts of southern and eastern Australia.

During the 2019–20 Australian bushfire season, the fire weather conditions in spring and December 2019 were unprecedented in the historical record (of 72 years throughout Australia). In particular, the long-term warming of 1.4 °C contributed to higher values of the Forest Fire Danger Index and Fire Weather Index. The 2019–20 Black Summer fires were exceptional for the scale, severity and synchrony of fires across southern and eastern Australia. More than 10.3 million hectares of native bushland was burned, as well as grasslands, agricultural lands, commercial forest plantations and peri-urban areas.

Australia also experiences tropical cyclones. Under climate change, the forecast for Australia is for a similar frequency of tropical cyclones, but an increase in intensity and associated rainfall, and the potential for cyclones to track further south.

Figure 2.5: Frequency of extreme heat events, 1910–2021



Source: Bureau of Meteorology

2.6 Energy

2.6.1 Energy market structure

Although the Australian, and state and territory, governments each maintain their own energy policies, the cross cutting nature of the energy sector requires governments to work together to ensure the safety, security, stability, and reliability of Australia's energy systems. In eastern Australia, which accounts for the overwhelming majority of Australia's economic activity, the interconnected nature of electricity and gas networks led state governments to apply a regulatory framework known as the national electricity and gas laws.

Governance for Australia's east coast energy system and markets involves 4 bodies:

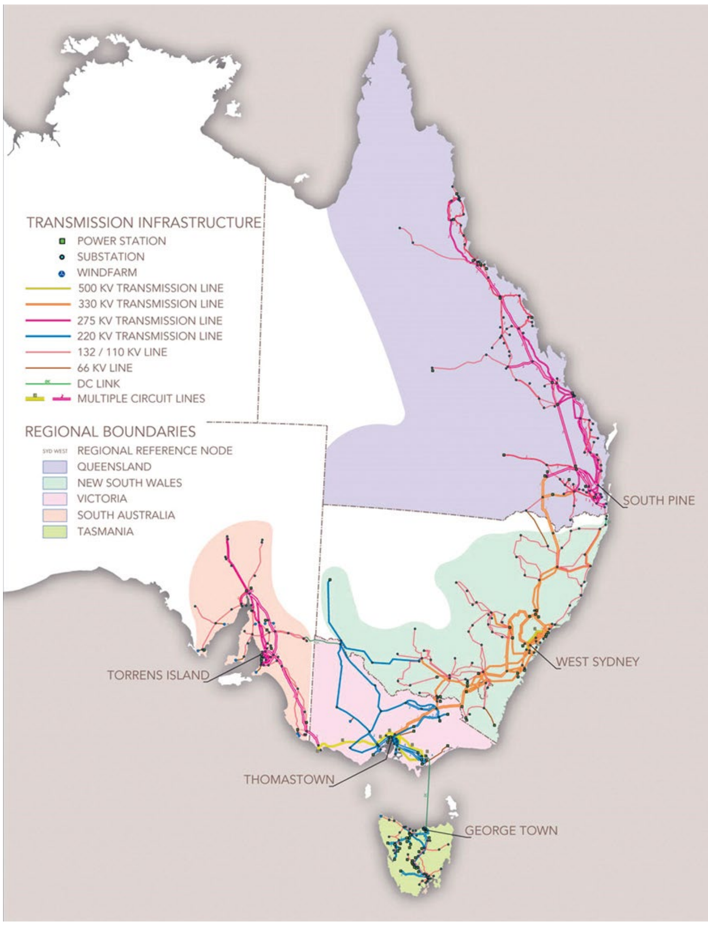
- The Australian Energy Market Commission (AEMC) makes rules for the National Electricity Market (NEM), elements of the gas market and related retail markets, and provides strategic and operational advice to the energy minister.
- The Australian Energy Regulator (AER) is the economic regulator of the wholesale electricity and gas markets in eastern Australia, and enforces rules establishes by the AEMC.
- The Australian Energy Market Operator (AEMO) manages the day-to-day system operation of the wholesale and retail energy markets, including the NEM, the Victorian Declared Wholesale Gas Market, the Short Term Trading Market, and the Gas Supply Hub.
- The Energy Security Board comprises heads of the AEMO, the AEMC and the AER, and provides oversight and advice to energy ministers on energy security, reliability and long-term planning.

Each of these agencies is guided by the National Electricity Objective, National Gas Objective and National Energy Retail Objective.

2.6.1.1 Australian electricity market

The Australian electricity market is largely made up of 3 separate large-scale systems: the NEM; the Western Australian Wholesale Electricity Market, made up of the South West Interconnected System and the North West Interconnected System; and the Darwin to Katherine network. The NEM is the largest market, which supplies around 80% of Australia's electricity consumption. These markets are separated because of their geographical locations. The NEM grid extends from Port Douglas in Queensland through New South Wales, the Australian Capital Territory, Victoria and Tasmania, and across to Port Lincoln in South Australia (Figure 2.6).

Figure 2.6: Map of Australia's National Electricity Market

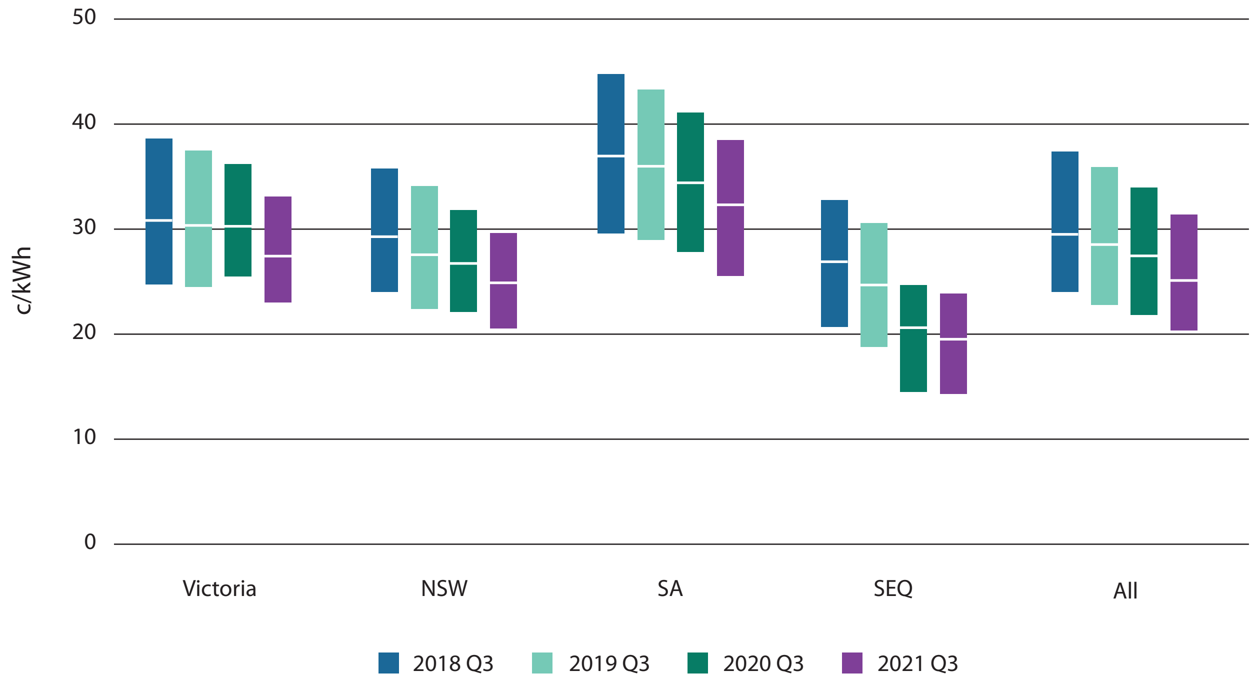


Source: Australian Energy Market Operator

2.6.1.2 Prices

From 2018 until the end of 2021, retail energy prices decreased due to steady decreases in wholesale electricity costs (Figure 2.7). Electricity retail prices surged in 2022 due to various factors, including the war in Ukraine, which led to steep increases in global coal and gas demand; generator outages; and increased demand due to a particularly cold start to winter.

Figure 2.7: Effective prices paid by residential customers, excluding GST



Source: ACCC 2022

Data are provided across 4 regions of the National Electricity Market: Victoria; New South Wales, encompassing the Australian Capital Territory; South Australia; and South-East Queensland, encompassing Brisbane, Ipswich, Gold Coast and Sunshine Coast.

The recent high wholesale prices have affected electricity retailers. Since 24 May 2022, 7 energy retailers servicing around 25,000 small, medium, and large customers exited the market and have had their retailer authorisations revoked. In the same period, a further 2 energy retailers voluntarily surrendered their retailer authorisations.

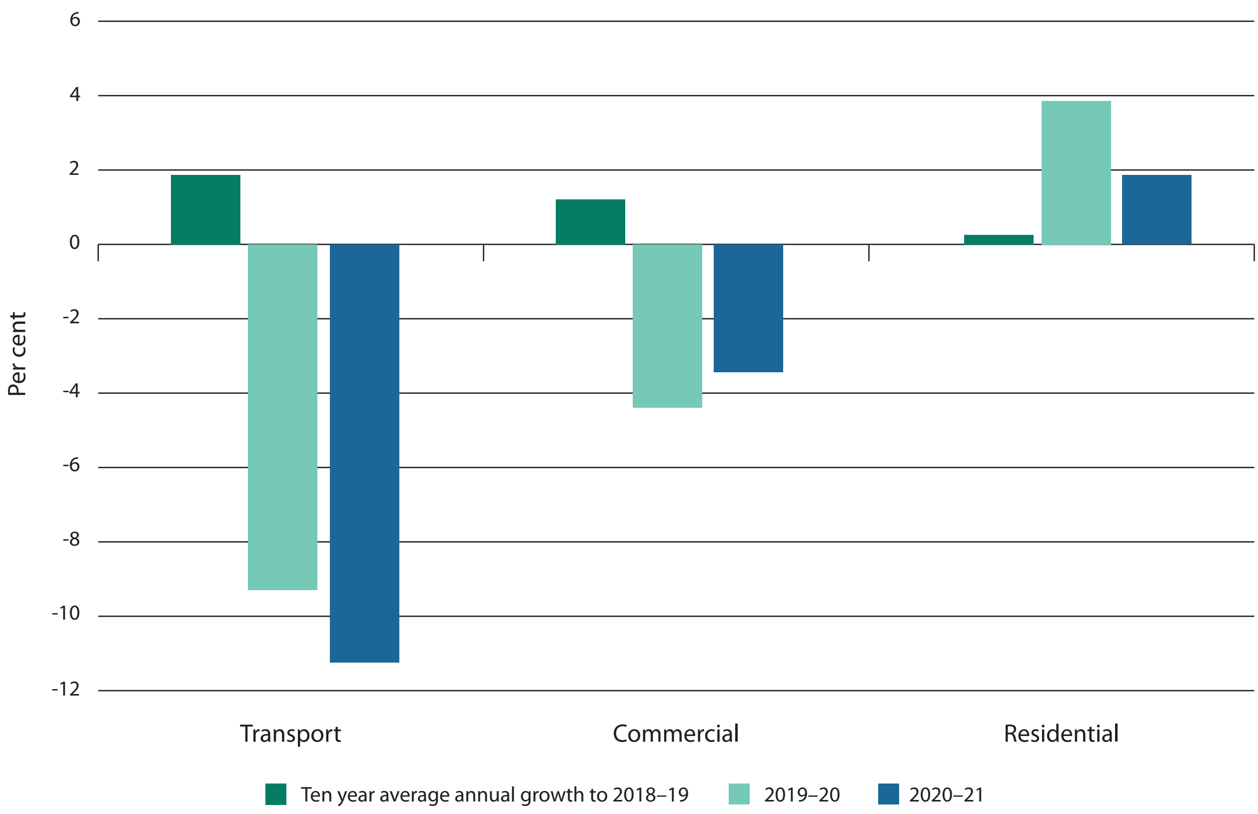
Most residential and small business customers are served by 3 large energy retailers: AGL Energy, Origin Energy and EnergyAustralia, which cover 64% of 7.4 million electricity customers and 82% of 2.4 million gas customers.

2.6.2 Domestic energy consumption

Australia's energy consumption peaked in 2018–19 before the COVID-19 pandemic at 6,188 petajoules (PJ), following average growth of 0.6% a year in the decade before (2008–09 to 2018–19). In 2020–21, consumption fell by 3.6% to 5,790 PJ, following a 3.0% fall the year before. Growth in energy consumption has generally remained below the rate of economic growth over the past 3 decades. This can mainly be attributed to a shift in the economy towards less energy-intensive sectors such as services and improvements in energy efficiency (DCCEEW 2022a).

At the sectoral level, transport and electricity generation are the 2 largest energy consumers in Australia, each accounting for around 25%. Manufacturing is the third largest, at 18%, but, because of its importance to the Australian economy, mining is generally reported separately at 15% (and is the fastest growing end sector at 7.6% over the past decade). The COVID-19 pandemic disrupted relatively stable long-term growth trends in sectors such as transport, residential and commercial, which were most strongly affected by pandemic restrictions and behaviour changes (Figure 2.8). For other sectors, such as mining, energy use remained relatively unaffected.

Figure 2.8: Ten-year pre-COVID average energy consumption growth rates, and 2019–20 and 2020–21 movement rates, selected sectors



Source: DCCEEW 2022a, Table E

Unsurprisingly, the largest reduction in energy use in 2020–21 occurred in the transport sector, which fell by 10.6%, caused by pandemic restrictions, which particularly affected aviation and to a lesser extent water transport. International arrivals shrank to a few thousand per month in mid-2020, after peaking at well over 1 million per month in the years leading up to 2020. Fuel use in the road sector was less strongly impacted as freight vehicle kilometres continued growing at trend, offsetting some of the 6% fall in passenger vehicle kilometres travelled in 2020–21.

Australia's primary energy consumption has long been dominated by fossil fuels, which accounted for 92% of consumption in 2020–21. However, this is the lowest share since the late 1970s and reflects strong growth in renewable energy sources, mainly solar photovoltaic (PV) (21.6% of renewable total) and wind (19.1%), in the electricity generation sector. These modern renewables have now overtaken bagasse (19.0%), wood (18.0%) and hydro (11.8%) in importance.

In 2020–21, oil accounted for the largest share of Australian energy consumption, at 36%, followed by coal at 29% and gas at 27%. These trends reflect sectoral-level consumption, where transport (oil) and electricity generation (coal) are dominant. Gas is used across a variety of sectors, but 2.0% growth over the 10 years to 2020–21 has been driven by the mining sector and expansion of Australia's liquefied natural gas (LNG) sector. Coal consumption, in contrast, has fallen at a rate of –2.4% over the same period, while oil has declined more gently (–0.5%).

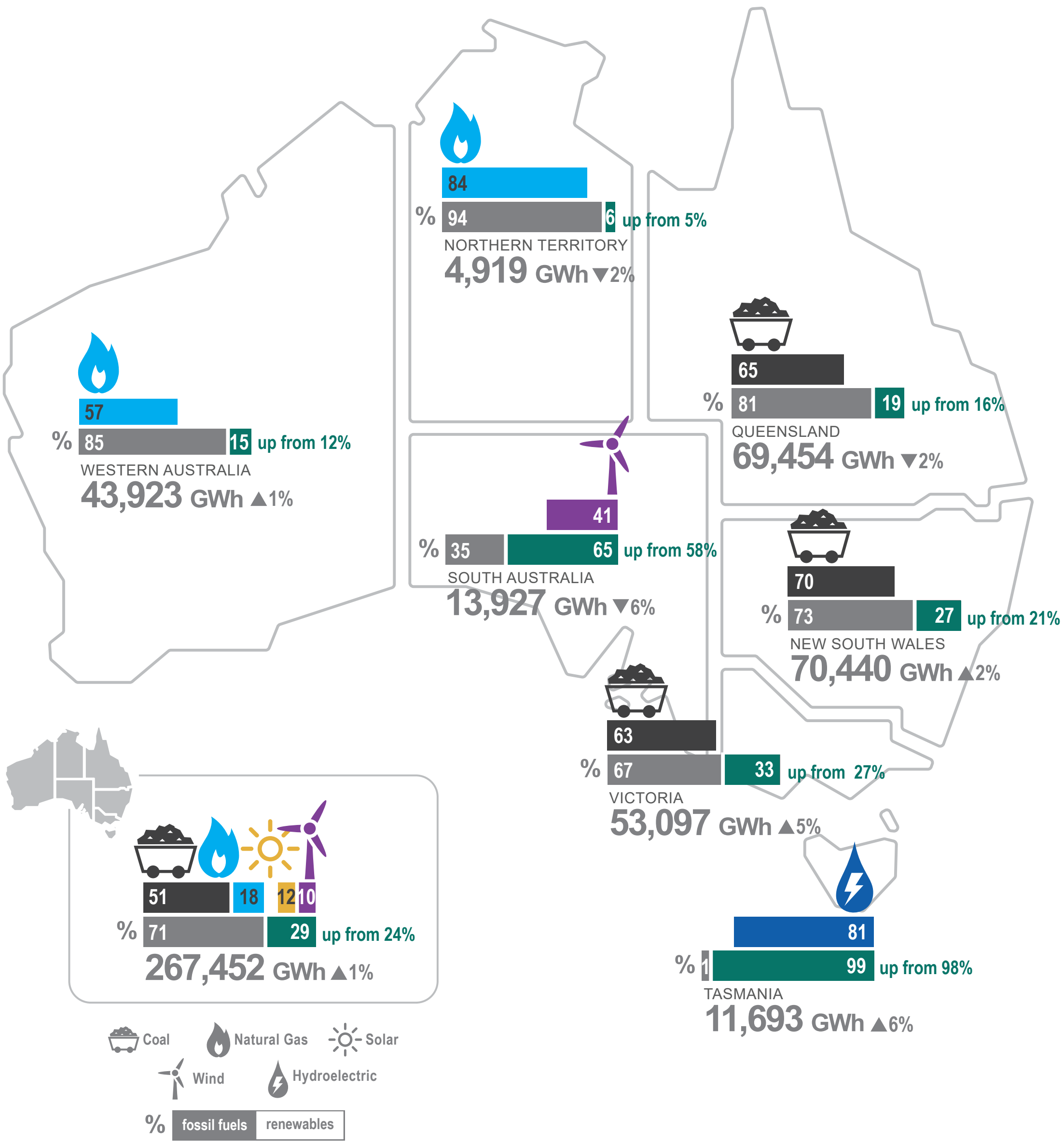
2.6.3 Electricity

Like many other developed countries, Australia is transforming its electricity market as part of its commitment to achieve a net zero economy by 2050. This transformation involves accelerating renewable energy deployment and phasing out emissions-intensive electricity generation.

In 2021, total electricity generation in Australia was 267 terawatt hours. Coal remained the biggest fuel source for electricity generation, at 51.4%, despite steady declines in recent years. Natural gas–fired generation was estimated to fall by just over 10%, and now accounts for 17.8% of electricity generation. Oil products also contributed almost 1.8%, mostly in off-grid applications such as mining.

Renewable electricity generation surged to contribute just over 29% of total generation in 2021 (Figure 2.9). Small-scale (mainly household PV systems) and large-scale solar generation increased by almost 31% combined, to account for 11.7% of all electricity generated. Wind power is the next largest source of renewable electricity generation, accounting for 10% of the total, followed by hydro at 6.1% and bioenergy at 1.3%.

Figure 2.9: Australian electricity generation, by fuel type



Source: DISER 2022, Australian Energy Statistics infographic

2.6.4 Energy sources

Production of primary energy generally follows similar trends to consumption, but, as Australia is a globally significant exporter of coal and LNG, these are generally exacerbated. For example, fossil fuels account for around 98% of production compared with 92% of consumption. Similarly, production fell more significantly than consumption in 2020–21, by 5.5%, to 18,952 PJ. Coal, natural gas and oil production underpinned the decline, with renewables the only major energy source to grow. More than two-thirds of Australian energy production is generally exported, not including uranium.

2.6.4.1 Coal

Coal is Australia's second largest export behind iron ore, with coal export income valued at around $39 billion in 2020–21. Australia holds the fourth largest black coal resource in the world, with around 10% of the world's economically recoverable reserves (75 billion tonnes in 2020). Australia is ranked second in the world for brown coal, with 23% of economically recoverable reserves (74 billion tonnes in 2020).

Australia is the world's largest exporter of metallurgical (coking) coal, and the second largest exporter of thermal coal. In 2020–21, almost all of the 171 million tonnes (Mt) of metallurgical coal produced in Australia and approximately 85% of the 228 Mt of thermal coal produced in Australia was exported. Brown coal is produced only for domestic consumption, which was approximately 42 Mt in 2020–21.

2.6.4.2 Gas

Australia holds approximately 1.3% of the world's economically recoverable conventional gas reserves, with 72,082 PJ, as well as coal seam gas reserves of 28,934 PJ. Shale and tight gas resources are estimated to be significant, although commercial extraction is yet to be proven, so this is highly uncertain.

Around one-quarter of Australia's gas was produced for the domestic market in 2020–21, with the other three-quarters exported as LNG. LNG exports increased by 6% in 2021–22 to 4,700 PJ, Australia's highest volume of exports on record. Following a wave of new projects over the past decade, LNG production capacity has more than doubled.

2.6.4.3 Oil

Australia has limited resources of crude oil, and most known remaining oil resources are condensate and naturally occurring LPG associated with large offshore gas fields. Australia holds around 0.1% of world crude oil reserves. In 2020–21, crude oil exports were 593 PJ (16 billion litres). Crude oil reserves based on current production rates are estimated at 6 years. For LPG, reserves are estimated at around 16 years, and 15 years for condensate reserves.

2.6.4.4 Uranium

Australia has the world's largest economically recoverable uranium reserves (estimated as 1,239 thousand tonnes in 2020), representing around one-third of global resources. At current rates of production, Australia's uranium resources will last a further 200 years. All production of uranium is exported under stringent conditions to ensure that it is used for peaceful purposes only.

2.6.4.5 Renewable energy

Renewable energy production is used entirely by the domestic market. Australia has outstanding solar and wind resources, which underpin expectations that renewable energy will come to dominate Australia's electricity supply (see also section 4.2.2). These resources may also support electricity or green hydrogen exports in the future.

On 2 June 2022, legislation came into effect that will allow the construction of offshore renewable energy infrastructure in Australian Commonwealth waters, such as offshore wind farms. It is anticipated that the first licences that would permit feasibility activities will be granted to offshore wind developers in 2023, with the first projects commissioned and operating by the late 2020s.

2.7 Transportation

Australia's road system accounts for 77% of passenger travel (in 2020–21) and is among the largest in the world at around 877,000 km.

The Australian rail system is one of the largest in the world. The non-urban components, approximately 95% of the total operational route-kilometres, carry mostly freight traffic. Commuter passenger traffic dominates in periphery urban areas, such as Newcastle to Sydney. Many freight-only lines in regional Australia only carry seasonal traffic and are of a low standard.

In 2019–2021, rail accounted for 2.5% of passenger travel, and air accounted for 7.5%.

Transport energy use increased by around 1.5% each year from 2015 to 2019, before the COVID-19 pandemic. Transport emissions increased by around 1% per year.

2.7.1 Passenger transport

Australia's passenger vehicle fleet consumes a relatively large amount of fuel by international standards because of the long distances between population centres, strong population growth and preference for larger vehicles. In 2020, the average rate of fuel consumption of passenger vehicles was 11.1 litres per 100 km. Aggregate fuel demand is increasing, aside from a temporary reduction due to the pandemic. In the 12 months ending 30 June 2020, passenger vehicles consumed an estimated 18,094 million litres of fuel, of which 79.9% was petrol.

Passenger cars account for around 73% of total passenger kilometres. Of the average 19.8 million vehicles registered in Australia during the year ending 30 June 2020, approximately 14.7 million (74%) were registered as passenger vehicles.

Sales in Australia of battery electric vehicles and plug-in hybrids tripled to 20,665 in 2021, up from 6,718 in 2019.

Public transport remains important in cities, especially for travel into central business districts, accounting for around 9% of total passenger kilometres within Australia's capital cities.

2.7.2 Domestic freight transport

Australia is a large country with a commensurately large domestic freight task. On an average day, around 11 Mt of domestic freight is moved in Australia. Road transport accounts for around 30% of the domestic freight task (in tonne-kilometres performed), and rail accounts for around 55%. Trucks are responsible for a large share of non-bulk commodity haulage. In contrast, rail dominates bulk commodity haulage.

Intrastate movements of bulk commodities from their area of production to the seaport or processing location account for a large proportion of rail freight. Much of this bulk commodity transport is the long-haul movement of iron ore, oil and coal for secondary industry by coastal ships. Haulage of primary products from inland mines and farms to coastal city markets and export ports is also significant. Mining haulage in north-west Australia contributed almost all growth in rail haulage. Road haulage is important in long distance freight transport on the north–south corridor linking cities along the eastern seaboard.

Australia's domestic freight task is expected to grow by 35% from 2018 to 2040 as a result of population growth, and increasing demand for Australian resources and produce, particularly from Asian markets.

2.8 Industry

2.8.1 Services

The Australian economy, like most developed economies, is services based. The services sector accounted for 66.9% of the total gross value added (GVA) in 2021–22 (ABS 2022c). The largest services sector in terms of value added was financial and insurance services, with $166.6 billion of GVA in 2021–22.

As of the June 2022 quarter, health care and social services employed the most people, at around 2.0 million workers (ABS 2022g). Services also play an increasingly important role in Australia's international trade. In 2020–21, education-related travel exports were worth $27.6 billion (ABS 2022f). The realised value of education-related travel exports decreased by 26.2% in 2020–21 compared with 2019–20, due to COVID-19-related travel restrictions.

2.8.2 Construction

The construction industry is the fifth largest contributor to Australia's economy, accounting for approximately 6.9% of total GVA in 2020–21 (ABS 2022c). The construction industry's share of employment and output has grown consistently since the 1990s, reflecting strong demand for mining-related construction during the mining investment boom, and more recently the expansion in residential building activity.

2.8.3 Mining

The Australian mining sector contributed approximately 10% of GDP in 2021–22 and has a strong comparative advantage internationally in several energy and mineral resource commodities. As a result, the mining sector is larger in Australia than in most other developed economies. In addition, resources and energy exports account for over 70% of Australia's export value.

Mining output fell by 0.7% in 2021–22 in real terms as a result of COVID-19 absences and heavy rainfall affecting production across a wide range of commodities. Despite this, export revenues increased due to higher commodity prices following the Russian invasion of Ukraine. Resource and energy exports are forecast to reach a record $450 billion in 2022–23, with iron ore, LNG, and metallurgical and thermal coal our largest exports by value. This will be well above the $422 billion recorded in 2021–22, which was the previous record. Higher prices are likely to drive increased investment and boost mining output in future years, potentially driving a new investment cycle for many commodities.

2.8.3.1 New energy metals and minerals

Australia currently produces almost half of the world's lithium. Over the next 5 years, Australia is forecast to produce up to one-fifth of the world's battery-grade lithium hydroxide. Australia is also a major producer of nickel (used heavily in batteries), with more than one-fifth of the world's nickel resources and producing around 200,000 tonnes a year. Australia's nickel export volumes are estimated to rise from 157,000 tonnes in 2021–22 to 202,000 tonnes in 2023–24, supported by the need for Australian nickel for the transition to low-emissions technologies (DISR 2022b). Australia is the third largest producer of raw cobalt and the eighth largest graphite reserves holder. Cobalt and graphite are used heavily in many types of batteries.

Over the longer term, the global energy transition is set to boost the demand for copper, due to its relatively heavy use in renewable energy technologies, battery storage and electric vehicles. Australia is the sixth largest mined copper producer in the world and has the second largest copper resources. Australia's copper exports are expected to grow to 977,000 tonnes by 2023–24 as production from new mines and mine expansions comes online. As output and export volumes grow, Australia's copper export earnings are projected to lift from $12.3 billion in 2021–22 to $13.9 billion in 2023–24 (DISR 2022a).

As well as lithium, Australia is the world's top producer of rutile (titanium), and the second largest producer of zircon and rare earth elements. Australia also has the world's largest reserves of rutile (titanium) and zircon (zirconium). Australia's reserves of critical minerals, including antimony, cobalt, lithium, manganese ore, niobium, tungsten and vanadium, rank in the top 5 globally (Geoscience Australia 2022). Australia's lithium export revenues are forecast to grow from $1.1 billion in 2020–21 to $13.8 billion in 2022–23. Although much of the forecast export growth is price driven, Australia's production capacity is also forecast to grow strongly over the outlook. Expected annual average growth of more than 20% a year will see production rise from 247,000 tonnes of lithium carbonate equivalent in 2020–21 to 387,000 tonnes in 2022–23 and 469,000 tonnes in 2023–24.

2.8.4 Manufacturing

In 2021–22, Australian manufacturing contributed $125 billion in GVA (ABS 2022c). Manufacturing is the seventh largest employer in Australia, employing 867,800 people (ABS 2022h). In 2021–22, manufacturing industry jobs paid more than $6,000 a year than the industry average (ABS 2022d). The manufacturing sector is also an important source of innovation, undertaking about 26% of Australia's research and development (ABS 2022k).

The manufacturing sector is an essential part of Australian supply chains. In 2019–20, almost half of Australian manufactured goods were used by Australian businesses to perform their production activities (ABS 2022b). Australian manufacturers sourced almost 80% of their inputs from other domestic industries (ABS 2022b).

As in many other developed countries, the manufacturing sector's share of output and employment in Australia has steadily declined over the past 50 years, falling from almost 30% of GDP to 5.8% in 2021–22, and from around 25% of employment to 6.4% of total employment (ABS 2022h). These trends are common across developed economies.

2.9 Waste

In 2020–21, Australia generated about 76 Mt of waste, an increase of 20% from 2006–07. Although population growth was a major contributor to the increase in waste production, on a per capita basis, waste declined by 3.3% over this time frame from 3.05 tonnes per capita in 2006–07 to 2.795 tonnes per capita in 2020–21. Approximately 63% of the total waste produced was recycled or recovered for embodied energy, an increase of 13% from 2006–07. The total waste disposed to landfill in 2020–21 was about 28 Mt.

All levels of government in Australia have established waste policies and programs.

At the national level, the Australian Government, and all state and territory governments have agreed to a National Waste Policy (2018). This policy is implemented through the National Waste Policy Action Plan (2019), which guides investment and supports policy reform to better manage Australia's waste and resource recovery.

The state and territory governments have the primary policy and legislative responsibility for waste management within their jurisdictions.

2.9.1 Waste sources

The Australian Government produces biennial National Waste Reports that provide data and information on Australia's waste generation, recovery, and fate for all waste streams and various material categories.

Much of the data included in the National Waste Reports are obtained from state and territory governments. The data are collected for monitoring and reporting by the states and territories, and mainly comprise tonnes of waste sent to landfill and various recovery operations. These data are supplemented, and sometimes replaced, by national industry data or other national estimates such as industry data on plastics recycling, ash and biosolids.

Waste sources are considered within 3 source streams: municipal solid waste from households and council operations, commercial and industrial waste, and construction and demolition waste. The reports also include 2020–21 data on commercial and industrial wastes from Australia's mining and minerals processing sectors, and organic agriculture and fisheries wastes.

In 2020–21, about 63.8 Mt or 2.48 tonnes per capita of 'core waste' (wastes managed by the waste and resource recovery sector) were generated. This is an increase from 57.5 Mt in 2016–17. The materials in this core waste included:

- 14.0 Mt of municipal solid waste from households and local government activities (543 kg per capita and 22% of the total)
- 20.8 Mt from the commercial and industrial sector (33% of the total)
- 29.0 Mt from the construction and demolition sector (45% of the total).

In 2020–21, Australia generated 14.4 Mt of organic waste consisting primarily of food, garden organics, timber and biosolids, with 6.8 Mt (47%) of this waste recycled. The resource recovery rate of 58% includes recycled waste, biosolids applied directly to land and recovered landfill gas.

In 2019–20, 6.3 Mt of packaging was placed on the Australian market, an increase of 6% from the previous year. Of this, 2.9 Mt (45%) was disposed to landfill. It is estimated that landfilled packaging contributes an additional 1.9 Mt of carbon dioxide emissions, with a lost value of $360 million.

2.9.2 Management practices

At a national level, the *Recycling and Waste Reduction Act 2020* (Cth) ('RaWR Act') sets out the framework for product stewardship arrangements in Australia, including mandatory, co-regulatory, and voluntary. 'Product stewardship' is an approach to managing products or materials in a way that reduces their environmental and human health impacts over their life cycle. It acknowledges that those involved in designing, manufacturing, and selling products have a shared responsibility for these products, including at end of life.

The *Product Stewardship (Oil) Act 2000* (Cth) creates the framework for the Product Stewardship for Oil (PSO) Scheme. The PSO Scheme pays incentives to industry to encourage the environmentally sustainable management and re-refining of used and recycled oil.

Under the RaWR Act, the responsible minister must publish a priority list each year naming products and materials that need urgent industry-led product stewardship action. The list signals that the minister may consider regulatory measures if industry does not act. The Australian Government recognises industry-led product stewardship schemes through an accreditation program. Assessments for accreditation consider how product stewardship schemes promote a circular economy, maximise the continued use of products and materials over their life cycle, and reduce harms to human health and the environment from products or materials. Accredited schemes are granted conditional use of government branding.

There is one co-regulatory scheme under the RaWR Act – the National Television and Computer Recycling Scheme, which has been in place since 2011 – and several government-accredited voluntary schemes. There is also national legislation providing product stewardship for used oil under the *Product Stewardship (Oil) Act 2000*.

Australia has a co-regulatory arrangement to manage and minimise the environmental impacts of used packaging. In 2018, environment ministers established the National Packaging Targets, which set specific goals to improve the circularity of materials across the system and reduce the amount of waste generated by 2025 or earlier.

The RaWR Act also provides for regulation of waste exports, such as waste glass, plastic and tyres, which can only be exported if they meet certain standards. Paper and cardboard waste exports will be regulated from 2024. To support development of local processing and address the capacity of existing facilities to meet increased demand, the Australian, state and territory governments have invested in recycling infrastructure funding programs. The Australian Government's Recycling Modernisation Fund is providing $250 million for new or upgraded infrastructure with funding at least matched by state and territory governments, and industry where applicable. The new infrastructure capacity is expected to sort, process, recycle and remanufacture more than 1 Mt of additional waste glass, tyres, plastic, and paper per year by July 2024.

2.10 Building stock and urban structure

Australia has experienced low-density urban development due to high availability of land and cars. In 2021, standalone houses accounted for 70% of Australian homes, and semidetached, row housing, town houses, flats and apartments accounted for 29%.

Of the 10.8 million dwellings in Australia in 2021, the vast majority were owned outright or with a mortgage (63%); 81% of households had a single family living in them.

In 2020–21, electricity was the main source of energy in buildings, playing an important role in residential buildings (49%), and in commercial and service-sector buildings (74%). The second largest source of energy for buildings is natural gas, accounting for a 34% share in residential buildings and 15% in commercial buildings. Wood, woodwaste, diesel, and LPG fulfilled the remaining energy demand for buildings.

Space heating and cooling is the end-use sector with the highest energy consumption, representing 41% of residential-sector energy demand in 2019. The balance of residential energy demand was 23% for water heating, 25% for appliances, 6% for cooking and 5% for lighting.

State and territory governments have responsibility for building regulation. On 26 August 2022, Australian, state and territory building ministers agreed to raise the energy efficiency provisions in the 2022 edition of Australia's National Construction Code (NCC), which is published by the Australian Building Codes Board, a joint initiative of the Australian and state and territory governments.

The key changes to the NCC are adopting a minimum energy rating standard of 7 stars and introducing an annual energy use budget. For the average new home, achieving a 7-star rating may require measures such as better insulation, higher quality glazing, and improved floor plans. Meeting the annual energy use budget will require the efficiency of the appliances used in new homes and rooftop solar and batteries to be considered for new houses and major retrofits. The energy efficiency changes for NCC 2022 also include new provisions to make it easier for people living in apartments to own electric vehicles, by requiring base infrastructure for future cabling and control points at the time of construction.

This change will commence on 1 May 2023, with a transitional period until 1 October 2023.

2.11 Agriculture

Australia's agriculture industries use about 55% of Australia's total land, farming the higher-rainfall coastal regions to the drier inland. In 2020–21, the estimated area of farms was 387 million hectares, owned or operated by 87,402 agricultural businesses in Australia. Grazing accounted for 332 million hectares or 86% of agricultural land, and cropping accounted for 32 million hectares or 8%.

Agricultural production is export oriented producing more than is required for domestic consumption. In 2020–21, the gross value of Australia's agricultural production was $73 billion (farm gate value), while the total value of agricultural exports totalled $49 billion (value at port). Australia's agricultural industries produce a range of crops, horticulture commodities and livestock, from grains, sugar, cotton, fruit, vegetables, nuts and wine grapes to dairy and beef cattle, sheep, lambs, and pigs. Wheat and beef, which are large sectors, are more export focused than dairy, horticulture, and pork.

2.12 Forests

As at 2016, Australia has 134 million hectares of forest, covering approximately 17% of the continent, and comprising 132 million hectares of native forests and 2 million hectares of commercial plantations. Australia's total forest area has increased since 2008, with a net increase of 4 million hectares between 2011 and 2016, driven by an increase in regrowth of cleared forest and a reduction in first-time forest clearing, together with an expansion of forest onto previously cleared areas, and establishment of environmental plantings and commercial plantations. A total of 46 million hectares of Australia's native forest is on land protected or managed for biodiversity conservation.

The annual area of public native forests harvested in Australia decreased by approximately 40% over the decade to 2016, to an annual average of 78,000 hectares, while production of wood from commercial plantations increased by a similar proportion over this period. These trends reflect a structural transition in the forestry industry in Australia, as existing plantations mature and native forests are increasingly reserved from production.

Clearing forest land for grazing and cropping contributes to greenhouse gas emissions, reported in Australia's greenhouse gas inventory under the land use, land-use change and forestry (LULUCF) sector. However, over the decade to 2016, sequestration of carbon dioxide in the LULUCF sector exceeded emissions, due to the growth of existing forests and the expansion of forest area.

Over the 5 years to 2016, the annual area of forest fire in Australia varied from 15 to 27 million hectares, mainly in forests across subtropical northern Australia. The annual area of fire in Australia's temperate forests is much less, but, in the Black Summer bushfires of 2019–20, a total of 8.5 million hectares of forest burned in southern and eastern Australia. Bushfires are the largest cause of year-to-year variability in emissions from Australian forests, although over time these are balanced by forest regrowth.

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3 Greenhouse gas inventory information

Key developments

In 2020, Australia's emissions per capita – 19.1 t CO_2-e per person – and the emissions intensity of its economy – 0.26 kg CO_2-e per dollar of real GDP – were at their lowest levels since reporting began in 1990. During the period 1990 to 2020, on a UNFCCC accounting basis, energy sector emissions (stationary energy, transport, and fugitive emissions from fuel extraction) accounted for the largest proportion of Australia's emissions profile. The energy sector experienced the greatest increase in emissions, followed by emissions from the industrial processes and product use sector. The LULUCF sector experienced the greatest reduction in emissions from 1990 to 2020, and changed from a net source to a net sink. Emissions from waste and agriculture also fell between 1990 and 2020.

Australia is committed to the continuous improvement of its national greenhouse gas inventory. Emissions estimates are prepared using the best available data and an inventory system that aligns estimation approaches at the facility level with those at the national and international level. Coupled with extensive and mature quality assurance (QA) and quality control (QC) processes, Australia's inventory system is designed to ensure emission estimates meet the UNFCCC quality criteria of transparency, time-series consistency, accuracy, completeness and comparability.

Since the seventh National Communication (2017) and fourth Biennial Report (2019), Australia has developed various measures to improve its national greenhouse gas inventory system and emissions estimates. These measures include the adoption of new data and methods and new source/sink categories, and the strengthening of QA and QC processes.

3.1 Overview of national emissions

Australia's net greenhouse gas emissions from all sectors decreased by 22.1% (138.3 Mt CO_2-e), from 626.3 Mt CO_2-e in 1990 to 488.0 Mt CO_2-e in 2020 under the UNFCCC accounting framework. Australia's net greenhouse gas emissions in 2020, excluding LULUCF sector emissions and removals, increased by 24.1% (102.5 Mt CO_2-e), from 425.6 Mt CO_2-e in 1990 to 528.1 Mt CO_2-e in 2020.

In accordance with National Communication reporting rules, unless otherwise stated, the greenhouse gas data in this report are consistent with Australia's 2022 National Inventory Submission, as updated as part of the September 2022 UNFCCC expert review.[1]

In addition to its annual National Inventory Submission, including the National Inventory Report (NIR), Australia publishes several supporting emissions estimates to provide more information on Australia's emissions on a regional and industry-by-industry basis. Together, these products constitute the Australian National Greenhouse Accounts (NGA; see Box 3.1).

1 The emission estimates were updated and finalised via resubmission of the Common Reporting Format tables. The update adjusted emissions from Stationary energy – Manufacturing Industries and Construction, and equated to less than 0.1% of Australia's emissions in 2019 and 2020. The update does not affect the description of emissions trends set out in the National Inventory Report 2020 or this chapter.

Box 3.1 Australia's National Greenhouse Accounts

Australia goes beyond its international emissions reporting obligations. The national inventory is captured in a suite of publicly available products called the NGA. Together they provide comprehensive, transparent information to government, the private sector and the public on Australia's greenhouse gas emissions from 1990 onwards.

The NIR is the cornerstone of the NGA. It enables Australia to meet its annual international emissions reporting obligations and provides the basis for assessing Australia's compliance with its international emissions reduction commitments. The NIR is prepared in accordance with relevant UNFCCC and Kyoto Protocol decisions, and Intergovernmental Panel on Climate Change (IPCC) guidance for emissions estimation.

In addition to the NIR, the NGA include:

- updates of Australia's National Greenhouse Gas Inventory, which provide timely information on emission trends, by sector and by gas; published quarterly
- state and territory greenhouse gas inventories; published annually
- the national inventory, broken down by economic sector rather than by UNFCCC classifications (as in this report); published annually
- an online database providing detailed greenhouse gas emissions data from the NGA, as well as emissions projections data; available at the national and state levels, and by economic and UNFCCC classifications, that can be queried through a dynamic interface and search function
- the Full Carbon Accounting Model (FullCAM). FullCAM is a key digital tool in the inventory's preparation, focused on the land sector. It has a public web interface.

The NGA are available from the website of the Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW): dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020.

3.1.1 Emission profile

In 2020, Australia's total net greenhouse gas emissions, including all sectors, were 488.0 Mt CO_2-e under the UNFCCC accounting framework (Table 3.1). Australia's net greenhouse gas emissions excluding LULUCF were 528.1 Mt CO_2-e in 2020.

Table 3.1: Australia's total net greenhouse gas emissions by sector (UNFCCC Inventory)

UNFCCC classification sector and subsector	Emissions (Mt CO_2-e)			Percentage change
	1990	2019	2020	1990–2020
1 Energy (combustion + fugitive)	293.7	431.6	415.9	41.6
Stationary energy	195.5	279.2	272.8	39.5
Transport	61.4	100.3	93.5	52.2
Fugitive emissions from fuel	36.8	52.0	49.6	34.9
Carbon capture and storage	n/a	n/a	0.01	n/a
2 Industrial processes and product use	25.9	33.4	32.7	26.4
3 Agriculture	84.9	69.8	67.8	–20.1

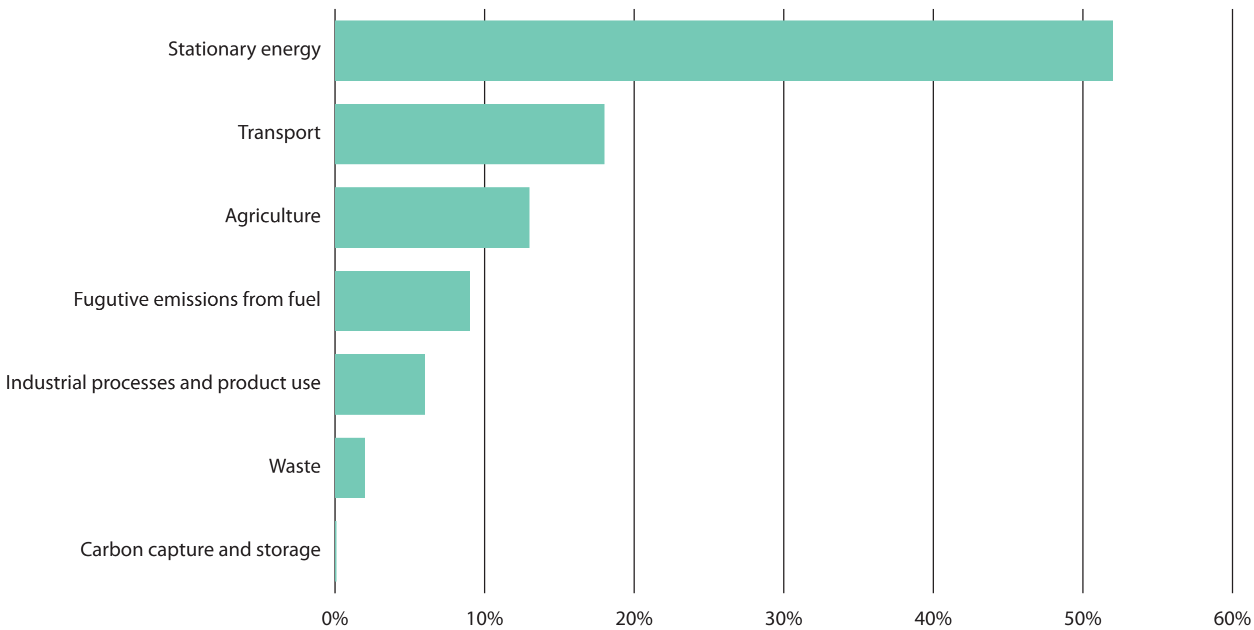
UNFCCC classification sector and subsector	Emissions (Mt CO_2-e) 1990	2019	2020	Percentage change 1990–2020
4 Land use, land-use change and forestry, *including natural disturbances provision*	200.6	−40.4	−40.1	−120.0
5 Waste	21.1	11.9	11.7	−44.5
Total net emissions	**626.3**	**506.2**	**488.0**	**−22.1**
Note: *Total net emissions without natural disturbances provision*	623.0	532.1	1,258.1	102.0

n/a = not applicable

3.1.2 Sector profile

Energy sector emissions (stationary energy, transport and fugitive emissions from fuels) account for the largest proportion of Australia's emissions profile, contributing 78.7% of total emissions in 2020 excluding LULUCF, while the agriculture sector contributes 12.8% (Figure 3.1). Emissions from the industrial processes and product use, and waste sectors were 6.2% and 2.2%, respectively, in 2020. LULUCF sector emissions and removals were a net sink of 40.1 Mt CO_2-e in 2020, representing a 5.4% reduction of Australia's total net emissions.

Figure 3.1: Contribution to total net CO_2-e emissions (excluding LULUCF) by sector, Australia, 2020



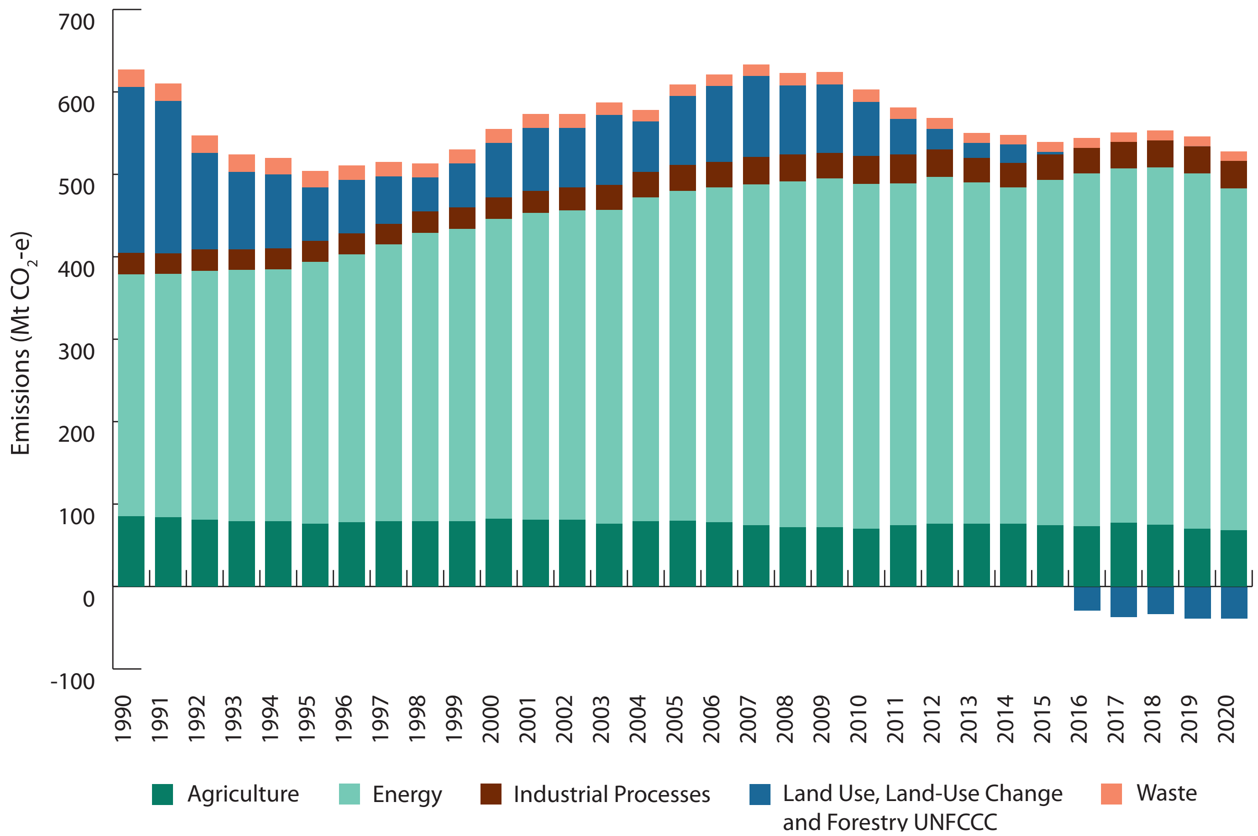
Note: LULUCF sector emissions and removals were a net sink in 2020. Please refer to Table 3.1 for further details on LULUCF emissions.
Source: DCCEEW 2022

Emissions increased during the 1990 to 2020 period for stationary energy (39.5%), transport (52.2%), fugitive emissions from fuels (34.9%), and industrial processes and product use (26.4%). Decreased emissions were recorded for waste (44.5%), agriculture (20.1%) and LULUCF (120.0%).

Figure 3.2 shows the emissions for each sector from 1990 to 2020. The principal drivers of these emission trends are as follows:

- **Energy – stationary energy.** The largest sectoral increase in greenhouse gas emissions during the 1990 to 2020 period was the 77.3 Mt CO_2-e (39.5%) increase in the stationary energy sector. This was driven in part by increasing population, household incomes, and export increases from the resource sector.
- **Energy – public electricity and heat production.** Emissions from the subsector in 2020 decreased by 39.7 Mt CO_2-e (18.7%) from the peak in 2009, despite continuing population and economic growth. This was primarily driven by a decrease in the total share of generation from coal from 85.7% in 2009 to 68.3% in 2020, and an increase in the share of generation from renewable energy in the national electricity market from 5.8% in 2009 to 23.4% in 2020, with the largest increases coming from wind and solar.
- **Energy – transport.** The main drivers for the increase in transport emissions are continuing growth in the number of passenger vehicles, an increase in diesel consumption in heavy vehicles and an increase in air travel.
- **Energy – fugitive emissions.** Emissions have increased during the period, largely due to increased production from open-cut coal mines and increased gas production. Liquefied natural gas (LNG) exports have increased significantly in recent years, increasing by 216.4% (54.2 Mt) from 2015 to 2020.
- **Industrial processes and product use.** Emissions in the industrial processes and product use sector have increased by 6.8 Mt CO_2-e (26.4%) between 1990 and 2020. The increase is primarily driven by the growth in hydrofluorocarbons (HFCs) in refrigeration and air-conditioning equipment, which replaced ozone-depleting chemicals phased out under the Montreal Protocol. Increased HFC emissions over the period from refrigeration and air conditioning were partly offset by declining emissions in other activities – specifically, metals production. Reductions in emissions from iron and steel production were due to plant closures, whereas reductions in emissions from aluminium production were due to improvements in process control and plant upgrades, as well as closures.
- **Agriculture.** Agricultural emissions have decreased by 17.1 Mt CO_2-e (-20.1%) since 1990. Climatic conditions (droughts, recovery from droughts, large seasonal differences, rainfall and floods) and economic forces (national and international markets and produce demand) both directly impact emissions from the agricultural sector. The overall decrease is primarily associated with reduced sheep numbers due to declining prices for wool in Australia following the collapse of the wool reserve price scheme. From 1995 to 2000, emissions increased due to higher beef cattle numbers and crop production, resulting in increased enteric fermentation and agricultural soil emissions. From 2000 until 2010, prolonged and widespread drought conditions over southern and eastern Australia contributed to reduced livestock populations, crop production and fertiliser use, resulting in lower emissions over this period. Emissions rose between 2011 and 2017 as Australia emerged from the Millennium Drought and farmers were able to increase herds, flocks and crop production. Drought conditions in more recent years have resulted in lower livestock numbers, and less crop production and fertiliser consumption, leading to decreases in emissions.
- **Waste.** Emissions from the waste sector have decreased by 9.4 Mt CO_2-e (-44.5%) because increases in waste generation associated with growing populations and industrial production have been offset by increased methane recovery. The majority of emissions in 2020 were from solid-waste disposal (72.6%), which improved methane recovery rates substantially over the period – from a negligible amount in 1990 to 8.4 Mt CO_2-e in 2020.
- **LULUCF.** The decrease in emissions from LULUCF since 1990 (240.8 Mt CO_2-e, –120.0%) was mainly due to lower rates of forest clearing for uses such as grazing, forest cover expansion (including post-1990 plantation establishment) and reduced harvesting of native forests.

Figure 3.2: Australia's total net CO_2-e emissions by sector, 1990–2020



Source: DCCEEW 2022

See CTF Tables 1 – 1(d) in Annex A for further data on Australia's emissions by sector. See NIR 2020 (DISER 2022) for more detailed descriptions of Australia's sectoral emissions trends.

3.2 Emissions by greenhouse gas type

In 2020, carbon dioxide (CO_2) accounted for 70.4% of Australia's total emissions (including LULUCF), followed by methane (CH_4; 22.6%) and nitrous oxide (N_2O; 4.6%) (Table 3.2). Other greenhouse gases made up the remaining 2.4% of Australia's inventory.

Table 3.2: Australia's total net greenhouse gas emissions by gas type (UNFCCC Inventory)

	1990		2020		Change
Greenhouse gas	**Emissions ($Mt CO_2$-e)**	**Percentage of total**	**Emissions ($Mt CO_2$-e)**	**Percentage of total**	**Emissions ($Mt CO_2$-e)**
Carbon dioxide (CO_2)	454.2	72.5	343.7	70.4	–110.5
Methane (CH_4)	144.9	23.1	110.1	22.6	–34.8
Nitrous oxide (N_2O)	20.9	3.3	22.3	4.6	1.4
Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3)	6.3	1.0	11.9	2.4	5.7
Total CO_2-e emissions	**626.3**	**100.0**	**488.0**	**100.0**	**–138.3**

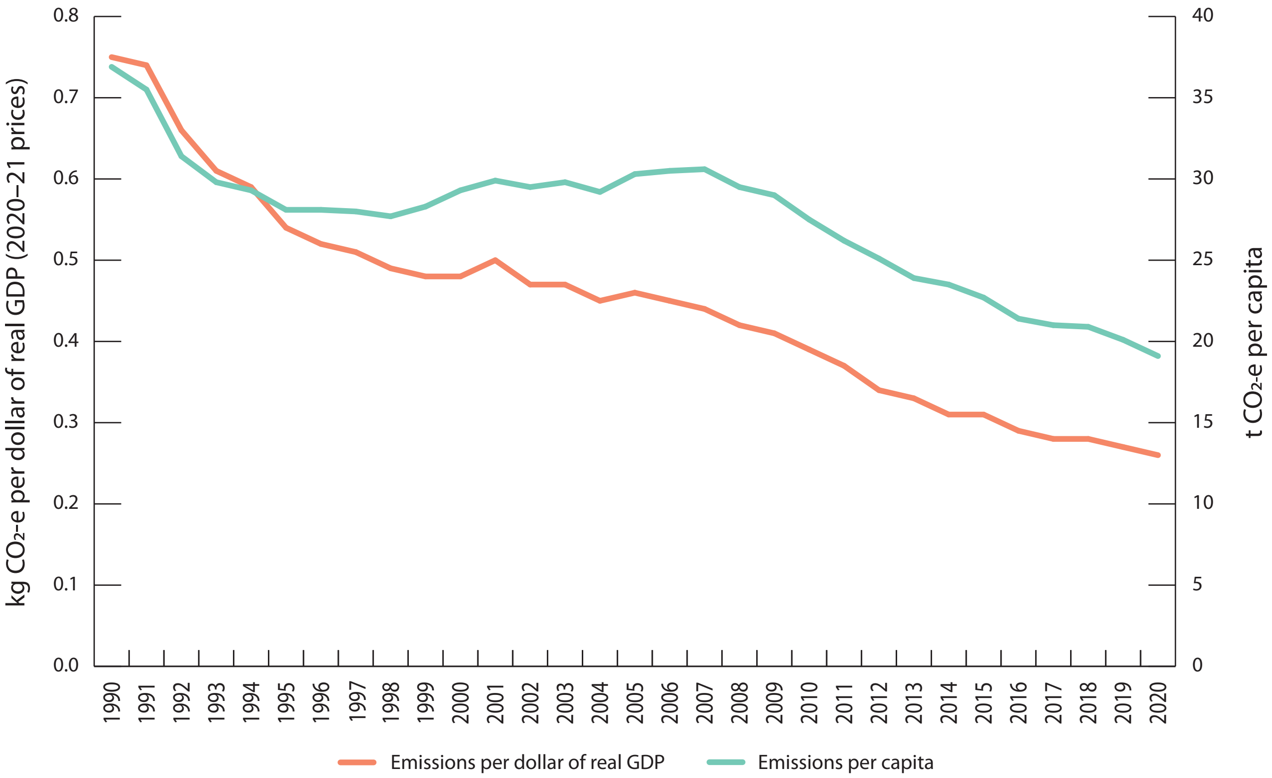
3.2.1 Australia's emissions intensity and emissions per capita

Australia's emissions per capita and per dollar of GDP are significantly lower than they were in 1990 (Figure 3.3). These reductions resulted from specific emissions management actions across sectors, the large reduction in land-use change emissions over the period and structural changes in the economy.

Australia's population grew strongly between 1990 and 2020 from 17.1 million in 1990 to around 25.7 million in 2020 (growth of 50.5%). Emissions per capita (based on the national inventory total) fell from an estimated 36.9 t CO_2-e per person in 1990 to 19.1 t CO_2-e per person in 2020, a 48.3% reduction.

Australia's GDP (chain volume measures) also grew over this period, from $838 billion in 1990 to around $1,981 billion in 2020 (growth of 136.4%). The economy's emissions intensity, based on the national inventory total, fell from 0.75 kg CO_2-e per dollar in 1990 to 0.26 kg CO_2-e per dollar in 2020, a 65.4% reduction.

Figure 3.3: Australia's emissions intensity and emissions per capita, 1990–2020



Sources: Emissions data from DCCEEW 2022; GDP chain volume measures from ABS 2022a; population from ABS 2022b

3.3 National inventory systems

In accordance with the guidelines for national systems (decision 19/CMP.1 annex paragraph 12(a) and decision 3/CMP.11), the responsibility for Australia's national inventory was assigned to a single agency, DCCEEW in 2022. This responsibility includes all aspects of activity data coordination, emissions estimation, QC, improvement planning, preparation of reports, and submission of reports to the UNFCCC on behalf of the Australian Government.

Since the seventh National Communication, the Australian Government enacted changes to the make-up of government departments. These changes included shifting the national inventory functions from the former Department of the Environment and Energy to the Department of Industry, Science, Energy and Resources in 2020, and then to DCCEEW in 2022.

The designated representative with overall responsibility for the national inventory is:

Assistant Secretary
National Inventory Systems and International Reporting Branch
Department of Climate Change, Energy, the Environment and Water
Australian Government
GPO Box 3090
Canberra ACT 2601
AUSTRALIA

Email: nationalgreenhouseaccounts@industry.gov.au

3.3.1 Coverage

Australia's inventory covers sources of greenhouse gas emissions resulting from human (anthropogenic) activities, and removals by sinks, grouped under the 5 sectors identified by the IPCC:

- energy (including stationary energy, transport and fugitive emissions from fuels)
- industrial processes and product use
- agriculture
- LULUCF
- waste.

The inventory covers the major greenhouse gases: CO_2, CH_4, N_2O, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Indirect greenhouse gases covered in ancillary fashion for reporting under the UNFCCC are carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic compounds. Sulfur dioxide (SO_2), an aerosol precursor, is included because emissions of this gas influence global warming.

Geographical coverage of the Australian inventory includes the 6 states (New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia), mainland territories (Australian Capital Territory, Jervis Bay Territory and Northern Territory), associated coastal islands, and external territories (Ashmore and Cartier Islands, Christmas Island, Cocos Islands, Coral Sea Islands, Heard and McDonald Islands, and Norfolk Island). Australia's Antarctic Program operations in the Antarctic are also covered.

3.3.2 Data sources

Data collection to support the preparation of Australia's inventory is managed centrally by DCCEEW, using a mix of approaches to ensure the reliable flow of data from other entities.

3.3.2.1 National Greenhouse and Energy Reporting scheme

Australia's mandatory national reporting system for companies is among the most comprehensive data collection systems for national greenhouse gas inventories in the world.

The legislative framework for the mandatory National Greenhouse and Energy Reporting (NGER) scheme was established through the *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act). The NGER scheme supports Australia's international inventory reporting obligations, and incorporates robust measurement, reporting and verification arrangements to provide confidence in the quality of collected data. The NGER Act and its subordinate legislation are available at cleanenergyregulator.gov.au.

Under the NGER scheme, companies whose energy production, energy use, or greenhouse gas emissions from the energy, industrial processes and product use, and waste sectors meet certain thresholds must report facility-level data to the Clean Energy Regulator (CER), a statutory agency of the Australian Government. The NGER scheme provides activity data inputs, such as fuel combustion, emissions factors at facility level and, in some cases, directly measured emissions.

Annual reports have been submitted by companies under the NGER scheme for Australian financial years since 2008–09. These data are used in the preparation of the national inventory.

The rules for the estimation of activity data, emissions factors and emissions by companies are well specified and set out in the National Greenhouse and Energy Reporting (Measurement) Determination 2008. For further detail on the Determination, see section 1.4.2 of Volume 1 of the NIR 2020.

DCCEEW has policy and legislative oversight of the NGER scheme. The CER manages the process of input data collection from companies, data verification and auditing, and disseminating these data to government agencies. The CER's Emissions and Energy Reporting System is used to collect the data.

The NGA framework guides the approach to company and facility emission estimation methodologies to ensure consistency among the relevant accounts: national, state and territory, industry, company and facility-level inventories. Company and facility emission estimation methodologies are designed to be consistent with national inventory methods, which in turn are consistent with the *2006 IPCC guidelines for national greenhouse gas inventories* (IPCC 2006). This integration of the estimation methods and data is critical for ensuring that changes in emissions at the facility level are captured efficiently and accurately in the national inventory. The default methods used by companies are derived from the national inventory methods, while the default emissions factors are derived using the Australian Greenhouse Emissions Information System (AGEIS) (see section 3.3.4).

As part of Australia's commitment to continuously improve its national inventory, the Determination is reviewed annually by DCCEEW. The reviews ensure that the NGER scheme aligns with Australia's international reporting obligations, and identifies options to improve the consistency, cost-effectiveness and accuracy of the methods available to estimate emissions. Proposed amendments to the Determination are customarily subject to public consultation.

Since the seventh National Communication, the Climate Change Authority (CCA) reviewed the operation of the NGER Act and its supporting legislative instruments in 2018. The CCA is an independent statutory agency that provides expert advice to the Australian Government on climate change policy. The CCA is required to review the operation of the NGER legislation every 5 years. In coming to its findings for the 2018 review, the CCA consulted widely with industry, government agencies and data users, and undertook its own research and analysis.

The CCA found that the NGER reporting system is working well, is fit for purpose and, in its current form, has strong support from industry, governments and others. More specifically, it found that the NGER scheme:

- generates a high-quality dataset that is accurate, has broad coverage and compares favourably against international schemes
- informs government energy and emissions policies, programs and activities at the Australian and state and territory levels
- uses approaches to measuring energy and emissions that are fit for purpose
- helps companies better understand their energy and emissions, and meet other reporting requirements
- informs investors and others, such as academics and analysts
- reduces duplication in reporting of emissions and energy across jurisdictions and minimises the regulatory burden on businesses.

The *Review of the National Greenhouse and Energy Reporting legislation – final report* is publicly available on the CCA's website at climatechangeauthority.gov.au/publications/review-national-greenhouse-and-energy-reporting-legislation-final-report.

The Australian Government's response to the review is available at dcceew.gov.au/about/reporting/obligations/government-responses/cca-review-nger.

3.3.2.2 Other data sources

NGER scheme data are the main source of energy, industrial processes and product use, and waste data used to compile the national inventory. They are supplemented by other published data sources only when necessary, with a strong reliance on data collected and published by Australia's principal economic statistics agencies – the Australian Bureau of Statistics (ABS), and the Australian Government Department of Industry, Science and Resources. These organisations have collected energy statistics for more than 40 years and use these data to meet Australia's reporting commitments to the International Energy Agency. The ABS is the national statistical agency with legislative backing for its collection powers. In conjunction with the Australian Bureau of Agricultural and Resource Economics and Sciences, the ABS is the major source of agricultural activity data.

Satellite imagery that is processed to determine land-cover change for the LULUCF sector is sourced from Geoscience Australia, Australia's principal satellite ground station and data processing facility. Data to support estimates of HFCs are sourced from compulsory reporting by importers under licensing arrangements under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (Cth). Solid-waste disposal data are provided by the Environmental Protection division of DCCEEW. Disposal data are collected annually as part of the National Waste Reporting initiative.

3.3.3 Estimation methods

The Australian approach to estimating greenhouse gas emissions and sinks uses a combination of country-specific and IPCC methodologies and emission factors. These methods are consistent with the IPCC 2006 guidelines and the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* (IPCC 2014a).

In general, Australia's national inventory uses a mix of tier 2 and tier 3 estimation methods, incorporating:

- facility-specific emission estimation processes
- characterisations of the capital and technology types at the point of emission
- dynamic relationships linking current emissions outcomes with the activity levels of previous years
- spatial differences in emissions processes across Australia.

The additional complexity in this approach allows emissions to be estimated more accurately. The full description of the methodologies used by Australia in emissions estimation is provided in the most recent NIR.

3.3.4 Supporting inventory systems

Estimation of emissions uses 2 customised digital information technology assets: AGEIS and, for the LULUCF sector, FullCAM (Figures 3.4a and 3.4b).

AGEIS was introduced to the inventory production process in 2005. It was designed to meet the Kyoto Protocol requirements for national inventory systems and is an integral part of the inventory preparation and publishing processes. The AGEIS software incorporates the emissions estimation methods used for the national inventory and associated QC procedures. It centralises emissions estimation, inventory compilation and reporting, and data storage activities. AGEIS supports high transparency levels for Australia's NGA, with emissions data publicly accessible through an interactive web interface: greenhouseaccounts.climatechange.gov.au.

AGEIS is continuing to be expanded and refined to support the range of NGA. Recent investment includes development to support emission estimation in accordance with Paris Agreement requirements, progressive integration of models to estimate Australia's emissions projections, and work to integrate quarterly emission estimation models into AGEIS.

While AGEIS is used for final preparation of Australia's NGA, the inventory uses FullCAM to estimate emissions and removals from the LULUCF sector and Kyoto Protocol LULUCF activities. FullCAM's spatially explicit, process-based ecosystems modelling capability continues to be updated by applying techniques described in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* (IPCC 2014a) and with national datasets.

FullCAM's modelling capability has been updated for:

- conversion of forests to other land uses (cropping and grazing)
- conversion of lands to forest
- croplands remaining croplands; cropland management
- the grassland component of grasslands remaining grasslands
- grazing land management
- the fire and harvesting components of native forests and plantations in forests remaining forests
- the growth and dieback or clearing of mangrove forests as a subset of forest conversions.

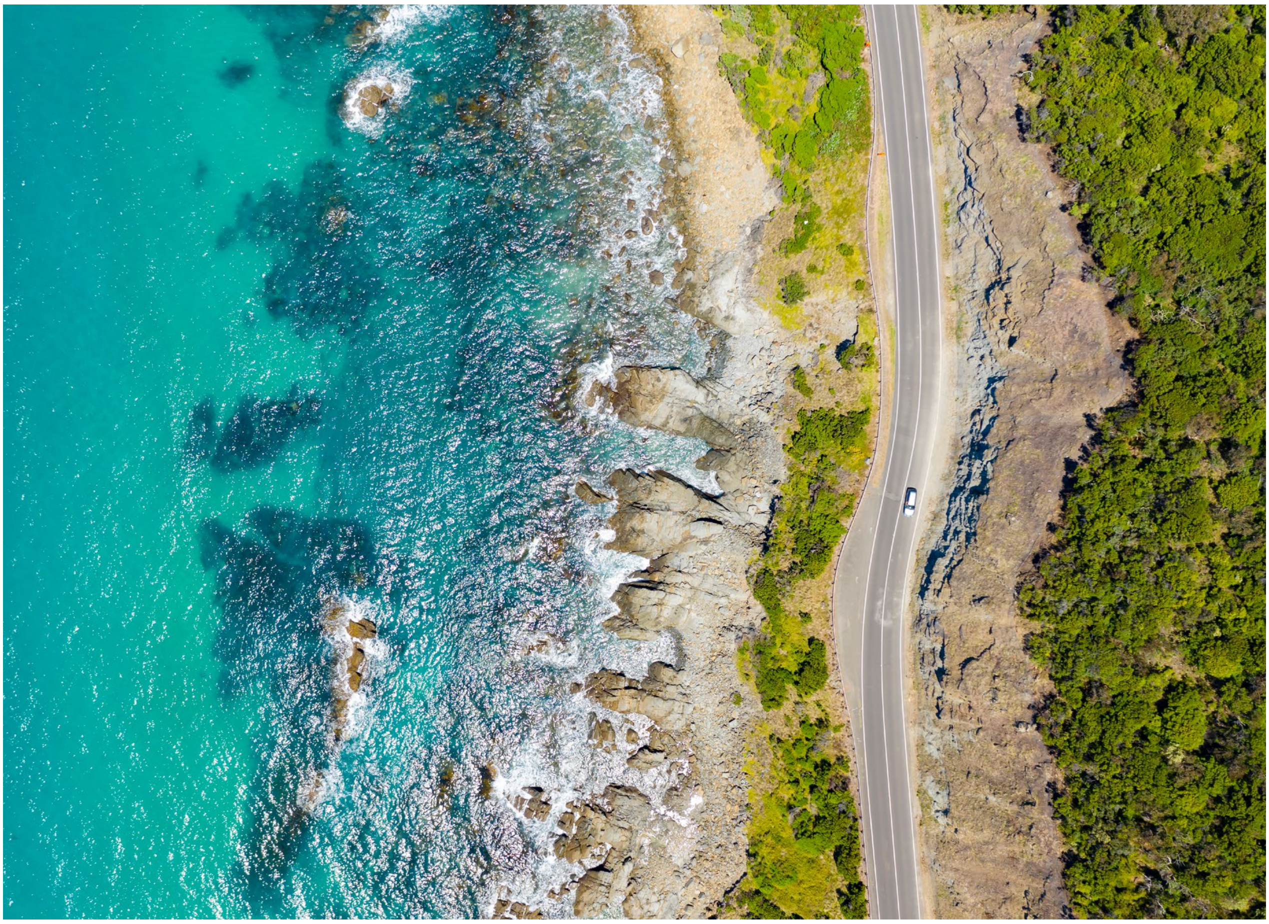
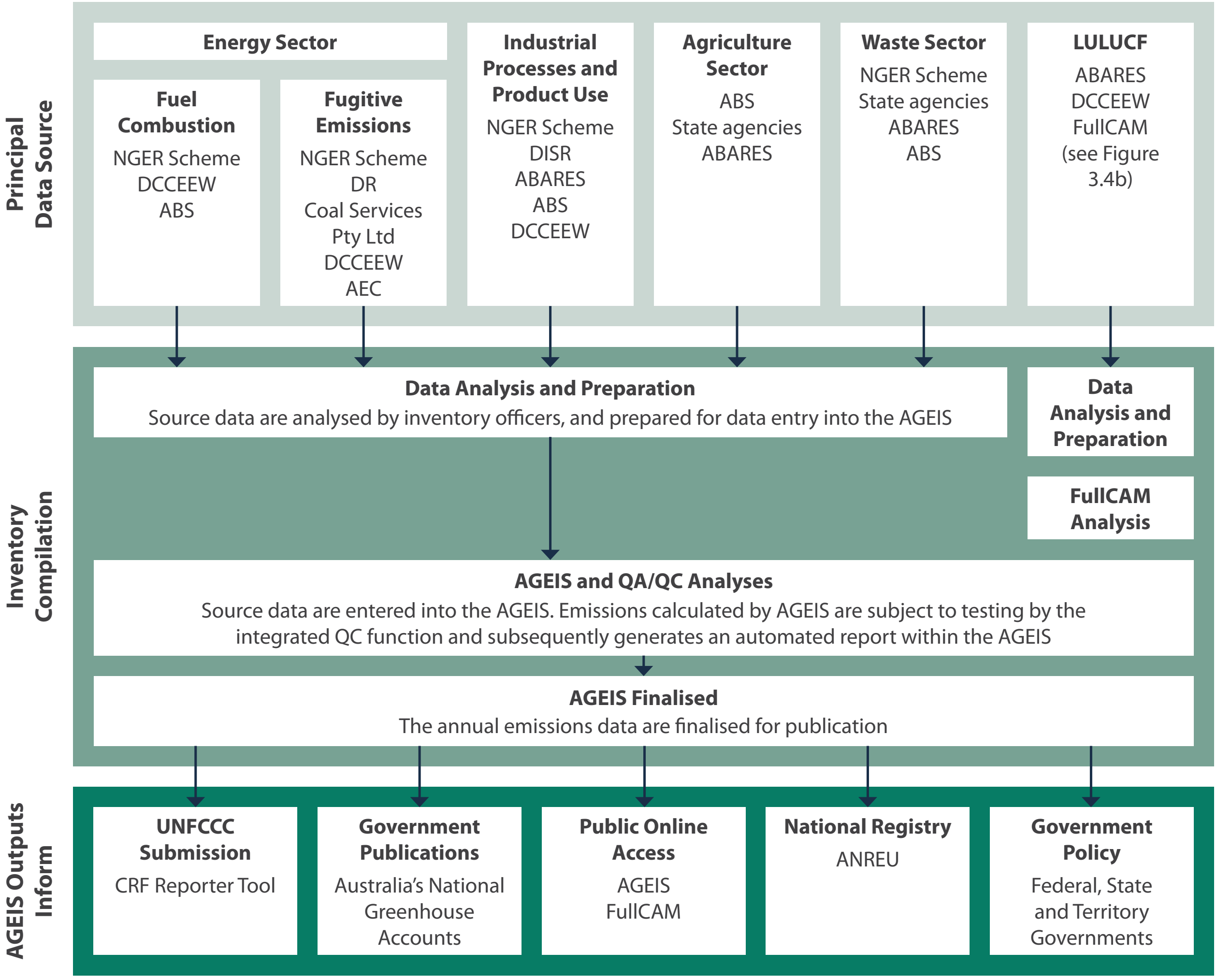


Figure 3.4a: Department of Climate Change, Energy, the Environment and Water inventory asset structures and relationships, AGEIS, December 2022

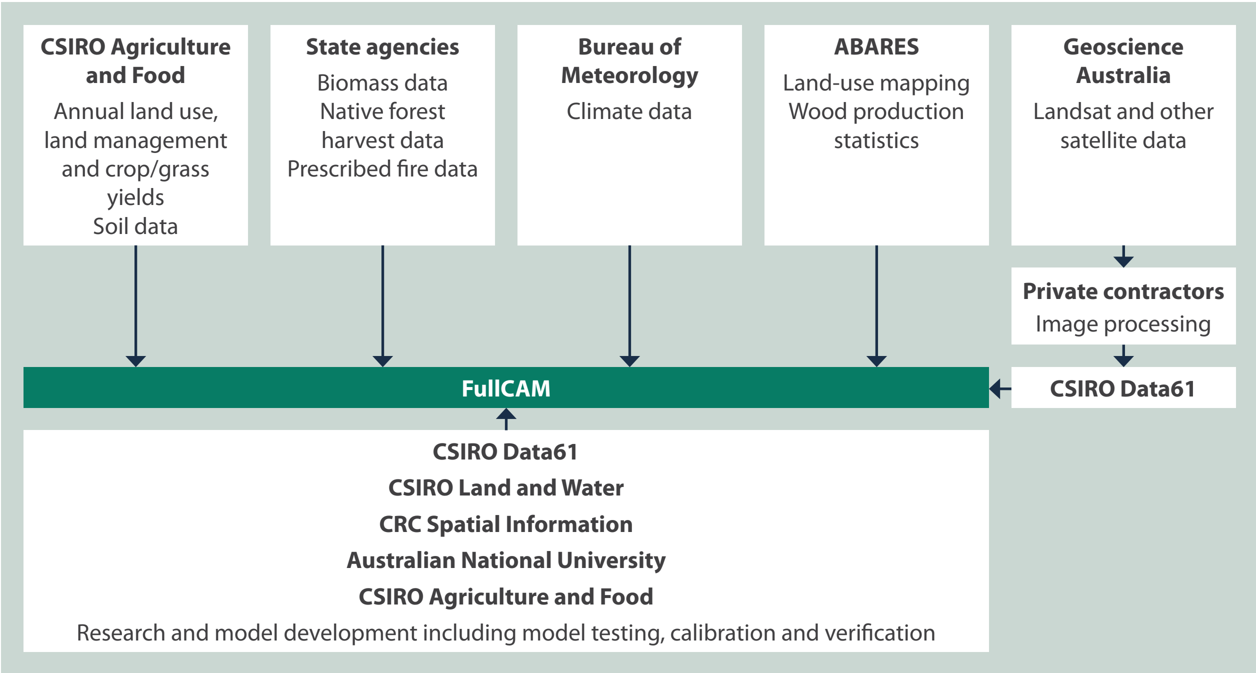


Acronym Key

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
AEC	Australian Electoral Commission
AGEIS	Australian Greenhouse Emissions Information System
ANREU	Australian National Registry of Emissions Units
Bureau	Bureau of Meteorology
CRC	Cooperative Research Centres
CRF	Common Reporting Format
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DISR	Department of Industry, Science and Resources
DR	Department of Resources (Queensland)
FullCAM	Full Carbon Accounting Model
LULUCF	Land use, land use change and forestry
NGER	National Greenhouse and Energy Reporting
QA	Quality assurance
QC	Quality control

Note: These asset structures and relationships are correct as at December 2022. For information on the asset structures and relationships when NIR 2020 (DISER 2020) was submitted in May 2022, please refer to Chapter 1 of NIR 2020.

Figure 3.4b: Department of Climate Change, Energy, the Environment and Water, FullCAM institutional arrangements, December 2022



DCCEEW staff and external consultants used by DCCEEW have extensive experience in inventory preparation. The department aims to maximise the number of staff with UNFCCC reviewer training and participation in UNFCCC expert review processes. All senior technical staff are qualified reviewers and have been accepted onto the UNFCCC Roster of Experts. Where particular technical expertise is not available within DCCEEW, expert consultants are engaged to undertake analysis and review work.

3.3.5 Quality assurance and quality control

Australia's national inventory is subject to mature and extensive QA and QC processes. These measures conform to IPCC guidelines and supplementary methodologies.

QA/QC processes for Australia's national inventory systems are outlined in the National Inventory Systems: Quality Assurance–Quality Control Plan and summarised in Australia's NIR 2020 (DISER 2022). These processes contribute to the production of accurate inventories. Uncertainties are reduced to the extent practicable, and estimates are transparent, documented, consistent over time, complete and internationally comparable.

Australia's key QC controls have been systematically built into the operation of AGEIS. Auditable checks are undertaken to reduce the risks of errors associated with activity data input, missing data, recalculations and the time series consistency of generated emission estimates. Input data and implied emission factors are checked for recalculations and time-series consistency before submission using AGEIS and the preparation of Common Reporting Format tables.

Systems have been established to monitor the outcomes of QA/QC risk mitigation strategies and control measures, principally managed through the AGEIS. Each year, evaluation of data collected under the monitoring systems is undertaken and documented. Following consideration of this document, planned improvements to the inventory are also documented in a National Inventory Systems: Inventory Improvement Plan.

Since the seventh National Communication and fourth Biennial Report, additional QA/QC activities and procedures have been implemented as identified in Australia's NIR 2020. These include:

- improvements to functionalities within the AGEIS to achieve efficiencies in the QC process, mitigate the risk of transcription errors, and improve workflows and data integrity

- improvements in transparency for revised data used in the recalculation process
- review of the carbon and energy balances as reported in the NIR
- review of the operation of the NGER Act and its supporting legislative instruments by the CCA in 2018
- review of wastewater emissions from abattoirs and other meat processing facilities and the inclusion of emissions from seafood processing by an external adviser in 2021.

3.3.5.1 Process for national consideration and approval of the inventory

Australia's draft NIR is considered by the National Greenhouse Gas Inventory Committee, which comprises representatives of the Australian, state and territory governments. Key domestic users of national inventory data are engaged in the formal review arrangements through the National Greenhouse Gas Inventory User Reference Group. This group includes Australia's premier science organisations, academics, sectoral experts from the consulting sector and industry representatives. The committee and the group meet up to twice per year.

The National Greenhouse Gas Inventory Committee and the National Greenhouse Gas Inventory User Reference Group are the principal mechanisms for formal external review of the report before its release. The release of each year's inventory and submission to the UNFCCC is approved by the deputy secretary of DCCEEW.

3.3.6 Recalculation of previously submitted inventory data and continuous improvement

Inventory estimates are periodically recalculated. This occurs for various reasons, including updated UNFCCC reporting guidelines, revisions in key external data sources, and revisions to data due to refinements in the estimation methodology or the inclusion of additional sources. Emissions estimates are recalculated for all previous years to ensure the accuracy of the estimates and to maintain consistency of the time series. These recalculations are conducted in accordance with the IPCC 2006 guidelines.

Consistent with Australia's commitment to continuous improvement, since the seventh National Communication and fourth Biennial Report, Australia has:

- implemented several land sector model improvements, as well as improvements in the oil and gas; coal-mine fugitives; and product uses as substitutes for ozone-depleting substances subsectors. The adoption of advanced methods, estimation and calibration techniques have increased the level of confidence in the sectors' emissions estimates
- continued to implement aspects of the IPCC 2013 wetlands supplement (IPCC 2014b) into the national inventory, including activity-based emissions for tidal marsh removal, seagrass, aquaculture and mangrove forest
- improved the national inventory system through strengthening of the planning, documentation and QC systems.

The inventory has progressively incorporated more facility-specific data obtained under the NGER scheme. Recalculations flowing from the change are identified and incorporated in Australia's NIRs. Detailed descriptions of any recalculations are included each year in those reports.

3.4 National registry

The Australian National Registry of Emissions Units (ANREU) is a system designed to meet one of Australia's commitments under the Kyoto Protocol. The Kyoto Protocol requires each country with an emissions reduction target to establish a national registry to ensure accurate accounting of the issuing, holding, transfer, acquisition, cancellation, retirement and carryover of Kyoto units.

The ANREU was initialised with the International Transaction Log on 19 December 2008. Since this date, the ANREU has been subject to annual independent assessments under Article 8 of the Kyoto Protocol. Each assessment has found that it continues to perform the functions, and adheres to the technical standards, adopted under the Kyoto Protocol. The independent assessment reports of Australia's ANREU are available on the UNFCCC website.

Organisations or individuals wanting to hold Kyoto units in Australia are required to have an ANREU account. The Australian Government authorises legal entities to transfer and acquire Kyoto units using the ANREU. Each entity is required to comply with the applicable provisions of the Kyoto Protocol and the decisions of the parties to the Protocol, including decision 11/CMP.1 'Modalities, rules and guidelines for emissions trading under Article 17 of the Kyoto Protocol'. This decision, along with decision 13/CMP.1 'Modalities for the accounting of assigned amounts under Article 7, paragraph 4 of the Kyoto Protocol' as amended by decisions 3/CMP.11 and 4/CMP.11, provides the basis for the rules underpinning the operation of the ANREU. The *Australian National Registry of Emissions Unit Act 2011* (Cth) and the Australian National Registry of Emissions Unit Regulations 2011 (ANREU Regulations) regulate the management and operation of the ANREU.

The ANREU is administered by the CER. The ANREU website is nationalregistry.cleanenergyregulator.gov.au.

Decisions under the Kyoto Protocol require Australia to maintain and make available through ANREU a list of entities authorised by the Australian Government to participate in international emissions trading. Australia is required to make certain information publicly available and to provide an online publicly accessible user interface to allow people to query and view the information. This can be found at nationalregistry.cleanenergyregulator.gov.au/report/listPublicReports.

Publicly available information includes:

- all authorised ANREU account holders
- current holdings of eligible Kyoto Protocol emission units for each authorised account
- the type of account (holding, cancellation or retirement)
- the commitment period for cancellation or retirement accounts
- account representative details for each account.

Personal information of account-authorised representatives is confidential and is not published in accordance with decision 13/CMP.1 paragraph 44 as amended by decision 3/CMP.11 and Regulation 50 of the ANREU Regulations.

The ANREU is not operated in a consolidated system with any other party's registry.

3.4.1 Name and contact information for the ANREU

Steven Stolk
Registry System Administrator
Clean Energy Regulator
GPO Box 621
Canberra ACT 2601
Australia

Tel: +61 2 6159 3100
Email: cer-registrycontact@cer.gov.au

3.4.2 Database structure and capacity of the ANREU

For a description of the database structure and capacity of the ANREU, see Volume 3, Annex 7 of Australia's NIR 2020. Recent changes to the ANREU are set out in Volume 3, Chapter 14 of the NIR 2020.

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4 Policies and measures

Key developments

Since the seventh National Communication, Australia has strengthened its policies to reduce greenhouse gas emissions and renewed its commitment to global climate action. Australia has legislated its emission reduction targets of at least 43% on 2005 levels by 2030 and net zero by 2050, consistent with its updated Nationally Determined Contribution under the Paris Agreement. The Australian Government has also restored the Climate Change Authority to independently assess and publish progress on Australia's climate action and targets.

On 1 December 2022, the Minister for Climate Change and Energy delivered the first Annual Statement on Climate Change to the Australian Parliament and committed to develop a net zero by 2050 plan. The plan will show Australia's pathway to net zero emissions by 2050.

The Australian Government is implementing climate policy initiatives designed to create jobs, cut power bills and reduce emissions by boosting renewable energy, including:

- a National Energy Transformation Partnership to achieve net zero emissions in the electricity system by 2050 and reach 82% renewable electricity by 2030.
- $157.9 million to deliver a suite of measures to support the secure and sustainable transformation of Australia's energy system
- $20 billion investment to upgrade the electricity grid to manage more renewable energy
- reforms to the Safeguard Mechanism that ensure that Australian industry reduces emissions consistent with our net zero commitments while remaining internationally competitive
- introducing climate reporting standards for financial institutions and large publicly listed companies
- support for new and emerging low-emissions technologies including hydrogen electrolysers, fuel switching, green metals, clean energy component manufacturing, reducing fugitive emissions and agricultural methane reduction and waste reduction
- $200 million investment in new community batteries across Australia to help lower energy bills, support the grid and maximise the benefits of Australia's rooftop solar transformation
- $100 million to establish solar banks around Australia, providing access to solar for around 25,000 households who are unable to install rooftop solar, including renters, people living in apartments, and low-income households
- $75 million to develop and deploy microgrid technology across First Nations communities, to increase access to cheaper, cleaner and more reliable energy
- developing Australia's first National Electric Vehicle Strategy.

These policies will help Australia meet its international emission reduction commitments. Many of the policies outlined in this chapter are at an early stage of implementation. Specific abatement estimates will depend on the exact design of each measure once implemented.

4.1 Policymaking process

4.1.1 Climate change policymaking responsibility

In Australia, all levels of government design, develop and implement climate change policies and measures (see also section 2.1).

The *Climate Change Act 2022* (Cth) provides a framework for Australia's national climate ambition and incorporates Australia's nationally determined contributions into Australian law. Key policies that are being implemented to achieve Australia's 2030 target include

- accelerating renewable electricity driven by initiatives at national and state and territory levels,
- the Safeguard Mechanism (targeting emissions from the country's largest industrial facilities),
- a comprehensive National Electric Vehicle Strategy and
- climate reporting standards for large publicly listed companies and large financial institutions.

These are complemented by policies across the energy, industrial, agricultural/land use and waste sectors, driving a whole-of-government effort at the national level to reach net zero emissions by 2050.

States and territories also pursue their own policies and targets that reflect the different characteristics of each jurisdiction. All states and territories have a target of net zero emissions by 2050 or earlier (see Table 4.2). Supporting policies include renewable energy programs, land-use controls (including planning zones to facilitate renewable energy projects), and regulations to encourage both recycling of waste and energy efficiency. Most state and territory governments, and many local councils, have set renewable energy targets and emission reduction goals.

The Australian, state and territory governments maintain links to share knowledge, resolve policy issues and collaborate on industry and community engagement. Ministerial-level discussions on climate change occur regularly through the Energy and Climate Change Ministerial Council. Federal, state and territory environment ministers meet at the Environment Ministers Meeting, which considers waste policy, including its relationship to climate policy.

4.1.1.1 Energy and Climate Change Ministerial Council

There have been several changes to intergovernmental arrangements in Australia since 2017 (see also section 2.1). In May 2020, the Energy National Cabinet Reform Committee (ENCRC) and the Energy Ministers' Meeting (EMM) were established to replace the former Council of Australian Governments (COAG) Energy Council following the disbandment of COAG (DCCEEW 2022a). The ENCRC and EMM were ministerial forums for the Australian and state and territory governments, and New Zealand, to work together on issues of national significance and key reforms in the energy sector.

Energy ministers have oversight of the 3 energy market institutions responsible for the operation of national energy markets and accelerating the deployment of renewable energy. The energy market bodies also collaborate through the Energy Security Board (see section 2.6.1) as the National Electricity Market transitions.

Energy ministers work closely with Energy Consumers Australia (ECA). ECA promotes the long-term interests of consumers with respect to the price, quality, safety, reliability and security of supply of energy services. This engagement helps ensure that the impact of the transition to renewables is minimised on consumers.

In 2022, National Cabinet agreed to form the Energy and Climate Change Ministerial Council by adding climate change to the name and scope of the EMM to reflect the level of coordination needed across the energy, climate change and adaptation policy areas to meet emissions targets and transition to net zero. The National Energy Transformation Partnership is a key priority of energy ministers, and reflects a shared agreement across the Australian, state and territory governments to work collaboratively on reforms to support the transformation of Australia's energy system to net zero.

4.1.1.2 Environment Ministers Meeting

The Environment Ministers Meeting comprises the Australian Minister for the Environment and Water and the environment minister from each Australian state and territory. It replaced the Meeting of Environment Ministers in 2020. This new forum has the same membership but a clearer focus than its predecessor, in keeping with the wider changes to Australia's intergovernmental forums recommended by the Conran Review. In April 2021, ministers agreed to pursue key national priorities for the next 12 months as part of a streamlined work program, and to develop a workplan that will achieve these outcomes (Conran 2020; DCCEEW 2021).

This group continues to have responsibility for advancing matters such as the National Waste Policy Action Plan (DCCEEW 2019a). In October 2022, ministers agreed that the National Waste Policy Action Plan will be expanded over the coming year to strengthen Australia's efforts towards our 2030 targets (DCCEEW 2022b).

4.1.1.3 National portfolio arrangements

In 2022, the Australian Government combined climate change, energy, environmental and water policy responsibility under a single agency, the Department of Climate Change, Energy, the Environment and Water (DCCEEW). This agency is now also responsible for international negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) (DPMC, 2022).

Between 2016 and 2019, energy and environment functions (including climate change mitigation and adaptation) were administered by the Department of the Environment and Energy. Between 2019 and May 2022, energy and climate mitigation functions were administered by the Department of Industry, Science, Energy and Resources, with climate science and adaptation functions administered by the Department of Agriculture, Water and the Environment. Before 2022, international negotiations under the UNFCCC were managed by the Department of Foreign Affairs and Trade.

There are 2 other agencies that support climate policy governance within the portfolio:

- The Climate Change Authority (CCA), created on 1 July 2012, is an independent statutory agency established by the *Climate Change Authority Act 2011* (Cth) ('CCA Act'). The CCA provides independent, expert advice to the Australian Government on climate change policy.
- The Clean Energy Regulator (CER) is an independent statutory authority established on 2 April 2012 under the *Clean Energy Act 2011* (Cth). It is responsible for administering schemes legislated by the Australian Government for measuring, managing, reducing or offsetting Australia's carbon emissions. This includes the Australia's carbon crediting scheme (previously known as the Emissions Reduction Fund), National Greenhouse and Energy Reporting System, Australian National Registry of Emissions Units, Safeguard Mechanism and Renewable Energy Target.

4.1.2 Monitoring and evaluation

Australia's national policies and measures are developed based on expert advice and continuous consultation with industry and the community. In addition, bodies such as the CCA and the Australian National Audit Office (ANAO) have key roles in ensuring policies are working effectively. ANAO conducts performance audits and audits of the performance measures of Commonwealth entities and Commonwealth companies and their subsidiaries.

4.1.2.1 Annual Statement to Parliament

The *Climate Change Act* requires the responsible minister to deliver an annual statement to Parliament on progress towards Australia's 2030 and 2050 emissions targets and international developments. The statement must also cover the effectiveness of the Australian Government's policies in contributing to national targets, the impact of emissions policy on rural and regional Australia, and risks to Australia from climate change impacts, such as those relating to Australia's environment, biodiversity, health, infrastructure, agriculture, investment, economy and national security. The Act requires that the minister consider the CCA advice.

These requirements enhance transparency and accountability in government action on climate change, and confirm the important role of independent expert advice. This will also help inform public debate.

The Act also requires that the minister ensure periodic independent reviews of the operation of the Climate Change Act are conducted. The first review is to be within 5 years of commencement, and then every 10 years after the completion of the first review. This will ensure the legislation remains fit for purpose as the international response to climate change evolves and Australia continues its transformation into a net zero emissions economy.

As part of the first Annual Statement to Parliament in December 2022, the Australian Government agreed with the CCA's advice that it should develop a plan showing Australia's pathway to net zero emissions by 2050. This will include Australia's 2035 emissions reduction target, and the priority policies to achieve it and ensure Australia remains on track to net zero.

4.1.2.2 Climate Change Authority reviews

The CCA periodically undertakes reviews of relevant legislation:

- The *Carbon Credits (Carbon Farming Initiative) Act 2011* (Cth) and associated instruments, which enable Australia's carbon crediting scheme. The CCA published its third legislative review of the Act in 2020 (CCA 2020). The fourth review of this Act is due for completion by 31 December 2023.
- The *National Greenhouse and Energy Reporting Act 2007* (Cth) and associated instruments, including the Safeguard Mechanism. The CCA published its most recent legislative review of the Act in 2018 (CCA 2018). The second review of the Act is due to be completed by 31 December 2023 (see also section 3.3.2.1).

The CCA's functions recently expanded as a result of the *Climate Change Act* and *Climate Change (Consequential Amendments) Act 2022* (Cth). The CCA provides advice to the minister responsible for climate change; specifically:

- on greenhouse gas emissions reduction targets to be included in Australia's new or adjusted nationally determined contributions
- for preparing the preparation of the minister's annual climate change statement on
  - progress made towards achieving Australia's greenhouse gas emissions reduction targets
  - international developments
  - the efficacy of climate change policies
  - the impact of climate change policies on rural and regional Australia
  - risks to Australia from climate change impacts.

The CCA undertakes special reviews on other matters as requested by the minister responsible for climate change or the Australian Parliament. The CCA has completed 2 special reviews since the seventh National Communication:

- Review of International Offsets, 2022
- Review of the National Wind Farm Commissioner, 2018.

The CCA also undertakes self-initiated research and analysis and has published 7 research reports since the seventh National Communication.

4.1.2.3 Reviews of Australian Renewable Energy Agency and Clean Energy Finance Corporation

Since the seventh National Communication, several reviews of the effectiveness of the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC) have been undertaken:

- Deloitte's 2018 independent statutory review of the CEFC found that the CEFC has facilitated the flow of finance into the clean energy sector, with CEFC investments successfully enabling projects that would not have otherwise proceeded, and attracting substantial private co-investment to projects (Deloitte 2018).
- Ernst and Young's 2019 evaluation of the impact and effectiveness of ARENA found that through its ongoing support of research and development, demonstration and deployment projects, ARENA has contributed to a more competitive renewables sector, including by reducing costs and advancing new technologies. Further, ARENA will continue to enable improvements (Ernst & Young 2019).

- The ANAO 2020 audit of ARENA's grant program management (ANAO 2020a) found that ARENA has
  - robust governance and oversight of its grant funding agreements
  - strategic plans that are mostly clear and consistent with its objectives
  - largely effective management of its grant programs
  - grant allocation aligned with its objectives.
- The ANAO's 2020 audit of the CEFC's ongoing management of its portfolio of investment projects, and of how well the CEFC is meeting its legislated objective, found that the CEFC had largely met its legislated objective of facilitating increased flows of finance into the clean energy sector. The review also found that the CEFC has largely effective risk management processes in place and that the CEFC has suitable arrangements in place to assess and approve investments and for their ongoing management (ANAO 2020b).

4.1.2.4 Review of schemes administered by the Clean Energy Regulator

Policies administered by the CER are regularly reviewed to ensure they remain effective. The ANAO will undertake a performance audit of the effectiveness of the CER's contracting, compliance and assurance activities relating to government purchase of Australian Carbon Credit Units in 2023 (ANAO, 2022).

4.1.2.5 Policy reviews

The Australian Government has commissioned expert reviews on the administration of its programs and to inform future policy (see Review of the integrity of Australian Carbon Credit Units below.)

Public consultation is integral to Australia's policymaking processes. Advice is sought through the release of discussion papers or draft legislation for public comment and through face-to-face consultation. For example, during 2022, the government consulted on the Safeguard Mechanism reforms and the National Electric Vehicle Strategy. The DCCEEW process for public consultations is clearly documented.

Review of the integrity of Australian Carbon Credit Units

The government has appointed former Chief Scientist Professor Ian Chubb to lead an independent panel of experts in a review of the integrity of Australian Carbon Credit Units (ACCUs). ACCUs are an important feature of Australia's carbon market and accounting arrangements, especially for programs such as Australia's carbon crediting scheme previously known as Emissions Reduction Fund, and Climate Active. The review panel will report to government by 31 December 2022 (DCCEEW 2022c).

The panel is examining the system's governance arrangements and legislative requirements, the integrity of the key methods used and the broader scheme settings that affect the integrity of ACCUs. Other matters to be examined by the panel include:

- the extent to which carbon projects are supporting positive environmental, social and economic outcomes for agriculture, biodiversity and the participation of First Nations people
- opportunities to maximise non-carbon benefits of projects
- requirements for the use of ACCUs under Climate Active.

The panel is consulting many stakeholder groups, including academics and experts, First Nations groups, project proponents, carbon service providers, industry groups, and relevant federal, state and territory government agencies.

4.1.3 Economic and social impacts

The transition to a net zero economy presents enormous economic potential for Australia, particularly with clean energy export opportunities (such as clean hydrogen, renewable electricity, green steel, iron ore and aluminium) and the development of new domestic industries to service the new energy economy.

Australian governments have various policies in place to encourage development of this potential and increase private-sector investment and job creation.

The Australian Government has created a Net Zero Economy Taskforce within the Department of the Prime Minister and Cabinet to focus on the regions most affected by the transition, and ensure they are well supported and will benefit. The taskforce will help coordinate work between state, territory, local and federal governments, and will work with local community groups and businesses. The goal of this collaboration is to ensure the social and economic outcomes of the transition work for everybody, especially those affected by closures of high-emissions businesses and industries.

The Annual Statement to Parliament must also report on the impact on rural and regional Australia of the Australian Government's policies that contribute to achieving national targets.

4.1.4 Publicly accessible information

The Australian Government continues to make publications and data accessible to the public through DCCEEW's website.

4.2 Policy and measures at the national level

4.2.1 Cross-cutting measures

The Australian Government has established various cross-cutting measures to address emissions.

4.2.1.1 National climate change legislation and net zero planning

On 13 September 2022, the Australian Parliament passed the *Climate Change Act 2022* and the *Climate Change (Consequential Amendments) Act 2022*.

The *Climate Change Act 2022* (Cth) legislates Australia's updated Nationally Determined Contribution of 43% emissions reduction below 2005 levels by 2030 and net zero emissions by 2050. It also tasks the CCA to assess and publish progress against these targets and advise government on future targets, including the 2035 target. Legislating Australia's targets gives certainty to investors and participants in the energy market and will help stabilise Australia's energy system.

The *Climate Change Act 2022* also enhances transparency and government accountability by requiring the minister responsible for climate change policy to report annually to Parliament on progress in meeting Australia's targets (see section 4.1.2.1).

The *Climate Change (Consequential Amendments) Act 2022* embeds the national targets in the objectives and functions of a variety of Australian Government agencies and schemes, including ARENA, the CEFC, Infrastructure Australia and the Northern Australia Infrastructure Facility. The government will consider further opportunities to embed Australia's climate targets into legislation.

As part of its first Annual Statement to Parliament in December 2022, the Australian Government committed to developing a net zero plan. The net zero plan will consider all elements of the CCA's advice that informed the development of that statement, including a national carbon market strategy, a technology and innovation strategy, and how to accelerate emissions reductions in heavy transport and industries not covered by the Safeguard Mechanism.

4.2.1.2 Australian Public Service target

The Australian Government is committed to an Australian Public Service (APS) with net zero emissions by 2030 (excluding the Australian Defence Force and security agencies, given their operational needs). With this commitment, the government is leading by example and contributing towards Australia meeting its national targets under the Paris Agreement.

Measures to get to the APS to net zero include:

- demand management and improved energy efficiency
- increasing renewable energy supply
- moving to low-emissions and electric vehicles, with a target of 75% of new passenger vehicle leases or purchases in the fleet being low emissions by 2025
- using government spending power to take action on climate change and support energy projects through the Buy Australian Plan
- quality offsets for residual emissions.

The 2022–23 Budget committed $7.1 million in 2022–23 and 2023–24 to help move the APS to net zero operations and maintain public accountability through annual emissions reporting.

Progress towards net zero emissions from the APS will be included within Australia's Annual Climate Change Statement to Parliament.

The APS net zero commitment was reinforced in November 2022 by Australia and more than 10 other governments, joining the Net Zero Government Initiative, led by the United States. The initiative commits governments around the world to lead by example and pledge to achieve net zero emissions across their own operations.

4.2.1.3 Powering Australia

Powering Australia is the Australian Government's policy suite for driving innovation and uptake of existing technology by existing industries, while investing in the technology and industries of the future. It includes various measures such as infrastructure investment (including Rewiring the Nation – see section 4.2.2.3), targeted grant funding and project co-investment and regulation.

Several technologies are identified as priorities for support, including solar, wind, batteries, clean hydrogen, green steel and aluminium, electric vehicles, and livestock feed. Powering Australia commits to various policies to support their ongoing development and deployment. The Australian Government is working to progressively implement these policies.

4.2.1.4 Safeguard Mechanism reforms

The Safeguard Mechanism puts emission limits on Australia's largest emitters. It applies to all facilities that emit more than 100,000 tonnes of CO_2-e per year. It places a limit, called a 'baseline', on each facility's greenhouse gas emissions, and places an aggregate limit on emissions from grid-connected electricity generators. Each year, each facility must prove their net emissions for that year are below their baseline, and the electricity generation sector must stay below its aggregate baseline. The Safeguard Mechanism commenced on 1 July 2016.

The Australian Government is introducing reforms to the Safeguard Mechanism to ensure emissions reductions from Australia's largest emitters are achieved in a gradual and predictable way, consistent with Australia's national emissions reduction targets. The reforms will apply to all facilities under the Safeguard Mechanism, except for grid-connected generators, which will continue to be covered by the sectoral baseline. The reforms will cover 28% of Australia's emissions and are expected to begin on 1 July 2023.

A crediting and trading framework is also expected to be established as part of the Safeguard reforms; enabling legislation is to be introduced into the Australian Parliament in late 2022. Safeguard facilities will be able to purchase and surrender ACCUs to reduce their emissions, which will interact with the new crediting and trading framework. To prevent carbon leakage, the reforms will also include tailored treatment for emissions-intensive, trade-exposed facilities.

The Safeguard Mechanism reforms will be implemented alongside a broader policy agenda to decarbonise existing industry and support new low-carbon industry. These initiatives include the Powering the Regions Fund (see section 4.2.1.7). This fund will support the deployment of low-emissions technology in the industrial sector and decarbonisation of existing industrial processes, including helping Safeguard facilities to meet their new baselines in hard to abate sectors.

4.2.1.5 Climate reporting standards

The Australian Government is introducing climate reporting standards, in line with international requirements. Compliance with the standards will be mandatory for financial institutions and large publicly listed companies.

The government will work with regulators to standardise and internationally align reporting requirements to ensure that climate-related disclosures are usable, credible and comparable. Disclosures will provide greater transparency and accountability about climate-related governance, strategy, risk management, targets and metrics, including greenhouse gas emissions.

The government will work closely with the financial regulators and undertake substantial consultation on these requirements and associated legislative reforms.

4.2.1.6 National Reconstruction Fund

The Australian Government is establishing the National Reconstruction Fund (NRF), a $15 billion financing vehicle that will support, diversify and transform Australia's industry and economy to secure future prosperity and drive sustainable economic growth. The NRF will provide finance including through loans, guarantees and equity to drive investments that add value and capability across 7 priority areas:

- value-add in resources
- value-add in the agriculture, forestry and fisheries sectors
- transport
- medical science
- renewables and low-emission technologies
- defence capability
- enabling capabilities.

The Australian Government has identified up to $3 billion for renewables and low emissions technologies. Funding support could include driving investments in green metals (steel, alumina and aluminium), clean energy component manufacturing, hydrogen electrolysers and fuel switching, agricultural methane reduction, and waste reduction.

The NRF will be governed by an independent board, with investment decisions made by the board consistent with the Australian Government's strategic direction and priorities as set out in an investment mandate. The Australian Government intends to have the NRF operational as early as possible.

4.2.1.7 Powering the Regions Fund

The Powering the Regions Fund will provide $1.9 billion in funding to help regional Australia in the transition towards net zero emissions. The fund aims to

- decarbonise existing industries, including helping Safeguard facilities meet their new baselines
- support the development of new clean energy industries and the deployment of low-emissions technology in the industrial sector
- develop regional workforces
- continue the purchase of ACCUs.

The Powering the Regions Fund has been established with uncommitted funding from the Emissions Reduction Fund and Climate Solutions Fund. The fund is intended to complement other initiatives and agencies such as the NRF, ARENA and CEFC. DCCEEW is currently consulting regional stakeholders and other interested parties on the design of the fund.

4.2.1.8 Australia's National Hydrogen Strategy

As the world moves towards net zero emissions, Australian governments and industry are working together to position Australia as a major producer, user and exporter of clean hydrogen. The growth of the hydrogen industry will be an important enabler of the industrial sector's decarbonisation in line with Australia's climate targets and driven by reforms to the Safeguard Mechanism. While many industries and industrial processes may be able to be electrified, it is expected that hydrogen will provide the only realistic way for some emissions-intensive processes to decarbonise.

Australia's National Hydrogen Strategy was agreed to by all Australian governments, and released in late 2019. The strategy sets a vision for a clean, innovative, safe and competitive hydrogen industry that benefits all Australians. The strategy sets out 57 nationally coordinated government actions to accelerate the commercialisation of hydrogen, reduce technical uncertainties, and build Australia's domestic supply chains and production capabilities. The actions include a National Hydrogen Infrastructure Assessment that examines how the supply chain will evolve over time and considers how infrastructure needs will differ by location. Another key early action is to review legislation and regulations relevant to hydrogen industry safety and development.

One such action is the scaling up of domestic demand through the blending of hydrogen in gas networks. A subsequent review found that there was ambiguity in the national gas regulatory framework as to whether the definition of natural gas could include biomethane and hydrogen.

On 20 August 2021, Australian energy ministers agreed to extend the national gas regulatory framework to include hydrogen blends, biomethane and other renewable gases. The reforms provide regulatory certainty, which supports investment in innovative projects that will reduce emissions in Australian gas networks.

The Australian Government is also developing an internationally aligned domestic hydrogen Guarantee of Origin scheme to provide future customers with robust and transparent information on the greenhouse gas emissions associated with hydrogen production. The scheme will track the carbon emissions associated with Australian hydrogen production, along with other characteristics such as the type of technology and energy source used in its manufacture.

Arup has estimated that by 2030, Australia could be exporting up to 500,000 tonnes of hydrogen per year to help meet 2,489,000 tonnes of predicted demand from Japan and South Korea alone, which would displace a substantial proportion of fossil fuel usage (Arup Australia 2019).

Since the strategy was released in late 2019, Australian governments have allocated billions of dollars to support and develop the hydrogen industry. Funding from the Australian Government includes more than $525 million to support the development of hydrogen hubs through the Regional Hydrogen Hubs Program and $300 million for the CEFC through its Advancing Hydrogen Fund.

4.2.1.9 Australia's carbon crediting scheme

Australia's carbon crediting scheme (known from 2014–2022 as the Emissions Reduction Fund) is made up of interrelated elements:

- methods that set the rules for eligible emissions reduction projects
- a framework for registering projects and crediting emissions reductions
- funding for government purchase of emissions reduction credits.

The ACCU review will examine the integrity of Australia's carbon crediting framework (see section 4.1.2.5).

Crediting

Australia's carbon crediting scheme allows businesses, community organisations, local councils, farmers and others to receive ACCUs by undertaking approved emissions reduction activities. Eligible activities include improving energy efficiency, fuel switching, capturing methane from landfills, and storing carbon in forests and soils (Table 4.1). Participants receive one ACCU for every tonne of emissions they reduce or avoid. Defined 'methods' set out which activities are eligible to earn ACCUs and how emissions reductions are to be measured, verified and reported (see Methods).

More than 1,300 emissions reduction projects are registered under the scheme.

Table 4.1: Carbon crediting (Emissions Reduction Fund) projects

Project type	Registered projects	Contracted emissions reductions (Mt CO_2-e)	Examples of eligible project activities
Agriculture	415	15.2	• Building soil carbon through changed farming practices such as crop stubble retention • Capturing and destroying the methane from animal effluent waste • Reducing emissions from beef cattle through efficient herd management
Energy efficiency	59	3.4	• Reducing energy-consumption emissions or industrial process emissions, such as replacement or modification of boilers or heating, ventilation, and air conditioning systems.
Industrial Facilities	4	0	• Reducing energy-consumption emissions or industrial process emissions produced by existing equipment
Industrial fugitives	12	1.7	• Capturing and destroying waste methane from coal mines • Reducing fugitive leak and venting emissions at oil and natural gas extraction, production, transport and processing facilities
Savanna burning	79	13.6	• Managing fires in Australia's savannas to avoid high-intensity fires
Transport	8	1.2	• Reducing emissions from air, land and sea transport through new technologies and more efficient practices
Vegetation	631	150.6	• Planting trees to grow carbon stocks • Regenerating native forest on previously cleared land • Protecting native forests by reducing land clearing
Waste	167	26.3	• Reducing the amount of waste in landfill, through composting, resource recovery, or separating organic household waste using dedicated council bins • Capturing methane from landfills and producing electricity • Treating wastewater at places such as sewerage plants or abattoirs

Project type	Registered projects	Contracted emissions reductions (Mt CO_2-e)	Examples of eligible project activities
Carbon capture and storage	1	0	• Reducing greenhouse gas emissions from industrial processes, or oil and gas activities, by capturing those emissions and permanently storing them underground
Total	**1,376**	**217**	**The full list of eligible activities is available at the Clean Energy Regulator website.**

Source: Clean Energy Regulator and Australian Government Department of Climate Change, Energy, the Environment and Water, as at 30 October 2022.

Purchasing

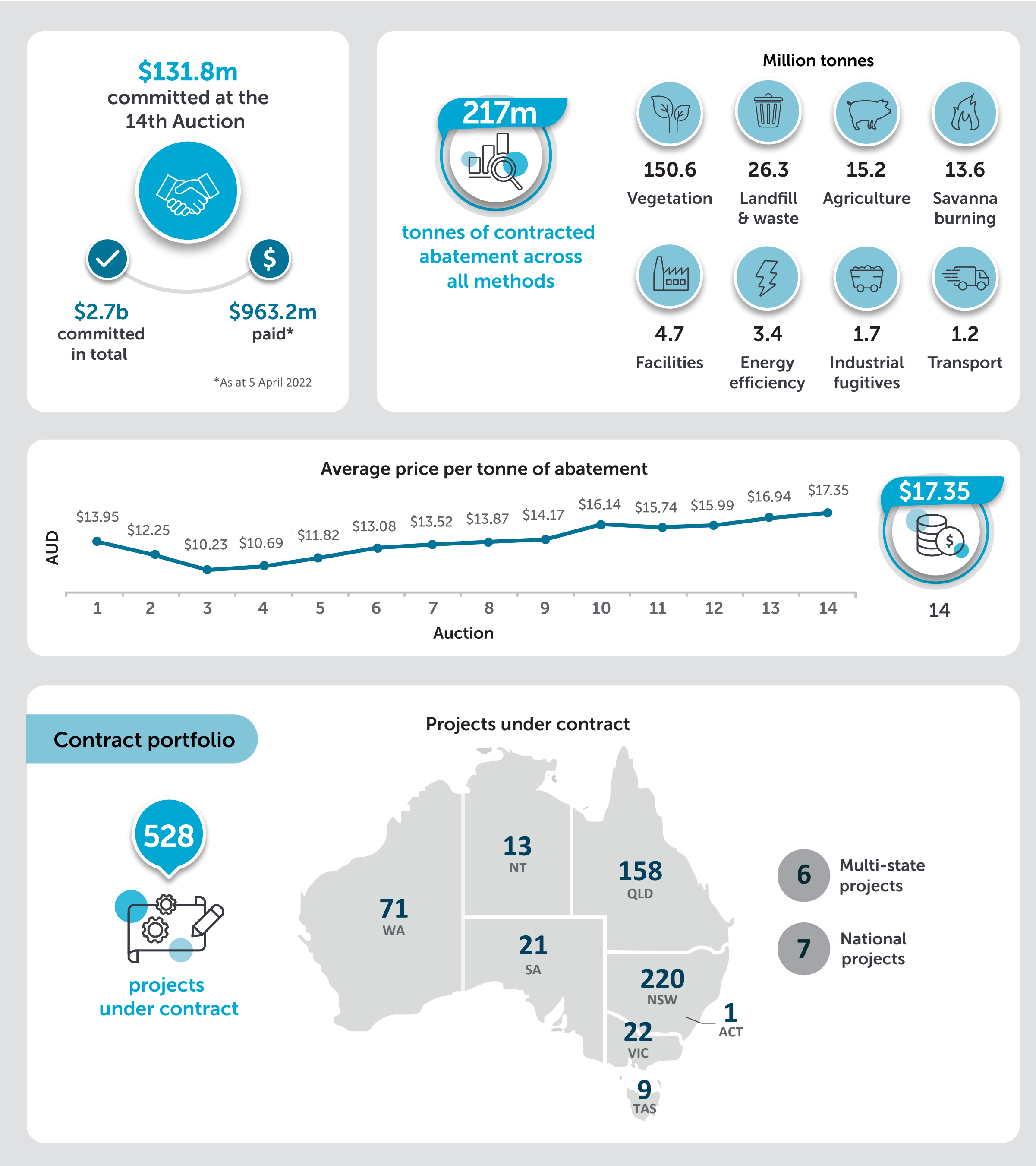
To date, the Australian Government has contracted over 217 million ACCUs (Figure 4.1), using a competitive process of reverse auctions in accordance with the legislated purchasing principles. All government purchases are made by the CER.

Participants register a project and bid to enter into contracts of up to 10 years' duration with the government. If a project does not earn sufficient ACCUs to meet the contractual obligations, the project proponent may need to 'make good' by buying ACCUs from someone else. For optional delivery contracts, the seller has the right, but not the obligation, to sell ACCUs from one project to the government at an agreed price over a set period. Participants may also sell ACCUs privately, such as to entities wanting to offset their emissions.

Future purchasing of ACCUs will occur through the Powering the Regions Fund (see section 4.2.1.7). Decisions on the quantum and mechanisms of ongoing government purchasing will be informed by the ACCU review and implementation of the Safeguard Mechanism reforms.

The full results of the auctions, application process, registered projects, and credits issued are available on the CER's website.

Figure 4.1: Clean Energy Regulator carbon credit results as at 30 October 2022



Methods

To be eligible to receive ACCUs, emissions reduction activities must be genuine and additional, going beyond business as usual. This is achieved by specifying eligible emissions reduction activities in legislative instruments known as 'methods'. Methods also define how the emissions reductions are to be measured, verified, reported and monitored. Methods can only be made if the independent Emissions Reduction Assurance Committee (ERAC) confirms they comply with legislated Offsets Integrity Standards. Additionally, the Minister for Climate Change and Energy is required by legislation to consider whether any adverse environmental, economic or social impacts are likely to arise from the activities covered by the method.

The availability of methods offering a wide range of eligible emissions reduction activities across the economy has been essential to the scheme's achievements. The CER works with industry, research organisations, technical experts and other Australian Government agencies to develop robust methods, underpinned by research and supported by industry. Methods are available for activities across all sectors in the economy, including:

- reducing emissions from agriculture and transport
- capture and combustion of coal mine waste gas
- improving the energy efficiency of commercial buildings and industrial facilities
- capture and combustion of landfill gas, including for electricity generation
- reforesting and revegetating land
- restoring coastal wetlands
- managing wildfires by savanna burning.

The CER is also responsible for administering the scheme. This includes registering projects, accrediting project auditors, issuing ACCUs, running auctions and managing contracts for delivery of emissions reductions. The CER ensures participants comply with the legislated requirements of the scheme including that projects are new, not required by law and are not funded by other listed government programs.

Emissions Reduction Assurance Committee

ERAC is an independent, expert committee that assesses scheme methods against the Offsets Integrity Standards specified in legislation. ERAC advises the Minister for the Climate Change and Energy on whether proposed new activities or variations to existing activities meet these standards.

ERAC release draft methods for public consultation before providing their advice to the minister. The consultation period for draft methods or variations of existing methods is 28 days, unless ERAC determines a shorter period of no less than 14 days is appropriate. ERAC monitors and reviews the effectiveness of methods over time and advises the minister whether a method should continue to apply or be available.

Other benefits

As well as reducing emissions, carbon crediting projects can provide important co-benefits such as improved soil health, farm productivity, biodiversity and ecosystem connection. Farmers are reinvesting revenue from projects to improve their properties. First Nations people have highlighted benefits including employment; supporting people to return and remain on their Country; transfer of knowledge to younger generations; and higher standards of mental and physical health.

Case study: First Nations people managing Country to reduce emissions

The Indigenous Carbon Industry Network (ICIN) is the peak industry body representing Indigenous-owned and operated carbon projects across Australia. Its members are Indigenous organisations that operate across north Australia to develop and deliver carbon projects, mainly through savanna fire management.

Its mission is to promote and facilitate an active, innovative and Indigenous-led carbon industry supporting healthy Country and better livelihoods for Indigenous people.

ICIN's members include 20 Indigenous organisations currently producing around 1.2 million Australian Carbon Credit Units each year through 35 Indigenous-owned savanna carbon farming projects employing hundreds of people in remote Australia. Indigenous-owned carbon projects have an excellent reputation for delivering high-value outcomes, not only for the climate, but also for Country, culture and community.

Guided by its member organisations, the network is working to improve awareness and understanding of the rapidly growing carbon industry, enable wider participation by Indigenous organisations across Australia, and to shine a light on Indigenous rights and interests in carbon. To this end, ICIN provides information and updates about the Indigenous carbon industry to its members as well as a space for discussion of key issues arising for Aboriginal and Torres Strait Islander people, through the National Indigenous Carbon Forum and workshops throughout the year. The network has also produced several key resources to support the sector, including:

- a guide to Indigenous carbon projects
- a report, *Mapping the opportunities for Indigenous carbon in Australia*
- best-practice guidelines, *Seeking free, prior and informed consent from Indigenous communities for carbon projects*
- videos showcasing Indigenous carbon projects
- an online network of Indigenous organisations that own carbon projects.

ICIN's activities are supported by funding from the Australian, Queensland, Northern Territory, Western Australian and New South Wales governments.

> *'It's really important to really think about where you are as Traditional Owners, understanding your rights and interest in this space, and making sure you get the right people and the right information.'*
>
> Cissy Gore-Birch, Co-chair, ICIN and Chair, Balanggarra Aboriginal Corporation

4.2.1.10 Climate Active

Climate Active is a partnership between the Australian Government and Australian businesses to encourage voluntary climate action. Before 2019, the program was known as the National Carbon Offset Standard. The program is supported by a combination of government funding and licence fees.

Climate Active certifies businesses that have credibly reached a state of carbon neutrality by measuring, reducing and offsetting their scope 1, 2 and 3 greenhouse gas emissions against the requirements of the Climate Active Carbon Neutral Standard. ACCUs created under Australia's carbon crediting scheme are eligible offset units under Climate Active.

Certification is available for organisations (business operations), products and services, buildings, events and precincts. Around 400 Australian businesses are certified in the program

In addition to the direct emission reductions achieved by participants, more than 33 Mt CO_2-e has been offset over the life of the Climate Active program.

4.2.1.11 Carbon capture, utilisation and storage

In October 2022, the Australian Government announced that it will establish a Carbon Capture Technologies Program to accelerate the development of novel and emerging carbon capture and utilisation technologies. This will include support for direct air capture and carbon dioxide use cases that provide long-term CO_2 storage, including in cement and other materials.

The government's CCUS Development Fund supports pilot and pre-commercial projects that are progressing towards commercial operations. The program is aimed at reducing emissions across energy generation, natural gas and hydrogen production, and heavy industries, including cement and chemical production and manufacturing.

In 2019, Australia and Japan signed the Memorandum of Cooperation on Carbon Recycling, which aims to accelerate collaboration on developing carbon recycling technologies. The memorandum enables research cooperation on technologies to use CO_2 as a key ingredient in the manufacture of various products, such as carbon fibre, or for use in the construction and agricultural sectors.

In 2021, the government established a carbon crediting method for carbon capture and storage to enable eligible projects to claim ACCUs for permanently locking away CO_2 in geological storage formations in Australia.

The government is proposing reforms to its Safeguard Mechanism to ensure that Australia's biggest emitters reduce emissions on a predictable trajectory consistent with Australia's climate ambitions (see section 4.2.1.4). This may result in the adoption of CCUS technologies.

4.2.1.12 International collaborations

Mission Innovation and the Clean Energy Ministerial

Australia was a founding member of Mission Innovation – a global initiative to increase public investment in clean energy research and development as part of global efforts to accelerate innovation breakthroughs in clean energy technologies. Australia was announced as vice-chair of the Mission Innovation Steering Committee in 2022.

In 2021, Australia supported the launch of Mission Innovation 2.0 (MI 2.0), to step up collective ambition and cooperation. It aims to catalyse a decade of action and investment in research and development to make clean energy affordable, attractive and accessible for all. Australia currently co-leads the Clean Hydrogen and Net Zero Industries Missions and is a member of the Green Powered Futures Mission. Each of the missions under MI 2.0 is at a different stage of implementation, and Australia is actively engaged in the implementation of relevant missions.

In September 2022, Australia joined the Zero Emission Shipping Mission under MI 2.0. The Zero Emission Shipping Mission aims to demonstrate commercially viable zero-emission ships by 2030, making vessels that operate on zero-emission fuels the natural choice for ship owners when they renew their fleet. Australia also joined the Carbon Dioxide Removal Mission, to advance research and demonstrations on CO_2 removal technologies such as direct air capture and enhanced mineralisation.

In 2021, Australia committed to support a third phase of the Clean Energy Ministerial. Members committed to focus on scaling up and accelerating uptake of clean energy technologies. Australia contributes to initiatives of the Clean Energy Ministerial, including as co-lead for the Clean Energy Solutions Centre (see chapter 9), and the Transforming Solar Initiative. Australia is an active contributor to the Clean Hydrogen Initiative; the Carbon Capture, Utilisation and Storage Initiative; the Equality in Energy Transitions Initiative; the Energy Management Working Group; the International Smart Grid Action Network; and the Super-efficient Equipment Appliance Deployment Initiative.

Bilateral partnerships

The Australian Government is working closely with international partners to advance practical action on climate change, support energy security, and build new clean energy industries. As part of our commitment to reduce Australia's emissions and advance clean energy technology, we are cooperating through 7 bilateral international clean energy partnerships to:

- advance clean energy supply chains and deployment
- deepen collaboration to tackle the global climate challenge
- support rapid regional and global decarbonisation, while building new clean energy trade opportunities for Australia.

Australia has clean energy partnerships in place with Germany, India, Japan, the Republic of Korea, Singapore, the United Kingdom, and the United States.

Separately, in June 2022, Prime Minister Albanese affirmed Australia's new commitment to a $200-million climate and infrastructure partnership with Indonesia (Prime Minister of Australia 2022b). The partnership will be launched as soon as agreement is reached upon its content.

4.2.2 Energy

Since the seventh National Communication, Australia's energy transition has continued to accelerate. The AEMO's 2022 Integrated System Plan predicts that, under its 2 most likely scenarios, renewable generation in the National Electricity Market (NEM; see section 2.6.1.1) will increase from 28% in 2020–21 to between 66% and 83% in 2030–31. That change is projected to have an associated emissions reduction – from 142 Mt CO_2-e in 2020 to between 33 and 79 Mt CO_2-e in 2030–31 (AEMO 2022).

4.2.2.1 National Energy Transformation Partnership

Managing the transformation of Australia's energy system requires a major collaborative investment from the Australian Government, its state and territory counterparts and the energy sector.

On 12 August 2022, energy ministers agreed to establish a new National Energy Transformation Partnership. The partnership is a framework for national alignment and cooperative action by the Australian, state and territory governments to support the smooth transformation of Australia's energy sector. Through the partnership, governments will identify and work together on specific actions to support the energy sector's transformation to help meet Australia's commitment to net zero by 2050. The aim is to ensure an orderly transition to a system based on variable renewables, storage and firming capacity rather than one based on coal- and gas-fired generation.

Under the Partnership, energy ministers will progress actions on the following priority themes:

- Accelerate nationally significant transmission projects – identify opportunities to accelerate delivery of priority transmission projects, and refine associated regulatory reforms so they are fit for purpose and streamlined.
- Plan for generation storage and adequacy – develop national forecasts to improve transparency of market entry and exit of generation and storage assets, coupled with robust capacity and system security planning.
- Understand demand evolution – cooperate on regional-level scenario planning as demand changes in the light of increasing electrification and demand management opportunities (including energy efficiency, distributed energy resources, electric vehicles and demand responses).
- Coordinate gas and electricity planning – improve integration between gas and electricity systems in terms of both planning and analysis – including on-demand scenarios as end users decarbonise.
- Address enabler requirements – address workforce, supply chain and community needs associated with ensuring ongoing growth of opportunities in transmission, renewable energy, storage and industry development.
- Enhance energy security management – collaborate on enhancements to cyber security, emergency management arrangements and fuel availability, to counter increasing geopolitical challenges, market uncertainty and natural disasters.

As a priority action under the Partnership, governments have agreed to fast-track an emissions objective into the national energy laws that set out the objectives of Australia's energy market bodies (AEMC, AER and AEMO; see section 2.6.1). This will provide the energy market bodies with the explicit capacity to consider emissions reduction in their work.

Governments will also work with First Nations people to co-design a new First Nations Clean Energy Strategy, to help shape and drive the clean energy transformation for communities.

4.2.2.2 National Energy Performance Strategy

The Australian Government is developing a National Energy Performance Strategy to lift the role of energy demand in energy system planning and drive better energy performance across the economy. The strategy will provide a framework to accelerate demand-side action, including energy efficiency to ease pressure on energy bills for households, businesses and industry; improve energy reliability; and reduce emissions.

While the strategy will take a whole-of-economy view, it will consider the different opportunities and challenges presented by parts of the economy through a sector-specific approach. This approach will consider the distinct energy requirements of various sectors and the different paths they may need to take to decarbonise and achieve greater energy performance.

The strategy will be supported by detailed policy analysis and data modelling, including best-practice domestic and international examples. The federal government will consult with state and territory governments, businesses, households, industry, researchers and non-government organisations throughout the development of the strategy.

4.2.2.3 Rewiring the Nation

Rewiring the Nation will invest $20 billion to upgrade, expand and modernise electricity grids to unlock renewables and storage capacity and drive down power prices. This will support renewables manufacturing, development of new clean energy industries and the deployment of low-emissions technologies.

Delivered in partnership with the CEFC, Rewiring the Nation will provide low-cost finance for transmission infrastructure, and develop regulatory reform and social licence initiatives. It will also support the implementation of AEMO's Integrated System Plan as well as transmission projects in Western Australia and the Northern Territory.

The first investments from Rewiring the Nation will fast-track critical Tasmanian and Victorian projects for cleaner, cheaper and more reliable energy. In October 2022, the Australian, Victorian and Tasmanian governments signed a partnership agreement to jointly fund the critical Marinus Link transmission project (see section 4.3.6.3). The Australian Government also provided concessional finance for the VNI West (KerangLink) interconnector, Victorian Renewable Energy Zones, Tasmanian Battery of the Nation projects, and Tasmanian transmission upgrades that are known as the North West Transmission Developments (Prime Minister of Australia 2022c).

4.2.2.4 Australian Made Battery Plan

The Australian Government has also committed to the Australian Made Battery Plan, which includes:

- publishing Australia's first National Battery Strategy to guide governments and industry towards a shared vision of end-to-end battery manufacturing
- partnering with the Queensland Government to create a battery manufacturing precinct in Queensland
- creating the Powering Australia industry growth centre to provide advanced technology and skills development to businesses looking to locally manufacture renewable energy technologies
- supporting 10,000 New Energy Apprenticeships, including around 2,000 expected in Queensland.

4.2.2.5 Offshore Electricity Infrastructure Framework

The Offshore Electricity Infrastructure Framework provides the regulatory framework for the development of offshore renewable energy infrastructure. The framework allows for the granting of various kinds of licences authorising offshore renewable energy infrastructure and offshore electricity transmission infrastructure in the Commonwealth offshore area (from 3 nautical miles offshore).

The framework provides the regulatory certainty needed to encourage investment in offshore renewable energy projects, such as offshore wind. The framework requires the minister to consider Australia's emissions reduction targets, as set out in the Climate Change Act, when deciding to declare areas as suitable for offshore renewable energy infrastructure.

State governments have adopted targets and developed renewable energy zones to manage their own planning processes. In New South Wales (NSW), 8 offshore wind farms registered commercial interest in the Illawarra Renewable Energy Zone (REZ), totalling 12.9 GW of generation, with an additional 7 registered in the Hunter–Central Coast REZ. Victoria has adopted targets of 2 GW of offshore wind by 2032, 4 GW by 2035 and 9 GW by 2040.

4.2.2.6 Renewable Energy Target

The Australian Government supports the uptake of renewable energy through the Renewable Energy Target. The Renewable Energy Target is helping transform Australia's electricity generation mix to cleaner and more diverse sources. It supports growth and employment in the renewable energy sector by providing financial incentives for investment in new renewable energy projects.

The Renewable Energy Target has 2 components – the Large-scale Renewable Energy Target and the Small-scale Renewable Energy Scheme. These schemes are estimated to have reduced emissions by a total of 41 million tonnes of CO_2-e in 2021, and this is expected to continue to increase up to 2030 and beyond.

Large-scale Renewable Energy Target

Eligible large-scale renewable energy generators, such as solar and wind farms, hydro-electric and biomass power stations, can create certificates under the Large-scale Renewable Energy Target. Electricity retailers are legally obligated to buy and surrender a certain amount of certificates to the CER each year. This market operates as a subsidy to renewable energy generators.

The 2020 target of 33,000 gigawatt hours (GWh) of large-scale renewable electricity has been met and has since been exceeded, with over 39,000 GWh of Large-Scale Generation Certificates (LGCs) in 2021 and eligible generation on track to reach approximately 44,000 GWh in 2022. The scheme continues until 2030; demand for LGCs now includes a substantial and rapidly increasing voluntary component as interest from companies and governments to demonstrate renewable energy use particularly as part of net zero commitments continues to increase.

Small-scale Renewable Energy Scheme

The Small-scale Renewable Energy Scheme assists home owners and small businesses with upfront costs of installing small-scale (less than 100-kilowatt capacity) wind, hydro, rooftop solar and solar water heater systems. Rather than an overall target, the Small-scale Renewable Energy Scheme operates on an annual basis and continues until 2030.

Australian households continued to install rooftop solar photovoltaic systems at a record rate in 2021, following 4 consecutive record-breaking years; 3.2 GW of rooftop solar photovoltaic capacity was installed in 2021. Australian households lead the world in rooftop solar installations – more than one-third of suitable homes now have rooftop solar – and are opting for increasingly larger systems as costs fall and payback periods remain short.

This scheme has helped Australian households to install more than 3.2 million solar photovoltaic systems and almost 1.4 million solar water heater systems. Installations of associated distributed energy resources, such as household and community batteries, are also increasing rapidly.

4.2.2.7 Equipment Energy Efficiency (E3) Program

The E3 Program is a cross-jurisdictional program through which the Australian Government, state and territory governments and the New Zealand Government collaborate to deliver a single, integrated program on energy efficiency standards and energy labelling for equipment and appliances. The underpinning legislation for the E3 Program is the *Greenhouse and Energy Minimum Standards (GEMS) Act 2012* (Cth).

The program regulates household and other appliances and equipment by setting minimum energy performance standards and applying an energy rating label to products sold in Australia. The program is reviewing additional appliances to expand the number of products covered under the legislation.

In 2020, the program contributed to avoiding an estimated 6 Mt of carbon emissions, the equivalent of taking 1.6 million cars off the road. In the same year, the E3 Program contributed more than $1.8 billion to the Australian economy in avoided energy costs.

4.2.2.8 Trajectory for Low Energy Buildings

The Trajectory for Low Energy Buildings provides a national plan, agreed to by all Australian state and territory energy ministers, for a path to zero-energy and zero-carbon buildings. Trajectory policies address specific barriers present at different stages of a home's life. They are designed to drive the uptake of residential energy efficiency upgrades (DCCEEW 2019b).

Australian households account for around 11% of Australian greenhouse gas emissions (DCCEEW 2022e) and changes in energy usage by buildings have a significant impact on the reliability of the energy grid. Buildings are long lived, so impacts of inefficient dwellings are felt for a long time. Two-thirds of non-residential buildings standing in 2050 will have been built or refurbished after 2019.

Work underway on the trajectory covers many issues:

- The minimum energy efficiency standards for new homes have been raised. On 26 August 2022, building ministers agreed to increase the minimum level of thermal performance from 6 to the equivalent of 7 stars under the Nationwide House Energy Rating Scheme (NatHERS) and introduce an energy budget covering the home's fixed appliances. The changes also make it easier for people living in apartments to make the switch to an electric vehicle, by providing base charging infrastructure at the time of construction.
- Energy use in homes is now more thoroughly assessed. In 2022, NatHERS has been expanded beyond a thermal performance rating to provide an additional rating for whole-of-home energy use. The rating accounts for a home's major fixed appliances and any energy generated onsite. NatHERS is also expanding to include in-home assessments of existing homes to support the national disclosure framework.
- Residential energy efficiency disclosure will be improved. A draft national framework was agreed to by energy ministers for broader consultation in 2022, with a view to finalising the framework in mid-2023. Disclosure of a home's energy efficiency performance can ensure consumers have relevant information to make more informed choices. This information may encourage improvements in the energy performance of residential dwellings, significantly reducing energy consumption and emissions.
- Minimum requirements for energy efficiency of rental properties will be established. A national framework for minimum energy efficiency rental requirements is due for finalisation in 2023, and will then be adapted and implemented by jurisdictions. Setting minimum requirements before properties are rented out can ensure those most vulnerable in the community have access to healthier and more affordable housing.

The Regulatory Impact Statement (RIS) informing the NatHERS changes anticipated clear benefits for households, including making homes more comfortable and reducing cost of living pressures by lowering ongoing energy bills. The RIS estimated that the new standards will achieve around 4.3 Mt CO_2-e abatement over 2022–2030, and over 14 Mt CO_2-e abatement in total out to 2060. It also found that every new house built should recoup any upfront costs through lower bills – on average around $180 per year.

Regarding energy efficiency of existing buildings, preliminary modelling indicates that implementing proposed policies for improving the energy efficiency of existing houses (National Construction Code [NCC] Class 1 only) in 2025 in all jurisdictions could deliver a net present value of $3.4 billion and reduce emissions by 40.3 Mt CO_2-e by 2050. For commercial buildings, policies could deliver a net present value of over $8.4 billion and reduce emissions by 26.6 Mt CO_2-e by 2030 and 87.5 Mt CO_2-e by 2050.

For commercial buildings, much work is underway:

- Energy ratings will apply to new commercial building types. The National Australian Built Environment Rating System (NABERS) is a voluntary rating tool that enables owners to compare the energy use of their building with similar buildings. New energy ratings for residential aged care facilities (launched in 2021), retirement living villages (2021), warehouses (2022) and cold stores (2022) enable these sectors to benchmark and promote their energy performance. New energy ratings for retail buildings and schools are under development, and on track to launch in 2023. These complement the energy ratings already available for office buildings and tenancies, shopping centres, hotels, data centres, public hospitals and apartment buildings. Also under development is a simplified 'universal benchmark' rating for commercial building sectors for which a NABERS rating is not available.
- The NCC will look more closely at energy efficiency of commercial buildings. The next triennial round of energy efficiency changes for the NCC will be concluded in 2025 and focuses on commercial buildings. Initial modelling has shown that a weighted-average reduction in regulated energy intensity of 26% can significantly improve energy efficiency while maintaining cost effectiveness.

4.2.2.9 Clean Energy Innovation Funding

The Australian Government supports clean energy innovation across the spectrum of research and development, demonstration and deployment. Research and development grants are provided by ARENA and the Australian Research Council. The CEFC, through its Clean Energy Innovation Fund, invests venture capital in early-stage clean technology companies. As well as its direct investments into these companies, the CEFC also supports the provision of seed capital via specialist accelerator co-investors. The Innovation Fund is operated in consultation with ARENA. Additionally, the CEFC promotes investment in clean energy technologies and projects through the provision of debt and equity.

Australian Renewable Energy Agency

ARENA is a statutory authority established by the *Australian Renewable Energy Agency Act 2011*, and began operations on 1 July 2012. ARENA provides research, development and deployment grant funding to improve the affordability and increase the supply of renewable energy in Australia. As at 30 September 2022, ARENA had committed $1.96 billion to more than 630 projects. This has been matched by $6.85 billion in co-funding, making the total project value $8.81 billion. These funds have supported projects spanning the commercialisation pathway, from research and development to demonstration and near-commercial deployment. ARENA acts as an enabler for technologies that achieve greenhouse gas reductions, and does not attribute abatement directly to its projects.

In 2020, ARENA was provided with an additional $1.4 billion in baseline funding, ensuring the agency can continue to support renewable energy projects until at least 2032. The Australian Government also expanded ARENA's functions to include the provision of support for energy efficiency and electrification technologies. Empowering ARENA to support energy efficiency and electrification projects will help to further increase the supply of renewable energy and ensure that Australia's electricity grid is better able to incorporate this increased supply.

In addition to the agency's support for projects via its baseline funding, since 2018 the Australian Government has also tasked ARENA with delivering other specific programs, including:

- $428 million as part of the Driving the Nation Fund to co-invest in projects to reduce emissions from Australia's road transport sector
- $171 million to deliver over 340 batteries as part of the Community Batteries for Household Solar program (see section 4.2.2.10)

- $160 million for the Large-Scale Battery Storage Round to accelerate demonstration of advanced inverter capabilities for battery projects at scale
- $75 million to develop and deploy microgrid technology across First Nations communities, to improve access to cheaper, cleaner and more reliable energy
- $50 million for the Regional Australia Microgrid Pilots Program, which supports pilot demonstrations of microgrid technologies in rural and regional Australia
- $50 million for the German–Australian Hydrogen Innovation and Technology Incubator (HyGATE), which supports pilot, trial, demonstration and research projects along the hydrogen supply chain
- $43 million for the Industrial Energy Transformation Studies Program, which assists large energy users to undertake studies to identify opportunities to lower their energy costs and reduce emissions
- $30 million to support the outcomes of the ARENA Bioenergy Roadmap through co-funding additional research, development and deployment of advanced sustainable aviation and marine biofuels.

ARENA draws on independent expert advice and works collaboratively with other agencies supporting clean energy innovation.

Case study: ARENA project snapshot – driving innovation in large-scale battery storage

In 2022 the Australian Government, through ARENA, allocated $160 million in new funding for large-scale battery storage projects. Following the expression-of-interest stage, ARENA invited 12 projects to submit full applications, which were due in late July 2022.

The funding round aims to demonstrate how batteries with advanced inverters can help stabilise the grid as thermal generation exits the market. ARENA expects the round to deliver up to 1 GW of new grid-scale batteries, which will be equipped with advanced inverter technology. Due to be constructed and operational by the end of 2024, these batteries should make a substantial contribution towards the amount of dispatchable electricity capacity available in Australia's electricity grid.

Case study: ARENA project snapshot: Genex Kidston Pumped Hydro Energy Storage Project

In 2021 the Australian Government, via ARENA, committed up to $47 million to support the construction of Genex Power's Kidston Stage 2 Pumped Hydro Energy Storage (K2-Hydro) project. This commitment builds on ARENA's provision of $9 million in funding for feasibility and development studies for the project.

The K2-Hydro project, Australia's first pumped hydro plant since 1984, will use 2 existing mining pits at the former Kidston Gold Mine as upper and lower reservoirs. During peak power demand periods, water will be released from the upper reservoir, passing through turbines and generating electricity. During off-peak periods water will be pumped from the lower to the upper reservoir using electricity imported from the National Electricity Market.

Once constructed, the 250 MW/2,000 MWh project will be able to provide up to 8 hours of energy storage.

This energy storage capacity will be used to store abundant solar and wind energy when it is available, and dispatch this energy back into the grid during the evening and other times of peak demand. This will help to ease the pressure on the electricity grid at times of high demand and provide rapid-response backup to fill unexpected gaps in electricity supply as Australia's electricity system transitions to renewables.

Clean Energy Finance Corporation

The CEFC is a statutory authority established by the *Clean Energy Finance Corporation Act 2012* (Cth), which commenced operations on 1 July 2013. The CEFC's mission is to accelerate investment in Australia's transition to net zero emissions. The CEFC uses debt and equity funding to promote investment in clean energy technologies through direct investments, which attract private-sector finance. It also makes indirect investments through the provision of wholesale debt facilities to strategic co-financing partners.

In 2021, the CEFC surpassed $10 billion in lifetime investment commitments. By 30 September 2022, the CEFC had made cumulative investment commitments of more than $11 billion to projects with a total value of more than $38 billion. These projects will reduce emissions from energy and industrial processes, and include solar and wind generation and energy storage. The CEFC invests commercially to increase the flow of funds into the clean energy sector, which includes renewable energy, energy efficiency and low-emissions technology projects.

The CEFC's investment portfolio is expected to generate a return above the government's costs of funds. Since inception, each dollar of CEFC investment commitments has been matched by $2.40 from the private sector.

The CEFC's lifetime commitments as at 30 June 2022 are in projects estimated to have achieved annual abatement of 7.3 Mt CO_2-e in 2020 and will achieve 8.4 Mt of abatement in 2030. Note that these estimates exclude estimated abatement from investment commitments made after 30 June 2022. Further, the CEFC does not claim that this abatement occurs independently of complementary policies such as the Renewable Energy Target.

Since the publication of Australia's seventh National Communication on Climate Change, the Australian Government has created 2 new funds within the CEFC; they are:

- the Advancing Hydrogen Fund, which makes up to $300 million in concessional finance available to support the growth of a clean, innovative, safe and competitive Australian hydrogen industry
- the Australian Recycling Investment Fund, which makes up to $100 million available to support recycling or recycled content projects using clean energy technologies, with a particular focus on waste plastics, paper, glass and tyres.

The CEFC will also be the financing arm for Rewiring the Nation with the 2022-23 Budget including an initial allocation of $8.6 billion to be used for Rewiring the Nation investments.

The CEFC also works through banks and other financial institutions to offer financial products to encourage businesses to make sustainable purchasing choices for energy-efficient equipment, fuel efficient, electric and hybrid vehicles, and to implement small-scale behind-the-meter renewable energy projects.

Case study: CEFC support for a hydrogen heavy-trucking transportation solution via the Advancing Hydrogen Fund

The CEFC's first investment through the Advancing Hydrogen Fund will help Ark Energy Corporation to produce green hydrogen to power 5 purpose-built zero-emissions trucks.

The project includes the construction of a 1-MW polymer electrolyte membrane hydrogen electrolyser, compressors, storage and refuelling infrastructure that will produce up to 158 tonnes of green hydrogen per year. It will be powered by renewable energy from a nearby solar farm.

These hydrogen-powered trucks will be used to deliver zinc ore from Townsville Port in Queensland to the Sun Metals refinery, where they will refuel with the green hydrogen produced onsite, before taking zinc ingots back to the port in a 30-km clean energy round trip. This is expected to deliver 1.3 kt of abatement in 2030.

Clean Energy Innovation Fund

The CEFC's $200 million Clean Energy Innovation Fund (CEIF) provides support to early-stage and emerging clean energy technologies.

Established in 2016, the CEIF draws on the technical expertise of ARENA, with final approval provided by the CEFC Board, which is responsible for all investment commitments made under the *Clean Energy Finance Corporation Act 2012* (Cth).

By 30 September 2022, more than $181 million in CEFC finance for projects worth more than $858 million had been invested in 26 counterparties under the CEIF. Investments include:

- $9.5 million to electric vehicle (EV) charging infrastructure and technology company JET Charge; CEIF investment in JET Charge's Series A and Series B funding rounds, enabled it to grow from 25 to almost 100 employees and expand its offerings from the sale and installation of charging stations to a diversified infrastructure and technology company focused on EV-charging infrastructure – this project was estimated to have produced 0.5 kt of abatement in 2020, and is projected to produce 24.4 kt of abatement in 2030
- $1.6 million to Downforce Technologies Limited to take the next step in developing and commercialising its data-based technology to cut the cost of measuring and monitoring soil health and carbon levels – a key component in reducing Australia's land-based emissions
- $1.9 million to Novalith, an Australian climate technology company that is looking to accelerate the development of its novel low-carbon sustainable approach to lithium production; the investment will help Novalith finance the construction and operation of a pilot plant in Sydney, as it moves towards the development of a commercial demonstration plant.

Case study: Samsara Eco offers infinite possibilities for plastic recycling

Australian company Samsara Eco is tackling the traditional limitations of plastics recycling by developing a process that allows plastics to be recycled iusing an enzyme that dramatically accelerates bacterial breakdown of plastics.

Samsara's patented process builds on a 2016 discovery of bacteria that produce an enzyme that consumes plastics. It involves a depolymerisation process that uses modified versions of these enzymes to quickly degrade plastic down into small molecules, producing a pelletised product that has the potential to completely replace the manufacture and use of virgin plastic.

Many current mechanical plastic recycling processes require clear and clean plastics, excluding millions of tonnes of hard-to-recycle plastics, included coloured, multilayered and mixed plastics. The ability to infinitely recycle plastics therefore has the potential to significantly increase plastic recovery rates and reduce the volumes of plastics that end up in landfill.

The CEFC has committed up to $1.1 million to assist the expansion of Samsara, through the CEIF.

4.2.2.10 Community solar

The Australian Government is looking to energy transformation at all levels, including in community and household projects.

Community batteries for household solar

The Australian Government will invest $200 million to deliver 400 community batteries across the country to maximise the benefits of Australia's rooftop solar transformation and reduce emissions and energy bills while supporting the grid and providing shared storage for up to 100,000 households. This measure is due to begin in 2022–23.

Community solar banks

The Australian Government will invest $100 million in community solar banks around Australia, providing access to cheap, clean energy to over 25,000 households currently unable to install rooftop solar such as renters, apartment dwellers and people who cannot afford the upfront costs. This measure is due to begin in 2023.

4.2.3 Transport

4.2.3.1 National Electric Vehicle Strategy

The Australian Government released a consultation paper on the National Electric Vehicle Strategy on 28 September 2022. The strategy will deliver a nationally consistent, comprehensive, and overarching framework to increase the supply and uptake of EVs (DCCEEW 2022d). The strategy will include consideration of:

- the introduction of fuel efficiency standards
- further measures to increase electric car sales and infrastructure
- policy settings to encourage Australian manufacturing of EVs, chargers, and components (especially batteries)
- addressing the policy implications of declining fuel excise.

The strategy will build on the following existing measures:

- the Electric Car Discount, which provides tax and import duty exemptions for eligible EVs (see section 4.2.3.2)
- the Driving the Nation Fund, which invests in cleaner transport, including by supporting installation of EV-charging and hydrogen refuelling technology (see section 4.2.3.3)
- a low-emission vehicle target for the Commonwealth fleet of 75% of new purchases and leases by 2025.

The strategy's development will be led by DCCEEW and implemented by Australian, state and territory governments, in collaboration with private-sector organisations where applicable.

4.2.3.2 Electric car discount

The Australian Government has introduced the Electric Car Discount to increase the uptake of electric vehicles by reducing prices. As part of the discount, low- and zero-emission cars below the luxury car tax threshold for fuel efficient vehicles (currently $84,916 in 2022–23) will be exempt from:

- import tariffs – currently a 5% tax on some imported cars
- fringe benefits tax – a tax on cars that are provided through work for private use.

On 28 November 2022, the Australian Parliament passed the *Treasury Laws Amendment (Electric Car Discount) Act 2022* (Cth). This Act provides the legislative framework to support the government's Electric Car Discount.

4.2.3.3 Driving the Nation Fund

The Australian Government will deliver a fast-charging network, committing an additional $275.4 million to the new Driving the Nation Fund, more than doubling the government's investment in clean transport infrastructure. The fund will support the installation of EV-charging and hydrogen refuelling technology across metropolitan, regional and rural areas. This will aid the uptake of EVs and encourage the use of new vehicle technologies across the country.

Through the fund, the Australian Government will cooperate with industry to invest in the deployment of EV charging, with a focus on blackspots to build a national charging network. Stations will be built at an average interval of 150 km, filling gaps in strategic locations and making it possible to drive around Australia in a low-emissions vehicle.

The first 2 investments from the new fund will be a national EV-charging network and a national expansion of hydrogen highways:

- $39.3 million (matched by a private organisation) to deploy 117 EV fast-charging stations on highways across Australia; the stations will work with all EV models and all other charging networks, and will use local content wherever possible
- partnering with states and territories to invest up to $80 million to roll out hydrogen highways across the nation to expand the options to decarbonise heavy transport.

4.2.3.4 International maritime decarbonisation obligations

The Australian Government is undertaking various steps to decarbonise the maritime sector, consistent and in collaboration with international efforts. Australia signed up to the Green Shipping Challenge at COP27, which encouraged countries, ports and shipping companies to announce actions at COP27 to align the industry with the 2015 Paris Agreement goal to keep global warming below 1.5 degrees.

New global ship energy efficiency measure

Australia is complying with its international obligations to implement the combined technical and operational global ship energy efficiency measure adopted by the International Maritime Organization in June 2021.

The measure aims to reduce the carbon intensity of the global fleet, for all ships of 400 gross tonnage and above, to 40% below 2008 levels by 2030. Decarbonising shipping will provide additional health benefits by reducing air pollutants, such as sulfur dioxide, nitrous oxide and particulate matter.

Clydebank Declaration for green shipping corridors

The 24 signatories to the Clydebank Declaration include the United Kingdom, the United States, Australia, Japan, New Zealand and Singapore. They are exploring actions to facilitate partnerships among all stakeholders along the value chain to establish green shipping corridors between groups of 2 or more ports. Possible options include favourable regulatory frameworks, incentives, information sharing and infrastructure investments. Clydebank signatories will facilitate coordinated action by various stakeholders along supply chains. These stakeholders include ship operators, charterers, cargo forwarders, fuel suppliers and financiers.

This is a voluntary agreement, launched at COP26 in November 2021, to establish at least 6 green shipping corridors by 2025. The Global Maritime Forum, a not-for-profit organisation, has agreed to provide voluntary support to coordinate the work of signatories and establish areas of collaboration until more formal coordination arrangements are put in place.

Quad Shipping Taskforce

Australia, the United States, Japan and India launched the Quad Shipping Taskforce in September 2021 to establish 2–3 green shipping corridors specifically in the Indo-Pacific region by 2030.

The taskforce has established a Ports Network comprising the inaugural Quad Ports of Yokohama, Mumbai, Los Angeles and Botany (Sydney) to share information on establishing practical green maritime routes. The taskforce is working to expand the Quad's Ports Network to include other Australian and Asia–Pacific ports.

Work is progressing on developing an agreed Quad definition and key building blocks of a green shipping corridor. The taskforce is planning to convene a Quad Transport Ministers meeting in early 2023 to launch the Quad vision and commitment to develop green ports and green shipping corridors in the Indo-Pacific.

Australia–Singapore Initiative on Low-Emission Technologies for Maritime and Port Operations

Announced in June 2021, the $30-million, 5-year partnership will accelerate the development and deployment of low-emissions fuels and technologies, such as hydrogen, that aim to reduce emissions in maritime and port operations.

The initiative sits under the memorandum of understanding between Australia and Singapore for cooperation on low-emissions solutions, signed in October 2020 to advance cooperation on practical low-emissions projects. In October 2022, Australia and Singapore announced further engagement on establishing a green shipping corridor through the broader Singapore-Australia Green Economy Agreement to facilitate trade and investment in green growth sectors that will support both countries' transitions to net zero emission economies.

DCCEEW leads this initiative with maritime expertise support from the Department of Infrastructure, Transport, Regional Development, Communications and the Arts. CSIRO is the Australian Government's delivery partner. This action is also part of Australia's commitments under the Green Shipping Challenge.

4.2.4 Industry, industrial processes and product use

Along with cross-cutting and energy measures that affect industry (see sections 4.2.1 and 4.2.2), Australia is addressing several industry-specific areas.

4.2.4.1 Hydrofluorocarbon emission reduction measures

Australia is implementing its hydrofluorocarbon (HFC) phase-down through an annual import quota that is reduced every 2 years and will reach an 85% reduction from baseline by 2036. Australia's HFC phase-down started in 2018, one year ahead of the Montreal Protocol's requirement, and is currently 25% below Australia's baseline.

The Australian Government is also working to reduce emissions by managing HFCs from import, through the supply chain to use within the economy, and then at end-of-life. Australia restricts access to HFCs used in refrigeration, air-conditioning and fire protection to licensed technicians and businesses. Licensed entities are required to have trade-based qualifications and appropriate equipment and to abide by Australian Standards and Codes of Practice to minimise preventable emissions.

All HFC refrigerant importers, bringing in bulk HFC or pre-charged equipment, are required to be part of a product stewardship scheme to manage refrigerants at end-of-life. Technicians are required to recover used refrigerant during servicing and from end-of-life equipment and return it for disposal. Returned refrigerant must be destroyed by an approved destruction facility which meets Montreal Protocol requirements.

The HFC phase-down is being implemented alongside the Montreal Protocol phase-out of hydrochlorofluorocarbons (HCFCs) under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (Cth). Australia is working closely with neighbour countries in the Pacific to support implementation of their HCFC phase-outs. The Department of Foreign Affairs and Trade provides funding for the Ozone Program (from the Overseas Development Assistance account) to help developing countries meet their Montreal Protocol obligations. Australia's contribution for 2021–2023 is $26 million.

4.2.4.2 Industrial energy tools

DCCEEW launched a series of industrial energy tools in December 2021 to help small-to-medium enterprises to assess their energy maturity and identify energy-saving strategies. These tools are made available on the energy.gov.au website.

When a user completes the activity, the tool generates a report which provides an assessment of energy maturity and recommendations and identifies opportunities for improving energy management practices, efficiency upgrades, and optimising equipment and processes.

4.2.5 Agriculture and land use, land-use change and forestry

Australia aims to protect its natural ecosystems at the same time as reaching emissions targets and supporting agricultural industries (see also section 6.3.2).

4.2.5.1 National arrangements to ensure LULUCF activities contribute to biodiversity and sustainability

The Australian Government's main land sector abatement policy is Australia's carbon crediting scheme, previously known as the Emissions Reduction Fund, which was originally established under the *Carbon Credits (Carbon Farming Initiative) Act 2011* (Cth) (see also section 4.2.1.9).

The scheme seeks to manage non-climate risks associated with carbon offset projects in several ways:

- Certain types of offsets projects are excluded from the scheme because of their likely adverse environmental and social impacts (Carbon Credits (Carbon Farming Initiative) Rule 2015 (Cth)). Examples of excluded project types include those involving planting of known weed species, and establishment of vegetation on land that has been subject to illegal clearing of a native forest or illegal draining of a wetland.
- The minister must consider any adverse environmental, economic or social impacts that could arise from projects before making a methodology determination.
- Participants are required to state whether their project is consistent with any natural resource management plan that applies to the project area when registering a sequestration or area-based project.
- Participants must obtain regulatory approvals required by all state, territory and federal laws relating to land use and development, the environment and water.
- Rules in carbon credit methodologies manage non-climate risks. For example, under the Plantation Forestry method (Carbon Credits (Carbon Farming Initiative—Plantation Forestry) Methodology Determination 2022), forest management plans must be prepared by a qualified, independent person that identifies and assesses the risks of adverse impacts arising from permanent plantings including wildings, weeds, pests, floods, access, social licence, fuel accumulation and genetic pollution risks. Methods can also contain restrictions referring to other laws that manage adverse impacts on the environment or work health and safety. For example, soil carbon projects must only clear or thin woody vegetation if it complies with applicable regional natural resource management plans, and relevant environmental and planning laws; and organic fertilisers including biochar can only be used in accordance with relevant laws to protect human health and the environment.

The Australian Government has also announced the creation of a Nature Repair Market. The scheme will recognise landholders who restore or manage local habitat and grants them biodiversity certificates which can then be sold to other parties (Prime Minister of Australia 2022a). The government will consult widely on the detailed rules for the scheme (e.g. on how biodiversity benefits should be measured and verified).

The scheme will make it easier for businesses, organisations and individuals to invest in landscape restoration and management. A nature repair market will also promote management of existing, remnant vegetation that provides habitat for native species. The markets for biodiversity and carbon credits will operate in parallel.

4.2.5.2 Methane emissions reductions in livestock

The 6-year $29-million Methane Emissions Reductions in Livestock program commenced in 2020–21. It aims to support the development and deployment of low-emission livestock feed technologies (feed supplements and forage feeds) to reduce livestock methane emissions. Stage 1 of the program funded projects to verify the emission reduction and productivity benefits of feed technologies. Stage 2 is funding 11 projects to develop and determine the feasibility of technologies to deliver feed supplements to grazing animals. Stage 3 will fund projects to undertake trials to validate the delivery technologies and demonstrate their emissions reduction and productivity impacts.

The Australian Government is also providing $8 million to support commercialisation of seaweed to be used as an emissions-reducing livestock feed supplement in Australia. The work program is initially focused on one species of seaweed, *Asparagopsis,* which has the potential to reduce methane emissions from cattle by up to 90%.

4.2.5.3 Soil carbon

Soil carbon is a growing area for Australia to abate emissions and increase productivity.

National Soil Carbon Innovation Challenge

The Australian Government established the $50 million National Soil Carbon Innovation Challenge in 2021. The challenge fast-tracks the development and commercial readiness of technology solutions to measure and estimate soil carbon stocks to a standard that could support greater participation in Australia's carbon crediting scheme. The grants support feasibility study, proof-of-concept, validation and early-stage commercialisation activities that aim to develop lower-cost, accurate technologies. Project teams engage and collaborate with landholders to ensure technology solutions can be used in cost-effective ways within diverse farm management operations in Australia.

National Soil Carbon Data Program

The $7 million National Soil Carbon Data Program began in 2021 to support partnerships to improve data about low-cost alternatives for measuring soil carbon. The program will provide publicly accessible data for use in new technologies to quantify soil carbon stock and stock change in Australian agricultural soils. The program will also support improvements to Australia's national greenhouse gas emissions inventory model for soil carbon (FullCAM; see section 3.3.4).

A key component of this program is the collection and analysis of high-quality temporal data on soil carbon stocks and stock change, representative of Australia's managed agricultural soils. This involves resurveying a targeted subset of sites included in the 2009 to 2012 Soil Carbon Research Program, led by CSIRO.

Data and research insights from this program could provide information to support decision-making in relation to other natural capital assets, agricultural productivity and climate change adaptation.

Carbon Farming Outreach and Extension

The $20.3 million Carbon Farming Outreach and Extension program commencing in 2023 will support outreach activities to empower more farmers and land managers, including First Nations people, to participate in Australia's carbon crediting scheme and adopt innovative carbon farming technologies and practices in their business.

The program will deliver advice and support to farmers and land managers through a comprehensive training package and online tools and resources. Grants will be provided to organisations with agriculture and land management expertise to deliver training and information to land managers across Australia.

4.2.5.4 Blue carbon

Blue carbon ecosystems, such as mangroves, saltmarshes, and seagrasses, capture and store carbon 30 to 50 times faster than terrestrial forests (McLeod et al., 2011). Australia is considered a global 'blue carbon hotspot' and harbours about 12 per cent of the world's blue carbon ecosystems, which hold about 7–12 per cent of global carbon stock (Kelleway 2017). The seagrass meadows surrounding the coral reefs in the Great Barrier Reef alone host an estimated 11 per cent of the world's seagrass blue carbon. Protection and restoration of blue carbon ecosystems provide a nature-based solution to reduce greenhouse gas emissions.

In addition to being large carbon sinks, coastal blue carbon ecosystems provide natural infrastructure that reduce climate change impacts such as flooding, sea level rise, and more frequent and severe storm surges on our coastal areas. Blue carbon ecosystems also provide habitat and nursery grounds for marine species, filter water flowing into our oceans and reef systems, and support people and livelihoods.

The Australian Government is investing $9.5 million over 4 years from 2021–22 to 2024–25 to implement 5 on-ground projects to restore degraded coastal blue carbon ecosystems in Australia as part of the Blue Carbon Conservation, Restoration and Accounting Program (see chapter 6). Internationally, this work is being implemented through the Blue Carbon Accelerator Fund, a joint initiative between the Australian Government and the International Union for Conservation of Nature. See chapter 6 for more information on the Blue Carbon Conservation, Restoration and Accounting Program.

The restoration projects will demonstrate, measure and account for the diverse benefits of restoration outcomes for climate, biodiversity and people, including carbon sequestration, climate mitigation and resilience benefits, and Indigenous values. The projects include co-design and collaboration with Traditional Owners and First Nations people.

Of the 5 restoration projects, 4 may be eligible to register under Australia's carbon crediting scheme's blue carbon method. By developing a trusted and credible approach to measuring and valuing the benefits of blue carbon ecosystems, the program aims to scale up private-sector investment in these ecosystems, including through carbon and environmental markets.

4.2.6 Waste management

Diverting or avoiding waste going to landfill helps reduce emissions of CO_2, methane and other greenhouse gases.

4.2.6.1 National Waste Policy

The National Waste Policy, under the *Recycling and Waste Reduction Act 2020* (Cth) (see section 2.9.2), provides a national framework for waste and resource recovery in Australia. It also highlights the importance of collaborative action and outlines the roles and responsibilities for everyone – businesses, governments, communities and individuals.

The policy outlines the 5 principles for waste management that will enable Australia to transition to a circular economy:

- Avoid waste.
- Improve resource recovery.
- Increase use of recycled material and build demand and markets for recycled products.
- Better manage material flows to benefit human health, the environment and the economy.
- Improve information to support innovation, guide investment and enable informed consumer decisions.

The first National Waste Policy was published in 2009 and an updated policy was published in 2018.

The 2019 National Waste Policy Action Plan drives implementation of 7 targets:

- Regulate waste exports.
- Reduce total waste generated by 10% per person by 2030.
- Recover 80% of all waste by 2030.
- Significantly increase the use of recycled content by governments and industry.
- Phase out problematic and unnecessary plastics by 2025.
- Halve the amount of organic waste sent to landfill by 2030.
- Provide data to support better decisions.

This plan complements and supports the implementation of better waste management plans by state and territory governments, local government, business and industry. In October 2022, ministers agreed to expand the National Waste Policy Action Plan over the coming year to strengthen Australia's efforts towards our 2030 targets.

In addition, the Safeguard Mechanism applies to large landfill facilities (see section 4.2.1.4).

4.2.6.2 Food Waste for Healthy Soils Fund

The $67 million fund aims to divert organic waste from landfill and create consistent, safe and high-quality recycled organics products for use in improving our agricultural soils. Australian Government funding is provided to state and territory governments and their industry partners on a minimum 1:1:1 basis.

The fund supports the Australian Government's goal to recover 80% of our organic waste materials by 2030, as set out in the National Waste Policy Action Plan by:

- $57 million in infrastructure funding to support new and improved organic waste recycling infrastructure
- $10 million to support the work of DCCEEW to ensure the quality, consistency and safety of recycled organic products and help unlock unused existing processing capacity through updating Australia's compost standard (AS4454-2012 Compost, Soil Conditioners and Mulches); education initiatives to reduce contamination and encourage the uptake of composts; and updating government procurement guidelines to stimulate markets for high-quality compost.

Infrastructure projects have been approved and agreements are being negotiated with state and territory governments. Projects will begin in late 2022 and end by 30 June 2025.

The fund will help divert up to 3.4 million tonnes of organic waste from landfill. If this goal is reached, Australia will recover 80% of its organic waste for productive use, resulting in over 2 Mt CO_2-e being avoided (AEAS, 2021).

4.3 Policy and measures at the state and territory and local levels

State and territory governments have built, expanded and strengthened existing policies since the seventh National Communication and introduced new policies and targets to support mitigation efforts. Each jurisdiction has a net zero target in place, as outlined in Table 4.2.

Table 4.2: State and territory net zero and interim climate commitments

Jurisdiction	Interim commitments	Net zero
Australian Capital Territory	50–60% reduction on 1990 levels by 2025; 65–75% by 2030 and 90–95% by 2040	2045
New South Wales	50% on 2005 levels by 2030	2050
Northern Territory	50% renewable energy for electricity by 2030 and 70% of energy requirements for remote communities through renewables by that date	2050
Queensland	30% reduction on 2005 levels by 2030; renewable energy target of 70% by 2032 and 80% by 2035	2050
South Australia	More than 50% reduction in net emissions from 2005 levels by 2030; 100% net renewable energy generation by 2030	2050
Tasmania	Tasmania has maintained net zero emissions for the last 7 years; current target is whole-of-economy net zero emissions, or lower, from 2030	2030
Victoria	28–33% by 2025 and 45–50% by 2030; 75–80% by 2035; renewable energy target of 65% by 2030 and 95% by 2035	2045
Western Australia	Reducing emissions from government operations by 80% below 2020 levels by 2030.	2050

4.3.1 Australian Capital Territory

4.3.1.1 Legislation

Under the *Climate Change and Greenhouse Gas Reduction Act 2010* (ACT), the Australian Capital Territory (ACT) has a target of net zero emissions by 2045.

4.3.1.2 Energy

The ACT Government has implemented a reverse auction process that achieved zero emissions from electricity by securing 100% renewable electricity from large-scale generators located across eastern and southern Australia as part of the NEM (see section 2.6.1.1). This process enables the ACT Government to deliver fixed-price contracts with large-scale renewable generators that were selected through a series of reverse auctions.

To maintain this achievement of 100% renewable electricity, the ACT's renewable electricity generators create large-scale generation certificates for all eligible generation and transfer them to the ACT. Since achieving 100% renewable electricity in 2020, the ACT has prevented approximately 2,029 kt CO_2-e from being released into the atmosphere (by comparison, 2020–21 emissions were 1,685 kt CO_2-e).

The ACT is taking the next step towards net zero emissions by committing to an electrification pathway and transition away from fossil fuel gas by 2045. The Powering Canberra: Our pathway to electrification paper outlines the ACT Government's intention to transition to renewable electricity and achieve net zero emissions by 2045 (ACT Government 2022a).

The Sustainable Household Scheme, launched in 2021, provides households and not-for-profit community organisations with zero-interest loans up to $15,000 that can be used to purchase efficient electric appliances, zero-emissions vehicles and infrastructure such as solar panels and battery storage to support the phase-out of fossil-fuel-gas appliances (ACT Government 2021d). This will be further supported by programs such as the Next Gen Energy Storage program to provide rebates for battery storage for solar-connected households and businesses (ACT Government 2021c), and a plan to deliver 250 MW of electricity storage as part of the Big Canberra Battery program currently in development (ACT Government 2021a).

Programs such as the Low Income Household Program and Home Energy Support Program enable local community members to access information and financial support to improve the energy efficiency of their homes. These programs are designed to ensure that the transition to a net zero society is fair and equitable, and that homes are healthy and comfortable (ACT Government 2021b).

The Energy Efficiency Improvement Scheme requires that electricity retailers help households and small-to-medium businesses save energy by delivering eligible energy savings activities to households and small-to-medium businesses or paying an Energy Savings Contribution to the ACT Government. This contribution is used to fund energy efficiency programs and support the administration of the scheme.

4.3.1.3 Transport

The ACT Government's Zero Emissions Transport Strategy 2022–2030 sets out policies that commit the ACT to phasing-out light internal combustion engine vehicles from 2035, expanding the public EV-charging network to ensure there are at least 180 publicly available charging stations in the ACT by 2025, and continuing advocacy for strong national policy (ACT Government 2022b).

4.3.2 New South Wales

4.3.2.1 Cross-cutting

In March 2020, the NSW Government released Net Zero Plan Stage 1: 2020–2030. The plan aims to deliver the long-term objective set out in the 2016 NSW Climate Change Policy Framework, which is to achieve net zero emissions by 2050. In a plan update released in September 2021, the NSW Government adopted an interim target of achieving a 50% reduction in the state's emissions compared with 2005 levels by 2030.

As reported in the NSW State of Environment 2021, the Net Zero Plan Stage 1 and its related policies – including the NSW Electricity Infrastructure Roadmap (see section 4.3.2.2) – are projected to reduce state emissions in 2030 by 28.6 Mt CO_2-e, to 37.3 Mt CO_2-e. In addition, NSW base case trends are projected to result in a further 20.4 Mt CO_2-e reduction in annual emissions by 2030. Total NSW emissions are expected to reduce to between 78.9 and 87.6 Mt CO_2-e by 2030, which is 47–52% below 2005 levels (NSW Government 2022).

Progress made towards achieving NSW's net zero emission targets will be reported annually via the NSW Net Zero Emissions Dashboard, accessible via the NSW Sharing and Enabling Environmental Data portal, and every 3 years within NSW State of Environment reports. The dashboard provides state and local government, businesses and communities with overall, sector and location-specific insights into emission trends and progress being made towards the state's emissions reductions targets.

In the 5 years between 2017 and 2022, more than $1.2 billion was invested from the NSW Climate Change Fund (CCF) on climate change mitigation and adaptation programs. The CCF will invest a further $2.8 billion on programs in the 8 years from 2022–23 to 2029–30, including to implement the Net Zero Plan and Electricity Infrastructure Roadmap.

Key policies relating to the *Net Zero Plan Stage 1: 2020–2030* and measures to reduce emissions in NSW since 2017 are:

- NSW Hydrogen Strategy
- NSW Electricity Infrastructure Roadmap and Renewable Energy Zones
- NSW Future Transport Strategy
- NSW Electric Vehicle Strategy
- NSW Future Energy Strategy (Transport)
- NSW Zero Emission Bus Transition Strategy
- NSW Net Zero Industry and Innovation Program
- NSW Waste and Sustainable Materials Strategy.

Hydrogen will help NSW achieve its target of halving emissions by 2030 compared to 2005 levels, and net zero by 2050, and create new opportunities for our heavy industry to decarbonise.

The 2021 NSW Hydrogen Strategy provides $3 billion in incentives and sets out a pathway to make the cost of green hydrogen production less than $2.80 per kilogram in New South Wales by 2030. Strategy actions include:

- establishing the $150 million hydrogen hub initiative, which will establish green hydrogen hubs, starting in the Illawarra and Hunter regions, to combine demand from existing and emerging hydrogen users to drive scale and reduce costs
- providing a 90% exemption from electricity network use-of-system charges for green hydrogen producers who connect to parts of the network with existing available capacity
- extending the Energy Security Safeguard to include a new Renewable Fuel Scheme with a legislated hydrogen target reaching 8 petajoules (67,000 tonnes) by 2030
- providing exemptions for green hydrogen production from government electricity schemes, such as the Energy Savings Scheme and the Peak Demand Reduction Scheme
- supporting the development of a hydrogen refuelling network and heavy vehicle trials across NSW's key freight corridors.

The full decarbonisation of the transport sector, enabled by green hydrogen, can substantially improve liveability. For example, eliminating tailpipe emissions in the heavy transport sector alone could avoid up to $2.8 billion in public health costs from particulate matter emissions. Substantially reduced noise pollution will also improve housing location profiles and allow truck operators to travel in off-peak hours, reducing congestion on our roads and improving productivity.

NSW will expand the Energy Security Safeguard to support hydrogen with a market-based scheme that provides financial incentives for green hydrogen production. The scheme could support an additional $6.4 billion in gross state product (GSP) and $212 million in emissions reduction benefits in present-value terms. It is expected to help the state's annual GSP to increase by more than $600 million every year from 2030.

In March 2022, the NSW Treasurer signed a memorandum of understanding with the Victoria and Queensland governments to partner to establish an east-coast hydrogen refuelling network. This agreement will demonstrate a decarbonisation pathway for the heavy freight sector and also provide a demand source for green hydrogen in NSW. This network's development will start with the creation of a hydrogen refuelling corridor along Australia's most-trafficked freight route, the Hume Highway. The $20 million joint initiative between the NSW and Victorian governments aims to establish at least 4 hydrogen refuelling stations between Sydney and Melbourne, and at least 25 hydrogen-powered trucks.

4.3.2.2 Energy

The 2020 NSW Electricity Infrastructure Roadmap is supporting the development of new electricity infrastructure in NSW, in strategically planned and coordinated REZs. The roadmap supersedes the NSW Renewable Energy Action Plan and Renewable Energy Advocate referred to in the seventh National Communication. It is built on 5 themes:

- driving investment in regional NSW by supporting regions
- delivering energy storage infrastructure by supporting long-term energy storage
- delivering REZs by coordinating transmission and renewable generation for local communities
- keeping the grid secure and reliable by backing the system with gas, batteries and other reliable sources as needed
- harnessing opportunities for industry by providing cheap, reliable and low-emissions electricity.

The roadmap is now largely implemented, with most key entities appointed, a large portion of regulations made, and several key reports and plans published. The remainder of this work will be completed by the end of 2022.

The roadmap aims to deliver at least 12 GW of renewable energy generation and 2 GW of long-duration storage by 2030, partly through private investment of up to $32 billion. The roadmap will reduce NSW's carbon emissions by a total of 90 Mt CO_2-e) by 2030. It is also expected to contribute to a material reduction in methane emissions in the state.

Of NSW's 5 coal-fired power stations that currently provide around three-quarters of the state's energy supply, 4 are scheduled to close by 2035, starting in 2023. Under the roadmap, the Infrastructure Safeguard is an investment signal to deliver the new electricity infrastructure NSW needs. The Infrastructure Safeguard provides a competitive tender framework for new generation, long-duration storage and firming projects.

These agreements will provide long-term certainty for investors and lower costs; in 2020, it was forecast that the roadmap was expected to reduce the total system cost for NSW consumers by $12 billion in net present-value terms and that savings under the roadmap would be $130 per year on average for a typical household during 2023–2040.

The NSW Government has developed First Nations guidelines as required by the *Electricity Infrastructure Investment Act 2020* (NSW) to provide guidance to project proponents and decision-makers on best-practice engagement and negotiation with local First Nations communities relating to new energy infrastructure projects. The guidelines were developed in collaboration with key First Nations stakeholders and communities and will enable electricity projects to create long-term economic and income opportunities for local Aboriginal communities.

The First Nations guidelines recommend roadmap proponents be required to submit an Aboriginal Participation Plan, demonstrating meaningful engagement with local First Nations communities and that commitments are in line with community expectations and state priorities.

4.3.2.3 Transport

The NSW Future Transport Strategy, refreshed in 2022, aims to deliver safe, healthy, sustainable, accessible and integrated passenger and freight journeys. The strategy outlines the commitment to achieving net zero emissions from Transport for NSW's operations and fleet by 2035. Sydney Trains has already transitioned its entire rail network to renewable electricity, becoming the first Australian heavy rail network to do so. This transition prevents the release of approximately 700 kt CO_2-e each year.

In 2018, the NSW transport sector was responsible for 22% of the total state emissions; 87% of transport emissions were derived from road transport, with almost 50% coming from passenger vehicles. The NSW Electric Vehicle Strategy aims to decarbonise this sector with a $633 million commitment over 4 years to increase the uptake of EVs. It is expected that significant private-sector investment will be leveraged as part of this strategy. The aim is to increase EV sales to more than 50% of new cars sold in NSW by 2030.

The 2020 NSW Future Energy Strategy (Transport) is part of NSW's commitment to securing transport energy needs from sustainable sources, and supports the transition of the transport sector to net zero emissions by 2050. The government agency responsible for roads, waterways and public transport, Transport for NSW, contributes around 6% of total transport emissions in NSW. The Future Energy Strategy aims to reduce emissions by up to 90% through actions such as:

- transitioning the state's 8,000 public buses to zero-emissions technologies
- transitioning the entire electrified rail network, including metro and light rail, to net zero emissions electricity by 2025.

The NSW Zero Emission Bus Transition Strategy is part of the NSW Government's commitment to invest $218.9 million over the next 7 years through the 2022–23 NSW Budget to transition 8,000 diesel and compressed natural gas public transport buses in NSW to zero-emissions technology by 2047. Over the life of this project (2021–2047), Transport for NSW estimates a total reduction of around 422 kt CO_2-e emissions. Further, $25 million will be invested over the next 3 years into regional trials in new and emerging technologies, including hydrogen fuel cell electric buses.

Around $2 billion in additional funding has been set aside to begin the scaled transition of more than 8,000 buses across NSW, subject to consideration of a final business case. Further investment will be required to complete the full transition to zero-emission buses across NSW.

4.3.2.4 Industry

The $1.05 billion NSW Net Zero Industry and Innovation Program is supporting and partnering with industry to move towards net zero emissions. A coordinated and collaborative approach is needed to deploy clean technologies, enabling infrastructure, and other associated decarbonising activities to support the scale and speed of the transition of industry to a low-carbon economy.

The Net Zero Industry and Innovation Program has 3 areas of focus:

- clean technology innovation ($195 million) to research, develop and commercialise new and emerging emissions reduction technologies
- new low-carbon industry foundations ($475 million) to lay the foundations for low-emissions industries by building enabling infrastructure and increasing the capability of supply chains in the state
- high-emitting industries support ($380 million) to help existing high-emitting industrial facilities to undertake major capital upgrades of plant and equipment to reduce emissions.

Under the New Low-Carbon Industry Foundations stream, Clean Manufacturing Precincts (CMPs) comprise co-located several industries that share a goal of creating a cluster of low-carbon industries. The program is supporting the establishment of consortiums of industry and community experts to develop a strategic decarbonisation roadmap for CMPs in the Hunter and Illawarra regions. From 2023, roadmaps, including a vision and delivery milestones, will be implemented for future industries in the regions. Businesses in CMPs can benefit by leveraging low-cost renewable energy including hydrogen, access to shared user infrastructure, labour pooling, input sharing, knowledge spillover and circular economy benefits.

The Clean Technology Innovation (CTI) stream is supporting the clean technology sector to achieve net zero emissions in NSW by 2050. The program has the aims of:

- accelerating and expanding the research, development and commercialisation of low-emissions technologies that show potential for becoming scalable, replicable and cost-effective
- creating an ecosystem that can develop the capability to drive repeated clean technology innovation
- attracting world-class clean technology companies and innovations to NSW.

The CTI stream recently launched its first round of grants for research, development and commercialisation projects, with the first projects expecting to start in early 2023. Future funding rounds are expected to continue to 2030.

While not all components of the Net Zero Industry and Innovation Program have updated abatement forecasts, the estimated mitigation impact of the program is at least 31 Mt CO_2-e by 2030, with potential annual carbon abatement of at least 8.4 Mt CO_2-e per year from 2030 onwards.

4.3.2.5 Waste

The NSW Waste and Sustainable Materials Strategy 2041 Stage 1: 2021–2027 aims to halve the amount of food and other organic waste sent to landfill and achieve net zero emissions from organics to landfill by 2030. It supersedes the Waste Less, Recycle More initiative referred to in the seventh National Communication.

Under the strategy, the NSW Government will require:

- the separate collection of food and garden organics from all NSW households by 2030
- the separate collection of food waste from targeted businesses and other entities that generate the highest volumes of food waste, including large supermarkets and hospitality businesses, by 2025
- large supermarkets to report on their surplus food donations to food rescue organisations.

To minimise the impact of landfill gas emissions, the NSW Government will require:

- landfill gas capture for landfills over a specified size and for all expanded or new landfills, with exemptions for certain circumstances
- net zero emissions for landfills that are subject to an environment protection licence; this must be achieved within a prescribed timeframe.

The proposed mandates are supported by:

- $65 million over 5 years to support the rollout of new collection services, the development of more processing capacity and a statewide education campaign
- $7.5 million over 5 years for installation of additional landfill gas infrastructure across NSW.

4.3.3 Northern Territory

The Northern Territory's Climate Change Response establishes the economy-wide target of net zero greenhouse gas emissions by 2050 (NT Government 2022). This target is aligned with that of the Australian Government and every other state and territory in Australia.

A key step in delivering the Emissions Reduction Strategy is close to completion – a study that identifies and calculates the Northern Territory's emissions sources and maps the Northern Territory's emissions trajectories (to 2050) under various economic development scenarios.

4.3.3.1 Cross-cutting

In October 2021, the Northern Territory Government released the Northern Territory Renewable Hydrogen Master Plan, which provides the framework for the development of a renewable hydrogen industry in the Northern Territory, with a focus on enabling activities required to secure private-sector investment. In the 2022 Budget, the Northern Territory Government announced funding to accelerate and expand the Northern Territory's hydrogen industry.

4.3.3.2 Energy

Electricity market reform

In the context of the developments happening in other electricity markets, the Northern Territory Government is working with industry and energy sector experts to develop fit-for-purpose market arrangements for the Northern Territory.

The Government conducted stakeholder consultation on the future market arrangements and design during 2022 and will announce the outcomes in due course.

Northern Territory renewable energy target

The Northern Territory Government has committed to a renewable energy target of 50% of the electricity consumed from grid-connected installations by 2030. The Renewable Energy Target Implementation Plan builds on current policy settings, both at a territory and federal level.

In October 2021, the Northern Territory Government released the Darwin–Katherine Electricity System Plan, which details the pathway to achieve the renewable energy target. In the 2022–23 Northern Territory Budget, funding was approved to move forward with the broader actions within the first 2 stages of the System Plan to 2026.

The Northern Territory Government entered into a project funding agreement with Desert Knowledge Australia to develop the Intyalheme Centre for Future Energy to assist the territory to achieve the renewable energy target. The Alice Springs Future Grid project, including the development of a plan in 2023 for the Alice Springs power system to achieve the target, is Intyalheme's primary activity. The project is expected to be completed in 2023.

Home and Business Battery Scheme

The Home and Business Battery Scheme started in April 2020. It provides grants of up to $6,000 to help home owners and businesses in the territory install batteries to accompany their rooftop solar systems. From 2 August 2021, grid-connected battery systems funded through the program have been required to be virtual-power-plant capable.

The scheme will support achievement of the Northern Territory's 50% renewable energy target by supporting transformation of the electricity grid.

Remote Power System Strategy

In April 2021, the Northern Territory Government announced the development of an open and contestable framework to deliver an average of 70% renewable energy to 72 remote Indigenous communities by 2030.

Work is progressing on the detailed analysis to map the optimal renewables development pathway, considering existing energy assets, community aspirations, electricity demand profiles and forecast growth. Aboriginal communities and Traditional Owners will be consulted to establish desires and expectations as part of this analysis.

4.3.4 Queensland

In July 2021, the Queensland Government released its Queensland Climate Action Plan 2020–2030. The plan sets the path to meet Queensland's climate targets and builds on the action already taken under the Queensland Climate Transition Strategy and the Queensland Climate Adaptation Strategy (Queensland Government 2020).

The plan has 3 targets:

- achieving zero net emissions by 2050
- powering Queensland with 50% renewable energy by 2030
- reducing emissions by at least 30% below 2005 levels by 2030.

The plan sets priorities for further action across 5 sectors: electricity, transport, agriculture, buildings and land. In 2022, the Queensland Government released the following strategies under the plan:

- Queensland Energy and Jobs Plan
- Queensland's Zero Emission Vehicle Strategy 2022–2032
- Queensland Resources Industry Development Plan
- draft Low Emissions Agriculture Roadmap.

The Queensland Energy and Jobs Plan is a critical part of the overall climate plan, and will deliver:

- 70% renewable energy by 2032 and 80% by 2035 (and legislation to establish these targets in law)

- 50% reduction in electricity sector emissions on 2005 levels by 2030
- 90% reduction in electricity emissions on 2005 levels by 2035–36.

By 2035, all publicly owned coal-fired power stations will be operating as clean energy hubs, and Queensland will have no regular reliance on coal generation.

As next steps, the Queensland Government will be preparing their:

- Zero Net Emissions Transport Plan
- Zero Net Emissions Infrastructure Plan
- Zero Net Emissions and Resilient Buildings Plan.

The Queensland Government, with the Australian Government and south-east Queensland local governments, has also committed to delivering a sustainable and climate-positive Brisbane 2032 Olympic and Paralympic Games ('Brisbane 2032'). Brisbane 2032 will accelerate Queensland's zero net emissions transition and deliver lasting climate legacies for host communities.

Case study: Decarbonisation of the Great Barrier Reef Islands Program

The Queensland Government's Decarbonisation of the Great Barrier Reef Islands program, which started in 2018, supports businesses and communities of the Great Barrier Reef islands to transition to a low-carbon future and build resilience to the impacts of climate change. The Queensland Government invested $1.73 million in the program to identify and develop place-based mitigation and resilience projects in collaboration with stakeholders in the region.

The first phase of the program focused on 25 resorts across 20 islands. For each resort, opportunities were identified and business cases developed for projects with the potential to reduce emissions and build resilience. The program found that if the resorts implemented these projects, they would collectively achieve annual energy savings of approximately $3.5 million and carbon savings of approximately 18.5 kt CO_2-e per year. The business cases have been used to help secure funding through the 'greening' element of the Great Barrier Reef Island Resorts Rejuvenation Program.

The second phase piloted a whole-of-community approach with the islands of Great Keppel, Magnetic, Palm and Masig. The program worked with resorts and communities to undertake sustainability assessments, identify priority decarbonisation and resilience opportunities, and develop project-ready businesses cases. Low-emission solutions identified included solar and battery combinations, biodiesel and biogas, solar hot water, electric vehicles, hybrid ferries, and wind and tidal turbines.

The program's whole-of-community pilot was successful because of its commitment to cultural integrity and place-based design. Embedding respectful, meaningful engagement with First Nations communities throughout, and elevating and strengthening cultural knowledge and expertise, ensured final project options were relevant, appropriate, and therefore more likely to successfully address climate change impacts and risks.

As one of the 4 whole-of-island communities participating in the program, Masig Islanders explored ways to reduce emissions and adapt to local climate-related impacts. Together with local organisations, key government agencies, and sustainability consultants, they established their community's carbon and sustainability footprint and identified a broad range of place-based projects that could help reduce emissions and increase resilience.

Eighteen projects were prioritised by the community, with comprehensive 'project-ready' business cases developed for each. One business case was to engage a dedicated on-island sustainability officer on Masig to help oversee delivery of several of the other projects. The Masig community considered this position to be fundamental to advancing projects that address energy generation and efficiency, water supply and treatment, waste, inter- and intra-island transport, and increasing resilience. These projects can be found in the report Sustainable Masig.

Case study: Land Restoration Fund

The Queensland Government's Land Restoration Fund (LRF) is expanding carbon farming opportunities in the state by supporting projects that deliver carbon credits plus environmental, social, economic, and First Nations co-benefits.

By valuing and paying a premium for carbon projects with co-benefits, the LRF is helping land managers, including farmers and First Nations people, generate new, regular income streams while improving Queensland's environment and waterways, providing more habitat for threatened species, and creating regional jobs.

The LRF is underpinned by the LRF Co-benefits Standard, which outlines how co-benefits from LRF projects are to be identified, measured, reported and verified. This standard, which is a market-leading innovation, ensures that co-benefits associated with carbon projects are evidence-based.

Investment highlights

- *Influencing voluntary land-use change:* More than 12,000 hectares of land contracted for LRF carbon projects is classified as Category X, meaning the land can be cleared without a permit under Queensland vegetation management laws. Because of the voluntary use change, this land will now have long-term protection. This demonstrates the impact that investment in carbon projects with co-benefits can have in promoting voluntary action by land managers to retain and restore native vegetation.
- *Reducing the risk of species decline from habitat loss, climate change, and development impacts:* LRF projects will result in more habitat for threatened wildlife through activities that restore native woodlands and forests through regrowth and environmental plantings.
- *Improving catchment condition, including those flowing to the Great Barrier Reef:* LRF projects in Reef catchments will improve catchment condition through environmental plantings and regeneration of native vegetation.
- *Driving new social and economic outcomes in Queensland:* The LRF contracted projects span 17 regional and rural Queensland local government areas. These projects are committed to sourcing goods and services from local businesses, training local workers, and using local manufacturers and other local businesses in the supply chain.
- *Supporting connection to Country:* The LRF supports projects led by First Nations people or that take place on Indigenous land. This includes 2 savanna burning projects in Cape York that will see Traditional Owners using on-ground mosaic burning methods. This method is culturally and environmentally beneficial as Traditional Owners are directly involved on-ground, allowing them to be more selective with burn areas so they can monitor sensitive biodiversity needs.

The LRF will continue to pursue a diverse portfolio of projects, ensuring that investments cover a range of locations, carbon methods, sizes and co-benefit outcomes with the aim of maximising the environmental, economic and social benefits that environmental markets can deliver in Queensland.

4.3.5 South Australia

4.3.5.1 Legislation

South Australia was the first state in Australia to introduce a climate change Act: the *Climate Change and Greenhouse Emissions Reduction Act 2007* (SA). The Act will be updated in the near future to legislate new emissions targets and strengthen climate change action.

4.3.5.2 Cross-cutting

In May 2022, South Australia declared a climate emergency. The response to the emergency is supported by existing and new government-led mitigation and adaptation actions. These include a Hydrogen Jobs Plan, initiatives to encourage uptake of electric vehicles, development of an Urban Greening Strategy, an independent implementation review of planning policies and development of a new state biodiversity act. More information on the actions being undertaken by the South Australian Government is available on the government website: SA Government Climate Change Action.

The South Australian Government is working to embed climate change considerations in government decision-making with a focus on improving climate risk management practices and reducing emission from government operations.

4.3.5.3 Energy

South Australia has transformed its energy system from 1% to 68% renewable energy in just over 15 years. By 2025–2026, the Australian Energy Market Operator forecasts this could rise to approximately 85%. In 2021, South Australia met 100% of its operational demand from renewable resources on 180 days (49% of the year). South Australia has an aspiration to achieve 100% net renewables by 2030, generating renewable electricity equal to 100% of its annual demand.

South Australia's Hydrogen Jobs Plan seeks to establish a competitive and sustainable green hydrogen sector. The plan began implementation in 2022 and is expected to be operational by the end of 2025. The South Australian Government is contributing $593 million to deliver the plan, which will include the construction of a hydrogen power station, electrolyser and storage facility in Whyalla, including:

- 250 MW (electrical) of electrolysers
- 200 MW of power generation (powered by the electrolysers)
- hydrogen storage facilities.

Operation of the electrolysers during the middle of the day will provide additional grid stability, by soaking up the state's renewable energy generated from large-scale wind and solar farms. In addition, the hydrogen generator will enhance system security by providing South Australia with a source of dispatchable renewable energy.

A new government enterprise, Hydrogen Power South Australia, will be established to own and operate the hydrogen power plant. The Office of Hydrogen Power South Australia has been established to oversee the initial implementation of the Hydrogen Jobs Plan in the interim. Hydrogen Power South Australia will offer firming services to renewable generation facilities (e.g. wind and solar farms) located in South Australia, using a contract structure that will ensure the reduced firming costs are passed onto South Australian energy users.

While the mitigation impact of the plan has not been calculated, it is expected to result in lower CO_2 emissions and potentially reductions in emissions of other greenhouse gases through improvements to industrial processes. The plan will also deliver other significant benefits, including:

- creating jobs
- generating dispatchable power (the hydrogen generator), enhancing grid security
- testing hydrogen production and generation technology at scale
- helping to unlock a pipeline of renewable energy developments and associated manufacturing opportunities
- supporting the clean energy transition and decarbonisation.

Other energy initiatives include the Retailer Energy Productivity Scheme, investment in grid scale storage, demand management, and South Australia's virtual power plant. South Australia is also supporting a range of electric vehicle initiatives to accelerate the uptake of electric vehicles in South Australia.

4.3.5.4 Agriculture and land use, land-use change and forestry

The South Australian Government has worked with the CER to assist in the development and release of the first accredited blue carbon method for tidal reconnection in January 2022. The Dry Creek project introduced tidal flow to salt ponds to deliver blue carbon offset opportunities and determine a blue carbon method. The Nature Conservancy, in partnership with the South Australian Government and a consortium of partners, has since provided resources, and secured a grant from the Australian Government Blue Carbon Ecosystem Restoration Grant, for a significant blue carbon coastal wetland restoration project.

South Australia has also pioneered seagrass restoration, in particular off the Adelaide metropolitan coast. The South Australian Government delivered the largest seagrass restoration project in Australia, restoring 10 hectares of seagrass using a new hessian-bag technique. It has now secured funding from the Australian Government Blue Carbon Ecosystem Restoration Grant to refine the technique, restore a further 20 hectares of seagrass, and investigate blue carbon accounting on these restoration projects. South Australia also plans to help develop the seagrass methodology for blue carbon projects.

South Australia's Carbon Farming Roadmap guides the development of agricultural and other land management practices to increase carbon stored in soil and vegetation (sequestration) or to reduce greenhouse gas emissions. A Growing Carbon Farming Pilot is an initiative to encourage carbon farming adoption and build the carbon market in South Australia.

Case study: Hornsdale Power Reserve – the world's first big battery

The 100-megawatt (MW), 129-megawatt hour (MWh) Hornsdale Power Reserve, also known as South Australia's Big Battery, was completed on 1 December 2017 (Hornsdale Power Reserve 2021). At the time it was the world's largest lithium-ion battery and one of the largest renewable energy developments in Australia.

The 50 MW, 64.5 MWh Hornsdale Power Reserve Expansion was completed in 2020, increasing capacity to 150 MW and adding Tesla's 'virtual machine mode', enabling the battery to provide inertia support services to the electricity grid.

The project was funded by the South Australian Government and Australian Government agencies, in addition to private investment from Neoen Australia and Tesla. The total project cost, including initial capital expenditure and facility upgrade, is $161 million (ARENA 2022).

The Hornsdale Power Reserve was intended to provide a battery storage facility to stabilise the South Australian electricity grid, improve the affordability of energy, facilitate integration of renewable energy in the state, and reduce the chance of load-shedding and blackout events.

In its first 2 years of operation, the Hornsdale Power Reserve confirmed the benefits associated with grid-scale batteries in the National Electricity Market, by reducing the cost of frequency control ancillary services by approximately $116 million in 2019 alone. The Hornsdale Power Reserve has also saved South Australian consumers over $150 million in electricity costs.

In 2022, the Hornsdale Power Reserve gained approval to become the first large-scale battery in the world to deliver grid-scale inertia services, replacing inertia services traditionally provided by gas or coal-fired generators. The reserve will have the capacity to provide an estimated 2,000 MW of equivalent inertia, or around 15% of the predicted shortfall in the state's network, which serves over 1.7 million people and 150,000 businesses.

Although the total amount of greenhouse gas emissions reduction achieved by the Hornsdale Power Reserve has not been estimated, it is expected that it will support the transition to renewable energy and net zero.

4.3.5.5 Waste

South Australia's Waste Strategy 2020–2025, and supporting policies and legislation – including the Valuing Our Food Waste strategy and *Single-use and Other Plastic Products (Waste Avoidance) Act 2020* (SA) – establish a framework and targets to help develop a circular economy. South Australia has the highest resource recovery rate (85%) and a recycling rate (80%) in Australia.

The strategy, which is reviewed every 5 years, is designed to reduce emissions of CO_2, methane and other greenhouse gases by diverting or avoiding waste going to landfill. The strategy has specific targets:

- zero avoidable waste to landfill by 2030
- Metropolitan Adelaide 2025 targets by waste sector
    - municipal solid waste diversion of 75%
    - commercial and industrial solid waste diversion of 90%
    - construction and demolition diversion of 95%
- per capita waste generation – 5% reduction from a 2020 baseline.

The strategy encourages high-impact action in new directions including food waste and single-use plastics, regulatory waste reforms, education and behaviour change, and supporting market development and remanufacturing. It is supported by legislation including the *Environment Protection Act 1993* (SA) and *Single-use and Other Plastic Products (Waste Avoidance) Act 2020*, (SA) which was the first legislation of its kind in Australia restricting the manufacture, production, distribution, sale and supply of certain single-use and other plastic products. The strategy is complemented by information and education programs including Replace the Waste, Which Bin, the development of tools and guides, and grants through the Business Sustainability Program and other funding opportunities. South Australia's Valuing Our Food Waste strategy is the first in Australia covering reduction of food waste for a jurisdiction. It integrates policy measures, behavioural change actions and support for industry to address the estimated 200 kt of food waste sent to landfill each year in South Australia.

The establishment of a circular economy has been estimated to reduce South Australia's greenhouse gas emissions by 27%, or 7.7 Mt CO_2-e (Green Industries SA 2020a):

- 21% greenhouse gas reduction by actioning efficient and renewable energy gains
- 6% greenhouse gas reduction by actioning material efficiency gains.

According to South Australia's Recycling Activity Survey 2019–20 Report, the state saved approximately 1.32 Mt CO_2-e in 2019–20 from recycling. Organics recycling contributed the greatest proportion of CO_2-e savings at 56%, despite representing 27% of all recovered material. Recycling and reducing waste can have other benefits; the Recycling Activity Survey Report states that resource recovery in 2019–20 was projected to achieve the following additional environmental benefits from recycling of these materials (Green Industries SA 2020b):

- cumulative energy demand saved – 14,800 terajoule
- water savings – 7,500 ML.

4.3.6 Tasmania

As a result of Tasmania's longstanding investment in renewable energy and the carbon sink in its forests, Tasmania was the first state in Australia to achieve net zero emissions, in 2013. Tasmania has maintained net zero emissions for the last 7 years. In November 2021, the Tasmanian Government committed to a whole-of-economy target of net zero emissions, or lower, from 2030.

4.3.6.1 Legislation

Legislation to amend the *Climate Change (State) Action Act 2008* (Tas) was passed by the Tasmanian Parliament. The Climate Change (State Action) Amendment Bill 2021:

- formalises the government's emissions reduction target
- consolidates the objects of the Act, including explicit reference to local government and the consideration of the impacts of climate change on the health and wellbeing of Tasmanians and future generations
- establishes a legislative framework for the government to partner with industry to develop emissions reduction and resilience plans for key industry sectors and subsectors, including energy; transport; agriculture; land use, land-use change and forestry; waste; and industrial processes and product use
- establishes a legislative framework for the Tasmanian Government to prepare a climate change action plan at least every 5 years, to ensure continued action to grow a climate-ready economy, reduce emissions and adapt to climate change
- establishes a legislative requirement for a statewide climate change risk assessment to be completed every 5 years
- increases the transparency and accountability of the Tasmanian Government's climate change response, including a requirement to table reports on greenhouse gas emissions and climate action in Parliament.

4.3.6.2 Cross-cutting

The government has committed to develop an Emissions Reduction and Resilience Plan for the government operations sector and establish a whole-of-government policy framework to embed climate change considerations in Tasmanian Government decision-making.

The Tasmanian Renewable Hydrogen Action Plan, released in March 2020, commits the state to developing a renewable hydrogen industry to meet local demand and for export by 2030. In May 2020, the government announced a $50 million Tasmanian Renewable Hydrogen Industry Development Funding Program to help activate a green hydrogen industry in Tasmania.

The 2021–22 Tasmanian Budget allocated funding for measures to support emissions reduction and reduce energy costs, including:

- $10 million for the Solar Power Sports Club scheme – a no-interest loan scheme for solar systems for clubs
- $5 million for the Renewable Energy Schools Fund
- $15 million investment to support energy efficiency in public housing
- $2 million to expand the No-Interest Loan Scheme. This scheme provides concession-card holders with a 50% subsidy towards energy-efficient appliances, with a no-interest loan for the balance.

The 2022–23 Tasmanian Budget provided $10 million over 4 years to replace ageing fossil fuel boilers in schools, hospitals and correctional facilities with renewable energy-powered alternatives, including bioenergy technology. In October 2022, the Tasmanian Government launched a $50-million Energy Saver Loan Scheme to provide interest-free loans of up to $10,000 for eligible applicants to invest in energy-efficient products.

4.3.6.3 Energy

Tasmania achieved its target of 100% self-sufficient renewable electricity generation in 2020. In November 2020, the government legislated a target to keep growing Tasmania's renewable electricity generation to 200% (of 2020 generation capacity) by 2040, with an interim target of 150% by 2030.

The Tasmanian Renewable Energy Action Plan, Tasmanian Renewable Hydrogen Action Plan and the Renewable Energy Coordination Framework set the government's vision and actions to grow the renewable energy sector sustainably over the next 20 years.

The Tasmanian Renewable Energy Action Plan, published in December 2020, details the government's vision for Tasmania's renewable energy future. It sets clear targets and actions designed to build on Tasmania's natural competitive advantages and attract large-scale investment to significantly grow and expand Tasmania's renewable energy sector into the future.

The Renewable Energy Coordination Framework was released in 2022. It prioritises the actions necessary to support the future growth of Tasmania's renewable energy sector. The 2022–23 Tasmanian Budget allocated $800,000 over 2 years to implement the framework.

Renewable electricity production is expected to be realised through the Battery of the Nation project and large-scale wind farm development. New renewable electricity generation will be supported by Project Marinus and the growth of new industries, such as green hydrogen production.

Marinus Link, the interconnector component of Project Marinus, is a proposed 1500-MW-capacity undersea and underground electricity connection to further link Tasmania and Victoria as part of Australia's future electricity grid.

Project Marinus is planned to be operational from 2029 for the first 750-MW stage and 2031 for the second 750-MW stage. It is expected to produce savings of at least 140 Mt CO_2-e nationally by 2050 and deliver up to $4.5 billion in positive net market benefits to NEM customers. It is expected to attract billions of dollars of investment in regional areas of Tasmania, including 1,400 jobs in Tasmania and more than $7 billion in additional economic activity to the state.

Marinus Link has collaborative funding, ownership and cost allocation arrangements involving the Australian, Tasmanian and Victorian governments. The total cost of the project is estimated to be $3.8 billion. The North West Transmission Developments (a key component of Project Marinus) will be wholly owned by the Tasmanian Government through TasNetworks.

Hydro Tasmania's Battery of the Nation projects investigate development opportunities in Tasmania's hydropower system expansion, including pumped hydro opportunities. The Battery of the Nation projects will be wholly owned by the Tasmanian Government through Hydro Tasmania. This includes the Tarraleah power station redevelopment (at a cost of approximately $700 million) and the Lake Cethana pumped hydro station (around $1.5 billion).

The Battery of the Nation projects will be staged to commence with Project Marinus, with the proposed Tarraleah power station redevelopment to commence in line with the first Marinus Link stage in 2029 and the potential pumped hydro station to commence with the second Marinus Link stage in 2031.

4.3.6.4 Transport

Since 2018, the Tasmanian Government has provided nearly $1.4 million in funding through the Electric Vehicle ChargeSmart Grants Program to support EV-charging infrastructure around Tasmania. The key aims are to stimulate the market to install the charging stations and to ensure the funding achieves the greatest benefit for Tasmania by increasing public EV-charging opportunities. Across 2 grant rounds, funding has been provided for the installation of 34 fast chargers and 66 destination and workplace chargers around the state. Once installation of all chargers is complete, each ChargeSmart-supported station will, on average, have another station within 47 km.

In the 2020–21 Tasmanian Budget, the government announced a target to transition the government vehicle fleet to 100% EVs by 2030. The initiative may also result in a greater number of EVs available in the second-hand vehicle market. Funding of $2.3 million over 3 years was allocated in the 2020–21 Budget and a further $2.25 million was allocated in the 2022–23 Budget to support the transition.

In the 2021–22 Budget, Metro Tasmania received $6 million over 2 years to deliver an electric bus trial. Funding has also been made available through the Tasmanian Renewable Hydrogen Industry Development Funding Program to Metro Tasmania for a hydrogen bus trial, with funding provided for up to 3 buses for up to 5 years.

As announced in the 2021–22 Budget, the government introduced a stamp duty waiver on the purchase of new or second-hand battery electric or hydrogen fuel cell vehicles for 2 years from 1 July 2021. This measure also includes a 2-year registration fee waiver on EVs purchased by rental car and tour bus companies.

4.3.6.5 Industry and industrial processes

In the 2020–21 Tasmanian Budget, the government announced new funding of $1.3 million over 4 years to introduce a $10 million no-interest loan scheme for large Tasmanian greenhouse gas-emitting businesses and industries to trial existing clean technologies or test new innovative production processes that will lead to reduced emissions.

4.3.6.6 Agriculture

The 2021–22 Tasmanian Budget allocated $250,000 for a Carbon Farming Advice Rebate Pilot Program, which is providing Tasmanian primary producers with rebates of up to $10,000 to offset the cost of obtaining expert advice on carbon farming projects tailored to their enterprise. The program is experiencing strong interest and will remain open until all funds are expended.

From 2018–19 to 2020–21, the Tasmanian Government delivered the On-Farm Energy Audit and Capital Grant Program, as announced in the 2018–19 Tasmanian Budget. The program provided audit grants to assist eligible farmers to engage a qualified professional to review their farm energy use, infrastructure and systems and identify savings strategies. Capital infrastructure grants were also available to provide a subsidy to assist eligible farm businesses to purchase new energy-saving or energy-efficient capital infrastructure to support improved or optimised on-farm energy efficiency. Maximum grant assistance available under the program was $20,000 per applicant.

Through the Pasture Pathways Small Project Fund, the Tasmanian Government has funded Farmers for Climate Action to promote climate-smart strategies for managing perennial pastures, improving soil carbon and reducing agricultural emissions.

4.3.6.7 Waste

The Tasmanian Government is implementing its Draft Waste Action Plan, released in 2019. The plan sets out a broad framework for waste management and resource recovery in Tasmania. Goals include achieving a 40% average recovery rate from all waste streams by 2025 and 80% by 2030, and to reduce the volume of organic waste to landfill in Tasmania by 25% by 2025 and 50% by 2030.

Several achievements have been made under the plan to date:

- The *Waste and Resource Recovery Act 2022* (Tas) introduced a statewide levy on waste to encourage the diversion of waste from landfill and drive investment in Tasmania's circular economy. The levy began on 1 July 2022.
- The *Container Refund Scheme Act 2022* (Tas) was passed by Tasmanian Parliament in March 2022. The Act provides for the introduction of a container refund scheme, due to start in 2023.
- The government allocated $3 million in the 2021–22 Budget to invest with industry in the construction of a rubber crumbing plant to turn end-of-life tyres into products that can be used in the road resurfacing program.
- The government established a $10 million Circular Economy Fund in the 2020–21 Budget. $6 million from the fund has been allocated to improve and increase food organics and garden organics reprocessing capacity across Tasmania. This includes one project in the south and another in the north of the state. This will result in the diversion of nearly 80 kt of organic waste from landfill and the subsequent avoidance of emissions from that waste.

From 2018 to 2020, the government delivered the Business Resource Efficiency Program, which helped small- and medium-sized businesses reduce their emissions and costs by implementing resource efficiency initiatives. An additional $200,000 funding has been committed to expand this program in 2022 and registrations are now open.

4.3.7 Victoria

4.3.7.1 Legislation

The *Climate Change Act 2017* (Vic) provides Victoria with the legislative foundation to manage climate change risks, maximise the opportunities that arise from decarbonisation, and drive transition to a climate-resilient community and economy with net zero emissions by 2050.

The Victorian Climate Change Act sets a target of net zero emissions by 2050 for Victoria. Following the November 2022 election, the Victorian Government has confirmed its intention to amend the Act to bring this target forward to 2045 and legislate its 2035 emissions reduction target.

To guide the transition to net zero emissions, Victoria has interim targets to reduce emissions by 28–33% below 2005 levels by 2025, and 45–50% below 2005 levels by 2030. Victoria met its 2020 target of 15–20% below 2005 levels and is on track to meet its 2025 target. The Victorian Government has also set a 2035 target of 75–80% below 2005 levels. This was based on an extensive review, including independent expert advice and consultation with stakeholders (DELWP 2021c).

The Victorian Government has set emission reduction pledges for each sector for 2021 to 2025 – this is the first of the 5-yearly pledges required by the Climate Change Act (DELWP 2021d). The pledges cover the entire Victorian economy – including innovation and research and development to support future emissions reductions in hard-to-abate sectors. For 2021–2025, the most significant emissions reductions will be from energy, the land sector and transport.

4.3.7.2 Cross-cutting

Under the Whole of Victorian Government Sector Pledge, the Victorian Government is reducing emissions from its own operations and leveraging the power of government spending to contribute to its emissions reduction goals. All Victorian Government operations, facilities and services will be powered with 100% renewable electricity by 2025. This will cut the Victorian Government's own emissions by almost three-quarters.

Victorian water corporations have committed to achieving world-leading targets by reducing emissions by 42.4% by 2025, 93.7% by 2030 and 100% (net zero) by 2035, the first state water sector in Australia to do so.

The Victorian Government will start to transition its fleet to zero-emissions vehicles (ZEVs), with 400 ZEVs added to the fleet by 2023. This will lower emissions, build local demand for ZEVs and increase the supply of more affordable second-hand ZEVs over time.

The Victorian Government will continue to install solar panels and improve the energy efficiency of government-owned facilities, including sporting facilities, hospitals, schools and public transport facilities.

4.3.7.3 Energy

The energy sector is Victoria's biggest source of emissions. To reduce emissions, the Victorian Government is investing $1.6 billion to build a clean energy economy, as outlined in the Victorian Energy Sector Pledge. The pledge was implemented in 2021 with the aim to reduce emissions, increase large- and small-scale renewable energy, build a reliable and secure electricity grid and improve energy efficiency.

The pledge will deliver significant emissions reductions through more than 20 programs, including:

- the Victorian renewable energy target of 50% renewable electricity by 2030 (now increased to 65% by 2030 and 95% by 2035) and energy storage targets of at least 2.6 GW by 2030 and 6.3 GW by 2035
- 6 successful projects announced under the VRET2 auction, bringing forward 623 MW of new renewable generation capacity and delivering up to 365 MW and 600 MWh of new battery energy storage
- release of the Offshore Wind Implementation Statement 1, outlining plans for the establishment of an offshore wind industry in Victoria (DELWP 2021a)
- investment in a next-generation electricity grid, including 6 renewable energy zones and the Victorian Big Battery – Australia's largest lithium-ion battery (DELWP 2021b)

- support for households and businesses to invest in solar panels and residential batteries through the Solar Homes and Solar Business programs
- increased energy efficiency, including encouraging uptake of efficient appliances and smart technologies, for households and businesses through the Victorian Energy Upgrades program
- encouraging electrification through removing barriers to 'all-electric' homes and appliances and substituting natural gas with clean alternatives through the Gas Substitution Roadmap.

4.3.7.4 Transport

Victoria's transport network is also a major – and rising – source of emissions. The Victorian Government is investing $100 million to accelerate the transition to ZEVs as outlined in the Victorian Transport Sector Pledge. The pledge was implemented in 2021 and aims to reduce emissions, increase update of ZEVs and improve public transport. It includes:

- $46 million ZEV subsidy program to provide grants to people and businesses to buy ZEVs
- support for a statewide EV fast-charging network
- adding 400 ZEVs to the Victorian Government fleet over the next 2 years
- zero-emissions bus trials to support a transition to 100% of new public buses being zero-emissions buses from 2025
- continued investment in public transport infrastructure and services.

The government is also improving Victoria's public transport system and walking and cycling paths to encourage more public and active transport use.

4.3.7.5 Industrial processes and product use

The Victorian Industrial Processes and Product Use Sector Pledge, implemented in 2021, aims to reduce leakage of refrigerant gases through advocacy for a stronger national regime and guidance for enhanced management of large refrigeration and air-conditioning systems. Its objective is to reduce emissions by reducing refrigerant gas leaks.

4.3.7.6 Agriculture and land use, land-use change and forestry

The Victorian Government is investing $120 million to phase out commercial native forest harvesting by 2030. Ending native forest timber harvesting will reduce Victoria's emissions and ensure that our old-growth forests – the habitat of our rarest native species – can exist and thrive for future generations.

The LULUCF sector pledge, implemented in 2021, aims to reduce greenhouse gas emissions, protect native forests, restore degraded landscapes and plant millions of new trees. It also aims to support affected communities and to protect and improve biodiversity. Measures include:

- ending native forest timber harvesting by 2030, including $120 million to support workers, businesses and communities transition from native forest harvesting to a plantation-based timber supply
- the $110 million Gippsland Plantations Investment Program to provide incentives for plantation investors to undertake industrial-scale planting to bolster Victoria's timber supplies
- Bushbank – a $76 million program to incentivise private and public landowners to restore and protect natural habitats and diversify income streams.

The Victorian Agriculture Sector Emissions Reduction Pledge lays the foundations to achieve substantial emissions reductions later this decade and beyond. The Victorian Government is focused on accelerating research in Victoria and strengthening the agriculture industry's ability to deploy low-emissions technologies and practices. Investment of $3.9 million will support research trials in pasture-based grazing systems for 2 promising methane-inhibiting feed additives. Findings of this research and the on-farm action planning pilot will inform the design of future policies and programs, including for the next round of sector pledges due in 2025.

Key actions in the pledge include:

- research trials in methane-inhibiting feed additives; on-farm action plans
- online spatial tools to assist farmers to reduce emissions
- establishing a shared vision for the sector in a net zero and climate-resilient economy.

Case study: Low-emissions agriculture innovation at the Ellinbank SmartFarm

Achieving significant emissions reductions in Victorian agriculture will require leading-edge research, innovation and deployment of new technologies and practices.

The Victorian Government is investing $3.9 million to accelerate 2 trials of methane-inhibiting feed additives, such as 3-NOP and seaweed (*Asparagopsis*) at Agriculture Victoria's Ellinbank SmartFarm research centre to test how they will work on Victorian farms. The 231-hectare, 500-cow Ellinbank SmartFarm is Australia's leading dairy innovation facility, and is on track to become the world's first carbon-neutral dairy farm by 2026. The SmartFarm will become carbon neutral by reducing methane emissions, improving fertiliser and manure management and generating electricity through solar, wind, hydro and biodigestion.

4.3.7.7 Waste

Two-thirds of Victoria's emissions from the waste sector result from the decomposition of organic material in landfill. The Victorian Government is investing $515 million to transform the state's waste and recycling system. This will divert waste from landfill to recycling and cut emissions, as well as reduce air, water and soil pollution. The 2020 plan, Recycling Victoria – a new economy will help businesses and households improve their resource efficiency, reduce waste and recycle more. It will also support the development of clean technologies that will facilitate new markets and new business opportunities for recycled materials.

The Recycling Victoria plan began in 2021; emission reduction measures in the plan include:

- waste system reform to separate organic waste from other forms of waste, support more effective organics recycling and help avoid emissions that occur when organic waste goes to landfill
- support for innovation for new recycled markets and creative solutions to waste
- support for businesses to improve their resource efficiency, reduce the disposal of waste to landfill, increase recycling and reduce business costs.

4.3.8 Western Australia

In 2022, the Western Australian Government announced its commitment to a whole-of-government 2030 emissions reduction target of 80% below 2020 levels, from government agency operations and government trading enterprises. This interim target of 80% below 2020 levels applies to emissions from all government agencies, including transport, health and education and energy and water utilities (WA Government 2022b).

To help achieve this target, the government will deliver initiatives to reduce the net emissions of government, including energy efficiency measures, procurement of renewable energy, reduced emissions in the government vehicle fleet and the use of local offsets.

4.3.8.1 Cross-cutting

Sectoral emissions reduction strategies

This measure was announced in 2021 and is in the planning stage, aiming for development by the end of 2023. Strategies will be developed to reduce emission from all sectors of the Western Australian Economy and transition to net zero emissions for the state by 2050. The Western Australian Government is developing its sectoral emissions reduction strategies (WA Government 2022c) in consultation with business, industry, research institutions and the community to transition the economy to net zero emissions.

The sectoral emissions reductions strategies will:

- provide robust emissions reduction pathways for Western Australia with tangible actions for reducing emissions consistent with the government's target of net zero emissions by 2050
- recognise the importance of significant action this decade to reduce emissions, transition emissions-intensive industries and protect Western Australia's economy from carbon transition risks.

Renewable Hydrogen Strategy

The Renewable Hydrogen Strategy, launched in 2019, sets out the Western Australian Government's areas of focus for the development of the hydrogen industry. The strategy aims to harness Western Australia's competitive advantages, including renewable energy resources, vast land mass and history of exporting energy to international markets. The Renewable Hydrogen Roadmap outlines how the government is supporting the development of the renewable hydrogen industry.

The strategy and roadmap will drive Western Australia's position as a major producer and exporter of renewable hydrogen. Focus areas for the plan and roadmap include:

- export – Western Australia is well placed to capture a significant share of the global hydrogen market due to its excellent renewable energy resources, skilled oil and gas workforce, proximity to Asia and export infrastructure
- remote applications – renewable hydrogen can reduce reliance on diesel for remotely located industries and communities
- hydrogen blending in natural gas networks – blending low concentrations of hydrogen into natural gas networks provides an opportunity to partially decarbonise the state's gas sector
- transport – fuel cell EVs present an early opportunity for hydrogen utilisation for mobility and freight transport.

The Western Australian Government is investing almost $90 million to drive the development of a renewable hydrogen industry, and has established a $10 million Renewable Hydrogen Fund to facilitate private-sector investment and leverage financial support to the renewable hydrogen industry.

This measure will interact with federal government initiatives targeting various economic sectors and Australia's National Hydrogen Strategy.

4.3.8.2 Energy

Energy Transformation Strategy

The Energy Transformation Strategy, which began in 2019, guides the Western Australian Government's response to the energy transformation underway in local electricity networks, and plans for the future of the power system (WA Government 2021).

Large- and small-scale renewables and batteries offer great opportunities for low-cost, low-emissions energy. However, the intermittent and uncontrolled nature of these energy sources is presenting challenges to the security, reliability and affordability of the power system, particularly in the South West Interconnected System (SWIS).

The first stage of work under the strategy was completed in May 2021 and delivered 3 work streams:

- distributed energy resources roadmap
- whole-of-electricity-system planning
- foundation regulatory frameworks
    - improving access to the SWIS electricity network
    - delivering the future power system (standards and regulations for new power systems).
    - On 14 July 2021, stage 2 of the strategy was launched, encompassing 4 themes:
- implementing the energy transformation taskforce decisions
- integrating new technology into the power system
- keeping the lights on as the power system transitions
- regulating for the future.

The initiatives under these 4 themes build on the work already started and are designed to take the Western Australian power system and wholesale market through to a new state from which to continue the transition. By 2025, new energy markets will be well established, current system security concerns will be addressed, and the whole-of-system plan will be refreshed.

Synergy Decarbonisation Plan

In 2022, the Western Australian Government announced that an estimated $3.8 billion will be invested in new green power infrastructure in the SWIS, including wind generation and storage, to ensure continued supply stability and affordability.

This will enable Western Australia's state-owned coal power stations to be retired by 2030, reducing emissions from the state-owned energy supplier, Synergy, by 80% by 2030. A new $547.4 million Collie Transition Package will support the town of Collie over the next decade, to grow new industries and jobs as local coal-fired power stations are retired.

Retiring these coal power stations will reduce emissions on the SWIS electricity grid by 40% compared with 2020–21 levels. This will lead to an estimated annual reduction in emissions of 5.9 Mt CO_2-e by 2030, including emissions reduction from Synergy and other government agencies.

Synergy and Western Australia's Water Corporation are currently undertaking analysis to determine the feasibility of a pumped hydro project forming part of its storage needs. Synergy is also investigating the feasibility of using hydrogen to power its existing gas generation assets. As part of these changes, the government has also committed to not commissioning any new natural gas-fired power stations on the SWIS after 2030.

The investment in new renewable power infrastructure is expected to pay for itself by 2030–31, when compared to the increasing electricity subsidies payable under the status quo.

4.3.8.3 Transport

The State Electric Vehicle Strategy started in 2020 and accelerated with the introduction of the Clean Energy Car Fund in 2022 (WA Government 2022d, e). The measure covers several initiatives to support uptake of EVs, including:

- rebates on EV purchases
- installation of a statewide EV-charging network
- government grants to support private-sector and local government investment in charging infrastructure

This measure will have an approximate cost of $80 million from 2021, and is complemented by recent federal government announcements to support EV uptake.

4.3.8.4 Industry, industrial processes and product use

Carbon Innovation Grants Program

The $15 million Carbon Innovation Grants Program was launched in October 2022 with the objective of reducing hard-to-abate emissions from heavy industry processes (WA Government 2022a). The program will run for 6 years and help Western Australian heavy industries transition to net zero carbon emissions, in line with the Western Australian Climate Change Policy. The program will fund feasibility studies and trials that help to avoid, reduce or offset carbon emissions from heavy industry processes, with a focus on supporting innovative technologies for carbon abatement and sequestration. Grants will be partly assessed on the extent of co-benefits for employment and environmental improvement.

Clean Energy Future Fund

The $19 million Clean Energy Future Fund is supporting the implementation of innovative clean energy projects in the state. The fund supports projects that demonstrate significant, cost-effective reductions in emissions, and which could lead to the broader adoption of innovative clean energy technologies.

The initiative started in 2020 and 2 projects were funded for a total of $2.6 million in round 1. Each year, these projects will generate 77 GWh of electricity and will save 53 kt CO_2-e of emissions.

In April 2022, 7 clean energy projects were offered grants worth more than $11.3 million in the second round of the fund. The projects are expected to:

- invest $197 million
- create up to 255 jobs during construction and 63 operational jobs
- generate 81 GWh each year
- avoid around 132,000 kt CO_2-e of emissions each year.

4.3.8.5 Agriculture and land use, land-use change and forestry

The aim of the $15 million Carbon Farming and Land Restoration Program (CF-LRP) is to realise the potential of the agriculture sector to sequester carbon. The CF-LRP will contribute to the growth of the Western Australian carbon market, enhance the long-term productivity of the agriculture sector, and deliver environmental, social, and economic co-benefits.

The CF-LRP has 3 elements:

- ACCU Plus – financial assistance to contribute to projects registered with the CER that sequester carbon and create co-benefits
- Future Carbon – provides grants to projects using innovative carbon sequestration activities to support the adoption of sustainable practices and contribute to a more climate-resilient agriculture industry; these projects will seek to develop new methods to assess and measure carbon (see Methods)
- complementary knowledge-building activities, such as education and outreach, marketing and communications that support delivery of the CF-LRP.

The first grant round was released in 2021–2022 and the second round in the 2022–2023. A third round is planned for 2023–2024. A second phase is anticipated in subsequent years. The first grant round is projected to sequester 400 kt of CO_2 from the atmosphere over the next decade through both soil carbon and land restoration projects.

4.3.9 Local government

Australia has 566 local government areas, many of which have innovative policies in place to partner with their local community to reduce emissions. A selection of these is summarised here.

4.3.9.1 Climate and energy

Greater Bendigo Climate Collaboration: The City of Greater Bendigo (Victoria) developed the Greater Bendigo Climate Collaboration in partnership with businesses and community groups so that they can work together to achieve zero emissions by 2030. The first 3 years of the program will help businesses, homes and schools act on climate, plan for zero emissions and get involved in community projects; run 6 community climate forums to understand the zero-emissions challenge and support and create city scale projects; and pull together regional stakeholders to identify and implement the top 10 zero-emissions projects for the region.

Moving Towards Net Zero Emissions: Clarence Valley Council (NSW) has been leading by example to reduce greenhouse gas emissions in its own operations. This was a good starting point for discussions with the community on how to achieve net zero emissions by 2050 across the whole local government area. The adopted community emissions reduction target is net zero emissions by 2040, with 2030 emissions being reduced by 35% compared with 2019 emission levels. By the end of 2022, the council is expecting a 15% reduction in its own emissions as compared to 2016–17.

Western Sydney Energy Program: The Western Sydney Councils program aims to realise energy, cost and emission savings for Western Sydney councils and their communities. The program's aspiration is to reduce Western Sydney's emissions by 200 kt CO_2-e each year; this equates to taking 46,000 cars off the road annually. Each year, efforts reduce emissions by almost 500 kt CO_2-e across a wide range of projects such as lighting and equipment upgrades, waste management, solar installations, and smart cities initiatives. The program has also saved more than $20 million.

Z-Net: Hepburn Z-NET is a collaborative partnership bringing together community groups, organisations, experts and Hepburn Shire Council to shift the Hepburn Shire (Victoria) to zero net energy by 2025 and zero net emissions by 2030.

Further emission reductions case studies (Towards Net Zero Greenhouse Gas Emissions – NSW) are available on the Local Government New South Wales website.

4.3.9.2 Renewable energy and storage

100 Percent Renewable Electricity Deal: All of the City of Sydney's (NSW) operations – including streetlights, pools, sports fields, depots, buildings and the historic Sydney Town Hall – are now run on 100% renewable electricity sourced from regional NSW, based on to a power purchase agreement to source electricity from 3 different generators. This deal is also supporting regional jobs and investment by enabling the construction of new renewable energy projects, including a community-operated project.

Central NSW Power Purchase Agreement: Orange City Council joined 15 councils across Central NSW and the Riverina to secure a joint contract for the supply of electricity through renewable energy until 2030, coordinated by the Central NSW Joint Organisation. Orange City Council will use 100% renewable energy to power its large sites and streetlights from 1 January 2023.

Community Battery: The Fitzroy North community battery is the first inner-urban community battery in Victoria. The project aims to demonstrate the operational and commercial viability of a community battery model in an inner-urban setting.

Hybrid Solar and Battery Off-Grid Stadium and Relief Centre: Nillumbik's Community Bank Stadium is now the region's main bushfire refuge area, thanks to the solar battery system established by the Nillumbik Shire Council (Victoria), which can run the facility in off-grid mode during times of emergency.

Melbourne Renewable Energy Project: The City of Melbourne (Victoria) partnered with 13 organisations to secure a 10-year renewable power purchase agreement that supported the construction of an 80-MW wind farm in regional Crowlands. The project developer also established a sustainable communities fund that now supports $25,000 of community grants annually.

4.3.9.3 Sustainable transport

Brisbane Metro Strategy: The Brisbane City Council strategy will see the city roll out an Australian-first metro service with 60 new electric buses. The electric bus charging system is one of the most significant developments in the EV industry worldwide. The on-board batteries can be charged in 4–6 minutes.

Charging the Regions: The Central Victorian Greenhouse Alliance worked in partnership with 13 local councils and the Victorian Government to roll out a network of public EV-charging infrastructure. In addition to council contributions, the alliance received funding under the Victorian Government's stimulus package to address the EV-charging station gaps identified in the Charging the Regions case study project. The funding fast-tracked investment in key towns to ensure there is a dense network of charging stations in the Mallee and Loddon Campaspe region, as well as other regions in Victoria. The project installed a mix of DC fast chargers, located on council land and in locations identified in collaboration with participating councils. In total, 23 EV-charging stations were installed across partner councils.

4.3.9.4 Community engagement, mobilisation and support

Cairns Youth Climate Summits: Cairns Regional Council (Queensland) held 2 climate summits for the region's young people in 2019 and 2021. The summits are an important avenue for youth in Cairns to share their aspirations for the environment and climate, learn from experts about the effects of climate change, and form networks of like-minded individuals.

Cool Changes: Macedon Ranges Shire Council's (Victoria) Cool Changes program helps communities in the Macedon Ranges Shire to respond to climate change and develop local climate action plans.

Climate Emergency Action Plan: Greater Shepparton City Council (Victoria) is developing climate action for the community. The plan is underpinned by a strong partnership approach between the community and council, while being supported by science-based evidence. It identifies 80 actions under its 4 strategic priorities of climate change leadership, transitioning to net zero emissions, building a climate-resilient community, and supporting a thriving and climate-ready agriculture.

Climate Emergency Response Plan: The Borough of Queenscliffe (Victoria) developed an award-winning Climate Emergency Response Plan in collaboration with the community. The plan commits to achieving net zero emissions by 2031, as well as interim steps including matching local electricity consumption with 100% renewable energy by 2025.

Empowering Penrith: Penrith City Council (NSW) created an online video series to provide residents with hints and tips on how to reduce their energy consumption at home. The 7-part video series covers a range of useful topics to help residents upskill and update themselves with the latest energy-saving information and technologies.

Go Solar: The Inner West Council (NSW) led a series of community engagement initiatives that has led to increasing solar PV in the community by 11% from 2018–9 to 2019–20. As a densely populated metropolitan area, a major barrier to entry in solar is that 40% of residents rent, and 44% live in apartments. Council sought to research new solar models to reach these neglected communities and break down barriers to help renters and apartment dwellers install solar.

Solar Savers Program: Nine Councils in Victoria collaborated via the Eastern Alliance for Greenhouse Action and the Northern Alliance for Greenhouse Action to help residents to install household solar systems. The program takes complexity and uncertainty out of installing solar by independently evaluating and selecting a solar installer and working closely with them throughout the installation process. This program has the additional benefit of increasing access to clean energy by providing support to low-income households.

Suitability Rebates for Residents and Businesses: Sustainability rebates from the Randwick City Council (NSW) incentivise residents and businesses to implement energy- and water-saving initiatives. Ten energy and water-saving rebates are available including for rooftop solar, battery storage, rainwater tanks, insulation, LED changeovers, and efficient swimming pool pumps. As of June 2021, a total of 263 rebates have been provided, resulting in 1,300 kW of rooftop solar, 170 kWh of battery storage, 22,000 litres in rainwater storage and 29 homes insulated.

Sustainability Incentives Scheme: The City of Adelaide (South Australia) provides financial incentives for sustainable technology installation in apartments, houses, and commercial buildings, to improve energy and water performance. This can have the added benefit of reducing costs, cutting carbon emissions and increasing the value of the property.

Trialling Tidal Gates at Swansea: Swansea is perched on the edge of Lake Macquarie (NSW), the largest coastal saltwater lake in the Southern Hemisphere. Tidal inundation is already a challenge for the town and predicted sea level rises are expected to increase the impact of high tides. Lake Macquarie City Council is trialling 3 tidal gates to determine which would best protect low-lying assets from current and future tidal inundation, storm surges and extreme weather events.

Using ambient computing technology to simulate extreme climate events: The threat of extreme fire weather due to climate change is increasing in NSW, yet many residents remain underprepared and do not have a written bushfire survival plan. Ku-ring-gai Council (NSW) undertook the Simtable project, which uses ambient computing technology to stimulate extreme fire weather, to increase engagement in their Climate Wise Communities workshop program.

4.4 Policies and measures no longer in place

4.4.1 Australian Government

- National Energy Guarantee
- National Energy Productivity Plan
- Smart Cities Plan/City Deals
- CCS Research Development and Demonstration Fund
- Solar Communities Program (last funding round in 2018)
- Low Emissions Technology Roadmap

4.4.2 States and territories

Australian Capital Territory:

- Climate Change Strategy and Action Plan, replaced by the ACT Climate Change Strategy 2019–2025
- Renewable Energy Industry Development Strategy

New South Wales:

- $112.5 million of funding towards energy efficiency and other programs to help households and small businesses save energy and money as part of a wider energy bill relief package
- NSW Energy Efficiency Action Plan

Northern Territory:

- Solar Energy Transformation Program (rollout completed in 2019)

Queensland:

- Queensland's Electric Vehicle Strategy, superseded by the Zero Emissions Vehicle Strategy
- Queensland Waste Avoidance and Resource Productivity Strategy 2014–24, superseded by the Waste Management and Resource Recovery Strategy

South Australia:

- SA Climate Change Strategy 2015–2050 – Towards a low-carbon economy
- 'Our Energy Plan'

Tasmania:

- Tasmanian Energy Strategy – Restoring Tasmania's Energy Advantage, superseded by the Tasmanian Renewable Energy Action Plan
- Climate Action 21: Tasmania's Climate Change Action Plan 2017–21, the Tasmanian Government has committed to develop the next climate change action plan within 6 months

Victoria:

- Victorian Climate Change Framework
- Victorian Climate Change Adaptation Plan 2017–2020
- Victorian Renewable Energy Action Plan
- Energy Efficiency and Productivity Strategy
- Greener Government Buildings Program

Western Australia:

- Low Emissions Energy Development Fund, superseded by the Clean Energy Future Fund
- Renewable Energy Buyback Scheme, superseded by the Distributed Energy BuyBack Scheme
- Western Australian Waste Strategy: Creating the Right Environment – Waste Avoidance and Resource Recovery Strategy 2030

Table 4.3: Summary of policies and measures by sector

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Climate change legislation	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Achieve and set national emissions targets and track progress	Regulatory	Implemented	Legislation incorporates Australian emissions targets into national law, sets requirements about advice from the Climate Change Authority to inform tracking and setting future targets, and requires relevant government agencies to consider targets when exercising their functions	2022	Australian Government	NE	NE
Net zero Australian Public Service*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF3, PFCs, SF_6	Australian Public Service operations	Voluntary Agreement	Adopted	The Australian Government is committed to an Australian Public Service with net zero emissions by 2030 (excluding the Australian Defence Force and security agencies because of their operational needs)	2022	Australian Government	NE	NE
Safeguard Mechanism reforms	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Reduce emissions from Australia's largest emitters in a gradual and predictable way, consistent with Australia's national emissions reduction targets of 43% below 2005 levels by 2030 and net zero emissions by 2050	Regulatory, economic	Adopted	Safeguard Mechanism reforms will build on the existing framework and gradually and predictably reduce baselines from the largest emitters on a trajectory that is broadly consistent with Australia reaching net zero by 2050. A crediting and trading framework is also expected to be established under the reforms	2023	Australian Government (DCCEEW); once implemented, administered by the Clean Energy Regulator	NE	46305
National Reconstruction Fund (NRF)	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Support, diversify and transform Australia's industry and economy to secure future prosperity and drive sustainable economic growth	Economic, fiscal	Adopted	$3 billion to provide finance, including loans, guarantees and equity to drive investments that add value and capability across 7 priority areas	2022	Australian Government (DISR)	NE	NE
Powering the Regions Fund*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Help regional Australia in the transition towards net zero emissions	Economic	Adopted	$1.9 billion to help regional Australia transition towards net zero emissions. The fund will unlock new opportunities to decarbonise existing industries; support the development of new, clean energy industries; develop regional workforces; and continue the purchase of Australian Carbon Credit Units	2023	Australian Government (DCCEEW)	NE	NE
Australia's National Hydrogen Strategy*	Energy, Transport, Industry/industrial processes	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Sets a vision for a clean, innovative, safe and competitive hydrogen industry that benefits all Australians	Other (strategy)	Implemented	57 nationally coordinated government actions that form the first steps towards developing the industry	2020	Australian Government (DCCEEW); corresponding state and territory government agencies implement the strategy at a jurisdictional level	NE	NE
Australia's carbon crediting scheme (formerly Emissions Reduction Fund)*	Cross-cutting	CH_4, CO_2, N_2O	Help reduce Australia's emissions by generating carbon credits from projects that avoid GHG emissions or sequester carbon	Other (voluntary regulated scheme)	Implemented	Australia's carbon crediting scheme creates incentives to carry out projects a to reduce and/or sequester emissions across the economy, as enabled by approved methods	2011	Australian Government (DCCEEW), Clean Energy Regulator	15476	20931
Climate Active*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Enable voluntary climate action and certify carbon neutral claims by organisations and businesses	Other (voluntary program)	Implemented	Certifies businesses that have credibly reached a state of carbon neutrality by measuring, reducing and offsetting their carbon emissions against the requirements of the Climate Active Carbon Neutral Standard	2010	Australian Government (DCCEEW)	6800	NE
Carbon Capture Technologies Program*	Cross-cutting	CO_2	Accelerate development of novel or emerging CO_2 capture and CO_2-use technologies	Economic	Implemented	$130 million program aimed at demonstrating the technical capability of, and reducing the costs of, novel technologies to enable their scale up over time and ensure that they are ready as potential avenues for abatement in the future	2023	Australian Government (DCCEEW)	NE	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Carbon Capture, Use and Storage Development Fund*	Cross-cutting	CO_2	Aimed at reducing emissions across energy generation, natural gas or hydrogen production, and heavy industries such as cement, manufacturing and chemicals production	Economic	Implemented	$50 million that supports pilot or pre-commercial carbon capture, use and storage (CCUS) projects progress towards commercial operations. Projects supported under the fund include: • CCUS applications with liquefied natural gas and biomethane production • direct air capture • use of CO_2 in the production of construction materials	2020	Australian Government (DCCEEW)	NE	NE
Rewiring the Nation*	Energy	CH_4, CO_2, N_2O	Aimed at modernising the grid to support a high share of renewable electricity	Fiscal	Implemented	$20 billion in low-cost finance to: • upgrade, expand and modernise electricity grids • unlock new renewables and storage capacity • drive down power prices	2022	Australian Government (DCCEEW), Clean Energy Finance Corporation	NE	NE
Australian Made Battery Plan	Energy		Support an end-to-end battery industry and kickstart battery manufacturing in Australia	Fiscal	Adopted	The plan will: • publish a National Battery Strategy • partner with the Queensland Government to create a Battery Manufacturing Precinct in Queensland • create a Powering Australia Industry Growth Centre to provide advanced technology and skills development to businesses looking to locally manufacture renewable energy technologies • support 10,000 New Energy Apprenticeships	2023	Australian Government (DISR, Department of Employment and Workplace Relations)	NE	NE
Offshore Electricity Infrastructure framework*	Energy	CH_4, CO_2, N_2O	Reduce emissions of GHGs in the electricity sector by encouraging the additional generation of electricity from renewable sources	Regulatory	Implemented	The framework provides the regulatory framework for the development of offshore renewable energy infrastructure, such as offshore wind, in the Commonwealth offshore area (from 3 nautical miles offshore)	2022	Australian Government (DCCEEW, DISR – National Offshore Petroleum Titles Administrator, National Offshore Petroleum Safety and Environmental Management Administrator)	NE	NE
Large-scale Renewable Energy Target (LRET)*	Energy	CH_4, CO_2, N_2O	Reduce emissions of GHGs in the electricity sector by encouraging the additional generation of electricity from renewable sources	Regulatory	Implemented	The LRET of 33,000 gigawatt hours by 2020 encouraged investment in large-scale renewable energy projects	2001	Clean Energy Regulator	22908	NE
Small-scale Renewable Energy Scheme (SRES)*	Energy	CH_4, CO_2, N_2O	Reduce emissions of GHGs in the electricity sector by encouraging the additional generation of electricity from renewable sources	Regulatory	Implemented	Scheme that helps home owners and small businesses to install eligible small-scale renewable energy systems and solar hot-water systems	2001	Clean Energy Regulator	14260	NE
Equipment Energy Efficiency (E3) Program*	Cross-cutting	CH_4, CO_2, N_2O	Drive improvements to the energy efficiency of new appliances and equipment sold; reduce energy consumption, related GHG emissions, and bills for households and businesses	Regulatory, information, education	Implemented	Cross-jurisdictional program through which the Australian Government, state and territory governments, and the New Zealand Government collaborate to deliver a single, integrated program on energy efficiency standards and energy labelling for equipment and appliances	1992	Regulatory – Australian Government (DCCEEW) Program – cross-jurisdictional between Australian Government and state and territory governments	6500	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Trajectory for Low Energy Buildings*	Cross-cutting	CH_4, CO_2, N_2O	Policies address specific barriers present at different stages of a home's life; they are designed to drive the uptake of residential energy efficiency upgrades	Regulatory	Implemented	Nationally agreed pathway to achieve zero energy (carbon ready) buildings in Australia's building sector	2019	Australian Government (DCCEEW, DISR), Australian Building Codes Board, states and territories	NE	4300
Australian Renewable Energy Agency (ARENA)*	Energy, Transport, Industry/industrial processes	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Improve the competitiveness of renewable energy technologies and increase the supply of renewable energy in Australia	Economic, research, information	Implemented	ARENA is a statutory authority providing research, development, demonstration and deployment grant funding to improve the affordability and increase the supply of renewable energy in Australia	2012	Australian Government (DCCEEW)	NE	NE
Clean Energy Finance Corporation (CEFC)*	Energy, Transport, Industry/industrial processes	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Facilitate increased flows of finance into the clean energy sector	Economic	Implemented	CEFC is a statutory authority that uses debt and equity funding to promote investment in clean energy technologies, namely renewable energy technologies, energy efficiency technologies, and low-emissions technologies and their supply chain	2013	Australian Government (DCCEEW)	7300	5700
Community Batteries for Household Solar*	Energy	CH_4, CO_2, N_2O	Provide community batteries	Economic	Implemented	$200 million program for new community batteries across Australia to reduce emissions and energy bills, support the grid and maximise the benefits of Australia's rooftop solar transformation	2022	Australian Government (DCCEEW)	NE	NE
Solar Banks*	Energy	CH_4, CO_2, N_2O	Provide solar photovoltaic access for households unable to install rooftop solar	Economic	Implemented	$100 million program to deliver solar banks around Australia, providing access to around 25,000 households that are unable to install rooftop solar, including renters, people living in apartments and low-income households	2022	Australian Government (DCCEEW)	NE	NE
National Electric Vehicle Strategy	Transport	CH_4, CO_2, N_2O	Provide a framework to enable Australia to become a competitive market for EVs by 2030, improving access to EVs to consumers and reducing road transport emissions	Economic, Education, Fiscal, Information, Regulatory, Research	Planned	The Strategy will deliver a nationally consistent, comprehensive, and overarching framework to increase the supply and uptake of EVs. The strategy will include: • consideration of fuel efficiency standards • further measures to increase EV sales and infrastructure • policy settings to encourage Australian manufacturing of EV chargers and components (especially batteries) • address policy implications of declining fuel excise	2023	Australian Government (DCCEEW), with Australian, state and territory governments working in collaboration with private sector organisations where applicable	NE	NE
Driving the Nation Fund*	Transport	CH_4, CO_2, N_2O	Support the installation of EV charging and hydrogen refuelling technology across Australia, to aid the uptake of EVs and encourage the use of new vehicle technologies across the country	Economic, fiscal	Implemented	The Australian Government will deliver a fast charging network, committing an additional $250 million to the new Driving the Nation Fund, doubling the investment to $500 million	2021	Australian Government (DCCEEW)	NE	NE
Electric Car Discount*	Transport	CH_4, CO_2, N_2O	Reduce import duties and taxes on eligible EVs, to encourage EV uptake	Fiscal	Implemented	Low- and zero-emission cars below the luxury car tax threshold for fuel-efficient vehicles (currently $84,916 in 2022–23) will be exempt from: • import tariffs – currently a 5% tax on some imported cars • fringe benefits tax – a tax on cars provided by the workplace for private use	2022	Australian Government (Treasury)	NE	NE
Global ship energy efficiency measure	Transport	CO_2	Reduce the carbon intensity of international shipping by 40% by 2030 compared with 2008 levels	Regulatory	Adopted	Australia is complying with its international obligations to implement the package of global technical and operational ship energy efficiency measures adopted by the International Maritime Organization in June 2021	2023	Australian Government (DITRDC), All ships of 400 gross tonnage and above	NE	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Clydebank Declaration	Transport	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Establish at least 6 green shipping corridors by 2025	Voluntary agreement	Adopted	The 24 signatories, which include the United Kingdom, the United States, Japan, New Zealand and Singapore, are exploring actions to facilitate partnerships among all stakeholders along the value chain to establish green shipping corridors between 2 or more ports. These actions include regulatory frameworks, incentives, information sharing and infrastructure requirements	2021	Australian Government (DITRDC). Various stakeholders along supply chains (e.g. ship operators, charterers, cargo forwarders, fuel suppliers, financiers)	NE	NE
Quad Shipping Task Force	Transport	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Establish 2–3 green shipping corridors in the Indo-Pacific region by 2030	Voluntary agreement	Adopted	Australia, the United States, Japan and India launched the Quad Shipping Task Force in September 2021 to develop key green corridor building blocks	2021	Australian Government (DITRDC), NSW Ports	NE	NE
Australia–Singapore initiative on low emission technologies for maritime and port operations	Transport	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Deploy clean hydrogen and ammonia maritime technologies that could facilitate a green shipping corridor between Australia and Singapore	Other (international partnership)	Adopted	$30 million, 5-year partnership	2022	Australian Government (DCCEEW with support from DITRDC and CSIRO)	NE	NE
HFC management – regulations*	Industry/industrial processes	HFCs	Reduce GHG emissions through a phase-down of imports of HFCs and equipment that contain HFCs, and by managing HFCs from import through the supply chain to end of life	Regulatory	Implemented	Australia is implementing its HFC phase-down through an annual import quota that reduces every 2 years and will reach an 85% reduction from baseline by 2036	2018	Australian Government (DCCEEW)	NE	4811
HFC management – information*	Industry/industrial processes	HFCs	Provide information to industry and consumers	Information	Adopted	The policy is intended to change behaviour by providing information about benefits of leak testing and servicing of installed equipment	2023	Australian Government (DCCEEW)	NE	1343
Development of Australia's seaweed farming*	Agriculture	CH_4	Develop and commercialise seaweed feed supplement to reduce CH_4 emissions from livestock such as sheep and cattle	Economic, research, information	Adopted	$8.1 million to support development of seaweed farming for the production of low-CH_4 cattle feed	2022	Fisheries Research and Development Corporation, Australian Sustainable Seaweed Alliance	NE	NE
Methane Emissions Reduction in Livestock (MERiL)*	Agriculture	CH_4	Support the development and deployment of low-emission livestock feed technologies to reduce CH_4 emissions from livestock	Economic, research, information	Implemented	$6 million for MERiL stage 1 is providing research grants to quantify emissions and productivity impacts of livestock feed technologies and ensure that they are safe to use. It is also developing a livestock emissions framework for feed technologies to inform updates to the National Greenhouse Gas Inventory	2021	Australian Government (DCCEEW, Clean Energy Regulator)	NE	NE
National Soil Carbon Innovation Challenge*	Agriculture	CO_2	Fast track development and commercial readiness of low-cost and accurate technology solutions to measure and estimate soil carbon stocks	Economic, research, information	Planned	$50 million program providing grants to support feasibility study, proof of concept, validation or early stage commercialisation activities relating to the development of lower-cost, accurate technological solutions for soil carbon measurement	2021	Australian Government (DCCEEW)	NE	NE
National Soil Carbon Data Program*	Agriculture	CO_2	Support partnerships to improve data in low-cost alternatives for measuring soil carbon	Economic, research, information	Implemented	$7.9 million program that seeks to provide a publicly accessible repository of data for developing rapid and cost-effective technologies to quantify soil carbon stock and changes in the stock in Australian agricultural soils. The program will also support improvements to Australia's national GHG emissions inventory model for soil carbon – Australia's Full Carbon Accounting Model (FullCAM)	2021	Australian Government (DCCEEW)	NE	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Carbon Farming Outreach Program*	Agriculture	CH_4, CO_2, N_2O	Support outreach activities to empower more farmers to participate in carbon crediting and adopt innovative carbon farming technologies and practices	Economic, research, information	Planned	$20.4 million program under which farmers will receive tailored advice about carbon farming and adopting low-emission technologies and practices from agricultural advisers, natural resource management groups, and agricultural research and extension organisations	2023	Australian Government (DCCEEW)	NE	NE
Blue Carbon Conservation, Restoration and Accounting*	Forestry/LULUCF	CH_4, CO_2, N_2O	Implement 5 on-ground projects that restore degraded coastal blue carbon ecosystems in Australia	Economic, research, information	Implemented	$9.5 million of funding that supports restoration projects that demonstrate and enable measurement of a range of diverse restoration outcomes for climate, biodiversity and people, including carbon sequestration, climate mitigation and resilience benefits, and Indigenous values. The projects include co-design and collaboration with Traditional Owners and First Nations people	2021	Australian Government (DCCEEW)	NE	NE
National Waste Policy Action Plan*	Waste management/ waste	CH_4, N_2O	Improve waste management and recycling activities	Regulatory, economic	Implemented	National framework for waste and resource recovery in Australia	2019	Australian Government (DCCEEW)	NE	NE
Food Waste for Healthy Soils Fund*	Waste management/ waste	CH_4, N_2O	Supports organic waste diversion from landfill and increased quantity and improved quality of recycled organic waste, especially for agricultural use	Economic	Implemented	$67 million fund	2021	Administered by the Australian Government; industry partners will undertake funded projects	NE	NE
Achieving 100% renewable electricity and phasing out fossil-fuel gas in the ACT*	Energy	CO_2, CH_4	Transition the Territory away from gas use, to help reach a target of net zero emissions by 2045	Economic, fiscal, regulatory, information, education	Implemented	The government has implemented a reverse auction process that achieved zero emissions from electricity by securing 100% renewable electricity from large-scale generators located across eastern and southern Australia as part of the National Electricity Market. The electrification pathway will be supported by continued growth and uptake of household and business solar photovoltaic systems and battery energy storage, as well as increased energy efficiency of buildings and appliances	2011	ACT Government	2029	NE
Sustainable Household Scheme*	Energy	CO_2, CH_4	Promote the uptake of renewable energy, battery storage, efficient electric household appliances and zero emissions vehicles to phase out gas use and help reach the target of net zero emissions by 2045	Economic	Implemented	The scheme provides zero-interest loans of up to $15,000 to households and not-for-profit community organisations to help with the upfront costs of investing in a range of products, including rooftop solar, energy-efficient appliances, and new and used zero emissions vehicles and charging infrastructure	2021	ACT Government	NE	NE
Next Gen Energy Storage*	Energy	CO_2	Promote the uptake of renewable electricity and battery storage to phase out gas use and help reach our target of net zero emissions by 2045	Economic	Implemented	The program supports the development of the energy storage industry in the ACT by providing a rebate to households and businesses for the purchase of a battery system that is coupled with solar panels, connected to the electricity grid and installed by an approved Next Gen retailer	2016	ACT Government	NE	NE
Big Canberra Battery*	Energy	CO_2	Support the transition to renewable electricity and to manage demand as the ACT continues to phase out gas use and help reach our target of net zero emissions by 2045	Economic	Implemented	The battery ecosystem will provide 250 megawatt of power with the aim to reduce pressure on the grid, put downward pressure on electricity prices as more households move to renewable energy and EVs, and generate new revenue opportunities for the ACT	2021	ACT Government	NE	NE
Low Income Household Program and Vulnerable Household Energy Support Scheme (aka Home Energy Support Program)*	Energy	CO_2	Ensure that the transition to a net zero society is fair and equitable, and that homes are healthy and comfortable	Economic	Implemented	Enable local community access to information and financial support to improve the energy efficiency of their homes	2016	ACT Government	NE	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Zero Emissions Transport Strategy 2022–30*	Transport	CO_2	Phasing out light internal combustion engine vehicles from 2035	Regulatory	Implemented	The strategy sets out policies that commit the ACT to phasing out light internal combustion engine vehicles from 2035, expanding the public EV charging network to ensure that there are at least 180 publicly available charging stations in the ACT by 2025, and continuing advocacy for strong national policy	2022	ACT Government	NE	NE
Net Zero Plan Stage 1: 2020–2030*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Foundation to achieve net zero emissions by 2050	Other (strategy)	Implemented	In the 5 years between 2017 and 2022, more than $1.2 billion was invested from the Climate Change Fund on climate change mitigation and adaptation programs. The fund will invest a further $2.8 billion on programs in the 8 years from 2022–23 to 2029–30, including to implement the Net Zero Plan and Electricity Infrastructure Roadmap	2020	NSW Government	NE	32950
Hydrogen Strategy*	Cross-cutting	CO_2	Attract more than $80 billion of investment to 2050, drive deep decarbonisation and set NSW up as a clean energy and economic superpower	Economic, regulatory	Implemented	The strategy is a nation-leading framework that provides $3 billion in incentives and sets out a clear and credible pathway to get green hydrogen production under $2.80 per kilogram in NSW by 2030	2021	NSW Government	NE	NE
Net Zero Industry and Innovation Program*	Cross-cutting	CH_4, CO_2, N_2O	Supporting a mature and thriving clean technology sector to achieve net zero emissions in NSW by 2050	Economic	Implemented	$195 million program that will provide funding for research, development and commercialisation projects out to 2030	2022	NSW Government	NE	31000
Clean manufacturing precincts*	Cross-cutting	CH_4, CO_2, N_2O	Develop roadmaps for clean energy manufacturing precincts in the Hunter and Illawarra regions	Economic, research, information	Implemented	$55 million program that is supporting the establishment of consortiums of industry and community experts to develop a strategic decarbonisation roadmap for clean manufacturing precincts in 2 regions. Roadmaps will be used to provide a pathway for the investment, job creation and infrastructure requirements to support these ambitions	2023	NSW Government	NE	NE
Electricity Infrastructure Roadmap and Renewable Energy Zones*	Energy	CO_2	Support the development of new electricity infrastructure in NSW. It will unlock up to $32 billion in private investment in regional energy infrastructure to 2030, including in strategically planned and coordinated Renewable Energy Zones	Regulatory	Implemented	The roadmap sets out a coordinated way to support private investment in at least 12 gigawatts of renewable energy generation and 2 gigawatts of long-duration storage by 2030. Under the roadmap, the Infrastructure Safeguard is an investment signal to deliver the new electricity infrastructure that NSW needs	2020	NSW Government	NE	NE
Electric Vehicle Strategy*	Transport	CO_2	Increase EV sales to more than 50% of new cars sold in NSW by 2030	Economic, fiscal, regulatory, information, education, research	Implemented	A $633 million commitment over 4 years that is expected to leverage significant private sector investment	2021	NSW Government	NE	NE
Future Energy Strategy (Transport)*	Transport	CO_2	Secure NSW's transport energy needs from sustainable sources and support the transition of the transport sector to net zero emissions by 2050	Other (strategy)	Implemented	Emissions reductions of up to 90% are planned through actions such as: • transitioning the state's 8,000-strong public bus fleet to zero emissions powered by renewable energy • transitioning the entire electrified rail network, including metro and light rail, to net zero electricity by 2025	2021	NSW Government	NE	NE
Waste and Sustainable Materials Strategy	Waste management/ waste	CO_2, CH_4	Halve food waste to landfill and achieve net zero emissions from organics to landfill by 2030	Economic, regulatory	Implemented	The strategy includes various mandates related to food and garden organics, and capture of landfill gas emissions, supported by: • $65 million over 5 years, which will support the rollout of new collection services, the development of more processing capacity and a statewide education campaign • $7.5 million over 5 years for installation of additional landfill gas infrastructure across NSW	2021	NSW Government	NE	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Renewable Hydrogen Master Plan*	Cross-cutting	CO_2	Provide a framework for a NT renewable hydrogen industry	Other (strategy)	Implemented	Framework for the development of an NT renewable hydrogen industry, focused on enabling activities required to secure private sector investment	2020	NT Government	NE	NE
Renewable energy target*	Cross-cutting	CO_2	50% of the electricity consumed from grid-connected installations to come from renewable sources by 2030	Fiscal	Adopted	The NT Government has a Renewable Energy Target Implementation Plan that builds on current policy settings at both Territory and federal levels	2020	NT Government	NE	NE
Remote Power System Strategy	Energy	CO_2	Deliver an average of 70% renewable energy to 72 remote Territory Indigenous communities by 2030	Regulatory	Planned	Development of an open and contestable framework to deliver an average of 70% renewable energy to 72 remote Territory Indigenous communities by 2030	2020	NT Government	NE	NE
Home and Business Battery Scheme*	Energy	CO_2	Support home owners and businesses to install batteries with their rooftop solar systems	Economic	Implemented	Grants of up to $6,000 to support home owners and businesses	2020	NT Government	NE	NE
Climate Action Plan 2030*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Set the path to meet Queensland's climate targets	Other (strategy)	Implemented	The plan sets priorities across 5 sectors for further action: electricity, transport, agriculture, buildings and land	2020	Qld Government	NE	NE
Renewable Energy and Hydrogen Jobs Fund*	Cross-cutting	CO_2	Support increased public ownership of commercial renewable energy and hydrogen projects, and development of energy infrastructure	Fiscal	Implemented	Supports investments by energy government-owned corporations in projects that support additional renewable energy generation and storage capacity in Queensland. This includes, but is not limited to, solar, wind, pumped hydroelectric storage, hydrogen and supporting network infrastructure	2021	Qld Government (Treasury)	NE	NE
Decarbonisation of the Great Barrier Reef Islands program*	Cross-cutting	CO_2	Identify potential mitigation/resilience projects for Great Barrier Reef island resorts and 4 whole-of-community islands Collaborate with stakeholders to assess opportunities and gaps, identify and prioritise potential projects, and develop project-ready business cases	Fiscal, voluntary agreement, information	Implemented	$1.73 million investment to identify and develop place-based options that would help reduce carbon emissions, increase resilience to the impacts of climate change, and reduce costs around energy, water and waste	2018	Qld Government	NE	NE
Energy and Jobs Plan*	Energy	CO_2	Establish new renewable energy and electricty sector emissions targets and outline how the government will achieve these targets	Other (strategy)	Implemented	• The plan outlines how Queensland's energy system will transform to deliver clean, reliable and affordable energy to provide power for generations. It will deliver: • 70% renewable energy by 2032 and 80% by 2035 (and legislation to establish these targets in law) • 50% reduction in electricity sector emissions on 2005 levels by 2030 • 90% reduction in electricity emissions on 2005 levels by 2035–36	2022	Qld Government (Department of Energy and Public Works)	NE	NE
Renewable Energy Zones*	Energy	CO_2	Ensure coordinated development of renewable energy zones to help deliver affordable, clean and reliable energy	Fiscal	Implemented	$145 million to establish 3 Queensland Renewable Energy Zones (QREZ) in northern, central and southern Queensland	2020	Qld Government (Department of Energy and Public Works)	NE	NE
Resources Industry Development Plan*	Industry/industrial processes	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Achieve a resilient, responsible and sustainable resources industry that grows as it transforms	Fiscal	Implemented	Sets out a pathway for a resources industry to create jobs and prosperity for generations to come – responsibly and sustainably	2022	Qld Government (Department of Resources)	NE	NE
Zero Net Emissions Transport Roadmap	Transport		A commitment under the Queensland Climate Action Plan	Fiscal	Planned	The roadmap is currently being developed; no further details can be provided at this time	2023	Qld Government (Department of Transport and Main Roads)	NE	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Draft Low Emissions Agriculture Roadmap	Agriculture, Forestry/LULUCF	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	A Queensland agribusiness sector that is a world leader in low carbon production and supply chains, maximising carbon farming opportunities	Other (strategy)	Planned	The draft roadmap provides a framework to reduce agricultural emissions and increase carbon farming. It outlines technologies and policies needed to facilitate a measured and continued decline in production-based GHG emissions, and practices producers can adopt now to better understand their GHG footprint and position their business to capitalise on low-emissions technologies as they become viable	2023	Qld Government (Department of Agriculture and Fisheries)	NE	NE
Land Restoration Fund*	Agriculture, Forestry/LULUCF	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Facilitate a pipeline of Queensland-based carbon offset projects; pursue environmental, economic and social co-benefits; and invest in research and development into emerging carbon farming areas	Fiscal	Implemented	The fund is expanding carbon farming in the state by supporting land sector carbon projects that deliver additional environmental, socio-economic and First Nations co-benefits. The fund supports landholders, farmers and First Nations peoples to generate new, regular income streams through carbon farming projects while providing valuable co-benefits such as healthier waterways, increased habitat for threatened species and more-resilient landscapes	2019	Qld Government (Department of Environment and Science)	NE	NE
Zero Net Emissions Infrastructure Plan	Cross-cutting		A commitment under the Queensland Climate Action Plan	Other (strategy)	Planned	The plan is currently being developed; no further details can be provided at this time	2023	Qld Government (Department of State Development, Infrastructure, Local Government and Planning)	NE	NE
Zero Net Emissions and Resilient Buildings Plan	Cross-cutting		A commitment under the Queensland Climate Action Plan	Other (strategy)	Planned	The plan is currently being developed; no further details can be provided at this time	2023	Qld Government (Department of Energy and Public Works)	NE	NE
Climate Change Action Plan 2021–2025*	Cross-cutting	CH_4, CO_2	Government-led objectives and actions for climate change mitigation and adaptation	Other (strategy)	Implemented	The action plan describes government–led actions addressing key objectives in 7 focus areas: • clean energy transition • climate smart economy • climate smart agriculture, landscapes and habitats • low-emissions transport • climate smart built and urban environments • resilient communities • government leading by example	2021	SA Government	NE	NE
Hydrogen Jobs Plan*	Cross-cutting	CO_2	Hydrogen production and grid management	Fiscal	Implemented	$593 million plan that will include the construction of a world-leading hydrogen power station, electrolyser and storage facility in Whyalla, including: • 250 megawatts electric of electrolysers • 200 megawatts of power generation (powered by the electrolysers) • hydrogen storage facilities	2022	SA Government	NE	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) ($kt\ CO_2\ eq$) 2020	2030[f]
Waste Strategy 2020–2025*	Waste management/ waste	CH_4, CO_2	Establish a framework and targets to help develop a circular economy	Other (strategy)	Implemented	The strategy, which is reviewed every 5 years, is designed to reduce emissions of CO_2, CH_4 and other GHGs by diverting or avoiding waste going to landfill. The strategy has specific targets: • Zero avoidable waste to landfill by 2030 • Metropolitan Adelaide 2025 targets by waste sector - municipal solid waste diversion of 75% - commercial and industrial solid waste diversion of 90% - construction and demolition diversion of 95% • Per capita waste generation – 5% reduction from a 2020 baseline	2020	SA Government	7700	NE
Valuing Our Food Waste 2020–2025*	Waste management/ waste	CH_4	Reduce food waste from households and business	Other (strategy)	Implemented	The first strategy in Australia covering reduction of food waste for a jurisdiction. It integrates policy measures, behavioural change actions and support for industry to address the estimated 200,000 tonnes of food waste sent to landfill each year in South Australia	2020	SA Government	NE	NE
Renewable Hydrogen Action Plan*	Cross-cutting	CO_2	Hydrogen production	Other (strategy)	Implemented	The plan commits to developing a Tasmanian renewable hydrogen industry to meet local demand and for export by 2030	2020	Tas Government	NE	NE
Renewable Hydrogen Industry Development Funding Program*	Cross-cutting	CO_2	Hydrogen production	Economic	Implemented	$50 million program to help activate a green hydrogen industry in Tasmania	2020	Tas Government	NE	NE
Renewable Energy Action Plan*	Energy	CO_2	Renewable energy production	Other (strategy)	Implemented	The plan sets clear targets and actions designed to build on Tasmania's natural competitive advantages and attract large-scale investment to significantly grow and expand the state's renewable energy sector into the future	2020	Tas Government	NE	NE
Renewable Energy Coordination Framework	Energy	CO_2	Renewable energy production	Other (strategy)	Implemented	The framework prioritises the actions necessary to support the future growth of the renewable energy sector	2022	Tas Government	NE	NE
Energy Saver Loan Scheme*	Energy	CO_2	Energy efficiency	Economic	Implemented	$50 million loan scheme that will provide interest-free loans of up to $10,000 for eligible applicants to invest in energy-efficient products	2022	Tas Government	NE	NE
Electric Vehicle ChargeSmart Grants Program*	Transport	CO_2	Increase public EV charging opportunities	Economic	Implemented	2 ChargeSmart programs have leveraged $4.2 million in total spend on charging infrastructure around the state	2018	Tas Government	NE	NE
Transport measures*	Transport	CO_2	Support the increased uptake of EVs	Economic, fiscal	Implemented	Measures include a target to transition the government vehicle fleet to 100% EVs by 2030, funding for electric and hydrogen bus trials, and a stamp duty waiver on new or second-hand EVs	2020	Tas Government	NE	NE
No-interest loan scheme for large emitting businesses	Industry/industrial processes	CO_2	Support trials of existing or new technologies to reduce emissions	Economic	Planned	$10 million no-interest loan scheme for large Tasmanian GHG-emitting businesses and industries to trial existing clean technologies or test new innovative production processes that will lead to reduced emissions	2023	Tas Government	NE	NE
Agriculture measures*	Agriculture	CH_4, CO_2	Reduce emissions from the agriculture sector	Economic	Implemented	Measures include a Carbon Farming Advice Rebate Pilot Program, On-farm Energy Audit and Capital Grant Program, and funding for research	2018	Tas Government	NE	NE
Waste Action Plan*	Waste management/ waste	CH_4, CO_2	Encourage recycling and resource recovery from waste	Regulatory	Implemented	The plan sets out a broad framework for waste management and resource recovery in Tasmania. Key actions include the introduction of a statewide waste levy, container refund scheme, and investment to increase food and garden organics reprocessing capacity across the state	2019	Tas Government	NE	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2030[f]
Whole of Victorian Government emissions reduction pledge*	Cross-cutting	CO_2	Reduce emissions from government operations	Regulatory, economic	Implemented	Reduce annual Victorian Government emissions by: • focusing on reducing emissions from electricity consumption through the transition to renewable energy • improving the energy efficiency of government operations, including government buildings and infrastructure • introducing steps to reduce emissions from public transport operations and the government's vehicle fleet	2021	Vic Government	NE	2700
Energy sector emissions reduction pledge*	Energy	CO_2	Reduce emissions, increase large and small-scale renewable energy, build a reliable and secure electricity grid, and improve energy efficiency	Economic, regulatory	Implemented	The pledge has a dual focus on switching to clean energy sources and managing energy demand through increased energy efficiency. It covers more than 20 programs, including the flagship Victorian Renewable Energy Target and the Victorian Energy Upgrades program	2021	Vic Government and the private sector	NE	3700
Transport sector emissions reduction pledge*	Transport	CO_2	Reduce emissions, increase uptake of zero emissions vehicles and improve public transport	Economic, fiscal	Implemented	Actions include: • $46 million subsidy program to provide grants to people and businesses to buy zero emissions vehicles • support for a statewide EV fast charging network adding 400 zero emissions vehicles to the Victorian Government fleet over the next 2 years • zero-emissions bus trials to support a transition to 100% of new public buses being zero-emissions buses from 2025 • continued investment in public transport infrastructure and services	2021	Vic Government, consumers, road users, councils and bus operators	NE	NE
Industrial processes and product use sector emissions reduction pledge	Industry/industrial processes	CO_2	Reduce emissions by reducing refrigerant gas leaks	Regulatory, information	Implemented	Advocacy for a stronger national regime and guidance for enhanced management of large refrigeration and air-conditioning systems	2021	Vic Government	NE	400
Land use, land-use change and forestry sector emissions reduction pledge*	Forestry/LULUCF	CH_4, CO_2	Reduce GHG emissions, protect native forests, restore degraded landscapes and plant millions of new trees. It also aims to support affected communities, and to protect and improve biodiversity	Economic, regulatory	Implemented	Measures include: • ending native forest timber harvesting by 2030, including $120 million to support workers, businesses and communities transition from native forest harvesting to a plantation-based timber supply • the $110 million Gippsland Plantations Investment Program to provide incentives for plantation investors to undertake industrial-scale planting to bolster Victoria's timber supplies • Bushbank – a $76.98 million program to incentivise private and public landowners to restore and protect natural habitats and diversify income streams	2021	Vic Government	NE	1400
Agriculture sector emissions reduction pledge*	Agriculture	CH_4, CO_2	Support innovation to lay the foundations for future emissions reductions	Economic	Implemented	Key actions in the pledge include: • research trials in CH_4-inhibiting feed additives, and associated on-farm action plans • online spatial tools for farmers to reduce emissions • establishing a shared vision for the sector in a net zero and climate-resilient economy	2021	Vic Government, farmers, universities and industry bodies	NE	NE

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Waste sector emissions reduction pledge*	Waste management/ waste	CH_4, CO_2	Reduce waste, increase recycling and create more value from Victorian resources	Economic, regulatory	Implemented	Emission reduction measures in the pledge include: • waste system reform to separate organic waste from other forms of waste, support more effective organics recycling and help avoid emissions that occur when organic waste goes to landfill • support for innovation for new recycled markets and creative solutions to waste • support for businesses to improve their resource efficiency, reduce the disposal of waste to landfill, increase recycling and reduce business costs	2021	Vic Government, local councils, businesses and households, through regulations, government investment and community education programs	NE	600
Sectoral Emissions Reduction Strategies (SERS)	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Develop strategies to reduce emissions from all sectors of WA's economy and transition to net zero emissions by 2050	Other (strategy)	Planned	The government is developing sectoral emissions reduction strategies in consultation with business, industry, research institutions and the community to transition our economy to net zero emissions	2023	WA Government (Department of Water and Environmental Regulation)	NE	NE
Government Emissions Interim Target	Cross-cutting	CO_2	Whole-of-government 2030 emissions reduction target of 80% below 2020 levels	Fiscal	Planned	Range of initiatives to reduce net emissions, including energy efficiency measures, procurement of renewable energy, reduced emissions in the government vehicle fleet and the use of local offsets. An estimated $3.8 billion will be invested in new green power infrastructure in the South West Interconnected System (SWIS), including wind generation and storage, to ensure emissions reduction, continued stability and affordability	2022	WA Government	NE	NE
Renewable Hydrogen Strategy*	Cross-cutting	CH_4, CO_2	Harness WA's competitive advantages, including world-class renewable energy resources, vast land mass and proud history of exporting energy to international markets	Other (TBC)	Implemented	The strategy sets out the government's strategic areas of focus for the development of the hydrogen industry. Areas of focus are export, remote applications, hydrogen blending in natural gas networks, transport	2019	WA Government (Department of Jobs, Tourism, Science and Innovation)	NE	NE
Energy Transformation Strategy*	Energy	CO_2	Guides the government's response to the energy transformation underway in local electricity networks, and plans for the future of the power system	Other (strategy)	Implemented	• Stage 1 delivered Distributed Energy Resources Roadmap, Whole of Electricity System Planning, Foundation Regulatory Frameworks – improving access to the SWIS electricity network, and Delivering the Future Power System (standards and regulations for new power systems) • Stage 2 is implementing the Energy Transformation Taskforce decisions around integrating new technology into the power system, keeping the lights on as the power system transitions and regulating for the future • By 2025, new energy markets will be well established, current system security concerns will be addressed, and the Whole of System Plan will be refreshed	2020	WA Government (Department of Mines, Industry Regulation and Safety – Energy Policy WA)	NE	NE
Synergy's Decarbonisation Plan*	Energy	CO_2	Retirement of state-owned coal power stations by 2030	Fiscal, regulatory	Implemented	Investment of $3.8 billion in new green power infrastructure to enable retirement of state-owned coal-fired power stations on the SWIS. Government has committed to not commissioning any new natural gas–fired power stations on the SWIS after 2030. The project includes funds to support the town of Collie to transition to new industries and create local jobs	2022	WA Government	NE	5900

Name of policy or measure[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Clean Energy Future Fund*	Energy	CO_2	Support implementation of innovative clean energy projects in WA	Economic	Implemented	The fund supports projects that demonstrate significant, cost-effective reduction in emissions, and which could lead to the broader adoption of innovative clean energy technologies	2020	WA Government (Department of Water and Environmental Regulation)	NE	NE
Electric Vehicle Strategy and Clean Energy Car Fund*	Transport	CO_2	Accelerate the uptake of EVs and the transition to net zero emissions for WA	Economic	Implemented	A range of initiatives to support uptake of EVs, including: • rebates on EV purchases • installation of a statewide EV charging network • government grants to support private sector and local government investment in charging infrastructure	2021	WA Government (Department of Water and Environmental Regulation – Energy Policy WA), Synergy, Horizon Power	NE	NE
Carbon Innovation Grants Program*	Industry/industrial processes	CO_2	Reducing hard to abate emissions from heavy industry processes	Economic	Implemented	Fund feasibility studies and trials to avoid, reduce or offset carbon emissions from heavy industry processes, supporting innovative technologies for carbon abatement and sequestration	2022	WA Government (Department of Water and Environmental Regulation)	NE	NE
Carbon Farming and Land Restoration Program*	Agriculture	CO_2	Realise the potential of the agriculture sector to sequester carbon	Economic	Implemented	The program has 3 elements: • ACCU Plus – financial assistance to carbon sequestration projects registered with the Clean Energy Regulator • Future Carbon – provides grants to projects using innovative carbon sequestration activities to support the adoption of sustainable practices and contribute to more climate-resilient agriculture industries • complementary knowledge building activities, such as education and outreach, marketing and communications	2021	WA Government (Department of Primary Industries and Regional Development)	NE	400

Note: The two final columns specify the year identified by the Party for estimating impacts (based on the status of the measure and whether an ex post or ex ante estimation is available).
Abbreviations: GHG = greenhouse gas; LULUCF = land use, land-use change and forestry.
a Parties should use an asterisk (*) to indicate that a mitigation action is included in the 'with measures' projection.
b To the extent possible, the following sectors should be used: energy, transport, industry/industrial processes, agriculture, forestry/LULUCF, waste management/waste, other sectors, cross-cutting, as appropriate.
c To the extent possible, the following types of instrument should be used: economic, fiscal, voluntary agreement, regulatory, information, education, research, other.
d To the extent possible, the following descriptive terms should be used to report on the status of implementation: implemented, adopted, planned.
e Additional information may be provided on the cost of the mitigation actions and the relevant timescale.
f Optional year or years deemed relevant by the Party.

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5 Projections and total effect of policies and measures

Key developments

Australia has committed to reducing its greenhouse gas emissions to 43% below 2005 levels by 2030, and net zero by 2050.

Under a baseline ('with measures') scenario, current emissions projections show that Australia is projected to reduce its greenhouse gas emissions to 32% on 2005 levels by 2030 and 38% on 2005 levels by 2035. The estimates take account of existing federal, state and territory policies and measures, as well as policies under the Powering Australia Plan which have been implemented already or where the detailed design is well progressed.

Under a 'with additional measures' scenario, Australia is projected to reduce its greenhouse gas emissions to 41% below 2005 levels by 2030 and 48% below 2005 by 2035. This scenario includes policies and programs under the Powering Australia Plan that are currently subject to consultation and detailed design. These include reforms to the Safeguard Mechanism and a national renewable electricity target of 82% by 2030 by 2030.

This chapter presents Australia's 2022 greenhouse gas emissions projections, along with Australia's approach to emissions projections, projection results and sectoral trends. Australia publishes projections of greenhouse gas emissions annually on the Department of Climate Change, Energy, the Environment and Water website. The estimates of greenhouse gas emissions from 1990 to 2020 in this chapter are consistent with Australia's 2020 National Greenhouse Accounts (DCCEEW 2022c). Projections of greenhouse gas emissions from 2021 to 2035 in this communication are consistent with Australia's emissions projections 2022 (DCCEEW 2022b).

The following sections outline Australia's approach to emissions projections, projection results and sectoral trends.

5.1 Australia's approach to emissions projections

Australia's emissions projections are prepared by gas and by sector. Emissions by gas are expressed in terms of carbon dioxide equivalent (CO_2-e) using the 100-year global warming potentials contained in the IPCC's Fifth Assessment Report, consistent with rules adopted under the UNFCCC Paris Agreement (Decision 18/CMA.1 Annex 2.D Paragraph 37). Australia's 2030 target and the emissions projections cover sources of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) that are included in Australia's annual national inventory under the UNFCCC.

Sectors reported are

- energy (subdivided into electricity, stationary energy (excluding electricity), transport, and fugitive emissions)
- industrial processes and product use (IPPU)
- agriculture
- waste
- land use, land-use change and forestry (LULUCF).

The emissions projections are estimated on a UNFCCC accounting basis consistent with Australia's accounting for the 2030 target. Reporting years for all sectors are reported for financial years as key data sources are published on this basis. For example, '2030' refers to financial year 2029–30.

The baseline ('with measures') emissions projections were prepared based on current implemented and adopted policies and measures as of September 2022. This includes announced policies under the Powering Australia Plan where there is sufficient detail to include them. The baseline ('with measures') emissions projections take account of the following policies under the Powering Australia Plan:

- Rewiring the Nation, to the extent that it supports delivery of state and territory renewable targets and plans
- Community Batteries for Household Solar program
- Community Solar Banks program
- the removal of the import tariff for certain electric vehicles (EVs)
- the EV target for the Commonwealth Fleet
- Government purchases of Australian Carbon Credit Units (ACCUs) under the Powering the Regions Fund.

The baseline ('with measures') emissions projections also take account of existing measures including:

- the Australian Government's Large-scale Renewable Energy Target and Small-scale Renewable Energy Scheme
- state and territory renewable energy and energy storage targets
- the impact of Australia's carbon crediting scheme
- implemented initiatives under the Australian Renewable Energy Agency (ARENA)
- Clean Energy Finance Corporation (CEFC) investments
- the legislated phase-down of HFCs
- the National Food Waste Strategy.

Australia is continuing to develop policies and measures to reduce emissions. The 'with additional measures' scenario includes policies as outlined above, as well as announced policies that are subject to ongoing consultation and design. These are:

- reforms to the Safeguard Mechanism
- a national renewable electricity target of 82% by 2030; supported by Rewiring the Nation.

The emissions projections do not include the following policies that are in the early stages of design and consultation, or for which there are insufficient data to estimate the likely emissions impacts:

- National Reconstruction Fund
- National Electric Vehicle Strategy
- aspects of the Powering the Regions Fund other than government purchase of ACCUs
- exemption of the Fringe Benefits Tax on Electric Cars.

Australia has not prepared a sensitivity analysis for the 2022 projections.

5.2 Summary of Australia's emissions projections

In June 2022, Australia updated its Nationally Determined Contribution (NDC), committing to reduce greenhouse gas emissions by 43% below 2005 levels by 2030 using a point target approach and an emissions budget approach. Australia also reaffirmed its target to achieve net zero emissions by 2050.

The point target is calculated as a 43 per cent reduction in the year 2030 from 2005 levels. The latest estimate of emissions in 2005 is 621 Mt CO_2-e, making the 2030 target equal to 354 Mt CO_2-e. Australia's progress is assessed as the difference between the target emissions and the projected emissions in 2030.

Australia's emissions budget is a 10-year commitment from 2021 to 2030. A trajectory to achieve the emissions budget (4,381 Mt CO_2-e) is calculated by taking a linear decline from 2020 to 2030, beginning from the 2020 target of 5% below 2000 levels and finishing at 43% below 2005 levels in 2030. Australia's progress is assessed as the difference in cumulative emissions between projected emissions and the target trajectory from 2021–2030.[1]

Australia's Emissions Projections 2022 (DCCEEW 2022b) reported that, under a baseline scenario, Australia's greenhouse gas emissions are projected to be 32% below 2005 levels in 2030 and 38% below 2005 levels in 2035. Cumulative emissions during 2021–2030 are projected to be 5% above Australia's 2021–2030 emissions budget. Under a 'with additional measures' scenario, which incorporates some but not all measures that are now being implemented under the Government's Powering Australia Plan, Australia's emissions are projected to be 41% below 2005 levels by 2030 and 48% below by 2035, and cumulative emissions are projected to be 1% above the 2021–2030 emissions budget.

In tracking towards Australia's target, emissions are adjusted to account for projected voluntary cancellation of ACCUs by individuals, companies, and organisations. After this adjustment, Australia is projected to achieve a 32% reduction on 2005 levels in 2030 in the baseline (with measures), and a 40% reduction on 2005 levels in 2030 in the 'with additional measures' scenario.[2]

The Australian Government is also working alongside global partners to tackle the climate crisis, achieve the goals of the Paris Agreement, and keep 1.5°C within reach. Should Australia decide to use cooperative approaches under Article 6 of the Paris Agreement towards achievement of its NDC or to authorise the use of internationally transferred mitigation outcomes towards the NDCs of other Parties, it would report on such use or authorisation through its Biennial Transparency Reports and consistent with guidance adopted under Article 6.

5.2.1 Emissions trends to 2030 under the baseline ('with measures') scenario

Australia's emissions are projected to decline to 422 Mt CO_2-e in 2030, which is 32% below 2005 levels.

From 2020 to 2030, most of the decline in emissions is projected to come from the electricity sector because of strong uptake of renewables supported by federal, state and territory policies. Smaller declines are projected from the waste, IPPU, and stationary energy sectors. This is in response to federal, state and territory policies, including the HFC imports phase-down and policies to reduce solid waste deposited in landfill, as well as energy efficiency and fuel switching.

From 2020 to 2030, emission increases are projected in the transport, agriculture and LULUCF sectors.

Transport emissions are projected to increase as transport activity recovers after COVID-19 pandemic restrictions. By 2030, transport emissions are projected to be similar to pre-pandemic levels. Although electric vehicle numbers grow to 2030, emission declines from this will be offset by growth in uptake of larger vehicles such as sport utility vehicles (SUVs) and utes and from increased activity and emissions from trucks.

1 For further information, see chapters 3 and 4 of the Biennial Report Annex.

2 For more information, see Appendix A of Australia's Emissions Projections 2022 (DCCEEW 2022b).

Agricultural emissions are also projected to increase to 2030 from historically low levels in 2020. This is due to projected restocking of the cattle herd including as drought conditions ease.

The net sink in the LULUCF sector is projected to decline in the second half of the decade, primarily due to plantation harvesting.

Smaller increases in emissions are projected from fugitive emissions as gas production shifts to basins with higher concentrations of CO_2.

5.2.2 Emissions trends to 2035 under the baseline ('with measures') scenario

Australia's emissions are projected to decline to 383 Mt CO_2-e in 2035, which is 38% below 2005 levels. Emissions from all sectors are projected to decline from 2030 to 2035 with the largest contributions to the decline in emissions coming from the electricity, stationary energy, transport, and LULUCF sectors. Emission declines from the electricity sector are projected to continue after 2030 as renewable uptake increases to meet state targets. Emissions from stationary energy and transport sectors are projected to decline due to increased electrification of vehicles, buildings, mining, and manufacturing processes.

Projected emission declines from LULUCF from 2031 reflect the impact of federal and state policies. These include reduced native forest logging and the Australian Government's continued purchasing of ACCUs under the Powering the Regions Fund. The fund is expected to support a high proportion of vegetation projects.

Figure 5.1: Australia's domestic emissions baseline (with measures) by sector, 1990 to 2035, Mt CO_2-e

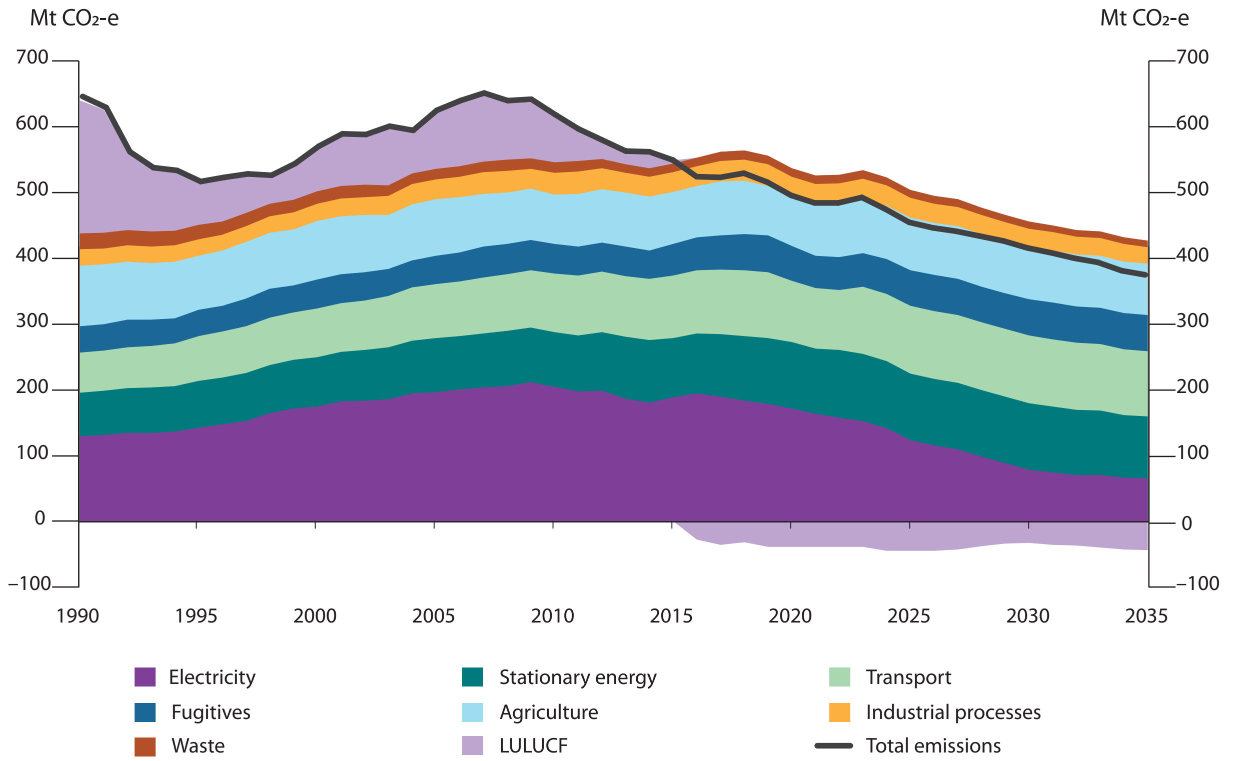


Table 5.1: Summary of emissions projections baseline (with measures) by sector and gas

	Historical – GHG emissions and removals ($Mt\ CO_2$-e)							Projected – GHG emission projections ($Mt\ CO_2$-e)		
Sector or gas	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Sector										
Electricity	130	143	175	197	205	189	172	124	79	66
Stationary energy (excluding electricity)	66	71	75	82	83	90	101	101	101	94
Transport	61	68	74	82	89	95	93	103	103	99
Fugitive emissions	40	40	44	43	45	48	53	54	55	55
Industrial process and product use	25	25	26	30	33	30	32	30	28	25
Agriculture	92	82	89	86	75	79	73	80	79	78
Waste	24	22	19	16	16	13	13	12	11	10
Land use, land-use change and forestry	202	67	68	85	68	5	−39	−45	−33	−44
Gas										
CO_2 emissions including net CO_2 from LULUCF	454	347	389	447	447	380	344	296	264	230
CO_2 emissions excluding net CO_2 from LULUCF	278	305	350	386	405	402	400	361	317	294
CH_4 emissions including net CH_4 from LULUCF	162	151	156	146	139	138	123	133	129	125
CH_4 emissions excluding net CH_4 from LULUCF	140	130	132	126	117	116	109	116	112	109
N_2O emissions including net N_2O from LULUCF	19	17	21	23	22	21	20	20	20	21
N_2O emissions excluding net N_2O from LULUCF	14	14	17	18	17	17	17	16	17	17
HFCs	1	1	1	4	7	9	11	10	8	7
PFCs	4	1	1	2	0	0	0	0	0	0
SF_6	0	0	0	0	0	0	0	0	0	0
NF_3	0	0	0	0	0	0	0	0	0	0
Total with LULUCF	641	518	569	621	615	549	498	459	422	383
Total without LULUCF	438	451	501	536	547	545	537	504	455	427

CH_4 = methane; GHG = greenhouse gas; HFCs = hydrofluorocarbons; LULUCF = land use, land-use change and forestry; $Mt\ CO_2$-e = megatonnes of carbon dioxide equivalent; NF_3 = nitrogen trifluoride; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF_6 = sulfur hexafluoride.

Note: Emissions are reported using the global warming potentials (GWPs) from the IPCC Fifth Assessment Report. The emission estimates reported in chapters 3 and 4 of the National Communication use GWPs from the IPCC Fourth Assessment Report.

Source: DCCEEW 2022b,c.

5.2.3 Emissions trends under the 'with additional measures' scenario

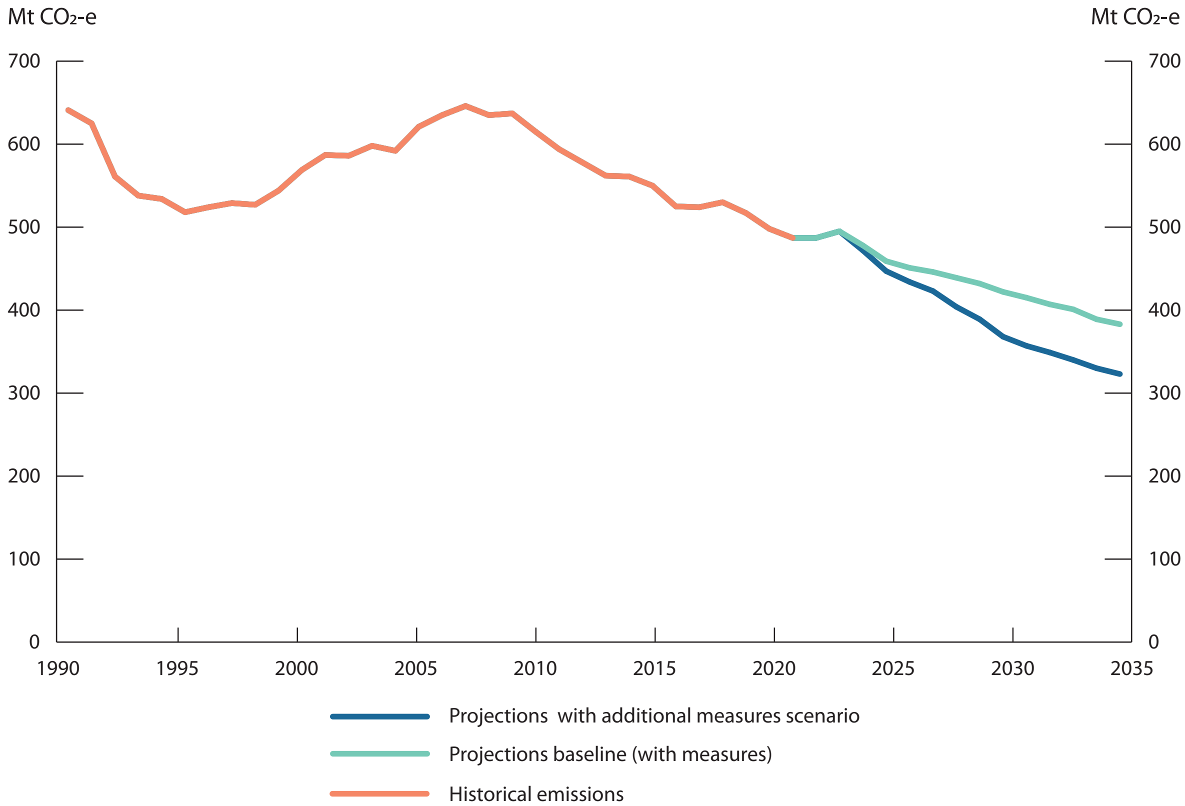
The 'with additional measures' scenario provides insights into the emissions impacts of announced policies that are still subject to ongoing consultation and detailed design. Broad assumptions have been made about the policy settings to enable modelling. These should not be interpreted as final policy decisions as the settings are subject to ongoing consultation and detailed design.

Under the 'with additional measures' scenario, Australia's emissions are projected to fall to 41% below 2005 levels by 2030, and cumulative emissions over 2021–2030 are projected to be 1% above the 2021–2030 emissions budget (Figure 5.2). Emissions are projected to decline to 323 Mt CO_2-e in 2035, which is 48% below 2005 levels.

In this scenario, there is increased generation from large-scale renewables such as utility solar and wind, and lower coal and gas generation than in the baseline. The scenario assumes that 82% renewable energy generation in Australia's electricity grids is maintained after 2030, with increasing demand resulting in a flatter emissions reduction trend from 2030 to 2035 in the electricity sector (compared with the baseline scenario).

In this scenario, aggregate Safeguard baselines are projected to fall to 100 Mt CO_2-e in 2030, which is 46 Mt CO_2-e lower than projected emissions under the baseline scenario. This abatement is assumed to be achieved through a combination of onsite abatement and the surrender of ACCUs. The baseline scenario includes ACCUs generated from existing offset projects and new projects supported by future auctions under the Powering the Regions Fund. In 2030, 9 Mt CO_2-e of the Safeguard Mechanism abatement task is assumed to be met through ACCUs, which is already included in the baseline projection. To avoid double counting, the 'with additional measures' scenario only includes abatement from the reforms to the Safeguard Mechanism that is not already included in the baseline.

Figure 5.2: Australia's emissions projections baseline (with measures) and 'with additional measures' scenario, 1990 to 2035, Mt CO_2-e



5.3 Emissions projections by sector in the baseline scenario

This section sets out the emissions projection results under the baseline ('with measures') scenario and key trends and drivers for each reported sector. Further information on sectoral results can be found in Australia's emissions projections 2022 (DCCEEW 2022b). Sector-specific methodologies are described in section 5.5.

The baseline (with measures) projections include some measures from the Powering Australia plan, as outlined in section 5.1. It includes Powering Australia Plan measures which have been implemented already or where the detailed design is well progressed. It does not include reforms to the Safeguard Mechanism or the national renewable electricity target of 82% by 2030, as these are included in the 'with additional measures' scenario.

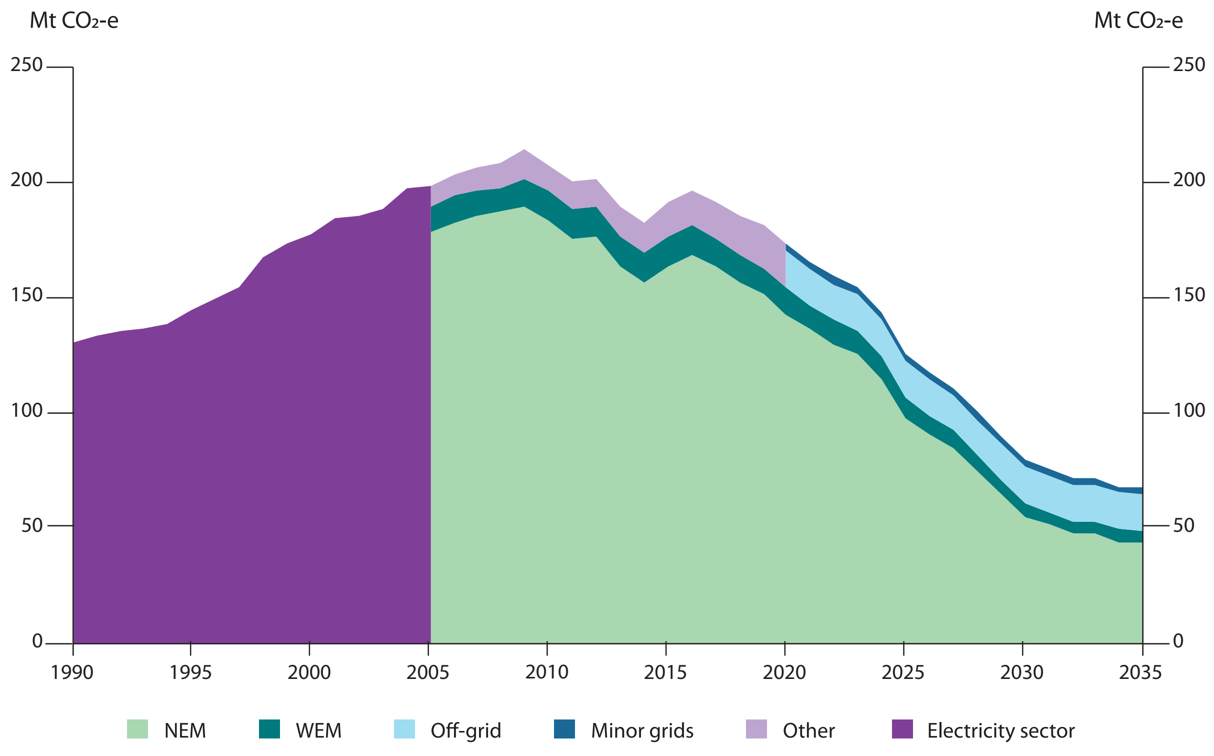
5.3.1 Projections of the energy sector (electricity)

Electricity emissions result from fuel combustion for electricity production in the National Electricity Market (NEM), Western Australia's Wholesale Electricity Market (WEM), the other small grids and off-grid. Electricity represents the largest share of emissions in the National Greenhouse Gas Inventory.

Emissions are projected to be 79 Mt CO_2-e in 2030 and 66 Mt CO_2-e in 2035.

These declines are driven by the projected continued decarbonisation of electricity generation across the country, including in the NEM. Renewables, particularly solar and wind, are projected to form a growing share of generation in the NEM. The Queensland Energy and Jobs Plan[3], Victoria's Energy Storage Targets[4] and Victoria's Offshore Wind Targets[5] contribute to the projected decline in electricity emissions in the NEM. The WEM also sees large deployment of renewables and storage over the projections period due to the Western Australian government's renewables announcement of 800 MW of new wind capacity and 2,000 MWh of storage.

Figure 5.3: Electricity emissions, 1990 to 2035



NEM = National Electricity Market; WEM = Wholesale Electricity Market (Western Australia)

3 Includes updated renewable energy targets of 70% by 2032 and 80% by 2035.

4 Target of 2.6 GW of renewable energy storage capacity by 2030 and 6.3 GW by 2035.

5 Offshore wind targets of 2 GW by 2032, 4 GW by 2035 and 9 GW by 2040.

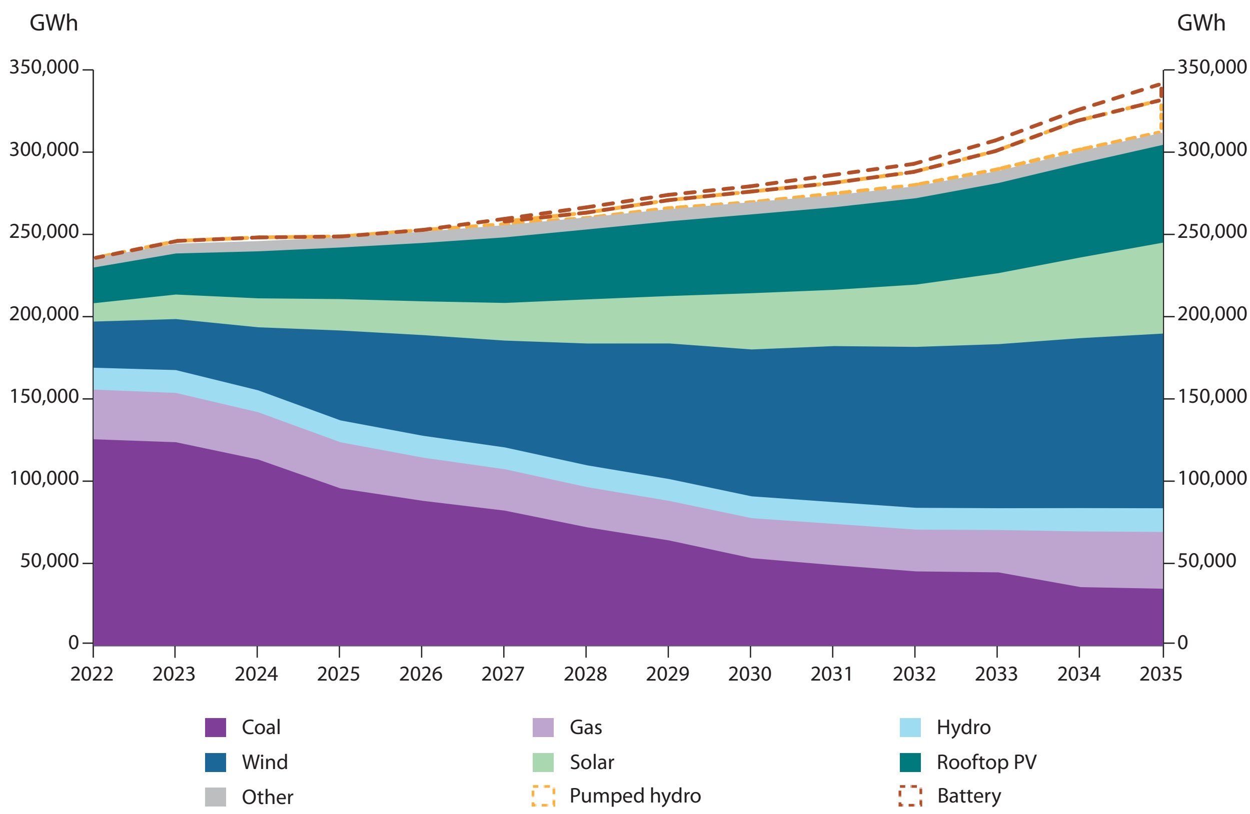
5.3.1.1 Emissions trends

Several coal generators are projected to close over the period to 2035, also lowering the emissions intensity of generation. The projections include recent closure announcements of Eraring power station in 2025 and Bayswater by 2033, both in the NEM; and Collie power station by late 2027 and Muja D in 2029 (both in the WEM). All publicly owned coal-fired power stations in Queensland are assumed to phase down by 2035, starting from 2028 when the first long-duration pumped hydro energy storage is projected to come online.[6]

The 2022 projections baseline scenario includes new Powering Australia measures which have already been implemented or where detailed design work is already complete, such as Community Batteries for household solar and Shared Solar Banks. Rewiring the Nation is included in the projections to the extent that it supports delivery of state and territory renewable targets and plans. Increasing battery storage, coupled with community solar banks, will lessen pressure on the grid by reducing reliance on grid generation at peak periods.

Greater electrification of light duty vehicles and other parts of the economy are projected to increase the demand for electricity. As this demand grows to 2035, so does the generation from renewable sources. Figure 5.4 shows modelled projections for sent-out generation by fuel type.

Figure 5.4: Fuel generation mix, 2022 to 2035 (GWh)

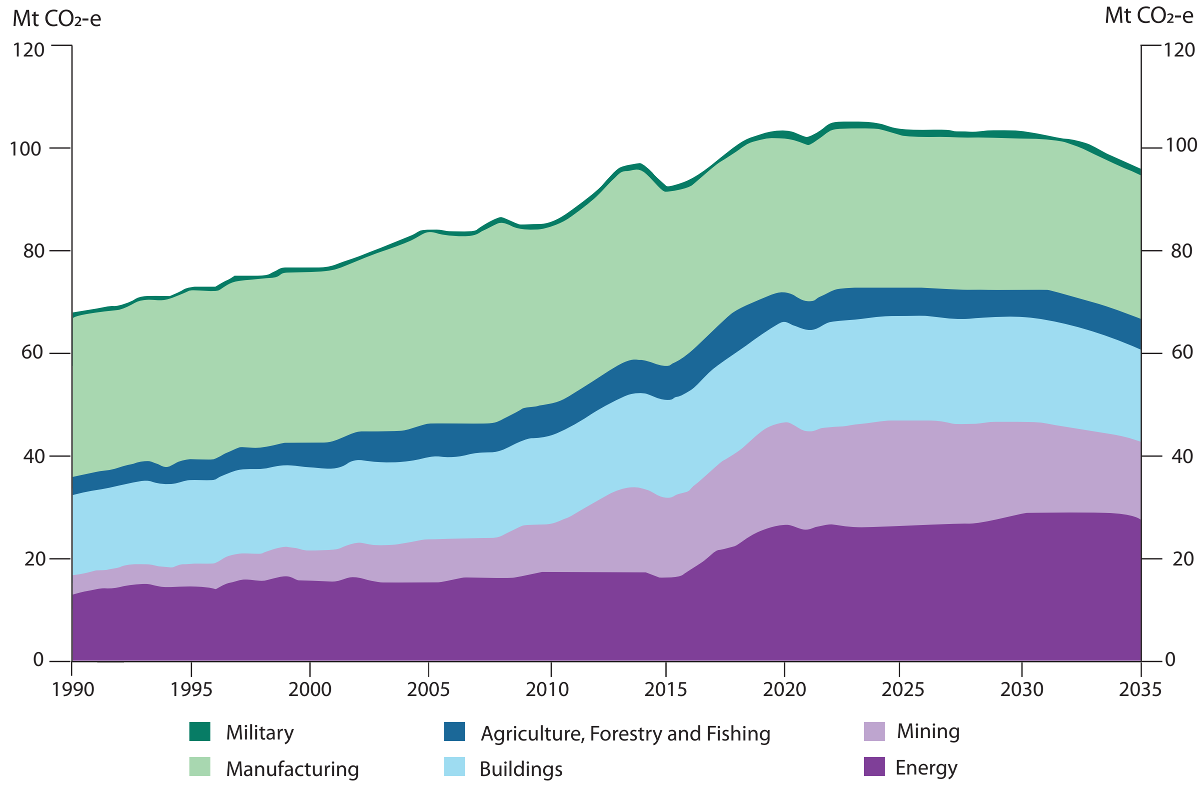


5.3.2 Projections of the energy sector (stationary energy excluding electricity)

Emissions from stationary energy are from the burning of fuels for energy used directly, in the form of heat, steam or pressure (excluding for electricity generation and transport). Stationary energy emissions are produced in almost all sectors of the economy. The stationary energy sector is subdivided into 6 subsectors for the purposes of the emissions projections: manufacturing; energy; buildings; mining; agriculture, forestry and fishing; and military. Fuel combusted in mobile equipment in these sectors is also included in stationary energy.

6 This aligns with the phase 2 period, as outlined in the *Queensland SuperGrid Infrastructure Blueprint* (Queensland Government 2022).

Figure 5.5: Stationary energy (excluding electricity), 1990 to 2035



5.3.2.1 Emissions trends

Stationary energy emissions are projected to remain relatively stable at around 101 Mt CO_2-e to 2030 and then decline by 7% to 94 Mt CO_2-e in 2035.

Manufacturing of goods is the largest subsector within the stationary energy sector. The emission intensity of the manufacturing subsector is projected to improve with production remaining relatively stable as emissions decline from 29 Mt CO_2-e in 2020 to 27 Mt CO_2-e in 2035. This decline in emissions is mainly due to the projected uptake of cleaner fuels and technologies, particularly after 2030, in the nonferrous metals, non-metallic minerals and chemical subsectors. These improvements include digestion technology upgrades and the uptake of mechanical vapour recompression evaporators in the alumina industry; a higher proportion of alternative fuels for clinker production; and improved burner design and efficiency improvements to incumbent technology in the ammonia industry. Adopting these technologies, where economic, reduces fuel use and emissions.

Other factors contributing to manufacturing subsector emissions are the Gibson Island fertiliser plant closure in late 2022, and new facilities starting operations in late 2022 (Kwinana and Kemerton lithium refineries) and 2025 (Perdaman chemical facility). Emissions trends in the energy subsector of stationary energy are mainly driven by liquefied natural gas (LNG) production. LNG accounted for 73% of energy subsector emissions in 2020, and its share is projected to increase to 76% in 2030 and 2035. Emissions from the energy subsector are projected to increase from 26 Mt CO_2-e in 2020 to 28 Mt CO_2-e in 2030 and remain relatively stable to 2035. This is mainly due to higher LNG and domestic gas production, partly offset by the closures of petroleum refineries in the early part of the decade. Improved energy efficiency of gas turbines in the oil and gas sector results in emissions reduction from oil and other gas.

The building subsector includes all the emissions from fuel combustion in residential and commercial buildings, as well as construction activities in infrastructure, and commercial and residential buildings. Emissions in this subsector are projected to slightly increase by 2% from 2020 to 2030, and then decline rapidly by 12% from 20 Mt CO_2-e in 2030 to 17 Mt CO_2-e in 2035. The primary drivers of the decline are new buildings transitioning to electric-only connections, and existing residential buildings switching to electricity from gas. State and federal energy efficiency measures also contribute to lower energy consumption in the building subsector.

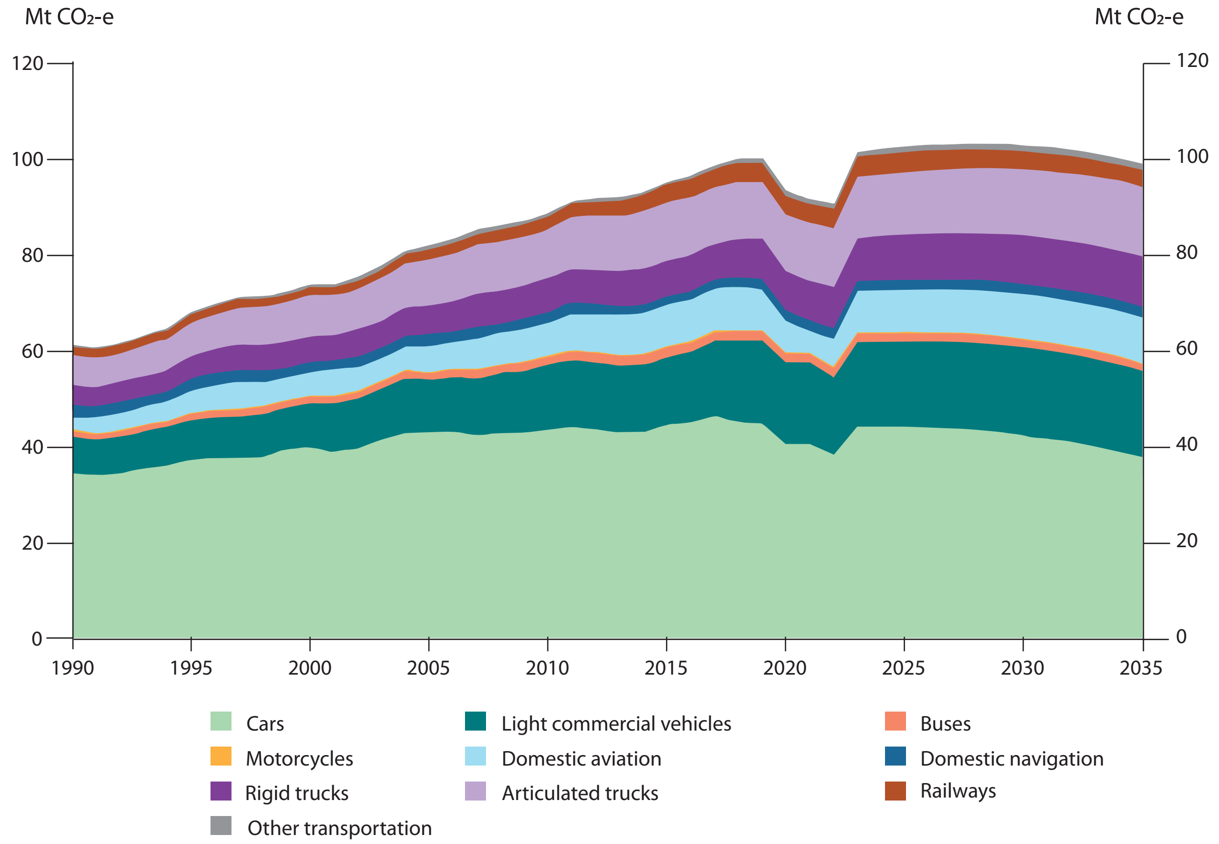
Emissions from the mining subsector are projected to decrease from 19 Mt CO_2-e in 2020 to 15 Mt CO_2-e in 2035. The mining subsector consists of coal mining and other mining. In 2022, other mining was primarily made up of emissions from iron ore (54%) and gold (18%) mining. Stationary energy emissions from coal production are projected to decline by 18% from 10 Mt CO_2-e in 2020 to 8 Mt CO_2-e in 2030, mainly driven by lower coal production. Emissions decline further to 7 Mt CO_2 e in 2035, largely due to the electrification of mining equipment. Emissions from other mining are projected to be relatively stable at around 10 Mt CO_2-e from 2020 to 2030, in line with commodity production projections. Emissions are projected to decline 20% to 8 Mt CO_2-e between 2030 and 2035, largely due to switching from diesel to electricity across all mining equipment categories. Electrification and displacing diesel are the key drivers of mining decarbonisation, with the trend projected to accelerate after 2030. The uptake of cleaner energy and technology is projected to reduce cumulative emissions in the mining subsector by around 9 Mt CO_2-e from 2023 to 2030 and by 16 Mt CO_2-e from 2031 to 2035.

Emissions from energy use in agriculture, forestry and fishing activities, and military subsectors are projected to remain relatively stable to 2035.

5.3.3 Projections of the energy sector (transport)

Emissions in the transport sector result from fuels combusted by road, domestic aviation, rail, domestic shipping, off-road recreational vehicle activity and gas pipeline transport. Road transport includes cars, light commercial vehicles, motorcycles, rigid trucks, articulated trucks, and buses. Emissions from the generation of electricity used in EVs and rail are accounted for in the electricity sector.

Figure 5.6: Transport emissions, 1990 to 2035



5.3.3.1 Emissions trends

Transport emissions were 100 Mt CO_2-e in 2019 and 93 Mt CO_2-e in 2020. Regulatory restrictions and behavioural change associated with the COVID-19 pandemic reduced aviation and light-duty vehicle activity. Emissions in the transport sector have remained below 2019 levels throughout the COVID-19 pandemic, with emissions dropping to 90 Mt in 2022. It is projected that from 2023 onwards, emissions from this sector will return to pre-pandemic levels. A small long-term impact on activity is assumed to reflect changes in behaviour resulting from the pandemic, such as increased working from home. From 2023 onwards, emissions are projected to increase from 102 Mt CO_2-e in 2023 to a peak of 103 Mt CO_2-e in 2028, before a decline to 2035.

The main contributors to transport emissions in Australia are light-duty vehicles, which includes cars and light commercial vehicles, such as vans and utes. In 2020, light-duty vehicle emissions accounted for 62% of all transport emissions, or 58 Mt CO_2-e. By 2030, emissions from these light-duty fleets are projected to be 61 Mt CO_2-e, 1 Mt CO_2-e lower than they were in 2019, dropping to 56 Mt CO_2-e in 2035.

Light-duty vehicle activity is expected to increase in line with population growth. This, alongside a trend towards heavier passenger cars (such as SUVs), offsets the effects of fuel economy improvements and technology switching over the next few years, so emissions remain stable in the near term. As uptake of electric and hybrid vehicles increases, emissions in the light-duty vehicle fleet segment begin to decline from around 2027.

Emissions from domestic aviation were 8 Mt CO_2-e in 2019, or 8% of total transport emissions. In 2022, emissions in this sector were 6 Mt CO_2-e. As activity returns to pre-pandemic levels, emissions are projected to reach almost 9 Mt CO_2-e in 2023, and then grow steadily with activity to 10 Mt CO_2-e in 2035.

Freight transport (rail, articulated trucks, rigid trucks and domestic marine), unlike domestic aviation and light-duty vehicles, was not materially impacted by the COVID-19 pandemic. In 2019, emissions in these sectors together were 26 Mt CO_2-e or 26% of total transport emissions. It is projected the emissions will increase to 30 Mt CO_2-e in 2030 and remain at this level in 2035. Emissions from heavy road vehicles (trucks and buses) increase at a slower rate than activity due to fuel switching (to hydrogen and EVs) and efficiency improvements, with effects more evident further into the projection period.

5.3.4 Projections of the energy sector (fugitive emissions)

Fugitive emissions are released during the extraction, processing and transport of fossil fuels. Fugitive emissions do not include emissions from fuel combusted to generate electricity, operate mining plant and equipment, or transport fossil fuels by road, rail or sea.

5.3.4.1 Emissions trends

Fugitive emissions from fuels were 53 Mt CO_2-e in 2020 and are projected to increase to 55 Mt CO_2-e in 2030 and then remain relatively stable until 2035.

Fugitive emissions from coal were 31 Mt CO_2-e in 2020 and accounted for 57% of all fugitive emissions. The primary drivers of emissions are the amount of coal produced, the emissions intensity of producing mines and the amount of methane captured. Coal fugitive emissions were lower in 2021 and 2022 as several mines reduced production primarily due to flooding events. Emissions are projected to increase in 2023 and 2024 as coal production returns to previous levels, supported by the high prices currently achieved for thermal and coking coal exports. Emissions are projected to remain relatively steady to 2028 and then decline due to reduced demand for Australian thermal coal and the closure of several large, gassy underground mines between 2028 and 2035.

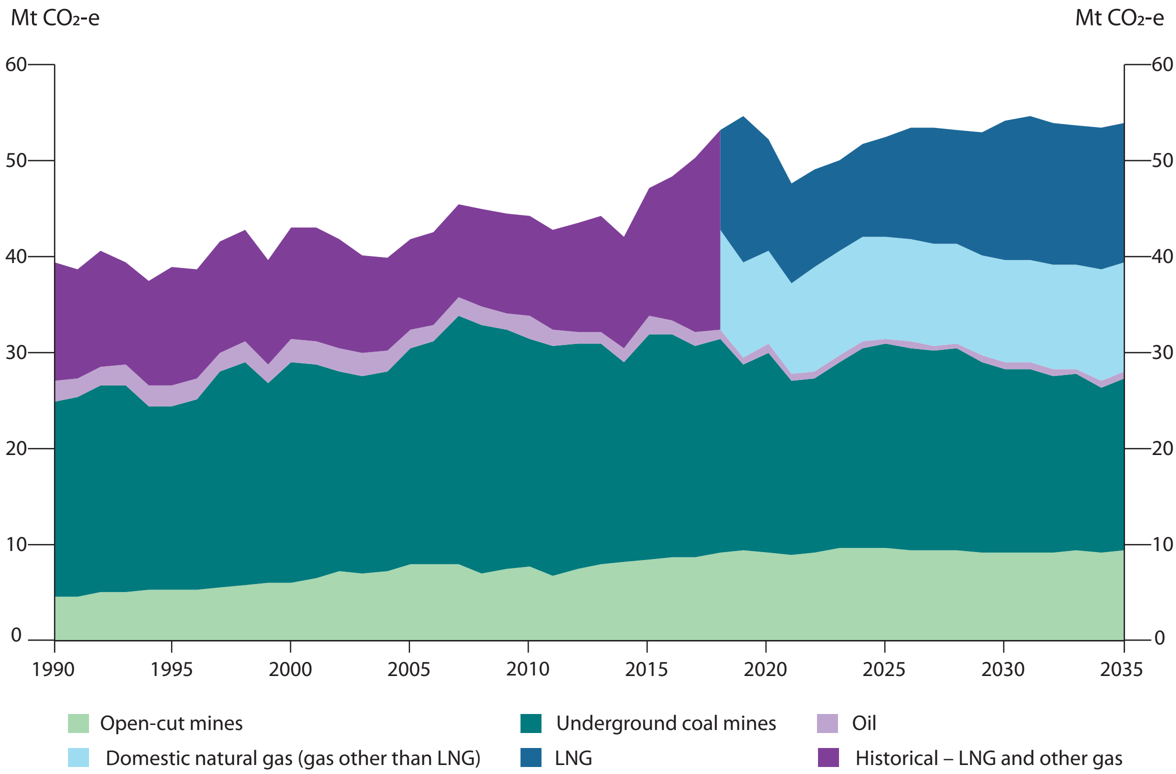
Fugitive emissions from oil and gas were estimated to be 23 Mt CO_2-e in 2020, representing 43% of all fugitive emissions. Emissions are projected to increase to 26 Mt CO_2-e in 2030 and 27 Mt CO_2-e in 2035.

Fugitive emissions from oil were estimated to be 1 Mt CO_2-e in 2020 and are projected to remain around that level in 2030 and 2035. Fugitive emission from gas are projected to grow to 2030 and 2035. This is due to new unconventional gas projects to meet domestic demand for gas as well as increased LNG production. The shifting to higher CO_2 basins to backfill existing LNG projects also contributes to increased fugitive gas emission.

Emissions are somewhat offset by 2 carbon capture and storage (CCS) projects in the projections: the Moomba

CCS project is assumed to commence in 2025 and capture around 1.7 Mt CO_2 per year; the Gorgon LNG CCS project is assumed to capture 3.4 Mt CO_2 per year.

Figure 5.7: Fugitive emissions, 1990 to 2035



5.3.5 Projections of the IPPU sector

The IPPU sector covers emissions from non–energy-related production processes. Emissions from this sector include by-product gases from chemical reactions in production processes, the release of synthetic greenhouse gases from commercial and household equipment, combustion of lubricant oils not used for fuels, and CO_2 used in food and beverage production.

5.3.5.1 Emissions trends

IPPU emissions are projected to decline from 32 Mt CO_2-e in 2020 to 28 Mt CO_2-e in 2030 and 25 Mt CO_2-e in 2035. This is largely due to projected declines in emissions from hydrofluorocarbons as the result of the HFC phase-down under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* and associated regulations, which legislates a decreasing annual import quota on bulk HFCs imports to 2036. Emissions from HFCs are projected to decline from 11 Mt CO_2-e in 2020 to 7 Mt CO_2-e in 2035.

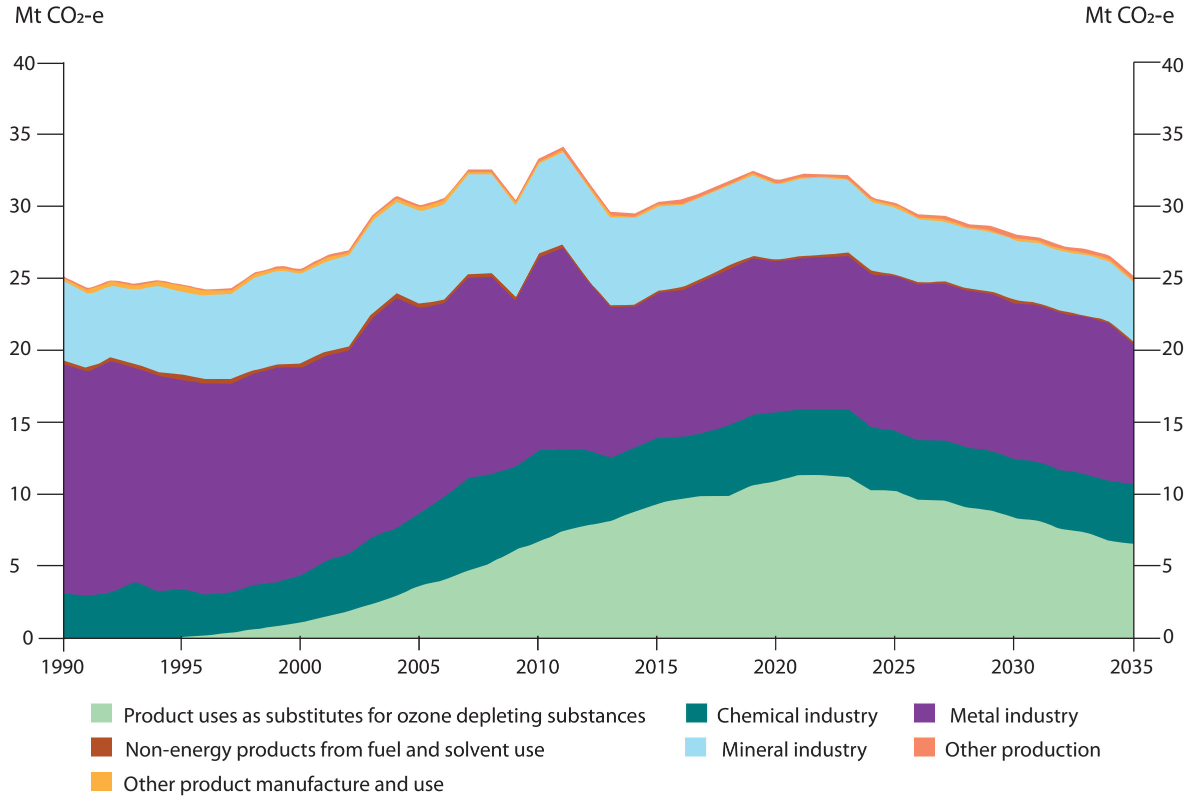
After product uses as substitutes for ozone-depleting substances, the metal industry is the second-largest subsector of IPPU, representing 33% of total emissions (10 Mt CO_2-e) in 2020. Emissions are projected to increase by 4% (to 11 Mt CO_2-e) by 2034, mainly due to slightly higher production forecasts and the opening of 2 lithium refineries in Western Australia. From 2034 to 2035, emissions are projected to decline by 11% (to 10 Mt CO_2-e) in line with projected technological improvements in steelworks facilities, such as natural gas direct reduction (DR) and electric arc furnace (EAF) processes.

Chemical industry emissions accounted for 15% of emissions in the IPPU sector in 2020. Emissions from this subsector are projected to decrease from 5 Mt CO_2-e in 2020 to 4 Mt CO_2-e in 2024 and remain relatively stable to 2035. The decline in projected emissions in the chemical sector reflects the announced closure of the Gibson Island fertiliser plant (Queensland), and industry emissions reduction projects.

Mineral industry emissions made up 16% of emissions in the IPPU sector in 2020 and are projected to decrease from 5 Mt CO_2-e in 2020 to 4 Mt CO_2-e in 2026 and then remain relatively stable to 2035. This reflects reductions in emissions from cement production, which accounts for about 54% of mineral industry emissions. The reductions are due to projected declines in domestic clinker production, which is somewhat offset by increases in lime production.

Emissions from all other IPPU subsectors are projected to be flat to 2030 and 2035.

Figure 5.8: Industrial processes and product use emissions, 1990 to 2035



5.3.6 Projections of the agriculture sector

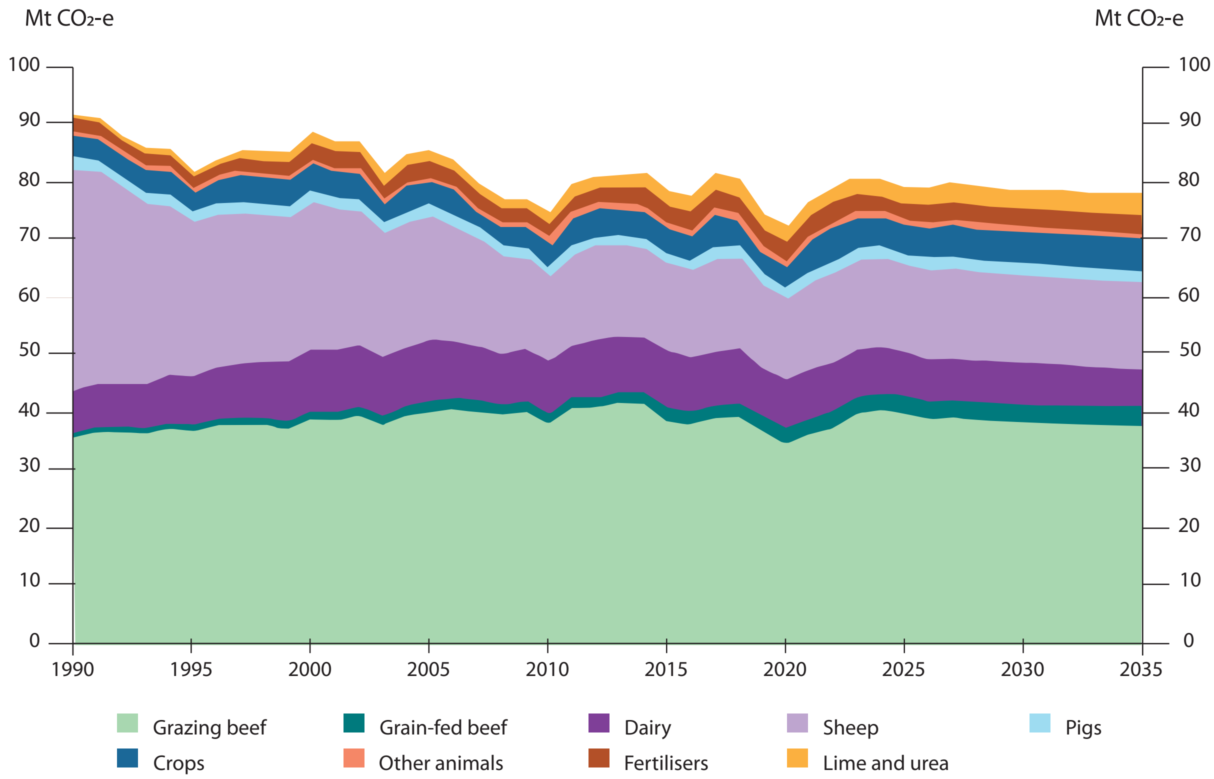
Agriculture sector emissions relate to biological processes associated with agricultural commodity production. This includes emissions from enteric fermentation being the digestive process of ruminant animals such as sheep and cattle, agricultural soils, manure management, liming and urea application, rice cultivation, and field burning of agricultural residues. The agriculture sector does not include emissions from energy used in farm machinery or electricity use, which are included in the electricity and stationary energy sectors.

Most agriculture emissions are methane and nitrous oxide from the consumption by livestock, decay or combustion of living and dead biomass, with a small amount of CO_2 emissions from the application of lime and urea.

5.3.6.1 Emissions trends

Agriculture emissions are projected to be 79 Mt CO_2-e in 2030, 6 Mt CO_2-e higher than in 2020. Emissions are expected to peak in 2023 at 81 Mt CO_2-e due to the influence of the ongoing La Niña event, which is continuing to ease drought conditions across northern and eastern agricultural areas. La Niña is associated with increased rainfall and cloudiness, which usually results in above-average winter–spring rainfall across the east and north of Australia. Agriculture emissions are projected to decline 1 Mt CO_2-e between 2030 and 2035 to 78 Mt CO_2e as agricultural activity is assumed to return to average seasonal conditions towards the end of the decade.

Figure 5.9: Agriculture emissions in the baseline scenario, 1990 to 2035, Mt CO_2-e



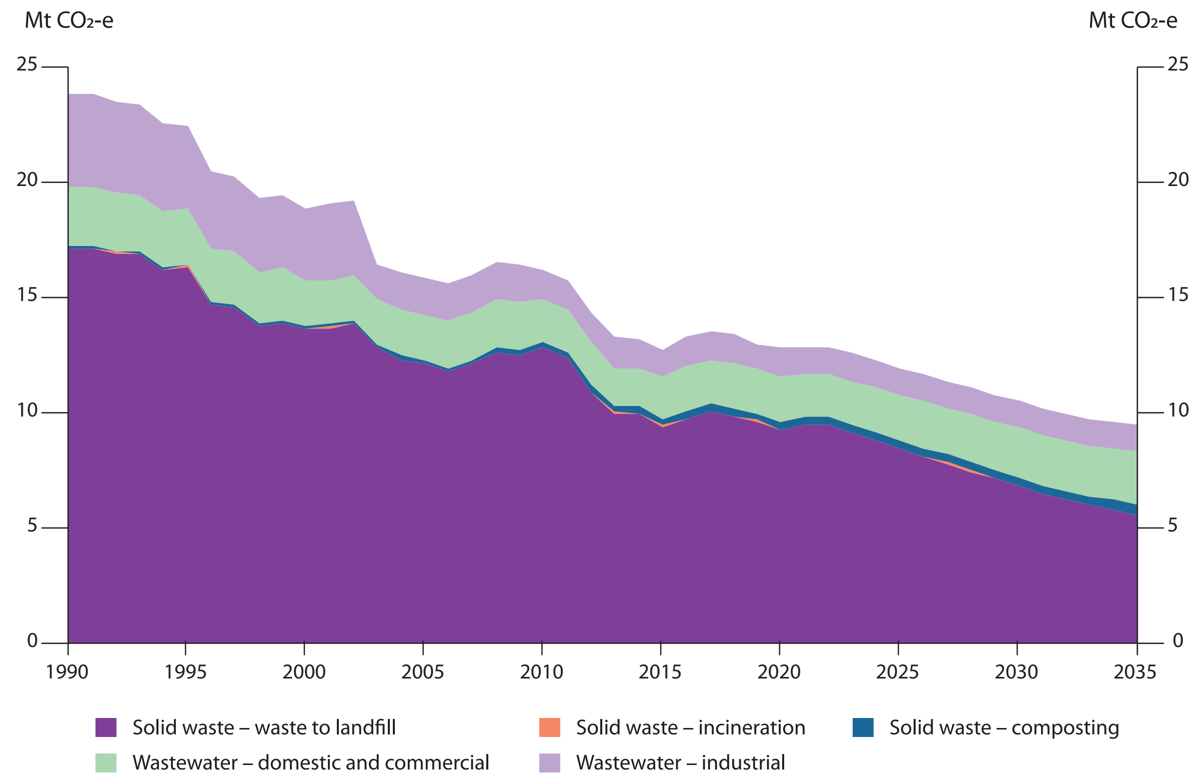
5.3.7 Projections of the waste sector

The waste sector covers emissions from: disposal of organic materials to landfill; wastewater emissions from domestic, commercial, and industrial sources; biological treatment of solid waste (composting); and a small contribution from waste incineration. Emissions are predominantly CH_4, generated from the anaerobic decomposition of organic matter. Small amounts of carbon dioxide and nitrous oxide are generated by the incineration and decomposition of human waste.

5.3.7.1 Emissions trends

Emissions in the waste sector are projected to decline from 13 Mt CO_2-e in 2020 to 11 Mt CO_2-e in 2030, and further to 10 Mt CO_2-e in 2035. The downward trend is primarily the result of federal, state and, territory policies to reduce the amount of solid waste deposited to landfill, and increased methane capture rates.

Figure 5.10: Waste emissions in the baseline scenario, 1990 to 2035, Mt CO_2-e



5.3.8 Projections of the LULUCF sector

The LULUCF sector includes both sources of greenhouse gas emissions and sinks that remove carbon dioxide from the atmosphere and sequester it as carbon in living biomass, debris, and soils.

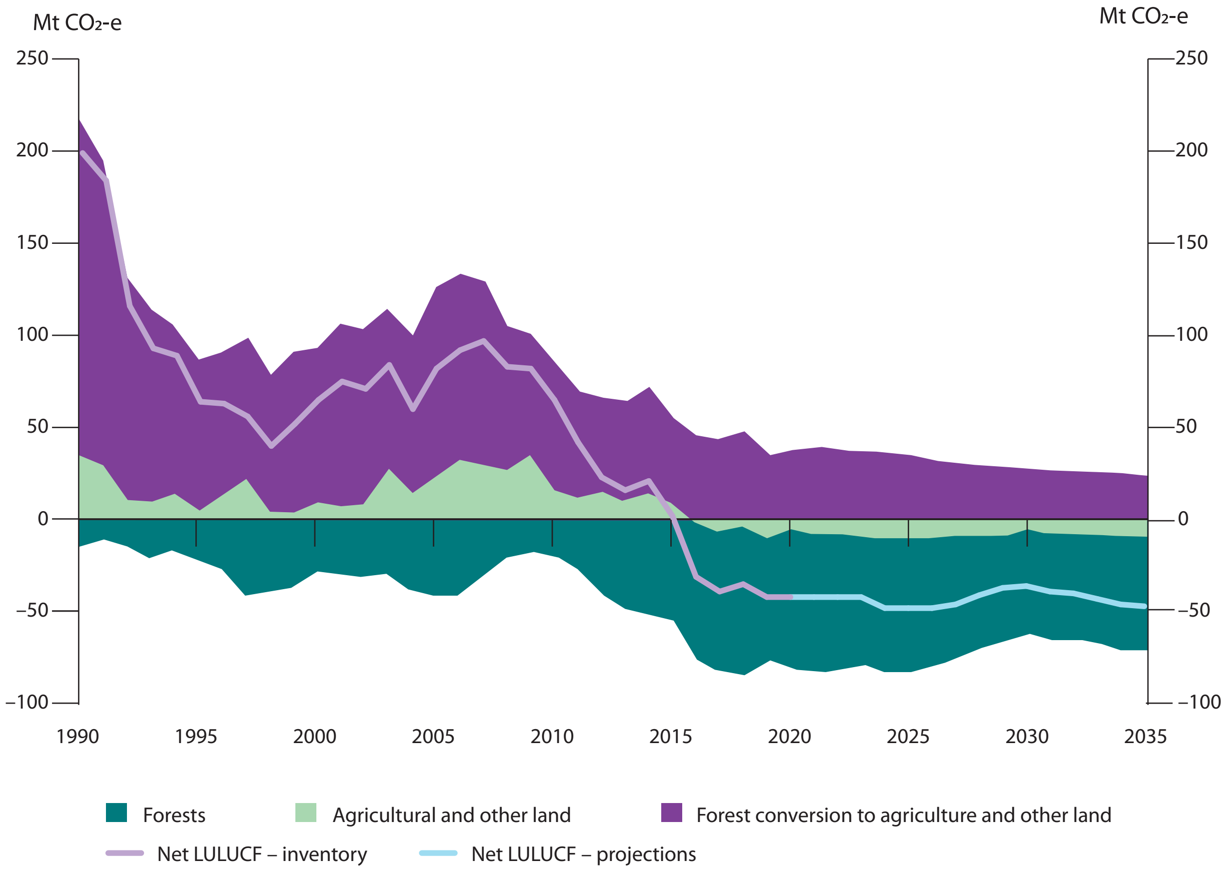
Changes to land management practices have had significant impacts on Australia's vegetation since 1990. Reduced vegetation clearing, especially primary forest clearing (that is, clearing of forest that has not been previously cleared), incentivizing revegetation, and the use of shelter belts have all contributed to increased carbon storage outcomes in Australia's forests and grazing lands.

The LULUCF sector projections are based on the UNFCCC inventory structure as described in Australia's *National Inventory Report 2020* (DCCEEW 2022c). The major categories used include:

- forest land, including forest land remaining forest and land converted to forest (e.g. harvest and regeneration of native forests, establishment and harvest of plantations, wildfires and prescribed burning) and includes sinks from regrowing forest on previously cleared land, and carbon stored in harvested wood products)
- forest clearing, emissions from the UNFCCC land use classification of forest converted to other land uses, includes direct clearing-related emissions and delayed emissions from previous clearing, mainly through the gradual loss of soil carbon over several years, but excludes sinks from regrowing forests on previously cleared lands
- cropland, woody horticulture and changes in soil carbon under herbaceous crops
- grasslands, changes in soil carbon through pastoral activities, fire management in savanna rangelands and changes in shrubby vegetation extent on grasslands

- wetlands and settlements, gains and losses of woody vegetation that is not already classified as forest land (e.g. sparsely planted trees or shrubs) on wetlands and within settlement boundaries sourced from catchment-scale land-use mapping from ABARES' catchment-scale land-use mapping, as well as aquaculture activities, dredging of seagrasses, and mangrove and tidal marsh conversions not already reported in forest land or forest conversions.

Figure 5.11: Land use, land-use change and forestry emissions, 1990 to 2035



5.3.8.1 Emissions trends

LULUCF emissions have decreased since 1990, reaching 39 Mt CO_2-e in 2020. The sector is projected to remain a net sink with emissions projected to be –33 Mt CO_2-e in 2030 and –44 Mt CO_2-e in 2035.

The emissions trend is largely driven by the changes in the forest land subsector. The sink declines to 2030 primarily due to plantation harvesting. To 2035, the sink increases mainly due to reduced native timber harvesting.

5.4 Projections of international bunker fuels emissions

International bunker fuel emissions result from international aviation and international marine transport activities. These emissions are excluded from the national inventory total, by international agreement. Emissions from international bunker fuels supplied in Australia were 18 Mt CO_2-e in 2019 and 14 Mt CO_2-e in 2020 as transport activity declined due to the COVID-19 pandemic restrictions. Emissions are projected to be 26 Mt CO_2-e in 2030, an increase of 87% above 2020 levels, and 31 Mt CO_2-e in 2035, an increase of 124% above 2020 levels[7].

7 Emissions from international bunker fuels were projected to 2035 based on the historical average annual growth rate from 1999 to 2019 for international aviation and international marine emissions reported in *Australia's National Inventory Report 2020* (DCCEEW 2022c).

The majority of growth in emissions is from the international aviation sector, accounting for 12 Mt CO_2-e in 2020 or 85% of international bunker fuels emissions. Activity in this sector is expected to return to pre-pandemic levels with emissions projected to rise to 2035 at an average of 3.9% a year based on historical trends to 23 Mt CO_2-e in 2030 and 28 Mt CO_2-e in 2035. International marine transport emissions have fluctuated in recent years, with average yearly emissions from this sector in 2009–2019 lower than those over the previous 10-year period. Emissions from this sector were 2.2 Mt CO_2-e in 2020.

Emissions from Australia's international marine transport sector are projected to increase slightly, with world demand for Australia's resources and commodities likely to lead to increased export volumes. Emissions are projected to grow to 2.7 Mt CO_2-e in 2030 and 2.9 Mt CO_2-e in 2035.

This projection does not take account of targets and ambitions under the International Civil Aviation Organization (ICAO) and International Maritime Organization (IMO). Depending on actions taken under these targets and ambitions, emissions from both international aviation and marine could be lower than currently estimated but cannot be reliably quantified at this time.

Australia is an active supporter of ICAO's efforts to reduce aviation emissions. At the ICAO 41st Assembly in October 2022, Australia fully supported the endorsement of a long-term aspirational goal (LTAG) for international aviation of net zero carbon emissions by 2050. Other measures that complement the goal include the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA aims to cap international aviation emissions at a global baseline and encourage sustainable aviation fuel uses to reduce emissions and offsetting where the baseline is exceeded. With the support of our international airlines, Australia has participated in the voluntary phase of CORSIA since it commenced in 2019.

As a member state, Australia supports the IMO's efforts to reduce greenhouse gas emissions from international shipping. The IMO is aiming to reduce the carbon intensity of international shipping by at least 40% by 2030. The Australian Government looks forward to further working with the IMO and its efforts towards sustainable shipping. In November 2022, Australia also signed up to the Green Shipping Challenge which encourages countries, ports and shipping companies to announce actions to align the industry with the 2015 Paris Agreement goal to keep global warming below 1.5 degrees.

5.5 Australia's methodology

Australia's emissions projections are prepared by analysts in the Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW). The projections are prepared to 2035 and draw on public data sources from government agencies and other bodies to inform estimates of production/activity or growth at the sectoral or subsectoral level. Energy savings and fuel switching estimates are based on publicly available data or data outputs from DCCEEW-commissioned research. These estimates, with relevant emission factors, are then used to calculate emissions for sectors. Emissions factors used are consistent with Australia's National Greenhouse Gas Inventory. A detailed breakdown of emissions from all sectors by gas is estimated using the Australian Greenhouse Emissions Information System (AGEIS). Details on AGEIS are provided in Chapter 3, section 3.3.4.

Emissions by gas for the agriculture, waste, IPPU, and fugitive emissions sectors are the direct outputs of the sectoral models. For other sectors in which the model outputs are in CO_2-e, the emission projections cover CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3 based on the corresponding inventory estimates and accounting for any policies that have an impact on the emissions of specific gases.

5.5.1 Data sources

The key data sources include:

- historical emissions data from the *National Inventory Report 2020* (DCCEEW 2022e)
- the latest *Quarterly update of Australia's National Greenhouse Gas Inventory* (DCCEEW 2022f)

- commodity forecasts and activity levels informed by publications and data from government agencies and other bodies, including
  - Office of the Chief Economist within the Department of Industry, Science and Resources
  - Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)
  - Australian Energy Market Operator (AEMO)
  - Clean Energy Regulator (CER).

DCCEEW applies consistent assumptions across all sectors of these projections. Data on underlying assumptions can be found at Common Tabular Format (CTF) Table 5 in Annex A.

5.5.2 Summary of sectoral models

Table 5.2 summarises the models used for calculating emissions for each sector. Sector-specific methodologies are discussed in greater detail in the following sections.

Table 5.2: Summary of sectoral models

Sector	Model (type, purpose)
Electricity	Emissions from Australia's largest grids (NEM, WEM and DKIS) are projected using PLEXOS, market-leading forecasting software. PLEXOS simulates energy market outcomes, including long-term investment planning and short-term half-hourly market behaviour. Purpose-built, bottom-up and top-down models are used for projecting emissions from Australia's off-grid and minor grid electricity networks.
Stationary energy	Purpose-built, bottom-up models estimating emissions are based on estimates of production and fuel switching/saving at the subsectoral level.
Transport	Purpose-built models are based on interrelated projections of vehicle activity and vehicle fleet technology by state, mode/vehicle type, and fuel/engine type. Emissions were derived from the projections as the product of projected activity and projected emissions intensity for each of the transport sector segments.
Fugitive emissions	Purpose-built, bottom-up models estimate emissions based on facility-level estimates of LNG production and for existing coal mines. Subsectoral models are based on state-level indicators of oil production and refinery output and basin-level data for domestically consumed natural gas.
Industrial processes and product use	Purpose-built, bottom-up models estimate emissions based on estimates of production at the subsectoral/facility level.
Agriculture	Purpose-built, bottom-up model estimates emissions based on agricultural production at the subsectoral level.
Waste	Purpose-built model has bottom-up (solid waste to landfill) and top-down (other waste subsectors) components. Waste emissions are calculated by subsector, and are driven by population, policies, and historical rates and trends of waste generation and diversion.
Land use, land-use change and forestry	Purpose-built model is based on state-level estimates of emissions and removals in the land sector in Australia's National Inventory and agricultural production consistent with the agriculture sector.

DKIS = Darwin-Katherine interconnected system; LNG = liquefied natural gas; NEM = National Electricity Market; WEM = Wholesale Electricity Market (Western Australia)

5.5.3 Electricity methodology and assumptions

5.5.3.1 Modelling approach

The electricity sector emissions projections have been prepared by DCCEEW using PLEXOS (market forecasting software) modelling for the NEM, WEM and Darwin Katherine Interconnected System (DKIS), and DCCEEW's internal modelling for off-grid electricity generation and the North West Interconnected System (NWIS).

NEM, WEM and DKIS

DCCEEW used PLEXOS to project emissions from Australia's NEM, WEM and DKIS electricity grids to 2035. PLEXOS is used for simulating energy market outcomes, including long-term investment planning and short-term half-hourly market behaviour. The PLEXOS model framework includes an investment model and a dispatch model that is based on the 2021 Electricity Statement of Opportunities (ESOO). The investment model determines the capacity mix to meet demand at the lowest system cost. The dispatch model dispatches a given set of generation assets to simulate detailed market outcomes. New large interconnector projects in the NEM are exogenous inputs into the model, in line with the progressive change pathway under AEMO's Integrated System Plan (AEMO 2022d), 2021–22 Inputs, Assumptions and Scenarios (AEMO 2022c) and advice from DCCEEW.

Off-grid

DCCEEW modelled emissions from Australia's off-grid electricity networks. Off-grid refers to all locations where small electricity networks operate, and includes 'microgrids'. Off-grid electricity demand is predominantly from industrial users for mining and LNG production.

Off-grid electricity emissions are calculated using 2 models. The first is a bottom-up model that is driven by the production of LNG at individual facilities, with production assumptions in line with estimates under the fugitive emissions sector modelling and electricity use assumptions based on information reported by facilities under the National Greenhouse and Energy Reporting (NGER) scheme. The second is a top-down model that is driven by demand for off-grid electricity excluding LNG and assumptions of changes in the fuel mix, in particular the uptake of solar technology.

For off-grid generation, emissions are calculated by the following equations for LNG and non-LNG off-grid electricity, respectively:

$$E_t = \sum_i (EF_{it} \,.\, EC_{it} \,.\, P_{it})$$

Where:

E_t = LNG off-grid electricity emissions in year t (Mt CO_2-e)

EF_{it} = facility-specific electricity emissions intensity factor in year t (Mt/MWh)

EC_{it} = facility-specific electricity consumption factor for unit of production in year t (MWh/Mt)

P_{it} = production at facility i in year t (Mt).

$$E_t = \sum_i (Ef_i \,.\, Fc_i \,.\, G_{it})$$

Where:

E_t = annual non-LNG off-grid electricity emissions in year t (Mt CO_2-e)

Ef_i = emissions factor for consumption by fuel i (Mt CO_2-e /PJ)

Fc_i = fuel consumption factor per unit of electricity generation (PJ/GWh)

G_{it} = electricity generation by fuel i in year t (GWh).

5.5.3.2 Activity data

NEM, WEM and DKIS

Forecasts of electricity demand are a key input into the electricity sector emissions projections. DCCEEW has sourced data from the AEMO's NEM Electricity Statement of Opportunities (AEMO 2022a) to inform electricity demand projections for the NEM, and from the WEM Electricity Statement of Opportunities (ESOO) to inform projections for the WEM (AEMO 2022e). The demand scenarios included in the projections were the ESOO 2022 progressive change scenario for the NEM and the expected growth scenario for the WEM. These demand scenarios include AEMO's forecasts for energy efficiency.

The electricity emissions projections include consumption of electricity from EVs consistent with estimates in the transport sector and electrification assumptions consistent with estimates in the stationary energy sector.

Data and information from the Utilities Commission of the Northern Territory (Utilities Commission of the Northern Territory 2022), which include demand forecasts by AEMO for the Commission, and trends from PLEXOS analysis are used in modelling the DKIS.

Small grids and off-grid

In the NWIS, electricity demand has been calculated using regression analysis between electricity generation and iron ore output.

Off-grid demand is derived using production estimates of LNG in line with assumptions in the fugitive emissions sector, and estimates under the report commissioned by DCCEEW from Advisian on electrification opportunities in Australian mining (Advisian 2022).

Renewable capacity

The CER's pipeline of large-scale renewable projects at July 2022 was used in the 2022 projections (CER 2022). The pipeline provides renewable uptake to the mid-2020s, after which new renewable capacity is induced by the PLEXOS modelling.

The CER's modelling of rooftop solar was used in the projections to 2027. After 2027, the projections adopt growth rates from AEMO's 2022 Inputs, Assumptions and Scenarios workbook (step-change scenario[8]) (AEMO 2022c).

Wind and utility solar are projected to meet a growing share of the underlying demand. To limit the emergence of negative demand events in the projections modelling, a level of curtailment was assumed to apply to some solar generation. In 2030 and 2035, this curtailment was assumed to reduce the output of rooftop photovoltaic (PV) systems by less than 1% of NEM demand.

Data sources

Table 5.3: Data source for electricity demand projections

Grid	Data source for electricity demand
National Electricity Market	AEMO Electricity Statement of Opportunities for the NEM
Wholesale Electricity Market	AEMO Electricity Statement of Opportunities for the WEM
Darwin Katherine interconnected system	Northern Territory Electricity Outlook Report (Utilities Commission of the Northern Territory 2022)
North West interconnected system	Iron ore production outlook (OCE 2022a; NIEIR 2021)
Off-grid	LNG production consistent with production assumptions in the *fugitives sector*.

AEMO = Australian Energy Market Operator; LNG = liquefied natural gas; NEM = National Electricity Market; WEM = Wholesale Electricity Market (Western Australia)

8 The step-change scenario aligns best with the CER rooftop solar trends to 2027. AEMO's progressive change scenario is used to inform all other inputs because it best reflects current policies.

Transmission

Transmission networks transport electricity from generators to distribution networks and then to customers. In Australia, there are transmission networks in each state, and both territories are serviced by a distribution network (see also section 2.6.1.1). The NEM is an interconnected transmission network on the east coast of Australia connecting Queensland, New South Wales, the Australian Capital Territory, Victoria and Tasmania.

The emissions projections are developed on the basis of adopted policies and measures. The projections assume that state renewable energy targets will be met in Queensland, Victoria, Tasmania, the Northern Territory and include the New South Wales Electricity Infrastructure Road Map.

When a data model is constrained with certain parameters, it can lead to the model making supplementary assumptions to meet a set requirement. In constraining the electricity model to meet state targets, the electricity emissions projections modelling assumes that the necessary transmission will be available to achieve the renewable targets.

5.5.4 Stationary energy (excluding electricity) methodology and assumptions

Emissions from the stationary energy sector are projected using modelling processes developed by DCCEEW. Projections are aggregated from 6 subsectors: energy; mining; manufacturing; buildings; agriculture, forestry and fishing and other, which is solely fuel used by military vehicles within Australia.

5.5.4.1 Modelling approach

The stationary energy models are a combination of facility-specific and top-down models depending on the emission source and the availability of data. The models are maintained and updated within DCCEEW. The structure of these models is provided in Table 5.4.

The production data for LNG are estimated at the facility-level, because each facility has a different emissions intensity. Emissions intensities are calculated based on emissions reported through the NGER scheme. The emissions intensity is updated yearly for each facility if new data are available.

5.5.4.2 Activity data

Activity data used in the stationary energy subsectors are presented in Table 5.4.

Emissions projections in the stationary energy sector are estimated using activity data from various sources including Office of the Chief Economist (OCE) commodity forecasts (OCE 2022a,b), Australian Energy Update (DCCEEW 2022a), Wood Mackenzie long-term outlook reports, IBISWorld industry reports, AEMO's Gas Statement of Opportunities (GSOO) (AEMO 2021, 2022b) and *Ammonia: Australia market outlook 2021* (MRC 2021). The emissions reductions from policies and measures were also included.

Table 5.4: Summary of activity data and calculation methods for each stationary energy subsector

Emissions subsector	Activity data	Calculation method
Energy		
LNG (facility level model)	Production data from the gas fugitives sector and emissions intensity from the NGER and various environmental impact studies; fuel savings and efficiency factors from Advisian (2022)	$E_t = \sum_i (EF_{it} \cdot P_{it})$ Where: E_t = emissions in year *t* (Mt CO_2-e) EF_{it} = facility-specific emissions factor in year *t* P_{it} = production at facility *i* in year *t*

Emissions subsector	Activity data	Calculation method
Other oil and gas extraction (top down model)	Western Australia gas demand from AEMO (2021); East Coast gas demand from AEMO (2022b); crude and condensate oil demand from OCE (2022a,b); fuel savings and efficiency factors from Advisian (2022)	$E_t = E_{t-1} . \Delta$ Production Where: E_t = emissions in year *t* (Mt CO_2-e) E_{t-1} = emissions in the previous year Δ Production = percentage change in production between year *t* and year *t* – 1
Manufacture of solid fuels (top down model)	Iron and steel growth rates from OCE[a] (2022a,b) and Wood Mackenzie long-term outlook report	
Domestic gas production and distribution (top down model)	Western Australia gas demand from AEMO (2021); east coast gas demand from AEMO (2022b)	
Petroleum refining (top down model)	Total refinery output from OCE (2022a,b)	
Mining		
Coal mining (top down model)	Production data from the coal fugitives sector; fuel savings and efficiency factors from Advisian (2022)	$E_t = (Fc_{t-1}. Ec. Ef. \Delta P) \times (1- Eti_t)$ Where: E_t = emissions in year *t* (Mt CO_2-e) Fc_{t-1} = fuel consumption in the previous year *Ec* = energy contents of the fuel *Ef* = emissions factors of the fuel ΔP = percentage change in production between year *t* and year *t* – 1 Eti_t = emissions reduction (percentage) from technological improvement in coal mining/ other mining in year *t*
Other mining (iron ore; gold; copper; nickel; zinc; bauxite lithium, and manganese) (top down model)	Production data from OCE (2022a,b) and Wood Mackenzie long-term outlook report; base year proportion of the type and amount of fuel used in each commodity derived from NGER energy data, fuel savings and efficiency factors from Advisian (2022)	

Emissions subsector	Activity data	Calculation method
Manufacturing (top down model)		
Nonferrous metals (alumina; aluminium; refined nickel, copper, zinc, lithium, lead/ acid battery, battery recycling, recycled metal, and e-waste)	Production data from OCE (2022a,b) and Wood Mackenzie long-term outlook report; base year proportion of the type and amount of fuel used in each commodity derived from NGER energy data; fuel savings and efficiency factors from Advisian (2020)	$E_t = Fc_{t-1}. Ec. Ef. Fs_t. \Delta P$ Where: E_t = emissions in year t (Mt CO_2-e) Fc_{t-1} = fuel consumption in the previous year Ec = energy content of the fuel Ef = emissions factor of the fuel Fs_t =fuel saving estimates (due to fuel switching, technology and efficiency opportunities) ΔP = percentage change in production between year t and year t – 1
Nonmetallic minerals (cement, lime, plaster and concrete; ceramics; glass and glass products and other)	IBISWorld industry reports analysis and Cement Industry Federation (CIF 2020); Decarbonisation Pathways for the Australian Cement and Concrete Sector (VDZ 2021); base year proportion of the type and amount of fuel used in the process derived from NGER energy data; fuel savings and efficiency factors from Advisian (2020)	
Iron and steel	Production data from OCE (2022a,b) and Wood Mackenzie long-term outlook report; fuel savings and efficiency factors from Advisian (2020)	
Pulp, paper and print	Data from DCCEEW (2022e); final data point (2022) held constant	
Chemicals (other petroleum and coal product and basic chemical, chemical and plastic)	*Ammonia: Australia market outlook* (MRC 2021) and derived proportion of the base year from NGER data; fuel savings and efficiency factors from Advisian (2020); other petroleum and coal product and plastic held constant at 2022 level	
Food processing, beverages and tobacco	n/a	10 year historical average emissions growth
Other manufacturing	n/a	

Emissions subsector	Activity data	Calculation method
Buildings (top down model)		
Residential and commercial	Annual gas consumption data from AEMO (2021, 2022b); wood and wood waste fuel use from DCCEEW (2022a); derived proportion of emissions from wood biomass and others from DCCEEW (2022e)	$E_t = E_{wt} + E_{ot}$ $E_{wt} = E_{wt-1}$. Δ Consumption $E_{ot} = E_{ot-1}$. Δ Demand Where: E_t = emissions in year *t* (Mt CO_2-e) E_{wt} = emissions in year *t* (Mt CO_2-e) from burning wood biomass at residential buildings E_{ot} = emissions in year *t* (Mt CO_2-e) from gas consumption in the buildings $E_{o/wt-1}$ = emissions in the previous year from consumption of wood or other fuels Δ Demand = percentage change in gas consumption in commercial /residential buildings between year *t* and year *t* – 1 Δ Consumption = percentage change in wood consumption between year *t* and year *t* – 1
Construction	Activity data from Australian Construction Industry Forum (ACIF 2022)	$E_t = E_{t-1}$. Δ Activity Where: E_t = emissions in year *t* (Mt CO_2-e) E_{t-1} = emissions in the previous year Δ Activity = percentage change in activity between year *t* and year *t* – 1
Agriculture, forestry and fishing (top down model)		
	Farm production data from ABARES (2022a,b); average rate of change in diesel consumption derived from NGER data	$E_t = (E_{t-1}$. Δ Production) × (1 – *Dcr*) Where: E_t = emissions in year *t* (Mt CO_2-e) E_{t-1} = emissions in the previous year Δ Production = percentage change in production between year *t* and year *t* – 1 *Dcr* = average rate of change in diesel consumption per unit of production Emissions held constant at 2027 level
Other (military) (top down model)		
	Data from DCCEEW (2022e)	10 year average of historical emissions

n/a = not available; NGER = National Greenhouse Energy Reporting scheme; OCE = Office of the Chief Economist

a Production data for most commodities are sourced from the OCE, which is provided to 2027. Growth rates from Wood Mackenzie long-term outlook reports have been used for 2028 and beyond.

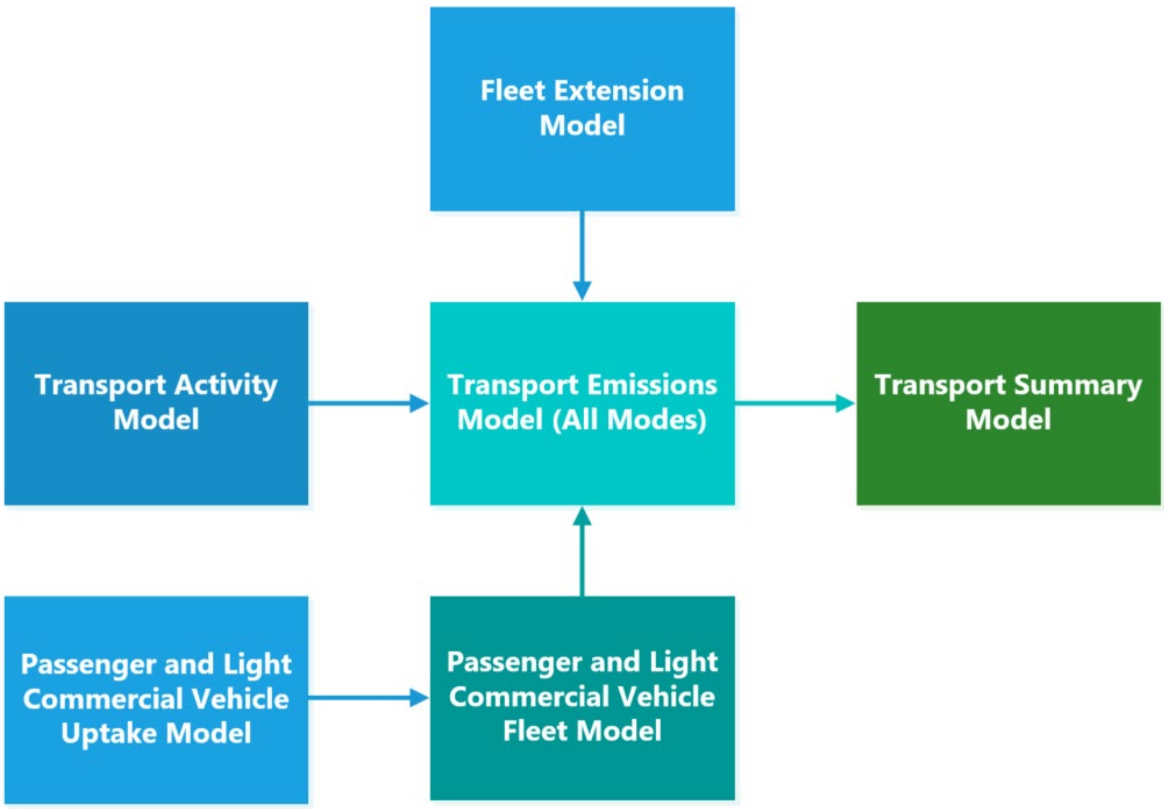
5.5.5 Transport methodology and assumptions

DCCEEW maintains an internal transport model to project emissions. The light duty vehicle subsector is modelled based on a detailed fleet model that tracks changes in the vehicle fleet over time. Other transport subsectors are modelled based on projected activity, changes in fleet efficiency and technology uptake. The exception to this modelling approach is for pipeline transport, because projected pipeline emissions were based on projections of state-level natural gas consumption and production (AEMO 2022d and Departmental analysis). For the remainder of the transport modelling, DCCEEW draws on inputs from various sources, which are detailed in the following sections.

5.5.5.1 Modelling approach

The transport sector emissions projections are modelled using several submodels outlined in Figure 5.12. The passenger and light commercial vehicle uptake model is an input into the passenger and light commercial vehicle fleet model. This fleet model then acts as an input along with the transport activity and fleet extension models into the final recalculation model. The output of the final recalculation model is then used as a final input into the transport summary model.

Figure 5.12: Simplified flowsheet of the transport sector emissions model



The transport sector model is based on projections of vehicle activity and vehicle fleet technology. The activity and fleet technology projections are segmented by state, mode/vehicle type, and fuel/engine type. Table 5.5 summarises the different modes and vehicle types included in the transport model and Table 5.6 lists the fuel and technology types used in the transport model.

Table 5.5: Modes and vehicle types in the transport emissions projections model

Mode	Vehicle Types
Road	Passenger vehicles
	Light commercial vehicles
	Articulated trucks
	Rigid trucks
	Buses
	Motorcycles
Marine	Passenger
	Freight
Aviation	Passenger
	Freight
Rail	Passenger
	Freight

Table 5.6: Fuel and technology types in the transport emissions projections model

Fuel Types	Technology Types
Diesel	Battery electric vehicle (BEV)
Gasoline	Hybrid electric vehicle (HEV)
Liquefied natural gas (LNG)	Plug-in hybrid electric vehicle (PHEV)
Liquefied petroleum gas (LPG)	Fuel cell electric vehicle (FCEV)

Projected emissions for transport models and vehicle types other than light duty vehicles are the product of projected activity and emissions intensity for each transport sector segment (by region, by mode/vehicle, by fuel/engine type). The emissions intensity of each segment is assumed to improve by 0.5% per year. In 2022, DCCEEW commissioned Transport Energy/Emission Research (TER) to undertake research and modelling relevant to the light-duty vehicle category. This research, along with available data from other sources, enabled a review of key inputs into the light-duty transport fleet model. Modelling capability was also built to enable the development of new uptake forecasts, with a focus on road vehicles. Revisions were also made for the transport activity model with the use of freight data provided by the Bureau of Infrastructure and Transport Research Economics (BITRE).

Compared to the transport modelling underpinning the 2021 projections, the transport model structure has remained broadly the same. However, various model inputs were updated including latest data, trends, and research.

5.5.5.2 Activity data

The production of the transport activity projections involves a hybrid approach in which vehicle kilometres travelled (VKT) is produced based on projected net-tonne-kilometres (NTK) for freight, and projected passenger kilometres travelled (PKT) for passenger activity.

To produce total projected passenger activity, DCCEEW recalculated state-level activity projections that were based on multiple linear regression-based forecasts using gross state product (GSP) and population projections. For the 2022 activity projections, updated inputs were used.

The input GSP series was informed by the Australian Bureau of Statistics (ABS 2021a), Centre for Population (2022), and the Department of the Treasury (2021) publications, as well as the Ministerial Statement on the Economy (Chalmers 2022). The population projections were similarly based on multiple sources, including publications by the Australian Bureau of Statistics (ABS 2018, 2022), Centre for Population (2022), and the Department of the Treasury (2021). These updated population and GSP series were then used to recalculate passenger activity projections using regression functions originally produced by Energeia (2020). For these revised activity projections, a small long-term impact in activity was assumed to reflect changes in behaviour resulting from the pandemic, such as increased working from home and virtual meetings. This reduction in passenger activity was applied as an annual adjustment to projected transport activity, with the impacts estimated to be 1.6% for aviation, 0.8% for private road transport, and 1.4% for public road transport and the rail and marine sectors.

Freight activity forecasts were based on new analysis from the BITRE. This included state-level freight activity projections for the road sector, and national-level freight projections for other modes (aviation, marine, rail). The series produced for both projected NTK and PKT were then used as inputs in calculating a final series for VKT.

Technology uptake

Technology uptake series for road vehicles were produced based on the analysis of multiple data sources, both historical and forecast. Historical sales data was sourced from VFACTS and used as an input to ensure the model was calibrated up to the 2022 financial year. This historical data was also analysed to inform the projected uptake series in terms of trends in the absolute sales of passenger and light commercial vehicles, along with trends in fuel type sales. Forecast data available for analysis included data produced by S&P Global for the Federal Chamber of Automotive Industries (FCAI), BITRE, and Bloomberg New Energy Finance. Forecast light-duty vehicle uptake was based on modelling completed for the Government by Energeia in 2020 and was used for both analysis and input. Energeia's modelling included vehicle sales technology projections based on a technology adoption function dependent on projected model availability and the projected first-year return on investment.

The final technology uptake series of use for the 2022 transport fleet model was developed through analysis of the data sources mentioned above. Trends in fuel type uptake were analysed and projected individually. Ratios in fuel type preference (e.g. gasoline to diesel, PHEV to BEV) were also analysed and factored into calculating the final technology uptake series.

The composition of the technology uptake series for passenger vehicles was developed separately to the light commercial series. The total number of passenger vehicles and light commercial vehicles projected to be sold was developed through analysis of both VFACTS historical data and the projected sales estimates. The technology uptake series compositions were then applied to the sales of passenger and light commercial vehicles respectively to arrive at projected uptake by fuel type and vehicle type. Table 5.7 summarises the projected new light-duty vehicle sales by fuel type as a proportion of total sales.

Table 5.7: Projected new light-duty vehicle sales by fuel type in the baseline scenario (%)

Financial Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Light Commercial Vehicles														
BEV	0.0	0.3	0.7	1.3	2.0	2.5	4.2	7.0	10.0	12.1	15.6	19.9	24.9	30.1
Diesel	91.8	91.9	91.6	91.0	89.9	88.9	87.1	84.3	81.3	79.3	76.2	72.4	68.1	63.6
Gasoline	8.1	7.8	7.8	7.7	7.6	7.5	7.4	7.1	6.9	6.7	6.5	6.1	5.8	5.4
HEV	0.0	0.0	0.0	0.0	0.5	1.1	1.3	1.5	1.9	1.9	1.7	1.5	1.2	0.9
PHEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Passenger Vehicles														
BEV	2.5	3.2	4.4	6.2	8.0	9.8	14.5	17.2	21.8	26.3	31.2	36.2	41.5	46.9
Diesel	16.0	12.3	11.4	11.1	10.6	10.1	9.1	8.6	8.1	7.2	6.6	6.1	5.8	5.6
Gasoline	70.6	73.6	71.5	68.2	64.6	61.4	56.1	52.8	48.4	45.1	42.7	40.5	39.4	38.2
HEV	10.2	10.1	11.4	12.6	14.1	15.3	16.1	16.6	16.4	16.3	15.0	13.5	10.8	8.0
PHEV	0.7	0.8	1.3	1.9	2.7	3.4	4.2	4.8	5.2	5.2	4.6	3.7	2.5	1.3

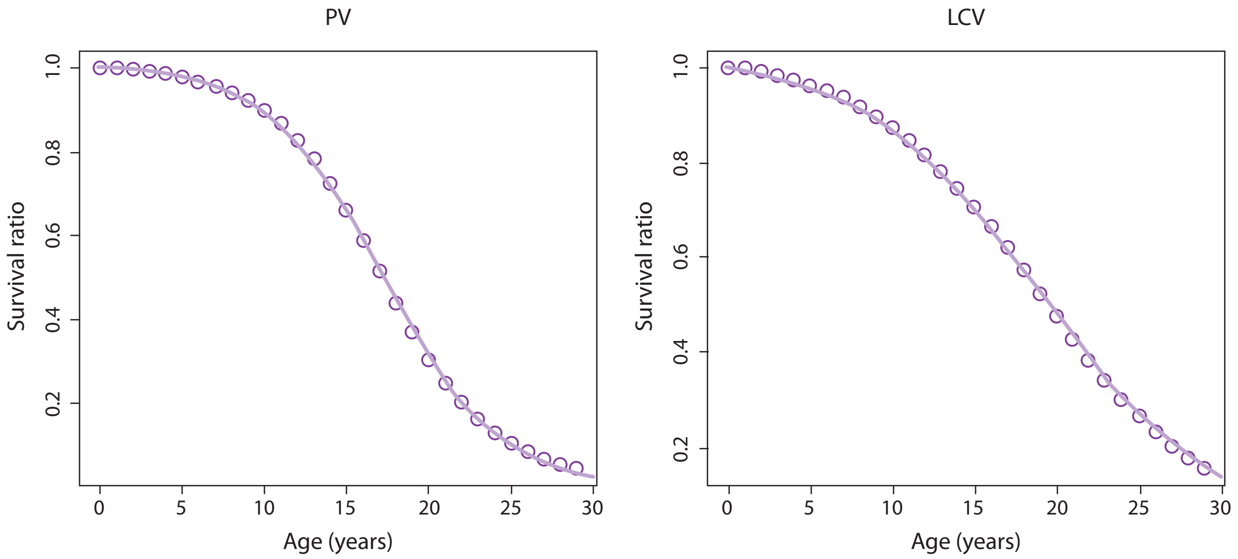
Note: Data is projected for financial years. For example, '2030' refers to the financial year 2029–30. These projections do not take account of new policies under the National Electric Vehicle Strategy. For example, if the Government introduced mandatory national vehicle fuel efficiency standards, this would increase the projected uptake of EVs and hybrid EVs in Australia.

Vehicle fleet real-world emissions intensities and survival curves

In 2022, DCCEEW made changes to the estimated emissions intensities and survival curves in relation to the light-duty vehicle fleet. These survival curves display the mathematical relationship between vehicle age and the proportion of the vehicle fleet that is retired. To support these updates, DCCEEW commissioned advice from Transport Energy-Emissions Research (TER).

TER provided updated survival curves for passenger cars and light commercial vehicles, which were incorporated into DCCEEW's fleet model (Figure 5.13).

Figure 5.13: Survival curves developed for passenger vehicles and light commercial vehicles



LCV = light commercial vehicles; PV = passenger vehicles
Source: TER 2022.

Light-duty vehicles sold in Australia have their emissions intensity measured based on the New European Driving Cycle test method. The Australian Government's Green Vehicle Guide publishes these intensities. Real-world emission intensities are generally higher than the test method, but the magnitude of difference is uncertain in the Australian context. DCCEEW commissioned TER to advise on historic and future emission intensities of vehicles. TER used the latest version of COPERT Australia (computer program to calculate emissions from road transport) as a basis for the development of energy intensities for fossil-fuelled vehicles by year of manufacture. Where required, information was extracted from the latest European COPERT version after making appropriate adjustments to more accurately represent Australian fleet characteristics.

DCCEEW compared the TER results with other public and internal sources including BITRE, the Australian Bureau of Statistics' (ABS) Survey of Motor Vehicle Use (SMVU) (ABS 2020) and the National Transport Commission's Carbon Dioxide Emissions Intensity for new Australian Light Vehicles 2021 (NTC 2022). For petrol and diesel vehicles, DCCEEW considered that the TER estimates were at the upper range of probable estimates. To construct the baseline projection, DCCEEW calibrated historical emissions intensities to the ABS SMVU. This survey collects data from respondents based on information provided by selected vehicle owners. Year-to-year variations were informed by data from TER 2022, NTC 2022 and BITRE. The TER intensities were used as a sensitivity to the baseline sensitivity (TER 2022). For Plug-in Hybrid Electric Vehicles (PHEVs) and Hybrid Electric Vehicles (HEVs) the emissions intensity ratio with petrol vehicles was taken from the TER results and applied to the baseline time series. Efficiency of internal combustion vehicles was assumed to improve at a rate of 0.9% per year. For the electricity efficiency of Battery Electric Vehicles (BEVs) and PHEVs, the data was taken directly from the TER report.

The emissions intensity of light-duty vehicles remains an area of uncertainty, given the relative lack of real-world testing data. The Australian Government is providing $14 million to the Australian Automobile Association over the next 4 years to test the real-world fuel usage of a range of popular cars, SUVs, and utes sold in Australia. Future emissions projections will consider the outputs from this work.

The TER report also investigated the deterioration of vehicle emission performance over time. The research concluded that there was not enough useful data or information available regarding CO_2 emission deterioration with age. It recommended that developing degradation factors could be worth further consideration in the future, for both internal combustion engine, EV and fuel cell vehicles (TER 2022).

5.5.6 Fugitive emissions methodology and assumptions

Emissions from the fugitive emissions sector are projected using emission estimation models maintained and updated by DCCEEW using external inputs. The models are a combination of facility-specific and top-down models, depending on the nature of the emission source and the availability of data.

5.5.6.1 Coal fugitives

Operating coal mines

Modelling approach

DCCEEW maintains a mine-by-mine model of fugitive emissions from operating coal mines. A mine-by-mine model takes account of the emissions intensity of each mine. These depend on the operational and geological characteristics of the mine.

$$E_t = \sum_i (P_{it} \,.\, EI_i \,.\, G_{it}) - \text{Measures}_t$$

Where:

E_t = annual emissions from operating coal mines in year t (Mt CO_2-e)

P_{it} = coal production at mine i in year t (kt)

EI_i = the emissions intensity of production at mine i, (Mt CO_2-e/kt coal)

Measures_t = abatement from policies and measures (e.g. forthcoming projects under the Powering the Regions Fund) in year t (Mt CO_2-e).

Activity data

The emissions intensity of coal mines includes all sources of fugitive emissions from vented CH_4 and CO_2, flaring and post mining. For operating mines, the emissions intensity is sourced from the most recent 5 years of National Greenhouse Gas Inventory data, which are based on company data reported under the NGER scheme. For some mines, expert judgment is applied to exclude years impacted by operational problems, to take into account trends in the emissions intensity of the mine that could be due to mining different parts of the coal resource or updated gas management practices. For prospective coal mines, the emissions intensity is sourced from environmental impact statements or is the average for currently operating mines in the same coal basin.

Mine-by-mine production estimates for existing and new mines are informed by OCE (2022a,b) for 2022–2027 and Wood Mackenzie for 2028 onwards. Coal production is separately estimated for thermal and coking coal production at each mine.

Production estimates from prospective new mines is scaled so that total Australian production of thermal and coking coal is consistent with an estimate of total demand for Australian coal. Total demand is consistent with the OCE for 2022–2027 and then utilises growth rates from Wood Mackenzie adjusted for domestic demand for Australian coal sourced from the electricity sector model and any announced closures not included in the Wood Mackenzie data. All prospective coal mines are scaled at an equivalent rate for thermal and coking coal mines; the projections do not make decisions on which prospective mines would and would not proceed. Scaling is undertaken for thermal and coking coal separately.

Production from brown coal mines is sourced from the electricity sector model.

Abandoned coal mines

Modelling approach

CH_4 emissions occur under certain conditions following the closure of underground coal mines. Emissions are estimated using a mine-by-mine model developed for the National Greenhouse Gas Inventory. The model is extended to include projected closures of underground coal mines to 2035.

$$E_t = \sum_i (ED_i \, . \, EF_i \, . \, (1 - F_{it})) - ER_{it}$$

Where:

E_t = emissions from abandoned coal mines in year *t* (Mt CO_2-e)

ED_i = annual emissions of mine *i* in the year before decommissioning (Mt CO_2-e)

EF_i = emission factor for mine *i* at a point in time since decommissioning. It is derived from the Emissions Decay Curves (DCCEEW 2022c)

F_{it} = fraction of mine *i* flooded at a point in time since decommissioning

ER_{it} = quantity of CH_4 emissions avoided by recovery at mine *i* in year *t* (Mt CO_2-e).

The model requires the CH_4 emissions at the time of closure, the mine type, mine void size and mine water inflow rates. Emissions at the time of closure and mine void volume are sourced from the operating coal mines model. Emission decay curves are calculated from the formulas published in the *National Inventory Report* (DCCEEW 2022c). Mine flooding rates are estimated based on the mine's water production region consistent with the National Greenhouse Gas Inventory.

Activity data

Closure dates are sourced from mine-by-mine forecasts provided by the OCE (OCE 2022a,b) and Wood Mackenzie and are consistent with the operating coal mines model.

5.5.6.2 Oil and gas fugitives

Oil

Oil fugitive emissions are separated into 5 subsectors:

- crude oil production
- crude oil transport
- exploration
- other – abandoned wells
- refining/storage
- flaring.

Modelling approach

Oil fugitive emissions projections for the crude oil production, crude oil transport, refining/storage and flaring are calculated using the following algorithm:

$$E_t = \sum_i (Pr_t \,.\, (EI_{cp} + EI_{ct} + EI_{rs} + EI_f))$$

Where:

E_t = oil fugitive emissions in the year t (Mt CO_2-e)

Pr_t = proxy indicator in year t

EI_{cp} = average emissions intensity for crude oil production (Mt CO_2-e / ML of crude oil and condensate production)

EI_{ct} = average emissions intensity for crude oil transport (Mt CO_2-e / ML of crude oil and condensate production)

EI_{rs} = average emissions intensity for refining/storage (Mt CO_2-e/ ML of refinery output)

EI_f = average emissions intensity for oil flaring (Mt CO_2-e / ML of crude oil and condensate production).

Projected emissions for oil exploration are calculated as a 10-year average of historical fugitive emission from oil exploration.

Projected emissions from abandoned wells is calculated based on historical rates of fugitive emissions growth from abandoned wells. For the 2022 projections, the assumed growth is 3%.

$$E_t = 1.03E_{t-1}$$

Where:

E_t = emissions in year t

E_{t-1}= emissions in the year t – 1.

Activity data

Activity data used to estimate emissions from oil and gas fugitives are provided in Table 5.8.

Table 5.8: Summary of data sources for preparing oil fugitive emissions

Fugitive emissions source	Proxy indicator	Source
Oil – production	Crude oil and condensate production	OCE (2022a,b)
Oil – transport	Crude oil and condensate production	OCE (2022a,b)
Oil – exploration	Historical 10-year average of emissions from oil exploration	DCCEEW (2022e)
Oil – abandoned wells	3% growth in emissions derived from historical growth in emissions	DCCEEW (2022e)
Oil refinery	Refinery output	OCE (2022a,b)
Oil – flaring	Crude oil and condensate production	OCE (2022a,b)

NIR = National Inventory Report; OCE = Office of the Chief Economist

Fugitive emissions from oil exploration and abandoned wells is small (0.002 Mt CO_2-e in total) and volatile from year to year. Historical emissions levels have been used to project future emissions from this source, in lieu of a more appropriate proxy indicator.

LNG facilities

Modelling approach

DCCEEW maintains a facility-by-facility model of fugitive emissions from LNG. Factors influencing the emissions from an LNG facility are the operation of the plant, the CO_2 concentration and source of the feed gas, abatement actions and annual production.

$$E_t = \sum_i (P_{it} \,.\, (EI_{vi} + EI_{fi} + EI_{oi}) - CCS_{it})$$

Where:

E_t = LNG fugitive emissions in year t (Mt CO_2-e)

P_{it} = production at facility i in year t (Mt LNG)

EI_{vi} = venting emissions intensity at facility i (Mt CO_2-e/Mt LNG)

EI_{fi} = flaring emissions intensity at facility i (Mt CO_2-e/Mt LNG)

EI_{oi} = other leaks emissions intensity at facility i (Mt CO_2-e/Mt LNG)

CCS_{it} = CO_2 captured and stored at facility i in year t (Mt CO_2).

Emissions intensities for venting, flaring and other fugitive leaks at operating facilities are based on NGER data. For newer facilities or new feed gas sources, emissions intensities are sourced from environmental impact statements or other sources if available.

Activity data

LNG production projections for each facility are informed by estimates from the OCE (OCE 2022a,b) and Wood Mackenzie. The projections consider committed and prospective additions and removals in capacity, given the global outlook for LNG.

Domestic natural gas

Modelling approach

Domestic natural gas is natural gas consumed in Australia. It is distinguished from LNG, which is predominantly produced for export. The small amount of LNG produced for domestic consumption is treated as domestic gas in the projections.

The sources of fugitive emissions from domestic natural gas in the projections are gas exploration, other post-meter emissions, other abandoned wells, production, processing, transmission, distribution, venting and flaring. Proxy indicators are used to project the growth in emissions at the state level from the subsectors as listed below.

$$E_t = \sum_i (P_{it} \,.\, EI_i) - CCS_{it}$$

Where:

E_t = annual emissions in year t (Mt CO_2-e)

P_{it} = gas production at basin i in year t (PJ)

EI_i = the emissions intensity of processing/processing/flaring/venting at basin i (Mt CO_2-e/PJ gas produced)

CCS_{it} = CO_2 captured and stored at facility i in year t (Mt CO_2-e).

The emissions intensities of processing, production, flaring and venting at basins across Australia were calculated from emissions estimates in the National Greenhouse Gas Inventory and historical gas production.

Activity data

Estimates of gas production for domestic consumption are informed by estimates from the OCE (OCE 2022a,b) and AEMO (2021, 2022b). For new gas developments, production estimates are informed by production estimates from Rystad Energy. Emissions intensities for new gas developments are derived from environmental impact statements if available, state average emission intensities from the National Greenhouse Gas Inventory (DCCEEW 2022e) and the CSIRO study of whole-of-life greenhouse gas emissions from the Surat Basin for the GISERA project (Schandl et al. 2019).

Table 5.9: Summary of data sources for gas fugitive emissions

Fugitive emissions source	Proxy indicator	Source
Distribution	Unaccounted gas losses	AEMO (2022b)
Exploration – flared	Total gas production	OCE (2022a,b); AEMO (2021, 2022b)
Exploration – leakage – conventional	Conventional gas production	OCE (2022a,b); AEMO (2021, 2022b)
Exploration – leakage – unconventional	Unconventional gas production	OCE (2022a,b); AEMO (2021, 2022b)
Exploration – venting – completions, conventional	Conventional gas production	OCE (2022a,b); AEMO (2021, 2022b)
Exploration – venting – completions, unconventional	Unconventional gas production	OCE (2022a,b); AEMO (2021, 2022b)
Exploration – venting – workovers	Unconventional gas production	OCE (2022a,b); AEMO (2021, 2022b)
Other – abandoned wells	Historical growth rate of emissions abandoned gas wells	DCCEEW (2022e)
Other – post meter emissions	Derived total appliance in the commercial and residential sector, Vehicle stock projections, Industrial natural gas consumption	ABS (2021b); Energy Consult (2015)
Processing	Domestic gas production (conventional and unconventional)	OCE (2022a,b); AEMO (2021, 2022b); emission projections models for LNG
Production – offshore platforms	Number of shallow and deep offshore platforms	AME Group; company reports
Production – onshore gathering and boosting – conventional gas	Conventional gas production	OCE (2022a,b); AEMO (2021, 2022b); emission projections models for LNG
Production – onshore gathering and boosting – unconventional gas	Unconventional gas production	OCE (2022a,b); AEMO (2021, 2022b); emission projections models for LNG
Production – onshore wells – conventional gas	Conventional gas production	OCE (2022a,b); AEMO (2021, 2022b); emission projections models for LNG
Production – onshore wells – unconventional gas	Unconventional gas production	OCE (2022a,b); AEMO (2021, 2022b); emission projections models for LNG
Production – onshore wells – water production	Unconventional gas production	OCE (2022a,b); AEMO (2021, 2022b); emission projections models for LNG

Fugitive emissions source	Proxy indicator	Source
Transmission and storage – LNG terminals	Number of LNG terminals operating	AEMO (2022b); AME Group; company reports
Transmission and storage – storage – LNG	Number of LNG storage stations operating	AME Group; company reports
Transmission and storage – storage – natural gas	Number of gas storage stations operating	AEMO (2022b); AME Group; company reports
Transmission and storage – transmission	Total pipeline length	APGA (2020); company reports
Venting and flaring – flaring – gas	Domestic gas production (conventional and unconventional)	OCE (2022a,b); AEMO (2021, 2022b)
Venting and flaring – venting – gas	Domestic gas production (conventional and unconventional)	OCE (2022a,b); AEMO (2021, 2022b)

AEMO GSOO = Australian Energy Market Operator Gas Statement of Opportunities; LNG = liquified natural gas; OCE REQ= Office of the Chief Economist, Resources and energy quarterly

5.5.7 IPPU methodology and assumptions

Emissions from the IPPU sector are projected using bottom-up models developed within DCCEEW. Where possible, emissions are projected by estimating fuel use at the facility level, to account for different fuel types, and the emissions intensity of production across facilities.

5.5.7.1 Modelling approach

A summary of data sources and model frameworks applied is provided in Table 5.10.

Unless otherwise specified, the emissions intensity of production is assumed to be constant across the entire projections period and is based on the emissions reported in Australia's *National Inventory Report 2020* (DCCEEW 2022e).

5.5.7.2 Activity data

Emissions projections in the IPPU sector are estimated using activity data from various sources including OCE commodity forecasts (OCE 2022a,b), Wood Mackenzie long-term outlook reports, ammonia production forecasts (MRC 2021), IBISWorld industry reports, and the Organisation for Economic Co-operation and Development (OECD 2022).

Emissions from the 'product uses as substitutes for ozone depleting substances' and 'other product manufacture and use' subsectors are estimated by extrapolating models used in the preparation of the National Inventory Report. A detailed methodology for these subsectors is available in the National Inventory Report 2020 (DCCEEW 2022e).

Table 5.10: Summary of sources and formula for each IPPU subsector

Emissions subsector	Data source	Formula
Chemical industry		
Ammonia	Production data from Ammonia: Australia market outlook 2021 (MRC 2021)	$E_t = \sum_i (U_{it} . EC_j . EF_j)$ Where: E_t = emissions in year t (Mt CO_2-e) U_{it} = natural gas consumption at facility *i* in year *t* EC_j = the energy content of natural gas EF_j = the emissions factor of natural gas
Nitric acid	DCCEEW estimates based on projected iron ore and coal production	$E_t = \sum_i (EF_{it} . P_{it})$ Where: E_t = emissions in year t (Mt CO_2-e) EF_{it} = facility-specific emissions factor in year *t* P_{it} = nitric acid production at facility *i* in year *t*
Titanium dioxide **Synthetic rutile**	World GDP growth from the Organisation for Economic Co-operation and Development (OECD 2022)	$E_t = \sum_i (U_{jit} . EC_j . EF_j)$ Where: E_t = emissions in year *t* (Mt CO_2-e) U_{jit} = the use of fuel *j* at facility *i* in year *t* EC_j = the energy content of fuel *j* EF_j = the emissions factor of fuel *j*
Acetylene	Population forecasts from ABS (2018, 2022) and Department of the Treasury (2021)	$E_t = E_{t-1} . \Delta$ Population Where: E_t = emissions in year *t* (Mt CO_2-e) E_{t-1} = emissions in the previous year Δ Population = percentage change in population between year *t* and year *t* – 1
Petrochemical and carbon black	n/a	$E_t = E_{t-1}$ Where: E_t = emissions in year *t* (Mt CO_2-e) E_{t-1} = emissions in the previous year

Emissions subsector	Data source	Formula
Metal industry		
Aluminium production	Production data from OCE (2022a,b) and Wood Mackenzie	$E_t = \sum_{i,j} (U_{jit} \,.\, EC_j \,.\, EF_j) + (PFC_{t-1} \,.\, \Delta \text{ Production})$ Where: E_t = emissions in year t (Mt CO_2-e) U_{jit} = the use of fuel j as a reductant at facility i in year t EC_j = the energy content of fuel j EF_j = the emissions factor of fuel j PFC_{t-1} = perfluorocarbon emissions in the previous year Δ Production = percentage change in production between year t and year $t - 1$
Iron and steel production	Production data from OCE (2022a,b) and Wood Mackenzie; fuel savings from Advisian (2020)	$E_t = \sum_{i} (EF_i \,.\, P_{it} - cs_{it})$ Where: E_t = emissions in year t (Mt CO_2-e) EF_i = facility-specific emissions factor P_{it} = production at facility i in year t cs_{it} = carbon content in steel at facility i in year t Emissions are adjusted to account for switching from coke.
Ferroalloys production	Company statements	$E_t = \sum_{i,j} (U_{jit} \,.\, EC_j \,.EF_j)$ Where: E_t = emissions in year t (Mt CO_2-e) U_{jit} = the use of fuel j as a reductant at facility i in year t EC_j = the energy content of fuel j EF_j = the emissions factor of fuel j
Other metal production (copper, nickel, silicon and lead)	Production data from OCE (2022a,b) and Wood Mackenzie	$E_t = \sum_{i,j} (U_{jit} \,.\, EC_j \,.\, EF_j)$ Where: E_t = emissions in year t (Mt CO_2-e) U_{jit} = the use of fuel j as a reductant at facility i in year t EC_j = the energy content of fuel j EF_j = the emissions factor of fuel j

Emissions subsector	Data source	Formula
Mineral industry		
Cement **Lime**	Contextual production forecast from Cement Industry Federation and IBISWorld industry report	$E_t = \sum_i (EF_i \cdot P_{it})$ Where: E_t = emissions in year t (Mt CO_2-e) EF_i = facility-specific emissions factor P_{it} = production at facility i in year t
Limestone and dolomite and other carbonates	DCCEEW estimates based on projected ceramics, ferroalloy production, glass production, and iron and steel production. Zinc production data from OCE (2022a,b) and Wood Mackenzie	$E_t = E_{t-1} \cdot \Delta$ Production Where: E_t = emissions in year t (Mt CO_2-e) E_{t-1} = emissions in the previous year Δ Production = percentage change in production between year t and year $t - 1$
Non-energy products from fuel and solvent use		
Lubricant use	n/a	$E_t = E_{t-1}$ Where: E_t = annual emissions in year t E_{t-1} = emissions in the previous year
Product uses as a substitute for ozone-depleting substances		
Product uses as a substitute for ozone-depleting substances	DCCEEW (2022e)	Based on National Inventory Report methodology
Other product manufacture and use		
Electrical equipment	DCCEEW (2022e)	Based on National Inventory Report methodology
SF_6 and PFCs from other product uses **N_2O from product uses**	Population forecasts from ABS (2018, 2022) and Department of the Treasury (2021)	$E_t = E_{t-1} \cdot \Delta$ Population Where: E_t = emissions in year t (Mt CO_2-e) E_{t-1} = emissions in the previous year Δ Population = percentage change in population between year t and year $t - 1$
Other production	DCCEEW estimates based on projected ammonia production and food, beverages and tobacco production	$E_t = E_{t-1} \cdot \Delta$ Production Where: E_t = emissions in year t (Mt CO_2-e) E_{t-1} = emissions in the previous year Δ Production = percentage change in production between year t and year $t - 1$

ABS = Australian Bureau of Statistics; DCCEEW = Department of Climate Change, Energy, the Environment and Water; n/a = not available; OCE = Office of the Chief Economist

5.5.8 Agriculture methodology and assumptions

Emissions from the agriculture sector are projected using bottom-up modelling developed by DCCEEW. The model is maintained and updated within DCCEEW using external inputs.

5.5.8.1 Modelling approach

Emissions from agricultural activity are calculated as

$$E_t = \sum_j \sum_l \sum_k \sum_i (N_{ki} . Ef_{kjil}) \times 10^{-3}$$

Where:

E_t = emissions in year t (Mt CO_2-e)

N_{ki} = quantity of activity type in each state, in relevant unit quantity (number of heads, kilotonnes, hectares, etc.)

EF_{kjil} = emissions factors of gas types, by gas source.

Emissions factors are in:

- kt/unit of activity/year
- Gg (gigagram)/unit of activity/year for rice cultivation.

Table 5.11: Symbols used in algorithms

Symbol	Variable	Variable categories
k^a	State	Australian Capital Territory, New South Wales, Northern Territory, Queensland, South Australia, Tasmania, Victoria, Western Australia
i^b	Activity type	Grazing beef cattle, grain-fed beef cattle, dairy cattle, sheep, wheat, rice, etc.
j^a	Gas type	CO_2, CH_4, N_2O
l^a	Gas source	Enteric fermentation, manure management, rice cultivation, agricultural soils, field burning of agricultural residues, lime and urea application

a Not all states, gas types and gas sources are relevant to all activity types.
b Activity types may contribute to several different gas sources.

The agriculture projections use emissions factors for activity derived from the *National Greenhouse Gas Inventory Quarterly Update: June 2022* (DCCEEW 2022f).

The projections include abatement from agriculture projects such as beef cattle herd management and destruction of CH_4 generated from manure in piggeries under the Australia's carbon crediting scheme. They also include abatement from the introduction of low emissions feed supplements such as asparagopsis and the compound 3-NOP.

5.5.8.2 Activity data

Emissions are projected by calculating the amount of agricultural activity in Australia each year. This is done by drawing on external data sources that contain activity numbers and activity growth rates (Table 5.12).

ABARES is a key data source informing the agricultural emissions projections. Where activity data are not available for particular commodities, an appropriate proxy such as production (quantity of end product), or a relevant driver such as growth in another connected commodity (as informed by historical comparisons) is used. For example, nitrogen fertiliser use increases in line with crop production. The assumption is that greater crop activity requires more nitrogen from fertilisers to support additional plant growth. Historical trends are also used to inform growth if projected activity data are unavailable.

Determining the impacts of climate change on agricultural commodities across Australia is particularly difficult due to locational variation and uncertainty around market responses. As a result of the complicated nature of climate change impacts on agricultural rates of productivity, activity data have not been adjusted for future climate change conditions, with the exception of the climate variability built into the ABARES forecast.

The projections also include a trend towards grain-fed beef cattle, as some farmers seek a more drought-resistant feed system. This trend has an impact on the overall emissions intensity of beef cattle production. The diets of grain-fed beef cattle are more energy intensive than those of grass-fed cattle. Animals convert a portion of this additional energy to emissions in the gut. However, as low-emissions feed supplements are introduced into the diets of ruminant livestock the emissions intensity of cattle and sheep are expected to decrease. This is expected to have the greatest effect on grain-fed cattle because the supplements can be delivered most effectively in feedlots.

Units of agricultural activity (e.g. head of cattle) are multiplied by relevant emissions intensities to arrive at an emissions estimate. The emissions intensities of activities are assumed to be constant across the projections period and are derived from the *National Greenhouse Gas Inventory Quarterly Update: June 2022* (DCCEEW 2022d).

As emissions within agriculture relate to biological processes, as well as manure and residue management, individual commodities can contribute several types of gases to multiple IPCC subsectors.

Table 5.12: Summary of principle data sources for Agriculture

Commodity	Emissions subsectors	Data sources	Unit of activity
Lime and urea	Liming and urea application	DCCEEW estimate based on historical trends	Kilotonnes
Fertilisers	Agricultural soils	DCCEEW estimate based on historical trends	Kilotonnes
Other animals	Enteric fermentation Manure management Agricultural soils	Activity held constant at final year of inventory	Heads of animal
Other animals – poultry	Manure management Agricultural soils	ABARES (ABARES 2022a; ABARES 2022b) OECD–FAO Agricultural Outlook (OECD–FAO 2022) DCCEEW estimate based on historical trends	Heads of animal
Pigs	Enteric fermentation Manure management Agricultural soils	ABARES (2022a,b) OECD–FAO Agricultural Outlook (OECD–FAO 2022) DCCEEW estimate based on historical trends	Heads of animal
Crops	Agricultural soils Field burning of agricultural residues Rice cultivation	ABARES (ABARES 2022a,b,c) DCCEEW estimate based on historical trends	Non-rice crops: Kilotonnes of crop Rice: Kilotonnes of rice, Hectares of area under cultivation
Sheep	Enteric fermentation Manure management Agricultural soils	ABARES (2022a,b) DISER estimate based on historical trends	Heads of animal

Commodity	Emissions subsectors	Data sources	Unit of activity
Dairy	Enteric fermentation Manure management Agricultural soils	ABARES (2022a,b) DCCEEW estimate based on historical trends	Heads of animal
Grain fed beef	Enteric fermentation Manure management Agricultural soils	ABARES (2022a,b) DCCEEW estimate based on historical trends	Heads of animal
Grazing (grass fed) beef	Enteric fermentation Manure management Agricultural soils	ABARES (2022a,b) DCCEEW estimate based on historical trends	Heads of animal

ABARES = Australian Bureau of Agricultural and Resource Economics and Sciences; DCCEEW = Department of Climate Change, Energy, the Environment and Water; DISER = Department of Industry, Science, Energy and Resources

5.5.9 Waste methodology and assumptions

The waste sector emissions projections are prepared by DCCEEW, and include 5 waste subsectors:

- solid waste to landfill
- biological treatment of solid waste (composting)
- incineration
- domestic and commercial wastewater
- industrial wastewater.

5.5.9.1 Modelling approach

The waste sector models largely replicate the methods used to calculate historical waste emissions. The solid waste sector modelling is completed on a site-specific basis to take account of the emission characteristics of individual landfills.

Solid waste deposited at landfills

A mix of increases and some decreases in the volume of waste disposed to landfill has been observed in Australia's states and territories since 1990. This reflects, in part, differences in population growth and the impacts of state government policies on waste management. A decline in waste disposed to landfill is expected to occur to 2035 as waste-reduction policies are implemented.

Waste quantities are recorded and reported in 3 source streams, which are:

- municipal solid waste (MSW)
- commercial and industrial (C&I) waste
- construction and demolition (C&D) waste.

The projections take account of current policies and measures at various levels of government. These include targets from the:

- National Food Waste Strategy (DoEE 2017): halve food waste generation by 2030
- National Waste Policy Action Plan (Australian Government 2019): 80% average resource recovery rate by 2030, reduce total waste generated by 10% per capita by 2030, halve the amount of organic waste sent to landfill for disposal by 2030
- Food Waste for Healthy Soils Fund (DCCEEW 2022d): supports the National Waste Policy target to halve the amount of organic waste sent to landfill for disposal by 2030.

Projects funded through the Recycling Modernisation Fund are also included, as are approved Energy from Waste projects, based on expected completion dates. These projects contribute to meeting the noted government targets, and therefore abatement was not generally considered to be additional. Projected resource recovery from these projects was calculated and would be included in the projections if it exceeded the government targets.

The projections also take account of commitments made by state and territory governments to reduce waste generation and increase recovery, as outlined in Tables 5.13 and 5.14.

Table 5.13: State and territory resource recovery targets

Jurisdiction	Stream	2025	2030	2040	2050	Strategy document
ACT	Overall	90%				ACT Government (2011)
NSW	Overall		80%			NSW Government (2021)
QLD	Overall	65%	80%	85%	90%	Queensland Government (2021)
	MSW	55%	70%	90%	95%	
	C&I	65%	80%	90%	95%	
	C&D	75%	85%	85%	85%	
VIC	Overall	72%	80%			Victoria State Government (2020)
WA	Overall	70%	75%			Waste Authority (2019)

ACT = Australian Capital Territory; C&D = construction and demolition waste; C&I = commercial and industrial waste; MSW = municipal solid waste; NSW = New South Wales; Qld = Queensland; Vic = Victoria; WA = Western Australia

Table 5.14: State and territory waste generation reduction targets (% reduction per capita)

Jurisdiction	Stream	2025	2030	2040	2050	Baseline year	Strategy document
ACT	Overall	No increase				2011	ACT Government (2011)
NSW	Overall		10%			2017	NSW Government (2021)
QLD	MSW	10%	15%	20%	25%	2018	Queensland Government (2021)
SA	Overall	5%				2020	Government of South Australia (2020)
VIC	Overall		15%			2020	Victoria State Government (2020)
WA	Overall	10%	20%			2015	Waste Authority (2019)

ACT = Australian Capital Territory; MSW = municipal solid waste; NSW = New South Wales; Qld = Queensland; SA = South Australia; Vic = Victoria; WA = Western Australia

Resource recovery rates were projected to change by the same amount each year to meet targets. Where no targets were applied, resource recovery rates were projected based on underlying growth rates from the *National Waste Report 2020* (Blue Environment 2020). The calculated waste recovery rates were then applied to waste generation estimates to calculate waste sent to landfill.

Waste generation rates per capita were projected to change by the same amount each year to meet targets. Where no targets were applied, waste generation rates were projected based on underlying growth rates from the *National Waste Report 2020*.

The projections consider upcoming approved Energy from Waste facilities. Once operational, these projects will reduce the amount of waste deposited to landfill. The combustion emissions from these facilities are counted in the electricity sector. These facilities are:

- Kwinana facility in Western Australia, which is expected to incinerate approximately 400 kilotonnes of waste annually
- East Rockingham facility in Western Australia, which is expected to process 300 kilotonnes of waste annually
- Renergi demonstration project in Western Australia, which is expected to divert up to 4 kilotonnes of organic waste and 8 kilotonnes of forestry and agricultural waste annually
- Laverton North waste gasification project in Victoria, which is expected to divert up to 200 kilotonnes of municipal solid waste annually
- Maryvale facility in Victoria, which is expected to process 325 kilotonnes of municipal solid waste annually.

Waste generation and recovery were projected by calculating the amount of waste deposited at landfills. Growth rates for the resource recovery of individual waste types were projected using data from the *National Waste Report 2020*, as well as policies aimed at certain waste types. The waste stream growth rates were then applied to the waste recovered in each state and territory.

Recovery rates for CH_4 were projected to increase by 0.25% per year. This rate of increase was based on a logarithmic trend of historical increases, which is expected to continue.

Historical waste is modelled on a facility-by-facility basis to reflect the characteristics of each landfill, including weather conditions. Future waste deposited is estimated on separate state and territory bases, reflecting the average conditions of landfills in each jurisdiction.

Biological treatment of solid waste

Policies at various levels of government in Australia are diverting organics from landfill to reduce landfill emissions and create market opportunities for organic waste products. Organic waste is treated through composting or anaerobic digestion.

The quantity of organic waste is projected from the amount of organic waste diverted from landfill. Policies aimed at diverting organic waste from landfill, such as the Food Waste for Healthy Soils Fund, are included in this projection.

Incineration

In Australia, incineration emissions are generated from thermal oxidation of clinical waste and solvents. The model assumes that clinical waste increases proportionately to population and the volume of solvents incinerated remains constant over the projection period.

At the time of publishing, several energy-from-waste projects had been approved. They will generate energy from the incineration of combustible waste. Under IPCC guidelines, emissions generated through the combustion of waste for energy are accounted for within the electricity sector.

Domestic and commercial wastewater

Emissions are estimated separately for unsewered and sewered populations, which have different assumed chemical oxygen demands (CODs).

The unsewered COD per capita ratio is applied to a projection of the unsewered population in each state and territory. Emissions are calculated based on the inventory CH_4 emissions factor and the percentage of wastewater anaerobically treated (50%).

The sewered COD per capita is applied to a projection of the sewered population in each state and territory. COD flows are used to estimate emissions from domestic and commercial wastewater facilities. COD influent refers to COD entering the wastewater facility in wastewater. COD outflow refers to:

- COD removed as sludge within the facility
- COD discharged from a facility as effluent, such as into rivers or the ocean
- COD in sludge removed to landfill or other land-based sites.

COD outflows are projected using ratios to COD influent. The ratios are a national average based on the latest inventory data. COD outflows are projected for each state and territory using the calculated ratio and the COD influent for the relevant year. This approach assumes that the proportion of COD outflow to COD influent remains constant over the projection timeframe.

The total CH_4 generated is the sum of CH_4 generated from wastewater and from sludge. These are calculated using the following formulas:

Methane generated from wastewater
= (COD influent – COD removed as sludge – COD discharged as effluent
× methane correction factor × methane emissions factor)

Methane generated from sludge
= (COD removed as sludge – COD removed to landfill or other land site
× methane correction factor × methane emissions factor)

The proportion of CH_4 recovered is held fixed from the latest inventory year.

N_2O emissions are calculated by replicating the same assumptions and calculations used to project CH_4 from the sewered population. However, N_2O emissions did not include any greenhouse gas recovery and are applied to the entire Australian population rather than only the sewered population.

Industrial wastewater

Industrial wastewater emissions are projected for the following subsectors: dairy production, pulp and paper production, meat and poultry processing, organic chemicals production, sugar production, beer production, wine production, fruit processing, and vegetable processing.

Projections are based on changes to commodity production levels. Growth rates are based on long-term forecasts using sector-specific metrics.

Inclusion of projects funded through Australia's carbon crediting scheme

The solid waste projection includes existing CH_4 recovery projects funded through Australia's carbon crediting scheme. The solid waste and wastewater projections include additional abatement, for example, capture of biogas at wastewater treatment facilities, incentivized by the carbon crediting scheme that are additional to the modelled business-as-usual scenario.

5.5.10 LULUCF methodology and assumptions

5.5.10.1 Modelling approach

The Full Carbon Accounting Model (FullCAM) provides the modelling framework for estimating land sector emissions in the National Greenhouse Gas Inventory and the emissions projections. FullCAM models the exchange of carbon between the terrestrial biological system and the atmosphere in a full/closed-cycle mass-balance model, which includes all biomass, litter/debris and soil pools. The model uses data on climate, soils, and management practices, as well as land-use changes observed from satellite imagery, to produce estimates of emissions and removals across the Australian landscape. A detailed description of the model is provided in the National Inventory Report (DCCEEW 2022e, Appendix 6.B).

5.5.10.2 Activity data

Most forest conversion activity in Australia is to maintain pastures for grazing activities. Some forest conversion occurs to support cropping. Smaller quantities occur for settlements, infrastructure, and reservoirs.

Most clearing activity in Australia is associated with the re-clearing of regrown forest vegetation. Land clearing restrictions have seen primary forest conversion stabilise at record low levels over the past decade.

For the 2022 projection, it was assumed that primary forest conversion would remain at historic low levels and that regrowth and re-clearing activity responds to changes in the number of livestock included in the projection for the agriculture sector. The projection also includes the assumption that a 10-year cycle of regrowth and re-clearing applies, which involves land managers re-clearing regrowth vegetation to maintain production.

For projections of net emissions from forest lands, log harvest forecasts were adopted from the business-as-usual scenario published in *Outlook scenarios for Australia's forestry sector: key drivers and opportunities* (Burns et al. 2015).

For cropland and grassland emissions projections, management practices are assumed to remain unchanged over the projection period, and emissions assumed to gradually return to long-run average levels.

The projections include state policies around declining native forest logging as well as abatement from vegetation, soil carbon, and savanna burning projects under the Australia's carbon crediting scheme.

5.5.11 Strengths and weaknesses of the projections methodology

Preparing the projections involves making forecasts about the growth path of a large number of variables, including activity data, demand for fossil fuels, energy efficiency and other abatement technologies, and economic growth. Australia recognises there can be considerable difficulty and uncertainty associated with making estimates about the future, and aims to reduce this risk through quality assurance processes.

Australia's modelling methodology has both strengths and weaknesses. Australia's modelling methodology strengths:

- The starting point for the projections is the latest estimates of historical emissions from the National Greenhouse Gas Inventory and the latest *Quarterly Update of Australia's National Greenhouse Gas Inventory*.
- The projections are updated and published annually as part of assessing progress towards achieving Australia's 2030 emissions reduction targets.
- The approach to preparing projections, the methodologies, and data sources used are reviewed internally annually and confirmed by a technical working group made up of government agencies and other experts as part of ongoing assessments to determine the appropriateness of current approaches and any potential improvements.
- The projections use data from publicly available information and estimates by government agencies, international sources, and consultants. Macroeconomic parameters informing the projections are consistent with forecasts from authoritative national sources including the Department of the Treasury and the ABS.
- Methodologies, assumptions, and results for each sector are subject to review by a technical working group made up of government agencies and other experts. Projection results are also subject to extensive internal quality assurance and quality control. The projections results and process can also be subject to an independent external audit from the Australian National Audit Office, which occurred in 2016 and 2017.

For Australian Government policies and measures, estimates of abatement are modelled collaboratively by policy analysts, projection analysts and modellers.

Australia's modelling methodology weaknesses:

- Future economic or production and activity estimates, used in the projections, are inherently uncertain.
- For some sectors, historical trends and relationships are assumed to continue to apply in the future. This may not be accurate due to structural or technological changes. A combination of quantitative and qualitative analysis is used to inform adjustments to projections to account for such changes.

It is difficult for the projections to consider the physical impact of climate change on the environment in a consistent manner across sectors. The impact of climate change is incorporated indirectly in the agriculture sector through ABARES activity forecasts, which use climate scenarios to represent seasonal conditions that can reasonably be expected to occur over the forecast period (ABARES 2021).

5.6 Total effect of policies and measures

Australia has estimated the total effect of policy and measures using a bottom-up approach in line with the Reporting Guidelines on National Communications. Emissions and removals from 1990 to 2020 are based on National Greenhouse Gas Inventory estimates, while values for 2021 and later are based on projections. Priority was given to policies and measures, or combinations of policies and measures, with the most impact on greenhouse gas emissions and removals and for which abatement can be estimated accurately.

Australia's emissions projections ('with measures' or baseline scenario) incorporates the impact of Australia's implemented and adopted polices and measures up to September 2022, when there is sufficient detail to include them. The baseline scenario excludes many elements of the Australian Government's Powering Australia Plan, which are still subject to development and public consultation. Details of the policies and measures are presented in Chapter 4.

Table 5.15 shows the quantified effect of Australia's implemented and adopted policies and measures. These policies and measures are delivering abatement and modifying long-term trends in anthropogenic greenhouse gas emissions.

Table 5.15: Total effect of policies and measures as at September 2022, Mt CO_2-e

	2020	2025	2030	2035
National emissions baseline ('with measures') (Mt CO_2-e)	498	459	422	383
Abatement from policies and measures (Mt CO_2-e)	50	131	205	258
Abatement by gas (Mt CO_2-e)				
CO_2	49	125	194	244
CH_4	1	2	5	6
N_2O	0	2	1	1
HFCs	0	3	5	7
PFCs	0	0	0	0
SF_6	0	0	0	0

CH_4 = methane; HFCs = hydrofluorocarbons; Mt CO_2e = megatonnes of carbon dioxide equivalent; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF_6 = sulfur hexafluoride
Source: DCCEEW 2022b; DCCEEW analysis

The abatement estimates above includes the following implemented and adopted policies and measures:

- Australian Government Large-scale Renewable Energy Target for 2020 and Small-Scale Renewable Energy Scheme
- state and territory renewable energy targets and plans
- various regulatory and voluntary federal, state and territory government energy-efficiency programs
- implemented initiatives under ARENA and the CEFC
- Australia's carbon crediting scheme
- state-based waste policy frameworks and the National Food Waste Strategy
- measures to support EV uptake
- the legislated phase-down and other measures to reduce use of hydrofluorocarbons
- investment in feed supplements in the agriculture sector.

5.6.1 Assumptions and uncertainties

Australia's policies and measures have often evolved over many years – and in some cases decades – since their inception. There is also a mix of policies shared across industries and government jurisdictions. As a result, Australia has not prepared a 'without measures' scenario because the assumptions required to model a counterfactual scenario of emissions in the absence of all policies would involve speculation and be highly uncertain.

Australia has estimated the impact of individual policies and programs, prioritising measures with the most impact and for which sufficient data are available or defensible assumptions can be made (e.g. modelling projected renewable generation, energy savings or projects supported under Australia's carbon crediting scheme). However, interlinkages between measures can make it difficult to assess abatement for some individual policies and measures. Therefore, determining how greenhouse gas emissions may have evolved in the absence of any policy or suite of policies is also difficult. Disentangling the impact of specific policies from prevailing economic factors is also difficult. For example, there is a degree of complexity in attempting to estimate the mitigation effect of the Australian Government's Small-scale Renewable Energy Scheme (SRES). The scheme creates a financial incentive for installing small-scale renewable energy systems, such as solar PV systems. Over the period this scheme has been in place, state and territory feed-in tariffs, other renewable energy programs, state renewable energy targets, increases in electricity prices and the falling costs of solar PV, have seen growth in solar PV installation beyond what could be attributed to the SRES alone.

In estimating the impact of policies that support renewable generation deployment, Australia has assumed that all rooftop solar, large-scale solar and wind renewable generation projected is attributed to the impact of policies at both the federal and state and territory levels. The methodology uses the projected renewable generation and applies the Australian grid-connected Scope 2 emissions factor for the 2006 financial year from the National Greenhouse Accounts (2021 publication).[9] Australia recognises that this estimate is highly uncertain as it is difficult to disentangle the impact of policies from the impacts other economic factors that would drive the deployment of renewables.

9 The grid average from 2005–06 was used to estimate the average emissions intensity that wind and solar would displace. In 2005–06, most of Australia's electricity was generated from coal and gas, while wind and solar combined represented less than 1% of total generation.

5.7 Changes since Australia's seventh National Communication and fourth Biennial Report

Since Australia's seventh National Communication and fourth Biennial Report, there have been updates to inventory estimates, sectoral data and the impact of policies and measures. This is reflected in changes to projected emissions in 2030 across submissions (Table 5.16).

Emissions projections for the seventh National Communication and fourth Biennial Report were produced using a combination of top-down and bottom-up modelling prepared by the (then) Department of the Environment and Energy analysts and external consultants. Projections were prepared to 2030.

For the eighth National Communication, the projections used a combination of top-down and bottom-up sectoral models. Improvements have been made to:

- the stationary energy (excluding electricity) model, to enable projections of energy consumption for the mining and manufacturing subsectors
- the gas fugitive emissions sectoral models, to enable disaggregated emissions projections at the gas basin level
- the solid waste model, to incorporate state and territory waste generation targets
- the transport model, which has undergone multiple improvements, including the inclusion of a revised series for light-duty vehicle emissions intensities, updated forecasts for light-duty vehicle technology uptake, and the incorporation of new freight activity projection data.

Changes in emissions by sector since the seventh National Communication and the fourth Biennial Report are shown in Table 5.16. Revisions in electricity sector emissions were driven by the rapid uptake of renewables in response to new policy incentives as well declining technology costs. Revisions in the LULUCF sector reflect updates and improvements of methods in the National Greenhouse Gas Inventory as well as the impact of federal and state and territory policies, outlined in the sectoral emission trend analysis in section 5.3.

Table 5.16: Comparative sectoral breakdown of projections for 2030 under a 'with measures' scenario, UNFCCC accounting

Greenhouse gas emission projections (Mt CO_2-e)	Electricity	Stationary energy (excluding electricity)	Transport	Fugitive emissions	IPPU	Agriculture	Waste	LULUCF	Total emissions
7th National Communication	173	103	112	53	32	82	10	4	570
4th Biennial Report	131	106	108	59	32	74	11	-10	511
8th National Communication	79	101	103	55	28	79	11	-33	422

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6 Vulnerability assessment, climate change impacts and adaptation measures

Key developments

Since the seventh National Communication on Climate Change in 2017, Australian governments, businesses and communities are continuing to build understanding of our changing climate and our ability to anticipate, manage and adapt.

These adaptation efforts are taking place against a backdrop of significant disasters and climate impacts. Most recently, the catastrophic 2019–20 Black Summer bushfires across south-east Australia and the 2022 flooding across the east coast of Australia have brought into focus the challenges in reducing the risk, impact and consequence of natural hazards in our changing climate, and the imperative to further adapt and build our resilience.

All Australian governments have invested in further projection and assessment work, and in building knowledge about climate impacts specific to their communities. Australia is also incorporating First Nations people's knowledge and experience to inform adaptation action. For example, Australia's *State of the Environment 2021 report* included First Nations authors for almost all chapters, a First Nations–led chapter, and First Nations–specific case studies throughout the report.

At a national level, the Australian Government has built on the inaugural National Climate Resilience and Adaptation Strategy 2015 by releasing the National Climate Resilience and Adaptation Strategy 2021–2025 and Australia's first Adaptation Communication. The 2021–2025 Strategy is designed to help governments, communities and businesses to better adapt to climate change, recognising that adaptation is a shared responsibility that requires sustained and ongoing action.

Complementing the release of the 2021–2025 Strategy, the Australian Government has strengthened institutional arrangements for adaptation and resilience by establishing the:

- Department of Climate Change, Energy, the Environment and Water so that interconnected issues such as climate mitigation and adaptation, as well as the climate and biodiversity crises, can be addressed holistically
- National Adaptation Policy Office to oversee implementation of the 2021–2025 Strategy, coordinate work on climate resilience and adaptation, work in partnership to drive investment and action, and report on Australia's adaptation progress
- National Emergency Management Agency to adapt and drive long-term resilience and preparedness to more intense and frequent disasters resulting from our changing climate
- Australian Climate Service to better understand the threats posed by a changing climate and natural hazards, to limit the impacts now and in the future.

Climate risks, impacts and adaptation are an important part of the suite of new climate policies being implemented since the federal election in 2022, some of which are included in Australia's 2022 updated Nationally Determined Contribution. Most significantly, the new *Climate Change Act 2022* requires the Australian Government to receive and respond to expert advice from Australia's independent Climate Change Authority, based on a citizen participatory process, about the risks to Australia from climate change impacts. The scope of risks includes those relating to Australia's environment, biodiversity, health, infrastructure, agriculture, economy and national security.

Many state, territory and local governments have also continued to develop and update climate adaptation, risk and vulnerability plans and strategies, and consider and respond to sector- and regional-specific impacts. Victoria, the Australian Capital Territory, South Australia and Tasmania have legislative frameworks jin place to guide their adaptation activities.

6.1 Climate change impacts across Australia

Australia's leading scientific and climate institutions have concluded that Australia's land temperature has warmed on average by over 1.4 °C since national records began in 1910 (CSIRO & Bureau of Meteorology 2022). Australia's climate varies widely from season to season, year to year, and region to region. Existing climate patterns, such as the El Niño–Southern Oscillation, Indian Ocean Dipole and Southern Annular Mode, affect our environment and communities in regular cycles. However, climate change is likely to exacerbate the impact of such cycles. Emissions that have already occurred will drive further changes over the coming decades, regardless of our future emissions pathway. Current and future emissions will have a major effect on the trajectory of climate change in the second half of the 21st century (Trewin, Morgan-Bulled & Cooper 2021).

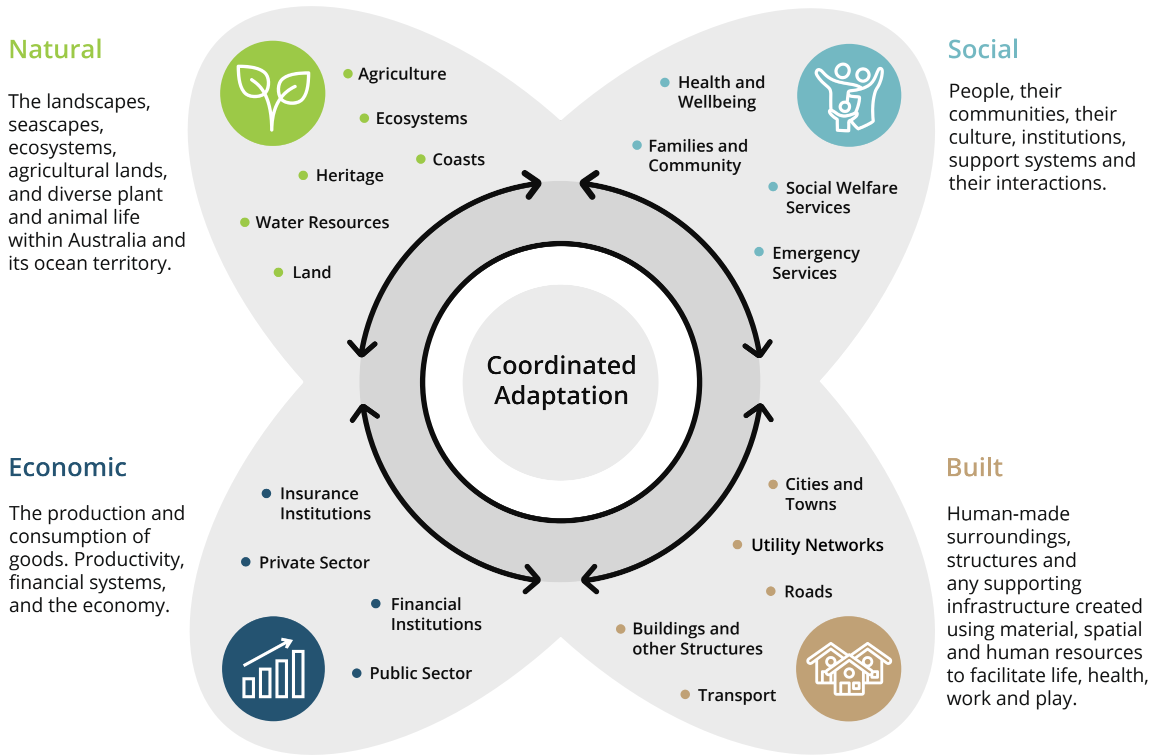
Australia welcomed the Intergovernmental Panel on Climate Change (IPCC) – Sixth Assessment Working Group II report, *Climate change 2022: impacts, adaptation and vulnerability*, which updated our understanding of the impacts of climate change on people, communities and natural ecosystems, and assessed vulnerabilities and adaptation options, including their effectiveness, feasibility and limits. The report showed that, for Australasia, climate risks are projected to increase for a wide range of systems, sectors and communities, and that impacts will be exacerbated by underlying vulnerabilities and exposures.

The IPCC assessment accords with Australian scientific observations that show that Australia and our region are experiencing rising temperatures, changing rainfall patterns, a higher frequency of extreme fire weather days, rising sea levels, rising sea temperatures and increasing ocean acidification (CSIRO & Bureau of Meteorology 2022). In recent years, we have experienced severe bushfires, droughts, flooding and storms. These extreme weather events are increasing because of climate change, and these trends are predicted to continue for at least several decades (IPCC 2021).

Australia conducts extensive, world-leading research on climate change processes and impacts (see section 8.2.1). The Australian Government ensures that regular information on general climate impacts is publicly available through the biennial *State of the climate* report, the 5-yearly *State of the environment* report and the Climate Change in Australia website. From 2022, the Australian Government Minister for Climate Change will also provide information about climate change policy and the risks to Australia from climate change impacts in the new Annual Climate Change Statement to Parliament, as required under the *Climate Change Act 2022* (Cth).

Whereas the seventh National Communication provided a summary of climate impacts by priority areas within the 2015 strategy, this National Communication summarises climate impacts and adaptation policies across 4 'domains': natural, built, economic and social. This reflects the approach used in the 2021–2025 Strategy, which uses these 4 domains to frame the approach to coordinated adaptation (Figure 6.1).

Figure 6.1: Climate change adaptation domains



Source: National Climate Resilience and Adaptation Strategy 2021–2025

While states and territories consider the economic domain within their climate adaptation plans and action, this domain is most relevant to the work of the Australian Government, in accordance with the 2012 COAG Roles and Responsibilities for Climate Change Adaptation in Australia agreement. As such, national-level analysis in this section describes climate change impacts against all 4 domains; section 6.4 reports progress of states and territories within the natural, built and social domains only.

6.1.1 Natural domain impacts

The natural domain includes plants and animals, ecosystems, landscapes, seascapes and waterways, and the industries that rely on them. Australia's biodiversity and ecosystems are some of the most diverse on Earth. This biodiversity is essential for human existence and holds intrinsic value.

Healthy ecosystems provide critical services such as fresh water, regulation of regional water cycles, soil fertility and crop pollination, carbon storage, recreation, and buffering from the impacts of hazards. These services, along with industries such as tourism, agriculture and fisheries that depend on natural resources and assets, are vital for both our prosperity and our wellbeing.

There are limits to the capacity of natural systems to adapt to the impacts of climate change. Climate change affects species health and distribution, and exacerbates the impacts of other environmental pressures.

6.1.1.1 Natural ecosystems

Every 5 years, the Australian Government conducts a comprehensive review of the state of the Australian environment. These independent national reports provide information about environmental and heritage conditions, trends, pressures and management. They cover the Australian continent, surrounding seas and Australia's external territories.

The *State of the Environment* 2021 report found that climate change is already having a widespread impact on natural ecosystems by causing changes in the life cycles, abundances and ranges of flora and fauna. This is exacerbated by extreme weather events associated with climate change, such as fires, droughts and floods causing mass mortality of species. It is also exacerbated by other threats to biodiversity and ecosystem function, such as land clearing, water diversion and invasive species.

In Australia, the impact of bushfires, and changing patterns, frequency and intensity of fires, on Australian species cannot be overstated. Around 42% of species listed under the *Environment Protection and Biodiversity Conservation Act 1999* ('EPBC Act') are threatened by changes in fire frequency and intensity. During the Black Summer bushfires of 2019–20, nearly 3 billion animals are estimated to have been killed or displaced (Royal Commission into National Natural Disaster Arrangements 2020). Although many plant species have adapted to bushfires, increased intensity and frequency of fires threaten their ability to recover and regenerate between fire seasons (Gallagher et al. 2021).

Beyond an increase in extreme fire seasons, increased temperatures, changes in rainfall patterns and other extreme weather events also contribute to a decline in flora and fauna biodiversity. Increases in temperature and decreases in rainfall have contributed to rapid flora loss, including in endangered plant communities. Alpine and eucalyptus ecosystems are particularly vulnerable to the impacts of climate change, both experiencing losses in diversity and becoming more susceptible to threats and extinction (Hoffmann et al. 2019). Rapid flora losses, including of mature trees, are often due to increased heat and reduced rainfall. Rapid losses of fauna are also affecting ecosystems as a whole.

Some fauna that are dependent on damp habitats, such as Quenda (the southern brown bandicoot), are likely to be vulnerable to rainfall decline (Valentine et al. 2012). More frequent drought is also making ecological communities susceptible to other disturbances, such as ringbarking by longicorn beetles as their larvae have greater survival when feeding on water-stressed trees (Caldeira et al. 2002).

Fauna species from forests and woodlands are particularly susceptible to extreme heat. For example, western ringtail possums are known to suffer heat stress at temperatures of 35 °C or more (Shedley & Williams 2014). An expected increase in the number and maximum temperature of very hot days is likely to be an additional threat to flora and fauna that are already near their physiological limits.

Fauna within aquatic ecosystems are known to be particularly sensitive to climate change. Mortality can result from increasing temperatures, and changes in water salinity and quality. Extreme heat events have resulted in mangrove and kelp dieback in the marine environment and mass fish kills in the Murray–Darling Basin. South-eastern Australia experienced 3 major fish death events in the lower Baaka/Barka – Darling River in 2018–19 (Green & Moggridge 2021). Reviews attributed the fish deaths to the lack of water flowing into the northern rivers and subsequently the Darling and lower Darling systems, combined with the long-term impacts of many years of overallocation of water resources throughout the Basin (Vertessy et al. 2019).

Case study: Tasmanian white gum (*Eucalyptus viminalis*) and West Australian tuart (*Eucalyptus gomphocephala*)

Climate change is being identified as a threat to critically endangered ecological communities on both sides of the Australian continent.

In 2021, after a comprehensive threat assessment by the then Australian Government Department of Agriculture, Water and the Environment and the national Threatened Species Scientific Committee, the Tasmanian White Gum (*Eucalyptus viminalis*) Wet Forest ecological community was listed as critically endangered under national environmental law. One of the major threats to this forest is the impact of climate change, specifically longer and greater-intensity heatwaves in northern Tasmania, operating in conjunction with other threats, to kill crucial habitat-forming white gum trees, including some of the tallest trees in the world. *E. viminalis* is known to be highly susceptible to stress due to climatic factors. The widespread nature of what was termed 'ginger tree syndrome' in Tasmania was noticed after high temperatures over several days since the 2012–13 summer (Mitchell 2015).

Significant numbers of trees are currently affected in northern Tasmania, and *E. viminalis* within the ecological community appears to have been particularly adversely affected, with significant mortality observed. Climate change projections indicate increasing frequency and intensity of heatwaves in Tasmania (Grose et al. 2010). Future climatic suitability modelling for *E. viminalis* (Harrison 2017) indicates that, under a high-emissions scenario consistent with current trajectories, around half of the Tasmanian White Gum Wet Forest's current range may be unsuitable for the dominant canopy species by 2050, and around 80% may be unsuitable by 2080.

On the far south-western side of Australia, in 2019, the Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain ecological community was also listed as critically endangered under national environmental law. Climate change is affecting south-west Western Australia at a rapid rate. Temperatures have been increasing since the early 20th century and are confidently predicted to continue increasing, both as a mean and as the maximum, with more very hot days likely. Rainfall has been declining in the region since the 1970s, and this is also projected to continue, with early winter rain possibly declining by as much as 45% by 2090 (Hope et al. 2015). Correspondingly, time spent in drought is expected to rise, while fire weather is expected to increase (Hope et al. 2015). This rapidly changing climate is affecting the health of various woodlands, forests and other ecosystems on the Swan Coastal Plain.

6.1.1.2 Coasts and coral reefs

Climate change impacts many aspects of Australia's marine and coastal environments. Increased marine temperatures have wide-ranging effects on ecosystems, and coastal ecosystems can be inundated by sea level rise and storm surges.

Climate change is the most serious threat to coral reefs worldwide, including the Great Barrier Reef. A key threat for the Great Barrier Reef is the increase in sea temperature, which is being driven by a rapid increase in global greenhouse gas emissions. This has a multitude of impacts on the Reef, including loss of coral habitat caused by more destructive marine heatwaves. Global analyses show that climate change has contributed to a fivefold increase in the frequency of severe coral bleaching events over the past 40 years (GBRMPA 2022). Marine heatwaves caused mass coral bleaching events on the Reef in 2016, 2017, 2020 and 2022.

Climate change is also likely to increase the proportion of severe tropical cyclones, and the frequency and severity of heavy rainfall events, which affect coastal ecosystems such as mangroves. Floodwaters can cause flood plumes and reduce the salinity of the sea water over reefs, both of which can impact coral reefs. Cyclones can cause extensive damage to both individual corals and reef structures.

6.1.1.3 Water resources

Climate change is having an impact on Australia's water resources. Climate risks for groundwater include reduced groundwater recharge and seawater intrusion to coastal aquifers; reduction of freshwater availability on small islands; and increased demand from communities, agriculture and industries due to increased evapotranspiration and reduced rainfall. Climate risks for surface water resources are reduced flows and water supply, and declining riverine health conditions. Conversely, regions impacted by an increase in the intensity of extreme rainfall events will be more at risk from flash and riverine flooding.

Water-related climate change impacts vary across the Australian continent.

- Across southern Australia, the combined effect of increasing temperatures and declining rainfall means that the frequency and intensity of droughts are expected to increase in the future. Reduced rainfall produces disproportionately larger reductions in catchment run-off and streamflow. For example, the annual mean streamflow into the Perth water storages from 2010 to 2016 was only 47 gigalitres, around 85% lower than the 1911–1975 average annual streamflow of 338 gigalitres. Over the same period, annual rainfall declined by around 15%.
- Conversely, there have been large increases in rainfall in many parts of north-western Australia. These are largest in the Kimberley region of Western Australia, where rainfall in some places has risen by 40% or more since the 1960s, but also extend to the western half of the Northern Territory (Trewin, Morgan-Bulled & Cooper 2021). Rainfall has also increased since the 1960s in interior regions of Western Australia. While these regions widely remain quite dry and with less agriculture and human settlement, the rainfall increases have been associated with increased water availability and streamflow.

As the largest river system on the driest inhabited continent on Earth, a healthy and productive Murray–Darling Basin is crucial for water and food security. The Australian Bureau of Meteorology provided an assessment of climate and hydrological trends and historical conditions across the Basin in 2020. This work found that the Basin area has warmed by around 1 °C since 1910, and that warming will continue, with more hot days, fewer cold days and increased daily minimum temperatures. Modelling predicts that a very dry future climate scenario could see the Basin 0.9–2.5 °C warmer and receiving 15% less annual average rainfall compared to present leves. More than three quarters of the long-term streamflow gauges in the Basin show a declining trend since records began in 1970. This is more severe in the northern Basin, where 94% of the gauges show a declining trend in streamflow. In regions where significant reduction in rainfall is projected, this will increase the gap between supply and demand, potentially further affecting ecosystems, industries and Basin communities.

6.1.1.4 Agriculture

Changes in climate are largely having a negative effect on Australian farmers, with higher temperatures and changes in seasonal rainfall patterns affecting the profitability of Australian farms. Analysis by the Australian Bureau of Agricultural and Resource Economics and Sciences found that changes in seasonal conditions have reduced annual average farm profits by 23% or around $29,200 per farm over the past 20 years, and larger reductions are projected to 2050 in the absence of adaptation (ABARES 2021). Since 2000, the risk of very low farm returns due to climate variability essentially doubled (relative to 1950 to 2000), increasing from a 1 in 10 frequency to more than 1 in 5 (ABARES 2020).

Climate change is likely to make conditions more difficult for agricultural production in the future. Projected outcomes vary significantly, due largely to uncertainty over future rainfall levels:

- Western Australian cropping farmers are likely to be affected more than those in eastern Australia.
- Inland or marginal regions could face an increased exposure to climate impacts over time relative to other parts of Australia.
- Farms are likely to face increased pressure under severe climate scenarios, largely due to the effects of higher temperatures such as animal heat stress resulting in declining livestock productivity and potentially increased stock losses.

6.1.2 Built domain impacts

Australia's built environment is more than our buildings. It includes green and urban spaces, cities and towns, and the networks of roads, transport, energy, water and telecommunications infrastructure that connect them. Gradual impacts such as sea level rise and temperature rise, and extreme events such as floods, heatwaves and bushfires, can both affect the liveability of our urban environments and pose challenges for ageing publicly and privately owned assets and infrastructure systems that were not designed and built with climate change in mind.

In cities, the effects of rising temperatures can be exacerbated because of the urban heat island effect. This effect is caused by the prevalence of heat-absorbing materials such as dark-coloured pavements and roofs, urban canyons trapping hot air, and a lack of shade and green space.

The Australian Infrastructure Audit 2019 observed that climate change will affect the essential functioning and liveability of our communities and cities. Likely impacts include:

- an increasing risk of interruptions to critical infrastructure and services due to more extreme weather events (e.g. pressure on public transport and health services due to increased frequency of heatwaves)
- increases in the occurrence and reach of disasters, including tropical cyclones extending into southern Queensland and northern New South Wales, and coastal flooding during peak tides encroaching further inland
- increased bushfire danger in the south and east of Australia
- a rise in the urban heat island effect (increased temperatures in built-up urban areas compared with surrounding areas due to the heat of the sun being absorbed and not reflected by urban surfaces) in our cities, particularly those with increasing development densities
- changes in rainfall patterns that will exacerbate drought conditions across southern Australia while increasing flooding across the north and west of the country
- changing city ecosystems due to pollution and disturbance, leading to species fragmentation, loss and stress, and an increased occurrence of invasive species.

6.1.3 Social domain impacts

The social domain includes our people, communities, culture, institutions and support systems, and the interactions between them. This includes families, health and education systems and services, social services, and emergency management services. There are strong relationships between the quality of the environment – air, water, and food systems – and physical and mental health and wellbeing.

As we adapt in the social domain, attention should be given to how vulnerable communities experience the impacts of climate change. Adaptation must be inclusive and account for the underlying factors that contribute to vulnerability, such as issues related to geography, culture, age, gender, diversity, disability and socioeconomic status.

6.1.3.1 Health and wellbeing

Climate change threatens the health and wellbeing of all individuals through its effects on social and environmental determinants of health, such as air and water quality, sufficient food and water, and secure shelter. Other identified impacts of climate change with health implications include:

- the spread of vector-borne diseases
- warmer temperatures in southern latitudes
- weather-related threats, such as the Victoria thunderstorm asthma event of 2016 during which 10 people died (Price et al. 2021)
- the mental health impacts of natural disasters
- indirect effects on health services from global impacts of climate change (e.g. increased demand for services due to possible future forced migration).

Detrimental effects of climate change will disproportionately impact priority populations, such as the very young and old, First Nations peoples, and people without ready access to adequate infrastructure and utilities (IPCC 2022). The compounding effects of climate change are also likely to be particularly relevant to rural and remote communities because of increased heat and water scarcity, and difficulties in attracting and retaining healthcare workers.

Climate change also means that the frequency and scale of disasters are increasing, and the health impacts on communities are growing. The Black Summer bushfires resulted in 33 direct deaths and exposed millions of people to heavy particulate air pollution (AIHW 2021). Smoke-related health costs from the fires are estimated at $1.95 billion (AIHW 2021). From late February to early April 2022, Australia's east coast endured 3 intense weather systems that led to record rains and flooding, resulting in at least 22 deaths and forcing thousands of people to evacuate their homes (Center for Disaster Philanthropy 2022; Moore 2022).

Disasters can also have an adverse impact on general health and wellbeing, including increased rates of stress, depression, anxiety, post-traumatic stress disorder, alcohol and substance abuse, aggression and violence, suicide, and exacerbation of other underlying mental health problems. Evidence from studies after the 2009 Victorian Black Saturday bushfires indicated that exposure to the bushfires increased the risk of experiencing a mental illness (Victorian Department of Health 2014).

6.1.3.2 First Nations peoples

Australia's *State of the Environment 2021* report included Indigenous authors, an Indigenous-led chapter, and Indigenous-specific case studies throughout the report. It provides an authority on climate impacts observed and felt by First Nations peoples.

State of the Environment 2021 report: climate chapter – Indigenous outlook and impacts

Indigenous people are dealing with a changing climate. Australia's climatic changes, along with the impacts of human activities and clearing of vegetation, all influence the way Indigenous people read Country for climate. Natural indicators of climate and environmental patterns are being overlaid by rising temperatures, sea level rise and ocean warming, shifting or delayed rainfall patterns, extreme weather, too much rain, and drier periods. The Indigenous seasons are changing or are being delayed because Earth's processes are being affected. In addition, a reduced frequency of cultural burning means that Country does not have the ability to regenerate and heal for the next season.

These changes will continue to impact Indigenous people's traditional knowledge systems, which have been in place for thousands of years. The ways in which Indigenous people read and predict weather and climate systems are based on their knowledge about Country, and the information has been passed down. If natural indicators continue to undergo extreme change and shift the cultural baseline, we will see Indigenous people's knowledge at risk of loss or transforming to a new norm.

Indigenous people will need to prepare, and adjust their knowledge systems, for the effects of changing climatic processes and climate change. The outlook depends on Indigenous voices, and their ability to be heard by climate policymakers and to be active agents of change.

With an increase in biodiversity loss and species extinction in Australia, Indigenous people's connection to their traditional lands and their knowledge systems are at risk of extreme change and cultural loss. For Indigenous people, some species are used for food and fibre, and others have healing properties. The loss of environment will have detrimental impacts on the availability of these plant and animal species, once rich in diversity, including the risk of extinction of some species. These climatic impacts force Indigenous people to adapt as a people.

6.1.4 Economic domain impacts

Climate change impacts will affect our economy in many different ways. These include the physical impacts of climate change, the indirect impacts climate change will have on Australia's industry mix, and the impacts of policy responses to reduce emissions or adapt to climate impacts. Some of our most important industries and biggest employers depend on the climate, such as the agriculture and tourism industries.

The *2021 intergenerational report* projects an outlook for the economy and the Australian Government's budget over the next 40 years. The report noted that the changing climate will impact locations, sectors and communities in diverse ways, driving both structural adjustment and corresponding innovation. It noted that Australia will need to manage climate risks to our economy through strategic environmental management and adaptation to protect communities and strengthen the resilience of the economy.

The Australian Budget 2022 notes that climate change presents significant risks and opportunities for Australia's economy, regions, industries and communities. It outlines that Australia is well placed to adapt and build resilience to the impacts of climate change and meet our emissions reduction targets.

The financial sector plays an important role in helping the economy adjust to climate change through appropriately pricing risks and encouraging the reallocation of capital to more sustainable areas. Australia's financial regulators have recognised that climate change is exposing the financial system to risks that will increase over time. For example, credit risk may increase through potential default on loans by businesses and households impacted by adverse climate events, as well as the potential for assets used as collateral to decline in value. To respond to these risks, regulators are working on improving identification, management and disclosure of climate-related risks. The government has committed to introduce internationally aligned climate reporting requirements for large businesses to ensure greater transparency of climate-related plans, risks and opportunities.

More frequent and severe climate-related natural disasters will increase costs for the insurance sector and consumers. Claims relating to natural disasters in the past decade have doubled those made in the previous decade in real terms (RBA 2019). This has flow-on effects on insurance affordability and coverage, potentially making it more difficult for households to hold adequate insurance (Royal Commission into National Natural Disaster Arrangements 2020). Changing weather systems may make parts of Australia more difficult to insure unless there are effective efforts to build resilience. For example, in northern Australia, where disaster risk is generally higher, home insurance premiums have risen much faster than in the rest of the country, and there has been a rise in the number of uninsured homes.

The *State of the Environment 2021* report reported that climate change is having a substantial impact on the economies of First Nations peoples. This includes a loss of access to foods and fibres essential to some traditional First Nations economies, requiring First Nations people to travel further to source materials. This has been exacerbated by a lack of recognition of the importance of First Nations peoples' cultural economic practices.

6.1.5 Disaster risk management impacts

The global climate strongly influences Australian natural hazards. Climate change drives disaster risk in several ways, including by altering the frequency, intensity and location of weather-related natural hazards, and by affecting our vulnerability to natural hazards.

Climate change is exacerbating underlying conditions and causing events to be more extreme and frequent. For example, the devastation from the Black Summer bushfires was in part due to the disaster being preceded by drought conditions, which increased the availability of bushfire fuel through the southern states.

The *State of the Climate 2022* report notes how climate change will exacerbate disasters in Australia, including that:

- tropical cyclones may be less frequent but more intense and deliver more extreme rainfall
- summer storms may be over shorter periods but in more intense bursts of rainfall
- there may be a higher frequency of high-fire-risk days.

In 2021, Deloitte Access Economics, reporting to the Australian Business Roundtable for Disaster Resilience and Safer Communities, found that disasters currently cost the Australian economy around $38 billion per year. Assuming current development patterns and population growth continue, this is forecast to reach at least $73 billion per year by 2060, even with ambitious global action to reduce emissions (Deloitte Access Economics 2021).

6.2 Climate change adaptation in Australia

Australia has taken a whole-of-nation coordinated approach in which governments at all levels, businesses, households and the community each have important, complementary and differentiated roles in adapting to the impacts of climate change.

6.2.1 Jurisdictional responsibilities

Climate change adaptation in Australia is underpinned by a series of agreements made between the Australian, state and territory governments through the Council of Australian Governments (COAG). These agreements set priority areas for adaptation action, and clarify roles and responsibilities for adaptation underpinning national and subnational adaptation plans and strategies.

As reported in the sixth National Communication, COAG agreed on a National Climate Change Adaptation Framework in 2007. The framework articulated joint priorities for collaboration and adaptation action, and initiated a range of activities to build resilience and adapt to climate change impacts, including enhancing research capacity and institutions for national climate change science and adaptation.

In 2012, and as reported in the seventh National Communication, the COAG Select Council on Climate Change, comprising ministers from the Australian Government and all state and territory governments, agreed the 2012 Select Council on Climate Change's Roles and Responsibilities for Climate Change Adaptation in Australia.

The Australian Government's role includes providing national leadership on adaptation reform, national climate science and information; managing climate risks to Australian Government assets and services; and maintaining a strong economy with a well-targeted safety net to ensure that climate change does not disproportionately affect vulnerable groups.

The Australian Government is currently undertaking a consultative, evidence-based and collaborative approach to raising adaptation ambition. Since the seventh National Communication, Australia has released our first Adaptation Communication to enhance the visibility and profile of adaptation, and to reflect on the adaptation progress Australia has made both at home and abroad. The Adaptation Communication sets out Australia's policy context for adaptation and climate resilience, as of November 2021.

The Australian Government is committed to our relationship with First Nations peoples regarding climate change, and to working closely with them to address the climate impacts they are facing (see sections 6.1.3.2 and 6.3.4.2).

In line with Australia's collaborative nationwide approach, state, territory and local governments play a significant role in adaptation (see section 6.4). Each state and territory has developed, or is developing, an adaptation strategy or plan to deliver on its responsibilities. Under Australia's federal system, states and territories are responsible for many areas of service delivery, including emergency management and health services, land-use planning, and management of assets and infrastructure in Australia. State and territory governments ensure that appropriate regulatory and market frameworks (e.g. infrastructure, state planning) are in place to deliver adaptation responses within their jurisdictions.

State and territory governments have statutory responsibility for local governments. Local governments manage climate change risks to the services, assets and infrastructure they control. There are 566 local government areas covering the whole of Australia, including unincorporated areas, without gaps or overlaps (ABS 2021). Although local government responsibilities vary from state to state, their responsibilities generally include planning and development approvals; administration and oversight of infrastructure, facilities and buildings; providing community services; and coordinating local emergency management responses. Most local governments have initial adaptation plans driven by state and territory governments. Some local governments have undertaken these plans in advance of their state or territory government. Supporting this work, the Australian Local Government Association has identified addressing the risks of climate change as a policy priority.

All state and territory governments, and many local governments, have undertaken or are planning to undertake climate change risk assessments, and have commenced climate preparedness and resilience work. State and territory governments provide regional climate science and adaptation information tailored for their decision-making context.

6.2.2 National climate strategies

In the seventh National Communication, the Australian Government reported on the National Climate Resilience and Adaptation Strategy 2015, which articulated how Australia was managing the risks of a variable and changing climate. It identified a set of principles to guide effective adaptation practice and resilience building, and outlined the Australian Government's vision for a climate-resilient future:

- Shared responsibility – governments at all levels, businesses, communities and individuals all have roles to play.
- Factor climate risk into decisions – consider the current climate and future change in all our decisions.
- Evidence-based risk management approach – apply the best available science.
- Assist the vulnerable – support those who are vulnerable to climate-related impacts.
- Collaborative, values-based choices – respect the knowledge and experience of those affected and involve them in decision-making.
- Revisit decisions and outcomes over time – review actions regularly and identify flexible pathways and opportunities.

Building upon those principles, the Australian Government released the National Climate Resilience and Adaptation Strategy 2021–2025 to provide a basis for adaptation work across each of the natural, built, social and economic domains. The purpose of the strategy is to set out what the Australian Government will do to support efforts across all levels of government, business and the community, to better anticipate, manage and adapt to the impacts of climate change (Table 6.1).

Table 6.1: National Climate Resilience and Adaptation Strategy 2021–2025 objectives and actions

Objectives	Actions
Objective 1: Drive investment and action through collaboration Governments, businesses and communities collaborate to build resilience and adapt	• Provide enhanced national leadership and coordination • Partner with governments, businesses and communities to act and invest
Objective 2: Improve climate information and services Australia has information to better predict, manage and adapt to climate change	• Deliver coordinated climate information and services to more users • Continue to deliver world-class climate science that informs successful adaptation
Objective 3: Assess progress and improve over time Australia assesses national climate impacts, evaluates adaptation progress and continuously improves	• Deliver national assessments of climate impacts and adaptation progress • Monitor and independently evaluate progress over time

Source: National Climate Resilience and Adaptation Strategy 2021–2025

The 2021–2025 Strategy aligns with and supports implementation of other national plans and strategies, including the National Disaster Risk Reduction Framework and supporting action plans, the 2021 Intergenerational Report, the 2021 Australian Infrastructure Plan, the Delivering Ag2030 report, Australia's Strategy for Nature and Australia's international Climate Change Action Strategy, which guides adaptation action in our region. Implementation of the strategy will support the integration of climate information in new plans and strategies as they are developed.

The 2021–2025 Strategy also supports Australia's ongoing adaptation commitments and actions under the Paris Agreement, both at home and abroad, including how we share our adaptation expertise, experiences and skills to achieve stronger resilience outcomes in the Pacific region.

On 13 March 2020, the Australian, state and territory governments endorsed the National Disaster Risk Reduction Framework to guide national action to address existing disaster risks and minimise new risks. The framework guides the collective efforts to reduce the costs and impacts of disasters by shifting national focus from recovery to risk reduction, by addressing existing disaster risks and minimising new risks. The framework provides for a more systemic approach to disaster management. It is underpinned by a comprehensive program of Australian Government measures, in partnership with states, territories and representatives from industry, to increase the resilience of Australian communities.

6.2.3 Assessment of risks and vulnerability to climate change

The Australian Government is taking action across all its agencies to identify climate risks, and build resilience into its assets, operations and areas of responsibility. Assessing climate impacts across government will also support better understanding of systemic vulnerability to climate change and assist in determining adaptation pathways.

The Australian Government continues work on a shared national understanding of Australia's climate risk. Projects include:

- a national climate risk assessment, in consultation with key stakeholders and experts, which will inform climate adaptation priorities
- an urgent assessment of the implications of climate change for national security. The Office of National Intelligence has produced a national assessment on climate change and national security risks for consideration by the Australian Government. Regular climate risk analysis will become an ongoing feature of Australia's security and economic wellbeing assessments
- a new program to improve climate risk assessments within the Australian Public Service to facilitate management of climate risks to public goods and assets. To support this work, the Australian Government published *Climate compass: a climate risk management framework for Commonwealth agencies*. Climate Compass is a framework designed to help Australian public servants manage the risks from the changing climate to policies, programs and asset management. It includes step-by-step instructions, guidance and information to develop an understanding of climate change risks. The Australian Government is continuing to implement the framework across all agencies, and supporting training and capability development of officials to fulfil these responsibilities.

The 2021–2025 Strategy includes a commitment for the Australian Government to undertake a regular assessment of national climate impacts and adaptation progress to determine opportunities, and underpin the setting of priorities for action plans and adaptation partnerships. These regular assessments support objective 3 of the 2021–2025 Strategy, which is to assess progress on adaptation and improve over time. Funding to scope this risk assessment was announced in the October 2022–23 Budget, and work has commenced. The national assessment will be co-designed and delivered in consultation with governments, businesses, professional groups and researchers. It will build on existing assessments undertaken in Australia by state and territory governments, industries and local communities, rather than replace the initiatives underway.

Australia continues to make leading contributions to the international understanding of our region's changing climate. Australian researchers contribute to IPCC reports; provide training and assistance to our Pacific partners; and develop further understanding of Southern Hemisphere, Southern Ocean and Antarctic climate science. Chapter 8 details Australia's work on producing climate modelling, projections and scenarios to inform climate adaptation.

6.2.4 Monitoring and evaluation framework

One of the key objectives in the 2021–2025 Strategy is to assess progress and improve over time. This includes a commitment for the Australian Government to deliver a national approach to monitoring adaptation progress, co-designed with governments, businesses, professional groups and researchers. Knowledge from monitoring and evaluation will provide important feedback to decision-makers and stakeholders, improve the effectiveness and efficiency of policies, and increase accountability for risks and adaptation commitments.

At the UNFCCC 26th Conference of the Parties, Australia joined the 2-year Glasgow-Sharm-el Sheikh Work Programme on the Global Goal on Adaptation and has participated in workshops aimed at establishing how collective adaptation progress can be assessed. These workshops focus on identifying qualitative and quantitative assessment approaches and – with the concurrent development of Australia's adaptation monitoring and evaluating processes – provide a 2-way learning opportunity.

6.3 Progress and outcomes of adaptation action

The Australian Government has already undertaken significant work in adaptation and continues planning to implement the 2021–2025 Strategy objectives (see Table 6.1).

In December 2022, the Climate Change Authority (see section 4.1.1.3) provided advice to inform the first Annual Climate Change Statement to Parliament. This advice concluded that the government could strengthen its adaptation and resilience efforts. With the impacts of the most recent unprecedented flooding still being felt as the first Annual Statement was delivered, and recovery still underway following the Black Summer bushfires, the importance of building community resilience to adapt and rebound more quickly is paramount.

The Australian Government accepts the Climate Change Authority's advice and will further consider it as national adaptation policies are strengthened. This includes improving climate risk management, and the quality and accessibility of climate and disaster risk information across all levels of government. To do this, Australia is continuing to develop a national vision for adaptation, based on extensive consultation, including with state and territory governments, local governments, industry and business groups, local communities and First Nations people, that can guide the government's work.

6.3.1 Progress against the 2021–2025 Strategy

Objective 1: Drive investment and action through collaboration

The Australian Government has taken proactive measures to progress Australia's adaptive capacity through collaboration, including through:

- establishing the National Adaptation Policy Office to provide a central point from which to coordinate and oversee work on climate resilience and adaptation across all governments, and provide a central point of contact and information for businesses and the community
- undertaking a proactive approach to the management of assets, investment and infrastructure to bolster system resilience. This approach is underpinned by the 2021 Australian Infrastructure Plan, which promotes the use of infrastructure to help communities prepare for future hazards
- enhancing reporting frameworks for large businesses to disclose climate-related governance, strategy, risk management, targets and metrics (including greenhouse gases), plans, risks and opportunities
- developing Australia's first National Health and Climate Strategy, which will identify priority areas where action is needed to reduce climate impacts on the health system and ensure that Australians continue to access good quality health care.

Objective 2: Improve climate information and services

The Australian Government is improving climate science and information, including through:

- introducing the updated Climate Change in Australia in 2020 to provide comprehensive regional-level data that projects climate change
- establishing the Australian Climate Service in 2021 to provide extensive climate and natural hazard data, information and advice into a single national view (see section 6.3.6)
- co-funding an update to CoastAdapt, Australia's coastal adaptation knowledge platform (see section 6.3.2.2)
- applying the corporate sector climate accountability and transparency requirements for risk management to the Australian Public Service, achieved through Climate Compass, which builds on the best climate change adaptation research and science over the past decade
- expanding the Indigenous Ranger Program to double the number of Indigenous Rangers, who use traditional knowledge to manage environmental outcomes (see also section 6.3.4.2)
- supporting Indigenous-led knowledge exchange on cultural burning and land management practices, including in the recovery of our native species and habitats from the Black Summer bushfires.

Objective 3: Assess progress and improve over time

The Australian Government is assessing its progress and reporting on its adaptation progress, including through:

- reinstating the Australian Treasury's role in climate modelling, climate risks and opportunities to increase financial data availability for the Australian economy
- requiring tabling of an Annual Climate Change Statement to Parliament by the end of each year, following the passage of the new *Climate Change Act 2022* (Cth). The 2022 Annual Climate Change Statement included reporting on Australia's adaptation activities.

In addition, the Australian Government has been working to mainstream adaptation initiatives across all domains by integrating adaptation measures and action through decision-making, policy and program planning and development, and budgetary processes. Australian Government initiatives supporting adaptation across the 4 domains include:

- protecting our unique environment through a suite of environmental policies, including programs aimed at protecting the Great Barrier Reef and associated industry from the threat of climate change – for example, through the Reef 2050 Long-Term Sustainability Plan
- the Coastal and Estuarine Risk Mitigation Program, which includes $50 million from Australia's Emergency Response Fund to help communities mitigate disasters relating to coastal hazards; it targets high-priority locally and nationally significant coastal and estuarine disaster risk mitigation projects.

6.3.2 Progress in the natural domain

The Australian Government is taking practical action to help our natural domain adapt to climate change. The Australian Government has 3 essential goals: to protect, to restore and to manage our environment. Action and investment will be guided by these goals to help build environmental resilience and adapt to the impacts of climate change.

The Australian Government plays an active role in protecting Australia's rich biodiversity, recognising the importance of environmental conservation to build resilience to the impacts of climate change. The Australian, state and territory governments have separate legislation and measures to conserve biodiversity and sustainably manage natural resources. The EPBC Act is the Australian Government's primary environmental regulatory framework. Its objectives include providing for the protection of the environment, conserving biodiversity, and recognising and promoting the role of First Nations peoples in conservation and biodiversity sustainability. Following an independent review of the EPBC Act (Samuel 2020), the Australian Government has committed to fundamental reform of the Act to improve outcomes for the environment, business and the community. Reforms will focus on improving environmental sustainability by building resilience to the impacts of climate change.

The National Environmental Science Program (NESP) is a long-term commitment to environment and climate research. Phase 1 of NESP invested $145 million from 2014–15 to 2020–21 into 6 research hubs, including the Earth Systems and Climate Change Hub and the Threatened Species Recovery Hub. The Earth Systems and Climate Change Hub received $23.90 million under NESP Phase 1 and progressed research on climate change adaptation in Australia by:

- sharing expert advice on bushfire conditions with key emergency management stakeholders for use in their climate policies
- contributing to the Royal Commission into National Natural Disaster Arrangements
- increasing knowledge of current and future extreme wet events
- providing understanding of extreme dry periods for better future water management
- updating sea level rise projections and a sea level rise calculator tool for coastal planning
- providing understanding of future trends in marine heatwaves to enable marine managers to better plan for and manage their future risks
- co-producing climate vulnerability and impact assessments for future-proofed industries.

The Threatened Species Recovery Hub received $32.98 million under NESP Phase 1 and progressed research on methods for the successful translocation of species affected by climate and other hazards.

The Australian Government provided a further $149 million in funding for Phase 2 of NESP (2020–2021 to 2026–2027), which established 4 new research hubs, including the Climate Systems Hub (see section 8.1.2.3). NESP includes support for a cross-program Climate Adaptation Initiative to drive integrative adaptation research.

6.3.2.1 Natural ecosystems

Since the seventh National Communication, the Australian Government has released major strategies for nature, biodiversity conservation and soils, and a major program for blue carbon.

The Australian Government has released Australia's Strategy for Nature 2019–2030 and supporting website, Australia's Nature Hub, to bring together existing work across the country to guide the development of new and innovative approaches to biodiversity conservation.

Australia's Strategy for Nature includes explicit consideration of climate change adaptation and resilience, including in managing species and ecosystems that are vulnerable to climate change. The strategy focuses on overarching goals that support healthy and functioning biological systems by promoting a stronger connection between people and nature, improving the way we care for nature, and building and sharing knowledge. It also provides an adaptive approach, allowing each jurisdiction flexibility in setting targets appropriate to the diverse environments being managed and to change targets as knowledge develops over the life of the strategy.

The $214.9 million Australian National Soil Strategy sets out how Australia will value, manage and improve our soil for the next 20 years, by prioritising soil health, empowering soil innovation and stewards, and strengthening soil knowledge and capability. Pursuing these goals is critical to Australia's food security, natural environment, and resilience to climate change and disasters.

Case study: The western swamp tortoise adaptation

The western swamp tortoise (*Pseudemydura umbrina*) is Australia's most endangered reptile and is a species that feeds and breeds only in water in south-western Australia. The western swamp tortoise has significantly declined in the past 50 years as a result of a combination of restricted geographic range, habitat clearance and increasing aridity – a factor that will worsen with a drying climate. Western swamp tortoises can live up to 100 years, but it can take 8–15 years before they mature and are ready to breed. Three decades ago, there were less than 50 western swamp tortoises left in the wild.

In a changing climate, assisted colonisation trials began in 2016, with juveniles bred at Perth Zoo released to wetlands that have longer wetter periods and a cooler climate. Further trials at alternative sites have continued and included the release of 73 western swamp tortoises in 2019, which is the largest release to take place for these critically endangered native reptiles. Early results are encouraging, and it is hoped that the species can continue to persist in these alternative sites in the longer term.

6.3.2.2 Coasts and coral reefs

The Australian Government is investing $50 million in 2022–23 to protect Australian coastal communities, infrastructure and ecosystems from coastal hazards through the Coastal Estuarine Mitigation Program (CEMP). CEMP targets high-priority, locally and nationally significant coastal and estuarine disaster mitigation projects that are proposed by state and territory governments. Successful applicants were announced in November 2022, and for the first time nature-based solutions will be an eligible adaptation measure under disaster funding.

This investment complements research under NESP to address risks to the marine and coastal environment. Under Phase 1 of NESP, the Earth Systems and Climate Change Hub allocated $25 million for the establishment and operation of the National Centre for Coasts and Climate. The centre ran from 2017 to 2019 and focused on working with stakeholders to identify the best ways of addressing climate change impacts on Australian coastal ecosystems, including through nature-based solutions. Under Phase 2 of NESP, the Marine and Coastal Hub and the Climate Systems Hub have continued the work of the centre and are driving coastal adaptation research.

From 2014 to 2017, as part of an $8.8 million investment in the National Climate Adaptation Research Facility, CoastAdapt was developed as a national climate adaptation knowledge platform. The platform was designed to support local governments in the coastal zone assess their climate risk and undertake adaptation planning. Additional funding was provided to update the site to ensure that the platform provides the latest information and 'how-to' guidance for coastal decision-makers, including interactive tools for shoreline mapping and sea level rise projections, for each local government area across coastal Australia.

Australia has established an overarching long-term strategy for the protection and management of the Great Barrier Reef. The Reef 2050 Long Term Sustainability Plan is supported by $4.4 billion in Australian and Queensland government funding for Reef protection initiatives to 2030.

One focus area of the Reef 2050 Plan is supporting adaptation to a changing climate. This is being delivered through Australia's world-leading Reef Restoration and Adaptation Program (RRAP). The RRAP research and development program is the world's largest program to help a significant ecosystem – in this instance the Reef – survive climate change. RRAP brings leading experts together to investigate new ways to help coral reefs adapt to climate change. This work includes researching and testing possibilities for seeding reefs with coral larvae that are more resilient to warmer waters, investigating ways to improve coral larvae survivability, and supporting natural restoration of damaged and degraded reefs. The program is also investigating concepts to shade and cool large areas of reef at risk of bleaching by spraying microscopic saltwater droplets into the air to make clouds more reflective of sunlight.

To protect our coastal blue carbon, the Australian Government is funding the Blue Carbon Conservation, Restoration and Accounting Program (see section 4.2.5.4).

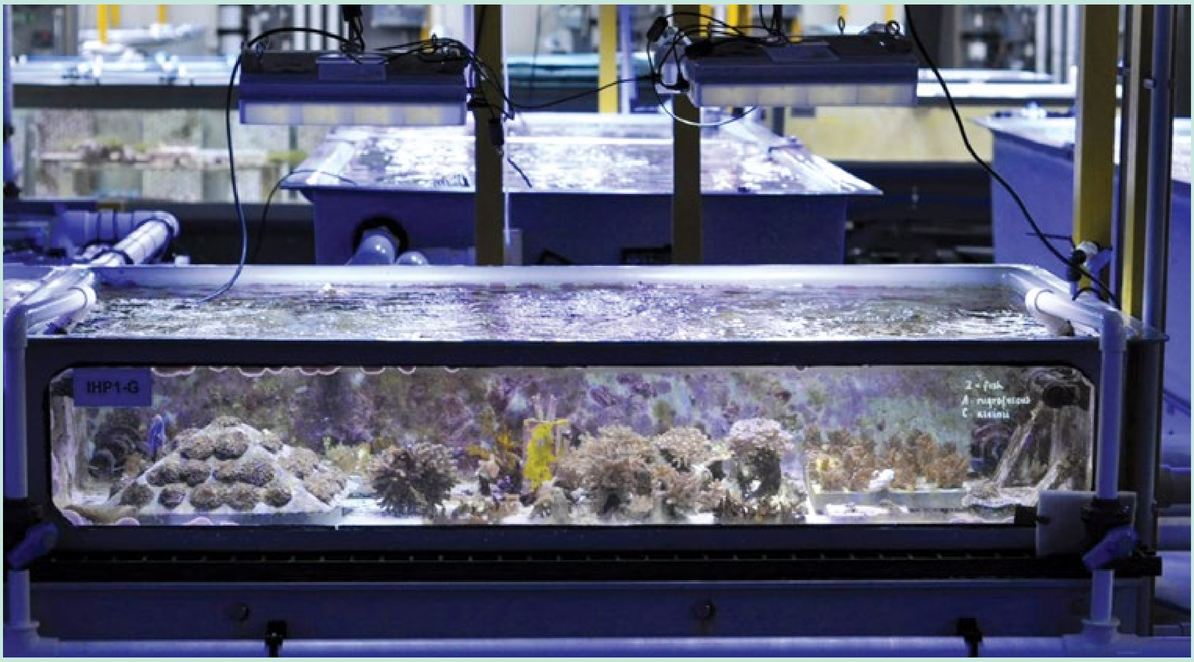
Case study: Innovation and adaptation protecting the Great Barrier Reef

The Australian Institute of Marine Science is using propagation to produce large numbers of healthy corals in an aquaculture facility to develop a deeper understanding of coral reproductive biology and ecology.

Coral fragments are collected from the Reef and brought to the facility for spawning. The spawn are collected and fertilised, and the larvae are then reared in nurseries and settled onto specially designed surfaces. Settled corals, or fragments made from the adults, are placed onto devices and placed onto the Reef. Divers then revisit the sites to identify and understand the environmental conditions in which corals survive and grow best.

This knowledge will help design and upscale coral aquaculture systems to enhance end-to-end survival of corals on degraded reefs from spawning to settlement and adulthood.

Figure 6.2: Coral propagation at the Australian Institute of Marine Science National Sea Simulator Facility; Department of Climate Change, Energy, the Environment and Water



Source: AIMS

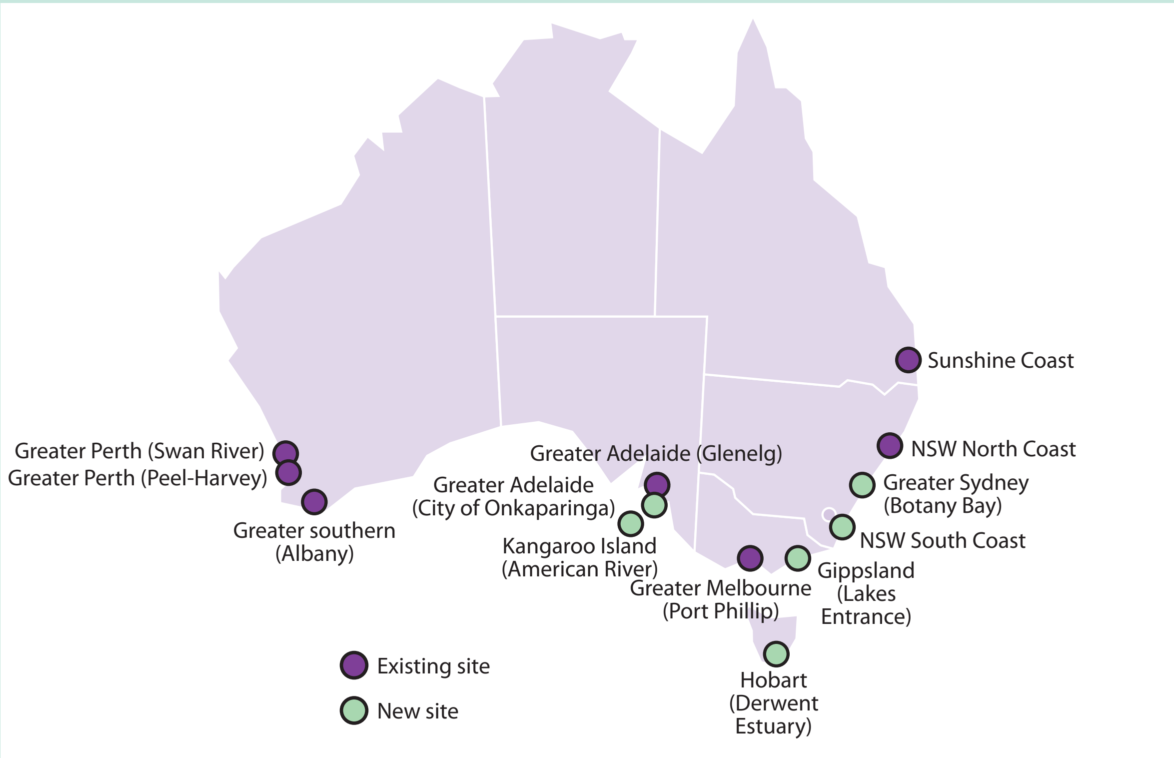
Case study: Rebuilding Australia's shellfish reefs

Before European arrival in Australia, shellfish reefs were common features of Australia's estuarine and coastal systems, stretching southwards from Noosa to Perth. However, as a result of overharvesting and pollution, less than 8% of shellfish reefs remain (Nature Conservancy Australia 2022). In 2020, the Australian Government partnered with the Nature Conservancy, committing $20 million towards the restoration of native shellfish reefs (oyster and mussel) in 13 coastal communities around Australian by June 2023.

The construction of shellfish reefs involves the transport and positioning of rock rubble. Depending on the local circumstances, the rock rubble is often 'seeded' with juvenile oysters and mussels from local hatcheries, although in other situations recruitment of shellfish takes place naturally. Newly constructed shellfish reefs take 3–5 years to become fully established, and 7–10 years to become mature and stable ecosystems. However, for the newly established reefs that have been completed under this project to date, there is already evidence that they are being used by marine species.

This project is demonstrating that shellfish reefs are an ecosystem that can be helped to recover and be saved from extinction. When completed, the 13 new reefs will contribute 40 hectares of thriving shellfish ecosystem across the Australian coast from Noosa in Queensland south to Tasmania and all the way west to Perth. In doing so, they will improve local biodiversity, and generate enduring environmental and economic benefits for local communities.

Figure 6.3: The 13 reef builder locations



Source: Heritage Reef and Ocean

Case study: Manta Ray Bay coral bommie relocation

On 28 March 2017, severe tropical cyclone Debbie generated waves greater than 8 metres that impacted many of the fringing reefs of the Whitsunday Islands. In Manta Ray Bay, massive, live coral (*Porites* sp.) bommies were dislodged and washed up onto the beach.

One of the management tools being investigated to help coral reefs resist, adapt to, and recover from, the impacts of climate change is the replacement or introduction of hard structure. This structure and habitat complexity are fundamental requirements for the settlement and growth of coral larvae and supporting fish biodiversity. Replacing the large coral bommies into the bay provided a low-risk management strategy.

Heavy machinery was used to move more than 100 m^3 (400 tonnes) of the large coral bommies back into the Great Barrier Reef Marine Park at Manta Ray Bay. The objectives of this project included habitat restoration, improved aesthetics, improved beach access to a highly popular location, ongoing access to public moorings, increased understanding of coral recruitment and recovery, and demonstration of proactive management after an extreme weather event. This project was led by the Great Barrier Reef Marine Park Authority and its Queensland Government partner, the Queensland Parks and Wildlife Service, and delivered through the Reef Joint Field Management Program.

The use of machinery, and the specific consultative and administrative pathways followed for the project provided a major opportunity to explore and establish new management tools in a rapidly changing tropical marine environment. With more powerful cyclones predicted for the Reef in the future, all options to assist recovery will be considered.

Relocation of the bommies provided habitat structure for coral recruitment and reef fishes. The latest annual monitoring (March 2022) recorded a total of 516 coral recruits from 12 genera on the surveyed bommies. Fish biodiversity has increased from 20 species (from 7 families) in 2018 to 55 species (from 13 families) in 2022.

A key outcome of the project has been an opportunity to measure natural recruitment and recovery on the bommies and compare this with other projects. For example, techniques are being developed that use live 'corals-of-opportunity' fragments (live corals broken from reefs through natural processes) to rapidly recolonise areas of unstable or bare substrate. Although monitoring is showing that natural recruitment is leading to recovery, it is expected that this will take approximately 10 years to be fully achieved. It is possible that a combination of techniques (structure replacement and the introduction of suitable live coral) could significantly speed up this process.

6.3.2.3 Water resources

The Australian Government is implementing various measures to respond to expected increases in water scarcity and variability because of climate change. In Australia, state and territory governments are responsible for managing water resources within their jurisdictions, and the Australian Government provides national coordination and leadership to drive policy and reform to manage water resources sustainably.

At the national policy level, the National Water Initiative (2004) is the framework that provides Australian governments with a coordinated approach to water management. The Australian Government has committed to working with state and territory governments to renew the National Water Initiative. The renewal process will consider enhancing water resources management in the face of climate change and extreme weather events.

The National Water Initiative (2004) is supplemented by a Considering Climate Change and Extreme Events in Water Planning and Management module. This module provides guidance and a suite of options for water planners for managing climate risks.

The legislative and policy frameworks that support management of the Murray–Darling Basin include the *Water Act 2007* (Cth), a Basin Plan, the Murray–Darling Basin Agreement and Water Resource Plans. These provide critical tools for managing climate risks, achieved by:

- recognising variability in climate, inflows and effects on water-dependent ecosystems
- identifying strategies to address these risks
- establishing mechanisms that ensure that ongoing monitoring, engagement and review occur, taking account of improved information and scientific knowledge as it becomes available.

To encourage the best use of water resources, Australia has established water markets that allow users to buy or sell their water rights on a permanent or temporary basis. Water trading encourages efficient water use by allowing water to be used where it is needed most, particularly in drier years.

The Australian Government is making significant investments in water science and the generation of knowledge to develop an information base for evidence-based decisions regarding adaptation. For example, the Australian Government is investing in a Water and Environment Research Program to provide an evidence base for a 2026 review of the Basin's management plan, as well as funding a major modelling uplift project to provide a whole-of-Basin hydrological modelling capacity and a Basin condition monitoring project.

Case study: Climate adaptation in the Murray–Darling Basin

The Murray–Darling Basin Plan (Basin Plan) sets out a coordinated approach to managing water resources among the 5 states and territories through which the Basin's rivers flow. It represents a major water reform and a key climate adaptation tool. The Basin Plan aims to balance environmental, social and economic considerations. This is achieved by reducing the amount of water that can be taken from the rivers by setting sustainable diversion limits (SDLs) for both surface water and groundwater for each catchment area in the Basin.

The Basin Plan was developed to ensure that climate variability and climate change would be considered in real time through limits on water extraction that consider water availability. Climate change patterns, as measured over decades, are considered through regular reviews of the Basin Plan and its subsidiary instruments (such as the Environmental Watering Plan and the catchment-scale Water Resource Plans).

Other features of the Basin Plan include:

- an adjustment mechanism to allow SDLs to be adjusted under certain circumstances
- rules for water trading and better access to water market information
- identifying the risks to continued water availability in the Basin, and strategies to manage them
- a monitoring and evaluation program, including an annual report on the effectiveness of the Basin Plan.

The first 8 years of the Basin Plan's implementation tested the policy under extreme climate conditions. The 2020 Basin Plan Evaluation came at the end of the driest 3 years on record for the Basin, part of an extended and unprecedented drought, which had a large impact on water availability and saw record low inflows, towns running out of water, mass fish deaths, extensive bushfires and significant water quality issues. The 2020 evaluation demonstrated that the Basin Plan helped cushion the impact of a warming climate during extremely dry periods through emergency releases of water for the environment, strengthening connectivity and flushing stagnant water. More than 2,000 gigalitres of surface water and 35 gigalitres of groundwater have been recovered for the Murray–Darling Basin environment under the Basin Plan.

The ongoing change in climate will significantly impact water availability and use, and management will require difficult decisions to be made at national, Basin and local scales. The next Basin Plan review is scheduled for 2026, and represents an opportunity to strengthen the consideration of climate change and climate adaptation in the Basin Plan. Additionally, a range of plausible hydroclimate futures for the Basin will help governments, communities and industries understand the possible range of climate change impacts and stress test water management tools to support a more resilient Basin.

6.3.2.4 Agriculture

The impacts of climate change are already being felt by the agriculture sector. Agriculture industries are developing methods to better understand and manage the physical impacts of climate change – for example, through changes to crop selection, land management and improved water-use efficiency. Adaptation efforts have reduced but not eliminated the impact of climate change over the past 20 years (ABARES 2020).

The $5 billion Future Drought Fund was established in 2019 to provide secure, continuous funding for drought resilience initiatives. The fund is investing $100 million each year to support farmers and their communities become more resilient to the effects of future drought. Building resilience to drought is intrinsically linked to climate resilience, including adaptation efforts. The fund is supporting adaptation efforts – for example, by:

- providing farmers with better information on the climate risks they face
- supporting the development of regional-, community- and farm-level drought resilience plans
- supporting development and adoption of drought-resilient agricultural practices and technologies.

The Carbon + Biodiversity Pilot is trialling market arrangements to generate income for landholders and farmers from plantings that deliver both biodiversity improvements and carbon abatements. Under this program, farmers will be incentivised to deliver long-term biodiversity improvements as part of a carbon project, receiving funding through a biodiversity payment and ownership of any future carbon credits. Increased biodiversity planting projects will have several benefits, including protecting dams and waterways, and reducing erosion, helping to protect agriculturally important natural systems from the impacts of climate change. Learnings from the pilot will contribute to the development of the proposed national nature repair (biodiversity) market.

In October 2018, Australia placed its plant genetic resources for food and agriculture into the International Treaty on Plant Genetic Resources for Food and Agriculture Multilateral System of Access and Benefit Sharing. The Multilateral System facilitates access to farmers, researchers and breeders to 64 of the world's most important crops, to work with and potentially improve. This assists global efforts to conserve and sustainably use plant genetic resources to ensure food security and promote sustainable agriculture worldwide.

6.3.3 Progress in the built domain

The Australian Government is taking practical action to help our built domain adapt to climate change. Australian governments, experts, industry and communities continue to develop standards and practices to improve the resilience of the built environment to climate change. Reforms include:

- upgrading energy efficiency provisions for residential buildings through the National Construction Code to a minimum of 7 stars (see also section 4.2.2.8)
- improving the efficiency of appliances and equipment by delivering energy efficiency standards and energy labelling (see also section 4.2.2.8), and promoting fuel switching to electric alternatives by supporting electricity infrastructure upgrades
- improving information for motorists and fleets, and integrating battery electric vehicles into the electricity grid (see also section 4.2.3.1)
- encouraging the deployment of on-site distributed energy and water systems or off-site low-carbon electricity to support the delivery of clean power and reduce electricity losses.

Australia is also expanding focus from the resilience of assets themselves to the contribution of assets to the resilience of the system. Research and advice developed by Infrastructure Australia are helping to chart a pathway for this systemic change. These include A Pathway to Infrastructure Resilience: *Opportunities for systemic change* (developed with Infrastructure NSW) and the 2021 Australian Infrastructure Plan. The latter makes recommendations to ensure that resilience is embedded through clear and harmonised guidance on how projects can address risks and value resilience. It focuses on driving change through:

- building community resilience to all hazards by considering systemic risks, interdependencies and vulnerabilities in infrastructure planning and decision-making

- meeting Australia's present and future needs by establishing the 'quadruple bottom line' (considering cultural, economic, environmental and social performance) as a goal for all infrastructure policy and investment
- building community trust in infrastructure decision-making and institutions by ensuring that infrastructure decisions are transparent, and reflect place-based community needs and preferences.

Cities are reducing their vulnerabilities to the urban heat island effect by implementing cool urban environments, protecting biodiversity and providing shared open spaces. Cities are also working collectively to develop and implement solutions; for example, both Sydney and Melbourne are members of the Resilient Cities Network, aiming to build the capacity of cities around the world to plan for and adapt to climate impacts while maintaining liveability, social cohesion and economic productivity.

The impacts of weather on some critical infrastructure networks such as electricity systems will become increasingly significant as the climate changes. The independent 2017 Finkel review into the Future Security of the National Electricity Market identified a need for improved climate data for the sector. The Australian Government's Electricity Sector Climate Information project has responded by delivering improved climate and weather information to support electricity sector resilience to climate change and extreme weather events. The project enables risks related to future weather events to be integrated into existing sector planning and risk modelling using a standard process. The project was a collaboration between CSIRO, the Bureau of Meteorology and the Australian Energy Market Operator.

The Australian Government invests in water-saving infrastructure projects and efficiency measures as a means of adapting to greater water scarcity because of climate change. Programs assist water users to reduce water losses from evaporation or seepage from water delivery channels or storages, including by modernising water delivery infrastructure and improving water management on farms.

Case study: Australian WELS scheme

The Water Efficiency Labelling and Standards (WELS) scheme is Australia's urban water-saving scheme. WELS reduces demand for high-quality drinkable water by informing consumers about water efficiency at the point of sale by way of a star rating system on whitegoods. Commencing in 2006, the scheme has helped raise community awareness of the need to be more efficient in our use of water in the urban environment.

WELS is Australia's most successful consumer water conservation program. A 2018 evaluation estimated per capita water savings of more than 112 gigalitres in 2018 (equivalent to 4,526 litres per person over the year), and forecast to rise year on year and reach 231 gigalitres by 2036 (equivalent to 7,117.5 litres per person per year). An additional benefit is in energy savings, as less energy is required to heat, pump and treat water, leading to a projected reduction in greenhouse gas emissions between 2006 and 2036 of more than 57 million tonnes of carbon dioxide equivalents.

The Australian, state and territory governments, and independent infrastructure advisory bodies are also working together to capture the full costs and benefits of systemic resilience by sharing information, including best-practice definitions and datasets, new assessments, guidance and decision-making tools. Several government and industry initiatives are underway to progress best-practice resilience planning, including:

- Resilience and Climate Risk Workshop – an annual online workshop led by the independent advisory agency Infrastructure Australia to ensure visibility of resilience and climate risk projects, identify opportunities for collaboration, and promote coherency and consistency in resilience and climate risk assessment and appraisal
- Resilience Valuation Initiative – a coalition of stakeholders seeking to value resilience and advance an accepted process with enabling methodologies for understanding the value of a resilience-building asset, network, feature or activity (Resilience Valuation Initiative 2022)
- Enabling Resilient Investment approach – an approach to value resilience by preparing for funding and financing, building resilience investment cases, and creating opportunities and pathways for adaptation (CSIRO 2022).

Case study: A digital twin of Darwin to monitor and navigate change

The Darwin Living Lab (DLL) is developing a virtual model, or 'digital twin', of Darwin to enable the City of Darwin to monitor change in key indicators (e.g. canopy cover, temperature, air quality), and test the impact of changes in asset management and scenarios of urban development. The digital twin allows stakeholders to investigate how patterns of urban vegetation impact land surface temperatures at a much finer resolution than previously possible. The tool also allows urban stakeholders to investigate the potential benefits, trade-offs and opportunities of urban planning scenarios; monitor the effects of past actions; and identify pathways to a more climate-resilient city.

The digital twin has been used to evaluate the economic value and return on investments of cooling and greening initiatives, specifically around increasing and maintaining Darwin's urban forest. In collaboration with CSIRO's Urban Monitor team, high-resolution (10 centimetre) maps have been generated of presence, area, condition, volume and height of urban vegetation (e.g. trees, shrubs, grass), impervious surfaces (buildings, roads) and bare ground and water, for the years 2011, 2016 and 2021. This information, coupled with local tree inventory data about species composition and condition, has quantified and valued the stocks and flows of various ecosystem services provided by Darwin's urban vegetation based on the international System of Environmental and Economic Accounting framework.

Land surface temperature has now been mapped and heat distribution patterns modelled against several built and natural urban features. This information was combined with socioeconomic and demographic data to estimate heat-health vulnerability risks at the neighbourhood scale. Hotspots were identified where heat-related health risk was high and adaptive capacity was low.

The DLL project is now building tools to inform tree planting locations within the city that account for long-term costs, benefits and risks, and their implications for urban biodiversity and human health.

6.3.4 Progress in the social domain

Australia recognises that adaptation must be inclusive and account for the underlying factors that contribute to vulnerability, such as issues related to geography, culture, age, gender, diversity, disability and socioeconomic status. The Australian Government's consideration of adaptation issues will seek to improve equality and fairness for vulnerable communities.

6.3.4.1 Health and wellbeing

Australia's efforts to adapt to climate change are supported by strong social institutions and assets, including a strong public health system, and leading climate and health research.

The Australian government has developed the National Preventive Health Strategy 2021–2030. This 10-year strategy highlights that Australia needs to increase its preparedness to respond to and mitigate the impact of climate change on health and wellbeing. It also identifies focus areas where a stronger and better-coordinated effort will enable accelerated gains in health over the next 10 years, as well as evidence-based policy achievements. The Australian Government is also developing a National Health and Climate Strategy that recognises climate change as a national priority.

The Australian Government is investing in research to address environmental and health impacts. In late 2021, the National Health and Medical Research Council, through the Special Initiative on Human Health and Environmental Change, awarded the Healthy Environments and Lives (HEAL) Network $10 million over 5 years to strengthen the Australian health system's resilience, preparedness and responsiveness to changing environmental conditions and extreme weather events. The HEAL Network is a collaborative, multidisciplinary coalition of 100 investigators and more than 30 organisations from across Australia that will provide national and international leadership in environmental change and health research.

Additionally, in response to the Black Summer bushfires, the Australian Government is investing in research into the physical and mental health impacts of bushfire smoke through the Medical Research Future Fund. A total of $5 million has been allocated for smoke-related research, including into physical and mental health impacts of smoke.

The Australian Government has invested funding to provide mental health support for Australians impacted by recent disasters, including the recent flood events and bushfires. Funding has been invested to provide mental health support for Australians, including for:

- local mental health services to meet immediate psychological needs of communities and vulnerable populations, including First Nations communities
- a Disaster Response Network of more than 500 trauma-trained psychologists that can be deployed to impacted communities as needed
- support for mental health of children and young people, including funding for Headspace services and Head to Health Centres in impacted areas
- Wellbeing and Resilience Grants, through Primary Health Networks (PHNs), to allow communities to respond to the losses, anxiety and distress they have experienced, as well as actively participate in their recovery
- availability of Emergency Response Coordinators in impacted PHN regions to help communities to coordinate access to mental health services, integrate support with state and local government efforts, and navigate the complex mental health system to reduce the burden on those in need of assistance
- investment in mental health telehealth services
- temporary changes to Australia's Medicare Benefits Schedule through the Better Access Initiative to double the number of subsidised psychological sessions available.

The National Mental Health Commission also led the development of the first National Disaster Mental Health and Wellbeing Framework. This framework offers an integrated cross-jurisdictional approach to supporting the mental health and wellbeing of people impacted by disasters. It will improve how governments, services and the community work together to support people's mental health and wellbeing before, during and after disasters. The framework has been endorsed by all jurisdictions in Australia.

6.3.4.2 First Nations peoples

The Australian Government is committed to working closely with First Nations peoples to address the climate impacts they are facing, including by:

- committing $15.9 million over 4 years for the establishment of a Torres Strait Climate Centre of Excellence to enable First Nations–led adaptation action
- doubling the number of Indigenous Rangers
- supporting Indigenous-led knowledge exchange on cultural burning and land management practices, including in the recovery of our native species and habitats from the Black Summer bushfires
- providing at least $100 million of the government's $1.2 billion investment in the Great Barrier Reef to be delivered with, and informed by, Traditional Owners
- recognising the values, perspectives and cultures of First Nations peoples on climate change through NESP
- increasing First Nations peoples' ownership and involvement in decision-making in relation to water resources – for example, through exploring the establishment of cultural flows within the Murray–Darling Basin, allowing First Nations peoples the right to use and manage specified water areas.

The Indigenous Ranger Program (IRP) supports 2-way knowledge sharing, combining traditional knowledge with conservation training to protect and manage land, sea and culture. This is leading to improvements in modern environmental science and contemporary approaches to land and water management.

Implemented by the National Indigenous Australians Agency in 2007, land and sea management activities vary between different ranger groups; however, common activities include threatened species monitoring, habitat restoration, biodiversity surveys, beach clean-ups, coastal patrols, management of weeds and feral animals, traditional fire management practices, tourism management and protecting cultural heritage sites.

Of ranger groups and Indigenous Protected Areas (IPAs), 80–90% reported undertaking cultural burning from 2018 to 2020. Cultural burning is the practice of First Nations peoples deliberately introducing fire into the landscape for various purposes, including ceremony; protecting cultural assets; maintaining environmental health or the health of specific plants and animals; and managing food, fibre and medicines.

Most cultural burns use cool or small, low-intensity fires that do not reach the canopy. Cultural burning increases biodiversity, promotes regenerative growth, improves soil health and causes a significant reduction in greenhouse gases from bushfires by reducing the frequency and extent of late dry-season fires. The scale of cultural burning varies greatly between projects.

The IRP and the IPA program also deliver other benefits:

- Improved environment – they contribute to environmental resilience through improved integrity of native vegetation communities, management of feral animals and weeds, and cultural burning.
- Economic – Indigenous Ranger and IPA program jobs are 'on-the-ground' caring for Country, which provide economic benefits for Aboriginal and Torres Strait Islander peoples, especially in remote regions.
- Improved health – Indigenous Rangers have demonstrated both wellbeing benefits (e.g. strengthened sense of identity and empowerment) and physical health benefits (e.g. improved blood pressure and cholesterol) associated with increased activity.
- Connection to Country and culture – they provide a pathway for senior knowledge holders to share First Nations ecological knowledge and cultural practices across generations.
- Language – they support renewed and sustained use of First Nations languages through connection to Elders and Country.
- Relationship building – they improve 2-way knowledge transfer, and allow the combination of traditional knowledge and western science to improve environmental outcomes.

Case study: National Indigenous Dialogue on Climate Change

In 2018, NESP initiated the National Indigenous Dialogue on Climate Change. The dialogue enabled Indigenous people from across Australia to come together to provide recommendations about what climate change information, co-design and engagement would be of greatest value to Indigenous communities. This event highlighted the importance of ongoing engagement, which led to the National First Peoples Gathering on Climate Change held in Cairns in 2021. This gathering was an opportunity to celebrate, learn from and enhance First Nations–led climate change action.

Outcomes from the 2 events included recommendations from First Nations people to:

- continue the engagement between scientific and traditional (2-way) knowledge of climate change
- ensure First Nations peoples' rights to Indigenous cultural and intellectual property through free, prior and informed consent
- support Indigenous-led projects based on 2-way knowledge about climate risks
- create opportunities for peer-to-peer learning between Traditional Owners as the best means of strengthening the application of their traditional knowledge
- provide Traditional Owners the opportunity to shape the forms of communication and engagement that represent the best value for their communities

Building on these events, the NESP Climate Systems Hub is bringing together Traditional Owner participants from across Australia to create the National First Peoples Platform on Climate Change (NFPPCC). In October 2022, the NFPPCC committee gathered in the Torres Strait islands, and will meet regularly over the next 5 years to give Aboriginal and Torres Strait Islander peoples access and opportunity to collaborate with scientists and amplify First Nations voices on climate change issues and climate adaptation.

6.3.5 Progress in the economic domain

Better understanding and proactively managing climate change will help Australian businesses to continue to prosper, and people to continue to have access to secure and meaningful jobs and opportunities in our future climate. Making efficient and well-targeted investments in adaptation now can reduce risks and avoid significant costs in the long term, while taking advantage of opportunities. Incorporating resilience into financial decision-making will help attract private investment in infrastructure and other assets able to withstand a changing climate, driving a shift towards a more climate-resilient economy.

The Australian Government is taking practical action to help our economic domain adapt to climate change. The Australian Government is a participant in the Coalition for Climate Resilient Investment and is seeking to establish collaborative mechanisms to help markets incorporate resilience into asset valuations or initial investment decisions.

The Hazard Insurance Partnership and Strategic Insurance Project was announced by the Australian Government in October 2022 to help reduce the cost of insurance in communities at risk of natural disasters and drive better outcomes for insurance holders. Specifically, it will identify the most pressing insurance issues in high-risk areas and test the best policy solutions to reduce insurance costs. As part of the project, the Australian Climate Service will also establish an enduring dataset on insurance affordability, underinsurance and non-insurance issues to help reduce the risks faced by policy holders. The package also includes a forum for cooperation between the Australian Government and the insurance sector, which will address issues driven by natural hazards

Australia's financial sector will continue to play an important role in shaping how we plan for and adapt to climate change. The Council of Financial Regulators (the Treasury, the Reserve Bank of Australia, the Australian Prudential Regulation Authority, and the Australian Securities and Investments Commission) has taken steps to improve the ability of Australian corporates and financial institutions to manage the financial risks associated with climate change, and to provide high-quality comparable disclosures on these risks.

To help private sector actors incorporate resilience into asset valuation and choice, the Australian Government agencies CSIRO and the National Emergency Management Agency, the Queensland Reconstruction Authority, Resilience New South Wales, private sector partner insurer IAG, and the commercial bank the National Australia Bank are undertaking a Resilience Investment Vehicle pilot. The pilot commenced in 2018, and aims to explore how public and private capital could be directed to finance new or adapt existing infrastructure that builds resilience, reduces climate and disaster risk, and can derive a financial return for investors. Learnings are applied to new resilience investment projects, which are tested for scalability and replicability. The pilot will also test solutions to the key barriers to unlocking capital for resilience, including:

- measuring resilience outcomes and ascribing a financial value so that resilience-building interventions can be monetised
- communicating the risks and benefits of resilience-building interventions
- requiring governance arrangements for collaboration between government, the private sector and the research sector.

The Australian Government is also improving the measurement and valuation of Australia's natural assets, working in partnership with interested banks and financial institutions to develop and trial natural capital metrics. This will better enable the environment to be considered in commercial decisions, reducing environmental degradation, and supporting increased private sector investment in maintaining and restoring our natural environment.

Important steps are also being taken in Australia through implementation of the National Strategy and Action Plan for Environmental–Economic Accounting, which provides a consistent national approach to linking environmental data with social and economic data. Environmental–Economic Accounts, or natural capital accounts, can help improve our understanding of the relationship between nature, the economy and social wellbeing. They track changes in our natural capital, including in ecosystem services. The Australian Bureau of Statistics and the Australian Government Department of Climate Change, Energy, the Environment and Water have partnered to develop Australia's first National Ocean Ecosystem Account, which focuses on blue carbon ecosystems, and their climate mitigation and resilience benefits. Phase One – mangrove and seagrass accounts, was released in August 2022, and Phase Two – kelp and saltmarsh accounts are due in November 2022.

6.3.6 Progress in disaster risk management

Australia recognises that reducing our vulnerability and exposure to disasters, including through climate change adaptation, will be key to increasing our resilience. A Deloitte Access Economic report found that, by investing in adaptation to climate change now, Australia could avoid $380 billion of economic costs from climate change and disasters over the next 30 years (Deloitte Access Economics 2022). Australia has world-class emergency services, and recognises that investment in infrastructure such as flood levees, drainage systems, evacuation centres and cyclone shelters remains critical in the lead-up to, during and in the aftermath of a disaster. However, as climate change exacerbates the frequency and/or severity of large-scale disasters, more can be done to address the systemic, root causes of disaster risk to both reduce the costs of disasters and build economic and social capital.

The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) and the Paris Agreement on Climate Change (Paris Agreement) provide clear guidance, which increases the coherence and consistency in how countries approach climate change and disaster risk reduction. The Sendai Framework and Paris Agreement collectively provide an international agenda towards a more sustainable, resilient and equitable future for all.

The National Disaster Risk Reduction Framework is Australia's domestic implementation of the Sendai Framework and guides national action to address existing disaster risks and minimise new risks. The risk reduction framework, endorsed by the Australian, state and territory governments on 13 March 2020, translates the first 3 Sendai Framework priorities into action for the Australian context, while the fourth priority of the Sendai Framework is largely being progressed through the Australian Disaster Preparedness Framework. The risk reduction framework is operationalised through national action plans. The First National Action Plan was released in December 2020 and was a critical step in Australia for national recognition that reducing disaster risk is beyond the sole responsibility of the traditional disaster management sector. The Second National Action Plan is currently being developed through a series of consultations.

As 2022–23 marks the halfway point of the 15-year Sendai Framework, Australia was asked to take stock of progress to date in implementing the framework domestically through a midterm review. This review was an important opportunity to gain insights, identify emerging best practice, and report on the achievements to date in reducing disaster risks in Australia.

Overwhelmingly, the national midterm review found that climate change driving extreme weather was cited as the most prevalent emerging issue that will impede and limit Australia's ability to achieve the outcome and goal of the Sendai Framework by 2030.

Australia's National Midterm Review was delivered to the United Nations Office for Disaster Risk Reduction on 30 September 2022 and was publicly released in mid-October 2022. Findings from Australia's midterm review were showcased at the Asia–Pacific Ministerial Conference on Disaster Risk Reduction, which took place on 19–22 September 2022 in Brisbane.

The National Emergency Management Agency commenced on 1 September 2022. This new agency brings together the capabilities of the former National Recovery and Resilience Agency, and Emergency Management Australia into a single institution that can provide end-to-end oversight of risk reduction, prevention, preparedness, response and recovery in Australia. The establishment of this new agency is a significant step forward in strengthening Australia's ability to prepare for, manage and recover from increasing disasters, both in number and severity.

Following the Royal Commission into National Natural Disasters Arrangements, the Australian Climate Service was established on 1 July 2021 to support better understanding of climate and natural hazard challenges, and the associated impacts (see section 8.1.2.2).

The Preparing Australia Communities Program – Local Stream has provided funding to 15 local projects to a total value of $150 million to mitigate or reduce disaster risk, impact and consequence associated with large-scale natural hazards.

The Coastal and Estuarine Risk Mitigation Program, funded from the annual $50 million pre-disaster resilience component of the Emergency Response Fund, seeks to deliver priority projects that mitigate the impact of disaster on communities and economies in and around coastal areas.

The joint Australian Government, state and territory commitment of $261 million for the 5-year Disaster Risk Reduction Package (2019–20 to 2023–24) also funds initiatives that are aligned with priorities of the Sendai Framework. The Australian Government's funding contribution seeks to support states and territories in reducing disaster risks at the state and local levels, and to deliver initiatives, in consultation with the states and territories, that reduce disaster risk at the national level for the benefit of all Australians.

The Australian Government is also taking action to reduce disaster risks by making changes to the Emergency Response Fund to establish the Disaster Ready Fund, which will make up to $200 million available annually (from 2023–24) for disaster prevention and resilience initiatives. This disaster risk reduction funding supports climate change adaptation projects, including flood levees, cyclone shelters, fire breaks and evacuation shelters, to protect lives and lower the cost of disasters.

Case study: Predicting flood extent and depth for emergency management authorities

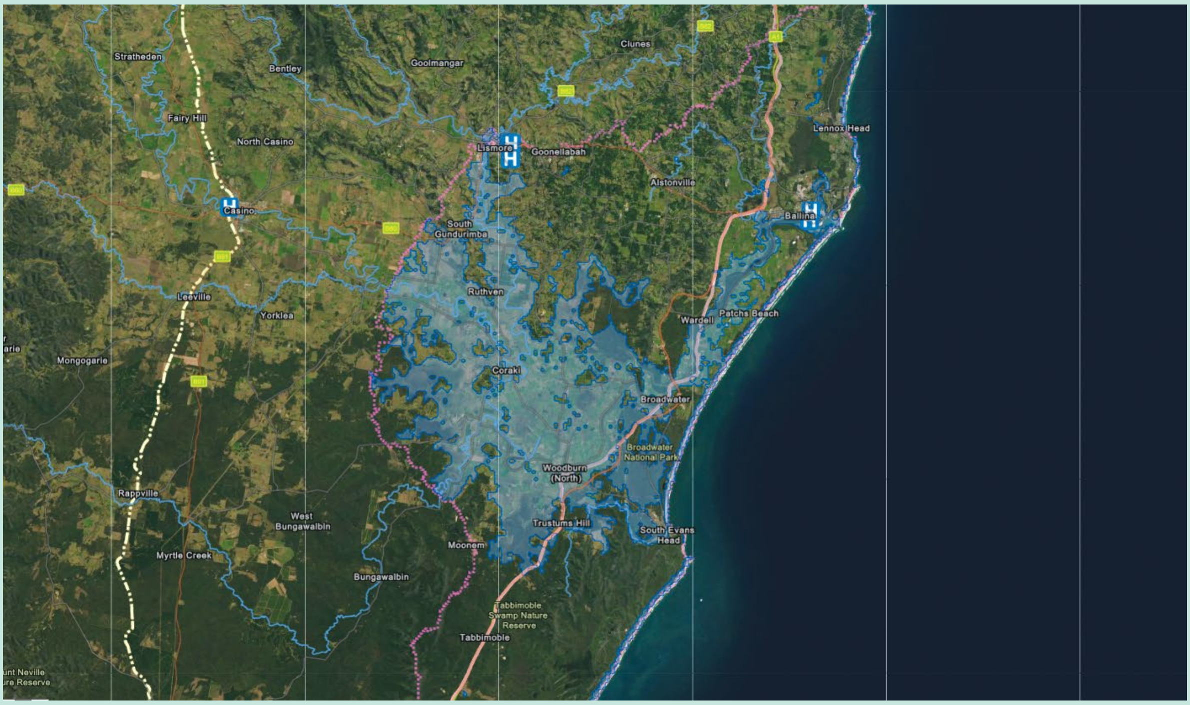
Areas along the east coast of Australia experienced floods in February, March, April and July 2022. The floods in February and March 2022 were particularly severe and led to the declaration of a national emergency for the flooded areas of New South Wales. Record floods were experienced in several locations, where they overtopped riverbanks and flood barriers, and caused extensive damage.

The floods were linked to climate conditions, including warmer than average waters in the Coral Sea and a La Niña event, which contributed to episodes of intense rainfall on already saturated soils. The Bureau of Meteorology had anticipated the likelihood of flood events during Australia's typical high-risk weather season from September to April.

The Australian Climate Service is supporting the National Emergency Management Agency in predicting flood extent and depth based on rainfall forecasts. This is a complex challenge that depends on the state of catchments, tides, rainfall and topography.

A proof-of-concept predictive flood inundation tool to predict floods in areas of coastal catchments in New South Wales, Queensland and the Northern Territory was trialled in February and March 2022. The timing coincided with the first of the east coast flood events. The areas of inundation (shown in light blue in Figure 6.4) were analysed with socioeconomic data to assist decision-makers in understanding who may be impacted by these events, and what businesses and supply chains were at risk. This informed response and relief decisions. The system will be developed further in 2022–23.

Figure 6.4: Screenshot from the flood intelligence tool. Light blue shading indicates areas of forecast inundation for Lismore, 8 March 2022



6.4 Australian state and territory government adaptation policies and strategies

As part of Australia's whole-of-nation approach, state and territory governments have an active and significant role in furthering climate adaptation, pursuing strategies and programs specific to their communities and regions. This work involves significant levels of collaboration, including with the Australian Government, other states and territories, and local governments.

All state and territory governments have produced publicly accessible material describing the observed and potential impacts of climate change specific to their jurisdiction, including:

- *Climate change snapshot* – Australian Capital Territory
- Regional climate change snapshots – New South Wales
- *State of the science and climate change impacts* report – Northern Territory
- Climate science and knowledge resources – South Australia
- Climate Futures for Tasmania
- Future Climate Tool – Victoria
- Climate Science Initiative – Western Australia.

These materials assist local, state and territory governments, as well as industry and communities, to prepare for the impacts of climate change. Research programs aim to inform and develop adaptation strategies (see also section 8.1.4).

6.4.1 Australian Capital Territory

6.4.1.1 Climate change impacts

Warming trends projected for the Australian Capital Territory are significant, with certain climate change impacts already 'locked in'. Using data from New South Wales and Australian Regional Climate Modelling (NARCliM) 1.5, the following climate change impacts under a high-emissions (RCP 8.5) scenario are projected to affect the Australian Capital Territory in 2045 compared with the 2000 baseline:

- higher average temperatures, with an increase of about 1.6 °C in both the average minimum and maximum daily temperatures
- 6 more days above 35 °C each year
- 29 fewer days below 2 °C each year
- increase in extreme weather events, including extreme rainfall
- increase in average and severe Forest Fire Danger Index days.

The Australian Capital Territory has already experienced severe weather events because of this warming trend. The Black Summer bushfires, followed by substantial hail and flooding events in Canberra, have already led to significant impacts on both natural ecosystems and the Australian Capital Territory economy.

6.4.1.2 Adaptation policies and strategies

The ACT Government has introduced several policies and strategies that seek to build the adaptation and resilience of Canberra's natural ecosystems and the community to the impacts of climate change. Examples include:

- ACT Nature Conservation Strategy
- ACT Planning Strategy (including the Planning System Review underway)
- Canberra's Living Infrastructure Plan: Cooling the City
- Climate Change Strategy 2019–2025
- Gawari Ngilanmanyin ('Remembering the bush'): a climate-wise landscape guide to the ACT
- Parliamentary and Governing Agreement of the 10th Legislative Assembly.

6.4.1.3 Monitoring and evaluation framework

The ACT Government undertakes a longitudinal community resilience survey on climate change every 5 years – the next is due in 2023. The last survey results from 2018 indicated that two-thirds of adults in the ACT region (66.9%) have moderate to high resilience to the expected effects of climate change, while one-third have low or very low (33.1%) resilience and are highly vulnerable to negative impacts from the effects of climate change.

Canberra's Living Infrastructure Plan has a target of 30% tree canopy cover (or equivalent) and 30% permeability target for surfaces in Canberra's urban footprint by 2045. Progress towards these targets is monitored through analysis of light detection and ranging (LiDAR) data of Canberra taken on a 5-yearly basis.

A monitoring and evaluation framework is being established around the implementation of energy efficiency policies and programs that aim to increase community resilience by reducing energy hardship and improving thermal comfort for low-income or otherwise vulnerable households. A range of monitoring and evaluation activities under this framework are also currently being developed to be implemented over coming years.

6.4.1.4 Progress and outcomes of adaptation action

Natural domain

The Australian Capital Territory is committed to the protection, conservation and restoration of its natural ecosystems, which are facing increasing pressure from the impacts of climate change.

The ACT Government has implemented 2 strategies that include actions to address the risks posed by the changing climate:

- The ACT Nature Conservation Strategy 2013–23 sets priorities for conservation action and helps to guide future planning of the Territory's open spaces, rural areas, urban areas, riverine corridors and nature reserves, and guide investment of funding and resources in nature conservation. This includes completing the Woodlands Restoration Program, which restored and connected 60,000 hectares of the largest remaining box gum grassy woodland in Australia.
- The ACT Biosecurity Strategy 2016–26 prioritises the effective management of biosecurity risks, which is critical to minimising the impacts of weeds, pest animals, and plant and animal pests and diseases on our economy, environment and the community.

The Nature Conservation Strategy Implementation Plan 2019–23 sets out new focus areas for the nature strategy, including:

- working with rural landholders to promote native vegetation and biodiversity
- supporting Traditional Custodians to apply land management methods on Country
- strengthening partnerships for conservation, including cross-border collaboration.

The ACT Government manages the ACT Environmental Grants Program, which is designed to provide opportunities for the community to address environmental issues they are concerned about with work that supports healthy and resilient reserves, parks, urban green spaces and rural lands, and offers protection for important local species and ecosystems. In the 2022–23 round of this program, more than $500,000 in grant funding was provided to more than 30 applicants.

In the agriculture sector, the ACT Government released a Capital Food and Fibre Strategy Discussion Paper in April 2022. The strategy proposes to address the key impacts of climate change on food systems by building drought resilience in the ACT farm sector. It will recognise Traditional Custodians' knowledge of land management and use of native plants and animals across Canberra to determine the best way forward for food and fibre production. The strategy will build on existing work such as the ACT Natural Resource Management's Sustainable Agriculture program, which aims to support healthy farm ecosystems, and improve productivity and farm income affected by challenges including soil erosion and acidification, drought and climate change, and loss of biodiversity. A Drought Resilience Plan is also being developed, partly funded through the Australian Government's Future Drought Fund.

The ACT Government is implementing its ACT Water Strategy 2014–2044: Striking the Balance as part of a broader water management program for the Territory. This strategy was released to support the Territory after it emerged from drought, and the priority shifted from a single water security focus to addressing new challenges for water resource management, including deteriorating water quality resulting from urban development, maintaining ageing stormwater infrastructure, and the need for enhanced stewardship of water resources and catchments. Key successes from this strategy to date include:

- establishment of the ACT and Region Catchment Management Coordination Group, an interjurisdictional coordination body committed to strengthening governance and catchment management in the Australian Capital Territory and surrounding regions for the long-term benefit of the ACT and region catchment
- commencement of the Australian Capital Territory– and Australian Government–funded ACT Healthy Waterways Project, which seeks to improve the quality of water entering Territory lakes and waterways that flow downstream into the Murrumbidgee River system
- delivery of the Upper Murrumbidgee Waterwatch Program to improve both community education and awareness of catchment health and effective catchment policy and management.

Built domain

The ACT Government has outlined several commitments to improving the resilience of Canberra's built environment in its Parliamentary and Governing Agreement of the 10th Legislative Assembly. Key commitments from the agreement include:

- adopting an ACT Appendix to the Building Code of Australia in conjunction with the Territory Plan Review, which will set out improved sustainability standards that all new buildings must meet, such as insulation, glazing, passive design, phasing out gas, and a requirement for electric vehicle charge points
- substantially lifting the quality and sustainability of the design and construction of new developments
- supporting clubs to become heat and smoke refuges for local communities, including ensuring appropriate air filtration systems, and financial payments for venues designated as official extreme weather refuge sites.

The ACT Government has also committed to several policies and programs that aim to improve the environmental sustainability of buildings in the Australian Capital Territory, including:

- the mandatory disclosure of residential energy efficiency ratings
- the Energy Efficiency Improvement Scheme
- commitments for climate-wise buildings under the ACT Climate Change Strategy 2019–25
- actions for improving building standards under several policies, such as the ACT Bushfire Smoke and Air Quality Strategy.

Canberra's Living Infrastructure Plan: Cooling the City is another significant policy designed to build adaptation and resilience to the impacts of climate change in the city.

Case study: Canberra's Living Infrastructure Plan: Cooling the City

Canberra is one of the fastest-growing capital cities in Australia and is expected to have more than 600,000 residents by 2050. Canberra is already feeling the effects of climate change, including higher temperatures and more frequent heatwaves. The urban heat island effect is exacerbating both daytime and night-time temperatures across the Australian Capital Territory.

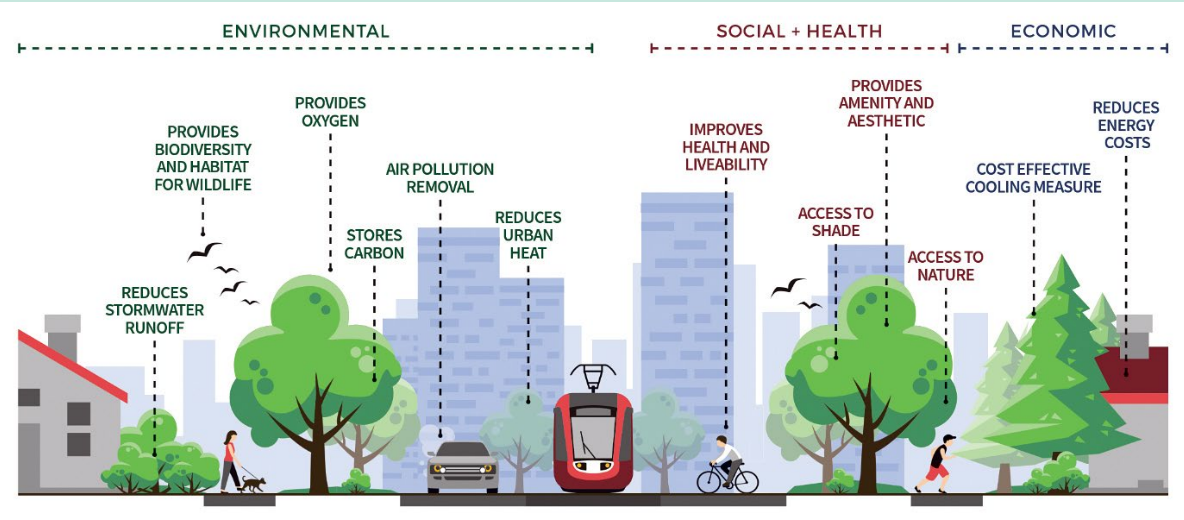
To address these impacts, Canberra's Living Infrastructure Plan: Cooling the City seeks to support Canberra as a growing city to adapt better to the effects of climate change. By 2045, the plan aims to provide Canberra's urban footprint with:

- 30% tree canopy cover or similar (e.g. green roofs, shrub beds, wetlands, rain gardens)
- 30% permeable surfaces (e.g. grass, gravel, porous paving).

Various actions under the Living Infrastructure Plan will contribute to its targets and outcomes. For example, in the 2021 autumn tree planting program, more than 4,000 trees were planted, and around 5,000 more will be planted during the 2021 spring tree planting program. Several further initiatives are also underway, including the development of a citizen science program and the provision of significant grant funding to a diverse range of community and environmental groups through the ACT Environment Grants and the ACT Nature in the City Grants programs.

The ACT Canopy Cover Map from 2020 shows the canopy cover across the Canberra urban area.

Figure 6.5: Everyday Climate Choices, 'Canberra's Living Infrastructure Plan: Cooling the City'



Social domain

Along with investment in the resilience of the built domain to protect residents, the ACT Government is taking steps to protect vulnerable Canberrans from the impacts of climate change by introducing energy efficiency programs and related measures aimed at increasing community resilience. These programs support thermal comfort for low-income or otherwise vulnerable households, including through:

- the introduction of a minimum energy efficiency standard for rental properties
- funding through the Household Energy Support Program, to provide support to low-income owners and households for sustainable home upgrades
- a pilot examining support for householders with chronic conditions who have high energy needs associated with one or more medical conditions
- funding to upgrade insulation in Housing ACT properties
- low-income utilities concessions and free home energy assessments to minimise energy hardship.

Disaster risk management

The ACT Government has invested in the improvement of its disaster risk management processes in response to the current and projected climate change impacts that are affecting the Australian Capital Territory.

The Australian Capital Territory's Emergency Management Plan includes hazard-specific subplans that are regularly updated to address natural disaster and extreme weather events that are being impacted by climate change. These include the Strategic Bushfire Management Plan, the Extreme Heat Sub Plan, the Flood Emergency Plan and the Storm Emergency Sub Plan.

Following the Black Summer bushfires, and subsequent flooding and hailstorms across Canberra, the ACT Government invested in building Canberra's resilience to natural disasters. The 2020 Bushfire and Flood Recovery Plan has ensured that opportunities to improve the resilience of ecological communities are seized, and that emerging risks from a changing climate are embedded in risk management processes.

The ACT Government has further undertaken an assessment of its risks to climate change through 2 key assessments:

- the Territory Wide Risk Assessment 2017, which provides a strategic level analysis of the natural hazards and other emergency risks, including climate change, facing the Australian Capital Territory and is currently being updated to identify emerging risks
- the ACT Climate Change Risk Assessment, which was commissioned in 2021 to improve understanding of the adaptation and resilience initiatives that are needed to manage the risks of climate change impacts to government.

6.4.2 New South Wales

6.4.2.1 Climate change impacts

The NSW climate has changed, creating significant changes in day-to-day weather patterns and a surge in disasters triggered by extreme weather events, such as floods and bushfires (Metcalfe & Costello 2021).

Since the pre-industrial period, New South Wales has warmed by 1.4–1.6 °C, which is 1.4 times faster than the global average (CSIRO & Bureau of Meteorology 2020). The state is likely to experience warming greater than 1.7 °C in the next 20 years (CSIRO & Bureau of Meteorology 2020). Climate change is also driving longer, hotter and more intense heatwaves in New South Wales. In Sydney, an extra 1,484 heat-related deaths occurred due to climate change between 1991 and 2018. More heatwaves are predicted under a high-emissions scenario, with an increase in the number of hot days over 35 °C by an average of 26 days per year.

Climate change is predicted to bring increased rainfall in summer and autumn, and decreased rainfall in spring and winter to New South Wales. Southern New South Wales has already experienced a 15% long-term decline in rainfall between April and October over the period 2000–2019 when compared with 1900–1999 levels (NSW Government 2022). At the beginning of 2020, 100% of New South Wales was in drought. Since 2017, many regions in New South Wales have faced the lowest rainfall and driest conditions in 120 years of records. In fact, 2019 was the driest and warmest year on record for New South Wales, and rainfall was 55% below average. The drought's economic, social and environmental impacts spread well beyond the farmgate, with communities experiencing significant financial and mental health hardships. The drought is estimated to have cost the NSW economy $5.7 billion of gross state product in 2018–19, with further estimated losses of $6.3 billion in 2019–20.

Floods cost people their lives, homes and livelihoods, and can have long-lasting impacts on communities. Floods are the most expensive type of disaster triggered by a natural hazard in Australia (Office of the Queensland Chief Scientist 2011). The 2022 flood events in New South Wales and Queensland are expected to be some of the most significant disasters economically in the recorded history of Australia (Climate Council 2022). The Insurance Council of Australia has recorded more than $3.3 billion worth of claims to date (Insurance Council of Australia 2022). The first 2022 flood in Lismore was the largest flood event in that city since records began in 1887. Four people lost their lives, and more than 2,000 premises became uninhabitable. As a result of climate change, the atmosphere is warmer and can hold more water, which can increase the intensity of flood events like those experienced in 2022 (NSW Government 2022).

New South Wales is predicted to experience earlier and longer bushfire seasons, with an increased number of high-fire-danger days with climate change. In the Black Summer bushfires, billions of animals were killed, injured or displaced, with more than 1 billion of them in New South Wales. Bushfire smoke cost Sydney's economy $12–50 million per day. Further economic impacts were faced by the tourism sector, with an estimated revenue loss of $4.5 billion.

6.4.2.2 Adaptation policies and strategies

The NSW Climate Change Policy Framework 2016 sets the NSW Government's long-term objectives of achieving net zero emissions by 2050 and helping New South Wales become more resilient to a changing climate. In June 2022, the NSW Government released the NSW Climate Change Adaptation Strategy, which sets out the NSW Government's approach to climate change adaptation, supported by funding of $93.7 million over 8 years.

The NSW Strategy sets 4 priority areas for NSW Government action:

- Develop robust and trusted metrics and information on climate change risk.
- Complete climate change risk and opportunity assessments.
- Develop and deliver adaptation action plans.
- Embed climate change adaptation in NSW Government decision-making.

Under the 4 priority areas, there are 16 actions, which set out a detailed program of work, including metrics development, research, development of climate change projections, adaptation communication, regular climate change risk and opportunity assessments and adaptation action plans, and actions to make climate change adaptation part of NSW Government decision-making. Climate change risk and opportunity assessments and adaptation action plans will be completed at least every 5 years, with the first to be released in 2023.

The NSW Government is partnering with the Canberra Region Joint Organisation and local councils to deliver the Blueprint for a Resilient South East NSW project. The project is delivering a regional resilience risk assessment, and will enable councils and communities in the region to better prepare for climate change. The project will empower councils to act, help embed climate change in decision-making, provide training to build capability, implement priority projects and build the case for investment in resilience. The project is co-funded by the NSW Government and the Australian Government.

Local Government NSW has partnered with the NSW Government Office of Energy and Climate Change in ongoing research on the resilience of local governments to climate change. This research presents the key findings from the latest survey of NSW local governments in relation to climate change. It explores topics including understanding of climate change across local government, actions and processes to prepare for and respond to impacts, and ways climate information is used by local government practitioners.

The Local Government Climate Change Toolkit was developed in consultation with council staff from the Local Government NSW Climate Action Professional Officers Group, which involved representatives from across New South Wales. The toolkit supports councils to assess their exposure to climate risk, make plans to adapt to potential impacts and reduce their emissions.

6.4.2.3 Monitoring and evaluation framework

The NSW Climate Change Adaptation Strategy includes actions to develop monitoring and evaluation for strategy actions and for the strategy itself. At least every 5 years, a panel of suitable experts will publish an evaluation report on the effectiveness of the strategy in building resilience and driving adaptation. The first evaluation report will be published in 2028, with future reports published at least every 5 years after that.

Under the strategy, the NSW Government will also publish whole-of-government climate change disclosures consistent with the Taskforce on Climate-related Financial Disclosures recommendations, and other leading international and national standards and guidance as they evolve. The first whole-of-government disclosure will be published in 2023.

The NSW Government will also publish data and projections on climate change risks, including the financial impacts of those risks, in the NSW Treasury Intergenerational Report, which is released every 5 years.

In late 2022, all NSW Government entities will be surveyed to understand their climate change risk management, planning and implementation of adaptation actions. The survey has been run every 3 years since 2015 and includes an assessment of adaptive capacity within each entity. The information is used to inform reviews and improvements to program design, including knowledge and capacity-building activities. Outcomes of the survey are reported to each responding entity so that they can baseline their own performance and make plans to improve.

6.4.2.4 Progress and outcomes of adaptation action

Natural domain

Protecting the natural environment of New South Wales is a key objective of NSW climate adaptation work. Climate change is predicted to be the greatest long-term threat to biodiversity in many regions and is listed as a key threatening process in state and Commonwealth legislation.

The Gondwana Rainforest is a World Heritage–listed area in northern New South Wales with exceptional biological diversity, and examples of the record of life on Earth and ongoing evolutionary processes. Climate change has been identified as the highest level of threat to the site's species and ecological communities. The Gondwana World Heritage Climate Change Adaptation Project integrates climate change adaptation into on-ground management to support conservation. It is anticipated that the processes from this project could be applied to other World Heritage properties in Australia.

The Saving our Species program provides a framework that aims to increase the number of NSW threatened species that are secure in the wild for the next 100 years, and control the key threats facing threatened plants, animals and ecological communities, including climate change. The program includes translocation projects to create climate refugia, particularly for threatened plants, and has work streams focused on increasing the capacity to respond to emergencies such as bushfires, floods and droughts to safeguard key species. The Biodiversity Indicators Program is also developing an indicator for the extent, frequency and intensity of physiological stress predicted for plants and animals due to climatic extremes, and how this has changed over time. It is also developing an indicator on the management effectiveness of planning for adaptation under climate change that is being implemented to support ecosystems.

The Biodiversity Conservation Trust in New South Wales strategically invests in biodiversity conservation on private land in New South Wales. Conservation on private land allows a holistic 'landscape-scale' approach to the protection of biodiversity, increasing our ecosystems' resilience to the effects of climate change by connecting protected areas and providing pathways for the movement of species. Connectivity and resilience to climate change are one of 4 criteria used to determine which sites to prioritise for investment. As the climate changes, many species and entire ecosystems are adapting by following suitable habitat conditions into new areas. This includes moving south or to a higher altitude to stay within thermal limits, or to move to higher-rainfall environments to escape drought. Improving connectivity will help to build the resilience of the protected area system under climate change.

The NSW Government has taken action to improve water sharing, management and use across the state. NSW water resources are under increasing pressure from climate change, a growing population, and changing industry and community needs. The NSW Water Strategy takes a strategic and integrated approach to improve the security, reliability, quality and resilience of NSW water resources over the long term.

Built domain

The NSW Government is committed to addressing the impacts of climate change on its built environment. The Cross-Dependency Initiative (XDI) NSW project is an international award-winning project that increases the resilience of critical infrastructure. It is run by the NSW Government in partnership with private enterprise. XDI delivers innovate risk management tools and technology that identify and quantify direct risks and the transfer of risks between critical infrastructure.

The NSW Increasing Resilience to Climate Change council grants helped address climate change risks and vulnerabilities facing NSW councils. They provided funding to address climate change risks and assist NSW councils to plan for and respond to heatwaves, storms, floods, drought and bushfires. A total of $2.8 million in grant funding was awarded to 32 councils and regional groups of councils over 3 funding rounds. All projects were completed by July 2022. Case studies are available of completed projects, showcasing outcomes and lessons learned. Resources developed through the program include guidelines, studies and educational resources.

The Cooler Classrooms program improves thermal comfort and air quality for students and teachers around the state, through a $500 million investment from the NSW Government. The 5-year program delivers sustainable air-conditioning, heating, fresh air ventilation systems, solar photovoltaics and battery storage to up to 922 existing schools.

The NSW Government is increasing the tree canopy in parks, streets and neighbourhoods through the Five Million Trees for Greater Sydney by 2030 project, which supports tree planting initiatives. The project is increasing the resilience of the Greater Sydney area to climate change while reducing urban heat. As well as providing much needed shade and shelter from heat, it will improve air and water quality, and improve health and wellbeing of citizens.

Social domain

Since 2014, the NSW Government has provided NSW communities, businesses, households and government with information and advice on how to adapt to climate change. AdaptNSW is a trusted source of information that provides relevant, localised information and empowers people to act.

The cultural values of Worimi Conservation Lands are being damaged and lost due to climate change impacts. In particular, middens, artefacts and burial sites in the dunes have been exposed and damaged by east coast lows, exacerbating the impacts of sand movement due to nearby sand mining. The Worimi Conservation Lands Board of Management recognises that the risk of further erosion and damage is high. The board is being supported by the NSW Government to make proactive and informed decisions about how to respond to climate change impacts, both now and in the future.

To date, the work has involved collecting data on the movement of dunes, works to stabilise the dunes, and developing a climate change adaptation plan. This plan outlines the cultural values of significance to the Worimi people, as well as the climate change risks and the priority actions that will protect both tangible and intangible cultural values.

Disaster risk management

The Climate Risk Ready NSW program builds the capability of state and local governments to assess and manage climate change risks to protect government assets, infrastructure and services. The program delivers the Climate Risk Ready NSW Guide and nationally accredited training.

Through its bushfire management programs, the NSW National Parks and Wildlife Service helps protect communities and assets by implementing hazard reduction and responding rapidly to bushfires. There were 2,111 hazard reduction activities completed in 2020–21, including 143 hazard reduction burns and 1,968 mechanical activities.

The Hawkesbury–Nepean Valley covers around 500 square kilometres and has the highest flood exposure in New South Wales because of its unique landscape and large existing population. The Hawkesbury–Nepean Flood Risk Management Strategy is being delivered together with local councils, businesses and the community to reduce the potential social and economic impacts of flooding, which unfortunately occurred in both 2021 and 2022.

As one of the largest coastal catchments in New South Wales, the Hunter Valley has always experienced flooding, and this flooding will continue as the climate changes. The Hunter Valley Flood Mitigation Scheme aims to reduce the impact of flooding on communities and ecosystems. The scheme is valued at $862 million and involves more than 830 individual assets such as levees, floodgates and drains throughout the Hunter Valley's rivers and floodplains. It reduces potential damage to properties by controlling the velocity, direction and depth of floodwaters.

With floods and storms predicted to become more extreme as the climate changes, the Floodplain Management Program is undertaking important activities to manage flood risk and build community resilience across New South Wales. The program works to reduce the impacts of flooding and flood liability on communities, and reduce private and public losses. Floodplain Management grants provide technical and financial support to councils and eligible public land managers to make informed decisions about managing flood risk by preparing and implementing management plans. In 2020–21, $5.4 million in funding was provided to 26 local government projects to deliver integrated floodplain management under the Climate Change Fund.

Changes in the NSW coastal environment are monitored and assessed by the Manly Hydraulics Laboratory's extensive data collection network. The laboratory maintains and operates a network of 178 flood and 46 estuary automatic water level recorders, 20 ocean tide sites, 75 rainfall recording stations and 7 offshore Waverider buoys. The data allow changes in the coastal environment to be monitored and assessed, and provide an improved understanding and awareness of current and future risks of flooding and coastal hazards. The data are also used by emergency agencies to generate warnings during extreme weather events.

6.4.3 Queensland

6.4.3.1 Climate change impacts

Queensland often experiences climate extremes such as floods, droughts, heatwaves and bushfires. Climate change is likely to exacerbate the frequency and severity of these events. Queensland will increasingly be affected by changes in temperature, rainfall, sea level and extreme weather conditions. The range of likely impacts to Queensland's climate in the coming years and decades presents opportunities and risks. Some of the likely climate change impacts for Queensland across different sectors include:

- erosion and infrastructure damage along the coastline
- increased threats to tourism infrastructure
- disruption to supply chains
- damage to cultural sites
- heat stress on livestock and crops
- coral bleaching
- more heat-related deaths
- increased fire season duration and fire intensity.

More information about climate change impacts is available in regional climate change impact summaries.

6.4.3.2 Adaptation policies and strategies

The Queensland Climate Adaptation Strategy 2017–2030 (Q-CAS) was released in 2017 with a vision for an innovative and resilient Queensland that addresses the risks and harnesses the opportunities of a changing climate. Q-CAS now forms part of the Queensland Climate Action Plan 2020–2030.

Q-CAS outlines 18 actions across 4 complementary pathways to address the climate adaptation needs of the community, governments and businesses:

- People and knowledge – empower best-practice climate science, education and engagement to support climate risk management within Queensland's communities.
- State government – embed the consideration of climate adaptation into policies, regulations and procedures, and address risks to assets and services.
- Local governments and regions – partner with local governments and other regional organisations to develop regional adaptation solutions, including embedding climate risk in planning and development decisions.
- Sectors and systems – assist sector leaders to collaborate with government agencies, local governments and other stakeholders to identify adaptation needs and prioritise adaptation activities.

6.4.3.3 Monitoring and evaluation framework

The Queensland Government is developing a monitoring and evaluation framework for both climate change adaptation and mitigation activities under the Queensland Climate Action Plan.

6.4.3.4 Progress and outcomes of adaptation action

Under Q-CAS, the Queensland Government has prepared Sector Adaptation Plans to prioritise climate change adaptation activities across key sectors and systems. Seven plans have been developed through collaborations with sector stakeholders, including agriculture, built environment and infrastructure, tourism, human health and wellbeing, biodiversity and ecosystems, small and medium business, and emergency services.

The Queensland Climate Ready program has been operating for more than 4 years, and supports Queensland Government departments to understand their climate risks and capacity to manage these risks. Three departments have completed their risk assessments, and 3 are in the process of doing so.

As part of the Queensland Climate Resilient Councils program, the Local Government Association of Queensland has developed a draft Climate Risk Management Framework for Queensland Local Government.

Queensland has also developed climate risk management tools to help households and small businesses through the climate risk assessment process and support adaptation decisions.

Natural domain

A Biodiversity and Ecosystems Climate Adaptation Plan was released in 2018. The plan was developed by sector leaders, and focuses on the challenges and opportunities that climate change poses to Queensland's natural terrestrial, freshwater and marine systems.

The Queensland *Water Act 2000* was amended in 2021 to ensure that water plans consider the long-term effects on water supply and security. The Queensland Government supports and coordinates the Queensland Water Modelling Network, a community of practice involving water sector professionals from state and local governments, utilities, researchers and consultants. This network is progressing a portfolio of work around incorporating climate projection information into water modelling for more sustainable management of water resources over the longer term.

The Queensland Government funded a research project with Seqwater and University College Dublin to develop a methodology for the inclusion of paleoclimate data into climate adaptation planning and water security programs, released in 2021. A key lesson from this work is that the historical observations post-1900 do not capture the full range of climatic variability that has occurred in Queensland over longer timescales. This project has delivered an online paleoclimate database of all local and remote data that can be used to better plan and prepare for extreme floods and droughts in Queensland under a changing climate.

The Queensland Government's LongPaddock website provides climate information, seasonal forecasts and decision-support tools to help producers improve their climate risk management.

Case study: Drought and climate adaptation in the Queensland agriculture sector

Queensland farmers face the challenge of farming in Australia's most disaster- and drought-prone state, and managing regions with some of the world's most variable rainfall. The Drought and Climate Adaptation Program (DCAP) is helping farmers better manage these drought and climate risks, and adapt to climate change by developing and delivering improved seasonal forecast products, decision-support tools and on-farm activities.

Climate scientists, government and non-government agencies, farmers and industry leaders are working together to improve business and climate resilience across Queensland grazing, cropping, sugarcane and horticulture industries. The DCAP delivery model focuses on applied research and development that results in adoption outcomes and practice change at the farm business level, including:

- forecasts of rainfall and temperature extremes
- customised climate and pasture growth forecasts for the grazing industry in northern Australia (rainfall burst forecasts, pasture growth alerts)
- understanding production impacts of critical temperature thresholds for horticultural crops, which supports decisions to diversify crop type and growing location (Climate Monitor)
- tools for understanding, measuring and reducing on-farm emissions (HortCarbon Info Tool)
- parametric insurance options to transfer risk (e.g. for cyclones and other climate extremes)
- the economics of drought management options across Queensland grazing industry regions
- strategies that overcome social and other barriers to adoption of climate-sensitive management practices.

Using these tools and information helps producers make better-informed management decisions, and improves their adaptive capacity to improve management of climate risks and opportunities, and climate change impacts.

Independent DCAP evaluation is demonstrating how farmers are adopting new technologies and practices to improve their business management. Over the life of DCAP since 2016, the program has engaged more than 15,000 farmers across more than 1,200 workshops, field days, webinars and other engagement activities. Queensland farmers are also sharing their stories of management changes that show their improved ability to manage climate risks that challenge their business, with more than 70 case studies and 123 narratives collected. More than 1,600 examples of practice change have also been recorded in the program to date.

Independent cost–benefit analysis has demonstrated a cost–benefit ratio of 1:5.3, considered to be at the high end for programs of this type across Australia.

Photos: Agriculture in Queensland, Department of Agriculture and Fisheries (Queensland)

Built domain

Climate risks to transport infrastructure are being managed through the Climate Change Risk Assessments for Infrastructure Projects.

Social domain

A human health and wellbeing Sector Adaptation Plan was released in 2018. Queensland was the first state or territory to have a detailed climate adaptation plan for health and wellbeing.

As at March 2022, Queensland Health has taken action to foster a climate-ready and environmentally sustainable public health system. The Climate Risk Strategy and the Climate Change Adaptation Planning Guidelines outline the plan to adapt to the impact of a changing climate on the health system.

The Queensland Government is partnering with the Local Government Association of Queensland to help Queensland local councils manage their climate risk through the Queensland Climate Resilient Councils (QCRC) and Qcoast2100 programs.

QCRC was established in 2016 and is delivered via the Local Government Association of Queensland through a partnership arrangement with the Department of Environment and Science. The QCRC program provides services and products to help local governments better plan and respond to climate change. On joining, council staff and members receive a face-to-face briefing on climate change risks and a governance assessment. There are now 54 Queensland local governments in the QCRC program.

The Queensland Government is investing $16.2 million to help coastal councils and their communities plan and prepare for coastal hazards (storm tide, coastal erosion and rising sea levels from climate change) through the Qcoast2100 program. The aim of the Qcoast2100 program, delivered in partnership with the Local Government Association of Queensland, is to enable councils to identify areas vulnerable to coastal hazards and assets at risk, and to develop Coastal Hazard Adaptation Strategies (CHAS) to identify adaptation measures for existing assets and inform planning for future development. As of August 2022, 37 of the 41 coastal councils in Queensland had been awarded funding under Qcoast2100, and most had completed a CHAS. The Qcoast2100 program received $3 million in 2021 to commence implementation of critical actions and works recommended in a CHAS.

Disaster risk management

The Queensland Future Climate website provides access to hazard assessments and case studies for heatwaves and water security. The Queensland Government has developed statewide risk assessments that can support future decisions, including the Queensland State Heatwave Risk Assessment 2019 and the Severe Wind Hazard Assessment for Queensland. Regional resilience strategies have also been developed; to date, regional resilience strategies have been delivered for the Central West and Mary regions.

The Tropical Cyclone Hazard Dashboard is a new application informing the current and future risk of severe winds from tropical cyclones across Queensland's regions and communities. The dashboard is an example of collaborative hazard assessment using Queensland's high-resolution climate simulations to build preparedness for natural disasters.

6.4.4 South Australia

6.4.4.1 Climate change impacts

South Australia will experience changed weather patterns, and more frequent and intense extreme weather events, including heatwaves. For Adelaide, the number of days over 40 °C is projected to approximately double by 2030, compared with the 1981–2010 period. Over the past decade (2012–2021), temperature observations show an average of more than 5 days a year over 40 °C in Adelaide, indicating that the rate of increase of very hot days could be greater than projected.

There has been a decline in average rainfall in the state, particularly in the southern agricultural regions, which is projected to continue. By 2030, annual rainfall across the state is projected to decline by between 1.7% and 6.8%, compared with the average of 1986–2005. By 2050, annual rainfall is projected to decline by between 4.0% and 23.0% compared with 1986–2005, depending on the region. Across all South Australian regions, rainfall declines are projected to be greater in spring than in any other season.

It is projected that the amount of time spent in drought will increase for all South Australian regions. The Murraylands, and Riverland and Limestone Coast landscape regions (southern regions) could see a 40% increase in time spent in drought to 60% by 2030, and a similar proportion for 2050. The Alinytjara Wilurara and SA Arid Lands landscape regions (northern regions) are projected to have a slight increase in time spent in drought by 2030 and a small additional increase by 2050.

An increase in the amount of rain falling in extreme rainfall events in southern Australia has been observed in recent decades, increasing the risk of flooding. Short-duration extreme rainfall events are often associated with flash flooding, and so these changes in intensity bring increased risk to communities.

The Forest Fire Danger Index (FFDI) takes measures of fuel dryness, temperature and wind speed to provide a measure of fire danger. There has been a trend of increase in the FFDI over more than 40 years over nearly all of South Australia.

Around 39–84 centimetres of sea level rise is projected to occur by the end of this century. Sea level rise is already being observed along the coasts of South Australia, consistent with these projections. The risks of coastal inundation are significantly increased with any rise in sea level.

6.4.4.2 Adaptation policies and strategies

The *Climate Change and Greenhouse Emissions Reduction Act 2007* (SA) sets South Australia's legislative framework for action on climate change.

Regional climate adaptation plans were completed for all state government regions by 2016. Regional leaders – including councils, landscape boards, Local Government Associations and Regional Development Australia organisations – partnered with the SA Government to develop the plans. The plans were based on assessments that identified the key risks to industry, the community and the natural environment, and the identification and prioritisation of adaptation options.

Green Adelaide is a statutory board established in July 2020 by the SA Government to create a cooler, greener, wilder and climate-resilient Adelaide. Green Adelaide is leading the creation of the first Urban Greening Strategy for metropolitan Adelaide. The strategy will bring together different sectors, knowledge and resources with a focus on reducing hard surfaces, increasing tree canopy cover (see also section 6.4.4.4), and meeting the urban green cover target of the 30-Year Plan for Greater Adelaide. The strategy will prioritise areas that are the most vulnerable to heat.

6.4.4.3 Monitoring and evaluation framework

The *Climate Change and Greenhouse Emissions Reduction Act 2007* (SA) sets out biennial reporting obligations for the SA Government. All reports under the Act, which draw from data produced by the Australian Government's national greenhouse gas inventory, are publicly available.

The Premier's Climate Change Council, an independent advisory body to the SA Government, assists in monitoring implementation of climate initiatives.

6.4.4.4 Progress and outcomes of adaptation action

Natural domain

South Australia has established a network of protected areas on public, private and Aboriginal-owned land, which secures long-term conservation of ecosystems. Areas protected under the *National Parks and Wildlife Act 1972* (SA) and the *Wilderness Protection Act 1992* (SA) make up 21.5% of the state. South Australia also has several marine parks.

Other important legislative mechanisms to protect natural ecosystems include:

- *Native Vegetation Act 1991* (SA) – provides incentives and assistance to landowners in relation to the preservation and enhancement of native vegetation, controls the clearance of native vegetation, and other purposes
- *Landscape South Australia Act 2019* (SA) – promotes sustainable and integrated management of the state's landscapes, makes provision for the protection of the state's natural resources, and other purposes.

In addition, the SA Government intends to introduce a new state biodiversity Act to protect biodiversity in the long term and facilitate more climate adaptation–oriented approaches to conservation.

Eight Regional Landscape Boards and the Green Adelaide Board (metropolitan) have been established under the *Landscape South Australia Act 2019* to deliver initiatives across the state to sustainably manage landscapes. Each board has developed individual Regional Landscape Plans, with climate change being identified as a key priority, driver or risk to be considered.

The *Coast Protection Act 1972* (SA) was enacted for the conservation and protection of the beaches and coast in South Australia. The Coast Protection Board was established to provide strategic oversight of the coast and exercise its functions in accord with its policies. Allowances for climate change–induced sea level rise have been included in the board's policies and implemented since 1991.

The Coast Protection Board continues to invest in key data to refine identification of coastal hazards, undertake flood mapping, and identify and protect priority coastal ecosystems. The Coast Protection Board, supported by the SA Department for Environment and Water, has:

- supported the management and protection of the Adelaide metropolitan coast
- provided guidance and direction to councils and other stakeholders on the sustainable use and development of the coast, including advice on protection from coastal hazards
- administered grants programs to support coastal councils to design and construct protection works
- commissioned studies to determine risk and adaptation options for coastal hazards.

The SA Government is working with industry to help the state's primary industries and regions adapt and respond to climate change. A range of policy, research and projects are being developed and delivered to prepare for known climate risks and impacts, as well as to reduce emissions and waste. This includes work on:

- the use of climate information in the cropping, livestock, and fisheries and aquaculture industries for decision-making, as well as future land and aquatic management
- productive and climate-resilient field and irrigated crops, including new crops for farming systems
- climate-resilient pasture systems, regenerative agriculture and carbon farming systems
- emissions reduction in livestock, particularly through feed supplements and feed base changes
- carbon sequestration opportunities for forestry production.

The SA Government has a comprehensive water planning, licensing and management system that manages limited water supplies. South Australia is diversifying water supplies and storages, including through the use of desalinated water, recycled water, and stormwater capture and reuse.

A Water Security Statement has been developed, which sets out priorities to ensure that South Australia's water resources continue to meet the needs of the environment, communities and economy.

An Urban Water Directions Statement has also been released, which outlines priorities and management principles that will inform future water infrastructure delivery, policy settings and organisational arrangements. Strategies for securing water resources in the changing climate are a key focus.

Built domain

In South Australia, significant planning system reforms have seen a staged implementation of the *Planning, Development and Infrastructure Act 2016* (SA), which is now operational. The reforms included consideration of climate change impacts with the full operation of the Planning and Design Code, a key planning instrument under the Act for the purpose of development assessment. The SA Government intends to undertake an implementation review of the Act and the Code to explore opportunities to deliver greater tree canopy coverage and green open space, and for the Code to be sensitive to biodiversity and future water needs.

Green Adelaide has delivered several initiatives, including:

- capture of LiDAR (light detection and ranging) data on tree canopy and urban heat, to be used to increase urban green cover
- capacity-building programs and courses across metropolitan Adelaide for households and schools
- grant programs to increase green infrastructure
- a Greening Prioritisation pilot study to identify priority areas for urban greening across metropolitan Adelaide
- development of guidelines to support tree planting and landscaping requirements of the urban planning code.

Case study: Urban heat and tree canopy mapping across South Australia

Over 2016–2020, 4 local government Regional Climate Partnerships (Resilient South, Adapt West, Resilient East and Adapting Northern Adelaide) partnered with state government agencies to undertake thermal imagery and LiDAR (light detection and ranging) data capture and mapping to provide a baseline for measuring future changes in urban heat and tree canopy cover.

Thermal imagery was captured during periods of sequentially hot days and analysed to identify areas that were hotter than their adjacent surroundings – these areas are commonly referred to as urban heat islands.

LiDAR data were captured and analysed to create several layers that can be used to map canopy extent and height for all vegetation greater than 3 metres in height. The layers include:

- digital canopy model / canopy height model, which describes the horizontal extent and vertical height of tree canopies
- tree canopy boundaries, showing the precise horizontal extent of tree canopies
- tree canopy coverage by unit area, describing the percentage of tree canopy per 100 square metres.

These data can be used by local councils and state government agencies in their own mapping systems alongside other datasets to help improve decision-making, refine policies, and target investment and action – for example, identifying where new street trees, vegetation and water-sensitive urban design initiatives could provide the greatest benefit for communities, and identifying where building footprints have changed.

The data are accessible on the SA Government Department for Environment and Water Urban Heat and Tree Canopy Mapping Viewer.

Social domain

The South Australian Health and Wellbeing Strategy 2021–2025 acknowledges the risk of climate change to health and wellbeing. Action to reduce emissions, adapt to climate change and build sustainability is included in this approach.

The SA Government is delivering the Healthy Parks Healthy People SA 2021–2026 initiative, by opening up the state's parks, and promoting the positive health values of quality green spaces and green infrastructure. This initiative resulted from a Public Health Partner Authority Agreement between the Department for Health and Wellbeing, Wellbeing SA and the Department for Environment and Water.

Many in the SA community are taking action to adapt to extreme heat, including state and local governments, regional stakeholders and research institutions. For example, SA Health is undertaking community education and engagement to manage personal heat-health impacts.

The SA Government supports Regional Climate Partnerships, which are regional, cross-sectoral groups delivering practical action to strengthen the climate resilience of their communities, economies, and natural and built environments across the state. Partners include councils, regional organisations of councils, Regional Development Australia organisations, Landscape Boards and the SA Government.

Some of the Regional Climate Partnerships are underpinned by sector agreements established under the state's climate change legislation. Sector agreements support collaboration, and align regional and on-ground climate actions with broader statewide climate change policy directions.

The SA Government also collaborates with local governments on a range of projects to reduce emissions and increase resilience, including urban greening, heat mapping and integrating climate change risks into asset management.

Case study: Kaurna Kardla Parranthi Cultural Burn

In 2021, the Kaurna community, Green Adelaide and the City of Adelaide Council collaboratively delivered the Kaurna Kardla Parranthi Cultural Burn Project in a remnant biodiversity area in the Adelaide Park Lands. Planning for the Cultural Burn began in 2019 when several workshops were held between the Kaurna Community, the City of Adelaide and the SA Government (Green Adelaide, and the National Parks and Wildlife Service). The workshops were held soon after Kaurna had been granted native title over their Country, and were well attended by both Kaurna Elders and young Kaurna people. These events allowed the Kaurna community to voice their aspirations for greater involvement in the planning and management of caring for their Country, and highlighted the desire to bring fire back to their country through cultural burning.

The project involved the reintroduction of traditional fire management practices into the Adelaide Park Lands for the first time in more than 240 years. The project is a demonstration of the strong partnership that has been established between the Kaurna community and state and local governments.

Considerable research and evidence suggests a correlation between an absence of traditional Aboriginal ecological land management practices and large-scale, extreme weather events, such as bushfires. For many thousands of years, First Nations peoples managed their land with fire, using 'cool burns' to clear land, germinate seed and attract animals. The reduction in Aboriginal land management practices has contributed to accumulation of a larger unmanaged fuel load – resulting in hotter fires, less habitat and food for animals, and an increase in invasive species.

The application of traditional ecological knowledge is intrinsically linked with Healthy Country/Healthy Community principles. Reaffirming Aboriginal fire management as a critical component of natural resource management, underpinned by positive ecological outcomes, will benefit First Nations communities and local government, as partnerships with Traditional Owners diversify and the collective knowledge is applied to manage Country.

Photo, Kaurna Kardla Parranthi Cultural Burn, SA Government

Case study: Resilient Asset Management Project – Resilient South

The Resilient Asset Management Project (RAMP) is a collaborative project between the 4 Resilient South councils (Cities of Marion, Mitcham, Holdfast-Bay and Onkaparinga) and the SA Government, in collaboration with CSIRO and the Value Advisory Partners' Enabling Resilience Investment initiative.

RAMP was initiated to develop an approach that will support councils to:

- understand how asset management decisions contribute to regional resilience
- understand the magnitude of climate change risks to selected asset classes and the functions they provide
- identify risk mitigation options to incorporate climate risk and adaptation considerations into existing council systems and processes
- identify effective mechanisms for funding response options and actions, and the institutional settings and requirements to enable these to be implemented.

Weather events have had significant and costly impacts on council assets across South Australia, and are projected to be more frequent and extreme. Climate resilience means being able to prepare for, cope with and recover from the impacts of weather-related events so that communities can stay productive, connected and strong. Council assets support community resilience in transport networks, community events, flood mitigation and emergency management. Resilient assets are those that can function effectively and benefit their communities in a changing climate.

Phases 1 and 2 of RAMP have been completed, delivering:

- a Research and Recommendations report that provides background on the context for RAMP, a summary of asset management systems and processes within the councils, a summary of barriers to change, a description of potential tools and approaches to be used by RAMP in the pilot project, and recommendations regarding the pilot project
- a tool to assess asset management with a climate resilience focus, based on existing asset maturity assessment frameworks, that will be tested with the councils and shared with other councils
- a specification for a pilot project to assess risks to selected asset classes, identify mitigation options, understand the costs and benefits of action compared with inaction, and develop information to support investment decision-making.

The next phases of RAMP will implement the pilot project, and then capture, distil and share project learnings with stakeholders including other SA councils.

Natural disaster risk

The Department for Environment and Water has produced a *Guide to climate projections for risk assessment and planning in South Australia 2022*, which outlines the risks of future weather-related hazards.

State emergency management supports prevention, preparedness, response and recovery for flooding events. Use of early warning systems, and investments in flood mapping, water-sensitive urban design, stormwater infrastructure and green infrastructure are being made to manage the impact of excess water in the landscape. The State Emergency Service has also released information on storm and flood for community awareness and preparedness, incorporating new national warning messaging.

The State Emergency Management Plan states that the SA Government may provide funding to local councils during and after a disaster. The financial support provided will vary, depending on the severity, nature and duration of the event.

6.4.5 Tasmania

6.4.5.1 Climate change impacts

Under a changing climate, Tasmania's terrestrial environments are projected to experience a rise in annual average temperatures of approximately 2.9 °C under a high-emissions scenario, and 1.6 °C under a low-emissions scenario. Temperature increases in Tasmania are less than the projected global average temperature rise, due to the moderating influence of the Southern Ocean.

Significant changes in seasonal and regional rainfall patterns are projected, including an increase in rainfall intensity and associated flooding. More hot summer days and heatwaves are projected, and fire seasons will become longer, with more days at the highest range of fire danger.

Coastal and marine environments will also experience significant impacts. Sea levels are projected to rise 0.17–0.22 m relative to 2010 values by 2050, and 0.22–0.70 m relative to 2010 values by 2100. Mean statewide sea surface temperature will increase in all seasons by the end of the century, and there will be a significant increase in pan evaporation of up to 19% by 2100. Increased frequency and intensity of storm events, and associated coastal erosion and inundation are also projected. Ocean acidification will increase, and there will be changes in nutrient levels and species distribution.

6.4.5.2 Adaptation policies and strategies

The Climate Change (State Action) Amendment Bill 2021 was passed by the Tasmanian Parliament in November 2022. It includes a range of measures that will improve the resilience of Tasmania's economy, community and environment to the impacts of a changing climate, including a requirement for the Tasmanian Government to:

- prepare a statewide climate change risk assessment within 2 years, and an update at least every 5 years
- partner with industry and business to develop sector-based emissions reduction and resilience plans within 2 years and update the plans at least every 5 years; the first transport plan will be prepared within 12 months
- prepare a climate change action plan within 2 years, and at least every 5 years thereafter. The Bill requires the action plan to include measures that build resilience to the impacts of climate change through adaptation measures.

Climate Futures for Tasmania (CFT) is the Tasmanian Government's most important source of downscaled climate change projections. CFT was developed in 2010 and provided the first fine-scale climate information for Tasmania. The Tasmanian Government has committed to reviewing and updating the downscaled climate projections for Tasmania under Tasmania's next climate change action plan. The government has committed to developing the action plan within 6 months of the passage of the Bill.

The Tasmanian Government has committed to developing a whole-of-government policy framework to embed climate change considerations in Tasmanian Government decision-making.

Following a 2018 analysis of Tasmanian local government's climate change governance, 17 of Tasmania's 29 councils participated in the Climate Resilient Councils program. Each council received a detailed project report that assessed how climate change is considered by the council, and suggested opportunities for further integration of climate-related risk management into council decision-making.

Expansion of the Climate Resilient Councils program to embed consideration of climate-related risks into local government decision-making will be considered as part of Tasmania's next climate change action plan. This work will enable councils to further understand and manage climate-related risks that are likely to affect their operations and service delivery.

6.4.5.3 Monitoring and evaluation framework

Climate Action 21: Tasmania's Climate Change Action Plan 2017–2021 (Climate Action 21) set the Tasmanian Government's agenda for action on climate change through to June 2021. It included a commitment to publish a report card each year on the progress of the 37 actions outlined in the action plan.

Tasmanian government agencies, in collaboration with partner organisations, were responsible for monitoring the actions they delivered. Four report cards providing updates on the implementation of Climate Action 21 have been publicly released since 2018. The fourth and final report card was released in August 2021.

The Climate Change (State Action) Amendment Bill 2021 establishes a requirement for the Minister for Climate Change to table in parliament an annual greenhouse gas emissions report, annual climate change activity statement, climate change action plan, statewide climate change risk assessment, and sector-based emissions reduction and resilience plans.

6.4.5.4 Progress and outcomes of adaptation action

Natural domain

The Tasmanian Government remains committed to the effective management and protection of the Tasmanian Wilderness World Heritage Area (TWWHA), which is recognised under the World Heritage Convention as having both cultural and natural heritage of Outstanding Universal Value. In September 2021, the Tasmanian Government released the Tasmanian Wilderness World Heritage Areas Natural Values Climate Change Adaptation Strategy 2021–2031, which aims to manage climate risk by planning for the potential impact of heatwaves, seasonality of weather variables, coastal erosion and extreme weather events.

In June 2022, the Tasmanian Parks and Wildlife Service also released a fire management plan for the TWWHA. The ecosystems of the TWWHA are a product of millennia of fire management, with records of people using fire as a management tool in the region extending back at least 40,000 years. Active fire management is still required to preserve the World Heritage values of the TWWHA and achieve the objectives of the TWWHA Management Plan, released in 2016.

The fire plan provides a strategic and comprehensive management framework for guiding fire management and mitigating bushfire risk into the future. It was developed through extensive consultation with stakeholders and the public. Key strategies in the plan include the development and implementation of a planned burning program and improving rapid attack capability (including winch-capable crew).

The Tasmanian Government's $3 million Agriculture Development Fund supports projects that demonstrate active partnerships with industry that have a clear pathway to deliver research outcomes directly to Tasmania's farmers, as well as contributing to sustainable growth and jobs in agriculture. In July 2022, the Tasmanian Government announced that Sea Forest, a Tasmanian company, was successful in its application for funding through the Agriculture Development Fund for a project to develop a commercial formulation for a seaweed (*Asparagopsis*)-based feed supplement that can be fed to cattle and sheep to reduce their methane emissions and deliver productivity gains.

Case study: Southern Tasmanian Councils Authority Regional Strategy – Adapting to a Changing Coastline in Tasmania

In August 2022, the Southern Tasmanian Councils Authority (STCA) released the Regional Strategy – Adapting to a Changing Coastline in Tasmania.

The STCA local government areas cover more than 40% of Tasmania's coastline. The coastline is diverse, with embayments, estuaries, open back shorelines, rocky coastlines, coastal cliffs and offshore islands that are exposed to the Indian Ocean and the Tasman Sea. Climate change is magnifying natural coastal processes, including inundation and erosion.

The strategy was developed through collaboration between specialist coastal consultants and the STCA Climate Program, with members representing 10 coastal councils in southern Tasmania. The Tasmanian Government (through Renewables, Climate and Future Industries Tasmania), the Local Government Association of Tasmanian and the Port Arthur Historic Site Management Authority were consulted during development of the strategy.

The strategy is a first step in helping Tasmanian councils to understand their role, and formalise pathways for caring and protecting the state's coastline and coastal communities for current and future generations. It will help councils to employ a strategic approach to existing or potential hazards on the coastline.

A risk management approach to helping communities adapt to a changing coastline is a central feature of the strategy. The strategy includes a suite of principles to guide the application of the risk management framework to development and use in the coastal zone on public and private land. The principles are based around 6 key themes:

- human safety
- the role of private property owners
- the role of councils
- minimising risk of future legal challenges and liability
- coastal hazard management and planning
- ecological and cultural values.

The principles are not prescriptive and allow flexibility for councils to develop local responses to meet their circumstances and resources.

Local councils may apply the strategy's principles to their coastal climate programs to prepare integrated hazards management plans for coastal and riverine catchments. For example, the City of Hobart is using the principles to inform the development of responses to managing coastal impacts, and engage with local coastal communities to assist them in understanding local impacts and identify key responses.

In 2020, the Tasmanian Government updated the existing Enterprise Suitability Mapping project. Enterprise Suitability Mapping is built from digital soil and climate modelling through on-farm soil sampling and climate sensing. Statewide Enterprise Suitability Maps are available for a range of agricultural commodities, including vegetables, cereals, pharmaceuticals, perennial horticulture, pastures and forestry. Users can view and query the maps, zoom into specific locations and overlay other relevant environmental or administrative spatial layers using the Land Information System Tasmania (LIST) map.

This mapping has informed the Enterprise Suitability Toolkit, a regional guide to help farmers with detailed on-farm investigations before making investment or operational decisions. The maps rate climate, landscape and soil variables to the requirements of a range of crops. This mapping allows farmers, industry or investors to identify:

- areas where crops or enterprises could potentially be introduced, intensified or diversified, guiding more detailed investigations at the farm or paddock scales
- possible risks or impediments to growing the crops and mitigation to improve suitability
- the wider viability of new enterprises at a state or regional scale.

The Enterprise Suitability Mapping, and underpinning soil and climate modelling culminated from intensive research and collaboration, and was one of the first operational examples of digital soil and climate mapping applied in Australia. All modelling and processes were published in peer-reviewed scientific journals, and presented at selected national and international conferences to ensure methodological rigour and transparency.

Since the start of 2018, the Tasmanian Government has committed $133.2 million to progress 6 new Tranche Three irrigation projects. The Australian Government is contributing $218.4 million to the Tranche Three program. The irrigation schemes will improve water security, enabling farm enterprises to adapt to changing rainfall patterns.

The Tasmanian Government's biosecurity import risk analysis process takes into account potential changes in pest, weed and disease distribution due to climate change. Climate change was also considered as part of a recent review of the state's fruit fly strategy (2017–2050).

The Tasmanian Government released the Rural Water Use Strategy in March 2021 to improve management of Tasmania's freshwater resources. Investment of $1.5 million has been committed to deliver the strategy and establish a River Health Advisory Project. Additionally, in May 2022, the Tasmanian Government announced a co-investment of $1.8 million between the Tasmanian Government and the Australian Government (through the National Water Grid Authority) to support 3 freshwater science projects to support evidence-based policy and decision-making in relation to climate change, groundwater risk assessment and water accountability by water users.

Agreement has been reached on establishing a Water Managers and Data Custodian Working Group involving key water managers across the state, including Hydro Tasmania, TasWater and the Bureau of Meteorology. The Working Group focuses on improving data sharing, accessibility and coverage of hydrological measurements, water quality and river health to support a range of ongoing water management activities.

Natural Resources and Environment Tasmania is delivering the Catchment Yield Science Update Project to determine the best method to update existing downscaled climate datasets and implement these into hydrological models in line with the latest climate science and for longer timescales.

Built domain

The Tasmanian Government is currently developing a set of Tasmanian Planning Policies (TPPs) to provide strategic direction on land-use planning matters. There are 7 TPPs covering the following topics: settlement, environmental values, environmental hazards, sustainable economic development, physical infrastructure, cultural heritage and planning processes.

Each TPP includes a principles and policy context section that outlines the overarching principles relating to the particular topic. The section also includes a climate change statement that identifies the likely impacts that climate change will have on the TPP topic, and describes how the responses to climate change issues are addressed and integrated within the policy content of the TPP.

The policy content is delivered through an 'Objective', which is an aspirational outcome in response to an issue, and several 'Strategies', which specify how the objective can be achieved. Climate change mitigation and adaptation strategies are integrated within the TPP topics.

The TPPs promote the following climate change responses specifically for cities and the built environment:

- prioritising infill and consolidation growth strategies
- prioritising the development of land with existing infrastructure capacity
- avoiding locating growth areas on land at risk of hazards caused by climate change
- integrating growth with existing transport systems
- providing a network of green spaces, and encouraging urban forests, street plantings, water-sensitive urban design and integration of shade and water features into public spaces
- supporting integrated transport networks that reduce car dependency, including public transport and a network of accessible infrastructure dedicated to active transport
- supporting higher-density housing in appropriate locations
- incorporating energy-efficient design in buildings
- supporting sustainable design practices that are energy- and resource-efficient, address temperature extremes and reduce carbon emission
- facilitating local, neighbourhood and specific site renewable energy generation to help diversify the local economy, improve sustainability outcomes, and build resilience and diversification around energy supply.

The Tasmanian Government has developed and implemented a system that coordinates mapping, planning and building controls for coastal hazards and coastal refugia. The system integrates the statewide Sea Level Rise Planning Allowances with storm surge out to 2100. The erosion modelling identifies likely rates of erosion from sea level rise and storm surge out to 2100 based on the underlying material and wave climate.

The system provides the Tasmanian Government and communities with an understanding of the public risk from coastal hazards now and out to 2100, underpinning the planning codes and building controls in hazardous areas for new development. This understanding will be built into TPPs, to provide a framework for the consideration of climate change impacts on the coast at the earliest possible stage in the planning process. This aims to avoid designating land for purposes that expose people and property to unacceptable levels of risk from coastal inundation and coastal erosion. The planning regulation will be supported by complementary building and construction controls.

The draft policies acknowledge that avoiding use and development in areas subject to coastal erosion and coastal inundation is not always achievable or desirable, so they include strategies to facilitate adaptation pathway responses, including:

- hazard reduction and protection measures being incorporated into the siting, design, construction and ongoing functioning of the use and development
- promoting strategic responses for existing settlements that are at risk of being impacted by coastal erosion and coastal inundation by considering the effectiveness, and the social, environmental and economic viability of strategies involving adaptation to changing conditions over time, planned retreat and protective works.

The Tasmanian Government has worked with coastal managers from local and state governments to use the coastal hazards and refugia mapping to understand the impact of climate change for existing settlements and values, and identify options to improve coastal adaptation approaches across Tasmania. Four information-gathering workshops were held throughout Tasmania. Information gained through the workshops has been used to inform the government's approach to managing the impacts of coastal hazards. This project built on the outcomes of the Tasmanian Coastal Adaptation Pathways project, which involved working with 12 localities to identify risks from coastal hazards to their local area and the development of adaptation pathways.

Social domain

The Healthy Tasmania Five-year Strategic Plan 2022–26, released in January 2022, identifies climate change and health as one of 8 areas of focus. The Tasmanian Government is currently developing a workplan to progress the Healthy Tasmania Climate Change and Health focus area. Key priorities include:

- raising awareness about the links between climate change and health, and ways communities can take action and respond to climate change
- creating more liveable communities that improve health and wellbeing, and tackle climate change. This includes active living strategies and supporting local food production, as well as actions to support good water and air quality
- supporting actions that protect priority populations from the impacts of climate change, such as bushfires, extreme heat and cold weather events.

The Tasmanian Government 2021–22 Budget committed $100,000 to engage with First Nations communities, directly and through existing structures such as the Aboriginal Heritage Council, to understand and manage impacts of climate change on culturally significant sites and cultural practices.

The Tasmanian Government undertook a pilot Aboriginal cultural burning program in 2021. This included a Cultural Burning Grants Program, with grants provided to undertake cultural burns, purchase equipment, travel to burn locations and attend Firestick Alliance Training. In June 2022, the Tasmanian Government announced that it will provide a further $1.3 million for Aboriginal cultural burning in Tasmania to support joint land management outcomes between the Parks and Wildlife Service and the Tasmanian First Nations peoples, including an extension of the Cultural Burning Grants Program. The Parks and Wildlife Service is currently undertaking a review of the 2021 program to inform the future structure of the program.

Disaster risk management

The Tasmanian Disaster Resilience Strategy 2020–2025 brings together sectors and communities to build on current actions that support disaster resilience. In 2020, the Tasmanian Government launched RiskReady, an online tool with the aim of improving community resilience to natural hazards by providing access to property-specific natural hazard information in a simple, understandable format. The website also provides high-level advice on how to reduce the risk of property damage and directs users to the relevant government agency for more information, including detailed risk mitigation and preparedness advice.

The Tasmanian Disaster Risk Assessment 2022 supports better understanding of the disaster risks that could impact Tasmania to identify ways to prevent such disasters from happening, explore current arrangements for such disaster events and suggest potential disaster risk reduction measures that build on current arrangements.

The Tasmanian Strategic Flood Mapping project, jointly funded by the Australian and Tasmanian governments, aims to:

- ensure that most Tasmanian will have access to a high-resolution digital terrain model through the collection of LiDAR data
- develop the Tasmanian Flood Map to support a flood risk assessment, and the development of land-use planning and building controls
- partner with local governments to undertake detailed flood studies and evacuation planning for the communities most at risk of flooding.

Through the Disaster Planning and Recovery for Tasmanian Businesses project, a series of workshops was held across regional Tasmania, supporting 48 Tasmanian businesses to undertake business continuity planning to prepare for, and respond to, extreme climatic events.

6.4.6 Victoria

6.4.6.1 Climate impacts

Long-term observational records show that Victoria's climate is changing under the influence of both natural variability and global warming. The average temperature across the state has increased by just over 1.2 °C since official Bureau of Meteorology records began in 1910 (Clarke et al. 2019). Over the past 30 years, Victoria's cool-season rainfall has declined compared with last century. Mean sea level for Melbourne (recorded at Williamstown) has risen by approximately 2 mm per year since 1966. There has been an increase in dangerous fire weather and in the length of the fire season across southern Australia since the 1950s (Clarke et al. 2019).

Climate projections suggest that Victoria will continue to become warmer and drier in the future (Clarke et al. 2019). However, natural year-to-year and decade-to decade variability mean that relatively cooler periods and very wet years will still occur.

By the 2050s, if the current rate of global warming continues, Victorian towns could experience around double the number of very hot days each year compared with the 1986–2005 average. By the 2090s, Victoria is projected to warm on average by 2.8–4.3 °C under a high-emissions scenario compared with 1986–2005 (Clarke et al. 2019). This would see Victoria frequently experiencing high temperatures that are currently unprecedented. Victoria is likely to have a significantly lengthened fire season, with the number of very high fire danger days likely to continue to increase. Sea levels along the Victorian coast are also likely to continue to rise (Clarke et al. 2019).

Annual rainfall is projected to decrease across the state, due to declines across autumn, winter and spring. When extreme rainfall events do occur, they are likely to be more intense. Areas of the Victorian Alps are projected to see a greater reduction in rainfall than the surrounding areas. Victorian alpine areas are also projected to continue to experience declining snowfall (35–75% by the 2050s under a high-emissions scenario). Comparison of observations and projections in Victoria suggest that temperature has been tracking towards the upper limit of projections, while winter rainfall has been tracking towards the drier end of projections.

Victoria's Climate Science Report 2019 describes how our climate is changing and includes local-scale future climate projections for Victoria, developed with CSIRO. The next report is due in 2024.

6.4.6.2 Adaptation policies and strategies

Victoria's approach to adapting to climate change is guided by a 5-yearly planning framework established under the *Climate Change Act 2017* (Vic). This comprises a Climate Change Strategy, Climate Science Report and Adaptation Action Plans. Victoria's Climate Change Strategy, released in 2021, outlines the Victorian Government's plan to achieve a net zero emissions, climate-resilient, prosperous and liveable state. The strategy is a 5-year plan that outlines emissions reduction targets and identifies Victoria's adaptation priorities. *Building Victoria's climate resilience* outlines the Victorian Government's current adaptation action and next steps, which are supported by a suite of sector-specific legislation, strategies and plans.

Adaptation Action Plans have been prepared for essential systems that are vulnerable to climate impacts or critical to climate resilience. The 7 plans – built environment, education and training, health and human services, natural environment, primary production, transport and water cycle systems – were published in 2022 and will be updated every 5 years to 2050. Each plan was informed by system experts as well as public consultation. The plans aim to build asset resilience, and help governments, industries and communities make climate-ready decisions.

Before the preparation of the 7 statutory Adaptation Action Plans, pilot Adaptation Action Plans were prepared in the health and human services system in 2019 and the water cycle system in 2018. These built on Victoria's Climate Change Adaptation Plan 2017–2020, which set out the Victorian Government's strategic priorities, measures and responses for adaptation.

Victoria's *Local Government Act 2020* (Vic) strengthened the mandate for councils to act on climate change, requiring mitigation and planning for climate change risks. Regional Adaptation Strategies are community-led plans outlining how Victorians want to adapt to climate change in their own communities. They were informed by regional climate projections and targeted guidance, and complement the system-based Adaptation Action Plans by ensuring that adaptation action is integrated locally and caters to diverse community needs, values and priorities across the state's different regions. More than 8,000 people contributed to the development of 6 community-owned strategies to guide local action over the next 5 years. Themes in the strategies include:

- preparing for and recovering from emergencies
- caring for the natural environment
- improving health and wellbeing
- strengthening the economy and workforce
- improving resilience of our built environment
- embracing renewable energy.

The Marine and Coastal Policy 2020 guides decision-makers in the planning, management and sustainable use of our coastal and marine environment. It provides direction to decision-makers, including local councils and land managers, on a range of issues, including dealing with the impacts of climate change. The Marine and Coastal Strategy 2022 is a 5-year action plan to implement the Marine and Coastal Policy. The strategy was developed with input from Traditional Owners, the Victorian Marine and Coastal Council, marine and coastal managers, communities and interest groups.

Building on the policy and strategy, Victoria's Resilient Coast: Adapting for 2100 provides a statewide approach for coastal hazard resilience and adaptation. It includes a framework, guidelines, and support for local government, land managers and communities to enable place-based leading practice and long-term coastal hazard adaptation.

The Supporting Our Regions to Adapt program, funded by the Sustainability Fund, supported collaboration within regional communities to strengthen resilience to climate change by building adaptive capacity and delivering place-based, locally relevant adaptation action. The program funded development of 6 Regional Adaptation Strategies and initial implementation of priority projects.

Community Climate Change Adaptation (3CA) Grants deliver on the Regional Adaptation Strategies. Grants were awarded to 17 community-led adaptation projects that addressed identified gaps and priorities in Victoria's regions. Some of the stories of community-led adaptation that the 3CA Grants have supported are on the Climate Change Adaptation Stories page. Victorian Traditional Owners developed the Cultural Landscapes Strategy in 2021 to provide direction to the Victorian Government about how it can enable and empower Traditional Owner self-determination in land management. The Cultural Landscapes Strategy sets out a framework and pathways to lead the planning and management of Country in line with cultural obligations to care for Country. Treaty and the Yoo-rrook Justice Commission are also key steps towards advancing self-determination and healing, and supporting Traditional Owners' rights on Country.

6.4.6.3 Monitoring and evaluation framework

A monitoring, evaluation, reporting and improvement framework (the MERI Framework) for adaptation in Victoria was developed in 2018 to analyse how successfully Victoria is adapting to the risks and impacts of climate change. This included the effectiveness of implementing actions in Victoria's Climate Change Adaptation Plan 2017–2020, the outcomes of these actions and how the state is adapting overall.

An 18-month interim review of Victoria's Adaptation Plan was published in 2019. The review informed stakeholders on the overall progress of climate change adaptation actions, facilitated learning and development, and provided information on progress towards short-term outcomes. The review identified success factors for progressing adaptation action, including having a clear narrative and evidence base for conversations, using local networks and trusted local sources to communicate, mainstreaming adaptation in different areas of government, proactively engaging with diverse stakeholders, and having a flexible, iterative approach to implementing adaptation programs.

Victoria's Climate Change Strategy includes an adaptation priority to 2025 to monitor, evaluate, report on and improve climate change adaptation by developing and implementing a new long-term framework based on statewide risk assessments.

6.4.6.4 Progress and outcomes of adaptation action

Natural domain

Victoria's Adaptation Action Plans for the natural environment and primary production systems include examples of some of the statewide adaptation actions undertaken in the natural domain.

The Natural Environment Climate Change Adaptation Action Plan 2022–2026 builds on recent adaptation progress and outcomes, including:

- responding to the 2019–20 bushfires by coordinating recovery and protecting biodiversity
- supporting Traditional Owners to apply their ecological knowledge and lead cultural heritage and related activities in areas affected by the 2019–20 bushfires
- looking beyond single fire events to consider long-term strategies for maximising ecosystem resilience
- implementing Victoria's biodiversity plan, Protecting Victoria's Environment – Biodiversity 2037, which ensures that the impacts of climate change are considered in all conservation decisions.

The Primary Production Climate Change Adaptation Action Plan 2022–2026 builds on recent adaptation progress and outcomes, including:

- implementing policies and strategies (such as Victoria's Agriculture Strategy) that support thriving primary industries to better manage climate risks and opportunities
- collaborating with and supporting primary producers to adapt to climate change
- investing in, testing and demonstrating new technology and programs
- developing and delivering information and tools with farmers.

Case study: Bushfire biodiversity response and recovery program

Following the Black Summer bushfires that significantly affected biodiversity in parts of Victoria, the Victorian Department of Environment, Land, Water and Planning has worked with species experts, academics and land managers to prioritise actions for fire-affected threatened species and habitats. This forms an overarching, multiyear program of initiatives. The 2019–20 bushfires demanded and received a swift recovery response. They also provided impetus to look beyond a single fire event and consider long-term strategies for maximising ecosystem resilience throughout Victoria.

The Bushfire Biodiversity Response and Recovery program includes the following focus areas and associated actions:

- Landscape resilience, which includes actions relevant to adaptation, such as
  - creating and supporting a safe haven network of ecological refuges across the state
  - revegetation and reseeding
  - spreading the risk to a species from population failures through genetic mixing to improve the fitness of populations and manage threats (e.g. Wilsons Promontory Sanctuary, genetic rescue of the southern brown bandicoot)
  - applying a cultural landscape lens to species renewal and resilience using cultural knowledge and practices.
- Knowledge and preparedness, which includes actions relevant to adaptation, such as
  - developing strategic guidance to prioritise direct interventions in species populations (e.g. to address genetic risk)
  - better targeting of research and monitoring of management effectiveness.

Case study: Innovative research and collaboration to help Australia's dairy industry become more climate-resilient

Increases in extreme climate events can have negative impacts on livestock welfare and farm productivity. Rising energy costs and the greater likelihood of power interruptions further impact profit.

Through Ellinbank SmartFarm, which opened in 2021, Agriculture Victoria Research is partnering with industry, agribusiness, the education sector and communities to develop SmartFarms, which actively engage in multidisciplinary research and innovation in key regional centres across Victoria.

The Ellinbank SmartFarm in Gippsland studies and tests creative technologies in a research environment accessible to the dairy industry. Farmers see demonstrations of effective, fit-for-purpose tools that can help them reduce energy costs and be more efficient. Projects include:

- optimising homegrown feed to improve farm operating profit
- improving heat-health and livestock welfare
- increasing production performance while reducing costs
- sustainably increasing annual milk production through nutrition and pasture management
- testing novel feeding strategies to reduce dairy cow methane emissions (and potentially other animals).

These investments generate understanding of aspects of climate change and primary production, particularly around seasonal challenges or climate-related hazards such as drought or heat, or particular commodities, such as grains or livestock. Longer-term and cross-industry challenges from climate change must also be addressed.

Case study: Victorian Coastal Monitoring Program

Victoria has a long history of weather variability, such as storms, droughts and floods. Climate change is projected to increase the risk to coastal environments through drivers such as sea level rise, changes in wave direction, and increases in swell energy and storm tide events. These drivers affect coastal erosion, sediment supply and inundation, and are expected to vary geographically across Victoria's coastal zone.

The Victorian Coastal Monitoring Program monitors wave climate, sediment movement and sediment budgets in priority coastal compartments of Victoria's open coastline. The program commenced in 2016 and has established 2 co-investment projects with universities, local government and citizen science volunteer groups:

- The Improving Coastal Erosion Assessments project works with university partners to establish monitoring sites across multiple locations of Victoria's coast and bays.
- The Coastal Wave Monitoring and Sea Level Rise Modelling project worked with university partners to monitor Victoria's coastal wave climate in offshore waters to improve predictions of future sea level rise, storm surge wave height and wave directions. This was completed in 2021.

The program consists of many complementary projects designed to provide Victoria with the most comprehensive assessment of coastal processes ever undertaken. In 2020, it was awarded the Australian Government Department of Industry, Science, Energy and Resources Eureka Prize for Innovation in Citizen Science.

Built domain

All sectors have an interest in effectively adapting the built domain, especially assets and infrastructure. Victoria's Adaptation Action Plans for the built environment, transport and water cycle systems include examples of some of the statewide adaptation actions undertaken in the built domain.

The Built Environment Climate Change Adaptation Action Plan 2022–2026 builds on recent adaptation progress and outcomes, including:

- introducing minimum standards for rented homes' energy efficiency
- mapping coastal inundation hazards and requiring planning schemes to respond to potential coastal impacts
- providing guidance for development in flood-affected areas
- mapping heat vulnerability and preparing advice
- improving planning and building system responses to bushfire risk
- building energy infrastructure resilience.

The Transport Climate Change Adaptation Action Plan 2022–2026 builds on recent adaptation progress and outcomes, including:

- considering long-term climate change in the planning, design, construction and operation of transport nfrastructure
- reviewing emergency management plans, and supporting passenger safety and wellbeing during heatwaves
- building climate scenarios into transport project flood and drainage models, standards and design outputs.

The Water Cycle Climate Change Adaptation Action Plan 2022–2026 builds on recent adaptation progress and outcomes, including:

- providing leadership on water and adaptation through Water for Victoria (the long-term plan for the water sector, as discussed in the case study below) and the Pilot Water Sector Climate Change Adaptation Action Plan 2018–2020
- improving water efficiency and reliability in regional communities
- providing hydrology and climate science for Victoria's water sector and supporting citizen science
- delivering regional catchment strategies through local and regional partnerships between catchment management authorities, Traditional Owners and the broader community
- implementing urban water strategies and drought preparedness plans
- collaborating with industry
- supporting vulnerable customers, schools and communities
- coordinating state-level responses to manage algal blooms
- improving the resilience of water and flood monitoring stations as part of Victoria's Bushfire Recovery Plan.

Case study: Planting trees for a cooler, greener Melbourne

The Victorian Government is investing $5 million to plant mature and young trees across Melbourne's west to help adapt to climate change by providing more shade and green spaces. Urban heat is an increasing threat to the liveability and productivity of cities, made worse by more frequent and extreme heat days and heatwaves caused by climate change. Heat extremes over warmer months are made worse in our urban areas by reduced vegetation cover, as well as hard materials and dark surfaces that absorb heat. This poses significant threats to the health and wellbeing of people, pets and native wildlife.

Melbourne's western suburbs experience some of the highest levels of urban heat vulnerability in metropolitan Melbourne. In 2018, Melbourne's west had just 5.5% canopy cover in urban areas, compared with 17.4% in the inner south-east and 25.9% in the east.

Planting trees to increase shade and cooling through urban forest and canopy cover can reduce air temperatures across a precinct by up to 2 °C, helping to reduce heat-related illness and death, and giving people better access to cooler green spaces. Temperature reductions directly under a canopy tree are even greater, at around 4 °C lower. Tree planting also benefits biodiversity by introducing varied tree sizes and species, and strengthening wildlife corridors. Trees can also help improve air quality by filtering pollutants, and support better stormwater management through increased infiltration and reduced runoff.

Case study: Water availability climate change guidelines

Victoria's climate is changing, and this poses many challenges for the water sector, as well as Victoria's businesses, industries and communities that rely on water.

Our water resources are largely climate-dependent, so planning for climate change is extremely important for Victorian water resource management. Multiple lines of evidence indicate that Victoria will be hotter and drier in the future, and this has clear implications for Victoria's water security.

Water for Victoria is a long-term direction for managing Victoria's precious water resources. Since its launch in 2016, significant progress has been made in meeting the challenges of climate change and population growth, and taking action to ensure that our water system is modern and efficient, future focused and affordable. Actions include protecting and restoring waterway health, supporting farmers' resilience with new infrastructure and skills, and partnering with Traditional Owners to better include First Nations peoples' water interests in water planning and management.

Water for Victoria actions are delivered in collaboration with water corporations, catchment management authorities, the Victorian Environmental Water Holder, Traditional Owner groups, local government and community partners.

The 2020 edition of the *Guidelines for assessing the impact of climate change on water availability in Victoria* builds on the previous edition published in 2016 and informs the next round of urban water strategies. The update is a response to Water for Victoria that requires climate change adaptation across Victoria's water systems.

The guidelines set out climate change scenarios for temperature, potential evapotranspiration, rainfall, runoff and groundwater recharge for assessing the impact of climate change on water availability, supply and demand across Victoria. They also include information on changes to climate variability associated with climate change, and information on stress and sensitivity testing. The guidelines can be adapted to suit a range of climate change impact assessments for water supply, demand and availability.

Case study: Guidance to inform health services of potential climate risk to infrastructure

Victoria's 2019 Pilot Health and Human Services Adaptation Action Plan saw new hospital essential engineering guidelines prepared in 2020–21. The new guidelines incorporate fundamental design principles informing the design and operation of emergency generators in a wider range of climate conditions. The guidelines also require designers to consider the potential effects of climate change and assess the potential risks posed to the project.

Hospital facilities built in designated bushfire-prone areas must now provide generating capacity beyond the standard requirements for that category of hospital. In remote or bushfire-prone areas, the design of on-site fuel storage must address potential delays to fuel supply replenishment under emergency conditions.

New sustainability guidelines for capital works provide information on the implications of climate change, and require these implications to be assessed, and appropriate responses integrated, during the design and construction of healthcare buildings.

Social domain

Victoria's Adaptation Action Plans for the health and human services, and education and training systems include examples of some of the key statewide adaptation actions undertaken to date in the social domain. Furthermore, under the *Public Health and Wellbeing Act 2008* (Vic), local governments must prepare municipal public health and wellbeing plans that consider climate change.

The Education and Training Climate Change Adaptation Action Plan 2022–2026 builds on recent adaptation progress and outcomes, including:

- partnering to comprehensively manage risks, prepare and plan, respond to and recover from extreme events
- requiring all schools to comply with Victoria's bushfire preparedness guidelines
- supporting education and training providers to incorporate climate change into teaching and learning, and integrating environmental sustainability as a priority outcome.

The Health and Human Services Climate Change Adaptation Action Plan 2022–2026 builds on recent adaptation progress and outcomes, including:

- providing leadership through the 2019 Pilot Health and Human Services Adaptation Action Plan
- supporting state and municipal public health and wellbeing planning to tackle climate change and its impacts on health
- establishing updated engineering and sustainability guidelines to ensure that health infrastructure is climate-resilient
- increasing social housing residents' thermal comfort and safety in their homes
- partnering with Victorian disability advocacy organisations to design inclusive emergency management planning approaches
- embedding climate risk responses in policies, procedures and capital investment decisions for assets such as hospitals, health services and housing.

Case study: Designing an inclusive approach to emergency management planning

Research shows the disproportionate impact of emergencies on people with disability, who are at higher risk of death, injury and loss of property. Recognising the importance of including people with disability in emergency management planning and decision-making, the Department of Families, Fairness and Housing has engaged the University of Sydney to partner with Victorian disability advocacy organisations to design an inclusive approach to emergency management planning in Victoria.

The project, which is currently underway, aims to build capacity in the disability community and emergency services sectors to work together to increase the resilience of people with disability, through peer-support advocacy and inclusive local emergency management planning.

Case study: Local government training

Local governments play a critical role in helping their communities to reduce emissions and adapt to climate change, and are often the first to respond to impacts. Their strong connections to the community and local knowledge mean that they are often best placed to recognise the need for adaptation at a local scale.

Victoria's *Local Government Act 2020* (Vic) strengthens the mandate for councils to act on climate change, requiring mitigation and planning for climate change risks. The *Public Health and Wellbeing Act 2008* (Vic) also requires local governments to prepare municipal public health and wellbeing plans that consider climate change.

Many of Victoria's local governments have shown leadership by setting their own emissions reduction pledges and adaptation plans. To acknowledge these actions and as a platform for local governments and the state government to work together towards a net zero future, councils are submitting voluntary council pledges under the *Climate Change Act 2017* (Vic).

To support council action, in 2021, the Victorian Government delivered 9 live, online, interactive training sessions for Victorian local government councillors and executives on climate change risk and adaptation, titled Your Council and Climate Change: Understanding the Risks and Learning to Adapt. This was accompanied by a 'train the trainer' program and a suite of targeted guidance and resources.

6.4.7 Western Australia

6.4.7.1 Climate change impacts

Western Australia is already experiencing the impacts of climate change:

- Western Australia has warmed by about 1.3 °C since 1910. Under a high-emissions scenario (RCP8.5), Western Australia's temperature is expected to increase by about 2 °C. Extreme temperatures in all regions are very likely to increase in the future. The number of very hot days (>40 °C) is projected to increase from about 1.5 to 5 days per year in Perth, and from 6 to 16 days in Broome.
- Since 1900, rainfall has increased over most of Western Australia, apart from the far west and southwest, where it has declined. The decline in southwest Western Australia has been larger than anywhere else in Australia and is highly attributable to human influence. Mean rainfall is projected to continue to decrease in south-western Australia, while changes over northern Australia remain uncertain. Rainfall variability and extreme rain events are projected to become more intense, leading to more very wet and very dry years.
- The number of days with dangerous weather conditions for bushfires has increased in nearly all locations.
- Sea levels are projected to rise by about 24 cm along the Western Australian coast.

The WA Government continues to undertake research into climate impacts and risks to support adaptive management. This includes research on the responses of aquatic species and communities to changing environmental conditions, groundwater investigations, fire science, forest hydrology and coastal hazards. The Western Australian Climate Science Initiative, in partnership with the NSW and Australian Regional Climate Modelling Project, and Murdoch University, is investigating climate impacts and extremes to help governments, businesses and communities understand and plan for climate risks.

6.4.7.2 Adaptation policies and strategies

The WA Government is committed to playing a positive role in climate change policy, including in reducing emissions and investing in renewable energy and adaptation. The Western Australian Climate Policy sets out a suite of initiatives to support adaptation planning and climate resilience. A statewide Climate Adaptation Strategy is being developed to position WA industries, cities and regions to better anticipate and adapt to climate change. Regional planning for native vegetation under the Native Vegetation Policy for Western Australia will support climate adaptation planning for natural ecosystems.

6.4.7.3 Monitoring and evaluation framework

The WA Government is developing a climate risk framework to enhance management of climate risks across the public sector. This framework will guide the monitoring, assessment and reporting of climate risks associated with the state's finances, infrastructure, physical assets and service delivery.

6.4.7.4 Progress and outcomes of adaptation

Natural domain

In 2022, the WA Government released the Native Vegetation Policy for Western Australia. The policy guides and supports government agencies, industry and the community to work together towards a net gain in native vegetation, through actions to improve policies, practices, systems and data. The policy seeks to manage native vegetation in ways that support biodiversity, while fixing carbon, supporting regional and First Nations peoples' employment, and improving business certainty.

The Forest Management Plan 2014–2023 provides the policy framework for managing public forests vested in the Conservation and Parks Commission in the south-west. An objective of the plan is to mitigate the impacts of climate change on south-west forests through a series of management activities and performance indicators.

The Department of Biodiversity, Conservation and Attractions implements the Enhanced Prescribed Burning Program to protect the community and the environment from the impacts of bushfire, which can be exacerbated in size and intensity by the effects of a drying climate. The program mitigates the impacts on forests from bushfires by reducing the frequency and size of bushfires.

The WA Healthy Rivers program routinely monitors the ecological health of more than 150 river sites, and the Healthy Estuaries WA program is undertaking various actions to build health and resilience of aquatic ecosystems by reducing nutrients and repairing riparian areas. The WA Government also supports restoration programs to build climate resilience, such as the Harvey River habitat restoration trial to create climate-resilient aquatic refuges.

The marine and terrestrial conservation reserve system of Western Australia is managed through a series of management plans prepared under the *Conservation and Land Management Act 1984*. The plans incorporate strategies to increase resilience of habitats and species to climate change by monitoring marine and terrestrial ecosystem values, and adapting management responses to reduce pressures.

The WA Government is investing $15 million into an Agriculture Climate Resilience Fund to help WA farmers and industry to respond to the challenges of climate change. The fund will support projects that will help farmers develop resilience to changes in climate, and the consequential changes in market expectations. It is designed to allow Western Australia to leverage funding from alternative sources, including the Australian Government, and philanthropic and commercial organisations. This investment will support the development and implementation of tailored solutions for climate and agricultural issues specific to local conditions and practices.

Water resource assessments across Western Australia incorporate climate change considerations into their development. These include groundwater drilling programs, mapping water availability, and surface water and groundwater modelling under a changing climate. The Gnangara Groundwater Allocation Plan reduces licensed groundwater abstraction in response to climate change. The plan is consistent with the government's Waterwise Perth Action Plan, which sets a target of 10% reduction in groundwater use by 2030.

Water service providers continue to build diversified water supply schemes across Western Australia. Water and wastewater infrastructure is being secured to ensure continued reliable water and wastewater services to north-west WA regional communities.

Ongoing climate change adaptation efforts in the water sector include:

- integration of water-sensitive urban design into strategic planning
- incorporation of future climate projections into water allocation plans
- the State Groundwater Investigation Program, including statewide seawater interface investigations
- engaging with stakeholders and Traditional Owners on water management issues, and setting up Strategic Aboriginal Water Reserves.

The Kep Katitjin – Gabi Kaadadjan Action Plan is part of the WA Government's response to climate change. It is the second plan in the waterwise program of work, with 10-year targets to transition to waterwise communities in Perth and Peel. A waterwise community is liveable, resilient, productive and sustainable. The plan is a coordinated, collaborative across-government approach led by the Department of Water and Environmental Regulation and delivered by 11 partner agencies. In addition to water efficiency and conservation efforts, more than half of the actions in the plan aim to improve biodiversity, urban greening and tree canopy cover, and help to mitigate urban heat impacts.

Built domain

METRONET is an integrated transport and land-use framework that will support growth of the Perth metropolitan region over the next 50–100 years. All METRONET projects are subjected to a comprehensive Climate Change Network Vulnerability and Risk Assessment, with a contractual requirement to provide adaptations to any high or very high risks identified. For example, on the Morley-Ellenbrook line project, flooding risk at Whiteman Park was mitigated by elevating the rail onto a viaduct.

Main Roads Western Australia, a WA Government agency with responsibility for the state's road network, continues to incorporate climate change considerations, including sea level rise and rising temperatures, into its standards for road and traffic engineering, and in the design and construction of bridges and pavements. A project to develop an understanding of the vulnerability of the existing Main Roads' road network to climate change has commenced. The project has developed a data-driven approach for accessing vulnerability that has been tested on 2 pilot projects. The project will give Main Roads a whole-of-network view of vulnerability under the latest climate change scenarios.

The WA State Planning Policy 2.6 – Coastal Planning provides for the long-term sustainability of Western Australia's coast. It also provides guidance for the incorporation of coastal hazards, including sea level rise, in the determination of land use and development in the coastal zone.

The WA Government has invested $33.5 million over 5 years to preserve and enhance coastal assets for the general public, build partnerships with local coastal managers, and help them understand and adapt to coastal hazards.

Climate change, sea level rise and a long-term oceanographic data collection program are used to identify vulnerable coastal areas and inform the planning and design of coastal infrastructure. For example, finished floor heights of buildings comply with State Planning Policy 2.6, and marine pile cut-off heights for floating pen systems account for a 50-year sea level rise to ensure that floating systems do not disengage from the supporting pile restraints and float away.

A coastal inundation assessment is underway to identify locations along the WA coast that contain built assets currently prone to coastal flooding and that are likely to require active management within the next 25 years. The study will identify practical pathways to improve existing coastal inundation management, with a particular objective to pilot a methodology that can be applied statewide to identify plausible inundation mitigation options and priorities for funding.

Case study: Managing coastal erosion and inundation hotspots

Rising sea levels, and increased frequency and intensity of storms along Western Australia's coast are likely to exacerbate coastal hazards, including flooding and coastal erosion. In 2019, an *Assessment of coastal erosion hotspots in Western Australia* report identified 55 hotspots where coastal erosion is expected to be a threat to coastal values and assets, and an additional 31 wait-list locations for future investigation.

The assessment highlighted that most physical assets in hotspot locations require management and adaptation actions within the next 25 years, the majority within the next 5–10 years. Of these, Port Beach and South Thompson Beach were identified as having high and pressing management needs, and another 12 hotspots were on the brink of becoming high, including Broome Town Beach, Ledge Point, Floreat Beach, Rockingham Town Beach, Mandurah's northern beaches and Koombana Bay (Bunbury).

The WA Government has invested $33.5 million over 5 years to fight erosion and protect Western Australia's coastline. This funding is helping coastal managers prepare coastal hazard risk management and adaptation plans (CHRMAPs); collect data; enable community engagement, training and education; and deliver priority implementation actions. Twenty-six CHRMAPs have been completed (some are due for review), and another 10 are underway. These cover 51 of the 55 coastal erosion hotspots.

Several coastal protection projects have also been completed, including the design and construction of a revetment to address severe erosion at South Thomson Bay (Rottnest); groyne construction at Quinns Beach (Wanneroo) and Drummond Cove (Geraldton); and environmental approvals, dredging and sand replenishment at Port Beach (Freemantle).

A separate coastal inundation assessment is underway to identify locations along Western Australia's coast that contain built assets currently prone to coastal flooding and that are likely to require active management within the next 25 years. The study will identify practical pathways to improve existing coastal inundation management within Western Australia, with a particular objective to pilot a methodology that can be applied statewide to identify plausible inundation mitigation options and priorities for funding.

Photo: South Thomson revetment, Western Australian Department of Transport

Social domain

The WA Government is supporting local governments to reduce greenhouse gas emissions, build resilience to climate change impacts, and enhance capacity and knowledge building to support action at a regional scale. The Regional Climate Alliance Program is an initiative under the Western Australian Climate Policy and aims to support local governments to take action on climate change, energy and sustainability through regional partnerships. The program currently supports 2 partnerships: the South Coast Alliance and the Goldfields Voluntary Regional Organisation of Councils, representing 13 local governments from the Great Southern and Goldfields regions. In 2021, the WA Local Government Association (WALGA), in partnership with the WA Government, launched the Climate Change Templates and Guidelines. The Templates and Guidelines are part of WALGA's Climate Action Framework and identify 4 categories of action that local governments can take to embed climate change planning into their operations and communities.

In 2019, the WA Government announced a Chief Health Officer Inquiry to investigate the implications on health of climate change, including more frequent and intense weather events. The inquiry's final report sets a blueprint for the next 10 years of the WA health system's climate change adaptation to protect the health of the community. It also sets out what health services can do to reduce emissions and waste. The WA Government has established a Sustainable Development Unit to coordinate a systemwide response on climate action and sustainability across the state health system. A Health Sector Adaptation Plan is being prepared, in consultation with government and private and community health sector stakeholders, to develop enhanced and shared understanding of climate risks to human health, and identify prioritised adaptation actions to address gaps in climate risk management and improve coordination of actions.

Disaster risk management

In 2013, the WA Government commenced the State Risk Project, which endeavoured to assess the 28 hazards prescribed in emergency management legislation. The project, forecast for completion in February 2023, has identified potential vulnerabilities that may be affected by these hazards. The State Emergency Management Committee will consider the next phase of assessing state risk, with an intent to leverage emerging technologies. This will enable a shift from a long-term static view of risk to a framework that will incorporate systemic risk, as well as dynamic risk assessment. Western Australia's Floodplain Mapping tool identifies flood risk in Western Australia and encourages stakeholders to consider climate change adaptation measures.

The WA Government is working closely with the Australian Government to reduce the risk of disasters. In May 2020, the WA and Australian Government entered into a National Partnership Agreement (NPA) for Disaster Risk Reduction. The purpose of this NPA is to fund disaster reduction activities that are intended to deliver the outcomes of Australia's National Disaster Risk Reduction Framework (see section 6.3.6).

The NPA is the primary funding mechanism for the National Disaster Risk Reduction (NDRR) Grants Program, overseen by the State Emergency Management Committee. The NDRR and its predecessor (the National Disaster Resilience Program) have supported a range of disaster risk reduction initiatives across the 7 managed natural hazards (bushfire, flood, storm, tsunami, heatwave, earthquake and cyclone). The 2022–23 grant round was modified to allow climate change–specific emergency management projects to be considered.

The State Emergency Management Committee has endorsed the development of a climate change adaptation plan for the emergency management sector to support the WA Climate Policy. A dedicated Climate Change Subcommittee will have oversight of the plan with the objective of:

- building enhanced and shared understanding of climate change impacts and risks for the sector
- embedding climate change risk and management considerations into emergency management decision-making, where relevant
- identifying and prioritising adaptation actions that can help to ensure that the sector is prepared for climate change.

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7 Financial, technological and capacity-building support

Key developments

The Australian Government's action on climate extends throughout the region. The area of focus for Australia's climate finance is the Indo-Pacific, and engagement is based on partnerships and respect. Australia is continuing efforts to align climate actions with the stated needs of governments in the Pacific and Asia. Australia's bilateral climate support is guided by Nationally Determined Contributions, National Adaptation Plans and development plans. Priorities are set by national governments, and ongoing collaboration and dialogue ensure that Australia continues to be a responsive and effective development partner.

Australian climate finance is primarily delivered through its development program. Australia shares science, technology and innovation to build capacity in the region, while recognising and building on existing strengths and local knowledge. Australia works through partner organisations to deliver training and infrastructure-building programs that directly target climate adaptation. Australia also plays a leading role in establishing and supporting partnerships to drive change.

Australia welcomed the call from COP27 for multilateral development banks to accelerate their efforts in this regard, by both increasing the total and proportional amounts of funding for climate change, and ensuring that this funding does not result in unsustainable debt. Australia also welcomed the historic progress at COP27 to establish new funding arrangements for loss and damage and will work with our partner countries to ensure that mobilised finance meets the needs of the most vulnerable countries, particularly in our region.

7.1 Climate finance

Australia recognises that climate change is the greatest threat to the livelihoods, security and wellbeing of our closest neighbours in the Pacific. Climate change is also a major threat to development progress and poverty reduction globally. Australia believes that climate change must be considered in all development activities and integrated across its entire development cooperation program. Activities and investments that count towards climate finance contributions are underpinned by Australia's Climate Change Action Strategy 2020–2025 (see Chapter 4), which includes details of how Australia will address climate change and strengthen sustainable development in its region and beyond.

In October 2022, the Australian Government increased its ODA budget by $1.4 billion over the next four financial years (2022–26). This will support new spending on climate action. At COP26 in Glasgow in November 2021, Australia committed to provide $2 billion of climate finance in 2020 to 2025. Australia is on track to meet this goal. Average annual climate disbursements have increased: the average annual spend from 2015–16 to 2017–18 was $255 million; the average annual spend from 2018–19 to 2019–20 was $333 million (comprising $360 million in 2018–19 because multilateral payments were brought forward, and $305 million in 2019–20); and in 2020–21 Australia's overall climate finance increased to $348 million.

Australia's climate finance is primarily delivered through its development program. Using the financial year 2019–20 as an example, 15% of climate finance was delivered through bilateral and regional programs, with climate as a primary objective; 41% of climate finance was provided through programs that had climate as a secondary objective; and 44% was provided through relevant contributions to multilateral environment funds and development banks, in which the proportion of climate finance for all donors is determined by the Organisation for Economic Co-operation and Development (OECD). All of Australia's climate finance before 2022 was delivered through grants, and this will continue to be the predominant method.

Australia has made progress on efforts to embed the integration of climate change considerations into all systems that support and deliver its development cooperation program. Key sectors for climate change integration are in programs related to environment, water, agriculture, infrastructure and disaster risk reduction.

To ensure that Australia's development cooperation aligns with partner government priorities, bilateral aid programs are regularly revisited and consulted upon with partner governments. From 2016 to 2020, Australia produced an Aid Investment Plan for each partner country. These plans outlined the strategic intent and development context unique to each partner country. They also considered how Australia could contribute to the national development plans of partner governments, including emissions reduction strategies and roadmaps to achieve Nationally Determined Contributions. Aid Investment Plans included performance benchmarks, mutual obligations and investment pipelines. Bilateral aid programs are reviewed annually through Country and Regional Development Program Progress Reports. These processes involve discussions with partner governments and other stakeholders, and ensure that the intent, progress and objectives of Australia's development programs are meeting the needs of developing countries.

Each country faces unique challenges, so some countries use bespoke mechanisms to ensure that support is aligned with government priorities. For example, in Tonga, Australia works through the Joint Policy Reform Matrix (JPRM), alongside other participating development partners, to ensure that international development assistance aligns with the Tongan Government's needs and priorities. The JPRM is a partnership between Tonga and its development partners and guiding ministries to ensure complementarity and collaborative outcomes, with budget support and technical assistance linked to the fulfilment of targets. Regular JPRM missions, coordinated by the World Bank, offer the opportunity to jointly determine shared targets to strengthen public finances and administration, enhance resilience to climate change and disasters, and improve human capital and competitiveness.

7.1.1 Bilateral and regional relationships

Given the critical importance of climate adaptation in the Pacific, Australia's ODA budget increase includes $900 million for the Pacific and Timor-Leste. This will support new spending on climate action, including a commitment to establish a new Pacific Climate Infrastructure Financing Partnership. The most recent climate finance commitment by Australia allocated at least $700 million to meet the Pacific's needs. By way of comparison, from 2015 to 2020, $408 million went towards climate change and all-hazards disaster resilience in the Pacific.

Australia's climate finance has focused on the small island developing states and Least Developed Countries in the Indo-Pacific region. Australia's climate finance expenditure on these was more than two-thirds of all bilateral, regional and global development assistance during 2015 to 2020.

Australia's bilateral official development assistance (ODA) relationships are negotiated in partnership with, and reflect the stated priorities of, national governments. Pacific countries have urged Australia to focus on adaptation, and to address the existential threats climate change poses to livelihoods, security and wellbeing. In response to these calls from the region, Australia's focus on adaptation to climate change impacts has stayed strong, remaining at least at 70% of bilateral and regional expenditure (excluding multilateral core contributions) since 2016.

Across South and South-East Asia, Australia works in partnership to support partner governments' plans to reach net zero emissions, and provide access to affordable clean energy. Australia also supports hazard and risk science, water security, and resilient infrastructure development. For example, Australian support to Indonesia has contributed to infrastructure, disaster risk reduction and environmental governance. In response to collaborative discussions about climate action between governments, Australia's future focus in Indonesia will be to increase support for the green economy and sustainable energy transition.

Indo-Pacific regional support also reflects the stated priority of building strong regional architecture. In the Pacific, Australia works through key Pacific regional organisations to support climate action and regional engagement on climate change. Australia provides longstanding financial assistance to regional organisations such as the Pacific Islands Forum Secretariat, the Pacific Community and the Secretariat of the Regional Environment Programme, to enable them to provide services and support to Pacific countries on climate change. Australia's close relationship with the Association of Southeast Asian Nations (ASEAN) has resulted in practical, effective change. The ASEAN–Australia Smart Cities initiative was announced at the ASEAN–Australia Special Summit in 2018 and has supported the development of sustainable city systems.

7.1.2 Multilateral contributions

Australia believes in the need for collective action through the multilateral system to address global challenges such as climate change.

Contributions to multilateral development banks and international climate and environment funds made up just over half Australia's climate finance across the period 2015 to 2020. Owing to the delivery of Australia's agreed contributions to capitalise the Asian Infrastructure Investment Bank in 2019–20 ($214 million), this decreased to just under a quarter of Australia's climate finance in 2020–21 following the delivery of Australia's agreed contributions to capitalise the Asian Infrastructure Investment Bank in 2019–20 ($214 million).

Australia contributed $907 million to the World Bank's International Development Association (IDA) from 2016–17 to 2020–21. This includes an IDA core contribution of $840.4 million and IDA supplemental payments of $66.7 million, but excludes the multilateral debt relief initiative for heavily indebted poor countries and arrears contributions. Australia also contributed $732 million to the Asian Development Bank's Asian Development Fund over the same period. Taken together, $360 million of these contributions were imputed by the OECD to be contributions for climate finance.

The Global Environment Facility (GEF) focuses on pressing environmental challenges, and is significant for the Indo-Pacific region and global efforts to address the impacts of climate change. Australia has supported the GEF since its inception more than 30 years ago. Australia provided $76.67 million over the GEF-7 period (July 2018 to June 2022), and has committed $80 million to the GEF-8 replenishment from July 2022 to June 2026. Australia holds a seat as member on the GEF Council in a donor constituency with New Zealand and the Republic of Korea.

7.1.3 Private sector finance

Australia recognises that for developing countries to realise their net zero ambitions, large-scale mobilisation of private finance and investment is needed to support public funds. Australia is increasing the development and deployment of non-grant financing mechanisms that help to connect ODA grant financing with private sector investment – with a renewed focus on using these mechanisms to focus on climate. These mechanisms are used for infrastructure (e.g. renewable energy) and for enterprises that will support the shift to greener supply chains in the region.

In the past 2 years, Australia's shift in focus of its non-grant finance mechanisms (debt, equity and guarantees) towards climate has seen a material increase in the amount of private finance mobilised towards climate. This will be captured in the next reporting period.

The approach Australia is taking to support mobilisation of private finance into the region's net zero transition is focused on blending finance, expertise and intellectual property, and considers the different risk profiles of different sector partners to achieve mutual climate-related outcomes. Australia works with governments to put in place supportive legal and regulatory environments, and build the capacity of financial intermediaries to raise and deploy finance for climate-positive infrastructure and enterprises.

Australia works through its own bespoke mechanisms, such as the Emerging Markets Impact Investment Fund, and through multi-country platforms, such as the Private Infrastructure Development Group. It also works in partnership with multilateral development banks – such as the Asian Development Bank – who manage the Australian Climate Finance Partnership on Australia's behalf. Increasingly, these mechanisms are drawing on pipelines that are being developed through partnerships with Convergence or the Private Financing Advisory Network. The Australian Government is also working closely with the domestic and international finance sector and business to increase its engagement in climate investment in the region.

7.1.4 National approach to tracking and reporting provision of support

Australian climate finance is determined through the annual Federal Budget appropriation process led by the Australian Parliament. Australia's methods for accounting climate finance expenditure are based on the OECD Development Assistance Committee (DAC) guidelines. Australia uses the DAC Rio markers to calculate climate finance. To ensure that its methodology is aligned with DAC best practice, Australia sought a DAC review of its proposed methodology and treatment of future non-grant expenditure and mobilised private finance. The DAC confirmed that Australia's approach was in line with its guidance and standards.

Australia is transparent about how it counts climate finance expenditure and has published clear guidance on its methodology. For programs that have a specific, primary climate objective, Australia counts 100% of expenditure as climate finance. If climate change is a secondary objective, the actual amount spent on climate change activities is counted. If this cannot be calculated, a default portion of the activity expenditure (30%) is counted. This represents a conservative average across the portfolio. This method of counting climate finance has not changed since the submission of Australia's last National Communication. Australia will use the OECD ODA grant-equivalent method to calculate the portion of official loans included as climate finance. Australia will also use the OECD methodology for calculating private finance mobilisation efforts attributable to Australia.

Australia's climate finance data are reported to the OECD and the UNFCCC for publication on their respective websites, as well as in Australia's Department of Foreign Affairs and Trade's annual ODA statistical report, published on the department's website (DFAT 2022a).

Australia supports efforts to develop coherent global standards on accounting climate finance. Australia took a leadership role in the COP26 negotiations, as Chair of the Umbrella Group of countries. It helped secure the important outcomes achieved in Glasgow, including for finalising strong Paris Agreement implementation rules for the operation of international carbon markets to ensure that markets deliver real and verifiable emissions reductions, and for the enhanced transparency framework, which is key to accountability.

A dedicated government section within Department of Foreign Affairs and Trade's Climate Resilience and Finance Branch tracks and reports on climate finance, and trains program managers across government about accurate climate finance reporting. This team provides quality assurance for annually reported figures. Grants are tracked using the Department of Foreign Affairs and Trade's AidWorks database. AidWorks has been improved to better collect the information needed to meet its various climate finance reporting obligations.

Contributions to Australia's climate finance that are not from ODA flows are also tracked by the Department of Foreign Affairs and Trade. These activities are delivered under the International Climate Change Engagement Program and include contributions to the UNFCCC of approximately $1.1 million per year, facilitation of Pacific delegates to engage with the IPCC, and support for regional partners to implement their Nationally Determined Contributions.

7.2 Technology development and transfer

Australia is a world leader in research and development across a wide range of technologies, and uses a technology-led approach to meeting the net zero challenge. Much of this innovation is developed collaboratively and these joint research relationships contribute greatly to successful development cooperation partnerships.

Through the Climate and Oceans Support Program in the Pacific, Australia's Bureau of Meteorology works with 14 Pacific country counterparts to prepare for climate extremes and communicate seasonal forecasts using a mix of traditional knowledge and western data. Indigenous Pacific communities have a deep understanding of plant and animal behaviour, temperature, rainfall and astronomical observations, and have used that information to make climate and weather predictions for thousands of years. This program combines that knowledge with western technology to provide information on sea level rise and data about tides and waves for shipping and fishing.

7.2.1 Infrastructure and transport

Technology development and transfer occurs across all sectors of Australia's development program. The sectors with the largest climate finance disbursements from 2016 to 2020 were infrastructure and transport. Programs that enabled the transfer of technology within the infrastructure and energy sectors have helped Australia's development partners meet Nationally Determined Contributions. The programs have delivered electricity, more resilient livelihoods through cyclone-proof markets and schools, guaranteed supply chains, and reduced emissions.

In the transport sector, Australia is helping to maintain, rehabilitate and reconstruct a safer, more reliable transport network in Papua New Guinea (PNG) through the PNG–Australia Transport Sector Support Program, particularly in the road and maritime sectors. PNG's critical transport infrastructure is increasingly threatened by extreme weather events, which cause flooding and erosion on road networks and damage port infrastructure. Australia is assisting with the review and upgrading of design standards that will help improve climate resilience of roads, bridges and maritime infrastructure.

The Australian Infrastructure Financing Facility for the Pacific (AIFFP) has agreed to more than $1 billion in financing across 10 major capital works in the Pacific. Included in this are 2 major renewable energy projects with the potential to modernise electricity grids, enable knowledge transfer and meet national Paris commitments. The $32 million Tina River transmission in Solomon Islands will connect the Tina River Hydropower project to the electricity grid in Honiara. The hydropower development (which Australia is co-financing) and transmission line will strengthen energy security, reduce the country's exposure to volatile global fuel prices and enable Solomon Islands to meet 100% of its Paris emissions reduction target. The AIFFP is also financing the $31 million development of a solar farm in Palau. The solar facility will provide up to 20% of Palau's electricity needs and help reduce Palau's dependency on imported diesel fuel. The AIFFP is also providing upstream support to Component C of the Nadi Flood Alleviation Project in Fiji, including an assessment of watershed conditions to support the development of flood models.

Australia worked with local authorities in Rakiraki, Fiji, to rebuild their municipal market, destroyed during Cyclone Winston in 2016, to withstand a category 5 cyclone. This activity was part of the Markets for Change partnership between Fiji, Australia and UN Women, involving strong engagement with the vendors (70% women in the Pacific). It included construction of a rural women's accommodation centre and a disability-inclusive resource and training centre. Similarly, Australian support for the redevelopment of the Gizo Market in Solomon Islands has ensured that it is now designed and built to withstand a category 5 cyclone and resist sea level rises. Further, the project created employment for local construction workers and sourced local sustainably harvested timber for the roof, setting an example for how infrastructure can deliver economic resilience in the face of increasing climate change threats and disasters.

In Vanuatu, Australia's Recovery Acceleration through Prefabricated Infrastructure Deployment pilot supported construction at the Balon School. This demonstrated a high-quality permanent prefabricated structure with a short construction period, which not only withstood Cyclone Harold in 2020, but also served as a cyclone shelter and delivered other community benefits.

7.2.2 Agriculture and food

Australian technology development and transfer also occurs in the water, agriculture, education, food, fisheries, governance and finance sectors.

In agriculture, Australia is helping to accelerate poverty reduction in Indonesia through the Promoting Rural Incomes through Support for Markets in Agriculture program. The program addresses food security, which is threatened by climate change, by creating resilient, inclusive and sustainable agricultural markets in the low-income province of East Nusa Tenggara. This is achieved by removing market barriers and introducing product and production innovations. This has led to 25,300 farmers increasing their income by 30% despite prolonged drought that has afflicted the province.

Australia's Business Partnerships Platform is working with the private sector to roll out an innovative vertical farming technology to increase sustainable food production and free up agriculture land for rehabilitation in Vietnam. The partnership is testing and expanding vertical farm technology to demonstrate the climate and economic value of vertical farms in the Mekong Delta, an area vulnerable to the impacts of climate change.

Food security and nutrition in Fiji, Tuvalu, Kiribati and Samoa have been threatened by rising sea levels, increasing salinity and lack of land. The Atoll Food Futures program is using Australian Foodcube garden systems to help Pacific atoll nations increase local food production by overcoming production constraints. The Foodcube is an innovative raised wicking garden system for growing fruits and vegetables. Together with compost and soil quality management research by the Australian Centre for International Agricultural Research, each Foodcube can produce up to 25 kg of fresh produce per year. With the use of Foodcubes, the quantity of fruit and vegetables households are consuming has increased, and income is also generated from sales when surplus produce is available.

Pacific island countries are the centre of origin for important staple root, fruit and nut crops. With climate change and increased frequency and intensity of natural disasters, there are increasing risks that this genetic diversity could be lost. The Centre for Pacific Crops and Trees (CePaCT) is a regional gene bank that conserves and distributes diverse food plant genetic material from key Pacific crops such as taro, yam, sweet potato, banana, cassava and breadfruit. CePaCT's work supports the Pacific's climate-resilient agricultural future and the region's capacity to support a food security response during disasters. Australia is supporting CePaCT's effort to build a cryopreservation facility, which will support CePaCT's mission for long-term conservation of key Pacific crops.

Table 7.1: Selected projects or programs that promoted practicable steps to facilitate and/or finance the transfer of, or access to, environmentally sound technologies

Program title

Climate and Oceans Support Programs in the Pacific

Purpose

The program supports 14 Pacific country counterparts to prepare for climate extremes and communicate seasonal forecasts, and provide information on sea level rise, tide and wave data for shipping and fishing.

Recipient countries

Recipient countries	Sector	Total funding	Years in operation
Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Niue, Nauru, Papua New Guinea, Palau, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu	Climate	$23 million	2018–2023

Description

The program has developed various prediction and decision-making tools, such as:

- the Pacific Ocean Portal, which provides ocean and tide data for tourism, fisheries and shipping sectors
- the Seasonal Climate Outlooks in Pacific Island Countries (SCOPIC), which generates seasonal outlooks
- the Pacific Sea Level Monitoring Project, which provides information about the implications of sea level rise
- the Water Storage Outlook Model, which seeks the most efficient use of current and future water supplies
- the Malaria Early Warning System, which provides a climate-based malaria risk index in the Solomon Islands.

Factors that led to the program's success

Working in partnership with the region's technical agencies including the Pacific Community, the Secretariat of the Pacific Regional Environment Programme, Geoscience Australia, the Bureau of Meteorology and New Zealand's National Institute of Water and Atmospheric Research, alongside the 14 meteorological services from across the Pacific.

Technology transferred

Projects within the program make use of innovative data-modelling tools and techniques and software. For example, SCOPIC is software that uses a statistical method for forecasting, and is used by national meteorological services in Pacific island countries. The Pacific Sea Level Monitoring Project provides tidal gauge facilities, and a network of Earth monitoring stations for geodetic observations.

7.3 Capacity building

Australia recognises that programs are most effective when implemented by skilled local people. Localisation underpins Australia's approach to development, and it is especially important when considering action on climate change, in which indigenous knowledge and understanding of unique country contexts are critical for success.

7.3.1 Skills development

Australia supports the Vanuatu Skills Partnership, which helps the Vanuatu Ministry of Education and Training build the skills ni-Vanuatu need to adapt to climate change and move towards clean, affordable, low-carbon growth in the tourism, agribusiness, handicraft and construction sectors. Women and men attending training through the ministry's skills centres learn about climate change and how it affects livelihoods and businesses in these sectors, so they can help develop solutions. Training courses are available in priority skills areas – for example, training for tour and bungalow operators to develop disaster action plans and access renewable energy. The partnership is also working in collaboration with government agencies to include the skills sector in climate change policy and planning, nationally and in the provinces.

Australia's Tonga Skills for Inclusive Economic Growth program supports skills sector reform linked directly to inclusive economic growth. It does so by focusing on sectors directly impacted by climate change, such as agriculture, construction and tourism. In the construction sector alone, Tonga Skills has helped 82 trainees graduate from their courses since 2018, with many going on to rebuild the thousands of homes destroyed by Cyclone Gita (February 2018).

In PNG, Australia has partnered with the Global Green Growth Institute to support capacity building in provincial governments under the Climate Resilient Green Growth project. Experts work alongside provincial authorities to mainstream climate-sensitive practices in regional development plans. The project uses a locally driven approach to promote inclusive, resilient and green actions in urban and rural areas. The project also involves components focused on preparing bankable investment proposals and enabling domestic climate finance mechanisms.

The Australia Awards program offers long-term scholarships to people from developing countries to study at Australian universities. The program includes degrees from undergraduate to doctorate, short courses, professional development fellowships and on-award enrichment programs. Climate-related disciplines have been a focus for the program for many years. From 2018 to 2022, 725 Australia Award Scholars from across the Indo-Pacific region studied climate-related disciplines in Australia. In 2021, Australia launched 4 virtual Australian Awards short courses covering climate change adaptation and grid integration of renewable energy. The program has now extended to 12 courses in Africa, Asia and the Pacific.

The Australian Government recognises international volunteering as a valuable approach to capacity development. The Australian Volunteers Program works on the principles of locally led capacity development, and long-term, mutually respectful partnerships with local organisations. One of the program's 3 impact areas are climate change, disaster resilience and food security. A recent evaluation in the Pacific identified positive impacts of the program and partner organisations' work (Gero et al. 2021). Improved resilience to the impacts of climate change were reported as a result of partners' work, and it was noted that 'to a large extent, the Australian Volunteers Program has contributed to partner organisations progressing their development objectives' in climate change and related sectors. Examples given included training and institutional capacity building; research support; building enhanced monitoring, evaluation and learning systems; and strategic development.

7.3.2 Evidence-based decision-making

Climate and ocean science is a key pillar of Australia's support, particularly in the Pacific region. Australia's development program and global engagement and advocacy centre around building knowledge and capacity for evidence-based decisions on climate change. For example, the Australian Government supports the Climate and Oceans Support Program in the Pacific (COSPPac) (see section 8.3.5).

Australia's Pacific Blue Carbon Program is supporting national climate action and livelihoods in PNG and Fiji through increased investment in blue carbon ecosystems. This includes an Indigenous engagement component to help integrate the knowledge and experience of First Nations peoples in managing these important environmental assets. This program is building capacity to measure, report on and verify carbon in mangroves and seagrasses, and to incorporate this information in countries' greenhouse gas accounts and climate-related policies. A key objective is to use pilot blue carbon projects to find ways to finance investment in nature ad nature-based solutions – for example, carbon offsets, and the protection and restoration of marine ecosystems.

The Australian Government coordinates the International Partnership for Blue Carbon with the support of the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization. The partnership connects government agencies with non-governmental organisations, intergovernmental organisations and research institutions from around the world to enable knowledge exchange and global collaboration on blue carbon. The partnership has grown to more than 50 members, who use the forum to connect, share and collaborate on technical issues.

The COSPPac supports Pacific island countries to monitor, analyse and communicate climate and oceans data and information for decision-making. COSPPac produces annual tide calendars using data sourced from the tide gauges and Global Navigation Satellite System stations. Photo credit: Department of Foreign Affairs and Trade.

7.3.3 International leadership

Australia worked closely with the UN Office for Disaster Risk Reduction to host the Asia–Pacific Ministerial Conference on Disaster Risk Reduction in 2022. The conference fostered continuous improvements in participating countries' efforts by sharing experiences and dialogue.

Australia supports several international partnerships to protect and conserve natural ecosystems and support global ocean-based climate action. As a member of the High Ambition Coalition for Nature and People and the Global Ocean Alliance, Australia is supporting a global target to protect 30% of land and sea by 2030.

Australia is a member of the High Level Panel for a Sustainable Ocean Economy (Ocean Panel), which recommends strong action on ocean-based climate solutions to reduce greenhouse gas emissions. The Ocean Panel leaders released a statement at COP26 (November 2021) highlighting the link between the ocean and climate, and the ocean-based actions that can help reduce greenhouse gas emissions.

Australia took a leading role in establishing the Asia–Pacific Rainforest Partnership to promote action and provide a platform to continue activities to reduce emissions from deforestation and forest degradation in the Asia–Pacific region. Regional collaboration within the partnership has focused on restoring degraded landscapes and protecting high-conservation-value forests; informing national policies that contribute to reducing rainforest loss and support sustainable economic development; and increasing the knowledge, understanding and conservation of the region's biodiversity, threatened species and watersheds.

As part of the partnership, Australia conceived and supports the Asia–Pacific Rainforest Summit, which brings together government, private sector, civil society and academic representatives to discuss forest conservation, climate change and the implementation of the Paris Agreement in the Asia–Pacific region. Following the success of the first summit in Sydney (2014), Australia assisted Brunei Darussalam to host the second summit in Bandar Seri Begawan in August 2016 and Indonesia to host the third summit in Yogyakarta in 2018.

Australia's support for the Women's Resilience to Disasters program seeks to empower women in Fiji, Kiribati and Vanuatu to lead Pacific solutions to disaster prevention, preparedness and recovery. It is complemented by a global online Knowledge Hub, which shares knowledge and good practice on gender-responsive disaster risk reduction. The program is delivered by UN Women.

The Australian Humanitarian Partnership's Disaster READY program is supporting more than 770 communities and schools in 4 Pacific Island countries and Timor-Leste to prepare for, and reduce the risk of, disasters. This includes building the capacity of communities, schools and churches to identify climate-related risks and incorporate mitigation and adaptation measures into disaster management plans. For example, activities in the Solomon Islands have combined traditional knowledge of forecasting weather with scientific data to boost community awareness of climate risks, and strengthen mitigation and response. An independent external evaluation found that the program was highly effective and had made a demonstrable contribution towards increasing the capacity of Pacific communities and governments to prepare for and respond to disasters (Kelly & Roche 2020).

Through the Australia Assists program, Australia deployed 66 experts to 18 partner countries across the Indo-Pacific between 2017 and 2020 to help prepare for disasters. Australia Assists is helping disaster management authorities, non-government organisations, United Nations organisations and regional bodies prepare better systems for responding to the increasing frequency, intensity and complexity of disasters.

7.4 Monitoring the impact of response measures

Australia is committed to delivering a high-quality development program that creates sustainable change and improves resilience. Monitoring impacts, both positive and negative, is part of Australia's approach to ensuring an effective development cooperation program. All development investments, including those with climate objectives, are assessed annually in a process that requires robust, independent evidence of effectiveness.

Stability, prosperity and resilience are the Tier One categories in Australia's performance system against which all development cooperation activities are measured. Climate change adaptation and disaster risk reduction are explicit indicators against which Australia measures its development outcomes. Performance reporting is published on the Department of Foreign Affairs and Trade's website.

Australia's development program has a robust policy that guides the approach to managing the environmental and social impacts of its aid investments (DFAT 2019). The 5 main areas in which safeguards are considered are:

- environmental protection
- children, vulnerable and disadvantaged groups
- displacement and resettlement
- indigenous people
- health and safety.

Australia adheres to the Do No Harm approach, and strives for consistency, transparency and accountability of decisions and actions. Complementary to its safeguards policy, Australia also has policies and strategies relating to climate change action, gender equality, disability-inclusive development, humanitarian assistance and Indigenous people that support the effective design and implementation of development cooperation.

Australia collaborates with global partners to improve the measurement of response actions. For example, Australia has been an active contributor to the Global Forest Observations Initiative by compiling guidance information and supporting the design and implementation of forest measurement, reporting and verification systems that comply with international requirements, including the enhanced transparency requirements negotiated under the Paris Agreement.

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8 Research and systematic observation

Key developments

Australia has made substantial progress in climate science research since the seventh National Communication.

Research efforts have continued to increase our understanding of the El Niño–Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD). These climate processes are a major influence on Australia's rainfall and seasonal weather patterns. Research efforts have focused on gaining greater understanding of climate extremes, including fire conditions and marine heatwaves.

Australia continues to be a leader in research in the Southern Ocean and Antarctica. This research improves understanding of the Southern Ocean's role in moderating Earth's average surface climate and how heat and CO_2 are absorbed by the ocean.

Regionally, Australia plays an important role in systematic observation. Observations contribute to global advancement and understanding of climate science. For example, Kennaook/Cape Grim Baseline Air Pollution Station, on Tasmania's west coast, is one of the 3 premier baseline air pollution stations in the world. Air samples have been collected since the mid-1970s to show changes in greenhouse gas levels and other air pollutants over time. Australia also has 6 Centennial Observing Stations, which are recognised by the World Meteorological Organization as providing a high-quality, 100-year record of at least one climate variable.

Australian scientists continue to make valuable contributions to global understanding of climate change. Australians have been authors or editors on the International Panel on Climate Change (IPCC) reports, including contributing to the Sixth Assessment Report and the special reports on oceans and land. Australia uses its national climate model (ACCESS) to simulate past climate and provide future climate projections for a range of future greenhouse gas and aerosol concentration scenarios. These projections contribute to international modelling for the World Climate Research Programme Coupled Model Intercomparison Project Phase 6 (CMIP6) and underpin components of the IPCC's Sixth Assessment Report.

8.1 General policy on and funding of research and systematic observation

The Australian Government invested $10.1 billion in innovation, science and research in the 2019–20 financial year. Industry Innovation and Science Australia is the independent statutory body responsible for providing strategic, whole-of-government advice on this investment. In 2021, Industry Innovation and Science Australia delivered the report Driving effective government investment in innovation, science and research (Industry Innovation and Science Australia 2021). The report identified investment and infrastructure priorities and areas – including research – to build Australia's capacity to respond to environmental change.

The National Collaborative Research Infrastructure Strategy (NCRIS) comprises nationally significant assets, facilities and services and associated expertise to support leading-edge research and innovation. Australia's research infrastructure network has been built over decades and underpins fundamental and applied research across many disciplines. In support of Australia's climate observations and research, NCRIS provides funding to projects such as the Atlas of Living Australia, the Australian Community Climate and Earth System Simulator (ACCESS-NRI), Australian Research Data Commons, the Integrated Marine Observing System (IMOS), National Computational Infrastructure, the National Sea Simulator, the Pawsey Supercomputing Centre and the Terrestrial Ecosystem Research Network. The National Research Infrastructure Roadmap details a path for Australia to build on strong existing national research infrastructure foundations and deliver step-change capability to support future research needs (DESE 2021).

8.1.1 Key science and research organisations

The Australian Government supports the development of climate science and information for decision-makers in government, business and the community to better understand the impacts of changing climate and manage risk. This includes ongoing contributions to science and research organisations, and funding for major research programs. State and territory governments contribute funding to many research programs and collaborate with Australian Government research organisations and programs.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is the national agency for scientific research in Australia. CSIRO research includes climate adaptation and mitigation; modelling and observing systems needed to monitor, understand and predict climate variability; investigation of the impact of weather and climate variability and change; and research into emissions reduction technologies.

The CSIRO Climate Science Centre brings together climate modelling and observations of the atmosphere and ocean. The mission of the centre is to deliver the climate knowledge Australia needs to inform an effective national response to the challenges of a variable and changing climate. Centre research includes national observation and analysis programs and networks to study climate change and variability in the past, present and future; climate and ocean dynamics; Earth system modelling; and carbon–climate feedbacks.

Key collaborations and outcomes include:

- national and regional climate forecasts and projections for climate impact assessments, which inform climate adaptation and mitigation responses
- observations of oceans and atmosphere, such as IMOS, the Kennaook/Cape Grim Science Program, ocean physics and chemistry, and networks to observe greenhouse gases and aerosols
- climate hazard information through the Australian Climate Service
- the Community Atmosphere Biosphere Land Exchange (CABLE), which is developed to be a world-class, community land surface model for use in resource management and weather, climate and Earth system modelling
- ocean and coastal forecasts for national security, marine industry, emergency response and management of marine resources
- air quality assessments and forecasts for communities, industry and regulatory authorities
- renewable energy resource assessments and forecasts for research and technology partners.

The Bureau of Meteorology (Bureau) is Australia's national weather, climate and water agency. Through regular forecasts, warnings, monitoring and advice spanning the Australian region and Antarctic territory, the Bureau provides one of the most fundamental and widely used services of government.

The Australian Antarctic Division (AAD) of the Department of Climate Change, Energy, the Environment and Water leads Australia's scientific program in Antarctica. Through collaborative research programs, the AAD delivers strategically important and globally ambitious research in Antarctic climate, environmental stewardship, Southern Ocean ecosystems and monitoring of East Antarctica.

The Australian Institute of Marine Science, Australia's tropical marine research agency, provides large-scale, long-term research to inform decision by governments, industry and the community about the management of Australia's marine estate.

Other national agencies contributing to Australia's climate science and research efforts include Geoscience Australia, which provides geological and geographic information, and the Australian Nuclear Science and Technology Organisation, which provides specialised advice on nuclear science and technology.

In 2016 the Australian Government established the National Climate Science Advisory Committee. The committee provided advice on a strategic direction for Australian climate science research and developed a national-level approach to address business and policy climate science research and development needs.

The independent committee was chaired by Dr Katherine Woodthorpe AO FTSE FAICD, and membership comprised the Australian Chief Scientist, and other senior representatives from across Australian climate science research, investment and policy agencies and institutions. The broad representation aimed to boost collaboration across agencies and sectors, ensure climate science activities are coordinated and prioritised, and guide investment to maintain and strengthen Australia's research capability.

The committee finalised its advice to the Australian Government in its 2019 report Climate science for Australia's future (NCSAC 2019), on the development of a strategy for Australian climate science, including identifying climate science priorities, strengths, capabilities and resourcing. The report highlights 6 core climate science research, policy and service domains necessary to support informed decision-making on climate change and climate risk and impacts:

- climate observations, data, analysis and infrastructure
- climate process studies
- climate modelling and projections
- climate risk, adaptation and services
- international engagement and dependencies
- research coordination and funding.

The report also advised on establishing ongoing climate science community coordination arrangements and provided 10 strategic recommendations to enhance, coordinate and deliver climate science for Australia's benefit.

8.1.2 Major research programs

Australia conducts a wide range of climate-centred research and development, focused on both Australia and the region (see also Chapter 7).

8.1.2.1 National Collaborative Research Infrastructure Strategy program

Climate research is supported by NCRIS, which drives research excellence and collaboration between researchers, government and industry. From 2017–18 to 2028–29, the Australian Government will provide $4 billion through NCRIS to deliver world-class research infrastructure. This attracts significant co-investment from state and territory governments, universities, research facilities and industry, multiplying the impact of NCRIS projects. The NCRIS network supports national research capability through 24 active projects and approximately 400 delivery partners, and employs nearly 1,600 highly skilled technical experts, researchers and facility managers. NCRIS facilities are used by more than 61,000 researchers, both domestically and internationally.

The 2021 National Research Infrastructure Roadmap (DESE 2021) identified the tools, technologies and expertise Australia's researchers and innovators need for the coming decade to continue to address national priorities and pressing global challenges. It identified environment and climate infrastructure as one of 5 areas where focused investment may create step-change in Australian research and innovation capability. It also recommended the development of a National Digital Research Infrastructure Strategy. Digital research infrastructure (data and computational capability) is fundamental to Australia's climate research efforts, and the strategy could help drive improved outcomes for researchers. The 2021 roadmap was released by the Australian Government in April 2022. In November 2022, the government announced $0.9 billon (over 2023–24 to 2027–28) to further support current NCRIS projects and provide continuity in services to researchers.

Research infrastructure projects funded by NCRIS that are integral to climate research and observations, domestically and internationally, include:

- Atlas of Living Australia, Australia's national biodiversity database
- AuScope, which provides research tools, data, analytics and support to Australia's geoscience community
- Australian Community Climate and Earth System Simulator (ACCESS-NRI), national research infrastructure to support development and research of Australia's weather and Earth systems modelling (see also sections 8.2.2.1 and 8.2.2.2)

- Australian Research Data Commons, which supports Australian research and innovation by driving excellence in the creation, analysis and retention of high-quality data assets
- Integrated Marine Observing System (IMOS), a nationwide collaborative research infrastructure initiative with a distributed observing network and information services designed to observe Australian oceans and improve understanding of the role of the ocean in the global climate system (see section 8.3.2)
- National Computational Infrastructure (NCI) and Pawsey Supercomputing Centre, which collaborate to provide high-performance computing and data services to Australian researchers, government and industry
- Terrestrial Ecosystem Research Network (TERN), which collects environmental data and samples from around Australia through field surveys, remote-sensing technologies such as drones and satellites, and monitoring of specific sites across the country (see section 8.3.3).

8.1.2.2 Australian Climate Service

The Australian Climate Service (ACS) was established for 4 years in 2021 with a $209.7 million investment from the Australian Government. The ACS will provide a data and intelligence service to integrate the Australian Government's extensive climate and natural hazard information into a single national view. Hosted by the Bureau, the ACS brings together expertise from the Bureau, CSIRO, the Australian Bureau of Statistics and Geoscience Australia to build a national capability that supports the National Emergency Management Agency in better understanding climate and natural hazard challenges and the associated impacts (see section 8.2.2.2). The ACS is designed to provide authoritative data, intelligence, models and tools to inform short- and long-term national responses to the effects of natural hazards in a changing climate. The ACS will have a $37.3 million per year ongoing operational budget from 2025–26.

8.1.2.3 National Environmental Science Program

The National Environmental Science Program (NESP) is a long-term commitment by the Australian Government to environment and climate research. The first phase invested $145 million (2014–15 to 2020–21) into 6 research hubs (including the Earth Systems and Climate Change Hub; see section 6.3.2). The second phase is investing $149 million (2020–21 to 2026–27) into 4 new research hubs.

Within this second phase, NESP funding of $38 million is allocated to the Climate Systems Hub to advance understanding of Australia's climate, its extremes, and associated drivers. This will directly inform climate adaptation solutions for Australia. The 4 new NESP hubs (Resilient Landscapes; Marine and Coastal; Sustainable Communities and Waste; Climate Systems) will draw on this research to develop decision-making tools and information to help prepare Australia to manage existing and emerging environmental risks.

NESP is committed to promoting open access to public sector and publicly funded information, including optimising the use and reuse of data. Open access to government-funded information is the default position, with exceptions made only for sensitivity reasons.

8.1.2.4 Australian Antarctic Science Program

The Australian Antarctic Science Program (AASP) is led by the AAD. The program includes research addressing climate change by the AAD, CSIRO, the Bureau, universities and other research agencies. The research is directed by the Australian Antarctic Strategic Plan and underpinned by the capabilities and assets of the Australian Antarctic Program, which include its Antarctic/sub-Antarctic stations (Casey, Davis, Mawson and Macquarie Island), and its aviation and shipping assets.

Antarctic climate research is supported by complementary and collaborative national initiatives:

- The Australian Antarctic Program Partnership (AAPP) is a partnership of Australia's leading Antarctic research institutions supported by the Australian Government Antarctic Science Collaboration Initiative. AAPP's focus is to improve our understanding of the role of the Antarctic and Southern Ocean within the global climate system and its implications for marine ecosystems. The AAPP research focuses on the Australian Antarctic Territory and adjacent Southern Ocean, and looks at priorities within the Australian

Antarctic Science Strategic Plan. The 10-year, $50 million program began in 2019 and its current term will conclude in 2029. The AAPP is a follow-on to the Antarctic Climate and Ecosystems Cooperative Research Centre (CRC) (ACE CRC) (see previous research contributions summarised in this report: ACE CRC 2020) and is a leader in polar and Southern Hemisphere climate research. The AAPP has 7 partners, including the AAD, the Bureau, CSIRO, Geoscience Australia, IMOS, the Tasmanian Government and the University of Tasmania.

- The Australian Centre for Excellence in Antarctic Science (ACEAS) is based at the Institute for Marine and Antarctic Studies at the University of Tasmania and is a partnership of 8 Australian universities. Other domestic partners include the AAD, CSIRO and Geoscience Australia. ACEAS has formal partnerships with more than 20 institutes across the United States, the United Kingdom, the Netherlands, France, Korea, Japan, Sweden, Finland and Germany. Funding of $20 million over 3 years from 2022–23 is being provided through the Australian Research Council's Special Research Initiatives scheme. ACEAS data will be made available under FAIR principles and in accordance with the provisions of the Antarctic Treaty. In addition to research, ACEAS has a strong focus on training and career development of early career researchers.
- The Securing Antarctica's Environmental Future (SAEF) is a research program funded by the Australian Research Council as a Special Research Initiative. The Council is investing $36 million over 7 years from 2021–22. Its mission is to understand the changes taking place across the Antarctic region to its climate and biodiversity, and develop innovative ways to forecast, mitigate and manage these changes. SAEF also collaborates with policymakers to identify conservation priorities and to inform decision-making.
- The Antarctic Gateway Partnership was an Australian Government initiative to increase polar research capability, which ceased in 2020. The partnership involved the University of Tasmania, the Institute for Marine and Antarctic Studies, the Australian Maritime College, CSIRO and the AAD. The research included the development of a next-generation polar autonomous underwater vehicle to acquire high-resolution data under sea ice and ice shelves to help understand how the oceans melt Antarctic ice shelves, and to quantify present and future Antarctic ice sheet mass loss and its contribution to sea level rise. Funding of $32 million over 6 years from 2014–15 for the partnership was provided through the Australian Research Council's Special Research Initiatives scheme.

8.1.2.5 Torres Strait Climate Centre of Excellence

The Torres Strait Climate Centre of Excellence is a partnership between the Torres Strait Regional Authority and the Department of Climate Change, Energy, the Environment and Water. The centre was established for 4 years in 2022 with a budget of $15.9 million. It will benefit Torres Strait Islander and other First Nations communities across the region and Australia by building capacity to respond to climate change through the integration of lived adaptation experiences, traditional knowledge and western science. The centre will support an enduring dialogue on climate change in the Torres Strait by connecting with other government initiatives delivering climate change action for First Nations People and through the NESP's First Peoples Gathering on Climate Change and First Nations–led project work.

8.1.2.6 Other collaborative research centres

The Australian Research Council's Centre of Excellence for Climate Extremes (CLEX) is Australia's premier climate-focused fundamental research centre, linking 5 Australian universities with other national and international capabilities. Its focus is on a process-based understanding of atmospheric, terrestrial and ocean extremes, and on building new understanding into the climate models used for projections (see also section 8.2.2.1). It is funded through to the end of 2024.

Natural Hazards Research Australia was established on 1 July 2021 as a collaborative research organisation to address the major challenges arising from natural hazards, including bushfires, floods, cyclones, heatwaves, storms and other hazards.

TERN is a national collaboration by universities and CSIRO that measures and observes changes in land-based ecosystems over time (see section 8.3.3).

See also section 8.2.3.1 for details of relevant centres funded under the CRC program.

8.1.3 Universities

Universities across Australia are active in various aspects of climate change research, from ocean and terrestrial observational studies to emissions reduction and adaptation responses. This includes several climate change–focused centres and collaborations such as CLEX, and through the AASP.

8.1.4 States and territories

State and territory governments support research programs aimed at informing and developing adaptation efforts (see Chapter 6). They also support key state- and territory-focused research programs, a selection of which follows. Together, through the Cross Jurisdictional Community of Practice for Climate Science, states and territories also partner with the NESP Climate Systems Hub to deliver policy-relevant science that tackles the environmental challenges of climate change and climate adaptation.

The New South Wales Government provides high-quality climate data and information for public use through the NSW and Australian Regional Climate Modelling (NARCliM) project (see Table 8.1 in section 8.2.2.4).

Climate Change in the Northern Territory was developed with the NESP Earth Systems and Climate Change Hub in 2020 and summarises how climate change is affecting the Territory.

The Queensland Government is collaborating with the University of Queensland on the the Queensland Future Climate Science Program (see Table 8.1 in section 8.2.2.4).

The South Australian Government's Climate Change Science and Knowledge Plan for South Australia identifies critical science and information needed to inform climate change risk assessment, mitigation, planning and adaptation responses in South Australia. Various tools are being developed to support implementation of the plan (see Table 8.1 in section 8.2.2.4).

Climate Futures for Tasmania provides climate change projections for Tasmania. In 2020, the existing Enterprise Suitability Mapping project was updated (see Table 8.1 in section 8.2.2.4). In addition, under *Tasmania's Climate Change Action Plan 2017–21* (Tasmanian Climate Change Office 2017), the Tasmanian Government has reviewed climate change modelling and identified research opportunities in several priority sectors.

Victoria's Climate science report (DELWP 2019) sets out the latest climate science and the implications for Victoria. The Victorian Water and Climate Initiative aims to better understand the influence of climate change on Victoria's water resources (see Table 8.1 in section 8.2.2.4).

The Western Australian Government is undertaking research to support climate impacts, risk assessment and adaptation planning through the Western Australian Climate Science Initiative (see Table 8.1 in section 8.2.2.4).

8.2 Research

Australian climate change science research falls into 4 main categories:

- foundational climate observations, monitoring and analysis, including climate monitoring and analysis to observe and understand the physical processes that drive the climate; Australia contributes to the global network of climate observations
- process-focused understanding, including
  - climate process research to understand the mechanisms that drive climate variability and climate change in our region
  - modelling using simulations of past, current and future climate scenarios to help Australia better understand climate and project future climate at global and regional scales
- climate risk, adaptation and services, including
  - research into the impacts of climate change
  - approaches to adaptation and mitigation
- emissions reduction technologies – developing technologies that reduce emissions.

8.2.1 Climate processes and impacts research

8.2.1.1 Ocean processes

Australia conducts various research projects focused on understanding ocean and climate processes, as well as ocean monitoring programs (see section 8.3.2).

El Niño–Southern Oscillation and the Indian Ocean Dipole

Australia's climate variability is influenced by large-scale, coupled ocean–atmosphere climate patterns and their interactions. These patterns include ENSO (comprising El Niño and La Niña modes), IOD, Southern Annular Mode (SAM), monsoons and the Madden–Julian Oscillation.

The NESP Climate Systems Hub has continued to research ENSO. New understanding of the 2 'flavours' of El Niño shows that El Niño events that have warmer waters concentrated on the central Pacific have a larger drying impact on Australia compared with those that have warmer waters centred on the eastern Pacific. Further work on the flavours of El Niño, including how their impacts and connections to Australian rainfall are projected to change under future scenarios, is currently underway. CLEX research has demonstrated that these flavours of El Niño have limited impact on the carbon cycle (Teckentrup et al. 2021).

Drawing on observations and climate model simulations, NESP Climate Systems Hub researchers showed that a positive IOD increases bushfire risk and severe droughts over south-east Australia, particularly when co-occurring with a central Pacific El Niño, as was the case in the 2 years leading up to the Black Summer bushfires. CMIP5 and CMIP6 climate model–based projections indicate that the frequency of consecutive, co-occurring positive IOD and Central Pacific El Niño events is expected to increase only marginally. However, the frequency of dry winter–spring seasons is projected to increase in all Australian regions under a high-emissions scenario, which would exacerbate the impacts of such events.

In 2018 and 2019, a positive IOD coincided with a Central Pacific El Niño, which particularly affected Australia. Such a coincidence is rare, and had only been observed once since 1911. It contributed to the extremely hot and dry conditions in the lead-up to the Black Summer bushfires (NESP Earth Systems and Climate Change Hub 2021). The extreme positive IOD event was investigated by NESP researchers. Strong positive IOD events may increase in frequency in the future. Further, strong El Niño events are projected to increase in amplitude and frequency under greenhouse warming. Model simulations show that when the Interdecadal Pacific Oscillation is disrupted, decadal temperature variability in the tropical Pacific is reduced. Reducing the influence of the South Pacific in the model reduces the extent of sea surface temperature variations during extreme El Niño and La Niña events.

In Australia, La Niña years are associated with increased intensity of rainfall across large areas of eastern and northern Australia between July and February (King et al. 2020), including an increase in the risk of landfalling tropical cyclones in the north-east (Chand et al. 2019) and in the frequency of heavy rain and flooding on the east coast (Power & Callaghan 2016).

NESP research identified a pattern of variability in ocean heat content, called the 'Asymmetric Mode' (AM), which is independent of global warming and other well-known modes (such as ENSO, IOD and SAM), and existed before the onset of global warming. The AM represents a global-scale shift in ocean warming between hemispheres that occurs over decades. The dominance of Southern Hemisphere warming appears to be waning, which means rates of ocean warming may soon increase in the Northern Hemisphere (NESP Earth Systems and Climate Change Hub 2021).

Ongoing research into large-scale modes of climate variability is largely undertaken through the university sector (CLEX), with remaining research from CSIRO mostly occurring within the NESP Climate Systems Hub.

Oceans surrounding Australia, including the Southern Ocean

Australia's oceans and seas include those off the mainland and its offshore territories in the Pacific, Southern and Indian oceans as well as the Timor, Tasman and Coral seas. Ocean currents have a strong controlling influence on climate, ecosystems, fish stocks, water quality and the transport of ocean debris. IMOS provides much of Australia's contribution to global ocean observations for climate (see section 8.3.2).

The Southern Ocean influences climate by taking up and storing more anthropogenic heat and CO_2 than any other latitude band of the ocean. The Southern Ocean also influences the productivity of marine ecosystems and the stability of the East Antarctic Ice Sheet, through ocean-driven melt of the buttressing ice shelves.

Research by the ACE CRC partnership has shown that the Southern Ocean is becoming fresher, more acidic and less oxygenated, and that all these processes are occurring more rapidly than in any other ocean. Delivery of this work is through an integrated program of physical and biogeochemical observations, modelling and synthesis. To add to infrequent shipboard sampling, there are investments in autonomous profiling floats that provide year-round observations of the East Antarctic sector of the Southern Ocean. They include novel biogeochemical sensors, and new floats that can profile the full ocean depth. The profiling floats provide the only feasible means of tracking changes in the ocean inventory of heat and carbon over broad regions (Tamsitt et al. 2021). Satellite remote sensing provides additional spatial and temporal context for the less frequent and spatially sparse in situ measurements, including the Surface Water and Ocean Topography satellite mission that provides measurements of sea surface height across a swath for the first time, and advances in ocean biomass estimates from satellite lidar instruments. The observational work is carried out in collaboration with IMOS, ACEAS and SAEF. A hierarchy of numerical models, from ultrahigh-resolution process models to global Earth system models, is used to assess the impacts of Southern Ocean change and the sensitivity of physical and biogeochemical processes to changes in climate.

The AAPP builds on the earlier ACE CRC work in the Southern Ocean (see ACE CRC 2020). It is investigating how and why the physical and biogeochemical environment of the Southern Ocean adjacent to the Australian Antarctic Territory is changing, and assessing the impacts of climate change, sea level, sea ice and marine ecosystems.

ACEAS is also advancing our understanding of the Southern Ocean, including its circulation, biogeochemistry, and the role it plays in climate both over Australia and globally. The Southern Ocean absorbs vast quantities of heat and carbon, but this might not be stable. Evidence is emerging of a threat to East Antarctic ice shelves due to the delivery of heat at the grounding lines of some of the region's marine-terminating ice sheets (Stokes et al. 2022). ACEAS undertakes this work by combining observational platforms, satellite autonomous measurements and process-based approaches with coupled ocean-ice and climate modelling. Numerical modelling work focuses on understanding the links and feedbacks between ocean, atmosphere, ecosystems, sea ice, ice shelves and ice sheets. This modelling work focuses on past changes, year-to-year and longer-term variability, ongoing change, and projections for the future (Huguenin, Holmes & England 2022).

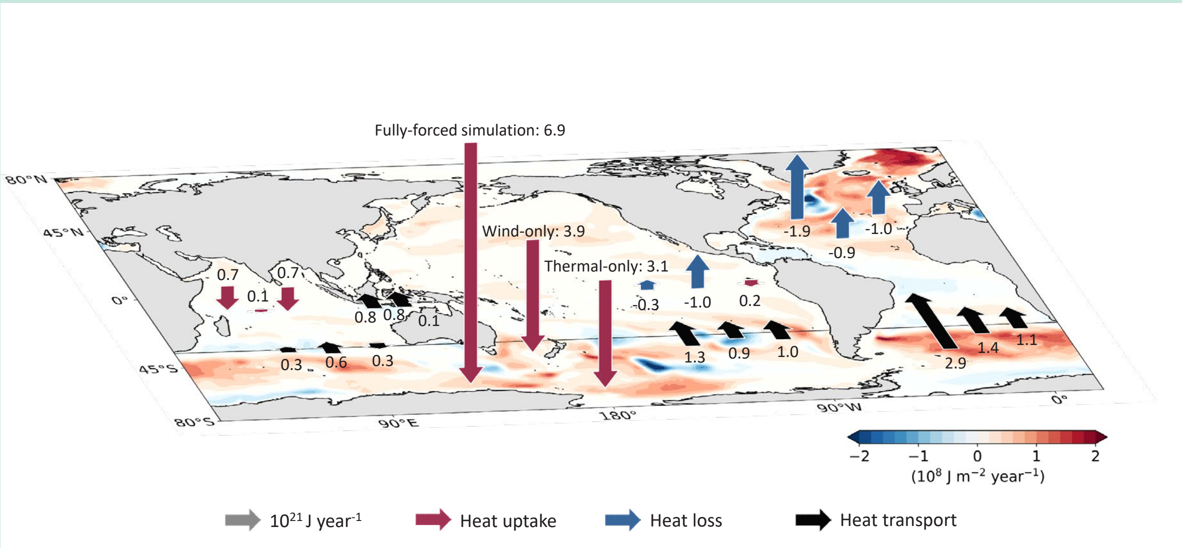
Research by CSIRO, in partnership with the University of Southampton in the United Kingdom, has revealed how changes in Southern Ocean circulation are affecting the East Antarctic Ice Sheet. The research shows how warming waters at the East Antarctic shelf are linked to a reorganisation of water masses that could potentially compromise the stability of the East Antarctic Ice Sheet (Herraiz-Borreguero & Naveira Garabata 2022).

Case study: Drivers and distribution of global ocean heat uptake over the past half century

ACEAS researchers have used observations in combination with targeted hindcast model experiments to show that the Southern Ocean accounts for almost all of the global ocean heat uptake of the past half century (Huguenin, Holmes & England 2022). This ocean heat uptake is facilitated by both cool sea surface temperatures and significant sensible heat gain driven by the region's strong westerly winds, alongside downward longwave radiation changes. Before this work, our knowledge of where ocean heat uptake occurred and where this heat is stored was limited by sparse observations.

The ACEAS project used a global ocean–sea-ice model, with observed conditions as inputs, to compare simulated ocean heat uptake with observations. The model incorporated a variety of improvements compared with existing models and captured the observed global ocean heat content change better than most previous ocean–sea-ice model simulations.

The work also demonstrated that the Southern Ocean heat uptake is due approximately equally to surface winds and thermal and radiative changes. These contributions, when restricted to the Southern Ocean, account for nearly all the global ocean heat uptake. These results address longstanding limitations in multi-decadal ocean–sea-ice model simulations and successfully reconcile estimates of ocean heat uptake, transport and storage.



Ocean heat uptake over the past half century, partitioned by ocean basin (Pacific, Indian, Atlantic and Southern oceans) and by dominant processes (wind-driven and radiative) after Huguenin et al. (2022).

Sea level rise

Currently, global sea levels are rising at an average of 3.5 cm per decade; however, the rate of sea level rise is not uniform around Australia and the impacts of sea level rise vary around our coastline. Coastal inundation and erosion pose tangible risks to coastal communities, ecosystems and infrastructure. Analysis of a range of coastal and nearshore variables, including sea level trends, extreme sea levels and waves, have improved our understanding of how marine and coastal extremes are changing in a warmer climate (Colberg et al. 2019; Melet et al. 2020). This work included an upgrade to the high-resolution sea level rise calculator tool Canute, which features new sea level rise projections and average return interval plots (Hinkel et al. 2019).

Wind waves

Wind waves are a type of wave created on the sea surface when the wind blows. They play a critical role in processes like coastal sediment transport and ocean–atmosphere heat exchanges. Climate change is driving changes to ocean surface winds and, in turn, wind waves, which are likely to contribute to future coastal flooding and erosion. Through Coordinated Ocean Wave Climate Projections, NESP Earth Systems and Climate Change Hub researchers used a new wind wave model to understand the projected changes to key characteristics of wind waves (Meucci et al. 2020).

8.2.1.2 Cryospheric climate processes

The cryosphere is those regions on Earth where fresh water is primarily found frozen as ice or snow. Cryospheric climate process research contributes to our knowledge of the long-term climate of Antarctica, the Southern Ocean and the globe more generally, and how the oceans, atmosphere, cryosphere and ecosystems interact on a wide range of spatial and temporal scales.

The AAPP is investigating the linkages between the Australian Antarctic Territory and the climate of Australia and the rest of the globe (Vance et al. 2022). Knowledge of past climate variability and change, combined with improved understanding of ocean–sea-ice interaction, of clouds and aerosols over the Southern Ocean and of the dynamics of Antarctic ice shelves underpin more reliable projections of future climate and sea level rise. This work builds on earlier AAPP work in the cryosphere (ACE CRC 2020). The research enables Australia to better manage the challenges of future climate variability and change. Ice shelves buttress the Antarctic ice sheet, providing a force that resists the flow of ice from the continent to the ocean. Understanding the sensitivity of ice shelves to changes in ocean, sea ice and atmosphere is therefore critical to assessing the Antarctic contribution to future sea level rise. The AAPP is also investigating the processes that cause ice shelves to lose mass (iceberg calving and basal melt by the ocean) and their sensitivity to changes in climate forcing. AAPP research on ice-mass loss by Antarctica was included in the recent IPCC Sixth Assessment Report of Working Group 1 report.

The cryospheric work of ACEAS focuses on observational, process-based and numerical modelling research. Numerical modelling work focuses on understanding fundamental properties of ice streams, the large glaciers within the Antarctic ice sheet, and projections of the future of these glaciers. ACEAS researchers are modelling the interactions between the ice sheet and ocean, and feedbacks in terms of sea level and ecosystem change. Antarctic field observations and remote-sensing satellite data are used to constrain processes, quantify past and present change, and understand the causes of that change.

A review of the East Antarctic Ice Sheet by ACEAS, AAPP, SAEF and other researchers assessed the potential for the ice sheet to contribute to future sea level rise (Stokes et al. 2022). Some glaciers that underwent notable mass loss during past warm periods are losing mass at present, but most projections indicate increased accumulation across the ice sheet over the 21st century, keeping the ice sheet broadly in balance. Beyond 2100, high-emissions scenarios generate increased ice discharge and potentially several metres of sea level rise within just a few centuries.

ACEAS researchers identified a new feedback mechanism that may increase future Antarctic ice sheet contribution to sea level change (Li, et al. 2022). The work identified large sedimentary basins beneath the ice sheet that are expected to contain substantial groundwater. As the ice sheet retreats due to climate and other forcings, the rate of groundwater expulsion from the sediments is expected to increase, lubricating the ice sheet base, and causing further acceleration of ice flow into the ocean. This process is not yet included in ice sheet and sea level projections.

8.2.1.3 Paleoclimatic studies

Paleoclimatology is the study of climates for which direct measurements were not taken. As instrumental records only span a tiny part of Earth's history, the reconstruction and identification of the causes of climate changes are important for understanding natural variation and present and future climates.

Ice cores provide the most powerful tool to determine how Earth's climate has varied in the past. Australia's contribution to international geophysical surveys has helped narrow the location of the ice that is likely to contain a 1-million-year climate record. The AAD is in the process of assembling the equipment required to drill a deep ice core in the interior of Antarctica.

The AAPP provides analysis of glacial ice cores to provide records of past climate and radiative forcing. Shallow cores, including those recently obtained from Antarctica by Australian and international collaborations, provide a detailed climate history record, and quantify feedbacks between climate and atmospheric chemistry and the carbon cycle over the past few thousand years with decadal resolution. Recent studies have identified links between Antarctic ice core records and the Australian hydroclimate (Armstrong, Kiem & Vance 2020). These studies use high-resolution ice core data for the past 2 millennia to show that instrumental rainfall records for the past century do not adequately reflect long-term extremes. The studies also point to anthropogenic factors contributing to drought in south-west Western Australia (Udy et al. 2021).

The Queensland Government, Seqwater and University College Dublin developed a methodology for the inclusion of palaeoclimate data in climate adaptation planning and water security programs. A key lesson from this work is that historical observations post-1900 do not capture the full range of climatic variability that has occurred within Queensland over longer timescales. High-quality, longer climate records developed from palaeoclimate data are valuable resources to inform our understanding of possible future climates. This project has also delivered an online palaeoclimate proxy database of all local and remote data that can be used to better plan and prepare for extreme floods and droughts in Queensland in a changing climate.

Through CSIRO, Australia contributed model data (CMIP6) to the Paleoclimate Modelling Intercomparison Project (Kageyama et al. 2018). The goal of the project is to understand the response of the climate system to different climate forcings for documented climatic states very different from the present and historical climates. Through comparison with observations of the environmental impact of these climate changes, or with climate reconstructions based on physical, chemical or biological records, the project also addresses the issue of how well state-of-the-art numerical models simulate climate change.

8.2.1.4 Extreme climate events

Australia experiences extreme climate events, including droughts, bushfires, east coast lows (ECLs), marine heatwaves and tropical cyclones. These events have serious impacts on the environment and society, including loss of life, property, and livelihoods (see section 6.1). Extreme events in Australia have already increased in frequency and intensity, with further changes projected to continue with rising global temperatures.

Climate extremes research continues to be a focus for numerous scientific programs, including the NESP Climate Systems Hub, CLEX, the ACS, the CSIRO Climate Science Centre and the Tasmanian Government.

Droughts

Droughts can have devastating impacts on agriculture, the environment, lives and livelihoods. Water is the most universally limiting factor in Australian production systems. Based on limited studies, climate models simulated under a high-emissions scenario suggest that multi-year droughts are likely to become more frequent over the coming century in response to global warming (Kirono et al. 2020). However, while there is increasing agreement among CMIP6 models around the projections of future droughts, the ability of global models to simulate multi-year droughts is very limited (Ukkola et al. 2018, 2020). Research findings also indicate that a flash drought is set in motion by lower-than-average rainfall, accompanied by abnormally high temperatures, a dry atmosphere, clear skies and more sunshine (Parker et al. 2021).

CLEX has made a series of major advances, ranging from new high-quality and long-term precipitation datasets (Contractor et al. 2020) through to how groundwater moderates vegetation processes during drought (Mu et al. 2021).

The Australian Government's Future Drought Fund has invested in the development of 2 digital platforms to provide information to the agricultural sector to help manage the impacts of drought. The Climate Services for Agriculture platform provides an understanding of how potential future climates might impact the production of key agricultural commodities. The Drought Resilience Self-Assessment Tool helps farmers with small- to medium-sized holdings understand and improve their financial, environmental and social resilience to drought and a changing climate.

Bushfires

There is a clear link between climate change and worsening bushfire weather conditions over the past 70 years (see also section 6.1.1). There is a trend towards more dangerous fire weather conditions in most regions, and an earlier start to the bushfire season in southern and eastern Australia. Further, fire-generated thunderstorms are being observed more frequently. NESP Earth Systems and Climate Change Hub research found that climate change has influenced the frequency and severity of 2 risk factors that are associated with fire-generated thunderstorms: dangerous fire weather conditions near the surface and conditions that allow smoke plumes to grow in height (Dowdy 2020). Recent hub research examined how this relates to actual fire occurrence and burned area, finding significant increases in bushfire occurrence in recent decades compared with previous decades, based on the available ground and satellite observations, particularly for the forested regions of south-east Australia.

The Bureau issues Fire Weather Warnings when weather conditions are conducive to the spread of dangerous bushfires. The McArthur Forest Fire Danger Index was calculated based on analysis of daily observations data from 1950 to 2016 throughout Australia. This dataset provides an indication of how extreme the regional conditions were for a particular period (week, month or season) compared with conditions experienced previously (back to 1950). This work developed a system that automatically updates daily to provide the latest information. Fire agencies around the country now receive this information to inform their understanding of the severity of current conditions relative to the past climate.

Future projections of the fire weather index were produced by the Bureau, showing clear trends towards more dangerous weather for bushfires in Australia due to increasing greenhouse gas emissions. The results for historical trends, based on observations and modelling of future projected changes in bushfire weather conditions, were used extensively for many applications, including as key inputs to the Royal Commission following the Black Summer fires.

CLEX research has focused on specific major bushfire events. For example, researchers developed a deeper understanding of the links between fire and climate variability (Abram et al. 2021), while also exploring the detailed understanding of factors influencing pyroconvection (Badlan et al. 2021a, b).

The Bushfire and Natural Hazards CRC (until closed in 2021) coordinated a comprehensive program of bushfire and natural hazards–related research. After the Black Summer bushfires, this work focused on extreme fire behaviour and what contributed to it; integration of cultural land management practices into fire prevention; and community engagement, participation and behaviour. With the conclusion of the CRC, Natural Hazards Research Australia has been funded to lead an end-user-driven research agenda, which will contribute to managing climate hazards.

Case study: Compound events

Australia has experienced a variety of compound events that have led to loss of life and harmed the Australian economy over the past decades. Compound events are combinations of weather and climate hazards that can cause more severe socio-economic impacts than hazards occurring in isolation (for more information on compound events, see Ridder et al. 2022).

Using observations and reanalyses, researchers developed the world's first climatology of compound events (Ridder et al. 2020). This was used to test how well climate models reproduced some events, and demonstrated that some CMIP6 models were effective (Ridder, Pitman & Ukkola 2021). This led to a global analysis of how types of compound events would change globally and over Australia (Ridder et al. 2022).

Projections show an increase in prolonged hot and dry compound events over all of Australia, which is likely to exacerbate fire risk. Current climate models also project an increase in wet and windy compound events in the northern parts of Australia (dominated by tropical cyclones and thunderstorms) and a decrease in events in the south, where fronts and frontal systems are the dominant drivers of extreme wind and rain.

Frost and heat shocks to crops

Frost is considered an extreme event in parts of Australia because of how much damage it does to quantity and quality of grains and other crops. Frost has been estimated to cost Australian grain growers around $360 million per year. CSIRO is conducting farm-scale frost mapping to inform tactical and strategic action to minimise frost-related crop damages. Paddock-scale minimum temperature maps have been developed, with the aim of building a low-cost method to predict severity and duration of frost events (Gobbett et al. 2021).

CSIRO is now leading a consortium to provide farmers with both on-farm monitoring and satellite-driven predictive tools that quantify yield losses from frost and heat events. Trials for the wheat and barley industries have been conducted to better align methods with farm management practices.

East coast lows and heavy rainfall

ECLs are low-pressure systems that form off the east coast of Australia. They can cause heavy rainfall, strong winds, large waves, widespread flooding and coastal erosion. They can have devastating impacts, including injury, loss of life, infrastructure damage and large insurance losses. At the same time, they provide a major source of rainfall and storage replenishment. Climate change may affect the intensity, frequency and duration of ECLs, with implications for coastal erosion, inundation, flooding and water security.

As the climate continues to warm, we can expect less frequent ECLs, but more intense rainfall, likely because warmer air is able to hold more water. These future changes for ECLs are similar to those expected for tropical cyclones – fewer are expected to occur but they will bring more intense rainfall (Peplar & Dowdy 2022). Researchers also found that short-duration (e.g. hourly) events produced by thunderstorms could increase in intensity by about 15% per degree of global warming (Cavicchia et al. 2019; Dowdy et al. 2019; Pepler & Dowdy 2021).

Marine heatwaves

A marine heatwave occurs when the ocean is unusually warm for a prolonged period, with the potential for major impacts on marine ecosystems. Joint research between IMOS, CLEX and NESP has transformed our understanding of marine heatwaves.

Marine heatwaves are becoming longer and more frequent. The annual number of marine heatwave days averaged across all parts of the ocean increased by 50% between 1925 to 1954 and 1987 to 2016. CLEX and NESP research has identified hotspots for marine heatwaves (Smale et al. 2019), future risks of marine heatwaves (Misera et al. 2021), and their impact on vulnerable communities (Holbrook et al. 2022). Marine ecosystems in the south-west Pacific, including around south-east Australia, are particularly at risk from marine heatwaves, with coral reefs being particularly vulnerable.

The Tasman Sea is a global hotspot for ocean warming, with sea temperatures rising at nearly 4 times the global average rate of ocean warming. Marine heatwaves historically have been expected to occur approximately once every 20 years. Under the low-emissions scenario, they are expected to occur once every 15 years by the end of the century, and under the high-emissions scenario, a marine heatwave is projected to occur almost every year (Perkins-Kirkpatrick et al. 2018). CLEX and NESP research has examined the processes and phenomena that cause these events and found that they can be local or remote (Holbrook et al. 2019; Li, et al. 2020). Insights about how very high-resolution ocean modelling can influence our understanding of marine heatwaves have shown that eddy-resolving ocean models are needed in future climate projections (Hayashida et al. 2020; Pilo et al. 2019).

Tropical cyclones

Tropical cyclones (intense low-pressure systems) are the most damaging weather events impacting northern Australia. An average of around 11 tropical cyclones form or move into the Australian region every year. Researchers have found distinct regional differences in favourable conditions for tropical cyclone formation across the Australian region. A research project has developed a method to identify geographic boundaries for regions where tropical cyclones can and cannot form. Projections of future changes in tropical cyclone behaviour were produced and made available online by the NESP Earth Systems and Climate Change Hub. Research outputs such as these increase confidence in the understanding of the influence of climate change on tropical cyclone number, and are used in Australia's official State of the Climate reports (e.g. CSIRO & Bureau of Meteorology 2022) and in recent IPCC reports.

Around 3 tropical cyclones pass within or near to the Great Barrier Reef Marine Park each year. Climate models indicate that the total number of tropical cyclones in the Great Barrier Reef region is expected to decrease by about 18% by the end of this century due to climate change, compared with the number observed in recent decades. However, while cyclone frequency is expected to decrease, intensity is expected to increase. The proportion of severe cyclones as a fraction of the total number of tropical cyclones that occur is likely to increase (Dixon et al. 2022).

From a coral reef perspective, intensity is only 1 factor that contributes to how damaging a cyclone will be. Field data from cyclones on the Great Barrier Reef (Puotinen et al. 2016) and in Western Australia (Puotinen et al. 2020) show that the most damaging cyclones are those that are large, strong and slow moving near reefs (Puotinen et al. 2016, 2020). Cyclones that meet all 3 conditions simultaneously are currently rare near the Great Barrier Reef (Dixon et al. 2022). Climate models are not yet able to resolve how these conditions (intensity, size, forward speed) will change in future reliably enough to predict whether or not damaging cyclones will become more common as the climate warms (Dixon et al. 2022). Further, the ability of climate models to accurately predict where cyclones will track within regions such as the Great Barrier Reef remains limited (Dixon et al. 2022).

Globally, the total accumulated cyclone energy (a measure that incorporates cyclone frequency, intensity and size) decreased in recent years because an increase in the relative proportion of intense storms has been offset by decreases in storm duration and frequency (Klotzbach et al. 2022). Modelled cyclone wave heights show a decrease in exposure of reefs to wave heights capable of damaging them (see Appendix C in Queensland Fire and Emergency Services & Geoscience Australia 2022).

8.2.2 Climate modelling and prediction

As climate change impacts become clearer, the need to plan for and respond to climate change is becoming more urgent and demanding. Many public and private sector groups are requesting more detailed guidance on climate change to inform their decision-making. Extreme events such as the Black Summer fires and the record-breaking floods of 2021–22 have brought into focus the need to improve resilience to natural hazards. The Australian, state and territory governments are producing updated information on climate modelling, climate projections and scenarios relevant to the assessment of climate change impacts and vulnerability.

Significant improvements have been made in making the diverse datasets more readily available to the climate impacts research community through the Federated Climate Data Initiative. The initiative provides an online interface through which technical users can access and interrogate all available dynamically downscaled datasets, including New South Wales, Queensland and Victorian downscaled projections data.

8.2.2.1 Climate modelling

NESP hubs provided climate and Earth system modelling for the World Climate Research Programme CMIP6. Two versions of Australia's national weather and climate model ACCESS were submitted to CMIP6: ACCESS-CM2 (Bi et al. 2020) and ACCESS-ESM1.5 (Ziehn et al. 2020). This work provides international benchmarking of Australia's Earth system modelling capability, and further development and application of the ACCESS modelling system to climate is ongoing within the NESP Climate Systems Hub.

CLEX research is examining how next-generation modelling systems improve our understanding of climate extremes. For example, researchers have examined the simulation of ocean currents and ocean eddies, and their influence on ocean heat uptake and marine extremes (Hayashida et al. 2020; Martínez-Moreno et al. 2021). In the atmospheric domain, studies include how well climate models capture crucial phenomenon, including atmospheric rivers (Reid et al. 2022), compound events and rainfall extremes (Bador et al. 2020). In the land domain, work on predicting mortality (De Kauwe et al. 2020) and using new approaches to plant hydraulics (Sabot et al. 2020) is leading to major improvements in national modelling capability. Underpinning this work is systematic model evaluation and benchmarking (Tselioudis et al. 2021; Ukkola, Abramowitz & De Kauwe 2022).

An outcome of CLEX research is the recognition that existing climate models are valuable tools at large scales but cannot explore every important detail. For example, how will systemic interaction of multiple extremes over a sustained period threaten the resilience of our economy (CLEX 2022)? How will environmental systems change in the future? To find these answers, CLEX is working with partners on next-generation climate models (e.g. Kiss et al. 2020), some with spatial resolutions at the kilometre scale. This is coupled with the ACCESS national research infrastructure and NCI facilities, which provide the capability to better simulate both ocean currents and ocean eddies, and thereby improve the simulation of ocean heat uptake and marine extremes.

8.2.2.2 Australia's weather, climate and Earth system modelling system

ACCESS is Australia's national modelling system for weather, climate and Earth system prediction and research. The modelling framework comprises independent component models (atmosphere, ocean and land) that can be coupled together to produce comprehensive models.

NCRIS has provided $7.6 million in support over 3 years to establish ACCESS as a national research infrastructure (ACCESS-NRI). The remit of ACCESS-NRI is to modernise the development, documentation and release processes for ACCESS models, to improve national modelling capacity and research outcomes. ACCESS-NRI will work with major research programs, such as the NESP Climate Systems Hub and CLEX, to further Australian research.

ACCESS represents a major advance over earlier, simpler climate models, and is tested and fed by data from Earth-observing satellites and other climate sensors. Modifications made by Australian researchers enable ACCESS to better simulate the weather and climate systems that affect Australia. ACCESS creates models and modelling outcomes to:

- provide information on weather and climate to decision-makers across many sectors
- develop synergy with research in numerical weather prediction, seasonal forecasting, ocean–sea-ice dynamics, coupled climate variability and palaeoclimate
- project future climate change scenarios over the 50+ year horizon
- support researchers and students to better understand the climate system and thereby further develop the ACCESS model framework
- enable Australia to contribute appropriate climate projections and scenarios to CMIP, which underpins knowledge of future climate for IPCC Assessment Reports.

ACCESS contributed to CMIP6 through a newly developed coupled ocean–atmosphere model (ACCESS-CM2), through Australia's first Earth System Model (ACCESS-ESM1.5) and Australia's ocean–sea-ice model (ACCESS-OM2) (Mackallah et al. 2022). ACCESS-ESM1.5 includes additional carbon cycle and land-use change processes to provide a more complete representation of the Earth system. ACCESS-CM2 uses a recent atmospheric component that provides higher vertical resolution and an improved aerosol scheme. ACCESS models CM2 and ESM1.5 are among the best-performing models in CMIP6, and ACCESS-ESM1.5 is ranked in the top 10 of the most downloaded models from the Earth System Grid Federation, highlighting its growing reputation and significance internationally.

Current work includes improving the resolution of these models, improving models of the carbon cycle and biophysical processes, and inclusion of atmospheric chemistry modules. Planning is underway for the next generation of ACCESS models in preparation for the next phase of CMIP7, and for exploring mitigation pathways and understanding the impacts of the large-scale deployment of nature-based solutions on the Earth system.

One of the major achievements of ACCESS is the improvement of weather forecasts. The atmospheric component of ACCESS is the basis for the Bureau's new multi-week and seasonal forecast system (ACCESS-S2), which was released in 2021. This system has greatly improved seasonal predictions, the ability to prepare for extreme events and decision-making on seasonal timescales.

8.2.2.3 National climate projections

The ability to understand and manage physical climate risks depends in a large part on high-quality and consistent climate information delivered in forms that are accessible to users and relevant to their needs. Climate projections provide estimates of how climate will evolve in the future under different assumptions of greenhouse gas emissions trajectories. They meet the growing need of governments, the private sector and communities to understand, plan for and manage the risks that a changing climate presents to our natural environment, economy, infrastructure, settlements, agriculture and health.

In 2015, CMIP5-based projections for Australia were released. These provided the most comprehensive projections for Australia at the time, and they remain relevant today. Through the Climate Change in Australia (CCiA) website, these projections provide many tools and datasets, including 'application-ready' datasets, along with guidance specifically designed to assist users of climate projections. To aid users of the projections, 8 models were preselected from a suite of almost 40 models to represent the range of climate change projected for Australia. For climate impact assessments, it is sometimes practical to narrow the selection of models still further while still capturing the range of potential impacts. This can be achieved by using the CCiA Climate Futures tool, which provides users with the means to readily implement CSIRO's Representative Climate Futures framework. This approach has been widely used in impact assessment in Australia and internationally (e.g. Burley et al. 2019; Orr et al. 2021; Parkes, Darbyshire & White 2020).

The needs of users have evolved rapidly and, by 2019, CCiA was assessed as no longer meeting many users' needs. Feedback from users and potential users of CCiA fell into 2 categories: user interface (how the messages were conveyed) and content. Consequently, in late 2020, CCiA was refreshed. This included web-design enhancements to improve user experience; new content on global warming levels; inclusion of national, state and territory climate statements; and page updates, including on projections.

The Australian Government established ACS in 2021 with a focus on increasing the national capability to prepare for and respond to natural hazards leading to disasters. A particular focus of ACS is the development of updated national climate and hazard projections. ACS differs from past projection efforts in that it is a service that brings together modelling, data, products, services and intelligence to ensure a robust means for climate change projections that support decision-making.

The need for the next generation of climate projections was affirmed in the *National Climate Resilience and Adaptation Strategy 2021–2025* (DAWE 2021). In 2022 the Australian Government, in collaboration with states and territories, formed a National Partnership for Climate Projections (NPCP), which oversaw the development of a *Climate Projections Roadmap for Australia* (in preparation). The NPCP includes key representatives from the Australian climate science community, including state and territory governments, the Bureau, CSIRO, universities, and Australian Government–funded initiatives such as the NESP hubs and the ACS. NPCP's aim is to develop a consistent approach to deliver comparable, robust, authoritative, fit-for-purpose future climate information to enable a wide variety of users to assess their climate risks and plan more efficiently for potential opportunities.

Several focused projection activities have been undertaken at national and state levels. Among the more notable has been the Electricity Sector Climate Information project, which developed downscaled climate change projections and associated scenarios to support an assessment of climate change risks to critical infrastructure. Other tools to forecast the on-ground impact of weather and climate systems have been developed by CSIRO. Forecasting tools include the following:

- Spark is a toolkit for the end-to-end processing of the simulation and analysis of wildfires. Users can design custom fire propagation models by building on Spark's computational fire propagation solver. They can add various input, processing and visualisation components, each tailored to wildfire modelling. Spark can be used for planning, warning and response, and research, and is used by fire behaviour specialists within bushfire combat agencies.
- Amicus is a multi-platform computer application that calculates expected fire behaviour from fire conditions that users enter. It uses current knowledge for predicting the behaviour and spread of bushfires in a range of vegetation types and provides simple calculations of expected fire danger. Amicus is also used by fire behaviour specialists within bushfire combat agencies.
- Swift is a toolkit for the end-to-end processing of the simulation and analysis of floods. Users can design custom workflows by building on Swift's computational shallow-water solver. They can add various input, processing and visualisation components, each tailored to flood modelling. The Swift toolkit provides hydrodynamic and coupled hydraulic modelling capability with analysis tools for mitigation options. Swift can be used for both catchment and coastal flood modelling, including sea level rise, for present and future flooding.

8.2.2.4 State and territory climate projections

Updates to state government–funded regional projections based on the latest (CMIP6) global models are currently underway for the Australian Capital Territory, New South Wales, Queensland and South Australia. The Western Australian Government is also in the early stages of developing their own regional projections products. Projections undertaken by state and territory governments since the seventh National Communication are summarised in Table 8.1.

Table 8.1: Regional climate change projections commissioned by state and territory governments

State or territory	Climate projections
Australian Capital Territory	The ACT Climate Change Snapshot summarises the NARCliM projections for the Australian Capital Territory.
New South Wales and Australian Regional Climate Modelling (NARCLiM)	The New South Wales Government provides high-quality climate data and information for public use through the NARCliM project. The partnership began in 2011 and includes the NSW, ACT, South Australian and Western Australian governments with input from the University of New South Wales and Murdoch University. The first NARCliM projections were delivered in 2014 and provided robust regional climate projections for use by NSW and ACT stakeholders to plan for a range of future changes in climate. The latest generation, NARCliM 1.5, was launched in 2021 with future versions planned for regular release to ensure that models can provide the up-to-date information needed for adaptation planning. Projections can be accessed via the NSW Climate Data Portal. Under the NSW Climate Change Adaptation Strategy, the NSW Government has committed to undertake climate change scenario analysis for the state by the end of 2024 and update it periodically to align with the latest evidence.
Northern Territory	Climate Change in the Northern Territory was developed with the NESP Earth Systems and Climate Change Hub in 2020 and summarises how climate change is affecting the Territory.
Queensland	The Queensland Future Climate Science Program is delivered through a partnership between the Queensland Government and the University of Queensland. This program has delivered dynamically downscaled high-resolution climate simulations, the Queensland Future Climate Dashboard (Syktus et al. 2020), and other resources to support climate adaptation. It includes regional-scale data and information on climate change across a range of regions. The first phase of the program was based on the CMIP5 downscaled simulations over Queensland. The high-resolution simulations currently available are based on an ensemble of downscaled CMIP5 global climate models (GCMs) with varying climate change signals. Work is underway to update the Queensland climate projections using the latest generation of climate models (CMIP6) for 3 emissions scenarios (SSP1-2.6, SSP2-4.5 and SSP3-7.0) and 15 ensemble runs. By utilising many models with broad representation of climate change signals, Queensland's regional climate simulations provide a comprehensive view of future climate for the state. Queensland has a track record of collaborating with experts from state and Commonwealth agencies and universities to turn climate simulations into fit-for-purpose data and information to support emergency services. Examples include the State Heatwave Risk Assessment for Queensland, the interactive heatwave case study, the Severe Wind Hazard Assessment for Queensland and the Tropical Cyclone Hazard Dashboard.

<table>
<tr><th>State or territory</th><th>Climate projections</th></tr>
<tr><td>South Australia</td><td>The South Australian Government's Climate Change Science and Knowledge Plan for South Australia identifies critical science and information needed to inform climate change risk assessment, mitigation, planning and adaptation in South Australia. Current actions for the implementation of the plan include the development of:

• a climate change projections mapping tool to allow interactive exploration and downloading of projected climate change for a range of parameters (NARCliM1.5), for points, and for defined regions such as council and landscape management areas
• Guide to climate projections for risk assessment and planning in South Australia 2022, for use by state government departments to inform decision-making on managing future climate change risk to infrastructure
• the Urban Heat and Tree Mapping Viewer, which enables exploration of high-resolution surface temperature data for the Adelaide metropolitan area
• the Coastal Flood Mapping Viewer, which identifies areas that may be vulnerable to coastal flooding at a regional scale and allows users to visualise the potential impacts of different sea level rises.</td></tr>
<tr><td>Tasmania</td><td>Climate Futures for Tasmania is the Tasmanian Government's most important source of fine-scale downscaled climate change projections and is an essential part of Tasmania's climate change response. In 2020, the existing Enterprise Suitability Mapping project was updated to incorporate climate change projections, to support decision-making for the agricultural sector. Enterprise suitability map layers are available for current climate, 2030 and 2050 for a range of agricultural commodities, including vegetables, cereals, pharmaceuticals, perennial horticulture, pastures and forestry (32 crops in total).

Under the Tasmania's Climate Change Action Plan 2017–21 (Tasmanian Climate Change Office 2017), the Tasmanian Government has undertaken a review of climate change modelling to identify research gaps and opportunities. The review identified research opportunities in several priority sectors, including agriculture, water infrastructure, biosecurity, tourism, aquaculture and fisheries (Bindoff et al. 2018). The $750,000 Climate Research Grants Program opened in 2020 and offered grants of up to $50,000 for climate research projects and the development of decision-support tools that address the areas of research need in Tasmania. Funding has been provided for 16 projects, including analysing biosecurity and invasive pests, understanding the risks of the changing climate for key industry sectors, and examining the health and wellbeing impacts of climate change. Twelve projects have been completed, and 2 are ongoing.</td></tr>
</table>

State or territory	Climate projections
Victoria	Victorian Climate Projections were developed by the Victorian Government in partnership with CSIRO. They delivered dynamically downscaled, high-resolution (5-km grid) projections using 1 regional climate model and 6 GCMs for both medium and high-emissions scenarios to the 2090s (DELWP 2019). The projections are made accessible via Victoria's Future Climate Tool that also includes indicators of climate-related hazards. Victoria's *Climate science report* (DELWP 2019) sets out the latest climate science and the implications for Victoria based on the 2019 Victorian Climate Projections. The Victorian Water and Climate Initiative is a partnership between the Victorian Government, the Bureau and CSIRO, which is currently in its second phase (2021 to 2024). The research program aims to better understand climate change impact on Victoria's water resources, understanding different weather types and their influence on rainfall, and improving rainfall and streamflow projections. Research findings from the first phase have been summarised in *Victoria's Water in a Changing Climate* (DELWP 2020), and informed climate change guidelines for water resource planning.
Western Australia	The Western Australian Climate Science Initiative, in partnership with the NSW and Australian Regional Climate Modelling Project and Murdoch University, is investigating climate impacts and extremes to help governments, businesses and communities understand and plan for climate risks. The initiative is delivering fine-resolution climate projections for Western Australia based on an ensemble of the latest global and regional climate model simulations. The projections will include 2 future emissions scenarios, more than 190 variables and 150 years of data from 1950 to 2100. The new projections are supporting governments, businesses, and the community to respond to climate change, reduce hazard risk and increase resilience of Western Australia to climate change.

Case study: Enterprise suitability toolkit

In 2020, the Tasmanian Government updated the existing Enterprise Suitability Mapping project. This mapping has informed the Enterprise Suitability Toolkit, a regional guide to help farmers with detailed on-farm investigations before making investment or operational decisions. The maps rate climate, landscape and soil variables against the requirements of a range of crops. This mapping allows farmers, industry and investors to identify:

- areas, down to the farm or paddock scale, where crops or enterprises could be introduced, intensified or diversified
- possible risks or impediments to growing the crops, and ways to improve land suitability
- the viability of new enterprises at a state or regional scale.

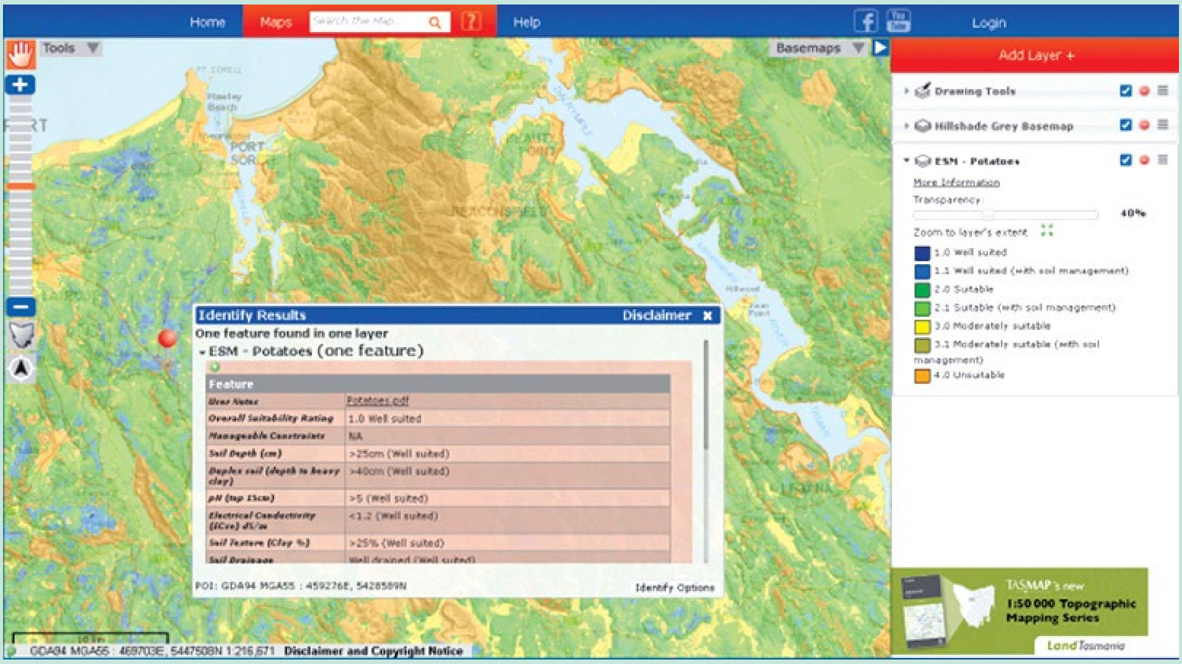
There are 3 types of enterprise suitability maps available for each crop. They are based on:

- current climate (to 2018)
- Climate Futures for Tasmania projection modelling (to 2030 and 2050).

The Enterprise Suitability Mapping is built from soil and climate modelling that uses data from on-farm soil sampling and climate sensing. The mapping assumes water for crop irrigation is available and does not limit production.

Statewide Enterprise Suitability Maps are available for many agricultural commodities, including vegetables, cereals, pharmaceuticals, perennial horticulture, pastures and forestry. Users can view and query the maps, zoom into specific locations, and overlay other relevant environmental or administrative spatial layers using the Land Information System Tasmania (LIST) map.

The Enterprise Suitability Mapping and underpinning soil and climate modelling were brought together by intensive research and collaboration. The project was one of the first operational examples of digital soil and climate mapping applied in Australia. All modelling and processes were published in peer-reviewed scientific journals and presented at selected national and international conferences to ensure methodological rigour and transparency.



LIST map example portraying Enterprise Suitability Map for Potatoes, showing an overall suitability rating as well as underlying soil and climate information (example produced for a site near Sassafras).

8.2.2.5 Climate scenarios

Climate scenarios use climate projections and other evidence to develop coherent, internally consistent and plausible descriptions of specific possible future states of the world. This ability to explore a range of different future states is particularly valuable when assessing climate risks, given the variability of impacts across scenarios. By applying climate scenarios in a climate risk assessment, decision-makers and organisations can understand, anticipate and plan for climate risks, including new extremes and increased frequencies of severe weather events.

The Australian Climate Scenarios Framework (in preparation) consists of 3 tiers of scenarios to support climate risk assessments and decision-making:

- Tier 1 – a national-scale overview over 4 large geographic areas defined by existing climatic zones across the continent
- Tier 2 – a set of regional-scale scenarios for different geographical regions and sectors
- Tier 3 – specialised datasets for specific applications.

The 3-tiered structure of the framework allows examination of scenarios of increasing specificity of place or sector. This allows organisations or sectors to tailor scenarios to meet their own needs within a nationally consistent framework. Tier 1 and 2 scenarios are intended to be used principally for climate risk screening and assessment. Detailed modelling of potential climate impacts for a specific sector or activity generally requires finer-grained information from a Tier 3 scenario, which requires more time and resources to develop.

The framework has been developed in partnership with the ACS and in consultation with state, territory and local governments, business and community stakeholders to ensure a full range of climate information needs are addressed. The scenarios are based on the best and most appropriate available climate data, including climate projections developed through the NPCP (see section 8.2.2.3).

8.2.3 Mitigation and adaptation approaches

8.2.3.1 Mitigation

The Australian Government supports the development of mitigation and adaptation approaches, including clean energy innovation, across the spectrum of research and development, demonstration, and deployment.

The Australian Renewable Energy Agency (ARENA) provides research, development and deployment grant funding to improve the affordability and increase the supply of renewable energy in Australia. As of 30 September 2022, ARENA had committed $1.96 billion to more than 630 projects. This has been matched by $6.85 billion in co-funding, making the total project value $8.81 billion. These funds have supported projects spanning the commercialisation pathway, from research and development to demonstration and precommercial deployment projects.

Funding from ARENA has helped to achieve several world and Australian firsts. Successes include support for the Australian National University with development of the world's most efficient solar photovoltaic cell (ARENA 2022) and SunDrive's recent breakthrough in mass production–compatible heterojunction technology (Carroll 2022).

The $200 million Clean Energy Innovation Fund supports early-stage and emerging clean energy technologies. The fund draws on the combined skills and experience of ARENA and the Clean Energy Finance Corporation (CEFC) and invests using CEFC finance. As at 30 September 2022, the CEFC has made cumulative investment commitments of more than $11 billion to projects, with a total value of more than $38 billion.

The CRC program provides grant funding to support industry-led collaborative research partnerships working on industry-identified problems to improve the competitiveness, productivity and sustainability of Australian industries. The program aims to lift levels of industry–research collaboration to assist in supporting science, research and commercialisation, and enable growth and productivity for globally competitive industries.
Key CRCs addressing climate mitigation and adaptation research include the following:

- The Heavy Industry Low-carbon Transition CRC was awarded a grant of $39 million over 10 years from 2021 to 2031 to develop and demonstrate the technologies needed to transform Australia's heavy industry to compete in the low-carbon global economy for carbon-neutral materials such as green iron, alumina, cement and processed minerals.

- The RACE (Reliable Affordable Clean Energy) for 2030 CRC was awarded a grant of $68.5 million over 10 years from 2020 to 2030 to lead collaborative research and innovation to reduce costs to business, enhance reliability of clean energy, cut carbon emissions, improve energy affordability and develop Australian energy technology businesses.
- The CRC for Transformations in Mining Economies was awarded a grant of $29.5 million over 10 years from 2020 to 2030 to drive transformational change to enable regions and communities to transition to a prosperous and sustainable post-mining future.
- The Blue Economy CRC was awarded a grant of $70 million over 10 years from 2019 to 2029 to pave the way for innovative, commercially viable and sustainable offshore developments that will see rapid increases in marine renewable energy output and seafood production.
- The Future Battery Industries CRC was awarded a grant of $25 million over 6 years from 2019 to 2025 to expand Australia's battery minerals and chemicals production; develop opportunities for specialist battery manufacture; support the deployment of batteries to households, communities and industry; and optimise the circular economy for the use and reuse of battery systems.
- The Future Fuels CRC was awarded a grant of $26.25 million over 7 years from 2018 to 2025 to transition energy infrastructure to a low-carbon economy using fuels such as hydrogen and biogas.
- The Future Energy Exports CRC was awarded a grant of $40 million over 10 years from 2020 to 2030 to execute cutting-edge, industry-led research, education and training to help sustain Australia's position as a leading liquefied natural gas exporter, and enable it to become a leading global hydrogen exporter.

CSIRO is working with the government, universities, industry and communities to develop and deliver a missions program to bolster Australia's recovery from the effects of the COVID-19 pandemic and build long-term resilience. 'Missions' are large-scale, impact-focused scientific and collaborative research initiatives aimed at making significant breakthroughs with a tangible end goal. CSIRO is currently leading 3 key missions to catalyse national effort on climate change challenges:

- Towards net zero. Help Australia's hardest-to-abate sectors – including steel, sustainable aviation fuel and agriculture – halve their emissions by 2035.
- Hydrogen Industry Mission. Help build Australia's clean hydrogen industry by scaling demand and driving down hydrogen cost to under $2 per kilogram.
- Drought resilience. Reduce the impacts of Australian droughts by 30% this decade.

Case study: Katanning Research Station Carbon Neutral Demonstration Project

The Western Australian Government has made an additional $4.2 million investment in its Katanning Research Station in the Great Southern Region of Western Australia to develop and demonstrate practical techniques and methods for mitigating carbon emissions from the livestock industry in the state. The research and development funding will provide evidence for farmers to confidently adopt new farming practices and technologies and build more sustainable businesses to satisfy increasing market demand for low-emissions products. Research scientists will test a range of ready-to-apply mitigation and sequestration practices and systems at the demonstration site, which together aim to reduce greenhouse gas emissions on the 2,100-hectare property by 100% by 2030.

The investment builds on the $3.8 million already invested in the development of the Katanning 20-pen Sheep Feed Intake Facility, the largest of its kind in Australia. The sheep facility will be used for research by the Department of Primary Industries and Regional Development and collaborators, while other research institutions and universities will also use the facility's assets for related livestock research.

8.2.3.2 Adaptation

Australia's support for adaptation responses starts with the development of information needed for effective decision-making for the future. This includes the effects of extreme events (see section 8.2.1.4) and climate change impacts across regions and sectors (see section 8.2.2).

Australia's adaptation research builds on this understanding to deliver specific guidance to enhance adoption and improve the effectiveness of adaptation responses. Chapter 6 provides details of Australia's work in adaptation at a national level (sections 6.2 and 6.3), and by the states and territories (section 6.3).

In addition, over the past 4 years CSIRO has been developing Climate and Hazard Risk Analytics Engine (INDRA). INDRA has 3 facets:

- It is an end-to-end product for climate vulnerability assessment, to support urban asset planning and management by local government and associated asset management organisations.
- It includes a platform to develop climate services products for clients; for example, the Climate Services for Agriculture tool helps Australian farmers and the broader agricultural sector understand climate risks and adapt accordingly. It provides historical climate data (1961 to 2021), seasonal forecasts (1 to 3 months) and future climate projections for 30-year periods centred around 2030, 2050 and 2070 at 5-km2 resolution across Australia. It also translates this information to provide regional- and commodity-specific insights.
- It provides a platform-based API service that feeds into other products being developed; for example, the Drought Resilience Self-Assessment Tool enables farmers to assess their resilience against climate change, including drought and other climate risks. Resilience assessments include financial, personal and social, and environmental indicators. Based on farmers' individual assessments, the tool provides tailored options and resources to help farmers build resilience.

The impacts of climate change continue to be felt across value chains, and previous work on value chain adaptation has equipped us with the tools to better understand resilience in supply chains in the face of disruptions (García-Flores et al. 2022; Lim-Camacho, Jeanneret & Hodgkinson 2021). Principles and frameworks used to better understand disruption, adaptive capacity, vulnerability and transformation can also be drawn on for understanding the range of responses to COVID-19 pandemic disruptions (Robins et al. 2020).

8.3 Systematic observation

Marine, coastal, freshwater, groundwater and atmospheric observation infrastructure is crucial in environment and climate research. Data, including long-term datasets, provide the foundation for climate change science. This is highlighted in the NPCP roadmap (see section 8.2.2.3). It suggests increasing observational capacity in coastal and estuarine areas, freshwater and groundwater systems, and increasing atmospheric monitoring capacity in urban and regional areas.

Australia's Global Climate Observing System (GCOS)–related activity is coordinated through the Bureau. Australia follows World Meteorological Organization policies on sharing data. Planning is undertaken to ensure appropriate alignment between Australian and international needs and the data collected.

The Bureau employs a comprehensive set of metadata practices, such as site and equipment documentation, overlap observations, instrument test reports and data management systems, to satisfy GCOS principles while keeping pace with changes in technology.

Several external factors affect the integrity of long-term climate stations. The most important are continuity of observations and changes in the stations' local environment that can result in changes in site exposure. The Bureau manages changes in site exposure where necessary, and continues to transition manual stations to automated observations to support technology improvements and improved consistency.

The World Meteorological Organization has established the concept and criteria for Centennial Observing Stations, which have a high-quality, 100-year record of at least 1 climate variable. Six Bureau sites have been nominated and approved as Centennial Observing Stations: Yamba (New South Wales), Willis Island and Wooltana (South Australia), Hobart (Tasmania), Mt Buninyong (Victoria) and Cape Leeuwin (Western Australia).

Southern Ocean observational work focuses on combining remote-sensing satellite data, autonomous floats and buoys, robotic under-ice vehicles, hydrographic surveys and targeted field campaigns to study both the marginal ice zone and the glacier system. Measurements provide insights into the oceanic conditions in these remote locations, which are key to understanding the threats of global warming to these major glacier outlets. The work is then combined with targeted high-resolution regional coupled ocean–ice modelling systems.

8.3.1 Atmospheric climate observing systems, including those measuring atmospheric constituents

The Kennaook/Cape Grim Baseline Air Pollution Station, located on the far north-west coast of Tasmania, provides vital information about changes to the atmospheric composition of the Southern Hemisphere and across the globe. In March 2021, the Tasmanian Government changed the placename of Cape Grim to Kennaook/Cape Grim, under its Indigenous dual-naming policy. The Bureau is responsible for maintaining and operating the facilities, while the science program is managed jointly by the Bureau and CSIRO, with contributions from the University of Wollongong, the Australian Nuclear Science and Technology Organisation and many international science institutions.

Kennaook/Cape Grim is an important site because the air sampled arrives at the station after long trajectories over the Southern Ocean under conditions described as 'baseline.' This baseline air is representative of a large area of the Southern Hemisphere, unaffected by regional pollution sources (there are no nearby cities or industry to contaminate the air).

As Australia's contribution to the Global Atmosphere Watch Programme, extensive data are collected for use in studies of sources and sinks of greenhouse gases and ozone-depleting substances, and in assessments of future atmospheric concentrations. Measurement and analyses of these gases, which are submitted to the Global Atmosphere Watch Programme and the Advanced Global Atmospheric Gases Experiment, are supported by the Kennaook/Cape Grim Science Program.

Other contributions to the Global Atmosphere Watch Programme include the total column ozone network and the Ozonesonde Network, which provide systematic long-term monitoring of stratospheric ozone, and the atmospheric transmission network. Australia operates 2 sites of the international Total Carbon Column Observing Network (Darwin and Wollongong), managed by the University of Wollongong.

The Bureau operates 3 sites of the GCOS Baseline Surface Radiation Network to monitor long-term changes in solar and terrestrial irradiance, and 10 other solar and terrestrial irradiance measurement stations that follow GCOS global climate monitoring principles. Air sampling is conducted at Australia's research stations in the Antarctic and sub-Antarctic.

The NESP Climate Systems Hub is developing an integrated carbon observatory system to support the further development and improvement of the National Greenhouse Gas Inventory (NGHGI). This observatory will produce the best estimate of the net carbon balance of Australia with resolution fine enough to focus on specific human activities and hotspots not fully accounted for in the current NGHGI. It consists of 3 components:

- a full carbon budget of Australia, which builds on and extends the anthropogenic components of the NGHGI and adds natural sources and sinks
- the training and parameterisation of a terrestrial biospheric model (the CABLE model) with data from the NGHGI and other flux data from OzFlux and remote sensing, to produce temporally and spatially resolved fluxes
- a regional atmospheric inversion using satellite atmospheric column CO_2 from the Orbiting Carbon Observatory-2.

Case study: Atmospheric radiation clouds and aerosols

The Australian Antarctic Program Partnership and its partners have a program examining atmospheric radiation clouds and aerosols.

Climate models have persistent biases in high southern latitudes. These biases reduce the reliability of climate model projections not just in Antarctica but globally. Of particular importance are biases in the radiation budget arising from inadequate representation of cloud processes and aerosols over the Southern Ocean, which impacts simulated temperature at Earth's surface and modelling of key climate processes.

The AAPP will use observations from ships, aircraft and satellites to improve understanding of the unique cloud and aerosol properties in the pristine atmosphere at high southern latitudes. These insights will then be used to develop new parameterisations of clouds and aerosols for use in climate models, including the Australian Community Climate and Earth System Model (ACCESS).

8.3.2 Ocean climate observing systems

IMOS is Australia's nationwide collaborative research infrastructure initiative with a distributed observing network and information services designed to observe Australian oceans. Its infrastructure is integrated across scales spanning the coast, continental shelf and open ocean, and across disciplines including physics, biogeochemistry, biology and ecosystem sciences. Sustained ocean observations under this initiative are helping to improve understanding of the role of the ocean in the global climate system, and the impact of Australia's major boundary currents on continental shelf environments, ecosystems and biodiversity. IMOS data feed into climate forecast models, including ACCESS and CSIRO's Bluelink. Through IMOS and other programs, Australia makes major contributions to building long-term ocean climate records in the Global Ocean Observing System and its component programs.

The Australian Ocean Data Network is a single access point for marine data collected by all IMOS facilities and for datasets published by Australian Government agencies. The network's international collaborations include being a member of the Research Data Alliance, the Federation of Earth Science Information Partners, the Open Geospatial Consortium and the Ocean Data Interoperability Platform. The Ocean Data Interoperability Platform is a project with the European Union and the United States that contributes to the removal of barriers hindering data sharing across scientific domains and international boundaries.

IMOS facilities operating in the Southern Ocean include Argo profiling floats and the Southern Ocean Time Series (SOTS). Argo floats provide measurements of temperature, salinity and currents in the upper 2,000 metres of the ocean. Australia's Argo program has contributed to the comprehensive study of the world's oceans, revealing the ongoing and steady rise of global ocean heat content, occurring predominantly in the Southern Hemisphere, and extending down to 2,000 metres and deeper. Australia is the second-largest contributor of active floats to the global Argo array (after the United States). The SOTS site is in the sub-Antarctic zone, approximately 350 nautical miles south-west of Tasmania; it is comprised of several elements, including a deep ocean sediment trap mooring, a surface biogeochemistry mooring and an air–sea flux mooring (the Southern Ocean Flux Station). Observations at the site include meteorological parameters, downwelling radiation, and sea water temperature and salinity, together with measurements of the surface and deep ocean properties that control the transfer of heat, moisture, energy and CO_2 between the atmosphere and the upper ocean.

These observations improve understanding of climate processes and are important because waters formed at the surface in this region, the Sub-Antarctic Mode and Antarctic Intermediate waters slide under warmer subtropical and tropical waters and carry CO_2 and heat into the deep ocean, out of contact with the atmosphere. This process also supplies oxygen for deep ocean ecosystems, and exports nutrients that fuel around 70% of global ocean primary production. SOTS is an Australian contribution to the international OceanSITES global network of time-series observatories and is the only comprehensive observation site maintained in the Southern Ocean.

Other important observations are collected in this region through the Animal Tagging Sub-Facility of the IMOS Animal Tracking Facility. Animal tagging deploys satellite relay data loggers on several species of Southern Ocean seals, including both Weddell and southern elephant seals. These data loggers collect high-resolution temperature and fluorescence profiles in the deep Southern Ocean and Antarctic waters. Data are transmitted in near real time using the Advanced Research and Global Observation Satellite (ARGOS) system. Fitting seals with these miniaturised loggers provide the ability to collect valuable oceanographic measurements in regions often inaccessible to ship-based researchers, and permit the collection of important data on ocean properties throughout the Antarctic winter – data previously unavailable but crucially important to oceanographic and climate studies.

The IMOS Acidification Moorings Facility deploys specially designed mooring systems that measure CO_2 of the ocean's surface and atmosphere at 3 sites in Australian waters: Maria Island (Tasmania) and Kangaroo Island (South Australia) to complement the 2 National Reference Stations there, and at Heron Island to provide high-frequency data on the Great Barrier Reef system. The acidification of the global ocean's surface waters is driven by CO_2 uptake from the atmosphere. This process poses one of the most significant threats to the health and sustainability of Australia's marine ecosystems, with evidence already emerging of declines in calcification for tropical and polar marine species. These moorings provide meteorological and additional data to improve understanding of environmental controls on CO_2 variability and ocean acidification in these key regions.

The IMOS Satellite Remote Sensing Facility Surface Waves Sub-Facility, formed in 2017, is collecting, calibrating and distributing ocean surface wind and wave data from current and next-generation satellite missions. The sub-facility produces and curates a global database of wind speed and wave height obtained from all altimeter missions that have flown since 1985. This new dataset represents the first global, long-duration, multi-mission altimeter and scatterometer dataset that is consistently calibrated, validated and quality controlled, and is publicly available through the IMOS Australian Ocean Data Network.

The IMOS Event Based Sampling Sub-Facility was initiated in December 2018 with the goal of monitoring marine heatwaves using Ocean Gliders. The ability of ocean gliders to provide high-resolution temporal and spatial observations of subsurface ocean temperature, and their relative portability, make them a valuable tool for monitoring marine heatwaves. Glider measurements of temperature and key biophysical variables (including oxygen, chlorophyll, salinity) aid in understanding the growth, peak and decay of these extreme ocean temperature events and their potential impacts on the marine environment. Data collected through this sub-facility are transmitted from ocean gliders in near real time and made publicly available through the IMOS Australian Ocean Data Network.

As part of IMOS, the Bureau and CSIRO jointly operate the Expendable Bathythermograph Ship of Opportunity Program, with support from the Department of Defence and international partners. This program monitors long-term trends in major oceanic circulation pathways around Australia, and has maintained several repeat lines in the Indian, Southern and Pacific oceans for over 3 decades. IMOS and the Bureau also collaborate to collect observations through the Sea Surface Temperature and Air-Sea Flux Ships of Opportunity IMOS sub-facilities, with the support of international partners.

As part of the Global Drifter Program, approximately 20 drifting buoys are deployed each year on an opportunity basis in the Southern and Indian oceans. The Bureau also provides logistic support to other agencies wanting to deploy drifting buoys in the Indian Ocean. Most deployments are from merchant ships on commercial shipping lines. These efforts contribute to the Global Drifter Program and mostly collect sea surface temperature data for calibrating and validating satellite data and sample barometric pressure used for weather forecasting purposes, including numerical weather prediction models. The satellite data are used in constructing climatologies. The ability of the expendable bathythermograph network to systematically map the upper ocean thermal field in multiple ocean basins with repeated trans-basin sections at eddy-resolving scales remains unmatched today and cannot be reproduced by any other observing platform (Goni et al. 2019).

Australia monitors sea level for many purposes – importantly, to identify long-term changes in mean sea level relative to the local land and wider global comparative benchmarks. The Bureau's sea level monitoring includes engineering, management and operational support to the Australian Baseline Sea Level Monitoring Array and the Pacific Sea Level and Geodetic Monitoring project, operated by the Bureau on the behalf of the Department of Foreign Affairs and Trade as part of the Climate and Oceans Support Program in the Pacific (COSPPac; see section 8.3.5). These projects monitor changes in sea level around Australia and the south-west Pacific in collaboration with Geoscience Australia, which determines the land movement component.

The National Operations Centre Tidal Unit specialises in sea level analysis for the production of national tide predictions, tide streams and related information. The team is responsible for managing a quality-controlled national database of observations made available to the scientific and wider communities.

In addition to in situ observations, Australia is dependent on satellite observations to monitor its surrounding oceans. The Bureau and CSIRO archive direct broadcast and imported satellite data, and deliver satellite-derived products for:

- sea-ice detection – mapping sea-ice change and variability, as well as fast ice that is of importance for climate modelling
- altimetry (a measure of sea surface height) – processing altimetry data for assimilation by ocean models to estimate ocean currents
- ocean colour – high-resolution datasets generated from satellite imagery for water quality monitoring over the Great Barrier Reef
- sea surface temperature – high-resolution datasets generated from advanced very high-resolution radiometer observations.

8.3.3 Atmospheric and terrestrial climate observing systems and datasets

TERN coordinates high-level ecosystem monitoring data infrastructure to address issues of national and global importance, including habitat and landscape condition, food, water, natural resource and biological security; adaptation to climate change; and the carbon economy. It is Australia's national instrument for measuring and observing changes in the country's land-based ecosystems over time, regardless of land use.

TERN is an integrated, standardised, site-based ecosystem observatory operated collaboratively by universities and CSIRO with 3 scales of monitoring. At the continental scale, monitoring is performed mostly with remote-sensing techniques based on satellite data blended with site and sensor data, with increasing use of airborne data from drones. For the regional scale, TERN has a network of hundreds of survey monitoring plots to detect biodiversity change over vast areas, including along rainfall gradients and ecosystem transition zones. At the local scale, TERN collects extensive data from its network of SuperSites located in representative locations, environments and biomes. These combine instrument or sensor measurements, from ground level to high flux towers, with field measurement of biophysical and ecological variables.

TERN also undertakes modelling and synthesis activities to extend and supplement observation data to produce a range of data products, such as continental monthly actual evapotranspiration maps. Importantly, TERN preserves and makes openly available from the TERN Data Discovery Portal the long-term data collected by TERN, Australian researchers, organisations, agencies and collaborating institutes. Together, TERN's data, soil and herbarium sample collection, and analytical tools support science that can inform political and managerial decision-making. It can also address grand societal challenges including food, water, natural resource and biological security; climate change mitigation and adaptation; and the carbon economy.

TERN's Cosmic-ray Soil Moisture Monitoring Network (CosmOz) and its OzFlux micrometeorological flux stations are each part of global data-sharing networks. CosmOz's novel probes use cosmic rays to measure average soil moisture over an area of about 30 hectares to depths of between 10 cm and 50 cm. TERN's OzFlux network belongs to the international FluxNet network, and provides continuous observations of energy, carbon and water exchange. TERN is also part of the Global Ecosystem Research Infrastructure, an integrated network of continental-scale research infrastructure aimed at delivering harmonised data and international partnerships, and enabling new understandings of global ecological processes. It also represents Australia in the global peak body, International Long Term Ecological Research.

Observations from the OzFlux network have provided insights into the topics of climate change and variability, disturbance and resilience, drought and heat stress, and synergies with remote sensing and modelling (Beringer et al. 2022). Ecosystem observatories are moving beyond CO_2 and water cycles to monitoring other greenhouse gases, especially emissions of methane from wetlands and nitrous oxide from agricultural systems.

Surface air temperature is recorded by the Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) dataset, which is maintained by the Bureau. The dataset employs the latest analysis techniques and takes advantage of digitised observational data to provide a daily record of Australian temperatures since 1910. The ACORN-SAT homogenised temperature database comprises 112 locations that maximise both length of record and network coverage across the continent. The data are robust and comparable through time. This enables climate researchers to better understand long-term changes in monthly and seasonal climate, and changes in day-to-day weather, such as the frequency of hot and cold extremes.

ACORN-SAT was first published in 2011. In 2018, the Bureau updated the dataset to ACORN-SAT version 2 to incorporate new data and harness improvements in scientific methodology (Trewin 2018). The ACORN-SAT dataset is updated regularly with new temperature observations as they become available. The most recent update is version 2.2, released in September 2021.

Australian freshwater observations provided to the Bureau are collected by Australian, state and local government agencies, as well as private organisations. These observations include streamflow, groundwater, surface water storages, meteorological variables, rural and urban water use, water trading information and water quality.

The Bureau operates the Australian Water Resources Information System as a central national repository for many of Australia's surface and groundwater observations. This system holds and disseminates data for thousands of measurement sites, including rivers, dams and groundwater sites. It also captures water quality and rainfall. Data from more than 6,500 stations are available on the Bureau's Water Data Online. Data from more than 100,000 bores can be found on Australian Ground Water Explorer.

The Bureau uses these observations to provide information on the prior, current and future status of Australia's water resources. Observations are made available through web-based products and web data services, providing daily updated assessments of the nation's surface water situation, regularly updated hydrological projections out to 3 months ahead, and annual integrated reports of freshwater resources.

As a large continent, Australia is dependent on satellites for some aspects of terrestrial observation. The Advanced Very High Resolution Radiometer direct broadcast record is being used to create a time series of the normalised difference vegetation index and other land-cover products. Since the 1990s, geostationary satellites have been used to estimate daily solar exposure, supporting the Australian energy sector. More recently, hourly time series and climatological averages of solar exposure have been developed. The Advanced Himawari Imager satellite, launched in 2014, provides solar exposure products with improved temporal and spatial resolution.

8.3.4 Cryosphere climate observing systems

The Australian Antarctic Data Centre manages data collected within the AASP and helps fulfil Australia's obligations under Article (III)(1)(c) of the Antarctic Treaty, which states 'Scientific observations and results from Antarctica shall be exchanged and made freely available.' Data collected from research projects and long-term observing projects can be accessed through the data centre.

Australia operates observing systems based at the 3 continental stations Mawson, Davi, and Casey, as well as Macquarie Island. In addition, ship-based observations and a network of automatic weather stations contribute Antarctic observation to the global observing network. This includes conducting regular measurements of ozone and atmospheric winds, sea-ice charting and ad hoc process-based observations.

8.3.5 Support for developing countries

The Australian Government has a long history of supporting Pacific Island countries (see Chapter 7), including to monitor, analyse and communicate climate, ocean and sea level information to strengthen climate and disaster resilience. Part of this assistance is the $26.8 million COSPPac Phase II (2018 to 2023).

Through COSPPac, the Australian Government supports 15 Pacific Island countries and territories with observational infrastructure operation and maintenance for long-term Pacific meteorological, climate and sea level data records. The program also supports the Pacific in the production of seasonal climate prediction services, communications, training and capacity development.

A midterm review of COSPPac Phase II found that it provides important, relevant and influential information to Pacific Island national meteorological service partners, and that Pacific partners acknowledge that Australia's contribution through COSPPac fills a unique, critical need in generating short-term seasonal climate projections and building capacity of national meteorological services.

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9 Education, training and public awareness

Key developments

Education providers, non-government and community organisations, and Australian governments at all levels all play roles in promoting climate change mitigation and adaptation and sharing information and resources to support that goal.

A review of the Australian primary and secondary curriculum over 2020 to 2022 has strengthened cross-curriculum links for the sustainability theme, providing learning opportunities for Australian children.

Training support is providing new knowledge and skills to various sectors. For example, the Sustainable Futures program (CSIRO 2022c) supports primary and secondary teachers, the Climate Risk Ready accredited course trains government staff, and the Clean Economy Workforce Skills Initiative is developing a 10-year workforce strategy exploring renewable energy.

Australia is committed to delivering public information to help local governments, organisations and households to mitigate and adapt to climate change. Public websites including energy.gov.au (updated in 2020) and Your Home (updated in 2021) provide detailed information to help users with planning and decision-making. The AdaptNSW website was redeveloped in February 2022 to provide information and tools for state and local government, industry, and organisations.

Internationally, the Knowledge Brokering Support Program (KBSP) (CSIRO 2022a) is an online learning initiative developed as part of the Australia Pacific Climate Partnership in 2021–22, which helps participants build brokering skills to ensure that climate change and future risk are incorporated into decision-making.

9.1 General policy on education, training and public awareness

The Australian Government has a leadership role in identifying and promoting national standards and priorities for students. State and territory government and non-government education institutions implement the Australian Curriculum (ACARA 2022a) and deliver school educational programs.

The Australian Government supports awareness and climate change education through the nationwide Australian Curriculum, which aims to ensure quality and consistency of education for all students. The Australian Curriculum contains content about sustainability, climate change and the impacts of carbon emissions (ACARA 2022b).

Over the past 5 years, the Australian Government has continued to publish datasets and resources to help decision-makers and communities understand and respond to the impacts of climate change. These include publication of greenhouse gas emissions data, and State of the climate (CSIRO & Bureau of Meteorology 2022) and State of the Environment (DCCEEW 2022) reports.

State and territory governments are promoting public awareness and supporting the community to act on climate change. Action plans, grant programs and information campaigns are helping the public to understand the risks and uncertainties of climate change.

Non-government organisations, including industry peak bodies and research institutes, are providing links between the public, educators and decision-makers. These organisations promote public awareness and understanding of climate change through research, networking, advocacy, training and media activities.

The Jobs and Skills Summit hosted by the Australian Government in September 2022 identified the energy sector as one of the areas where government and industry should work together to maximise jobs and opportunities. Summit participants highlighted the importance of crossjurisdictional energy transition workforce planning, to make sure Australia has the mobile workforce that can meet the different needs around Australia.

As an outcome of the summit, Jobs and Skills Australia is undertaking a Clean Energy Workforce Capacity Study for delivery as a priority in 2023. This project will look at the clean energy workforce, providing a clear picture of the workforce needs for Australia's transition to clean energy. It will bring together a range of related work being undertaken across government to provide a snapshot of occupation needs for a low emissions economy, their geographic distribution, a transition analysis and a study of the existing workforce.

The capacity study is a critical investment that will build a more complete picture of the clean energy workforce needs, supporting both government and private sector investment. It will be based on a mix of qualitative and quantitative research.

9.2 Primary, secondary and higher education

9.2.1 Primary and secondary education

The Australian Government acknowledges the need to provide students with access to high-quality educational resources that allow them to understand the basics and impacts of climate change, and empower them to be part of creating a more climate-resilient future. This includes providing a foundational understanding of science, and skills in scientific inquiry, knowledge communication and evidence-based decision-making.

Sustainability is one of 3 cross-curriculum priorities that have been built into the Australian Curriculum across learning areas and year levels from the beginning of school up to Year 10. Sustainability includes the knowledge, understanding and skills necessary to design for effective sustainability action, including considering issues such as resource depletion and climate change. The review of the Australian Curriculum from 2020 to 2022 recommended strengthened connections between learning areas and the cross-curriculum priorities, including sustainability. The amended curriculum was endorsed by federal, state and territory education ministers in April 2022, and will be ready for implementation in schools across Australia from 2023.

The Sustainable Futures program (CSIRO 2022c) is an education program coordinated by the CSIRO that supports primary and secondary teachers working with students in years 3 to 10. Teachers who register with the program receive free access to digital teaching resources, which include a variety of ideas and activities to support the teaching of sustainability and the environment in Australian schools. CSIRO also hosts the Year 10/11 STEM Virtual Work Experience Program (CSIRO 2022d), providing opportunities for 15–20 STEM students to participate in climate science–focused work each year.

State and territory governments have also developed education programs on climate change. For example:

- The New South Wales Government's Environmental Education Policy supports environmental education programs in public schools in New South Wales. The NSW Department of Education has 25 environmental and zoo education centres (NSW Department of Education 2022) that support learning and teaching about sustainability and have developed specialised teaching resources that address the sustainability cross-curriculum priority.
- The Climate Ready Schools program (Green Adelaide 2022) is an initiative of Green Adelaide (a statutory board established by the South Australian Government) in partnership with groups of metropolitan local governments, including Resilient South, Resilient East and Adapt West. The program provides primary and high schools with climate change learning packages and teacher support. The year-long program helps students and teachers learn about climate change, including what it means on a local scale, and empowers students to deliver a climate adaptation project for their school and local community.
- As part of Climate Action 21: Tasmania's Climate Change Action Plan 2017–21, the Tasmanian Government partnered with organisations on local climate change education and outreach initiatives, including the Curious Climate Schools project. Curious Climate Schools was led by interdisciplinary researchers at the Centre for Marine Socioecology at the University of Tasmania and included around 1,000 students across 21 Tasmanian primary and secondary schools and colleges in most areas of the state.

- Under the Victorian Government's Education and Training Climate Change Adaptation Action Plan 2022–2026 (DET 2022), the next 5 years will focus on ensuring that decision-makers, educators and learners have the information, tools and capacity to respond to current and future climate impacts, particularly those related to health and wellbeing, and infrastructure and assets. Actions in the plan help Victorians learn about climate change and how to plan for climate resilience.

9.2.2 Higher education

Australian universities share their climate change expertise through research collaboration, scholarships and international partnerships, and as providers of high-quality university education in climate change. Australia's universities offer many tertiary qualifications that integrate climate change and sustainability education. These qualifications cover disciplines such as science; engineering; arts and social sciences; business, economics and management; law; medicine; and cross-disciplines. Courses are available to both domestic and international students, and these courses help build climate expertise in Australia and the broader Asia–Pacific region.

As well as its extensive investment in climate research through organisations such as the Australian Research Council (see Chapter 8), the Australian Government Department of Education, invests in research to support climate change preparedness and response, including, for example, development of hydrogen applications for regional industries (Central Queensland University 2021) and the establishment of the research Institute for Northern Agriculture and Drought Resilience (Charles Darwin University 2021).

Australia's vocational education and training sector is developing workforce skills and knowledge to identify and manage climate change risks. Registered training organisations deliver nationally recognised climate-related training in environmental management and sustainability; conservation and land management; environmental technology; sustainable operations; renewable and sustainable energy; energy and water efficiency; and retrofitting buildings.

9.3 Training programs

Australian governments are funding training programs to prepare workforces for the demands of an economy that is responding to climate change. Programs are available across Australia; Australia is also working to build capacity in the region (see section 7.3).

As part of the 2022–23 October Budget the government announced a number of complementary measures that will support the priorities identified through the Jobs and Skills Summit. The first phase of the New Energy Apprenticeships will entitle eligible apprentices in the clean energy industry to access financial support of up to $10,000 over the duration of their apprenticeship, as well as additional mentoring and assistance. This energy sector support is part of a broader program under the New Energy Skills Program to invest in fit-for-purpose training pathways for new energy industry jobs to make sure that Australians are skilled and ready to capitalise on the opportunities of our net zero future.

The New South Wales Government continued to deliver the Climate Risk Ready accredited course through Western Sydney University, with 148 government staff trained since January 2021. These staff were chosen to receive a subsidy to attend the course. The course has also been trialled with local council representatives and with a cohort of interjurisdictional adaptation policy and program leads, and was well received. After the course, all participants were able to either commence or complete a climate change risk assessment for their project, division or organisation. A fourth cohort of participants will commence the course in September 2022.

The Victorian Government's Clean Economy Workforce Skills Initiative, launched in 2020, is developing a 10-year workforce strategy exploring renewable energy, circular economy practices and climate change adaptation. The initiative includes a new 16-member Jobs and Skills Taskforce responsible for providing independent expert advice to the government on the Victorian clean economy sector's skills needs.

This is complemented by the $6 million Clean Economy Workforce Capacity Building Fund to help drive Victoria's clean energy future and net zero emissions by 2050 through projects that promote training for an expanded clean economy workforce. The fund will continue to foster valuable opportunities for collaboration between the Victorian technical and further education sector, the training sector and industry on new training, jobs and products.

9.4 Resource and information centres

The Australian Government provides strong support for the collection and analysis of emissions data and the building of climate change knowledge (see Chapter 8). Australia's research capabilities and expertise in climate science enable the Australian Government to provide current, reliable and tailored information about mitigation and adaptation to climate change in the Australian context.

DCCEEW publishes comprehensive data on Australia's emissions and projected emissions. The Australian National Greenhouse Accounts is a series of comprehensive reports and databases that estimate, and account for, Australia's greenhouse gas emissions on national, state and territory bases. Individuals and households can obtain emissions data for states and territories, economic sectors and years from the Australian Greenhouse Emissions Information System. The National Greenhouse Gas Inventory Quarterly Update provides up-to-date emissions data every quarter. Australia's emission projections provide detailed information on Australia's emissions trends and how we are tracking against our emissions reduction targets, including sector-specific analyses.

The Bureau of Meteorology and CSIRO monitor, analyse and communicate observed and future changes in Australia's climate. The sixth and seventh biennial State of the climate reports, published in November 2020 and November 2022, respectively, drew on current climate research and encompassed observations, analyses and projections to describe year-to-year variability and longer-term changes in Australia's climate. The science informs economic, environmental and social decision-making by governments, industries and communities.

Governments in Australia also invest in public information to support everyday decision-making by businesses, households and communities on how to reduce emissions and adapt to climate change. The energy.gov.au, Energy Rating and Your Home websites provide detailed information that is regularly updated to capture current technologies and opportunities. As noted in the seventh National Communication, programs such as the Australian Government's Greenhouse and Energy Minimum Standards, the minimum energy performance standards and the energy rating labels requirements continue to inform Australians on energy-efficient appliance choices. Similarly, the Green Vehicle Guide continues to provide information on the performance of light vehicles. These initiatives are key tools to drive mitigation in the community.

Mt Resilience is an interactive web augmented-reality experience created by the Australian Broadcasting Corporation in collaboration with CSIRO, the Bureau of Meteorology and Phoria. It allows people to explore a hypothetical town, Mt Resilience, to learn what can be done in towns and cities to adapt to climate change and extreme events. CSIRO developed an accompanying prototype site called 'Getting to Mt Resilience' to allow people to explore how adaptation pathways and transitions can be created to adapt to future change.

Increasingly, adaptation and impact management are becoming of critical concern to Australian communities. The National Emergency Management Agency partners with the Australian Institute for Disaster Resilience (AIDR), which collects, develops, curates and shares knowledge to educate and promote good practice in resilience and disaster risk reduction on behalf of government. AIDR manages the Australian Disaster Resilience Knowledge Hub, a national, open-source platform that supports and informs policy, planning, decision-making and good practice in disaster resilience. The Knowledge Hub also includes the Australian Disaster Resilience Handbook Collection, which provides guidance on national principles and best practices for undertaking disaster resilience activities.

Natural Hazards Research Australia (NHRA) was established on 1 July 2021 through a Commonwealth grant. NHRA works closely with the Australian, state and territory governments, emergency services agencies, universities and industry to deliver a multidisciplinary research program focused on natural hazard resilience and disaster risk reduction. The NHRA is currently establishing its 10-year research plan. Once fully established, it will provide practical research to inform how Australia can reduce preventable deaths, better prepare communities to deal with natural disasters, and develop technological solutions to mitigate risks.

CSIRO and the Bureau of Meteorology have collaborated to develop the Climate Services for Agriculture platform (DAFF 2022) to provide accessible climate information for farmers, rural and regional communities, and industry. Available data include indices such as frost risk, heat risk and rainfall that are relevant for different commodities. Data are available for past (1961 to 1990), current (1991 to 2020) and projected periods (2030, 2050 and 2070).

With funding from Microsoft, CSIRO piloted Australia's first Microsoft Farmbeats for Students initiative (CSIRO 2022b). The initiative gave nearly 400 Year 9 and 10 students from 18 schools experience in using artificial intelligence and other data tools to explore agricultural challenges in a changing climate.

Healthy Country AI (NAILSMA 2021) is an Indigenous-led program involving the North Australian Indigenous Land and Sea Management Alliance and CSIRO. Over the past 4 years the program has brought together Indigenous knowledge and innovative technologies, including drones and artificial intelligence, to enable Traditional Owners to survey species and habitats as they change due to climate change, and other drivers of change, on Indigenous-titled lands.

The New South Wales Government's AdaptNSW website was first launched in 2014 and redeveloped in February 2022. The website provides localised climate change and hazard information in the form of regional snapshots, based on New South Wales and Australian Regional Climate Modelling climate projections. It also provides support for climate change adaptation with tools, resources and case studies of adaptation. The site is designed to help households, community groups, business and government prepare for and respond to the impacts of climate change.

The Queensland Government's Queensland Future Climate Dashboard (Queensland Government 2022c) provides the main gateway to climate projection data and information for Queensland. The dashboard was released in 2018 to provide free access to climate projection, heatwave and rainfall information for Queensland, and allows users to explore, visualise and download the latest high-resolution climate modelling data for specific regions, catchments, disaster areas, Local Government Areas and grid squares. The dashboard is supported by the Queensland Future Climate: Understanding the data web page that explains how climate projections work, and gives guidance on how to interpret and apply the information to meet user needs.

These resources have been delivered under the Queensland Future Climate Science Program, a partnership between the Queensland Government Department of Environment and Science and the University of Queensland. This program has delivered dynamically downscaled, high-resolution (10-km grid cell) climate projection data for 2 emissions scenarios (RCP4.5 and 8.5), 11 different climate models, 32 climate variables and various time periods (including daily, monthly and seasonal).

The Queensland Government developed climate risk management tools to help households and small businesses (Queensland Government 2022a, b) prepare for the effects of climate change. These tools were released in 2019 to help households and businesses through the climate risk assessment process and to support adaptation decisions. The Queensland Government has also partnered with the Chamber of Commerce and Industry Queensland to pilot the delivery of a climate risk management training program based on the tool for small businesses.

The Victorian Government's Past, present and future climate ebook for the Victorian mallee gathers together tools and resources on historical rainfall and temperature data, climate trends and projections. The ebook was developed with farmers in response to demand from producers for locally relevant and tailored climate information, to inform on-farm decision-making. The ebook presents information from *Victorian climate projections 2019* (Clarke et al. 2019) and *Victoria's climate science report 2019* (DELWP 2019). In addition, the team worked with climate scientists to calculate future growing degree days – growth and development of certain crops and pests during the growing season – from the projections.

The Western Australian Government has made an additional $4.2 million investment in its Katanning Research Station Carbon Neutral Demonstration Project (DPIRD 2022) to develop and demonstrate practical techniques and methods for mitigating carbon emissions from the livestock industry in the state. The research and development funding will provide evidence for Western Australian farmers to adopt new farming practices and technologies, and build more sustainable businesses to satisfy increasing market demand for low-emissions products. Research scientists will test a range of ready-to-apply mitigation and sequestration practices and systems at the demonstration site, which aim to reduce greenhouse gas emissions on the 2,100-hectare property to net zero by 2030.

9.5 Public information campaigns

The Australian Government launched the Powering Forward campaign in October 2017. The campaign aimed to raise awareness and understanding among businesses and households of Australian Government actions to secure affordable and reliable energy, and provide practical information to assist them to better manage their energy use and so reduce their energy bills. The campaign ran across newspapers, digital news sites, social media, television and radio.

The Australian Government released a public communication campaign in September 2021 to help all Australians understand government initiatives to cut emissions and the progress Australia has made. The campaign included a website (positiveenergy.gov.au – now retired) and spots on television, radio, press, cinema and digital platforms.

9.6 Involvement of the public and non-government organisations

All parts of the Australian community are participating in the national effort to reduce greenhouse gas emissions and manage the challenges associated with climate change. The role of First Nations Australians is fundamental to this effort, given their knowledge of Country, potential to benefit from climate action and exposure to the impacts of climate change.

Case study: The First Nations Clean Energy Network

The First Nations Clean Energy Network (FNCEN) was launched in November 2021. It is made up of First Nations people, groups, community organisations, First Nations land councils, unions, academics, industry groups, technical advisers, legal experts, renewables companies and others – all working in partnership to ensure that First Nations communities share in the benefits of Australia's clean energy transition. The FNCEN is led by a steering group of First Nations leaders.

Australia's rapid transition to renewable energy will require access to vast areas of land and waters, including space for thousands of kilometres of new transmission infrastructure.

Enabling and empowering First Nations to play a key and central role in Australia's renewable energy transition goes beyond just social licence issues – it presents a unique opportunity for Australia to design a system that is fair and just, and can provide many social and economic benefits for First Nations.

As a national, First Nations–led coalition, the FNCEN aims to enable and empower First Nations to participate in, benefit from, respond to, and shape renewable energy projects that impact their land, waters and Sea Country.

The FNCEN's approach is built on 3 pillars:

- Community – the FNCEN supports First Nations communities to shape the design, development and implementation of clean energy projects at every scale.
- Industry partnerships – the FNCEN acts as an innovation hub, promoting best-practice standards and principles that companies should adopt and investors should require before committing capital to a clean energy project.
- Policy reform – the FNCEN advocates the lifting of significant federal and state regulatory barriers that inhibit investment and discourage energy security and clean energy generation.

Building on the success of the inaugural First Nations Clean Energy Symposium in July 2022, the FNCEN is developing a suite of materials to place First Nations in the centre of Australia's energy transition. These materials include a set of best-practice principles and a clean energy negotiations guide for First Nations. The FNCEN will also be playing a key role in the delivery of the First Nations Clean Energy Strategy, which will see First Nations people share in the benefits of the renewables revolution. Federal, state and territory energy ministers committed to support the development of this strategy in the Energy Ministers' Communiqué of 12 August 2022.

Companies and industry associations are playing a pivotal role across the economy. As noted in Chapter 4, the Australian Government is supporting more than 400 organisations to become carbon neutral through Climate Active.

The finance sector is also playing a critical role in driving public awareness and action to reduce emissions. The Investor Group on Climate Change (IGCC) is a collaboration of Australian and New Zealand institutional investors focused on the impact of climate change on investments. IGCC represents investors with tens of trillions in funds under management around the world. IGCC has more than 7.5 million members in Australia and New Zealand. IGCC aims to raise awareness of the potential impacts, both positive and negative, of climate change on the investment industry, corporate, government and community sectors; encourage best-practice approaches to facilitate the inclusion of the impacts of climate change in investment analysis by the investment industry; and provide information to help the investment industry understand and incorporate climate change into investment decisions.

Non-governmental organisations also promote public awareness and understanding of climate change through their efforts at the community level. Environmental and climate research organisations such as Earthwatch Australia undertake independent research, education and communication programs and work with governments, policymakers, businesses, scientists and communities to develop effective climate change solutions.

Community-based environmental organisations such as the Australian Conservation Foundation, the Climate Council, Environment Victoria, Climate for Change and the Word Wildlife Fund Australia run climate change campaigns and provide education and training that advocate reducing greenhouse gas emissions; improving energy efficiency; investing in public transport; using clean, renewable sources of energy; and showing international leadership on climate change. Climate Action Network Australia, the Australian arm of Climate Action Network International, is a network of more than 75 local, state, national and international environmental, development, research and advocacy groups from Australia. This network advocates for and supports its member organisations to take actions to protect people from climate change and to safeguard our natural environment.

The Australian Youth Climate Coalition undertakes activities to educate and engage young people about climate change. It includes Australia's first Indigenous youth climate network, Seed, which is working towards its goals for a just and sustainable future with strong cultures and communities powered by renewable energy. Likewise, organisations such as Cool Australia, the Australian Association for Environmental Education and Science Teachers for Climate Awareness undertake programs and training activities to provide climate education resources for young people.

Climate alliances of other professions and vocations are also using their expertise to increase awareness of climate-related impacts throughout Australia. These alliances include the Australian Firefighters Climate Alliance, Doctors for the Environment Australia, Farmers for Climate Action and Emergency Leaders for Climate Action.

Australia also hosts several independent climate change research institutes, usually affiliated with universities. These institutes frequently share knowledge with policymakers and engage the public in the climate change dialogue through free public seminars and discussion groups. Some of the leading examples include the Institute for Climate, Energy & Disaster Solutions at the Australia National University, the Climateworks Centre at Monash University and the Global Change Institute at the University of Queensland.

9.7 Participation in international activities

Australia actively partners with other countries and multilateral organisations to advance climate change knowledge, education and awareness. The Australian Government is committed to assisting other countries, especially developing countries in our region, to adapt to the unavoidable impacts of climate change and to reduce their greenhouse gas emissions. Our efforts in facilitating capacity building and technology transfer at international level are detailed in Chapter 7.

As an initiative under the Clean Energy Ministerial (see Chapter 4), Australia supports the Clean Energy Solutions Centre (CESC). CESC has been co-led and co-funded by Australia and the United States since its inception in 2011. CESC is an online portal of clean energy policy information and tools, offering peer-to-peer learning, remote expert assistance and online training. CESC has a comprehensive library of resources for policymakers, an online webinar platform supporting a community of energy policy experts and an expert assistance service for policymakers. The expert assistance service has responded to more than 200 requests, and delivered more than 300 webinars. Most CESC users are from developing countries.

The Knowledge Brokering Support Program (KBSP) is an online learning initiative developed by CSIRO as part of the Australia Pacific Climate Partnership (supported by the Australian Government Department of Foreign Affairs and Trade). The program uses tools that have been co-developed by CSIRO and regional partners to help participants build brokering skills to use climate change and future risk in decision-making. The program was refined with the assistance of 2 Pacific training cohorts in 2021 and 2022. The Australian Council for International Development partnered with the project to host the online learning platform for KBSP, and the Queensland University of Technology supported the design aspects of KBSP. The Pacific Climate Change Centre became a key partner and will host the KBSP e-learning platform, which will provide greater accessibility to the materials for people in the Pacific region.

Australia's state and territory governments are actively engaging with other jurisdictions to learn, share experiences and build support for effective global climate action. New South Wales, South Australia and Victoria are current members of the Under2 Coalition, a global network of subnational governments that aims to achieve net zero emissions by 2050. Involvement in the Under2 Coalition provides these states with the opportunity to demonstrate leadership at the international level, build capacity through peer learning and influence the global dialogue on climate change.

All Australian states and territories, along with Scotland and Wales, are the founding members of the Net Zero Futures Policy Forum. The forum, an Under2 Coalition initiative, is a voluntary international collaboration designed to address the practical challenges of achieving net zero emissions and make use of the policy levers available to state and regional governments.

9.8 Monitoring, review and evaluation of the implementation of Article 6 of the Convention

Australia does not have a formal monitoring, review and evaluation mechanism in place for assessing the implementation of Article 6 of the UNFCCC. However, as demonstrated in this chapter, the government is committed to providing our citizens with the tools and opportunities to play an active, meaningful role in climate action. Australia has a wealth of programs established to raise public awareness and encourage public participation in our response to climate change.

In Australia, national communications are prepared to provide international audiences with an account of Australia's policy efforts and progress towards meeting commitments under the UNFCCC. As the preparation of National Communications is not considered as a policymaking or policy-review process, there has been no direct public consultation in preparation of this report.

However, National Communications are prepared in collaboration with a wide variety of stakeholders, including all levels of government, scientific experts and community organisations. The Australian Government recognises the role of public participation in responding to climate change, and meaningful public engagement is central to Australia's climate change policy development and decision-making processes. As noted in Chapter 4, the *Climate Change Act 2022* (Cth) requires the Climate Change Authority to provide advice to the minister on Australia's emissions reduction targets, and to include public consultation as part of the development of advice.

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Australia's 8th National Communication on Climate Change

ANNEX A. FIFTH BIENNIAL REPORT

Contents

1. Introduction

Australia is pleased to submit its fifth Biennial Report in conjunction with the eighth National Communication on Climate Change.

This report provides information on greenhouse gas emissions and trends, including information on Australia's national greenhouse gas inventory and emissions projections.

2. Information on greenhouse gas emissions and trends

A description of Australia's national greenhouse gas emissions and trends, including underpinning national inventory arrangements, is presented in Chapter 3 of its eighth National Communication on Climate Change.

Detailed data on Australia's greenhouse gas emissions can be found in Common Tabular Format (CTF) Table 1 – 1(d) of this annex. If there are any inconsistencies between the numbers and information provided in the CTF tables in this document and those in the Biennial Report Common Tabular Format Application, the Australian Government considers this document to be authoritative.

CTF Table 1: Emissions trends: summary

Greenhouse gas emissions	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt CO_2 eq																																%
CO_2 emissions without net CO_2 from LULUCF	278,154.16	278,154.16	279,528.51	284,525.34	288,870.54	293,696.55	305,003.00	311,886.13	320,282.63	334,075.98	343,488.63	349,635.49	357,132.37	361,540.81	369,279.51	382,820.89	386,153.53	392,384.30	399,624.80	404,233.07	407,065.01	405,103.32	403,828.77	406,150.91	397,887.46	393,952.88	401,793.06	411,264.29	414,358.31	416,283.83	416,761.93	400,333.47	43.93
CO_2 emissions with net CO_2 from LULUCF	454,227.62	454,227.62	440,737.80	379,212.30	362,471.20	362,808.12	346,926.57	354,938.98	353,182.12	353,814.30	370,990.82	389,018.37	407,770.60	407,331.94	425,660.79	419,177.37	447,096.75	457,712.68	471,952.70	462,929.05	463,425.80	446,578.01	422,139.55	407,709.31	392,142.92	390,891.02	380,416.83	357,580.22	351,760.01	362,300.20	358,083.26	343,712.15	-24.33
CH_4 emissions without CH_4 from LULUCF	125,133.25	125,133.25	124,199.25	123,239.84	120,116.18	117,269.42	115,838.53	115,157.29	118,004.54	117,835.00	114,164.53	118,052.18	117,110.62	115,485.97	108,530.05	110,016.93	112,300.31	111,294.13	111,645.92	109,033.21	107,797.78	104,768.45	106,310.04	106,641.05	106,249.16	103,494.60	103,955.98	103,078.58	105,002.79	105,796.25	99,367.73	97,303.74	-22.24
CH_4 emissions with CH_4 from LULUCF	144,870.64	144,870.64	143,511.65	141,570.86	136,772.67	134,040.21	134,640.25	132,339.57	137,768.69	135,244.82	134,622.72	139,577.58	137,571.25	136,774.31	131,416.67	130,136.38	130,275.08	133,330.73	131,706.27	128,964.72	128,906.78	123,937.97	125,560.59	124,071.06	124,348.99	123,604.85	123,504.42	122,117.46	124,939.56	121,998.50	114,047.13	110,093.39	-24.01
N_2O emissions without N_2O from LULUCF	16,084.65	16,084.65	15,683.91	15,513.32	15,972.74	16,394.37	15,562.64	16,826.27	17,617.69	17,673.21	18,148.09	19,088.84	19,403.20	19,909.20	18,758.96	20,441.00	20,511.08	20,417.38	18,821.08	19,147.73	19,661.26	19,537.87	20,287.68	20,490.30	19,263.64	19,673.14	19,054.83	19,042.91	20,719.44	19,578.74	18,751.65	18,586.65	15.56
N_2O emissions with N_2O from LULUCF	20,903.28	20,903.28	20,248.79	19,710.64	20,027.49	20,471.73	19,624.39	21,192.31	21,899.96	21,918.66	22,887.10	24,141.85	24,336.37	24,905.67	24,109.72	25,165.04	25,427.78	25,541.95	24,112.47	24,332.38	25,033.68	25,247.50	26,137.02	26,041.55	24,528.68	24,848.88	23,770.19	23,444.09	25,012.49	23,398.03	22,354.39	22,272.44	6.55
HFCs	1,424.68	1,424.68	1,424.68	1,333.18	1,829.87	1,028.12	1,018.65	278.04	464.73	660.92	985.27	1,252.66	1,685.16	2,112.15	2,647.35	3,185.10	3,859.01	4,271.70	4,957.94	5,568.86	6,446.19	7,070.97	7,817.92	8,207.62	8,566.91	9,293.00	9,844.64	10,248.98	10,476.34	10,443.95	11,285.31	11,564.39	711.72

Greenhouse gas emissions	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt CO_2 eq																																%
PFCs	4,607.01	4,607.01	4,610.74	4,603.28	3,315.53	2,164.43	1,530.84	1,410.40	1,228.15	1,660.52	1,139.06	1,287.06	1,801.88	1,727.62	1,683.98	1,713.85	1,791.70	687.06	582.68	444.52	358.55	283.32	301.30	294.88	192.00	192.54	171.32	224.92	202.63	236.00	303.14	270.31	-94.13
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
SF_6	220.56	220.56	239.34	258.11	276.87	295.61	316.21	289.10	266.77	240.21	211.29	212.43	218.80	225.10	229.11	230.66	196.22	186.07	175.13	163.32	146.99	129.81	118.16	114.98	108.17	105.63	116.17	117.13	115.36	145.27	136.86	90.90	-58.79
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Total (without LULUCF)	425,624.31	425,624.31	425,686.44	429,473.08	430,381.73	430,848.50	439,269.88	445,847.23	457,864.51	472,145.83	478,136.87	489,528.65	497,352.03	501,000.84	501,128.98	518,408.44	524,811.85	529,240.64	535,807.55	538,590.71	541,475.79	536,893.74	538,663.88	541,899.74	532,267.33	526,711.78	534,936.02	543,976.81	550,874.87	552,484.02	546,606.62	528,149.46	24.09
Total (with LULUCF)	626,253.79	626,253.79	610,773.00	546,688.37	524,693.63	520,808.22	504,056.92	510,448.39	514,810.42	513,539.42	530,836.25	555,489.95	573,384.05	573,076.79	585,747.64	579,608.40	608,646.54	621,730.19	633,487.20	622,402.86	624,317.99	603,247.58	582,074.53	566,439.40	549,887.67	548,935.92	537,823.58	513,732.80	512,506.39	518,521.95	506,210.09	488,003.60	-22.08
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt CO_2 eq																																%
1. Energy	293,666.65	293,666.65	295,406.86	301,560.68	304,891.72	305,988.75	318,379.28	324,878.12	335,863.55	350,014.54	355,403.20	364,335.94	371,917.07	375,144.18	380,527.93	393,349.18	400,057.22	405,873.96	413,894.77	418,602.48	423,434.48	418,387.00	415,192.34	420,619.32	414,055.13	408,090.73	418,703.55	428,056.56	430,153.54	432,557.74	431,584.98	415,868.44	41.61
2. Industrial processes and product use	25,902.44	25,902.44	25,083.78	25,674.84	25,403.93	25,407.54	25,051.49	24,608.93	24,689.23	25,806.24	26,229.50	26,128.90	27,090.48	27,591.63	30,133.76	31,477.78	30,705.99	31,079.10	33,214.03	33,279.96	31,115.45	34,089.08	34,909.04	32,520.28	30,168.27	30,144.51	31,065.31	31,194.87	31,842.68	32,574.68	33,409.37	32,728.68	26.35
3. Agriculture	84,926.98	84,926.98	84,131.04	81,404.16	79,409.42	79,465.42	75,915.23	78,100.89	79,320.66	79,064.99	79,129.02	82,258.00	81,264.18	81,132.92	75,665.49	79,168.84	79,773.26	78,241.31	74,314.74	71,861.85	72,165.02	69,784.02	74,352.72	75,780.02	75,966.97	76,429.62	73,559.27	72,639.84	76,552.45	75,148.80	69,752.77	67,830.81	-20.13
4. Land Use, Land-Use Change and Forestry[b]	200,629.48	200,629.48	185,086.56	117,215.29	94,311.90	89,959.72	64,787.04	64,601.17	56,945.91	41,393.59	52,699.37	65,961.30	76,032.03	72,075.94	84,618.66	61,199.97	83,834.70	92,489.54	97,679.64	83,812.14	82,842.20	66,353.84	43,410.65	24,539.66	17,620.34	22,224.14	2,887.56	-30,244.01	-38,368.48	-33,962.08	-40,396.53	-40,145.86	-120.01
5. Waste	21,128.23	21,128.23	21,064.76	20,833.40	20,676.67	19,986.79	19,923.88	18,259.28	17,991.07	17,260.07	17,375.16	16,805.82	17,080.29	17,132.11	14,801.79	14,412.64	14,275.37	14,046.28	14,384.01	14,846.43	14,760.84	14,633.64	14,209.78	12,980.11	12,076.96	12,046.93	11,607.88	12,085.54	12,326.19	12,202.81	11,859.50	11,721.53	-44.52
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Total (including LULUCF)	626,253.79	626,253.79	610,773.00	546,688.37	524,693.63	520,808.22	504,056.92	510,448.39	514,810.42	513,539.42	530,836.25	555,489.95	573,384.05	573,076.79	585,747.64	579,608.40	608,646.54	621,730.19	633,487.20	622,402.86	624,317.99	603,247.58	582,074.53	566,439.40	549,887.67	548,935.92	537,823.58	513,732.80	512,506.39	518,521.95	506,210.09	488,003.60	-22.08

Notes: Further detailed information could be found in the common reporting format tables of the Party's greenhouse gas inventory, namely "Emission trends (CO_2)", "Emission trends (CH_4)", "Emission trends (N_2O)" and "Emission trends (HFCs, PFCs and SF_6)", which is included in an annex to this biennial report.

1 kt CO_2 eq equals 1 Gg CO_2 eq.Abbreviation: LULUCF = land use, land-use change and forestry.

a The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the Conference of the Parties. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

b Includes net CO_2, CH_4 and N_2O from LULUCF.

CTF Table 1(a): Emissions trends: CO_2

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
1. Energy	258,947.04	258,947.04	260,930.36	265,474.81	269,536.38	272,316.64	283,304.13	289,904.97	298,072.37	311,278.98	319,802.88	326,371.60	334,087.84	338,371.68	344,354.39	356,985.38	362,065.66	367,325.86	373,133.78	378,473.93	384,020.29	379,525.93	377,598.40	382,674.70	376,071.11	372,355.14	379,924.90	389,464.30	392,020.05	393,737.93	394,697.53	378,736.70	46.26
A. Fuel combustion (sectoral approach)	251,674.55	251,674.55	253,929.16	258,171.11	262,399.64	265,436.49	276,243.42	283,143.92	291,385.02	304,377.02	312,637.74	318,418.74	325,915.56	330,364.18	337,196.41	350,127.44	355,151.20	360,279.47	365,629.63	370,991.21	376,054.17	371,336.16	369,724.20	374,387.71	367,224.70	363,082.43	369,097.04	377,024.39	377,158.62	376,812.30	374,498.28	361,451.53	43.62
1. Energy industries	142,550.69	142,550.69	145,798.89	149,113.82	150,856.91	151,678.66	157,480.76	162,065.78	168,676.29	181,214.84	188,386.24	191,258.17	198,424.84	200,450.99	203,856.49	212,910.90	215,219.58	219,705.34	222,727.89	224,490.41	230,787.72	224,948.31	219,013.48	220,698.05	209,738.68	203,485.18	210,371.28	217,547.75	216,605.66	212,752.09	211,883.58	206,005.41	44.51
2. Manufacturing industries and construction	35,866.54	35,866.54	35,411.64	34,991.93	35,542.95	36,314.33	37,242.62	37,257.61	37,342.36	37,440.66	37,694.58	38,507.77	38,027.96	38,705.24	39,194.99	40,063.57	41,127.21	40,191.29	40,457.91	42,551.08	40,172.09	39,306.73	40,476.86	42,444.03	45,496.85	45,880.88	42,279.34	40,998.83	40,210.41	41,202.85	41,150.59	41,245.77	15.00
3. Transport	59,819.96	59,819.96	59,161.86	60,087.58	61,560.97	62,998.06	66,231.55	68,032.40	69,277.18	69,393.71	70,156.60	71,712.11	71,659.44	73,057.25	75,417.28	78,428.10	79,578.61	80,924.74	82,929.96	84,024.70	84,937.79	86,490.73	89,171.01	89,767.52	90,051.24	91,219.81	93,379.09	94,437.02	96,119.30	98,510.31	98,629.98	91,814.83	53.49
4. Other sectors	13,018.36	13,018.36	13,114.24	13,484.55	13,939.09	13,886.88	14,598.53	15,013.66	15,275.71	15,625.54	15,773.55	16,311.59	17,170.17	17,565.27	18,172.02	18,147.23	18,608.09	18,809.04	18,693.93	19,085.45	19,329.81	19,709.21	20,172.47	20,613.95	21,034.42	21,479.50	22,130.01	22,942.54	23,307.20	23,426.52	22,049.11	21,446.45	64.74
5. Other	419.00	419.00	442.53	493.23	499.71	558.57	689.95	774.48	813.49	702.26	626.76	629.11	633.15	585.44	555.64	577.64	617.70	649.05	819.94	839.56	826.78	881.18	890.39	864.17	903.52	1,017.06	937.32	1,098.26	916.05	920.53	785.03	939.07	124.12

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
B. Fugitive emissions from fuels	7,272.50	7,272.50	7,001.20	7,303.70	7,136.74	6,880.15	7,060.71	6,761.05	6,687.34	6,901.96	7,165.14	7,952.86	8,172.28	8,007.50	7,157.98	6,857.94	6,914.46	7,046.39	7,504.14	7,482.73	7,966.11	8,189.78	7,874.20	8,286.99	8,846.41	9,272.71	10,827.85	12,439.91	14,861.43	16,925.63	20,199.25	17,272.75	137.51
1. Solid fuels	1,183.88	1,183.88	1,171.77	1,300.99	1,195.27	1,119.44	1,111.53	1,222.65	1,333.08	1,320.77	1,127.85	1,150.51	1,218.13	1,239.48	1,098.17	1,056.49	1,295.99	1,212.91	1,284.96	1,162.36	1,308.41	1,292.10	1,545.96	1,580.22	1,887.70	1,837.87	1,909.73	2,063.87	2,143.26	2,361.50	2,062.35	2,381.21	101.14
2. Oil and natural gas and other emissions from energy production	6,088.62	6,088.62	5,829.43	6,002.71	5,941.47	5,760.71	5,949.19	5,538.40	5,354.26	5,581.19	6,037.29	6,802.35	6,954.16	6,768.01	6,059.81	5,801.46	5,618.47	5,833.48	6,219.18	6,320.36	6,657.70	6,897.67	6,328.23	6,706.78	6,958.71	7,434.84	8,918.12	10,376.04	12,718.17	14,564.13	18,136.90	14,891.54	144.58
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	12.42	100.00
2. Industrial processes	18,551.26	18,551.26	17,889.27	18,286.60	18,492.86	20,436.72	20,699.38	20,976.97	21,028.08	21,439.65	22,143.53	21,534.55	21,197.52	21,210.20	22,970.51	23,771.60	22,095.40	23,199.44	24,645.57	23,898.61	21,070.97	23,357.89	23,999.35	21,400.50	19,747.16	19,075.33	19,304.02	19,105.40	19,445.07	19,839.77	19,367.64	18,768.76	1.17
A. Mineral industry	5,489.59	5,489.59	5,152.40	4,966.20	5,195.81	5,996.30	5,826.27	5,901.64	5,977.02	6,357.07	6,439.33	6,231.93	6,238.69	6,291.22	6,429.03	6,389.42	6,478.76	6,669.00	6,985.47	6,898.40	6,408.14	6,303.98	6,453.94	6,411.44	6,105.31	6,004.46	5,878.57	5,691.71	5,599.67	5,522.20	5,589.24	5,227.58	-4.77
B. Chemical industry	1,054.69	1,054.69	1,061.08	1,114.75	1,181.62	1,213.30	1,379.75	1,397.95	1,373.47	1,550.46	1,544.67	1,696.09	1,957.79	1,989.85	2,347.20	2,525.76	2,681.46	3,395.44	3,968.88	3,411.06	3,138.47	3,538.27	3,488.64	3,184.17	3,091.60	3,079.08	3,170.93	3,063.00	3,073.58	3,267.92	2,820.77	2,987.15	183.23
C. Metal industry	11,644.47	11,644.47	11,331.68	11,860.44	11,759.37	12,863.00	13,085.71	13,259.68	13,255.06	13,111.73	13,745.16	13,177.30	12,559.72	12,479.91	13,734.63	14,357.16	12,513.83	12,730.76	13,315.67	13,190.96	11,125.92	13,036.79	13,563.09	11,398.78	10,125.11	9,608.86	9,863.70	9,904.96	10,374.47	10,659.50	10,558.58	10,162.12	-12.73
D. Non-energy products from fuels and solvent use	279.93	279.93	259.04	257.65	266.01	271.58	268.79	278.54	279.93	279.93	271.58	284.11	293.86	299.43	307.79	334.25	253.89	243.75	227.25	234.82	237.03	247.40	232.10	188.11	184.77	181.23	175.09	172.90	184.05	171.25	180.05	178.36	-36.28

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
E. Electronic industry																																	
F. Product uses as ODS substitutes																																	
G. Other product manufacture and use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
H. Other	82.57	82.57	85.07	87.56	90.06	92.55	138.85	139.16	142.59	140.46	142.79	145.12	147.46	149.79	151.86	165.01	167.47	160.49	148.29	163.38	161.41	231.45	261.58	218.01	240.37	201.70	215.73	272.83	213.30	218.90	218.99	213.55	158.62
3. Agriculture	582.01	582.01	634.90	689.81	767.03	868.78	919.40	945.55	1,153.69	1,328.72	1,512.90	1,701.12	1,818.64	1,930.41	1,925.92	2,035.07	1,963.45	1,829.69	1,815.79	1,830.38	1,943.18	2,189.14	2,200.55	2,045.07	2,038.11	2,490.91	2,532.97	2,663.25	2,861.74	2,674.71	2,665.38	2,796.55	380.50
A. Enteric fermentation																																	
B. Manure management																																	
C. Rice cultivation																																	
D. Agricultural soils																																	
E. Prescribed burning of savannas																																	
F. Field burning of agricultural residues																																	
G. Liming	215.35	215.35	260.26	316.77	382.83	487.77	439.54	385.99	485.72	585.83	720.58	738.22	761.69	1,021.29	1,050.19	1,079.51	1,076.18	1,072.84	1,069.51	1,065.53	1,159.49	1,252.83	1,088.30	924.62	760.32	1,138.74	1,224.39	1,153.39	1,318.39	1,318.39	1,318.39	1,318.39	512.22

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
H. Urea application	366.67	366.67	374.64	373.04	384.20	381.01	479.86	559.57	667.97	742.90	792.32	962.90	1,056.96	909.12	875.73	955.56	887.27	756.85	746.28	764.85	783.69	936.31	1,112.25	1,120.46	1,277.80	1,352.17	1,308.58	1,509.86	1,543.35	1,356.33	1,347.00	1,478.16	303.13
I. Other carbon-containing fertilizers	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.00
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
4. Land Use, Land-Use Change and Forestry	176,073.46	176,073.46	161,209.29	94,686.95	73,600.66	69,111.57	41,923.58	43,052.85	32,899.49	19,738.32	27,502.18	39,382.88	50,638.23	45,791.13	56,381.28	36,356.48	60,943.22	65,328.38	72,327.90	58,695.98	56,360.79	41,474.69	18,310.77	1,558.40	-5,744.54	-3,061.85	-21,376.23	-53,684.07	-62,598.30	-53,983.63	-58,678.68	-56,621.31	-132.16
A. Forest land	-14,917.65	-14,917.65	-11,850.25	-15,694.88	-22,365.19	-17,160.97	-22,157.18	-27,903.42	-41,981.44	-38,255.41	-37,587.87	-27,977.21	-30,400.78	-32,321.55	-30,207.03	-38,714.61	-42,373.13	-41,496.69	-34,523.05	-24,753.66	-22,871.43	-24,960.83	-32,221.14	-47,103.00	-52,465.10	-55,545.11	-59,670.73	-78,869.24	-82,312.73	-83,559.90	-70,614.44	-79,323.01	431.74
B. Cropland	45,465.95	45,465.95	39,920.07	26,919.84	24,669.53	22,062.90	13,001.86	14,174.98	11,801.34	5,059.27	4,948.32	3,386.50	6,220.34	6,114.67	7,570.05	8,327.63	11,589.25	10,500.74	10,392.71	10,308.35	11,100.79	5,075.15	6,067.54	3,423.90	5,547.47	5,964.56	1,669.20	-2,956.76	-3,194.97	-1,809.62	-1,334.67	2,533.26	-94.43
C. Grassland	143,823.75	143,823.75	130,821.63	81,507.89	70,351.32	64,797.49	52,731.57	56,640.43	62,577.56	53,574.88	60,166.51	65,322.78	75,866.22	73,216.07	80,509.00	69,046.27	92,984.32	95,834.28	95,954.64	73,144.71	67,000.70	60,521.31	43,077.52	44,381.72	40,893.34	46,039.13	36,650.71	28,460.12	23,468.10	33,699.79	15,336.98	22,125.34	-84.62
D. Wetlands	1,770.99	1,770.99	2,077.13	2,183.37	1,590.08	474.18	543.59	1,324.35	1,436.37	1,264.74	1,260.26	1,246.19	564.77	1,033.09	867.02	275.90	909.12	1,360.63	1,113.81	1,394.30	1,384.67	993.87	1,367.17	314.56	343.93	360.61	431.60	-256.26	-319.79	-660.45	-475.16	-905.20	-151.11

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
E. Settlements	7,316.88	7,316.88	6,812.01	6,474.72	6,189.48	6,008.23	5,324.17	5,251.38	5,401.40	5,229.81	5,043.69	5,159.62	4,917.73	4,601.95	4,998.88	5,289.70	5,544.49	5,945.26	5,737.25	5,056.79	4,780.25	4,539.52	5,081.06	4,605.06	4,018.05	4,103.39	3,775.27	4,385.07	4,351.40	3,566.33	3,347.54	3,187.95	-56.43
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
G. Harvested wood products	-7,386.47	-7,386.47	-6,571.31	-6,703.99	-6,834.56	-7,070.26	-7,520.44	-6,434.88	-6,335.75	-7,134.97	-6,328.73	-7,754.99	-6,530.06	-6,853.10	-7,356.65	-7,868.40	-7,710.83	-6,815.82	-6,347.45	-6,454.51	-5,034.20	-4,694.33	-5,061.37	-4,063.84	-4,082.23	-3,984.43	-4,232.29	-4,447.01	-4,590.31	-5,219.78	-4,938.93	-4,239.65	-42.60
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
5. Waste	73.84	73.84	73.99	74.13	74.26	74.40	80.09	58.64	28.50	28.62	29.33	28.21	28.36	28.52	28.69	28.85	29.02	29.31	29.67	30.14	30.58	30.36	30.48	30.63	31.08	31.50	31.18	31.33	31.46	31.41	31.38	31.47	-57.39
A. Solid waste disposal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
B. Biological treatment of solid waste																																	
C. Incineration and open burning of waste	73.84	73.84	73.99	74.13	74.26	74.40	80.09	58.64	28.50	28.62	29.33	28.21	28.36	28.52	28.69	28.85	29.02	29.31	29.67	30.14	30.58	30.36	30.48	30.63	31.08	31.50	31.18	31.33	31.46	31.41	31.38	31.47	-57.39
D. Waste water treatment and discharge																																	
E. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.00
6. Other (as specified in the summary table in CRF)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
Memo items:																																	
International bunkers	6,460.40	6,460.40	6,436.17	6,645.57	7,050.38	7,431.58	8,613.75	9,111.05	9,141.94	9,532.99	9,804.70	10,192.67	10,489.67	9,620.18	8,770.82	9,992.89	10,948.22	11,554.70	11,925.51	12,209.31	12,188.05	12,442.13	11,958.10	12,918.58	12,970.43	14,128.32	14,067.18	15,011.33	16,179.10	16,922.53	17,720.65	13,888.55	114.98
Aviation	4,382.71	4,382.71	4,558.80	4,837.20	5,244.36	5,396.78	5,908.34	6,363.53	6,595.99	7,293.38	7,328.88	7,394.30	7,861.32	6,751.90	5,974.78	7,173.67	8,292.48	8,393.76	9,357.83	9,271.62	9,474.02	10,347.62	10,093.39	10,472.02	11,026.03	11,893.25	11,822.06	12,627.61	13,613.10	14,415.98	15,338.74	11,757.88	168.28
Navigation	2,077.69	2,077.69	1,877.37	1,808.37	1,806.02	2,034.79	2,705.40	2,747.52	2,545.95	2,239.61	2,475.82	2,798.37	2,628.35	2,868.28	2,796.04	2,819.22	2,655.74	3,160.94	2,567.69	2,937.70	2,714.02	2,094.52	1,864.70	2,446.56	1,944.39	2,235.07	2,245.12	2,383.71	2,566.00	2,506.55	2,381.92	2,130.67	2.55
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass	15,142.27	15,142.27	15,017.92	13,705.03	15,366.51	16,319.27	17,109.55	18,140.99	19,020.64	19,328.69	19,067.45	19,243.87	18,429.67	16,548.89	18,217.18	18,497.26	19,092.02	19,106.11	19,274.57	19,671.58	14,734.32	17,225.56	16,224.78	16,595.14	18,101.18	17,928.42	19,106.94	19,095.57	20,078.41	16,299.03	15,423.18	15,788.50	4.27
CO_2 captured	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA		NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00
Long-term storage of C in waste disposal sites	50,956.33	50,956.33	52,111.54	53,264.15	54,401.29	55,530.69	56,684.79	57,892.46	59,087.44	60,292.57	61,550.45	62,779.28	64,088.49	65,353.06	66,619.63	67,912.66	69,282.36	70,655.75	71,975.26	73,290.70	74,606.15	75,873.67	77,066.59	78,309.32	79,433.75	80,536.31	81,646.19	82,716.46	83,769.65	84,793.79	85,918.69	87,033.69	70.80
Indirect N_2O																																	

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
Indirect CO_2 (3)	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	0.00
Total CO_2 equivalent emissions without land use, land-use change and forestry	278,154.16	278,154.16	279,528.51	284,525.34	288,870.54	293,696.55	305,003.00	311,886.13	320,282.63	334,075.98	343,488.63	349,635.49	357,132.37	361,540.81	369,279.51	382,820.89	386,153.53	392,384.30	399,624.80	404,233.07	407,065.01	405,103.32	403,828.77	406,150.91	397,887.46	393,952.88	401,793.06	411,264.29	414,358.31	416,283.83	416,761.93	400,333.47	43.93
Total CO_2 equivalent emissions with land use, land-use change and forestry	454,227.62	454,227.62	440,737.80	379,212.30	362,471.20	362,808.12	346,926.57	354,938.98	353,182.12	353,814.30	370,990.82	389,018.37	407,770.60	407,331.94	425,660.79	419,177.37	447,096.75	457,712.68	471,952.70	462,929.05	463,425.80	446,578.01	422,139.55	407,709.31	392,142.92	390,891.02	380,416.83	357,580.22	351,760.01	362,300.20	358,083.26	343,712.15	-24.33
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00

Abbreviations: CRF = common reporting format, LULUCF = land use, land-use change and forestry.

a The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the Conference of the Parties. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

b Fill in net emissions/removals as reported in CRF table Summary 1.A of the latest reported inventory year. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

CTF Table 1(b): Emissions trends: CH_4

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
1. Energy	1,310.32	1,310.32	1,299.22	1,361.14	1,326.45	1,255.67	1,306.64	1,298.68	1,406.34	1,437.30	1,307.23	1,397.20	1,386.42	1,335.25	1,300.72	1,303.89	1,367.89	1,391.67	1,479.04	1,453.46	1,428.95	1,409.88	1,355.88	1,371.10	1,373.59	1,289.06	1,419.75	1,413.73	1,395.53	1,430.37	1,355.75	1,366.56	4.29
A. Fuel combustion (sectoral approach)	131.65	131.65	134.02	137.42	138.72	136.23	133.83	131.17	128.54	122.71	115.70	110.37	107.73	96.59	94.01	92.30	87.33	85.42	82.70	81.40	85.83	84.53	76.26	79.56	77.95	82.04	83.95	90.88	87.94	90.32	85.56	75.55	-42.62
1. Energy industries	6.12	6.12	5.93	5.93	6.33	6.12	6.54	6.78	7.06	9.08	9.23	11.50	11.87	12.92	11.78	12.46	12.32	12.69	12.98	14.44	22.70	23.30	18.08	21.83	20.61	25.92	29.09	36.67	34.43	38.12	34.69	25.94	323.95
2. Manufacturing industries and construction	2.06	2.06	2.00	1.88	2.05	2.17	2.23	2.28	2.24	2.28	2.29	2.26	2.10	2.08	2.12	2.19	2.28	2.35	2.40	2.48	1.94	2.27	2.28	2.39	2.56	2.45	2.49	2.44	2.42	2.37	2.31	2.26	9.48
3. Transport	26.35	26.35	26.29	26.99	27.83	28.59	29.67	30.18	30.24	29.31	28.74	27.32	26.01	26.32	25.49	24.93	22.00	21.27	19.89	18.80	18.13	17.76	16.64	16.07	15.48	15.14	15.17	14.96	14.57	13.74	13.01	12.29	-53.35
4. Other sectors	97.10	97.10	99.78	102.61	102.48	99.33	95.36	91.88	88.95	82.00	75.42	69.27	67.74	55.25	54.60	52.70	50.70	49.09	47.40	45.65	43.02	41.16	39.24	39.25	39.26	38.50	37.17	36.78	36.49	36.06	35.52	35.02	-63.93
5. Other	0.03	0.03	0.02	0.03	0.02	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.03	0.04	43.99
B. Fugitive emissions from fuels	1,178.68	1,178.68	1,165.20	1,223.72	1,187.73	1,119.44	1,172.80	1,167.51	1,277.80	1,314.59	1,191.53	1,286.83	1,278.69	1,238.66	1,206.71	1,211.59	1,280.56	1,306.26	1,396.35	1,372.06	1,343.12	1,325.35	1,279.62	1,291.54	1,295.64	1,207.01	1,335.81	1,322.85	1,307.59	1,340.05	1,270.19	1,291.02	9.53
1. Solid fuels	871.21	871.21	885.67	923.41	930.11	856.22	857.13	876.49	973.66	1,013.92	944.01	1,016.51	1,006.63	982.86	970.73	990.27	1,068.35	1,100.09	1,192.81	1,163.45	1,139.22	1,101.95	1,070.37	1,071.40	1,065.67	994.10	1,098.99	1,089.39	1,044.41	1,066.09	976.07	1,007.03	15.59
2. Oil and natural gas and other emissions from energy production	307.46	307.46	279.53	300.30	257.62	263.22	315.67	291.02	304.14	300.67	247.52	270.32	272.06	255.80	235.98	221.32	212.21	206.17	203.53	208.61	203.91	223.40	209.25	220.14	229.98	212.91	236.82	233.46	263.18	273.96	294.12	283.99	-7.64

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
C. CO_2 transport and storage																																	
2. Industrial processes	3.26	3.26	3.00	3.29	3.33	3.72	3.93	4.02	3.93	4.11	3.84	3.47	3.24	3.21	3.46	3.45	3.27	3.55	3.57	3.57	3.09	3.69	3.90	3.01	2.74	2.60	2.75	2.79	2.80	2.95	2.88	2.86	-12.44
A. Mineral industry																																	
B. Chemical industry	0.44	0.44	0.40	0.41	0.32	0.40	0.52	0.59	0.57	0.51	0.48	0.58	0.49	0.50	0.58	0.55	0.55	0.57	0.57	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.54	0.43	0.43	0.43	0.43	-0.92
C. Metal industry	2.83	2.83	2.60	2.88	3.01	3.32	3.41	3.42	3.36	3.60	3.36	2.89	2.75	2.71	2.88	2.90	2.72	2.98	3.00	3.00	2.51	3.12	3.33	2.44	2.16	2.02	2.17	2.25	2.36	2.52	2.45	2.42	-14.22
D. Non-energy products from fuels and solvent use	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00
E. Electronic industry																																	
F. Product uses as ODS substitutes																																	
G. Other product manufacture and use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
3. Agriculture	2,862.06	2,862.06	2,838.98	2,748.00	2,664.32	2,648.47	2,542.87	2,589.58	2,606.08	2,597.84	2,577.08	2,666.03	2,628.71	2,613.18	2,462.88	2,535.11	2,568.44	2,513.76	2,427.37	2,331.07	2,315.56	2,219.26	2,352.30	2,397.17	2,413.12	2,389.94	2,296.35	2,249.58	2,334.28	2,335.52	2,167.17	2,079.95	-27.33
A. Enteric fermentation	2,585.32	2,585.32	2,569.39	2,477.59	2,395.85	2,375.07	2,289.65	2,328.02	2,337.43	2,328.44	2,310.18	2,396.20	2,341.27	2,326.08	2,214.41	2,271.83	2,294.68	2,230.90	2,170.89	2,086.32	2,070.66	1,973.62	2,090.82	2,124.32	2,139.53	2,118.31	2,032.02	1,999.26	2,061.71	2,066.73	1,928.37	1,849.84	-28.45

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
B. Manure management	246.04	246.04	242.73	239.20	235.27	236.77	223.32	223.73	225.26	231.68	227.88	235.37	245.54	249.91	234.48	238.92	256.44	255.10	248.20	238.07	235.89	235.78	239.37	246.29	246.02	250.59	244.81	238.20	246.50	250.01	232.08	223.55	-9.14
C. Rice cultivation	19.02	19.02	15.35	20.58	20.35	21.94	21.39	24.81	27.56	23.46	23.63	20.82	28.10	22.97	7.29	10.60	8.22	16.22	3.16	0.33	1.14	3.01	12.04	16.38	18.06	12.19	11.07	4.41	13.67	10.16	1.26	0.83	-95.65
D. Agricultural soils	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.00
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0.00
F. Field burning of agricultural residues	11.68	11.68	11.52	10.63	12.85	14.68	8.52	13.02	15.82	14.26	15.39	13.65	13.80	14.22	6.70	13.76	9.10	11.53	5.12	6.35	7.87	6.85	10.07	10.17	9.51	8.85	8.46	7.70	12.40	8.62	5.46	5.73	-50.97
G. Liming																																	
H. Urea application																																	
I. Other carbon-containing fertilizers																																	
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
4. Land use, land-use change and forestry	789.50	789.50	772.50	733.24	666.26	670.83	752.07	687.29	790.57	696.39	818.33	861.02	818.43	851.53	915.46	804.78	718.99	881.46	802.41	797.26	844.36	766.78	770.02	697.20	723.99	804.41	781.94	761.56	797.47	648.09	587.18	511.59	-35.20
A. Forest land	234.94	234.94	234.02	252.92	260.66	236.45	229.08	240.68	212.87	203.38	207.56	243.60	225.86	242.36	252.81	243.76	234.01	256.44	285.26	327.44	325.75	318.97	346.55	308.35	295.90	312.07	323.25	295.14	290.15	241.85	242.33	214.24	-8.81
B. Cropland	23.21	23.21	21.35	10.16	6.90	6.46	6.05	5.06	5.69	5.27	4.63	4.73	4.45	4.80	4.15	4.15	4.35	4.04	3.53	2.58	2.04	2.04	1.60	1.33	1.26	2.10	1.49	1.60	1.00	0.80	0.69	0.52	-97.77
C. Grassland	374.76	374.76	345.96	290.46	272.98	277.30	281.03	295.07	312.16	315.91	346.44	377.87	372.39	375.39	379.23	336.41	350.12	380.10	384.49	328.30	320.52	313.66	294.09	275.38	283.06	292.54	259.77	248.93	246.41	222.48	210.12	202.11	-46.07

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
D. Wetlands	149.94	149.94	165.55	174.92	121.49	146.53	232.17	143.33	256.25	168.40	256.55	231.41	212.85	225.87	275.82	216.44	125.85	236.31	125.07	135.44	193.11	129.37	125.45	110.76	142.38	196.33	196.12	214.40	258.57	182.04	133.31	94.23	-37.15
E. Settlements	6.64	6.64	5.62	4.78	4.24	4.10	3.74	3.15	3.59	3.43	3.15	3.40	2.87	3.11	3.45	4.02	4.66	4.56	4.06	3.49	2.94	2.74	2.33	1.38	1.39	1.37	1.31	1.48	1.33	0.93	0.73	0.48	-92.82
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
G. Harvested wood products																																	
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
5. Waste	829.69	829.69	826.77	817.16	810.55	782.92	780.10	714.02	703.82	674.15	678.43	655.39	666.05	667.79	574.15	558.22	552.40	542.79	555.86	573.22	564.31	557.91	540.31	494.36	460.52	458.19	439.39	457.05	467.51	463.01	448.91	442.78	-46.63
A. Solid waste disposal	609.46	609.46	608.92	602.79	601.16	577.85	582.79	526.23	521.62	493.98	498.95	491.13	492.96	499.96	462.03	444.51	438.11	427.10	438.27	454.43	451.31	462.45	446.02	396.78	365.99	364.71	346.54	356.69	368.48	361.01	353.75	340.41	-44.14
B. Biological treatment of solid waste	0.35	0.35	0.48	0.62	0.75	0.88	1.01	1.15	1.28	1.41	1.55	1.68	1.81	1.94	2.08	2.21	2.34	2.52	2.66	2.87	3.01	3.40	3.95	4.02	4.09	4.15	4.21	4.32	4.39	4.46	4.49	4.55	1,198.32
C. Incineration and open burning of waste	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.06	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	
D. Waste water treatment and discharge	219.79	219.79	217.28	213.66	208.55	204.10	196.20	186.58	180.92	178.75	177.93	162.58	171.28	165.89	110.04	111.50	111.95	113.16	114.92	115.93	109.99	92.06	90.34	93.56	90.44	89.32	88.64	96.05	94.64	97.55	90.67	97.82	-55.49
E. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.00
6. Other (as specified in the summary table in CRF)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
Total CH_4 emissions without CH_4 from LULUCF	5,005.33	5,005.33	4,967.97	4,929.59	4,804.65	4,690.78	4,633.54	4,606.29	4,720.18	4,713.40	4,566.58	4,722.09	4,684.42	4,619.44	4,341.20	4,400.68	4,492.01	4,451.77	4,465.84	4,361.33	4,311.91	4,190.74	4,252.40	4,265.64	4,249.97	4,139.78	4,158.24	4,123.14	4,200.11	4,231.85	3,974.71	3,892.15	-22.24
Total CH_4 emissions with CH_4 from LULUCF	5,794.83	5,794.83	5,740.47	5,662.83	5,470.91	5,361.61	5,385.61	5,293.58	5,510.75	5,409.79	5,384.91	5,583.10	5,502.85	5,470.97	5,256.67	5,205.46	5,211.00	5,333.23	5,268.25	5,158.59	5,156.27	4,957.52	5,022.42	4,962.84	4,973.96	4,944.19	4,940.18	4,884.70	4,997.58	4,879.94	4,561.89	4,403.74	-24.01
Memo items:																																	
International bunkers	0.21	0.21	0.19	0.18	0.18	0.21	0.27	0.27	0.26	0.23	0.25	0.28	0.26	0.29	0.28	0.28	0.27	0.32	0.26	0.30	0.28	0.22	0.20	0.25	0.21	0.24	0.24	0.26	0.28	0.27	0.26	0.23	11.50
Aviation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	245.24
Navigation	0.20	0.20	0.18	0.17	0.17	0.20	0.26	0.26	0.24	0.21	0.24	0.27	0.25	0.28	0.27	0.27	0.25	0.30	0.25	0.28	0.26	0.20	0.18	0.23	0.19	0.21	0.21	0.23	0.24	0.24	0.23	0.20	2.35
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass																																	
CO_2 captured																																	
Long-term storage of C in waste disposal sites																																	
Indirect N_2O																																	
Indirect CO_2 (3)																																	

Abbreviations: CRF = common reporting format, LULUCF = land use, land-use change and forestry.

a The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the Conference of the Parties. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

CTF Table 1(c): Emissions trends: N_2O

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
1. Energy	6.58	6.58	6.70	6.90	7.36	7.65	8.08	8.41	8.83	9.41	9.80	10.18	10.63	11.38	12.27	12.64	12.73	12.60	12.70	12.72	12.38	12.13	12.41	12.31	12.23	11.78	11.02	10.90	10.89	10.27	10.05	9.96	51.29
A. Fuel combustion (sectoral approach)	6.45	6.45	6.57	6.78	7.24	7.54	7.97	8.31	8.75	9.32	9.71	10.08	10.52	11.28	12.18	12.56	12.65	12.52	12.61	12.63	12.29	12.02	12.32	12.19	12.11	11.66	10.86	10.70	10.62	10.02	9.74	9.73	50.92
1. Energy industries	1.70	1.70	1.63	1.66	1.73	1.73	1.80	1.84	2.04	2.25	2.23	2.34	2.64	2.99	3.37	3.45	3.64	3.65	3.76	3.74	3.93	3.79	4.18	4.12	4.09	3.91	3.17	3.21	3.23	3.01	3.00	3.15	85.01
2. Manufacturing industries and construction	1.13	1.13	1.11	1.02	1.12	1.17	1.22	1.28	1.32	1.33	1.32	1.30	1.24	1.25	1.26	1.29	1.34	1.33	1.37	1.42	1.09	1.27	1.29	1.38	1.51	1.48	1.49	1.47	1.53	1.50	1.47	1.44	27.01
3. Transport	3.07	3.07	3.28	3.52	3.81	4.05	4.35	4.58	4.78	5.12	5.54	5.81	5.98	6.40	6.88	7.13	6.98	6.86	6.81	6.79	6.59	6.29	6.16	6.01	5.80	5.57	5.47	5.25	5.08	4.73	4.57	4.47	45.55
4. Other sectors	0.53	0.53	0.54	0.56	0.57	0.57	0.58	0.59	0.60	0.60	0.60	0.60	0.64	0.62	0.66	0.66	0.68	0.66	0.65	0.66	0.65	0.65	0.65	0.67	0.68	0.68	0.70	0.73	0.75	0.75	0.68	0.65	22.12
5. Other	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	134.97
B. Fugitive emissions from fuels	0.14	0.14	0.12	0.13	0.12	0.11	0.12	0.10	0.09	0.09	0.09	0.10	0.11	0.10	0.08	0.08	0.08	0.08	0.09	0.09	0.10	0.10	0.08	0.11	0.12	0.12	0.16	0.21	0.27	0.25	0.30	0.23	69.02
1. Solid fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	384,431.94
2. Oil and natural gas and other emissions from energy production	0.14	0.14	0.12	0.13	0.12	0.11	0.12	0.10	0.09	0.09	0.09	0.10	0.11	0.10	0.08	0.08	0.08	0.08	0.09	0.09	0.10	0.10	0.08	0.11	0.12	0.12	0.16	0.20	0.27	0.25	0.30	0.23	67.51
C. CO_2 transport and storage																																	

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
2. Industrial processes	3.41	3.41	2.83	3.73	4.72	4.66	4.66	5.21	5.38	5.71	5.55	5.89	7.07	7.50	8.44	8.36	9.00	8.88	9.27	10.45	10.12	10.59	8.64	8.14	4.99	4.74	5.24	4.79	5.15	6.16	7.53	6.59	92.94
A. Mineral industry																																	
B. Chemical industry	3.34	3.34	2.76	3.65	4.64	4.58	4.58	5.13	5.29	5.63	5.47	5.82	6.99	7.43	8.35	8.26	8.93	8.80	9.19	10.38	10.06	10.52	8.56	8.08	4.93	4.69	5.19	4.74	5.09	6.10	7.48	6.53	95.67
C. Metal industry	0.07	0.07	0.07	0.08	0.07	0.08	0.07	0.08	0.09	0.08	0.09	0.07	0.08	0.08	0.09	0.09	0.07	0.08	0.08	0.08	0.06	0.07	0.08	0.06	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.05	-28.75
D. Non-energy products from fuels and solvent use	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00
E. Electronic industry																																	
F. Product uses as ODS substitutes																																	
G. Other product manufacture and use	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	0.00
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
3. Agriculture	42.93	42.93	42.02	40.32	40.38	41.56	38.34	41.66	43.67	42.92	44.26	46.66	46.07	46.55	40.83	46.16	45.63	45.53	39.65	39.45	41.39	40.65	44.78	46.33	45.64	47.62	45.70	46.10	51.46	47.27	43.32	43.74	1.89
A. Enteric fermentation																																	
B. Manure management	0.77	0.77	0.78	0.81	0.83	0.89	0.96	0.96	0.95	1.03	1.09	1.34	1.45	1.53	1.51	1.48	1.70	1.76	1.78	1.52	1.53	1.53	1.64	1.63	1.65	1.70	1.86	1.88	1.91	1.99	2.05	2.06	168.52
C. Rice cultivation																																	

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
D. Agricultural soils	41.70	41.70	40.78	39.07	39.03	40.07	37.03	40.18	42.08	41.31	42.53	44.76	44.04	44.44	39.05	44.11	43.57	43.29	37.67	37.66	39.53	38.83	42.73	44.27	43.58	45.54	43.49	43.90	49.01	44.91	41.04	41.44	-0.62
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0.00
F. Field burning of agricultural residues	0.47	0.47	0.46	0.44	0.52	0.60	0.34	0.53	0.64	0.58	0.64	0.57	0.57	0.59	0.27	0.57	0.37	0.47	0.20	0.26	0.32	0.28	0.42	0.42	0.41	0.37	0.35	0.32	0.53	0.37	0.23	0.24	-48.34
G. Liming																																	
H. Urea application																																	
I. Other carbon containing fertlizers																																	
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
4. Land use, land-use change and forestry	16.17	16.17	15.32	14.08	13.61	13.68	13.63	14.65	14.37	14.25	15.90	16.96	16.55	16.77	17.96	15.85	16.50	17.20	17.76	17.40	18.03	19.16	19.63	18.63	17.67	17.37	15.82	14.77	14.41	12.82	12.09	12.37	-23.51
A. Forest land	4.42	4.42	4.59	4.71	4.66	4.35	4.27	4.36	4.05	3.97	4.23	4.56	4.30	4.56	4.67	4.41	4.35	4.59	4.83	5.48	5.65	6.07	6.57	5.93	5.77	5.68	5.56	5.07	5.04	4.39	4.38	4.21	-4.77
B. Cropland	0.53	0.53	0.48	0.30	0.23	0.20	0.22	0.18	0.19	0.20	0.20	0.15	0.16	0.16	0.17	0.14	0.19	0.12	0.17	0.13	0.12	0.14	0.13	0.09	0.12	0.12	0.09	0.12	0.05	0.06	0.07	0.07	-85.99
C. Grassland	10.16	10.16	9.15	7.93	7.59	7.98	8.04	8.97	9.08	9.11	10.35	11.21	11.05	10.98	11.94	10.20	10.67	11.26	11.52	10.51	10.70	11.08	10.88	10.47	9.99	10.20	8.93	8.38	8.26	7.33	6.69	6.96	-31.47
D. Wetlands	0.26	0.26	0.25	0.23	0.23	0.19	0.18	0.26	0.29	0.31	0.34	0.38	0.33	0.36	0.36	0.30	0.31	0.34	0.34	0.36	0.39	0.38	0.38	0.36	0.37	0.36	0.35	0.31	0.31	0.27	0.28	0.27	3.34
E. Settlements	0.14	0.14	0.12	0.11	0.09	0.10	0.09	0.08	0.08	0.08	0.09	0.09	0.08	0.07	0.09	0.09	0.11	0.11	0.10	0.10	0.08	0.09	0.09	0.06	0.05	0.05	0.05	0.05	0.05	0.03	0.03	0.03	-77.51

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
G. Harvested wood products																																	
H. Other	0.01	0.01	0.02	0.03	0.03	0.04	0.03	0.04	0.04	0.04	0.05	0.06	0.07	0.08	0.08	0.08	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.16	0.15	0.15	0.18	0.19	0.18	0.21	0.20	0.23	1,682.62
5. Waste	1.05	1.05	1.08	1.11	1.14	1.14	1.15	1.18	1.23	1.27	1.29	1.32	1.34	1.37	1.41	1.44	1.46	1.50	1.54	1.63	2.09	2.20	2.25	1.98	1.79	1.88	1.99	2.11	2.04	2.00	2.03	2.08	98.76
A. Solid waste disposal																																	
B. Biological treatment of solid waste	0.04	0.04	0.06	0.08	0.10	0.11	0.13	0.15	0.16	0.18	0.20	0.21	0.23	0.25	0.27	0.28	0.30	0.32	0.34	0.37	0.39	0.44	0.51	0.51	0.52	0.53	0.54	0.55	0.56	0.57	0.57	0.58	1,198.32
C. Incineration and open burning of waste	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE	
D. Waste water treatment and discharge	0.96	0.96	0.98	0.99	1.00	0.99	0.98	1.00	1.07	1.09	1.09	1.10	1.11	1.12	1.14	1.15	1.16	1.18	1.20	1.26	1.70	1.76	1.75	1.47	1.26	1.35	1.45	1.55	1.48	1.43	1.46	1.50	55.49
E. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.00
6. Other (as specified in the summary table in CRF)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Total direct N_2O emissions without N_2O from LULUCF	53.98	53.98	52.63	52.06	53.60	55.01	52.22	56.46	59.12	59.31	60.90	64.06	65.11	66.81	62.95	68.59	68.83	68.51	63.16	64.25	65.98	65.56	68.08	68.76	64.64	66.02	63.94	63.90	69.53	65.70	62.92	62.37	15.56
Total direct N_2O emissions with N_2O from LULUCF	70.15	70.15	67.95	66.14	67.21	68.70	65.85	71.12	73.49	73.55	76.80	81.01	81.67	83.58	80.91	84.45	85.33	85.71	80.91	81.65	84.01	84.72	87.71	87.39	82.31	83.39	79.77	78.67	83.93	78.52	75.01	74.74	6.55

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
Memo items:																																	
International bunkers	0.08	0.08	0.08	0.07	0.08	0.08	0.10	0.11	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.12	0.13	0.12	0.11	0.10	0.12	0.11	0.12	0.12	0.13	0.14	0.14	0.14	0.12	44.95
Aviation	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.06	150.67
Navigation	0.06	0.06	0.05	0.05	0.05	0.06	0.07	0.08	0.07	0.06	0.07	0.08	0.07	0.08	0.08	0.08	0.07	0.09	0.07	0.08	0.07	0.06	0.05	0.07	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.06	2.35
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass																																	
CO_2 captured																																	
Long-term storage of C in waste disposal sites																																	
Indirect N_2O	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	NO, NE, IE	0.00
Indirect CO_2 (3)																																	

Abbreviations: CRF = common reporting format, LULUCF = land use, land-use change and forestry.

a The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the Conference of the Parties. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

CTF Table 1(d): Emissions trends (HFCs, PFCs and SF_6)

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
Emissions of HFCs and PFCs - (kt CO_2 equivalent)	6,031.70	6,031.70	6,035.43	5,936.47	5,145.40	3,192.55	2,549.49	1,688.43	1,692.88	2,321.44	2,124.33	2,539.72	3,487.04	3,839.77	4,331.34	4,898.95	5,650.71	4,958.76	5,540.62	6,013.38	6,804.74	7,354.29	8,119.22	8,502.50	8,758.91	9,485.54	10,015.97	10,473.91	10,678.97	10,679.95	11,588.45	11,834.70	96.21
Emissions of HFCs - (kt CO_2 equivalent)	1,424.68	1,424.68	1,424.68	1,333.18	1,829.87	1,028.12	1,018.65	278.04	464.73	660.92	985.27	1,252.66	1,685.16	2,112.15	2,647.35	3,185.10	3,859.01	4,271.70	4,957.94	5,568.86	6,446.19	7,070.97	7,817.92	8,207.62	8,566.91	9,293.00	9,844.64	10,248.98	10,476.34	10,443.95	11,285.31	11,564.39	711.72
HFC-23	0.10	0.10	0.10	0.09	0.12	0.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.05	0.06	0.07	0.08	0.07	0.06	0.06	0.06	0.06	0.04	0.06	0.07	0.08	0.08	-11.98
HFC-32	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.05	0.08	0.10	0.12	0.16	0.17	0.16	0.21	0.27	0.34	0.38	0.36	0.43	0.44	100.00
HFC-41	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-43-10mee	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	0.00
HFC-125	NO	NO	NO	NO	NO	0.00	0.01	0.03	0.06	0.08	0.12	0.15	0.21	0.26	0.32	0.39	0.19	0.23	0.27	0.33	0.42	0.47	0.54	0.58	0.67	0.75	0.77	0.83	0.85	0.87	0.93	0.95	100.00
HFC-134	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	100.00
HFC-134a	NO	NO	NO	NO	NO	0.00	0.04	0.10	0.16	0.23	0.34	0.44	0.59	0.74	0.93	1.11	0.89	1.09	1.26	1.34	1.49	1.53	1.69	1.79	1.88	2.17	2.39	2.37	2.29	2.24	2.43	2.49	100.00
HFC-143	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-143a	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.04	0.18	0.22	0.27	0.32	0.36	0.40	0.49	0.54	0.52	0.52	0.56	0.63	0.62	0.61	0.63	0.64	100.00

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
HFC-152	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-152a	NO	NO	NO	NO	NO	NO	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	0.03	0.04	0.05	0.05	0.05	0.06	0.05	0.06	0.07	0.10	0.13	0.12	0.11	0.10	0.10	0.10	100.00
HFC-161	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-227ea	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	100.00
HFC-236cb	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-236ea	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-236fa	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
HFC-245ca	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-245fa	NO	NO	NO	NO	NO	NO	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	0.04	0.03	0.03	0.03	0.03	0.03	0.05	0.06	0.07	0.10	0.10	0.09	0.08	0.04	0.07	0.07	100.00
HFC-365mfc	NO	NO	NO	NO	NO	NO	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	NO, IE	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.04	0.04	100.00
Unspecified mix of HFCs(4) - (kt CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Emissions of PFCs - (kt CO_2 equivalent)	4,607.01	4,607.01	4,610.74	4,603.28	3,315.53	2,164.43	1,530.84	1,410.40	1,228.15	1,660.52	1,139.06	1,287.06	1,801.88	1,727.62	1,683.98	1,713.85	1,791.70	687.06	582.68	444.52	358.55	283.32	301.30	294.88	192.00	192.54	171.32	224.92	202.63	236.00	303.14	270.31	-94.13

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
CF_4	0.51	0.51	0.51	0.51	0.37	0.24	0.17	0.16	0.14	0.19	0.13	0.14	0.20	0.19	0.19	0.19	0.20	0.08	0.06	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.03	0.02	0.03	-94.12
C_2F_6	0.07	0.07	0.07	0.07	0.05	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	-94.17
C_3F_8	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C_4F_{10}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
c-C_4F_8	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C_5F_{12}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C_6F_{14}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C10F18	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
c-C3F6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Unspecified mix of PFCs(4) - (kt CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Unspecified mix of HFCs and PFCs - (kt CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Emissions of SF_6 - (kt CO_2 equivalent)	220.56	220.56	239.34	258.11	276.87	295.61	316.21	289.10	266.77	240.21	211.29	212.43	218.80	225.10	229.11	230.66	196.22	186.07	175.13	163.32	146.99	129.81	118.16	114.98	108.17	105.63	116.17	117.13	115.36	145.27	136.86	90.90	-58.79

Greenhouse gas source and sink categories	Base year[a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	kt																																%
SF_6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	-58.79
Emissions of NF_3 - (kt CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00

Abbreviations: CRF = common reporting format, LULUCF = land use, land-use change and forestry.

a The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the Conference of the Parties. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

c Enter actual emissions estimates. If only potential emissions estimates are available, these should be reported in this table and an indication for this be provided in the documentation box. Only in these rows are the emissions expressed as CO_2 equivalent emissions.

d In accordance with the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories", HFC and PFC emissions should be reported for each relevant chemical. However, if it is not possible to report values for each chemical (i.e. mixtures, confidential data, lack of disaggregation), this row could be used for reporting aggregate figures for HFCs and PFCs, respectively. Note that the unit used for this row is kt of CO2 equivalent and that appropriate notation keys should be entered in the cells for the individual chemicals.)

3. Quantified economy-wide emissions reduction targets

Australia committed to a Quantified Economy-wide Emissions Reduction Target (QEERT) of 5% below 2000 levels by 2020, assessed on an emissions budget basis (Australia's 2020 target), under the UNFCCC (see CTF Table 2(a)).

In addition to its QEERT, Australia also committed to a second commitment period (CP2) target under the Kyoto Protocol (KP) and 2030 and 2050 targets under the Paris Agreement. Australia reported progress towards its CP2 target through its annual National Inventory Report in accordance with decision 1/CMP.8 and supplementary reporting requirements under KP Article 7. Australia's emissions estimates for CP2 have been finalised following UNFCCC expert review in 2022. Australia's performance against this target will be determined through the upcoming true-up period review and compliance assessment processes.

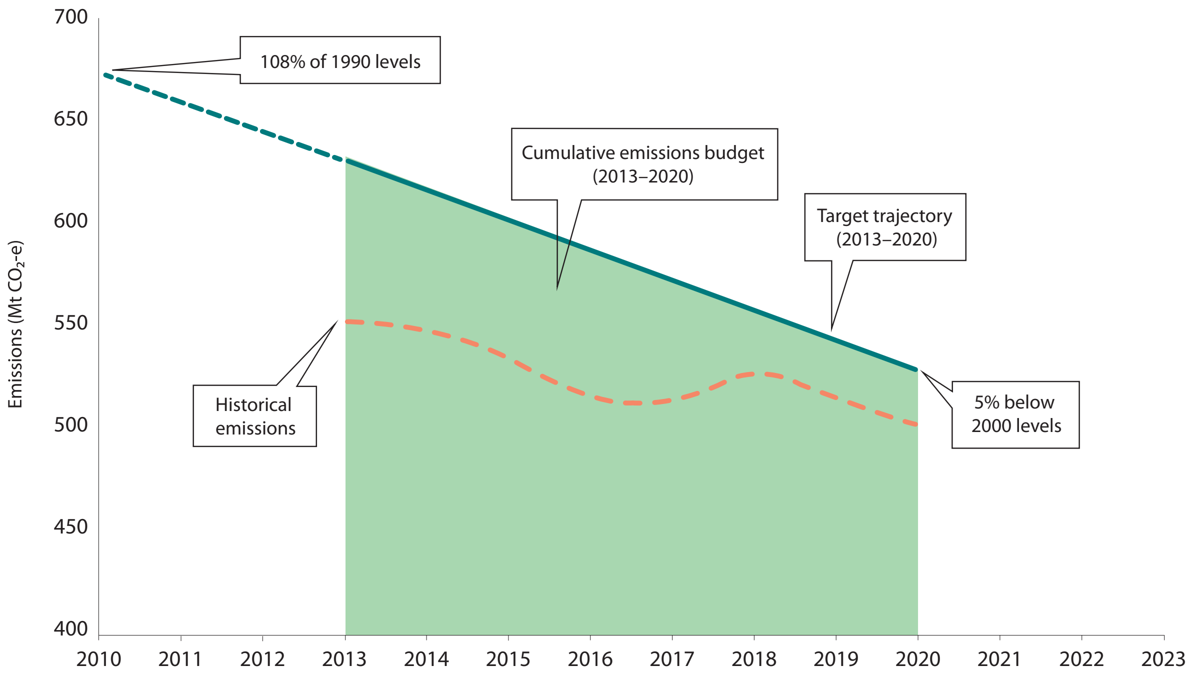
Under the Paris Agreement, Australia has committed to an economy-wide emissions reduction target of 43% below 2005 levels by 2030. The 2030 commitment is both a single-year target to reduce emissions 43% below 2005 levels in 2030 and a multi-year emissions budget during 2021–2030. Australia has also committed to achieve net zero emissions by 2050.

Australia is implementing a substantial and rigorous suite of new policies across the economy to drive the transition to net zero. These policies cover every sector of the economy (see Chapter 4 for more information).

3.1 Details of Australia's QEERT

Australia's QEERT took the form of an emissions budget for the period 2013 to 2020. As shown in Figure 3.1, the budget was calculated using a straight-line trajectory from 2010 to 2020. This trajectory began at Australia's previous target, the KP CP1 target (108% of 1990 levels), and finished at 5% below 2000 levels in 2020. The shaded area under the trajectory for 2013–2020 was the emissions budget for the 2020 target. Based on national greenhouse gas inventory emission estimates – finalised following UNFCCC expert review of Australia's 2020 National Inventory Submission – the emissions budget was 4,628 million tonnes carbon dioxide equivalent (Mt CO_2-e).

Figure 3.1: Australia's QEERT



Australia's QEERT includes all emissions and removals of greenhouse gases reported in its annual national inventory under the KP. This includes the gases CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3; the energy, industrial processes and product use, agriculture and waste sectors; and KP land use, land-use change and forestry (LULUCF) subclassifications (Deforestation, Afforestation/Reforestation, Forest Management, Cropland Management, Grazing land Management and Revegetation).

The global warming potential values (GWPs) used in the inventory are from the Intergovernmental Panel on Climate Change Fourth Assessment Report, and are prescribed in decision 24/CP.19 (see CTF Table 2(c)). CO_2-e of these gases are calculated using the GWP values for a 100-year time horizon.

Australia's KP inventory is submitted as supplementary information in its annual National Inventory Submission (chapters ES.2.2 and 11).

3.2 Approach to reporting progress under the QEERT

Australia assessed progress towards its QEERT by comparing cumulative net emissions during 2013–2020 with the emissions budget for that period. The QEERT was achieved if cumulative emissions during 2013–2020 were less than the emissions budget. This analysis used KP inventory estimates.

For each year of the 2013–2020 budget period, Australia's annual net emissions were the sum of emissions from the energy, industrial processes and product use, agriculture and waste sectors and net emissions from each of the KP LULUCF subclassifications. Australia's approach to accounting for emissions and removals from the LULUCF subclassifications was consistent with the approach taken for all other inventory sectors, as set out in CTF Table 2(d). Emissions and removals for each LULUCF subclassification were estimated by applying methodologies and activity definitions as set out in section 4.3 of the annex.

3.3 Carry-over and market-based mechanisms

Australia was eligible to carry over an overachievement from the first KP commitment period (represented by first commitment period Assigned Amount Units) into its Previous Period Surplus Reserve Account. Domestic action over the QEERT commitment period 2013–2020 enabled Australia to meet its QEERT without the use of any KP overachievement or any market-based mechanism. Australia has committed to not carry over any overachievement on its QEERT or its KP targets to meet its Paris Agreement targets.

CTF Table 2(a): Description of quantified economy-wide emission reduction target: base year[a]

Party	Australia	
Base year /base period	2000	
Emission reduction target	% of base year/base period	% of 1990[b]
	5.00	15.70
Period for reaching target	2013–2020	

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

b Optional.

CTF Table 2(b): Description of quantified economy-wide emission reduction target: gases and sectors covered[a]

Gases covered		Base year for each gas (year):
CO_2		2000
CH_4		2000
N_2O		2000
HFCs		2000
PFCs		2000
SF_6		2000
NF_3		2000
Other Gases (specify)		
Sectors covered[b]	Energy	Yes
	Transport[f]	Yes
	Industrial processes[g]	Yes
	Agriculture	Yes
	LULUCF	Yes
	Waste	Yes
	Other Sectors (specify)	

Abbreviations: LULUCF = land use, land-use change and forestry.

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

b More than one selection will be allowed. If Parties use sectors other than those indicated above, the explanation of how these sectors relate to the sectors defined by the IPCC should be provided.

f Transport is reported as a subsector of the energy sector.

g Industrial processes refer to the industrial processes and solvent and other product use sectors.

CTF Table 2(c): Description of quantified economy-wide emission reduction target: global warming potential values (GWP)[a]

Gases	GWP values[b]
CO_2	4th AR
CH_4	4th AR
N_2O	4th AR
HFCs	4th AR
PFCs	4th AR
SF_6	4th AR
NF_3	4th AR
Other Gases (specify)	

Abbreviations: GWP = global warming potential

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

b Please specify the reference for the GWP: Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) or the Fourth Assessment Report of the IPCC (4th AR).

CTF Table 2(d): Description of quantified economy-wide emission reduction target: approach to counting emissions and removals from the LULUCF sector[a]

Role of LULUCF	LULUCF in base year level and target	Included
	Contribution of LULUCF is calculated using	Other (see section 4.3 for details)

Abbreviation: LULUCF = land use, land-use change and forestry.

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

Based on KP LULUCF classification system: Deforestation, Afforestation/Reforestation, Forest Management, Cropland Management, Grazing land Management and Revegetation.

CTF Table 2(e)I: Description of quantified economy-wide emission reduction target: market-based mechanisms under the Convention[a]

	Possible scale of contributions (estimated kt CO_2 eq)
CERs	NA. See CTF Table 4(b)
ERUs	As above
AAUs[i]	As above
Carry-over units[j]	As above
Other mechanism units under the Convention (specify)[d]	
NA	

Abbreviations: AAU = assigned amount unit, CER = certified emission reduction, ERU = emission reduction unit.

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

d As indicated in paragraph 5(e) of the guidelines contained in annex I of decision 2/CP.17.

i AAUs issued to or purchased by a Party.

j Units carried over from the first to the second commitment periods of the Kyoto Protocol, as described in decision 13/CMP.1 and consistent with decision 1/CMP.8.

CTF Table 2(e)II: Description of quantified economy-wide emission reduction target: other market-based mechanisms[a]

Other market-based mechanisms (Specify)	Possible scale of contributions (estimated kt CO_2 eq)
	NA. See CTF Table 4(b).

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

CTF Table 2(f): Description of quantified economy-wide emission reduction target: any other information[a,b]

NA

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

b This information could include information on the domestic legal status of the target or the total assigned amount of emission units for the period for reaching a target. Some of this information is presented in the narrative part of the biennial report.

4. Progress in achievement of quantified economy-wide emission reduction target

4.1 Mitigation action, its impacts and progress towards Australia's QEERT

Chapter 4 of Australia's eighth National Communication provides a comprehensive overview of Australia's policies, plans and proposals to meet our Quantified Economy-wide Emission Reduction Target (QEERT), organised by sector. In addition to the explanatory text, policies are summarised in CTF Table 3. If the information is available, CTF Table 3 quantifies the emissions reductions expected from the policies set out in Chapter 4 of Australia's eighth National Communication. Chapter 4 also covers enabling policies and proposals that seek to mitigate and manage the economic and social consequences of the transition as well as make the most of opportunities, including for jobs, investment and local climate action.

4.1.1 Domestic institutional arrangements relating to Australia's QEERT

Australia's policies and measures are developed based on expert advice and consultation with industry and the community; they are often implemented by independent bodies and within strict governance frameworks. Major policies are regularly reviewed to ensure they remain effective in meeting Australia's commitments under the UNFCCC and the Paris Agreement.

The Australian Government Department of Climate Change, Energy, the Environment and Water has policy responsibility for climate mitigation and Australia's national inventory system that tracks progress towards Australia's QEERT. The Climate Change Authority provides independent, expert advice to the Australian Government on climate change policy. The Clean Energy Regulator is responsible for administering schemes legislated by the Australian Government for measuring, managing, reducing or offsetting Australia's emissions. This includes Australia's carbon crediting scheme, the Safeguard Mechanism and the Renewable Energy Target. The Australian Renewable Energy Agency makes renewable energy solutions more affordable and increases the amount of renewable energy used in Australia. The Clean Energy Finance Corporation co-invests with the private sector to increase the flow of funds into renewable energy, energy efficiency and low-emissions technologies.

Further information on institutional arrangements including changes since the last Biennial Report can be found in chapters 3 and 4 of the eighth National Communication.

4.2 Greenhouse gas emissions in relation to the QEERT

Australia achieved its QEERT. This conclusion was reached following a comparison of cumulative net national emissions from 2013 to 2020 against the emissions budget for that period. As set out in Table 4.1, cumulative emissions from 2013 to 2020 were 4,200 million tonnes carbon dioxide equivalent (Mt CO_2-e), 428 Mt CO_2-e (or 9%) less than the emissions budget of 4,628 Mt CO_2-e. In point-in-time terms, Australia's net national emissions in 2020 were 9.8% below 2000 levels.

Further information on Australia's QEERT, including its coverage and accounting approach, can be found in Chapter 3 of this Annex.

Table 4.1: Comparison of cumulative net emissions and emissions budget associated with Australia's QEERT

Calculation of 2020 emission reduction task	5% below 2000 level in 2020 (Mt CO_2-e)
Cumulative net emissions 2013–2020 (1)	4,200
Emissions budget 2013–20 (2)	4,628
Emissions reduction task (1) – (2)	–428

Table 4.2 presents Australia's net national emissions for the QEERT commitment period 2013–2020, and base year 2000, on the basis of the Kyoto Protocol (KP) classification system. According to this classification system, the table includes emissions and removals from energy, industrial processes and product use, agriculture and waste sectors and the following KP land use, land-use change and forestry (LULUCF) subclassifications: Deforestation, Afforestation/Reforestation, Forest Management, Cropland Management, Grazing land Management and Revegetation. The estimates in Table 4.2 were finalised through the UNFCCC expert review of Australia's 2022 National Inventory Submission.

Table 4.2: Net emissions associated with Australia's QEERT

KP sector and subsector	Emissions (Mt CO_2-e)									Percentage change
	2000	2013	2014	2015	2016	2017	2018	2019	2020	2000–2020
1. Energy	364.3	414.1	408.1	418.7	428.1	430.2	432.6	431.6	415.9	14.1
2. Industrial processes and product use	26.1	30.2	30.1	31.1	31.2	31.8	32.6	33.4	32.7	25.3
3. Agriculture	82.3	76.0	76.4	73.6	72.6	76.6	75.1	69.8	67.8	–17.5
4. LULUCF activities	66.0	19.1	20.0	–1.8	–29.4	–37.9	–26.0	–33.1	–27.2	–141.2
5. Waste	16.8	12.1	12.0	11.6	12.1	12.3	12.2	11.9	11.7	–30.3
Total net emissions (including LULUCF)	**555.5**	**551.4**	**546.7**	**533.2**	**514.6**	**513.0**	**526.4**	**513.5**	**500.9**	**–9.8**

4.3 Estimates of emission reductions and removals from LULUCF

Australia used the KP classification system for reporting emissions estimates from the LULUCF sector when tracking progress towards the QEERT. For all LULUCF classifications, emission estimates in the reporting period may be compared with estimates in the base year, which is 2000. In summary, the net emissions from the LULUCF sector were –27.2 Mt CO_2-e in 2020, 93.2 Mt CO_2-e less than net emissions in 2000. Information on the contribution of the LULUCF sector to Australia's progress towards its QEERT is provided in CTF Tables 4, and 4(a)I and the Supplementary table.

Australia reported net emissions from Deforestation, Afforestation/Reforestation, Forest Management, Cropland Management, Grazing land Management and Revegetation. The concordance between the 2 classification systems is set out in Table 4.3.

Table 4.3: Reconciliation table between UNFCCC and Kyoto Protocol classifications

UNFCCC	Kyoto Protocol
Forest land	
Forest land – multiple-use public forest	Forest Management
Forest land – pre-1990 plantations	Forest Management
Forest land – harvested private native forests	Monitored for forest management activity
Forest land – other native forest	Monitored for forest management activity
Forest land – biomass burning in nontemperate areas	Grazing land Management
New plantations since 1990	Afforestation/Reforestation
Native regeneration since 1990 – direct human-induced	Afforestation/Reforestation
Forest land previously converted to other land uses since 1990	Deforestation
Forest land previously converted to other land uses prior to 1990	Afforestation/Reforestation
Land converted to forest prior to 1990	Monitored for forest management activity
Cropland	
Cropland – permanent	Cropland Management
Perennial woody horticulture	Cropland Management
Forest land converted to cropland since 1990	Deforestation
Forest land converted to cropland prior to 1990	Cropland Management
Grassland converted to cropland	Cropland Management (crop–pasture rotations)
Grassland	
Grasslands – permanent	Grazing land Management
Forest land converted to grassland since 1990	Deforestation
Forest land converted to grassland prior to 1990	Grazing land Management
Cropland converted to grassland	Cropland Management (crop–pasture rotations)
Settlements	
Settlements – sparse woody vegetation gained or lost since 1990	Revegetation
Settlements – sparse woody vegetation gained or lost prior to 1990	Not in scope of KP
Forest land converted to settlements since 1990	Deforestation
Forest land converted to settlements prior to 1990	Not in scope of KP
Wetlands	
Wetlands – sparse woody vegetation gained or lost since 1990	Revegetation

UNFCCC	Kyoto Protocol
Wetlands – sparse woody vegetation gained or lost prior to 1990	Not in scope of KP
Wetlands – biomass burning in nontemperate areas	Grazing land Management
Forest land converted to wetland since 1990	Deforestation
Forest land converted to wetlands prior to 1990	Not in scope of KP

4.3.1 Deforestation

The net emissions from the Deforestation classification were 26.1 Mt CO_2-e in 2020, 45.9 Mt CO_2-e less than in 2000. The classification definitions and the methodologies used to derive the estimates are described in NIR 2020 Volume 3.

4.3.2 Afforestation/Reforestation

The net emissions from the Afforestation/Reforestation classification were –17.0 Mt CO_2-e in 2020, 5.5 Mt CO_2-e less than in 2000. The classification definitions and the methodologies used to derive the estimates are described in NIR 2020 Volume 3.

4.3.3 Forest Management

The net emissions from the Forest Management classification were –29.2 Mt CO_2-e in 2020, 16.1 Mt CO_2-e less than in 2000. For Forest Management, reference-level accounting, as is applicable under the KP, has not been applied. Instead, Forest Management is treated the same way as any other sector.

Net emissions for harvested wood products are estimated using the IPCC production approach.

Natural disturbance (fire, cyclone) impacts are managed through the application of the IPCC default method for the treatment of natural disturbance emissions, set out in the IPCC 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.

Natural disturbance impacts are beyond control and not materially influenced by Australia, because they occur despite significant and costly efforts to manage disturbances. Australia engages in ongoing efforts to prevent, manage and control natural disturbances to the extent practicable (as reported in NIR 2020 Volume 3).

Australia's national forest carbon monitoring system is used to estimate the emissions. The system is also used to identify any subsequent removal of carbon from the lands affected by natural disturbances, and to monitor lands affected by natural disturbances for salvage logging or subsequent land-use change to account for any associated emissions.

Australia does not apply a cap in accounting for Forest Management.

4.3.4 Cropland Management

The net emissions from the Cropland Management classification were 1.8 Mt CO_2-e in 2020, 1.3 Mt CO_2-e more than in 2000. The classification definitions and the methodologies used to derive the estimates are described in the NIR 2020 Volume 3.

4.3.5 Grazing land Management

The net emissions from the Grazing land Management classification were –9.0 Mt CO_2-e for 2020, 26.9 Mt CO_2-e less than in 2000. The classification definitions and the methodologies used to derive the estimates are described in the NIR 2020 Volume 3.

4.3.6 Revegetation

The net emissions from the Revegetation classification were 0.2 Mt CO_2-e for 2020, 0.03 Mt CO_2-e more than in 2000. The classification definitions and the methodologies used to derive the estimates are described in the NIR 2020 Volume 3.

4.3.7 Other

Australia does not include estimates of emissions from drainage and rewetting of organic soils.

Information is provided in CTF Tables 4, 4(a)I and 4(b) and the Supplementary table for estimates of emission reductions and removals and the use of units from the market-based mechanisms and LULUCF activities.

CTF Table 3: Progress in achievement of the quantified economy-wide emission reduction target: information on mitigation actions and their effects

Name of mitigation action[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Climate change legislation	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Achieve and set national emissions targets and track progress	Regulatory	Implemented	Legislation incorporates Australian emissions targets into national law, sets requirements about advice from the Climate Change Authority to inform tracking and setting future targets, and requires relevant government agencies to consider targets when exercising their functions	2022	Australian Government	NE	NE
Net zero Australian Public Service*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Australian Public Service operations	Voluntary Agreement	Adopted	The Australian Government is committed to an Australian Public Service with net zero emissions by 2030 (excluding the Australian Defence Force and security agencies because of their operational needs)	2022	Australian Government	NE	NE
Safeguard Mechanism reforms	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Reduce emissions from Australia's largest emitters in a gradual and predictable way, consistent with Australia's national emissions reduction targets of 43% below 2005 levels by 2030 and net zero emissions by 2050	Regulatory, economic	Adopted	Safeguard Mechanism reforms will build on the existing framework and gradually and predictably reduce baselines from the largest emitters on a trajectory that is broadly consistent with Australia reaching net zero by 2050. A crediting and trading framework is also expected to be established under the reforms	2023	Australian Government (DCCEEW); once implemented, administered by the Clean Energy Regulator	NE	46305
National Reconstruction Fund (NRF)	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Support, diversify and transform Australia's industry and economy to secure future prosperity and drive sustainable economic growth	Economic, fiscal	Adopted	$3 billion to provide finance, including loans, guarantees and equity to drive investments that add value and capability across 7 priority areas	2022	Australian Government (DISR)	NE	NE
Powering the Regions Fund*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Help regional Australia in the transition towards net zero emissions	Economic	Adopted	$1.9 billion to help regional Australia transition towards net zero emissions. The fund will unlock new opportunities to decarbonise existing industries; support the development of new, clean energy industries; develop regional workforces; and continue the purchase of Australian Carbon Credit Units	2023	Australian Government (DCCEEW)	NE	NE
Australia's National Hydrogen Strategy*	Energy, Transport, Industry/industrial processes	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Sets a vision for a clean, innovative, safe and competitive hydrogen industry that benefits all Australians	Other (strategy)	Implemented	57 nationally coordinated government actions that form the first steps towards developing the industry	2020	Australian Government (DCCEEW); corresponding state and territory government agencies implement the strategy at a jurisdictional level	NE	NE
Australia's carbon crediting scheme (formerly Emissions Reduction Fund)*	Cross-cutting	CH_4, CO_2, N_2O	Help reduce Australia's emissions by generating carbon credits from projects that avoid GHG emissions or sequester carbon	Other (voluntary regulated scheme)	Implemented	Australia's carbon crediting scheme creates incentives to carry out projects a to reduce and/or sequester emissions across the economy, as enabled by approved methods	2011	Australian Government (DCCEEW), Clean Energy Regulator	15476	20931
Climate Active*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Enable voluntary climate action and certify carbon neutral claims by organisations and businesses	Other (voluntary program)	Implemented	Certifies businesses that have credibly reached a state of carbon neutrality by measuring, reducing and offsetting their carbon emissions against the requirements of the Climate Active Carbon Neutral Standard	2010	Australian Government (DCCEEW)	6800	NE
Carbon Capture Technologies Program*	Cross-cutting	CO_2	Accelerate development of novel or emerging CO_2 capture and CO_2-use technologies	Economic	Implemented	$130 million program aimed at demonstrating the technical capability of, and reducing the costs of, novel technologies to enable their scale up over time and ensure that they are ready as potential avenues for abatement in the future	2023	Australian Government (DCCEEW)	NE	NE

Name of mitigation action[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) ($kt\ CO_2\ eq$) 2020	2030[f]
Carbon Capture, Use and Storage Development Fund*	Cross-cutting	CO_2	Aimed at reducing emissions across energy generation, natural gas or hydrogen production, and heavy industries such as cement, manufacturing and chemicals production	Economic	Implemented	$50 million that supports pilot or pre-commercial carbon capture, use and storage (CCUS) projects progress towards commercial operations. Projects supported under the fund include: • CCUS applications with liquefied natural gas and biomethane production • direct air capture • use of CO_2 in the production of construction materials	2020	Australian Government (DCCEEW)	NE	NE
Rewiring the Nation*	Energy	CH_4, CO_2, N_2O	Aimed at modernising the grid to support a high share of renewable electricity	Fiscal	Implemented	$20 billion in low-cost finance to: • upgrade, expand and modernise electricity grids • unlock new renewables and storage capacity • drive down power prices	2022	Australian Government (DCCEEW), Clean Energy Finance Corporation	NE	NE
Australian Made Battery Plan	Energy		Support an end-to-end battery industry and kickstart battery manufacturing in Australia	Fiscal	Adopted	The plan will: • publish a National Battery Strategy • partner with the Queensland Government to create a Battery Manufacturing Precinct in Queensland • create a Powering Australia Industry Growth Centre to provide advanced technology and skills development to businesses looking to locally manufacture renewable energy technologies • support 10,000 New Energy Apprenticeships	2023	Australian Government (DISR, Department of Employment and Workplace Relations)	NE	NE
Offshore Electricity Infrastructure framework*	Energy	CH_4, CO_2, N_2O	Reduce emissions of GHGs in the electricity sector by encouraging the additional generation of electricity from renewable sources	Regulatory	Implemented	The framework provides the regulatory framework for the development of offshore renewable energy infrastructure, such as offshore wind, in the Commonwealth offshore area (from 3 nautical miles offshore)	2022	Australian Government (DCCEEW, DISR – National Offshore Petroleum Titles Administrator, National Offshore Petroleum Safety and Environmental Management Administrator)	NE	NE
Large-scale Renewable Energy Target (LRET)*	Energy	CH_4, CO_2, N_2O	Reduce emissions of GHGs in the electricity sector by encouraging the additional generation of electricity from renewable sources	Regulatory	Implemented	The LRET of 33,000 gigawatt hours by 2020 encouraged investment in large-scale renewable energy projects	2001	Clean Energy Regulator	22908	NE
Small-scale Renewable Energy Scheme (SRES)*	Energy	CH_4, CO_2, N_2O	Reduce emissions of GHGs in the electricity sector by encouraging the additional generation of electricity from renewable sources	Regulatory	Implemented	Scheme that helps home owners and small businesses to install eligible small-scale renewable energy systems and solar hot-water systems	2001	Clean Energy Regulator	14260	NE
Equipment Energy Efficiency (E3) Program*	Cross-cutting	CH_4, CO_2, N_2O	Drive improvements to the energy efficiency of new appliances and equipment sold; reduce energy consumption, related GHG emissions, and bills for households and businesses	Regulatory, information, education	Implemented	Cross-jurisdictional program through which the Australian Government, state and territory governments, and the New Zealand Government collaborate to deliver a single, integrated program on energy efficiency standards and energy labelling for equipment and appliances	1992	Regulatory – Australian Government (DCCEEW) Program – cross-jurisdictional between Australian Government and state and territory governments	6500	NE
Trajectory for Low Energy Buildings*	Cross-cutting	CH_4, CO_2, N_2O	Policies address specific barriers present at different stages of a home's life; they are designed to drive the uptake of residential energy efficiency upgrades	Regulatory	Implemented	Nationally agreed pathway to achieve zero energy (carbon ready) buildings in Australia's building sector	2019	Australian Government (DCCEEW, DISR), Australian Building Codes Board, states and territories	NE	4300

Name of mitigation action[a]	Sectors affected[b]	GHGs affected	Objective and/or activity affected	Type of instrument[c]	Status of implementation[d]	Brief description[e]	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO_2 eq) 2020	2030[f]
Australian Renewable Energy Agency (ARENA)*	Energy, Transport, Industry/industrial processes	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Improve the competitiveness of renewable energy technologies and increase the supply of renewable energy in Australia	Economic, research, information	Implemented	ARENA is a statutory authority providing research, development, demonstration and deployment grant funding to improve the affordability and increase the supply of renewable energy in Australia	2012	Australian Government (DCCEEW)	NE	NE
Clean Energy Finance Corporation (CEFC)*	Energy, Transport, Industry/industrial processes	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Facilitate increased flows of finance into the clean energy sector	Economic	Implemented	CEFC is a statutory authority that uses debt and equity funding to promote investment in clean energy technologies, namely renewable energy technologies, energy efficiency technologies, and low-emissions technologies and their supply chain	2013	Australian Government (DCCEEW)	7300	5700
Community Batteries for Household Solar*	Energy	CH_4, CO_2, N_2O	Provide community batteries	Economic	Implemented	$200 million program for new community batteries across Australia to reduce emissions and energy bills, support the grid and maximise the benefits of Australia's rooftop solar transformation	2022	Australian Government (DCCEEW)	NE	NE
Solar Banks*	Energy	CH_4, CO_2, N_2O	Provide solar photovoltaic access for households unable to install rooftop solar	Economic	Implemented	$100 million program to deliver solar banks around Australia, providing access to around 25,000 households that are unable to install rooftop solar, including renters, people living in apartments and low-income households	2022	Australian Government (DCCEEW)	NE	NE
National Electric Vehicle Strategy	Transport	CH_4, CO_2, N_2O	Provide a framework to enable Australia to become a competitive market for EVs by 2030, improving access to EVs to consumers and reducing road transport emissions	Economic, Education, Fiscal, Information, Regulatory, Research	Planned	The Strategy will deliver a nationally consistent, comprehensive, and overarching framework to increase the supply and uptake of EVs. The strategy will include: • consideration of fuel efficiency standards • further measures to increase EV sales and infrastructure • policy settings to encourage Australian manufacturing of EV chargers and components (especially batteries) • address policy implications of declining fuel excise	2023	Australian Government (DCCEEW), with Australian, state and territory governments working in collaboration with private sector organisations where applicable	NE	NE
Driving the Nation Fund*	Transport	CH_4, CO_2, N_2O	Support the installation of EV charging and hydrogen refuelling technology across Australia, to aid the uptake of EVs and encourage the use of new vehicle technologies across the country	Economic, fiscal	Implemented	The Australian Government will deliver a fast charging network, committing an additional $250 million to the new Driving the Nation Fund, doubling the investment to $500 million	2021	Australian Government (DCCEEW)	NE	NE
Electric Car Discount*	Transport	CH_4, CO_2, N_2O	Reduce import duties and taxes on eligible EVs, to encourage EV uptake	Fiscal	Implemented	Low- and zero-emission cars below the luxury car tax threshold for fuel-efficient vehicles (currently $84,916 in 2022–23) will be exempt from: • import tariffs – currently a 5% tax on some imported cars • fringe benefits tax – a tax on cars provided by the workplace for private use	2022	Australian Government (Treasury)	NE	NE
Global ship energy efficiency measure	Transport	CO_2	Reduce the carbon intensity of international shipping by 40% by 2030 compared with 2008 levels	Regulatory	Adopted	Australia is complying with its international obligations to implement the package of global technical and operational ship energy efficiency measures adopted by the International Maritime Organization in June 2021	2023	Australian Government (DITRDC). All ships of 400 gross tonnage and above	NE	NE
Clydebank Declaration	Transport	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Establish at least 6 green shipping corridors by 2025	Voluntary agreement	Adopted	The 24 signatories, which include the United Kingdom, the United States, Japan, New Zealand and Singapore, are exploring actions to facilitate partnerships among all stakeholders along the value chain to establish green shipping corridors between 2 or more ports. These actions include regulatory frameworks, incentives, information sharing and infrastructure requirements	2021	Australian Government (DITRDC). Various stakeholders along supply chains (e.g. ship operators, charterers, cargo forwarders, fuel suppliers, financiers)	NE	NE
Quad Shipping Task Force	Transport	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Establish 2–3 green shipping corridors in the Indo-Pacific region by 2030	Voluntary agreement	Adopted	Australia, the United States, Japan and India launched the Quad Shipping Task Force in September 2021 to develop key green corridor building blocks	2021	Australian Government (DITRDC), NSW Ports	NE	NE

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Australia–Singapore initiative on low emission technologies for maritime and port operations	Transport	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Deploy clean hydrogen and ammonia maritime technologies that could facilitate a green shipping corridor between Australia and Singapore	Other (international partnership)	Adopted	$30 million, 5-year partnership	2022	Australian Government (DCCEEW with support from DITRDC and CSIRO)	NE	NE
HFC management – regulations*	Industry/industrial processes	HFCs	Reduce GHG emissions through a phase-down of imports of HFCs and equipment that contain HFCs, and by managing HFCs from import through the supply chain to end of life	Regulatory	Implemented	Australia is implementing its HFC phase-down through an annual import quota that reduces every 2 years and will reach an 85% reduction from baseline by 2036	2018	Australian Government (DCCEEW)	NE	4811
HFC management – information*	Industry/industrial processes	HFCs	Provide information to industry and consumers	Information	Adopted	The policy is intended to change behaviour by providing information about benefits of leak testing and servicing of installed equipment	2023	Australian Government (DCCEEW)	NE	1343
Development of Australia's seaweed farming*	Agriculture	CH_4	Develop and commercialise seaweed feed supplement to reduce CH_4 emissions from livestock such as sheep and cattle	Economic, research, information	Adopted	$8.1 million to support development of seaweed farming for the production of low-CH_4 cattle feed	2022	Fisheries Research and Development Corporation, Australian Sustainable Seaweed Alliance	NE	NE
Methane Emissions Reduction in Livestock (MERiL)*	Agriculture	CH_4	Support the development and deployment of low-emission livestock feed technologies to reduce CH_4 emissions from livestock	Economic, research, information	Implemented	$6 million for MERiL stage 1 is providing research grants to quantify emissions and productivity impacts of livestock feed technologies and ensure that they are safe to use. It is also developing a livestock emissions framework for feed technologies to inform updates to the National Greenhouse Gas Inventory	2021	Australian Government (DCCEEW, Clean Energy Regulator)	NE	NE
National Soil Carbon Innovation Challenge*	Agriculture	CO_2	Fast track development and commercial readiness of low-cost and accurate technology solutions to measure and estimate soil carbon stocks	Economic, research, information	Planned	$50 million program providing grants to support feasibility study, proof of concept, validation or early stage commercialisation activities relating to the development of lower-cost, accurate technological solutions for soil carbon measurement	2021	Australian Government (DCCEEW)	NE	NE
National Soil Carbon Data Program*	Agriculture	CO_2	Support partnerships to improve data in low-cost alternatives for measuring soil carbon	Economic, research, information	Implemented	$7.9 million program that seeks to provide a publicly accessible repository of data for developing rapid and cost-effective technologies to quantify soil carbon stock and changes in the stock in Australian agricultural soils. The program will also support improvements to Australia's national GHG emissions inventory model for soil carbon – Australia's Full Carbon Accounting Model (FullCAM)	2021	Australian Government (DCCEEW)	NE	NE
Carbon Farming Outreach Program*	Agriculture	CH_4, CO_2, N_2O	Support outreach activities to empower more farmers to participate in carbon crediting and adopt innovative carbon farming technologies and practices	Economic, research, information	Planned	$20.4 million program under which farmers will receive tailored advice about carbon farming and adopting low-emission technologies and practices from agricultural advisers, natural resource management groups, and agricultural research and extension organisations	2023	Australian Government (DCCEEW)	NE	NE
Blue Carbon Conservation, Restoration and Accounting*	Forestry/LULUCF	CH_4, CO_2, N_2O	Implement 5 on-ground projects that restore degraded coastal blue carbon ecosystems in Australia	Economic, research, information	Implemented	$9.5 million of funding that supports restoration projects that demonstrate and enable measurement of a range of diverse restoration outcomes for climate, biodiversity and people, including carbon sequestration, climate mitigation and resilience benefits, and Indigenous values. The projects include co-design and collaboration with Traditional Owners and First Nations people	2021	Australian Government (DCCEEW)	NE	NE
National Waste Policy Action Plan*	Waste management/ waste	CH_4, N_2O	Improve waste management and recycling activities	Regulatory, economic	Implemented	National framework for waste and resource recovery in Australia	2019	Australian Government (DCCEEW)	NE	NE

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Food Waste for Healthy Soils Fund*	Waste management/ waste	CH_4, N_2O	Supports organic waste diversion from landfill and increased quantity and improved quality of recycled organic waste, especially for agricultural use	Economic	Implemented	$67 million fund	2021	Administered by the Australian Government; industry partners will undertake funded projects	NE	NE
Achieving 100% renewable electricity and phasing out fossil-fuel gas in the ACT*	Energy	CO_2, CH_4	Transition the Territory away from gas use, to help reach a target of net zero emissions by 2045	Economic, fiscal, regulatory, information, education	Implemented	The government has implemented a reverse auction process that achieved zero emissions from electricity by securing 100% renewable electricity from large-scale generators located across eastern and southern Australia as part of the National Electricity Market. The electrification pathway will be supported by continued growth and uptake of household and business solar photovoltaic systems and battery energy storage, as well as increased energy efficiency of buildings and appliances	2011	ACT Government	2029	NE
Sustainable Household Scheme*	Energy	CO_2, CH_4	Promote the uptake of renewable energy, battery storage, efficient electric household appliances and zero emissions vehicles to phase out gas use and help reach the target of net zero emissions by 2045	Economic	Implemented	The scheme provides zero-interest loans of up to $15,000 to households and not-for-profit community organisations to help with the upfront costs of investing in a range of products, including rooftop solar, energy-efficient appliances, and new and used zero emissions vehicles and charging infrastructure	2021	ACT Government	NE	NE
Next Gen Energy Storage*	Energy	CO_2	Promote the uptake of renewable electricity and battery storage to phase out gas use and help reach our target of net zero emissions by 2045	Economic	Implemented	The program supports the development of the energy storage industry in the ACT by providing a rebate to households and businesses for the purchase of a battery system that is coupled with solar panels, connected to the electricity grid and installed by an approved Next Gen retailer	2016	ACT Government	NE	NE
Big Canberra Battery*	Energy	CO_2	Support the transition to renewable electricity and to manage demand as the ACT continues to phase out gas use and help reach our target of net zero emissions by 2045	Economic	Implemented	The battery ecosystem will provide 250 megawatt of power with the aim to reduce pressure on the grid, put downward pressure on electricity prices as more households move to renewable energy and EVs, and generate new revenue opportunities for the ACT	2021	ACT Government	NE	NE
Low Income Household Program and Vulnerable Household Energy Support Scheme (aka Home Energy Support Program)*	Energy	CO_2	Ensure that the transition to a net zero society is fair and equitable, and that homes are healthy and comfortable	Economic	Implemented	Enable local community access to information and financial support to improve the energy efficiency of their homes	2016	ACT Government	NE	NE
Zero Emissions Transport Strategy 2022–30*	Transport	CO_2	Phasing out light internal combustion engine vehicles from 2035	Regulatory	Implemented	The strategy sets out policies that commit the ACT to phasing out light internal combustion engine vehicles from 2035, expanding the public EV charging network to ensure that there are at least 180 publicly available charging stations in the ACT by 2025, and continuing advocacy for strong national policy	2022	ACT Government	NE	NE
Net Zero Plan Stage 1: 2020–2030*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Foundation to achieve net zero emissions by 2050	Other (strategy)	Implemented	In the 5 years between 2017 and 2022, more than $1.2 billion was invested from the Climate Change Fund on climate change mitigation and adaptation programs. The fund will invest a further $2.8 billion on programs in the 8 years from 2022–23 to 2029–30, including to implement the Net Zero Plan and Electricity Infrastructure Roadmap	2020	NSW Government	NE	32950
Hydrogen Strategy*	Cross-cutting	CO_2	Attract more than $80 billion of investment to 2050, drive deep decarbonisation and set NSW up as a clean energy and economic superpower	Economic, regulatory	Implemented	The strategy is a nation-leading framework that provides $3 billion in incentives and sets out a clear and credible pathway to get green hydrogen production under $2.80 per kilogram in NSW by 2030	2021	NSW Government	NE	NE

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Net Zero Industry and Innovation Program*	Cross-cutting	CH_4, CO_2, N_2O	Supporting a mature and thriving clean technology sector to achieve net zero emissions in NSW by 2050	Economic	Implemented	$195 million program that will provide funding for research, development and commercialisation projects out to 2030	2022	NSW Government	NE	31000
Clean manufacturing precincts*	Cross-cutting	CH_4, CO_2, N_2O	Develop roadmaps for clean energy manufacturing precincts in the Hunter and Illawarra regions	Economic, research, information	Implemented	$55 million program that is supporting the establishment of consortiums of industry and community experts to develop a strategic decarbonisation roadmap for clean manufacturing precincts in 2 regions. Roadmaps will be used to provide a pathway for the investment, job creation and infrastructure requirements to support these ambitions	2023	NSW Government	NE	NE
Electricity Infrastructure Roadmap and Renewable Energy Zones*	Energy	CO_2	Support the development of new electricity infrastructure in NSW. It will unlock up to $32 billion in private investment in regional energy infrastructure to 2030, including in strategically planned and coordinated Renewable Energy Zones	Regulatory	Implemented	The roadmap sets out a coordinated way to support private investment in at least 12 gigawatts of renewable energy generation and 2 gigawatts of long-duration storage by 2030. Under the roadmap, the Infrastructure Safeguard is an investment signal to deliver the new electricity infrastructure that NSW needs	2020	NSW Government	NE	NE
Electric Vehicle Strategy*	Transport	CO_2	Increase EV sales to more than 50% of new cars sold in NSW by 2030	Economic, fiscal, regulatory, information, education, research	Implemented	A $633 million commitment over 4 years that is expected to leverage significant private sector investment	2021	NSW Government	NE	NE
Future Energy Strategy (Transport)*	Transport	CO_2	Secure NSW's transport energy needs from sustainable sources and support the transition of the transport sector to net zero emissions by 2050	Other (strategy)	Implemented	Emissions reductions of up to 90% are planned through actions such as: • transitioning the state's 8,000-strong public bus fleet to zero emissions powered by renewable energy • transitioning the entire electrified rail network, including metro and light rail, to net zero electricity by 2025	2021	NSW Government	NE	NE
Waste and Sustainable Materials Strategy	Waste management/ waste	CO_2, CH_4	Halve food waste to landfill and achieve net zero emissions from organics to landfill by 2030	Economic, regulatory	Implemented	The strategy includes various mandates related to food and garden organics, and capture of landfill gas emissions, supported by: • $65 million over 5 years, which will support the rollout of new collection services, the development of more processing capacity and a statewide education campaign • $7.5 million over 5 years for installation of additional landfill gas infrastructure across NSW	2021	NSW Government	NE	NE
Renewable Hydrogen Master Plan*	Cross-cutting	CO_2	Provide a framework for a NT renewable hydrogen industry	Other (strategy)	Implemented	Framework for the development of an NT renewable hydrogen industry, focused on enabling activities required to secure private sector investment	2020	NT Government	NE	NE
Renewable energy target*	Cross-cutting	CO_2	50% of the electricity consumed from grid-connected installations to come from renewable sources by 2030	Fiscal	Adopted	The NT Government has a Renewable Energy Target Implementation Plan that builds on current policy settings at both Territory and federal levels	2020	NT Government	NE	NE
Remote Power System Strategy	Energy	CO_2	Deliver an average of 70% renewable energy to 72 remote Territory Indigenous communities by 2030	Regulatory	Planned	Development of an open and contestable framework to deliver an average of 70% renewable energy to 72 remote Territory Indigenous communities by 2030	2020	NT Government	NE	NE
Home and Business Battery Scheme*	Energy	CO_2	Support home owners and businesses to install batteries with their rooftop solar systems	Economic	Implemented	Grants of up to $6,000 to support home owners and businesses	2020	NT Government	NE	NE
Climate Action Plan 2030*	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Set the path to meet Queensland's climate targets	Other (strategy)	Implemented	The plan sets priorities across 5 sectors for further action: electricity, transport, agriculture, buildings and land	2020	Qld Government	NE	NE

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Renewable Energy and Hydrogen Jobs Fund*	Cross-cutting	CO_2	Support increased public ownership of commercial renewable energy and hydrogen projects, and development of energy infrastructure	Fiscal	Implemented	Supports investments by energy government-owned corporations in projects that support additional renewable energy generation and storage capacity in Queensland. This includes, but is not limited to, solar, wind, pumped hydroelectric storage, hydrogen and supporting network infrastructure	2021	Qld Government (Treasury)	NE	NE
Decarbonisation of the Great Barrier Reef Islands program*	Cross-cutting	CO_2	Identify potential mitigation/ resilience projects for Great Barrier Reef island resorts and 4 whole-of-community islands Collaborate with stakeholders to assess opportunities and gaps, identify and prioritise potential projects, and develop project-ready business cases	Fiscal, voluntary agreement, information	Implemented	$1.73 million investment to identify and develop place-based options that would help reduce carbon emissions, increase resilience to the impacts of climate change, and reduce costs around energy, water and waste	2018	Qld Government	NE	NE
Energy and Jobs Plan*	Energy	CO_2	Establish new renewable energy and electricty sector emissions targets and outline how the government will achieve these targets	Other (strategy)	Implemented	• The plan outlines how Queensland's energy system will transform to deliver clean, reliable and affordable energy to provide power for generations. It will deliver: • 70% renewable energy by 2032 and 80% by 2035 (and legislation to establish these targets in law) • 50% reduction in electricity sector emissions on 2005 levels by 2030 • 90% reduction in electricity emissions on 2005 levels by 2035–36	2022	Qld Government (Department of Energy and Public Works)	NE	NE
Renewable Energy Zones*	Energy	CO_2	Ensure coordinated development of renewable energy zones to help deliver affordable, clean and reliable energy	Fiscal	Implemented	$145 million to establish 3 Queensland Renewable Energy Zones (QREZ) in northern, central and southern Queensland	2020	Qld Government (Department of Energy and Public Works)	NE	NE
Resources Industry Development Plan*	Industry/industrial processes	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Achieve a resilient, responsible and sustainable resources industry that grows as it transforms	Fiscal	Implemented	Sets out a pathway for a resources industry to create jobs and prosperity for generations to come – responsibly and sustainably	2022	Qld Government (Department of Resources)	NE	NE
Zero Net Emissions Transport Roadmap	Transport		A commitment under the Queensland Climate Action Plan	Fiscal	Planned	The roadmap is currently being developed; no further details can be provided at this time	2023	Qld Government (Department of Transport and Main Roads)	NE	NE
Draft Low Emissions Agriculture Roadmap	Agriculture, Forestry/LULUCF	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	A Queensland agribusiness sector that is a world leader in low carbon production and supply chains, maximising carbon farming opportunities	Other (strategy)	Planned	The draft roadmap provides a framework to reduce agricultural emissions and increase carbon farming. It outlines technologies and policies needed to facilitate a measured and continued decline in production-based GHG emissions, and practices producers can adopt now to better understand their GHG footprint and position their business to capitalise on low-emissions technologies as they become viable	2023	Qld Government (Department of Agriculture and Fisheries)	NE	NE
Land Restoration Fund*	Agriculture, Forestry/LULUCF	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Facilitate a pipeline of Queensland-based carbon offset projects; pursue environmental, economic and social co-benefits; and invest in research and development into emerging carbon farming areas	Fiscal	Implemented	The fund is expanding carbon farming in the state by supporting land sector carbon projects that deliver additional environmental, socio-economic and First Nations co-benefits. The fund supports landholders, farmers and First Nations peoples to generate new, regular income streams through carbon farming projects while providing valuable co-benefits such as healthier waterways, increased habitat for threatened species and more-resilient landscapes	2019	Qld Government (Department of Environment and Science)	NE	NE
Zero Net Emissions Infrastructure Plan	Cross-cutting		A commitment under the Queensland Climate Action Plan	Other (strategy)	Planned	The plan is currently being developed; no further details can be provided at this time	2023	Qld Government (Department of State Development, Infrastructure, Local Government and Planning)	NE	NE

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Zero Net Emissions and Resilient Buildings Plan	Cross-cutting		A commitment under the Queensland Climate Action Plan	Other (strategy)	Planned	The plan is currently being developed; no further details can be provided at this time	2023	Qld Government (Department of Energy and Public Works)	NE	NE
Climate Change Action Plan 2021–2025*	Cross-cutting	CH_4, CO_2	Government-led objectives and actions for climate change mitigation and adaptation	Other (strategy)	Implemented	The action plan describes government–led actions addressing key objectives in 7 focus areas: • clean energy transition • climate smart economy • climate smart agriculture, landscapes and habitats • low-emissions transport • climate smart built and urban environments • resilient communities • government leading by example	2021	SA Government	NE	NE
Hydrogen Jobs Plan*	Cross-cutting	CO_2	Hydrogen production and grid management	Fiscal	Implemented	$593 million plan that will include the construction of a world-leading hydrogen power station, electrolyser and storage facility in Whyalla, including: • 250 megawatts electric of electrolysers • 200 megawatts of power generation (powered by the electrolysers) • hydrogen storage facilities	2022	SA Government	NE	NE
Waste Strategy 2020–2025*	Waste management/ waste	CH_4, CO_2	Establish a framework and targets to help develop a circular economy	Other (strategy)	Implemented	The strategy, which is reviewed every 5 years, is designed to reduce emissions of CO_2, CH_4 and other GHGs by diverting or avoiding waste going to landfill. The strategy has specific targets: • Zero avoidable waste to landfill by 2030 • Metropolitan Adelaide 2025 targets by waste sector - municipal solid waste diversion of 75% - commercial and industrial solid waste diversion of 90% - construction and demolition diversion of 95% • Per capita waste generation – 5% reduction from a 2020 baseline	2020	SA Government	7700	NE
Valuing Our Food Waste 2020–2025*	Waste management/ waste	CH_4	Reduce food waste from households and business	Other (strategy)	Implemented	The first strategy in Australia covering reduction of food waste for a jurisdiction. It integrates policy measures, behavioural change actions and support for industry to address the estimated 200,000 tonnes of food waste sent to landfill each year in South Australia	2020	SA Government	NE	NE
Renewable Hydrogen Action Plan*	Cross-cutting	CO_2	Hydrogen production	Other (strategy)	Implemented	The plan commits to developing a Tasmanian renewable hydrogen industry to meet local demand and for export by 2030	2020	Tas Government	NE	NE
Renewable Hydrogen Industry Development Funding Program*	Cross-cutting	CO_2	Hydrogen production	Economic	Implemented	$50 million program to help activate a green hydrogen industry in Tasmania	2020	Tas Government	NE	NE
Renewable Energy Action Plan*	Energy	CO_2	Renewable energy production	Other (strategy)	Implemented	The plan sets clear targets and actions designed to build on Tasmania's natural competitive advantages and attract large-scale investment to significantly grow and expand the state's renewable energy sector into the future	2020	Tas Government	NE	NE
Renewable Energy Coordination Framework	Energy	CO_2	Renewable energy production	Other (strategy)	Implemented	The framework prioritises the actions necessary to support the future growth of the renewable energy sector	2022	Tas Government	NE	NE

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Energy Saver Loan Scheme*	Energy	CO_2	Energy efficiency	Economic	Implemented	$50 million loan scheme that will provide interest-free loans of up to $10,000 for eligible applicants to invest in energy-efficient products	2022	Tas Government	NE	NE
Electric Vehicle ChargeSmart Grants Program*	Transport	CO_2	Increase public EV charging opportunities	Economic	Implemented	2 ChargeSmart programs have leveraged $4.2 million in total spend on charging infrastructure around the state	2018	Tas Government	NE	NE
Transport measures*	Transport	CO_2	Support the increased uptake of EVs	Economic, fiscal	Implemented	Measures include a target to transition the government vehicle fleet to 100% EVs by 2030, funding for electric and hydrogen bus trials, and a stamp duty waiver on new or second-hand EVs	2020	Tas Government	NE	NE
No-interest loan scheme for large emitting businesses	Industry/industrial processes	CO_2	Support trials of existing or new technologies to reduce emissions	Economic	Planned	$10 million no-interest loan scheme for large Tasmanian GHG-emitting businesses and industries to trial existing clean technologies or test new innovative production processes that will lead to reduced emissions	2023	Tas Government	NE	NE
Agriculture measures*	Agriculture	CH_4, CO_2	Reduce emissions from the agriculture sector	Economic	Implemented	Measures include a Carbon Farming Advice Rebate Pilot Program, On-farm Energy Audit and Capital Grant Program, and funding for research	2018	Tas Government	NE	NE
Waste Action Plan*	Waste management/ waste	CH_4, CO_2	Encourage recycling and resource recovery from waste	Regulatory	Implemented	The plan sets out a broad framework for waste management and resource recovery in Tasmania. Key actions include the introduction of a statewide waste levy, container refund scheme, and investment to increase food and garden organics reprocessing capacity across the state	2019	Tas Government	NE	NE
Whole of Victorian Government emissions reduction pledge*	Cross-cutting	CO_2	Reduce emissions from government operations	Regulatory, economic	Implemented	Reduce annual Victorian Government emissions by: • focusing on reducing emissions from electricity consumption through the transition to renewable energy • improving the energy efficiency of government operations, including government buildings and infrastructure • introducing steps to reduce emissions from public transport operations and the government's vehicle fleet	2021	Vic Government	NE	2700
Energy sector emissions reduction pledge*	Energy	CO_2	Reduce emissions, increase large and small-scale renewable energy, build a reliable and secure electricity grid, and improve energy efficiency	Economic, regulatory	Implemented	The pledge has a dual focus on switching to clean energy sources and managing energy demand through increased energy efficiency. It covers more than 20 programs, including the flagship Victorian Renewable Energy Target and the Victorian Energy Upgrades program	2021	Vic Government and the private sector	NE	3700
Transport sector emissions reduction pledge*	Transport	CO_2	Reduce emissions, increase uptake of zero emissions vehicles and improve public transport	Economic, fiscal	Implemented	Actions include: • $46 million subsidy program to provide grants to people and businesses to buy zero emissions vehicles • support for a statewide EV fast charging network adding 400 zero emissions vehicles to the Victorian Government fleet over the next 2 years • zero-emissions bus trials to support a transition to 100% of new public buses being zero-emissions buses from 2025 • continued investment in public transport infrastructure and services	2021	Vic Government, consumers, road users, councils and bus operators	NE	NE
Industrial processes and product use sector emissions reduction pledge	Industry/industrial processes	CO_2	Reduce emissions by reducing refrigerant gas leaks	Regulatory, information	Implemented	Advocacy for a stronger national regime and guidance for enhanced management of large refrigeration and air-conditioning systems	2021	Vic Government	NE	400

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Land use, land-use change and forestry sector emissions reduction pledge*	Forestry/LULUCF	CH_4, CO_2	Reduce GHG emissions, protect native forests, restore degraded landscapes and plant millions of new trees. It also aims to support affected communities, and to protect and improve biodiversity	Economic, regulatory	Implemented	Measures include: • ending native forest timber harvesting by 2030, including $120 million to support workers, businesses and communities transition from native forest harvesting to a plantation-based timber supply • the $110 million Gippsland Plantations Investment Program to provide incentives for plantation investors to undertake industrial-scale planting to bolster Victoria's timber supplies • Bushbank – a $76.98 million program to incentivise private and public landowners to restore and protect natural habitats and diversify income streams	2021	Vic Government	NE	1400
Agriculture sector emissions reduction pledge*	Agriculture	CH_4, CO_2	Support innovation to lay the foundations for future emissions reductions	Economic	Implemented	Key actions in the pledge include: • research trials in CH_4-inhibiting feed additives, and associated on-farm action plans • online spatial tools for farmers to reduce emissions • establishing a shared vision for the sector in a net zero and climate-resilient economy	2021	Vic Government, farmers, universities and industry bodies	NE	NE
Waste sector emissions reduction pledge*	Waste management/ waste	CH_4, CO_2	Reduce waste, increase recycling and create more value from Victorian resources	Economic, regulatory	Implemented	Emission reduction measures in the pledge include: • waste system reform to separate organic waste from other forms of waste, support more effective organics recycling and help avoid emissions that occur when organic waste goes to landfill • support for innovation for new recycled markets and creative solutions to waste • support for businesses to improve their resource efficiency, reduce the disposal of waste to landfill, increase recycling and reduce business costs	2021	Vic Government, local councils, businesses and households, through regulations, government investment and community education programs	NE	600
Sectoral Emissions Reduction Strategies (SERS)	Cross-cutting	CH_4, CO_2, HFCs, N_2O, NF_3, PFCs, SF_6	Develop strategies to reduce emissions from all sectors of WA's economy and transition to net zero emissions by 2050	Other (strategy)	Planned	The government is developing sectoral emissions reduction strategies in consultation with business, industry, research institutions and the community to transition our economy to net zero emissions	2023	WA Government (Department of Water and Environmental Regulation)	NE	NE
Government Emissions Interim Target	Cross-cutting	CO_2	Whole-of-government 2030 emissions reduction target of 80% below 2020 levels	Fiscal	Planned	Range of initiatives to reduce net emissions, including energy efficiency measures, procurement of renewable energy, reduced emissions in the government vehicle fleet and the use of local offsets. An estimated $3.8 billion will be invested in new green power infrastructure in the South West Interconnected System (SWIS), including wind generation and storage, to ensure emissions reduction, continued stability and affordability	2022	WA Government	NE	NE
Renewable Hydrogen Strategy*	Cross-cutting	CH_4, CO_2	Harness WA's competitive advantages, including world-class renewable energy resources, vast land mass and proud history of exporting energy to international markets	Other (TBC)	Implemented	The strategy sets out the government's strategic areas of focus for the development of the hydrogen industry. Areas of focus are export, remote applications, hydrogen blending in natural gas networks, transport	2019	WA Government (Department of Jobs, Tourism, Science and Innovation)	NE	NE

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Energy Transformation Strategy*	Energy	CO_2	Guides the government's response to the energy transformation underway in local electricity networks, and plans for the future of the power system	Other (strategy)	Implemented	• Stage 1 delivered Distributed Energy Resources Roadmap, Whole of Electricity System Planning, Foundation Regulatory Frameworks – improving access to the SWIS electricity network, and Delivering the Future Power System (standards and regulations for new power systems) • Stage 2 is implementing the Energy Transformation Taskforce decisions around integrating new technology into the power system, keeping the lights on as the power system transitions and regulating for the future • By 2025, new energy markets will be well established, current system security concerns will be addressed, and the Whole of System Plan will be refreshed	2020	WA Government (Department of Mines, Industry Regulation and Safety – Energy Policy WA)	NE	NE
Synergy's Decarbonisation Plan*	Energy	CO_2	Retirement of state-owned coal power stations by 2030	Fiscal, regulatory	Implemented	Investment of $3.8 billion in new green power infrastructure to enable retirement of state-owned coal-fired power stations on the SWIS. Government has committed to not commissioning any new natural gas–fired power stations on the SWIS after 2030. The project includes funds to support the town of Collie to transition to new industries and create local jobs	2022	WA Government	NE	5900
Clean Energy Future Fund*	Energy	CO_2	Support implementation of innovative clean energy projects in WA	Economic	Implemented	The fund supports projects that demonstrate significant, cost-effective reduction in emissions, and which could lead to the broader adoption of innovative clean energy technologies	2020	WA Government (Department of Water and Environmental Regulation)	NE	NE
Electric Vehicle Strategy and Clean Energy Car Fund*	Transport	CO_2	Accelerate the uptake of EVs and the transition to net zero emissions for WA	Economic	Implemented	A range of initiatives to support uptake of EVs, including: • rebates on EV purchases • installation of a statewide EV charging network • government grants to support private sector and local government investment in charging infrastructure	2021	WA Government (Department of Water and Environmental Regulation – Energy Policy WA), Synergy, Horizon Power	NE	NE
Carbon Innovation Grants Program*	Industry/industrial processes	CO_2	Reducing hard to abate emissions from heavy industry processes	Economic	Implemented	Fund feasibility studies and trials to avoid, reduce or offset carbon emissions from heavy industry processes, supporting innovative technologies for carbon abatement and sequestration	2022	WA Government (Department of Water and Environmental Regulation)	NE	NE
Carbon Farming and Land Restoration Program*	Agriculture	CO_2	Realise the potential of the agriculture sector to sequester carbon	Economic	Implemented	The program has 3 elements: • ACCU Plus – financial assistance to carbon sequestration projects registered with the Clean Energy Regulator • Future Carbon – provides grants to projects using innovative carbon sequestration activities to support the adoption of sustainable practices and contribute to more climate-resilient agriculture industries • complementary knowledge building activities, such as education and outreach, marketing and communications	2021	WA Government (Department of Primary Industries and Regional Development)	NE	400

Note: The two final columns specify the year identified by the Party for estimating impacts (based on the status of the measure and whether an ex post or ex ante estimation is available).
Abbreviations: GHG = greenhouse gas; LULUCF = land use, land-use change and forestry.
a Parties should use an asterisk (*) to indicate that a mitigation action is included in the 'with measures' projection.
b To the extent possible, the following sectors should be used: energy, transport, industry/industrial processes, agriculture, forestry/LULUCF, waste management/waste, other sectors, cross-cutting, as appropriate.
c To the extent possible, the following types of instrument should be used: economic, fiscal, voluntary agreement, regulatory, information, education, research, other.
d To the extent possible, the following descriptive terms should be used to report on the status of implementation: implemented, adopted, planned.
e Additional information may be provided on the cost of the mitigation actions and the relevant timescale.
f Optional year or years deemed relevant by the Party.

CTF Table 4: Reporting on progress[a, b]

	Total emissions excluding LULUCF	Contribution from LULUCF[d]	Quantity of units from market based mechanisms under the Convention		Quantity of units from other market based mechanisms	
Year[c]	**(kt CO_2 eq)**	**(kt CO_2 eq)**	**(number of units)**	**(kt CO_2 eq)**	**(number of units)**	**(kt CO_2 eq)**
Base year/period (2000)	489,528.65	65,992.84	NA	NA	NA	NA
2000	489,528.65	65,992.84	0.00	0.00	0.00	0.00
2005	524,811.85	92,639.21	0.00	0.00	0.00	0.00
2010	536,893.74	60,757.60	0.00	0.00	0.00	0.00
2011	538,663.88	32,856.03	0.00	0.00	0.00	0.00
2012	541,899.74	28,629.51	0.00	0.00	0.00	0.00
2013	532,267.33	19,083.13	0.00	0.00	0.00	0.00
2014	526,711.78	20,036.57	0.00	0.00	0.00	0.00
2015	534,936.02	-1,773.28	0.00	0.00	0.00	0.00
2016	543,976.81	-29,355.80	0.00	0.00	0.00	0.00
2017	550,874.87	-37,886.64	0.00	0.00	0.00	0.00
2018	552,484.02	-26,038.48	0.00	0.00	0.00	0.00
2019	546,606.62	-33,092.44	0.00	0.00	0.00	0.00
2020	528,149.46	-27,204.28	0.00	0.00	0.00	0.00

Abbreviation: GHG = greenhouse gas, LULUCF = land use, land-use change and forestry.

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

b For the base year, information reported on the emission reduction target shall include the following: (a) total GHG emissions, excluding emissions and removals from the LULUCF sector; (b) emissions and/or removals from the LULUCF sector based on the accounting approach applied taking into consideration any relevant decisions of the Conference of the Parties and the activities and/or land that will be accounted for; (c) total GHG emissions, including emissions and removals from the LULUCF sector. For each reported year, information reported on progress made towards the emission reduction targets shall include, in addition to the information noted in paragraphs 9(a–c) of the UNFCCC biennial reporting guidelines for developed country Parties, information on the use of units from market-based mechanisms.

c Parties may add additional rows for years other than those specified below.

d Information in this column should be consistent with the information reported in table 4(a)I or 4(a)II, as appropriate. The Parties for which all relevant information on the LULUCF contribution is reported in table 1 of this common tabular format can refer to table 1.

CTF Table 4(a)I: Progress in achieving the quantified economy-wide emission reduction targets – further information on mitigation actions relevant to the contribution of the land use, land-use change and forestry sector in 2019[a,b]

	Net GHG emissions/removals from LULUCF categories[c]	Base year/period or reference level value[d]	Contribution from LULUCF for reported year	Cumulative contribution from LULUCF[e]	Accounting approach[f]
	(kt CO_2 eq)				
Total LULUCF	-33,092.45	65,992.85	-99,085.28	-550,976.79	Other (see section 4.3 for details)
A. Forest land	-45,050.83	-24,563.71	-20,487.12	-184,108.60	Other (see section 4.3 for details)
1. Forest land remaining forest land	-28,920.66	-13,092.55	-15,828.11	-101,551.09	Other (see section 4.3 for details)
2. Land converted to forest land	-16,130.17	-11,471.16	-4,659.01	-82,557.51	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
B. Cropland	-1,536.31	3,299.80	-4,836.10	-20,625.84	Other (see section 4.3 for details)
1. Cropland remaining cropland	-2,454.65	477.66	-2,932.30	-9,383.90	Other (see section 4.3 for details)
2. Land converted to cropland	918.34	2,822.14	-1,903.80	-11,241.94	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
C. Grassland	10,163.08	82,388.08	-72,225.00	-338,745.25	Other (see section 4.3 for details)
1. Grassland remaining grassland	-11,422.35	17,924.53	-29,346.89	-92,348.81	Other (see section 4.3 for details)
2. Land converted to grassland	21,585.43	64,463.55	-42,878.11	-246,396.44	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
D. Wetlands	252.94	178.55	74.39	-189.81	Other (see section 4.3 for details)
1. Wetland remaining wetland	251.82	145.64	106.18	18.18	Other (see section 4.3 for details)
2. Land converted to wetland	1.12	32.91	-31.79	-207.99	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
E. Settlements	3,078.67	4,690.13	-1,611.45	-7,307.29	Other (see section 4.3 for details)
1. Settlements remaining settlements	-77.76	21.28	-99.03	-436.17	Other (see section 4.3 for details)
2. Land converted to settlements	3,156.43	4,668.85	-1,512.42	-6,871.12	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)

	Net GHG emissions/ removals from LULUCF categories[c]	Base year/period or reference level value[d]	Contribution from LULUCF for reported year	Cumulative contribution from LULUCF[e]	Accounting approach[f]
	(kt CO_2 eq)				
F. Other land	NA, NO	NA, NO	NA, NO	NA, NO	Other (see section 4.3 for details)
1. Other land remaining other land	NA	NA	NA	NA	Other (see section 4.3 for details)
2. Land converted to other land	NO	NO	NO	NO	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
G. Other	IE	IE	IE	IE	Other (see section 4.3 for details)
Harvested wood products	IE	IE	IE	IE	Other (see section 4.3 for details)

Abbreviations: GHG = greenhouse gas, LULUCF = land use, land-use change and forestry, NO = Not occurring, IE = Included elsewhere, NE = Not estimated, NA = Not applicable.

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

b Parties that use the LULUCF approach that is based on table 1 do not need to complete this table, but should indicate the approach in table 2. Parties should fill in a separate table for each year, namely 2011 and 2012, where 2014 is the reporting year. Parties that use the LULUCF approach that is based on table 1 do not need to complete this table, but should indicate the approach in table 2. Parties should fill in a separate table for each year, namely 2019 and 2020, where 2022 is the reporting year. CTF table 4(a)I has been used to present Australia's LULUCF estimates, as it is a better option for reporting purposes than using CTF table 4(a)II. Each LULUCF classification field in this table has been completed using net emissions data according to the KP LULUCF classifications. A Supplementary Table has been included in the Annex which presents KP LULUCF data against KP LULUCF classifications to demonstrate progress against Australia's QEERT.

c For each category, enter the net emissions or removals reported in the most recent inventory submission for the corresponding inventory year. If a category differs from that used for the reporting under the Convention or its Kyoto Protocol, explain in the biennial report how the value was derived.

d Enter one reference level or base year/period value for each category. Explain in the biennial report how these values have been calculated.

e If applicable to the accounting approach chosen. Explain in this biennial report to which years or period the cumulative contribution refers to.

f Label each accounting approach and indicate where additional information is provided within this biennial report explaining how it was implemented, including all relevant accounting parameters (i.e. natural disturbances, caps).

g Specify what was used for the category "other". Explain in this biennial report how each was defined and how it relates to the categories used for reporting under the Convention or its Kyoto Protocol.

CTF Table 4(a)I: Progress in achieving the quantified economy-wide emission reduction targets – further information on mitigation actions relevant to the contribution of the land use, land-use change and forestry sector in 2020[a, b]

	Net GHG emissions/ removals from LULUCF categories[c]	Base year/period or reference level value[d]	Contribution from LULUCF for reported year	Cumulative contribution from LULUCF[e]	Accounting approach[f]
	(kt CO_2 eq)				
Total LULUCF	-27,204.27	65,992.85	-93,197.13	-644,173.92	Other (see section 4.3 for details)
A. Forest land	-46,228.98	-24,563.71	-21,665.27	-205,773.87	Other (see section 4.3 for details)
1. Forest land remaining forest land	-29,227.17	-13,092.55	-16,134.62	-117,685.71	Other (see section 4.3 for details)
2. Land converted to forest land	-17,001.81	-11,471.16	-5,530.65	-88,088.16	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
B. Cropland	2,271.90	3,299.80	-1,027.90	-21,653.74	Other (see section 4.3 for details)
1. Cropland remaining cropland	1,758.06	477.66	1,280.40	-8,103.50	Other (see section 4.3 for details)
2. Land converted to cropland	513.84	2,822.14	-2,308.30	-13,550.24	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
C. Grassland	13,637.05	82,388.08	-68,751.04	-407,496.29	Other (see section 4.3 for details)
1. Grassland remaining grassland	-9,012.88	17,924.53	-26,937.42	-119,286.23	Other (see section 4.3 for details)
2. Land converted to grassland	22,649.93	64,463.55	-41,813.62	-288,210.06	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
D. Wetlands	263.69	178.55	85.14	-104.67	Other (see section 4.3 for details)
1. Wetland remaining wetland	271.49	145.64	125.85	144.03	Other (see section 4.3 for details)
2. Land converted to wetland	-7.80	32.91	-40.71	-248.70	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
E. Settlements	2,852.07	4,690.13	-1,838.06	-9,145.35	Other (see section 4.3 for details)
1. Settlements remaining settlements	-77.89	21.28	-99.17	-535.34	Other (see section 4.3 for details)
2. Land converted to settlements	2,929.96	4,668.85	-1,738.89	-8,610.01	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)

	Net GHG emissions/ removals from LULUCF categories[c]	Base year/period or reference level value[d]	Contribution from LULUCF for reported year	Cumulative contribution from LULUCF[e]	Accounting approach[f]
	(kt CO_2 eq)				
F. Other land	NE	NO, NA	NE	NE	Other (see section 4.3 for details)
1. Other land remaining other land	NE	NA	NE	NE	Other (see section 4.3 for details)
2. Land converted to other land	NE	NO	NE	NE	Other (see section 4.3 for details)
3. Other[g]					Other (see section 4.3 for details)
G. Other	IE	IE	IE	IE	Other (see section 4.3 for details)
Harvested wood products	IE	IE	IE	IE	Other (see section 4.3 for details)

Abbreviations: GHG = greenhouse gas, LULUCF = land use, land-use change and forestry, NO = Not occurring, IE = Included elsewhere, NE = Not estimated, NA = Not applicable.

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

b Parties that use the LULUCF approach that is based on table 1 do not need to complete this table, but should indicate the approach in table 2. Parties should fill in a separate table for each year, namely 2011 and 2012, where 2014 is the reporting year. Parties that use the LULUCF approach that is based on table 1 do not need to complete this table, but should indicate the approach in table 2. Parties should fill in a separate table for each year, namely 2019 and 2020, where 2022 is the reporting year. CTF table 4(a)I has been used to present Australia's LULUCF estimates, as it is a better option for reporting purposes than using CTF table 4(a)II. Each LULUCF classification field in this table has been completed using net emissions data according to the KP LULUCF classifications. A Supplementary Table has been included in the Annex which presents KP LULUCF data against KP LULUCF classifications to demonstrate progress against Australia's QEERT.

c For each category, enter the net emissions or removals reported in the most recent inventory submission for the corresponding inventory year. If a category differs from that used for the reporting under the Convention or its Kyoto Protocol, explain in the biennial report how the value was derived.

d Enter one reference level or base year/period value for each category. Explain in the biennial report how these values have been calculated.

e If applicable to the accounting approach chosen. Explain in this biennial report to which years or period the cumulative contribution refers to.

f Label each accounting approach and indicate where additional information is provided within this biennial report explaining how it was implemented, including all relevant accounting parameters (i.e. natural disturbances, caps).

g Specify what was used for the category "other". Explain in this biennial report how each was defined and how it relates to the categories used for reporting under the Convention or its Kyoto Protocol.

Supplementary table: Cancun 2020 target inventory: KP LULUCF classifications data against KP LULUCF classifications

	Unit	Base year/ period or reference level value[b]	Net GHG emissions/ removals from LULUCF categories[a]	Contribution from LULUCF for reported year	Cumulative contribution from LULUCF[c]	Accounting approach[d]
This table presents KP LULUCF classifications data against KP LULUCF classifications to demonstrate progress against Australia's 2020 QEERT						
2019						
Total KP LULUCF	kt CO_2 eq	65,993	−33,092	−99,085	−550,977	Other (See section 4.3 of BR for more details)
A Article 3.3 activities	kt CO_2 eq	60,516	−33,092	−93,609	−550,977	
A.1 Deforestation	kt CO_2 eq	71,987	9,531	−62,456	−347,275	
A.2. Afforestation/ Reforestation	kt CO_2 eq	−11,471	25,661	37,132	−264,717	
B Article 3.4 activities	kt CO_2 eq	5,477	−16,130	−21,607	−82,558	
B.1 Forest Management	kt CO_2 eq	−13,093	−42,624	−29,531	−203,702	
B.2 Cropland Management	kt CO_2 eq	478	−28,921	−29,398	−101,551	
B.3 Grazing land Management	kt CO_2 eq	17,925	−2,455	−20,379	−9,384	
B.4 Revegetation	kt CO_2 eq	167	−11,422	−11,589	−92,349	
B.5 Wetland drainage and rewetting[e]	kt CO_2 eq	NA	NA	NA	NA	NA
2020						
Total KP LULUCF	kt CO_2 eq	65,993	−27,204	−93,197	−644,174	Other (See section 4.3 of BR for more details)
A Article 3.3 activities	kt CO_2 eq	60,516	9,084	−51,432	−398,707	
A.1 Deforestation	kt CO_2 eq	71,987	26,086	−45,902	−310,619	
A.2 Afforestation/ Reforestation	kt CO_2 eq	−11,471	−17,002	−5,531	−88,088	
B Article 3.4 activities	kt CO_2 eq	5,477	−36,288	−41,765	−245,467	
B.1 Forest Management	kt CO_2 eq	−13,093	−29,227	−16,135	−117,686	
B.2 Cropland Management	kt CO_2 eq	478	1,758	1,280	−8,103	
B.3 Grazing land Management	kt CO_2 eq	17,925	−9,013	−26,937	−119,286	
B.4 Revegetation	kt CO_2 eq	167	194	27	−391	

	Unit	Base year/ period or reference level value[b]	Net GHG emissions/ removals from LULUCF categories[a]	Contribution from LULUCF for reported year	Cumulative contribution from LULUCF[c]	Accounting approach[d]
B.5 Wetland drainage and rewetting[e]	kt CO_2 eq	NA	NA	NA	NA	NA

Abbreviations: GHG = greenhouse gas, LULUCF = land use, land-use change and forestry, NO = Not occurring, NE = Not estimated, IE = Included elsewhere, NA = Not applicable.

[a] For each category, enter the net emissions or removals reported in the most recent inventory submission for the corresponding inventory year. If a category differs from that used for the reporting under the Convention or its Kyoto Protocol, explain in the biennial report how the value was derived.

[b] Enter one reference level or base year/period value for each category. Explain in the biennial report how these values have been calculated.

[c] If applicable to the accounting approach chosen. Explain in this biennial report to which years or period the cumulative contribution refers to.

[d] Label each accounting approach and indicate where additional information is provided within this biennial report explaining how it was implemented, including all relevant accounting parameters (i.e. natural disturbances, caps).

[e] Australia did not elect this nonmandatory Activity for reporting.

CTF Table 4(b) Reporting on progress[a, b, c]

Australia did not use units from market-based mechanisms to achieve its QEERT. Australia has committed to not carry over any overachievement on its QEERT or its Kyoto Protocol targets to meet its Paris Agreement targets.

Units of market based mechanisms			**Year 2019**	**Year 2020**
Kyoto Protocol units[d]	Kyoto Protocol units (1)	(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA
	AAUs	(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA
	ERUs	(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA
	CERs	(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA
	tCERs	(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA
	lCERs	(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA
Other units[d,e]	Units from market-based mechanisms under the Convention	(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA
	NA	(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA
	Units from other market-based mechanisms	(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA
Total		(number of units)	NA	NA
		(kt CO_2 eq)	NA	NA

Abbreviations: AAUs = assigned amount units, CERs = certified emission reductions, ERUs = emission reduction units, lCERs = long-term certified emission reductions, tCERs = temporary certified emission reductions.
Note: 2011 is the latest reporting year.

a Reporting by a developed country Party on the information specified in the common tabular format does not prejudge the position of other Parties with regard to the treatment of units from market-based mechanisms under the Convention or other market-based mechanisms towards achievement of quantified economy-wide emission reduction targets.

b For each reported year, information reported on progress made towards the emission reduction target shall include, in addition to the information noted in paragraphs 9(a-c) of the reporting guidelines, on the use of units from market-based mechanisms.

c Parties may include this information, as appropriate and if relevant to their target.

d Units surrendered by that Party for that year that have not been previously surrendered by that or any other Party.

e Additional rows for each market-based mechanism should be added, if applicable.

(1) The NA notation in this table is intended to indicate that Australia did not use units from market-based mechanisms to achieve its QEERT.

5. Projections

Information on Australia's emissions projections ('with measures' scenario, by sector and by gas) is contained in Chapter 5 of the eighth National Communication and CTF Tables 6(a) and 6(c). Information on modelling framework and changes since the last Biennial Report submission is also contained in Chapter 5 of the eighth National Communication.

CTF Table 5: Summary of key variables and assumptions used in the projections analysis[a]

Key underlying assumptions		Historical[b]										Projected			
Assumption	**Unit**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Population	thousands	17,170.00	18,120.00	19,141.00	20,312.00	22,172.00	23,985.00	NA	NA	NA	NA	25,639.00	26,945.00	28,768.00	30,589.00
Gross domestic product – Real GDP	2019 AU$m	838,296.00	941,750.00	1,159,299.00	1,363,823.00	1,567,246.00	1,794,289.00	NA	NA	NA	NA	1,980,866.00	2,233,368.00	2,532,165.00	2,889,404.00
Electricity generation (as generated) – excluding renewables	TWh	139.00	156.00	192.00	208.00	230.00	218.00	NA	NA	NA	NA	205.00	136.00	87.00	78.00
Electricity generation (as generated) – including renewables	TWh	155.00	173.00	210.00	229.00	252.00	252.00	NA	NA	NA	NA	265.00	255.00	274.00	315.00
Coal production	Run of Mine, Mt	241.03	287.14	366.04	460.51	543.57	642.64	NA	NA	NA	NA	604.82	636.88	578.31	558.12
LNG production	Mt	2.00	7.02	7.92	10.59	17.87	25.04	NA	NA	NA	NA	79.24	81.73	87.85	85.99
Iron ore production	Mt	109.89	136.99	159.14	251.11	421.84	776.26	NA	NA	NA	NA	911.14	988.89	992.40	880.71
Aluminium production	Mt	1.24	1.33	1.74	1.89	1.92	1.65	NA	NA	NA	NA	1.57	1.62	1.64	1.64
Iron and Steel production	Mt	6.68	8.43	8.05	7.39	6.89	4.74	NA	NA	NA	NA	5.48	5.80	5.79	5.74
Residential gas consumption	PJ	87.90	104.70	118.50	128.40	144.11	160.60	NA	NA	NA	NA	167.04	154.73	155.06	123.27
Commercial gas consumption	PJ	34.00	42.50	49.50	44.03	47.82	43.69	NA	NA	NA	NA	41.57	42.52	42.25	32.96
Grazing beef cattle	million head	21.95	22.54	23.87	24.39	23.26	23.68	NA	NA	NA	NA	21.23	25.02	24.37	24.44

Key underlying assumptions						Historical[b]							Projected		
Assumption	**Unit**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**	**2035**
Grain fed beef cattle	million head	0.33	0.45	0.58	0.82	0.75	0.93	NA	NA	NA	NA	1.11	1.23	1.34	1.47
Dairy cattle	million head	2.56	2.74	3.14	3.07	2.54	2.81	NA	NA	NA	NA	2.43	2.17	2.08	1.90
Solid waste disposal	Kt	16,500.47	17,549.85	19,745.83	20,726.29	20,067.82	18,375.77	NA	NA	NA	NA	18,245.49	15,222.33	11,114.17	8,978.61
Annual road transport activity	billion km travelled	162.00	181.00	199.00	219.00	229.00	249.00	NA	NA	NA	NA	246.00	274.00	291.00	310.00
Motor vehicle stocks	million	9.87	10.95	12.37	13.92	16.06	18.01	NA	NA	NA	NA	19.81	21.68	22.36	23.22

Abbreviations: NA= Not Applicable; AU$m = Australian dollars, millions; kt = kilotonnes; LNG = liquefied natural gas; Mt = megatonnes; PJ = petajoules; TWh = terawatt hours

a Parties should include key underlying assumptions as appropriate.

b Parties should include historical data used to develop the greenhouse gas projections reported.

CTF Table 6(a): Information on updated greenhouse gas projections under a 'with measures' scenario[a]

	GHG emissions and removals[b] ($kt\ CO_2$ eq)								GHG emission projections ($kt\ CO_2$ eq)	
	Base year (2000)	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2019**	**2020**	**2030**
Sector[d,e]										
Energy	294,173.83	236,009.70	253,818.02	294,173.83	321,695.65	333,562.58	327,344.44	335,116.67	326,297.06	234,670.87
Transport	74,017.67	61,370.71	68,214.37	74,017.67	82,045.09	88,653.83	95,254.61	100,204.02	93,342.44	102,831.29
Industry/industrial processes	25,719.79	25,111.84	24,608.91	25,719.79	30,085.10	33,390.57	30,385.87	32,547.21	31,883.89	28,088.29
Agriculture	88,716.15	92,096.41	82,278.75	88,716.15	85,972.68	75,100.37	78,940.36	74,824.85	72,627.12	79,103.94
Forestry/LULUCF	67,984.78	202,464.36	66,593.45	67,984.78	85,447.20	68,021.91	4,711.20	-39,033.97	-39,019.26	-33,121.89
Waste management/waste	18,728.48	23,582.71	22,226.40	18,728.48	15,884.28	16,234.77	12,860.48	13,139.20	12,981.14	10,724.46
Other (specify)										
Gas										
CO_2 emissions including net CO_2 from LULUCF	389,018.37	454,227.62	346,926.57	389,018.37	447,096.75	446,578.01	380,416.83	358,083.26	343,712.15	264,436.20

	GHG emissions and removals[b] (kt CO_2 eq)								GHG emission projections (kt CO_2 eq)	
	Base year (2000)	1990	1995	2000	2005	2010	2015	2019	2020	2030
CO_2 emissions excluding net CO_2 from LULUCF	349,635.49	278,154.16	305,003.00	349,635.49	386,153.53	405,103.32	401,793.06	416,761.93	400,333.47	317,493.51
CH_4 emissions including CH_4 from LULUCF	156,326.89	162,255.11	150,797.08	156,326.89	145,908.09	138,810.53	138,324.95	127,732.79	123,304.60	128,749.59
CH_4 emissions excluding CH_4 from LULUCF	132,218.44	140,149.24	129,739.16	132,218.44	125,776.34	117,340.66	116,430.70	111,291.86	108,980.18	112,394.62
N_2O emissions including N_2O from LULUCF	21,468.42	18,588.49	17,451.22	21,468.42	22,611.95	22,451.63	21,137.92	19,878.90	19,806.03	20,339.45
N_2O emissions excluding N_2O from LULUCF	16,974.98	14,303.46	13,839.26	16,974.98	18,239.72	17,374.28	16,944.73	16,675.12	16,528.40	16,758.99
HFCs	1,150.49	1,193.65	862.28	1,150.49	3,699.51	6,735.33	9,343.46	10,688.48	10,952.80	8,374.86
PFCs	1,157.58	4,143.53	1,376.83	1,157.58	1,611.45	254.73	154.06	273.50	243.12	276.10
SF_6	218.95	227.33	325.92	218.95	202.24	133.79	119.74	141.06	93.69	120.77
NF_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other (specify)										
Total with LULUCF[f] (1)	**569,340.70**	**640,635.73**	**517,739.90**	**569,340.70**	**621,129.99**	**614,964.02**	**549,496.96**	**516,797.99**	**498,112.39**	**422,296.97**
Total without LULUCF (2)	**501,355.93**	**438,171.37**	**451,146.45**	**501,355.93**	**535,682.79**	**546,942.11**	**544,785.75**	**555,831.95**	**537,131.66**	**455,418.85**

Abbreviations: CH_4=methane; GHG = greenhouse gas; HFCs = hydrofluorocarbons; kt CO_2e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry; NF_3 = nitrogen trifluoride; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF_6 = sulfur hexafluoride

a In accordance with the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part II: UNFCCC reporting guidelines on national communications", at a minimum Parties shall report a 'with measures' scenario, and may report 'without measures' and 'with additional measures' scenarios. If a Party chooses to report 'without measures' and/or 'with additional measures' scenarios they are to use tables 6(b) and/or 6(c), respectively. If a Party does not choose to report 'without measures' or 'with additional measures' scenarios then it should not include tables 6(b) or 6(c) in the biennial report.

b Emissions and removals reported in these columns should be as reported in the latest GHG inventory and consistent with the emissions and removals reported in the table on GHG emissions and trends provided in this biennial report. Where the sectoral breakdown differs from that reported in the GHG inventory Parties should explain in their biennial report how the inventory sectors relate to the sectors reported in this table.

c 20XX is the reporting due-date year (i.e. 2014 for the first biennial report).

d In accordance with paragraph 34 of the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part II: UNFCCC reporting guidelines on national communications", projections shall be presented on a sectoral basis, to the extent possible, using the same sectoral categories used in the policies and measures section. This table should follow, to the extent possible, the same sectoral categories as those listed in paragraph 17 of those guidelines, namely, to the extent appropriate, the following sectors should be considered: energy, transport, industry, agriculture, forestry and waste management.

e To the extent possible, the following sectors should be used: energy, transport, industry/industrial processes, agriculture, forestry/LULUCF, waste management/waste, other sectors (i.e. cross-cutting), as appropriate.

f Parties may choose to report total emissions with or without LULUCF, as appropriate.

1 The total with LULUCF for 2025 and 2035 are 458,661.97 and 383,266.90, respectively.

2 The total without LULUCF for 2025 and 2035 are 503,599.67 and 427,382.32, respectively.

CTF Table 6(c): Information on updated greenhouse gas projections under a 'with additional measures' scenario[a]

	GHG emissions and removals[b] (kt CO_2 eq)								GHG emission projections (kt CO_2 eq)	
	Base year (2000)	1990	1995	2000	2005	2010	2015	2019	2020	2030
Sector[d,e]										
Energy (1)	294,173.83	236,009.70	253,818.02	294,173.83	321,695.65	333,562.58	327,344.44	335,116.67	326,297.06	217,888.84
Transport (2)	74,017.67	61,370.71	68,214.37	74,017.67	82,045.09	88,653.83	95,254.61	100,204.02	93,342.44	102,831.29
Industry/industrial processes (3)	25,719.79	25,111.84	24,608.91	25,719.79	30,085.10	33,390.57	30,385.87	32,547.21	31,883.89	28,088.29
Agriculture (4)	88,716.15	92,096.41	82,278.75	88,716.15	85,972.68	75,100.37	78,940.36	74,824.85	72,627.12	79,103.94
Forestry/LULUCF (5)	67,984.78	202,464.36	66,593.45	67,984.78	85,447.20	68,021.91	4,711.20	-39,033.97	-39,019.26	-33,121.89
Waste management/waste (6)	18,728.48	23,582.71	22,226.40	18,728.48	15,884.28	16,234.77	12,860.48	13,139.20	12,981.14	10,724.46
Other (specify)										-37,043.80
Safeguard mechanism reforms (7)										-37,043.80
Gas										
CO_2 emissions including net CO_2 from LULUCF (8)	389,018.37	454,227.62	346,926.57	389,018.37	447,096.75	446,578.01	380,416.83	358,083.26	343,712.15	248,099.48
CO_2 emissions excluding net CO_2 from LULUCF (9)	349,635.49	278,154.16	305,003.00	349,635.49	386,153.53	405,103.32	401,793.06	416,761.93	400,333.47	301,156.79
CH_4 emissions including CH_4 from LULUCF (10)	156,326.89	162,255.11	150,797.08	156,326.89	145,908.09	138,810.53	138,324.95	127,732.79	123,304.60	128,342.82
CH_4 emissions excluding CH_4 from LULUCF (11)	132,218.44	140,149.24	129,739.16	132,218.44	125,776.34	117,340.66	116,430.70	111,291.86	108,980.18	111,987.85
N_2O emissions including N_2O from LULUCF (12)	21,468.42	18,588.49	17,451.22	21,468.42	22,611.95	22,451.63	21,137.92	19,878.90	19,806.03	20,300.91
N_2O emissions excluding N_2O from LULUCF (13)	16,974.98	14,303.46	13,839.26	16,974.98	18,239.72	17,374.28	16,944.73	16,675.12	16,528.40	16,720.45
HFCs (14)	1,150.49	1,193.65	862.28	1,150.49	3,699.51	6,735.33	9,343.46	10,688.48	10,952.80	8,374.86
PFCs (15)	1,157.58	4,143.53	1,376.83	1,157.58	1,611.45	254.73	154.06	273.50	243.12	276.10

	GHG emissions and removals[b]								GHG emission projections	
	($kt CO_2 eq$)								($kt CO_2 eq$)	
	Base year (2000)	1990	1995	2000	2005	2010	2015	2019	2020	2030
SF_6 (16)	218.95	227.33	325.92	218.95	202.24	133.79	119.74	141.06	93.69	120.77
NF_3 (17)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other (specify)										-37,043.80
CO_2-e safeguard mechanism reforms										-37,043.80
Total with LULUCF (18)	**569,340.70**	**640,635.73**	**517,739.90**	**569,340.70**	**621,129.99**	**614,964.02**	**549,496.96**	**516,797.99**	**498,112.39**	**368,471.14**
Total without LULUCF (19)	**501,355.93**	**438,171.37**	**451,146.45**	**501,355.93**	**535,682.79**	**546,942.11**	**544,785.75**	**555,831.95**	**537,131.66**	**401,593.02**

Abbreviations: CH_4 = methane; GHG = greenhouse gas; HFCs = hydrofluorocarbons; kt CO_2e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry; NF_3 = nitrogen trifluoride; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF_6 = sulfur hexafluoride

1 Abatement from reforms to the safeguard mechanism have been calculated in aggregate. Abatement has not been estimated for each sector so actual emissions from this sector would likely be lower than reported.
2 As above.
3 As above.
4 As above.
5 As above.
6 As above.
7 Total abatement from the safeguard mechanism is estimated to be 13,926 kt CO_2-e in 2025, 46,305 kt CO_2-e in 2030 and 64,433 kt CO_2-e in 2035. Abatement is assumed to be achieved through a combination of on-site abatement and the surrender of ACCUs. 9,261 kt CO_2-e of the abatement task is assumed to be met through ACCUs that are already included in the baseline projection.
8 Abatement from reforms to the safeguard mechanism have been calculated in aggregate. Abatement has not been estimated for each greenhouse gas so actual emissions of this gas would likely be lower than reported.
9 As above.
10 As above.
11 As above.
12 As above.
13 As above.
14 As above.
15 As above.
16 As above.
17 As above.
18 The total with LULUCF for 2025 and 2035 are 447,113.63 and 323,294.54, respectively.
19 The total without LULUCF for 2025 and 2035 are 492,051.34 and 367,409.96, respectively.

6. Provision of financial, technological and capability-building support to developing country parties

Australia provides financial, technological, and capability-building support to developing countries to build their capacity to reduce carbon emissions and to take action to adapt to the effects of climate change (see Tables 6–11, and Chapter 7 of the eighth National Communication):

- Table 6 summarises public financial support over the reporting period (2018–19 to 2019–20).
- Table 7 provides information on public financial support through multilateral channels.
- Table 8 provides information on public financial support through bilateral, regional and other channels.
- Table 10 provides information on support for technology development and transfer.
- Table 11 provides information on programs that provide capacity-building support.

Australia's climate finance for this 2-year period:

- included both mitigation and adaptation measures; more than 70% of bilateral, regional and global programs contributed to adaptation
- was provided as grants and fully expensed
- was prioritised towards countries most vulnerable to climate change, with over two-thirds of bilateral, regional and global programs expected to benefit Small Island Developing States and Least Developed Countries.

Australia sources its public climate finance from annual appropriations. This supports new and additional financial, technological and capacity-building support for developing countries. Australia only counts climate finance if the investment targets climate change adaptation or mitigation, in addition to other development outcomes. For the purposes of this report, 'provided' means funds have been transferred from the Australian Government to a recipient (which may be a multilateral organisation). Funds are reported in AUD millions. Currency exchange rates are based on annual average conversion rates as published by the Australian Taxation Office.

For multilateral contributions for which climate change is the primary focus of the institution, Australia counts 100% of the core contribution as climate finance. If climate change is one of several work areas of the institution, Australia applies international standard coefficients to determine the climate change component of the core contribution. These coefficients are derived from the imputed shares calculated by the OECD Development Assistance Committee Secretariat.

For bilateral, regional and global programs, Australia accounts its climate finance at the individual activity level and then aggregates these figures:

- If the activity has an explicit primary climate change objective, the entire activity value is accounted as climate finance.
- If the activity has an explicit secondary climate change objective, component activities are identified and the proportion of each component that is delivering climate results is estimated, and the total of all components is calculated. If this cannot be calculated, a default proportion of the activity expenditure – 30% – is counted. The same process is applied to determine the split of adaptation versus mitigation support.

In some cases, spending on each activity can be clearly attributed to either mitigation or adaptation. However, if the activities are achieving both mitigation and adaptation and it is not possible to apportion the expenditure between the 2 outcomes, then Australia reports its support as 'cross cutting'.

Table 6 (CTF Table 7): Provision of public financial support: summary information in 2019[a]

Allocation channels	Year									
	Australian dollar – AUD					USD[b]				
	Core/ general[c, 1]	Climate-specific[d, 2]				Core/ general[c, 1]	Climate-specific[d, 2]			
		Mitigation	Adaptation	Cross-cutting[e]	Other[f]		Mitigation	Adaptation	Cross-cutting[e]	Other[f]
Total contributions through multilateral channels:	689,192,372.73			241,443,408.46		517,445,633.46			181,275,711.07	
Multilateral climate change funds[g]	66,952,867.70			58,126,181.87		50,268,213.07			43,641,137.35	
Other multilateral climate change funds[h]	16,987,867.70			14,768,912.42		12,754,491.07			11,088,499.45	
Multilateral financial institutions, including regional development banks	604,976,796.07			166,054,517.63		454,216,578.50			124,673,731.83	
Specialized United Nations bodies	17,262,708.96			17,262,708.96		12,960,841.89			12,960,841.89	
Total contributions through bilateral, regional and other channels		31,171,409.31	96,283,089.56	11,160,804.12			23,403,494.09	72,289,343.64	8,379,531.73	
Total	**689,192,372.73**	**31,171,409.31**	**96,283,089.56**	**252,604,212.58**		**517,445,633.46**	**23,403,494.09**	**72,289,343.64**	**189,655,242.80**	

Note: Explanation of numerical footnotes is provided in the documentation box after tables 7, 7(a) and 7(b).
Abbreviation: USD = United States dollars.

a Parties should fill in a separate table for each year, namely 2015 and 2016, where 2018 is the reporting year.
b Parties should provide an explanation of the methodology used for currency exchange for the information provided in tables 7, 7(a) and 7(b) in the documentation box.
c This refers to support to multilateral institutions that Parties cannot specify as being climate-specific.
d Parties should explain in their biennial reports how they define funds as being climate-specific.
e This refers to funding for activities that are cross-cutting across mitigation and adaptation.
f Please specify.
g Multilateral climate change funds listed in paragraph 17(a) of the "UNFCCC biennial reporting guidelines for developed country Parties" in decision 2/CP.17.
h Other multilateral climate change funds as referred in paragraph 17(b) of the "UNFCCC biennial reporting guidelines for developed country Parties" in decision 2/CP.17.

Documentation Box:

1: Core/general
The Australian financial year runs from 1 July to 30 June. The figures for 2019 are for the period 1 July 2018 – 30 June 2019. USD exchange rates are based on annual average conversion rates for the relevant financial year as published by the Australian Taxation Office: (FY2018/19: 0.7508). Source: Average rate for year ended 30 June 2019: https://www.ato.gov.au/Tax-professionals/TP/Rates-for-financial-year-ending-30-June-2019/

The figures for 2020 are for the period 1 July 2019 – 30 June 2020. USD exchange rates are based on annual average conversion rates for the relevant financial year as published by the Australian Taxation Office: (FY2019/20: 0.6878). Source: Average rate for year ended 30 June 2020: https://www.ato.gov.au/Tax-professionals/TP/Rates-for-financial-year-ending-30-June-2020/ Australia makes core contributions to UNDP. However, the OECD DAC does not currently calculate an imputed share for UNDP. In the absence of a robust calculation method, Australia does not count a portion of our core contribution as climate finance. Global programs refer to investments that deliver activities across multiple countries or regions.

2: Climate-specific
Australia sources its climate finance from new and additional development budget appropriations passed by the Australian Parliament on an annual basis. The methodology Australia employs to track climate finance expenditure is based on the Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) Rio statistical markers for climate change mitigation and adaptation.
For contributions through multilateral channels, Australia counts a percentage of its core contributions according to the imputed shares calculated by the OECD DAC for 2019 and 2020 respectively. For bilateral, regional and global programs, Australia assesses each activity to determine if it has an explicit climate change objective (based on OECD DAC guidance) and whether this is a primary or secondary objective. For an explanation of this methodology see Australia's 5th Biennial Report.

3: Status
Australia only reports on funds which have been disbursed, that is, transferred to partner countries / organisations.

4: Funding source

5: Financial instrument
Australia's climate finance contributions are wholly grant-based in these years.

6: Type of support
Australia reports all climate finance through multilateral channels as being cross-cutting. For bilateral, regional and global programs, Australia assesses each activity to determine if the support is for adaptation, mitigation or cross-cutting. Most of Australia's country and regional programs, and its portfolio of global programs, contain a mix of mitigation and adaptation activities. For recipient countries / regions that have more than one type of support, Australia has separated the climate finance accordingly. See Australia's 5th Biennial Report for a full explanation.

7: Sector
Australia allocates sectors in the BR based on OECD DAC Sector Codes assigned when aid activities are established. Other sectors have been specified where Australia's climate finance is significant, for example 'Environmental Policy and Administrative Management' categorised as 'Other (Environment)'. 'Other (Other sectors)' refers to additional sectors reported on under DAC guidance which are not captured by the BR sector options and where Australia's climate finance is relatively modest, for example health and education. All funds disbursed through multilateral channels are classified as 'cross-cutting' to reflect a broad range of sectors.

Each Party shall provide an indication of what new and additional financial resources they have provided, and clarify how they have determined that such resources are new and additional. Please provide this information in relation to table 7(a) and (b).

Table 6 (CTF Table 7): Provision of public financial support: summary information in 2020[a]

Allocation channels	Year									
	Australian dollar – AUD					USD[b]				
	Core/ general[c, 1]	Climate-specific[d, 2]				Core/ general[c, 1]	Climate-specific[d, 2]			
		Mitigation	Adaptation	Cross-cutting[e]	Other[f]		Mitigation	Adaptation	Cross-cutting[e]	Other[f]
Total contributions through multilateral channels:	453,861,740.20			117,619,457.51		312,166,104.91			80,898,662.87	
Multilateral climate change funds[g]	2,790,000.00			2,338,410.60		1,918,962.00			1,608,358.81	
Other multilateral climate change funds[h]										
Multilateral financial institutions, including regional development banks	449,618,992.28			113,828,298.99		309,247,942.89			78,291,104.04	
Specialized United Nations bodies	1,452,747.92			1,452,747.92		999,200.02			999,200.02	
Total contributions through bilateral, regional and other channels		21,471,589.13	139,609,641.74	10,913,653.58			14,768,159.00	96,023,511.59	7,506,410.93	
Total	**453,861,740.20**	**21,471,589.13**	**139,609,641.74**	**128,533,111.09**		**312,166,104.91**	**14,768,159.00**	**96,023,511.59**	**88,405,073.80**	

Note: Explanation of numerical footnotes is provided in the documentation box after tables 7, 7(a) and 7(b).
Abbreviation: USD = United States dollars.

a Parties should fill in a separate table for each year, namely 2015 and 2016, where 2018 is the reporting year.
b Parties should provide an explanation of the methodology used for currency exchange for the information provided in tables 7, 7(a) and 7(b) in the documentation box.
c This refers to support to multilateral institutions that Parties cannot specify as being climate-specific.
d Parties should explain in their biennial reports how they define funds as being climate-specific.
e This refers to funding for activities that are cross-cutting across mitigation and adaptation.
f Please specify.
g Multilateral climate change funds listed in paragraph 17(a) of the "UNFCCC biennial reporting guidelines for developed country Parties" in decision 2/CP.17.
h Other multilateral climate change funds as referred in paragraph 17(b) of the "UNFCCC biennial reporting guidelines for developed country Parties" in decision 2/CP.17.

Documentation Box:

1: Core/general
The Australian financial year runs from 1 July to 30 June. The figures for 2019 are for the period 1 July 2018 – 30 June 2019. USD exchange rates are based on annual average conversion rates for the relevant financial year as published by the Australian Taxation Office: (FY2018/19: 0.7508). Source: Average rate for year ended 30 June 2019: https://www.ato.gov.au/Tax-professionals/TP/Rates-for-financial-year-ending-30-June-2019/

The figures for 2020 are for the period 1 July 2019 – 30 June 2020. USD exchange rates are based on annual average conversion rates for the relevant financial year as published by the Australian Taxation Office: (FY2019/20: 0.6878). Source: Average rate for year ended 30 June 2020: https://www.ato.gov.au/Tax-professionals/TP/Rates-for-financial-year-ending-30-June-2020/ Australia makes core contributions to UNDP. However, the OECD DAC does not currently calculate an imputed share for UNDP. In the absence of a robust calculation method, Australia does not count a portion of our core contribution as climate finance. Global programs refer to investments that deliver activities across multiple countries or regions.

2: Climate-specific
Australia sources its climate finance from new and additional development budget appropriations passed by the Australian Parliament on an annual basis. The methodology Australia employs to track climate finance expenditure is based on the Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) Rio statistical markers for climate change mitigation and adaptation. For contributions through multilateral channels, Australia counts a percentage of its core contributions according to the imputed shares calculated by the OECD DAC for 2019 and 2020 respectively. For bilateral, regional and global programs, Australia assesses each activity to determine if it has an explicit climate change objective (based on OECD DAC guidance) and whether this is a primary or secondary objective. For an explanation of this methodology see Australia's 5th Biennial Report.

3: Status
Australia only reports on funds which have been disbursed, that is, transferred to partner countries / organisations.

4: Funding source

5: Financial instrument
Australia's climate finance contributions are wholly grant-based in these years.

6: Type of support
Australia reports all climate finance through multilateral channels as being cross-cutting. For bilateral, regional and global programs, Australia assesses each activity to determine if the support is for adaptation, mitigation or cross-cutting. Most of Australia's country and regional programs, and its portfolio of global programs, contain a mix of mitigation and adaptation activities. For recipient countries / regions that have more than one type of support, Australia has separated the climate finance accordingly. See Australia's 5th Biennial Report for a full explanation.

7: Sector
Australia allocates sectors in the BR based on OECD DAC Sector Codes assigned when aid activities are established. Other sectors have been specified where Australia's climate finance is significant, for example 'Environmental Policy and Administrative Management' categorised as 'Other (Environment)'. 'Other (Other sectors)' refers to additional sectors reported on under DAC guidance which are not captured by the BR sector options and where Australia's climate finance is relatively modest, for example health and education. All funds disbursed through multilateral channels are classified as 'cross-cutting' to reflect a broad range of sectors.

Each Party shall provide an indication of what new and additional financial resources they have provided, and clarify how they have determined that such resources are new and additional. Please provide this information in relation to table 7(a) and (b)

Table 7 (CTF Table 7(a)): Provision of public financial support: contribution through multilateral channels in 2019[a]

Donor funding	Total amount – Core/general[d, 1] – Australian dollar – AUD	Total amount – Core/general[d, 1] – USD	Total amount – Climate-specific[e, 2] – Australian dollar – AUD	Total amount – Climate-specific[e, 2] – USD	Status[b, 3]	Funding source[f, 4]	Financial instrument[f, 5]	Type of support[f, g, 6]	Sector[c, f, 7]
Total contributions through multilateral channels	689,192,372.73	517,445,633.46	241,443,408.46	181,275,711.07					
Multilateral climate change funds	66,952,867.70	50,268,213.07	58,126,181.87	43,641,137.35					
1. Global Environment Facility	34,965,000.00	26,251,722.00	29,151,369.45	21,886,848.18	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund	15,000,000.00	11,262,000.00	14,205,900.00	10,665,789.72	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds	16,987,867.70	12,754,491.07	14,768,912.42	11,088,499.45					
Global Green Growth Institute	16,987,867.70	12,754,491.07	14,768,912.42	11,088,499.45	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Multilateral financial institutions, including regional development banks	604,976,796.07	454,216,578.50	166,054,517.63	124,673,731.83					
1. World Bank	221,523,659.96	166,319,963.90	69,496,402.60	52,177,899.07	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
2. International Finance Corporation									
3. African Development Bank									
4. Asian Development Bank	212,713,000.06	159,704,920.45	33,951,121.94	25,490,502.35	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank									
7. Other	170,740,136.05	128,191,694.15	62,606,993.09	47,005,330.41					
Asian Infrastructure Investment Bank	170,740,136.05	128,191,694.15	62,606,993.09	47,005,330.41	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting

Donor funding	Total amount: Core/general[d, 1] Australian dollar – AUD	Core/general[d, 1] USD	Climate-specific[e, 2] Australian dollar – AUD	Climate-specific[e, 2] USD	Status[b, 3]	Funding source[f, 4]	Financial instrument[f, 5]	Type of support[f, g, 6]	Sector[c, f, 7]
Specialized United Nations bodies	17,262,708.96	12,960,841.89	17,262,708.96	12,960,841.89					
1. United Nations Development Programme									
2. United Nations Environment Programme									
3. Other	17,262,708.96	12,960,841.89	17,262,708.96	12,960,841.89					
Multilateral Fund for the Implementation of the Montreal Protocol	15,667,810.00	11,763,391.75	15,667,810.00	11,763,391.75	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Intergovernmental Panel on Climate Change	433,000.00	325,096.40	433,000.00	325,096.40	Disbursed	OOF	Grant	Cross-cutting	Cross-cutting
UN Framework Convention on Climate Change	1,161,898.96	872,353.74	1,161,898.96	872,353.74	Disbursed	OOF	Grant	Cross-cutting	Cross-cutting

Abbreviations: ODA = official development assistance, OOF = other official flows, USD = United States dollars.

a Parties should fill in a separate table for each year, namely 2015 and 2016, where 2018 is the reporting year.

b Parties should explain, in their biennial reports, the methodologies used to specify the funds as disbursed and committed. Parties will provide the information for as many status categories as appropriate in the following order of priority: disbursed and committed.

c Parties may select several applicable sectors. Parties may report sectoral distribution, as applicable, under "Other".

d This refers to support to multilateral institutions that Parties cannot specify as being climate-specific.

e Parties should explain in their biennial reports how they define funds as being climate-specific.

f Please specify.

g This refers to funding for activities that are cross-cutting across mitigation and adaptation.

Table 7 (CTF Table 7(a)): Provision of public financial support: contribution through multilateral channels in 2020[a]

Donor funding	Total amount				Status[b, 3]	Funding source[f, 4]	Financial instrument[f, 5]	Type of support[f, g, 6]	Sector[c, f, 7]
	Core/general[d, 1]		Climate-specific[e, 2]						
	Australian dollar – AUD	USD	Australian dollar - AUD	USD					
Total contributions through multilateral channels	453,861,740.20	312,166,104.91	117,619,457.51	80,898,662.87					
Multilateral climate change funds	2,790,000.00	1,918,962.00	2,338,410.60	1,608,358.81					
1. Global Environment Facility	2,790,000.00	1,918,962.00	2,338,410.60	1,608,358.81	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund									
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds									
Multilateral financial institutions, including regional development banks	449,618,992.28	309,247,942.89	113,828,298.99	78,291,104.04					
1. World Bank	207,940,000.00	143,021,132.00	67,202,049.20	46,221,569.44	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
2. International Finance Corporation									
3. African Development Bank									
4. Asian Development Bank	59,036,000.00	40,604,960.80	7,736,077.44	5,320,874.06	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank									
7. Other	182,642,992.28	125,621,850.09	38,890,172.35	26,748,660.54					
Asian Infrastructure Investment Bank	182,642,992.28	125,621,850.09	38,890,172.35	26,748,660.54	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting

Donor funding	Total amount				Status[b, 3]	Funding source[f, 4]	Financial instrument[f, 5]	Type of support[f, g, 6]	Sector[c, f, 7]
	Core/general[d, 1]		Climate-specific[e, 2]						
	Australian dollar – AUD	USD	Australian dollar - AUD	USD					
Specialized United Nations bodies	1,452,747.92	999,200.02	1,452,747.92	999,200.02					
1. United Nations Development Programme									
2. United Nations Environment Programme									
3. Other	1,452,747.92	999,200.02	1,452,747.92	999,200.02					
Intergovernmental Panel on Climate Change	340,000.00	233,852.00	340,000.00	233,852.00	Disbursed	OOF	Grant	Cross-cutting	Cross-cutting
UN Framework Convention on Climate Change	1,112,747.92	765,348.02	1,112,747.92	765,348.02	Disbursed	OOF	Grant	Cross-cutting	Cross-cutting

Abbreviations: ODA = official development assistance, OOF = other official flows, USD = United States dollars.

a Parties should fill in a separate table for each year, namely 2015 and 2016, where 2018 is the reporting year.

b Parties should explain, in their biennial reports, the methodologies used to specify the funds as disbursed and committed. Parties will provide the information for as many status categories as appropriate in the following order of priority: disbursed and committed.

c Parties may select several applicable sectors. Parties may report sectoral distribution, as applicable, under "Other".

d This refers to support to multilateral institutions that Parties cannot specify as being climate-specific.

e Parties should explain in their biennial reports how they define funds as being climate-specific.

f Please specify.

g This refers to funding for activities that are cross-cutting across mitigation and adaptation.

Table 8 (CTF Table 7(b)): Provision of public financial support: contribution through bilateral, regional and other channels in 2019[a]

Recipient country/ region/project/ programme[b]	Total amount – Climate-specific[f, 2] – Australian dollar – AUD	USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
Total contributions through bilateral, regional and other channels	138,615,302.99	104,072,369.46						
/ Global (ODA)	17,169,547.75	12,890,896.45	Disbursed	ODA	Grant	Adaptation	Agriculture, Other (Disaster prevention and preparedness), Energy, Other (Environment), Forestry, Industry, Other (Other sectors), Water and sanitation	- Global Agriculture and Food Security Program - Australian Humanitarian Partnership - Australian Water Partnership - World Bank Global Facility for Disaster Reduction and Recovery - Australian Red Cross Humanitarian Partnership - Water and Sanitation Initiative Global Programming - International Coral Reef Initiative - Supporting Implementation of the Sendai Framework - World Heritage Committee - Grow Asia (World Economic Forum) - AIMS support to implement Blue Charter commitments - Geoscience support for Sendai Implementation - Australian NGO Cooperation Program (2018-19) - Australian Volunteers
/ Global (ODA)	5,192,288.61	3,898,370.29	Disbursed	ODA	Grant	Mitigation	Energy, Other (Environment), Other (Other sectors), Transport	- The Private Infrastructure Development Group - Exporting Australian Traditional Fire Management - Business Partnerships Platform - Partnership for Renewable Energy Finance & Trade - Australia Awards

Recipient country/ region/project/ programme[b]	Total amount Climate-specific[f, 2] Australian dollar – AUD	USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Global (ODA)	3,832,183.23	2,877,203.17	Disbursed	ODA	Grant	Cross-cutting	Energy, Other (Environment), Other (Other sectors), Transport, Water and sanitation	- Infrastructure Development Fund - Commonwealth Climate Finance Access Hub II - Nationally Determined Contribution Partnership - Climate Finance Fund - Australia Awards
/ Global (OOF)	1,405,101.00	1,054,949.83	Disbursed	OOF	Grant	Cross-cutting	Cross-cutting	- International Climate Change Engagement Program
/ Pacific Regional	15,312,170.88	11,496,377.89	Disbursed	ODA	Grant	Adaptation	Agriculture, Other (Environment), Other (Other sectors)	- Australia Pacific Climate Partnership - Fisheries Development Assistance in the Pacific - Coral Reef Innovation Project - Pacific Regional Market Access (PHAMA Plus) - Pacific Food Security Initiative - Climate and Agriculture - Deployable Recovery - Social Infrastructure - Benefit Sharing Fund and development projects - Investing in a Resilient Pacific 2016-2019
/ Pacific Regional	10,799,280.54	8,108,099.83	Disbursed	ODA	Grant	Mitigation	Other (Environment)	- Australia Pacific Climate Partnership - Pacific Regional Blue Carbon Initiative
/ Pacific Regional	1,455,000.00	1,092,414.00	Disbursed	ODA	Grant	Cross-cutting	Other (Environment), Other (Other sectors)	- UNDP Pacific Sub Regional Centre - Pacific Nationally Determined Contributions Hub - Pacific Women Climate Change Negotiators Training

Recipient country/ region/project/ programme[b]	Total amount: Climate-specific[f, 2]: Australian dollar – AUD	Total amount: Climate-specific[f, 2]: USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Fiji	622,439.90	467,327.88	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Fiji Access to Quality Education Program - Fiji Program Support Facility: Preparedness and Response
/ Fiji	61,323.18	46,041.44	Disbursed	ODA	Grant	Mitigation	Other (Other sectors)	- Fiji Access to Quality Education Program
/ Fiji	690,000.00	518,052.00	Disbursed	ODA	Grant	Cross-cutting	Other (Other sector)	- Supporting Private Sector Development in Fiji
/ Kiribati	3,918,154.14	2,941,750.13	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Kiribati Improved Basic Education - The Kiribati Facility
/ Kiribati	233,246.26	175,121.29	Disbursed	ODA	Grant	Cross-cutting	Other (Other sectors)	- Kiribati Growth and Economic Management Initiative
/ Nauru	1,134,000.00	851,407.20	Disbursed	ODA	Grant	Adaptation	Other (Other sectors), Transport	- Nauru Infrastructure and Services
/ Papua New Guinea	26,942,216.17	20,228,215.90	Disbursed	ODA	Grant	Adaptation	Agriculture, Energy, Other (Environment), Other (Other sectors), Transport, Water and sanitation	- PNG Transport Sector Support Program Phase 2 - Joint Understanding Technical Enabling Unit - PNG-Australia Incentive Fund - Climate Change Portfolio - Economic and Social Infrastructure Program - Health Services Sector Development Program - Private Sector and Rural Development - Food systems initiative
/ Papua New Guinea	1,627,553.72	1,221,967.34	Disbursed	ODA	Grant	Mitigation	Agriculture, Other (Other sectors)	- Kokoda Initiative - Private Sector and Rural Development

Recipient country/ region/project/ programme[b]	Total amount – Climate-specific[f, 2] – Australian dollar – AUD	Total amount – Climate-specific[f, 2] – USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Papua New Guinea	1,979,161.82	1,485,954.69	Disbursed	ODA	Grant	Cross-cutting	Agriculture, Other (Environment), Other (Other sectors)	- Private Sector and Rural Development - Climate Change Portfolio
/ Samoa	14,436.05	10,838.59	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Samoa Parliament Complex Redevelopment Phase II
/ Solomon Islands	5,767,351.51	4,330,127.52	Disbursed	ODA	Grant	Adaptation	Other (Disaster prevention and preparedness), Energy, Other (Other sectors), Transport	- Education Sector Program 2 - Solomon Islands Growth Program: Strongim Bisnis; Gizo Market Redevelopment - Solomon Islands Transport Sector-Based Approach Phase II - Gender Inequality of Risk - Solomon Islands - Solomon Islands Humanitarian & Disaster Management
/ Solomon Islands	3,150,000.00	2,365,020.00	Disbursed	ODA	Grant	Mitigation	Agriculture, Energy, Other (Other sectors)	- Solomon Islands Growth Program: Support to the energy sector - Solomon Islands Rural Development Program
/ Tonga	99,560.73	74,750.20	Disbursed	ODA	Grant	Adaptation	Other (Disaster prevention and preparedness)	- Disaster Preparedness and Response
/ Tonga	4,691,855.61	3,522,645.19	Disbursed	ODA	Grant	Mitigation	Energy, Other (Other sectors)	- Tonga Renewable Energy Project - Tonga Economic and Public Sector Reform Program - Tonga Energy Roadmap
/ Tuvalu	789,896.67	593,054.42	Disbursed	ODA	Grant	Adaptation	Other (Environment), Other (Other sectors)	- Good Governance and Economic Growth - Pacific Technical Assistance Mechanism

Recipient country/ region/project/ programme[b]	Total amount		Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
	Climate-specific[f, 2]							
	Australian dollar – AUD	USD						
/ Vanuatu	6,901,290.89	5,181,489.20	Disbursed	ODA	Grant	Adaptation	Other (Other sectors), Transport	- Roads for Development Transition Program - Vanuatu Skills for Economic Growth Phase IV - Vanuatu Education Support Program Phase II - Vanuatu Education Support Program - Port Vila Urban Development Project - Wan Smolbag Theatre Community Partnership - Vanuatu Health Sector Support 2010 - 2019 - Volcano Recovery Program 2019-2022 - Roads for Development Program Phase Two
/ South and West Asia Regional	3,701,460.23	2,779,056.34	Disbursed	ODA	Grant	Adaptation	Agriculture, Energy, Water and sanitation	- Sustainable Development Investment Portfolio Phase 2
/ South and West Asia Regional	2,071,110.23	1,554,989.56	Disbursed	ODA	Grant	Mitigation	Agriculture, Energy, Water and sanitation	- Sustainable Development Investment Portfolio Phase 2
/ South and West Asia Regional	1,118,705.12	839,923.80	Disbursed	ODA	Grant	Cross-cutting	Agriculture, Energy, Water and sanitation	- Sustainable Development Investment Portfolio Phase 2
/ Afghanistan	3,109,124.36	2,334,330.57	Disbursed	ODA	Grant	Adaptation	Agriculture, Other (Other sectors)	- Australia Afghanistan Community Resilience Scheme - Humanitarian Action in Afghanistan
/ Bangladesh	2,205,900.00	1,656,189.72	Disbursed	ODA	Grant	Adaptation	Other (Disaster prevention and preparedness), Other (Other sectors)	- Strategic Partnership Arrangement Phase 2 with Building Resources Across Communities (BRAC)

Recipient country/ region/project/ programme[b]	Total amount Climate-specific[f, 2] Australian dollar – AUD	 USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Bangladesh	245,100.00	184,021.08	Disbursed	ODA	Grant	Mitigation	Other (Disaster prevention and preparedness), Other (Other sectors)	- Strategic Partnership Arrangement Phase 2 with Building Resources Across Communities (BRAC)
/ Pakistan	1,350,000.00	1,013,580.00	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Pakistan Humanitarian Support
/ Pakistan	150,000.00	112,620.00	Disbursed	ODA	Grant	Cross-cutting	Other (Other sectors)	- Pakistan Humanitarian Support
/ Sri Lanka	270,000.00	202,716.00	Disbursed	ODA	Grant	Adaptation	Other (Disaster prevention and preparedness), Other (Other sectors)	- Sri Lanka Humanitarian Assistance 2016-20
/ East Asia Regional	1,077,546.52	809,021.92	Disbursed	ODA	Grant	Adaptation	Other (Environment), Other (Other sectors), Water and sanitation	- Oxfam-Civil Society Engagement in Water Governance - Supporting Mekong River Commission and Mekong governments - ASEAN-Australia Smart Cities - Mekong - Australia Water Facility - Research for Development on Water Governance - Regional Maritime Cooperation Southeast Asia
/ East Asia Regional	269,597.45	202,413.76	Disbursed	ODA	Grant	Mitigation	Other (Environment), Other (Other sectors), Water and sanitation	- ASEAN-Australia Smart Cities - Supporting Mekong River Commission and Mekong governments - Mekong - Australia Water Facility - Regional Maritime Cooperation Southeast Asia

Recipient country/ region/project/ programme[b]	Total amount		Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
	Climate-specific[f, 2]							
	Australian dollar – AUD	USD						
/ East Asia Regional	174,042.26	130,670.93	Disbursed	ODA	Grant	Cross-cutting	Other (Environment), Other (Other sectors), Water and sanitation	- Supporting Mekong River Commission and Mekong governments - Mekong - Australia Water Facility - Research for Development on Water Governance - Regional Maritime Cooperation Southeast Asia - Smart Cities design 2018-19
/ Cambodia	258,498.07	194,080.35	Disbursed	ODA	Grant	Mitigation	Energy, Water and sanitation	- 3i: Investing In Infrastructure
/ Indonesia	4,052,417.19	3,042,554.82	Disbursed	ODA	Grant	Adaptation	Agriculture, Other (Other sectors), Transport, Water and sanitation	- Australia Indonesia Partnership for Rural Economic Development Program - Promoting Rural Income thru Support in Agriculture - Indonesia Infrastructure Program (KIAT) Phase 1 - Governance for Growth KOMPAK
/ Indonesia	1,900,282.47	1,426,732.07	Disbursed	ODA	Grant	Mitigation	Agriculture, Other (Environment), Other (Other sectors), Transport	- Indonesia Australia Partnership for Environmental Governance - Maritime Capacity Building Initiative - Australia Indonesia Partnership for Rural Economic Development Program - Promoting Rural Income thru Support in Agriculture - Governance for Growth KOMPAK
/ Indonesia	123,364.43	92,622.02	Disbursed	ODA	Grant	Cross-cutting	Other (Other sectors), Transport, Water and sanitation	- Indonesia Infrastructure Program (KIAT) Phase 1
/ Myanmar	303,768.57	228,069.44	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Livelihoods and Food Security Trust Fund

Recipient country/ region/project/ programme[b]	Total amount: Climate-specific[f, 2]: Australian dollar – AUD	Total amount: Climate-specific[f, 2]: USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Myanmar	3,527.43	2,648.39	Disbursed	ODA	Grant	Mitigation	Other (Other sectors)	- Livelihoods and Food Security Trust Fund
/ Vietnam	1,541,808.00	1,157,589.45	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Australia - World Bank Strategic Partnership in Vietnam Phase 2
/ Vietnam	250,992.00	188,444.79	Disbursed	ODA	Grant	Mitigation	Other (Other sectors)	- Australia - World Bank Strategic Partnership in Vietnam Phase 2
/ Other Regional	650,000.00	488,020.00	Disbursed	ODA	Grant	Mitigation	Other (Environment), Industry, Other (Other sectors)	- Digital Earth Africa Phase II - Indian Ocean and IORA

Abbreviations: ODA = official development assistance, OOF = other official flows; USD = United States dollars.

a Parties should fill in a separate table for each year, namely 2015 and 2016, where 2018 is the reporting year.

b Parties should report, to the extent possible, on details contained in this table.

c Parties should explain, in their biennial reports, the methodologies used to specify the funds as disbursed and committed. Parties will provide the information for as many status categories as appropriate in the following order of priority: disbursed and committed.

d Parties may select several applicable sectors. Parties may report sectoral distribution, as applicable, under "Other".

e Parties should report, as appropriate, on project details and the implementing agency.

f Parties should explain in their biennial reports how they define funds as being climate-specific.

g Please specify.

h This refers to funding for activities that are cross-cutting across mitigation and adaptation.

Table 8 (CTF Table 7(b)): Provision of public financial support: contribution through bilateral, regional and other channels in 2020[a]

Recipient country/ region/project/ programme[b]	Total amount – Climate-specific[f, 2] – Australian dollar – AUD	Total amount – Climate-specific[f, 2] – USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
Total contributions through bilateral, regional and other channels	171,994,884.45	118,298,081.52						
/ Global (ODA)	20,544,439.43	14,130,465.44	Disbursed	ODA	Grant	Adaptation	Agriculture, Other (Disaster prevention and preparedness), Other (Environment), Industry, Other (Other sectors), Transport, Water and sanitation	- Australian Humanitarian Partnership - Integrated deployable civilian capability - Australian Water Partnership - Water for Women - Australian Red Cross Humanitarian Partnership - Grow Asia (World Economic Forum) - International Coral Reef Initiative - Private Finance for Development - Business Partnerships Platform - World Heritage Committee - Supporting Implementation of the Sendai Framework - Private Sector Development Partnerships - Water and Sanitation Initiative Global Programming - Australian NGO Cooperation Program - Australia Awards - Australian Volunteers
/ Global (ODA)	7,543,319.62	5,188,295.23	Disbursed	ODA	Grant	Mitigation	Other (Disaster prevention and preparedness), Energy, Other (Environment), Other (Other sectors), Transport, Water and sanitation	- Private Finance for Development - The Private Infrastructure Development Group - Exporting Australian Traditional Fire Management - Partnership for Renewable Energy Finance and Trade - Australian NGO Cooperation Program - Australia Awards - Australian Volunteers

Recipient country/ region/project/ programme[b]	Total amount – Climate-specific[f, 2] – Australian dollar – AUD	Total amount – Climate-specific[f, 2] – USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Global (ODA)	7,158,720.56	4,923,768.00	Disbursed	ODA	Grant	Cross-cutting	Energy, Other (Environment), Other (Other sectors), Transport, Water and sanitation	- Australian Climate Finance Partnership - Commonwealth Climate Finance Access Hub II - Infrastructure Development Fund - Blue Dot Network - Australian NGO Cooperation Program - Australia Awards - Australian Volunteers
/ Global (OOF)	1,544,857.28	1,062,552.84	Disbursed	OOF	Grant	Cross-cutting	Cross-cutting	- International Climate Change Engagement Program
/ Pacific Regional	23,384,715.44	16,084,007.28	Disbursed	ODA	Grant	Adaptation	Agriculture, Other (Environment), Other (Other sectors)	- Australia Pacific Climate Partnership - Fisheries Development Assistance in the Pacific - Climate and Agriculture - Climate Risk and Early Warning Systems Initiative - Coral Reef Innovation Project - Kiwa Initiative – Nature Based Solutions for Climate Resilience - Pacific Regional Market Access (PHAMA Plus) - UNDP Pacific Sub Regional Centre - Pacific Food Security Initiative - Deployable Recovery - Social Infrastructure - Science Circus Pacific - Pacific Technical Assistance Mechanism Phase 2

Recipient country/ region/project/ programme[b]	Total amount – Climate-specific[f, 2] – Australian dollar – AUD	Total amount – Climate-specific[f, 2] – USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Pacific Regional	363,636.36	250,109.09	Disbursed	ODA	Grant	Mitigation	Agriculture, Other (Environment), Other (Other sectors)	- Climate and Agriculture - Exploring options for climate change mitigation in the Pacific
/ Pacific Regional	916,360.29	630,272.61	Disbursed	ODA	Grant	Cross-cutting	Other (Environment)	- Pacific Regional Blue Carbon Initiative - Pacific Women Climate Change Negotiators Training
/ Fiji	953,955.36	656,130.50	Disbursed	ODA	Grant	Adaptation	Other (Disaster prevention and preparedness), Other (Other sectors)	- Supporting Private Sector Development in Fiji - Fiji Program Support Facility: Preparedness and Response Fund - Nadi Flood Alleviation Project - Fiji - Water - Access to Quality Education Program in Fiji
/ Kiribati	4,028,080.98	2,770,514.10	Disbursed	ODA	Grant	Adaptation	Industry, Other (Other sectors)	- Kiribati Improved Basic Education - The Kiribati Facility - Kiribati Growth and Economic Management - Kiribati Infrastructure
/ Marshall Islands	125,329.78	86,201.82	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- RMI Partnership for Development
/ Micronesia, Federated States of	130,776.30	89,947.94	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- FSM Partnership for Development
/ Nauru	1,134,000.00	779,965.20	Disbursed	ODA	Grant	Adaptation	Other (Other sectors), Transport	- Nauru Infrastructure and Services

Recipient country/ region/project/ programme[b]	Total amount		Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
	Climate-specific[f, 2]							
	Australian dollar – AUD	USD						
/ Papua New Guinea	42,414,378.02	29,172,609.20	Disbursed	ODA	Grant	Adaptation	Agriculture, Other (Disaster prevention and preparedness), Energy, Other (Environment), Other (Other sectors), Transport, Water and sanitation	- PNG Transport Sector Support Program Phase 2 - Private Sector and Rural Development - Economic and Social Infrastructure Program - Health Services Sector Development Program - Climate Change Portfolio - Justice Services Stability for Development - Joint Understanding Technical Enabling Unit - PNG-Australia Incentive Fund - Food Systems Initiative - PNG Food Futures initiative
/ Samoa	1,070,935.38	736,589.36	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Samoa Fiscal Resilience Program - Samoa Parliament Complex Redevelopment Phase II
/ Solomon Islands	5,049,340.15	3,472,936.15	Disbursed	ODA	Grant	Adaptation	Other (Disaster prevention and preparedness), Energy, Other (Other sectors)	- Education Sector Support Program - Solomon Islands Growth Program: Strongim Bisnis; Gizo Market Redevelopment - Solomon Islands Disaster Management and Climate Resilience - Education Sector Program 2 - Solomon Islands Disaster Prepapredness & Response Activities - Women's Disaster Resilience in the Pacific - Solomon Islands
/ Solomon Islands	355,000.00	244,169.00	Disbursed	ODA	Grant	Mitigation	Energy, Other (Other sectors)	- Solomon Islands Growth Program: Support to the Solomon Islands energy sector

Recipient country/ region/project/ programme[b]	Total amount: Climate-specific[f, 2]: Australian dollar – AUD	Total amount: Climate-specific[f, 2]: USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Tonga	1,259,293.05	866,141.76	Disbursed	ODA	Grant	Adaptation	Other (Disaster prevention and preparedness), Other (Other sectors)	- Tonga Economic and Public Sector Reform Program - Disaster Preparedness and Response
/ Tonga	2,885,789.19	1,984,845.80	Disbursed	ODA	Grant	Mitigation	Energy	- Tonga Energy Roadmap
/ Tuvalu	1,011,630.82	695,799.68	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Tuvalu Good Governance and Economic Growth - Fiji Program Support Facility: Australian Government Support to Tuvalu Education - Tuvalu Education Support Program
/ Vanuatu	8,588,395.57	5,907,098.47	Disbursed	ODA	Grant	Adaptation	Energy, Other (Other sectors), Transport	- Vanuatu Education Support Program Phase II - Roads for Development Program Phase Two - Vanuatu Skills for Economic Growth Phase IV - Volcano Recovery Program - Vanuatu Health Program - Governance for Growth Phase 3 - Wan Smolbag Theatre Community Partnership
/ South and West Asia Regional	2,975,515.85	2,046,559.80	Disbursed	ODA	Grant	Adaptation	Agriculture, Energy, Water and sanitation	- South Asia Water Security Initiative - Sustainable Development Investment Portfolio Phase 2
/ South and West Asia Regional	1,023,300.00	703,825.74	Disbursed	ODA	Grant	Mitigation	Agriculture, Energy, Water and sanitation	- Sustainable Development Investment Portfolio Phase 2
/ South and West Asia Regional	739,939.15	508,930.14	Disbursed	ODA	Grant	Cross-cutting	Agriculture, Energy, Water and sanitation	- Sustainable Development Investment Portfolio Phase 2

Recipient country/ region/project/ programme[b]	Total amount: Climate-specific[f, 2] Australian dollar – AUD	USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Afghanistan	4,023,589.56	2,767,424.90	Disbursed	ODA	Grant	Adaptation	Agriculture, Other (Other sectors)	- Humanitarian Action in Afghanistan - Australia Afghanistan Community Resilience Scheme
/ Afghanistan	19,413.29	13,352.46	Disbursed	ODA	Grant	Mitigation	Agriculture, Other (Other sectors)	- Afghanistan Reconstruction Trust Fund
/ Nepal	500,000.00	343,900.00	Disbursed	ODA	Grant	Cross-cutting	Water and sanitation	- Water Governance Investment in Nepal
/ Pakistan	1,500,000.00	1,031,700.00	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Pakistan Humanitarian Support
/ East Asia Regional	1,824,488.07	1,254,882.90	Disbursed	ODA	Grant	Adaptation	Other (Environment), Other (Other sectors), Water and sanitation	- Mekong - Australia Water Facility - Mekong Regional Water Governance Program – Inclusion Project Phase II - ASEAN-Australia Smart Cities - Supporting Mekong River Commission and Mekong governments - Oxfam-Civil Society Engagement in Water Governance - Program Management for Greater Mekong Water Resources Program
/ East Asia Regional	69,334.13	47,688.02	Disbursed	ODA	Grant	Mitigation	Other (Environment), Other (Other sectors), Water and sanitation	- Supporting Mekong River Commission and Mekong governments
/ East Asia Regional	53,776.30	36,987.34	Disbursed	ODA	Grant	Cross-cutting	Energy, Other (Environment), Transport	- Partnerships for Infrastructure
/ Cambodia	4,938,615.00	3,396,779.40	Disbursed	ODA	Grant	Adaptation	Agriculture, Energy, Water and sanitation	- Cambodia Agricultural Value Chain Program Phase 2 - 3i: Investing In Infrastructure
/ Cambodia	129,000.00	88,726.20	Disbursed	ODA	Grant	Mitigation	Energy, Water and sanitation	- 3i: Investing In Infrastructure

Recipient country/ region/project/ programme[b]	Total amount Climate-specific[f, 2] Australian dollar – AUD	USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Indonesia	8,712,694.51	5,992,591.28	Disbursed	ODA	Grant	Adaptation	Agriculture, Other (Disaster prevention and preparedness), Other (Other sectors), Transport, Water and sanitation	- Indonesia Infrastructure Program (KIAT) Phase 1 - Promoting Rural Income thru Support in Agriculture - Australia-Indonesia Partnership for Disaster Risk Management - Palembang City Sewerage Project - Indonesia Australia Partnership for Economic Development
/ Indonesia	5,823,336.54	4,005,290.87	Disbursed	ODA	Grant	Mitigation	Agriculture, Energy, Other (Environment), Other (Other sector), Transport, Water and sanitation	- Indonesia Infrastructure Program (KIAT) Phase 1 - Indonesia Australia Partnership for Environmental Governance - Palembang City Sewerage Project - Maritime Capacity Building Initiative - Promoting Rural Income thru Support in Agriculture - Multilateral Development Bank Infrastructure Assistance Program
/ Myanmar	1,016,995.78	699,489.70	Disbursed	ODA	Grant	Adaptation	Other (Other sectors)	- Livelihoods and Food Security Trust Fund
/ Philippines	80,426.00	55,317.00	Disbursed	ODA	Grant	Adaptation	Agriculture	- Climate Knowledge Disaster Risk Management Small-holder Farmers (Philippines)
/ Philippines	2,959,460.00	2,035,516.59	Disbursed	ODA	Grant	Mitigation	Other (Other sectors)	- Advancing Multilateral Partnerships for Economic Development
/ Timor-Leste	1,515,924.16	1,042,652.63	Disbursed	ODA	Grant	Adaptation	Agriculture	- TOMAK - Farming for Prosperity (Timor-Leste)

Recipient country/ region/project/ programme[b]	Total amount: Climate-specific[f, 2]: Australian dollar – AUD	Total amount: Climate-specific[f, 2]: USD	Status[c, 3]	Funding source[g, 4]	Financial instrument[g, 5]	Type of support[g, h, 6]	Sector[d, g, 7]	Additional information[e]
/ Vietnam	2,858,622.53	1,966,160.58	Disbursed	ODA	Grant	Adaptation	Other (Other sectors), Transport	- Aus4transport - Australia - World Bank Strategic Partnership in Vietnam Phase 2
/ Other Regional	467,500.00	321,546.50	Disbursed	ODA	Grant	Adaptation	Industry, Other (Other sectors)	- Digital Earth Africa Phase II - Indian Ocean and IORA
/ Other Regional	300,000.00	206,340.00	Disbursed	ODA	Grant	Mitigation	Other (Other sectors)	- Digital Earth Africa Phase II

Abbreviations: ODA = official development assistance, OOF = other official flows; USD = United States dollars.

a Parties should fill in a separate table for each year, namely 2015 and 2016, where 2018 is the reporting year.

b Parties should report, to the extent possible, on details contained in this table.

c Parties should explain, in their biennial reports, the methodologies used to specify the funds as disbursed and committed. Parties will provide the information for as many status categories as appropriate in the following order of priority: disbursed and committed.

d Parties may select several applicable sectors. Parties may report sectoral distribution, as applicable, under "Other".

e Parties should report, as appropriate, on project details and the implementing agency.

f Parties should explain in their biennial reports how they define funds as being climate-specific.

g Please specify.

h This refers to funding for activities that are cross-cutting across mitigation and adaptation.

Table 10 (CTF Table 8): Provision of technology development and transfer support[a,b]

Recipient country and/or region	Targeted area	Measures and activities related to technology transfer	Sector[c]	Source of the funding for technology transfer	Activities undertaken by	Status	Additional information[d]
Indonesia	Mitigation and Adaptation	Promoting Rural Income thru Support in Agriculture (PRISMA-2) uses the market systems development approach in the areas of agriculture, horticulture, livestock, and aquaculture sectors to stimulate systemic market change and improved smallholder farmer resilience and competitiveness through access to new markets, better inputs, know-how and technology.	Agriculture	Public	Public	Implemented	PRISMA-2 is the second phase of the successful Australia Indonesia Partnership for Rural Economic Development (AIP-Rural) program (2013-2018). It aims to increase the incomes of an additional 700,000 smallholder farming households by 30% by December 2023. At least 60% of the beneficiaries will consist of farmers living below USD2.5 per day at PPP (Purchasing Power Parity).
Pacific Region	Adaptation	The Coral Reef Innovation Project uses innovative technology (ReefCloud) to enhance developing country capabilities to gather and assess information on coral reef resilience and inform appropriate management actions based on these assessments. ReefCloud is a digital tool that allows real time reef monitoring and preservation.	Other (Ocean)	Public	Public	Implemented	This project supports developing countries in the Pacific to better manage their coral reefs. Activities include training on the operation and application of the Reef Cloud platform to better report reef cover and health. It assists policy and decision makers to analyse and monitor information to enhance resilience-based coral reef management; and supports Pacific regional organisations to access better data to inform decision making on reef protection and management.
Pacific Region	Adaptation	The Climate and Oceans Support Program in the Pacific Phase 2 (COSPPac) works with Pacific Island stakeholders to analyse and interpret climate, oceans and tidal data to produce valuable services for island communities. This information helps island communities to prepare for, and mitigate the impacts of severe climate, tidal and oceanographic events. The Seasonal Climate Outlook decision support tool software uses statistical method to determine forecast probabilities, and provides graphics and text to support outlooks.	Other (Research)	Public	Public	Implemented	COSPPac is funded by the Australian Government and implemented by the Bureau of Meteorology. The program partners with Geoscience Australia, the Pacific Community (SPC) and Secretariat of the Pacific Regional Environment Programme (SPREP).

Recipient country and/or region	Targeted area	Measures and activities related to technology transfer	Sector[c]	Source of the funding for technology transfer	Activities undertaken by	Status	Additional information[d]
Pacific Region	Mitigation and Adaptation	The Australia Pacific Climate Partnership (APCP) provides technical assistance and support to the Australian development program to strengthen climate and disaster resilience. One example of technology transfer is the provision of technical designs for solar in Samoa as part of Australia's support to the legislative assembly buildings.	Energy	Public	Public	Implemented	APCP delivers technical climate change and disaster risk reduction advice to the Australian Government and implementing partners in programming, design, procurement, implementation, and review of its development investments in the Pacific, across all sectors and countries. It brokers knowledge to inform aid development processes, and undertake program-wide monitoring, evaluation and learning, to ensure that Australia's aid investments are effectively managing climate and disaster risks and delivering low-carbon, resilient growth in the region.
Pacific Region	Mitigation and Adaptation	The Australian Infrastructure Financing Facility for the Pacific (AIFFP) supports renewable and lower-emissions energy generation and transmission. The AIFFP is making a key contribution to meeting the challenges of climate change in the region. The Markham Valley Solar Project and the Tina River Transmission System in Solomon Islands are examples of this.	Infrastructure , Energy	Private and Public	Private and Public	Implemented	AIFFP partners with governments and private sector in the Pacific and Timor-Leste, to provide grant and loan financing for high quality, transformational energy, water, transport, telecommunications and other infrastructure.
Asia Pacific	Mitigation and Adaptation	Science and Technology for Climate Partnerships (SciTech4Climate) connects leading Australian scientists and climate specialists with development partners in the Indo-Pacific to ensure our region's response to climate change is supported by the best available science and technological advances. Projects include technology to accurately map seagrass meadows, trials of thermotheretic desalination units, household water purification systems, and trials of climate-smart agricultural innovations.	Agriculture, Other (Research)	Public	Public	Implemented	Through SciTech4Climate, DFAT is partnering with Australia's national science agency, CSIRO and the Australian National University (ANU) to develop practical actions to adapt to the effects of climate change and reduce greenhouse gas emissions in the Indo-Pacific.

Recipient country and/or region	Targeted area	Measures and activities related to technology transfer	Sector[c]	Source of the funding for technology transfer	Activities undertaken by	Status	Additional information[d]
Pacific Region, Papua New Guinea	Mitigation	The Australia Business Partnership Program (BPP) Sola PayGo has partnered with the Australian Government as well as payment services provider Bmobile and product manufacturer d.light to enable distribution of household solar systems and kits at scale.	Energy	Private and Public	Private and Public	Implemented	Australia's Business Partnerships Platform supports partnerships on investments that deliver a social and commercial return. It is a mechanism for businesses to formally partner with the Australian government for co-investment.
Papua New Guinea	Mitigation	Pawarim Komuniti is an off-grid electrification program that provides rural households, community services facilities and businesses with reliable and affordable access to clean energy services. Grants have supported the provision of solar home systems and streetlights in remote areas of West Sepik, solar fridges, power and lighting systems, water tanks and health supplies in Oro, solar home kits to college students, and solar street lights around community water stations and kitchen taps in Morobe.	Energy	Private and Public	Private and Public	Implemented	Pawarim Komuniti supports government, development partners, civil society and private sector with information on successful off-grid electrification models. It works across some the most remote areas of PNG to provide technically and economically viable clean energy solutions.
Tonga	Mitigation	Australia supports the Outer Islands Renewable Energy Program (OIREP) which instals grid-connected photovoltaic power systems on nine of Tonga's outer islands. Using renewable energy, such as solar, helps communities recover faster from disasters and provides more affordable sources of power.	Energy	Public	Public	Implemented	Australia is helping Tonga meet its target of 50 percent renewable energy by 2020 through by supporting the Outer Islands Renewable Energy Program (OIREP) which is implemented by the Asian Development Bank.

Recipient country and/or region	Targeted area	Measures and activities related to technology transfer	Sector[c]	Source of the funding for technology transfer	Activities undertaken by	Status	Additional information[d]
Tonga	Mitigation	Australia supports the Tonga Renewable Energy Project (TREP) which is improving the storage of use of electricity generated from solar photovoltaic and wind power on Tongatapu with a large battery energy storage system (BESS) capacity, improving electricity generation from renewable resources on seven islands, and upgrading grid technologies.	Energy	Public	Public	Implemented	The Tonga Renewable Energy Program is supported by Australia and implemented by the Asian Development Bank.
Africa	Adaptation	Australia is a partner on Digital Earth Africa which will convert 30 years of satellite remote sensing data into ready-to-use data for businesses, governments, NGOs, research and academic institutions and multilaterals, to develop applications that utilise the platform's data, including to inform climate-related decisions. The Platform is being developed by Geoscience Australia's Digital Earth Australia. The project uses Open Data Cube software.	Other (Research)	Public	Public	Implemented	Digital Earth Africa Phase II follows on from the Africa Regional Data Cube (ARDC), launched in May 2018. That pilot made use of the Open Data Cube technology developed by Geoscience Australia in the first continental scale, operational service of Earth Observation decision-ready products for Australia.
Fiji	Adaptation	The Nadi Flood Alleviation Project has provided the technology on watershed management and upstream flood mitigation required to address residual flood risk, including sediment management infrastructure, catchment land use management measures, awareness, forecasting and warning.	Water and sanitation	Public	Public	Implemented	The Nadi Flood Alleviation Project will mitigate future damage to the Fijian economy and livelihoods from floods in the commercial centre of Nadi town and on the Nadi flood plain.

Recipient country and/or region	Targeted area	Measures and activities related to technology transfer	Sector[c]	Source of the funding for technology transfer	Activities undertaken by	Status	Additional information[d]
Papua New Guinea	Adaptation	Through the PNG-Australia Transport Sector Support Program (TSSP) Australia is assisting PNG to adapt to extreme weather events by upgrading the design standards for roads and bridges to improve climate resilience. PNG's critical transport infrastructure is increasingly threatened by extreme weather events that cause flooding and erosion on road networks, and degrade the condition of port infrastructure.	Transport	Public	Public	Implemented	The TSSP first commenced in 2007 and is a long-term commitment by the Australian government to support PNG.
Fiji, Solomon Islands, Vanuatu	Adaptation	Australia is the principle donor for UNWomen's Markets for Change program that has helped communities, especially women, with economic infrastructure that can withstand the effects of climate change. The program supported the community in Raki Raki, Fiji to rebuild their municipal market to cyclone-proof specifications.	Other (Infrastructure)	Public	Public	Implemented	Markets for Change reduces the risk of sexual and physical violence against women market sellers. The program provides climate resilient roofing and secure accommodation for rural market vendors, as well as building skills to improve economic opportunities.
Solomon Islands	Adaptation	Australia supported the redevelopment of the Gizo Market in Solomon Islands and ensured it was designed and built to withstand a Category 5 cyclone and resist sea level rises.	Other (Infrastructure)	Public	Public	Implemented	The Gizo Market redevelopment sourced local sustainably harvested timber for the roof construction, and includes a sustainable water supply and sanitation facilities. It sets an example for how infrastructure can deliver economic resilience in the face of increasing climate change threats and disasters.
Vanuatu	Adaptation	The Recovery Acceleration through Prefabricated Infrastructure Deployment (RAPID) pilot explored options for high-quality permanent prefabricated structures that can be used in response to naural disasters - for schools and community halls, and for cyclone shelters in future disasters. The buildings withstood Category 5 tropical cyclone Harold in 2020.	Other (Infrastructure)	Public	Public	Implemented	Balon School in Vanuatu was a pilot site for the RAPID program, and the disaster resilient buildings withstood Tropical Cyclone Harold - a Category 5 storm that swept through the Pacific in 2020. The school buildings served as cyclone shelters over two days of the worst weather, and hosted community services in the weeks following.

Recipient country and/or region	Targeted area	Measures and activities related to technology transfer	Sector[c]	Source of the funding for technology transfer	Activities undertaken by	Status	Additional information[d]
Pacific Region	Adaptation	The Atoll Food Futures program helps Pacific atoll nations increase local food production through the provision of Foodcube" garden systems. The Foodcube is an innovative raised wicking garden system that incorporates novel compost and soil quality management research developed by the Australian Centre for International Agricultural Research (ACIAR). Each Foodcube has the potential to produce up to 25kg of fresh produce per annum.	Agriculture	Public	Public	Implemented	This project seeks to address the challenges in local food production in Pacific atoll nations that are exacerbated by climate change. Rising sea levels, poor soil quality, increasing salinity, little-to-no access to seeds and planting material and lack of land have resulted in many nations relying on low-quality imported foods to meet basic nutritional requirements. This has led to a deterioration in diet quality and health, and increasing rates of malnutrition, overnutrition and non-communicable diseases.
Pacific Region	Adaptation	Australia's is supporting the Centre for Pacific Crops and Trees (CePaCT) effort to build a cryopreservation facility, which will deliver technology that can greatly enhance CePaCT's mission for long term conservation of key Pacific crops. The facility will ensure Pacific communities have access to diverse, nutritious domestic food and sustainable livelihoods.	Agriculture	Public	Public	Implemented	The Pacific Community's Centre for Pacific Crops and Trees (CePaCT) is the only regional gene bank that has the capacity to conserve and distribute diverse food plant genetic material from key Pacific crops such as taro, yam, sweet potato, banana, cassava, and breadfruit. CePaCT's work represents the foundation of the Pacific's climate resilient agricultural future and underpins the region's capacity to support a food security response during disasters.

a To be reported to the extent possible.

b The tables should include measures and activities since the last national communication or biennial report.

c Parties may report sectoral disaggregation, as appropriate.

d Additional information may include, for example, funding for technology development and transfer provided, a short description of the measure or activity and co-financing arrangements.

Table 11 (CTF Table 9): Provision of capacity-building support[a]

Recipient country/region	Targeted area	Programme or project title	Description of programme or project b,c
Kiribati	Multiple Areas	Skills for Employment Program (SfEP)	The Skills for Employment Program (SfEP), referred to as the 'Kiribati Facility" supports the Government of Kiribati to provide labour market demand driven skills development to young people who seek to work in domestic and off-shore labour markets. The program supports the Kiribati Institute of Technology (KIT) which is being developed as a demand driven training provider catering for domestic, regional and international labour markets. Climate-related activities include plumbing skills training to manage Kiribati's increasingly scarce water resources, electrotechnology for maintaining solar panels, and environment and sustainability training.
Pacific Region	Mitigation	Science Circus Pacific	The Science Circus Pacific program promotes science, technology, engineering and maths (STEM) education in Pacific island countries. Its cross-cutting capacity building model engages families and communities, tertiary and basic education, and government to reflect the wider learning ecosystem in the Pacific. In the long term, it aims to further enable Pacific partners to build the knowledge, skills and local talent that Pacific nations will need to respond to long term challenges related to heath and climate.
Pacific Region	Adaptation	Governance for Resilience in the Pacific (Gov4Res)	Governance for Resilient Development in the Pacific Program (Gov4Res) supports governments across the Pacific region to include climate change and disaster risk factors in their planning, budgeting and implementation.
Pacific Region	Adaptation	Climate and Oceans Support Program in the Pacific (COSPPac)	The Climate and Oceans Support Program in the Pacific (COSPPac) works to enhance the capacity of Pacific Islands to manage and mitigate the impacts of climate variability and tidal events. The project works with stakeholders in the Islands to build tools that can forecast and report on climate, tides and the ocean. It then works with partners to determine how best to communicate this information to communities, businesses and governments.
Pacific Region	Multiple Areas	Australia Pacific Climate Partnership (APCP)	The Australia Pacific Climate Partnership (APCP) provides technical assistance and support to the Australian development program in the Pacific to strengthen climate and disaster resilience. This is undertaken through training of Australian government staff as well as implementing partners such as NGOs and national governments. Resources are developed to assist in capacity development such as climate and health briefs, climate science updates and risk profiles for each country. The APCP has also launched a climate alumni network that provides professional development and skills for climate professionals in the Pacific.
Pacific Region	Adaptation	Empower Women, Impact Climate: Climate Change Negotiation Skills for Women in the Pacific	The Empower Women, Impact Climate: Climate Change Negotiation Skills for Women in the Pacific program provides a multi-tiered training and travel support program to train women leaders and build the capacity of twelve Pacific Island nations' delegations to advocate for just climate policies. By training participants in diplomacy and negotiation skills, teaching advanced knowledge of the climate change negotiations, contributing to the development of leadership skills, providing connections and networking with other women leaders, and supporting participants as part of their national delegations, this program enables women leaders from the Pacific, to also serve effectively on the frontlines of climate change policymaking and implementation.

Recipient country/region	Targeted area	Programme or project title	Description of programme or project b,c
Global (26 developing countries)	Multiple Areas	Australian Volunteers Program	The Australian Volunteers Program matches skilled Australians with organisations in partner countries to help these organisations to deliver on their own objectives. The program uses international volunteering as a people-centred approach to capacity development. The program has three impact areas: one of which is climate change, food security and disaster risk reduction.
Global	Multiple areas	Australian Awards	Australia Awards Scholarships are long-term awards administered by the Department of Foreign Affairs and Trade. They aim to contribute to the development needs of Australia's partner countries in line with bilateral and regional agreements, including climate change and disaster education and skills training. They provide opportunities for people from developing countries, particularly those countries located in the Indo-Pacific region, to undertake full time undergraduate or postgraduate study at participating Australian universities and Technical and Further Education (TAFE) institutions. The study and research opportunities provided by Australia Awards Scholarships develop the skills and knowledge of individuals to drive change and contribute to development in their own countries.
Global	Adaptation	Australia Assists	Australia Assists is an Australian government mechanism, managed by RedR, for deploying technical specialists to work with governments, multilateral agencies and communities to prepare for, respond to, and recover from disasters and conflict.
Pacific Region	Mitigation	Australia Pacific Training Coalition (APTC)	As Australia's flagship Technical and Vocational Education and Training (TVET) investment in the region, the Australia Pacific Training Coalition (APTC) works collaboratively with national governments, development partners, private sector, organisations for people with disabilities, civil society organisations and Pacific TVET institutions across ten countries. This includes developing a climate and disaster resilience training module and integrating it into sectoral training.
Pacific Region	Mitigation	Pacific Fusion Centre	The Pacific Fusion Centre delivers training and strategic analysis against security priorities identified by Pacific Island Forum Leaders in the 2018 Boe Declaration on Regional Security, which includes climate change as the single biggest threat to the region. Their work enhances information sharing, cooperation, analysis and assessment, and expands situational awareness and capacity across the Pacific.
Pacific Region	Adaptation	Shifting the Power Coalition	Australia supports the Shifting the Power Coalition that spans a network of close to 100,000 grassroots, intergenerational and inclusive movements in seven Pacific Island Forum countries. It is the only women-led regional alliance focused on strengthening the collective power, influence and leadership of diverse Pacific women to respond to disasters and climate change. Through its work, the coalition brings attention to women's collective peacebuilding, community-led activism, Pacific-driven innovation and humanitarian expertise as well as Pacific women's collective and personal lived realities.
Fiji, Papua New Guinea, Samoa, Solomon Islands, Tonga, Vanuatu	Adaptation	PHAMA Plus	The Pacific Horticultural and Agricultural Market Access Program (PHAMA Plus) provides practical, targeted assistance and training to help Pacific island countries manage regulatory aspects associated with exporting primary and value-added products. This encompasses gaining access for products into new markets, and helping to manage issues associated with maintaining and improving existing trade - as well as supporting climate and disaster resilience for agricultural communities through awareness training and demonstration farms for climate smart agriculture. PHAMA Plus is supported by the Australian and New Zealand governments.

Recipient country/region	Targeted area	Programme or project title	Description of programme or project b,c
Global	Adaptation	Australian Centre for International Agricultural Research's (ACIAR)	The Australian Centre for International Agricultural Research (ACIAR) supports the Pacific in building understanding to address the impacts of climate change on food systems resilience and livelihood security. For example, in Fiji, ACIAR is undertaking training and facilitation activities to enable value-add opportunities for agroforestry, actions to support market pull for senile coconut stems by converting them to high-value engineered wood products and increasing the productivity and profitability of beekeeping. In addition, ACIAR is also enabling a targeted assessment to explore opportunities for the implementation of conservation agriculture and sustainable intensification of smallholder farming systems as a transformational adaptation to climate change.
Papua New Guinea	Multiple Areas	PNG Climate Change Portfolio and Australia Awards	A collaboration between the PNG Climate Portfolio and Australia Awards supported 26 PNG nationals from the public and private sector to undertake a Graduate Certificate in Environment Management (Climate Change Policy) at the University of Queensland. Now equipped with skills to develop, implement and understand both national and international climate change policies, it is hoped these graduates will go on to make a difference both at the government and community level in building resilience against the impacts of climate change.
Papua New Guinea	Multiple Areas	Climate Futures	The Climate Futures project supported by Australia aims to address challenges in accessing and applying climate science and information by bringing together world leading climate science expertise and PNG based development organisations to co-design and test new methods of integrating science into adaptation decision-making. It also strives to build the capacity of local NGOs to act as climate knowledge brokers.
Papua New Guinea	Adaptation	Green Growth Plans	The Australian Government provides funding to the Global Green Growth Institute (GGGI) to support Enga, Milne Bay, and New Ireland Provinces to mainstream the development policies, plans, and budgets of provinces in PNG to be climate-resilient, environmentally sustainable, and socially inclusive, implement bankable projects, and mobilise green investments and climate finance mechanisms to support this effort.
Papua New Guinea	Adaptation	Transport Sector Support Program	The PNG – Australia Transport Sector Support Program Phase 2 (TSSP2) provides technical assistance and capacity development for the six PNG transport sector agencies related to roads, aviation and ports to strengthen climate and disaster resilience.
Vanuatu	Adaptation	Vanuatu Skills program	The Vanuatu Skills Partnership helps the Ministry of Education and Training build the skills ni-Vanuatu need to adapt to climate change and move towards clean, affordable low carbon growth in the tourism, agribusiness, handicraft and construction sectors. The Partnership has developed a Climate Change Strategy for the operations of the Ministry's Skills Centres.
Solomon Islands	Multiple Areas	Education Sector Support Program	The Education Sector Support Program is a joint Australia and New Zealand program to support the Solomon Islands Government to implement its Education Strategic Framework. One component of the program seeks to better integrate climate change into curriculum, education resources and teacher training.

Recipient country/region	Targeted area	Programme or project title	Description of programme or project b,c
Solomon Islands	Multiple Areas	Solomon Islands Infrastructure Program	The Solomon Islands Infrastructure Program supports capacity development in the Solomon Islands Government and construction industry to strengthen climate and disaster resilience through infrastructure project planning and delivery.
Fiji	Multiple Areas	Fiji Education Facility	Australia is supporting the Fijian Ministry of Education, Heritage, and Arts with technical assistance to incorporate climate change and disaster resilience into the cross-cutting themes in the national school curriculum review.
Kiribati	Multiple Areas	Kiribati Institute of Technology	Australia's support to the Kiribati Institute of Technology has developed a climate change module introducing students to climate change as a global issue with impacts for national economies and local communities and livelihoods. It is also developing a climate and disaster resilience TVET course for Kiribati.
Samoa	Multiple Areas	Tautua - Samoa Education Support Program	Australia is supporting the integration of climate change and disaster resilience in infrastructure, curriculum, and teacher training for Samoa's schools through technical assistance and budget support. Australia has supported the development of a Climate Change and Disaster Risk Resilience Strategy for the Education Sector.
Tonga	Multiple Areas	Tonga Skills for Inclusive Economic Growth	Australia is assisting the Tongan leadership to address the skills shortage through its Tonga Skills for Inclusive Economic Growth (Tonga Skills) Program. It supports skills sector reform linked directly to inclusive economic growth through the economic empowerment of women, the disabled and Tongans in remote and more vulnerable communities. In the construction sector alone, Tonga Skills has helped 82 trainees graduate from their courses since 2018, with many going on to rebuild the thousands of homes destroyed by Cyclone Gita.
Tonga	Mitigation	Tonga Renewable Energy Program	Australia supports the Asian Development Bank's Tonga Renewable Energy Project (TREP) which is improving the storage and use of electricity generated from solar photovoltaic and wind power in Tonga. The project includes capacity building and project management support, with an emphasis on providing women with training and economic empowerment opportunities.
Palau	Multiple Areas	Palau International Coral Reef Centre	Australia has provided a grant under the Direct Aid Program to the Palau International Coral Reef Center to support their school education program which includes resilience to climate and disaster resilience. Australia is providing technical support on their curriculum.
Papua New Guinea	Multiple Areas	PNG Economic and Social Infrastructure	The PNG Economic and Social Infrastructure Program (ESIP) works across a range of priority sectors for the PNG-Australia Partnership to improve the provision and sustainability of services across PNG. The program supports PNG Government reform of state-owned enterprises, hard infrastructure delivery, and policy and regulatory support. ESIP is responsible for Australia's electrification support to the PNG Government which includes helping rural and remote communities' access to clean energy, and capacity support to PNG Power and the National Energy Authority. The program also provides capacity support to Water PNG to develop management plans for water and waste services.

Recipient country/region	Targeted area	Programme or project title	Description of programme or project b,c
Global	Multiple Areas	International Partnership for Blue Carbon	The International Partnership for Blue Carbon connects government agencies with non-government organisations, intergovernmental organisations and research institutions from around the world, with a joint vision to protect, sustainably manage and restore global coastal blue carbon ecosystems – mangroves, tidal marshes and seagrasses.
Africa	Technology Development and Transfer	Digital Earth Africa Phase II	Digital Earth Africa Phase II follows on from an initial phase that identified African needs and priorities in the use of satellite data and tools and existing capacity. This program is building a continent-wide data and information infrastructure platform. It is converting decades of satellite remote sensing data into ready-to-use data for a wide range of users. It builds the capacity of African institutions to access and manage the data to enable stakeholders, including businesses, governments, NGOs, research and academic institutions and multilaterals, to develop applications that utilise the platform's data. The UN Economic Commission for Africa (UNECA) hosts Digital Earth Africa, which is accessible by agencies from more than 50 African countries.
Pacific Region	Technology Development and Transfer	Coral Reef Innovation Project	The Coral Reef Innovation Project uses innovative technology (ReefCloud) to enhance developing country capabilities to gather and assess information on coral reef resilience and inform appropriate management actions based on these assessments. Activities include training for reef managers, scientists, and other users in developing countries on the operation and application of the Reef Cloud platform; assisting policy and decision makers to analyse and monitor information; and supporting Pacific regional organisations to access better data to inform decision making.
Global	Technology Development and Transfer	World Heritage Committee	During Australia's term on the UNESCO World Heritage Committee (2017 to November 2021) Australia worked to strengthen the integrity and implementation of the World Heritage Convention through policy-making, provision of technical expertise, capacity building and financial contributions. Australia is now continuing World Heritage initiatives to drive best practice through innovation, science and adaptive management approaches, and by assisting other countries to build management capacity and to prepare World Heritage nominations.
Pacific Region	Adaptation	Women's Resilience to Disasters (WRD)	Women's Resilience to Disasters (WRD) supports Pacific women, their governments and other stakeholders to create and lead Pacific solutions which ensure gender equality, diversity and inclusion are fully reflected in prevention, preparedness, and recovery policy frameworks, systems and processes. By supporting local leadership and solutions, the program contributes to regional and global knowledge sharing and advocacy on women's leadership for disaster resilience.

a To be reported to the extent possible.

b Each Party included in Annex II to the Convention shall provide information, to the extent possible, on how it has provided capacity-building support that responds to the existing and emerging capacity-building needs identified by Parties not included in Annex I to the Convention in the areas of mitigation, adaptation and technology development and transfer.

c Additional information may be provided on, for example, the measure or activity and co-financing arrangements.

7. Other reporting matters

Australia's domestic arrangements established for the process of the self-assessment of compliance with emission reductions, in comparison with emission reduction commitments, are addressed in section 4.1.2 of Australia's eighth national communication. Australia considers that its eighth national communication and fifth biennial report includes all information relevant to the achievement of the objective of the Convention.

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